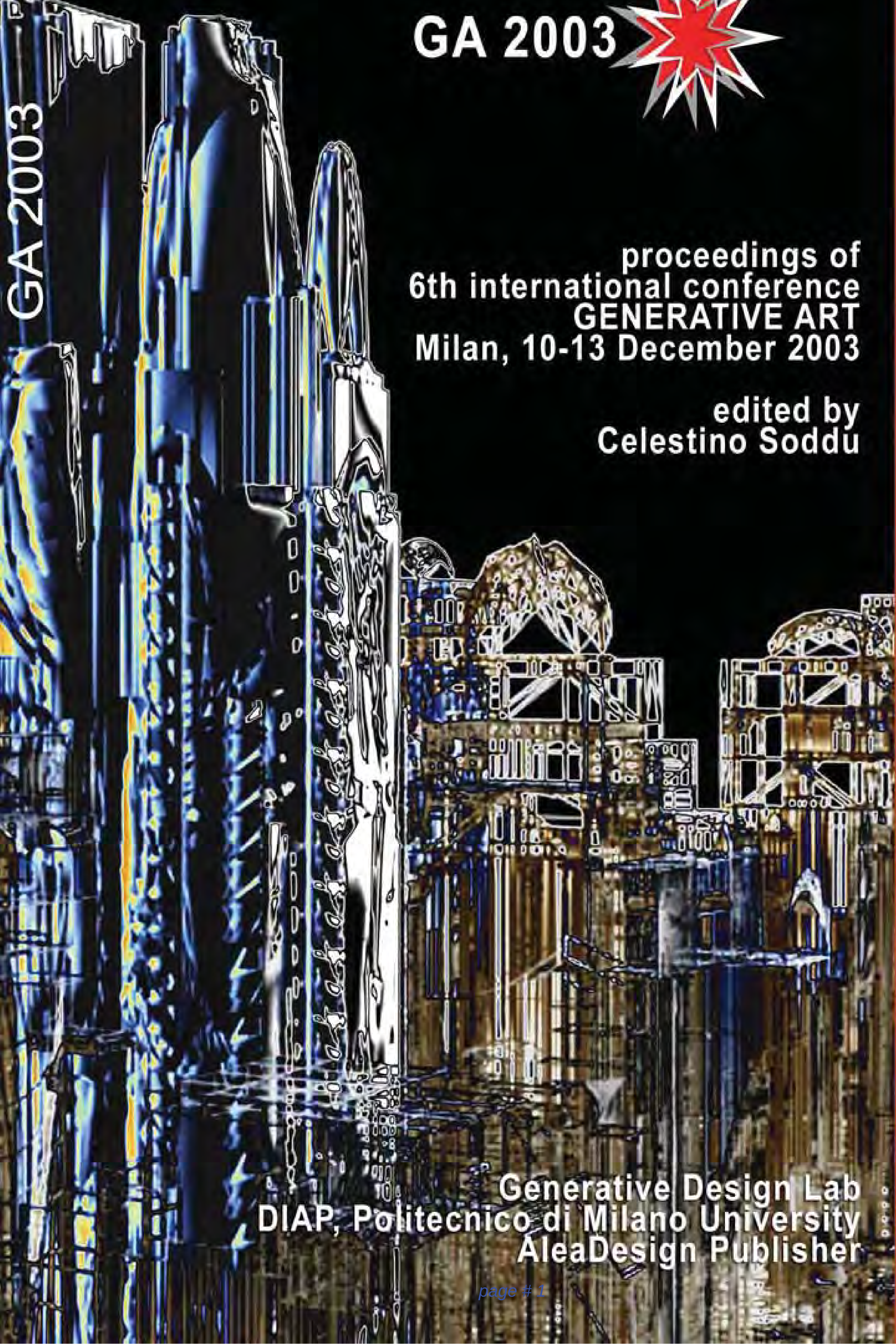
GA 2003



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Celestino Soddu

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Edited by Celestino Soddu
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Index of papers of GA2003

Index of short papers, posters, artworks and performances

Visionary Aesthetics and Architecture Variations

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1.0 Abstract

This paper describes the use of Generative Approach to construct the transformation processes of artificial environment. In particular urban and architectural environments with long history are considered.
The aim was to design generative codes able to generate detailed architectural projects of new buildings and new imprintings inside existing historical environments. These new architectures had to fit, or better to increase the specific town evolution.
These design experiments follow my first generative projects, dated from 1988, concerning Italian Medieval Towns and subsequent evolutions. These were conducted in 2002 and 2003 in Hong Kong, Macau, Shanghai, Nagoya, TelAviv, Rome, Los Angeles, Chicago, NewYork and Washington DC.
The challenge is to generate Visionary Variations of complex environments by using Morphogenesis codes. As in nature to reach, by using generative codes, the complex contemporary quality of detailed architectural projects.

2.0 History and Nature

Our goal is to associate the natural environments to the artificial environments that had been marked by the time and cultural processes. Historical cities that have had a cultural stratification through the centuries seems to be more natural. They seems to fit our more deep needs in living environmental systems as a mirror of our life. This wonderful quality belongs to ancient cities like Rome and in modern cities like NY City and Chicago that stratified, in the last centuries, different cultures. This is a process that works as an identifiable and recognizable concept of ideal City.
This analogy with nature is due to a lot of factors. Each of these factors is a fundamental part of the natural image of these complex artificial systems. In my work each one is described and designed with a generative morphogenesis code, with algorithms that, as an artificial DNA, work to define the evolution of town environments.

2.1 Uniqueness. Generation versus Cloning

First factor. Aesthetics of Transformation versus Aesthetics of Repetition.
The association of the adjective "artificial" with the concept of repetition of objects all equal can help us to consider a historical city as a natural world. No architecture, in cities born and evolved before the last century, is equal to another. May be that we can discover similarity, but not repetition.
Our good harmony feeling inside natural environments is also due to the appreciation of uniqueness and un-repeatebility of natural realities. No tree is equal to another, also if it is similar. Each tree is unpredictable, also if it is not a surprise. It is recognizable.

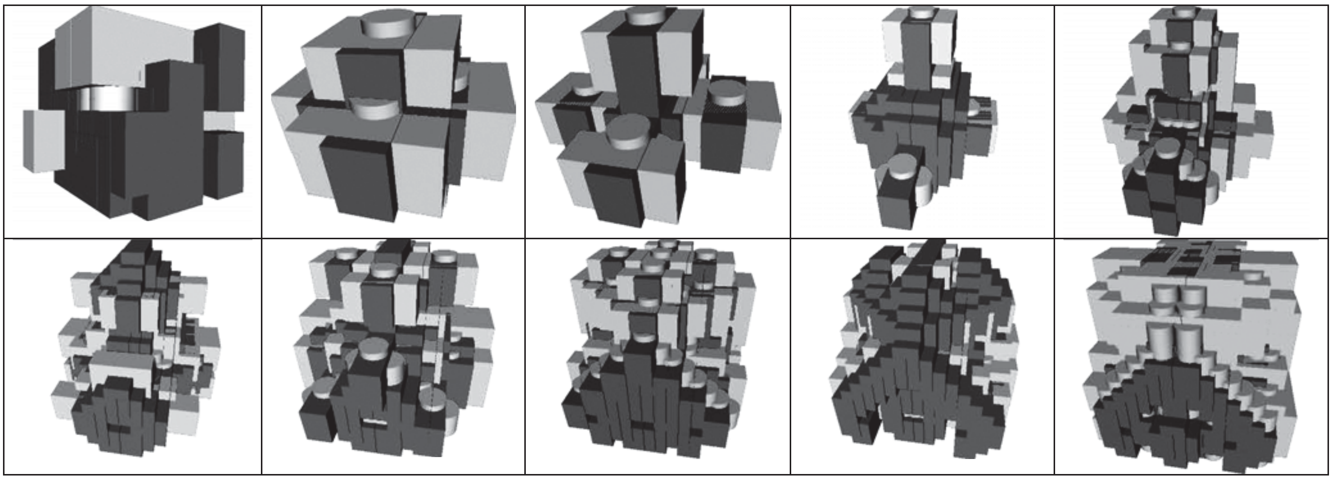
In the artificial worlds we can work to build this quality by using a morphogenesis approach. We can design "natural" species instead of objects. As happens in nature, these species generate endless sequences of individual realities.
Generative Design can fit these human needs. As Leonardo codes, we can do that by designing the Dna of possible architectural and urban scenarios.
After two centuries of cloned objects and versus the concept of architecture and design of artificial objects as equal repetition of the same result, considered "optimal", with Generative Approach we can find again the ability to design and to produce artificial worlds emulating the nature oneness and un-repeatability.
So, avoiding the random-form approach, we can design extended artificial DNA, and we can control these artificial species from the whole to the details of each possible generated individuals.
Generative design is the construction of an idea/code as similarity of individuals that belong to a same species. It is not only the generation of random results waiting for the emergence of unexpected form which could satisfy the expectations of people with not-well defined aim.
The species is a design product. New individual don't emerge from random. Each scenario is one of the possible endless representations of the same generative processes, of the same concept/idea. Each result is different because of unpredictable factors of the context in which each individual lives, but each result belongs the applied morphogenesis codes.

2.2 Complexity, Artificial Life and Cellular Automata

Second factor. Natural organic structure of historical cities comes from progressive contaminations of different concepts in a running time line. The complexity of a long-lived-town's system cannot be emulated without running again the same type of progressive path. In this sense the generative methodology has to foresee a series of transformation logics, which we could assume as concepts representation. Each generative project has to activate and to run artificial lives that manage, dynamically, the progressive mutual contaminations of these concepts.

"In order to realize complexity and clarity, one needs to define operational logics that are strongly structured and that explicitly mirror a simple subjective approach. First of all, complexity cannot be reached in a single step. If we try to draw a city we will always make a simplified representation of it, or, at most, one that is strongly allusive with respect to a particular and limited reading key. The urban images of Piranesi, the series of engravings on the "Carceri" are, perhaps, the highest visionary representations of the urban and architectural complexity in a single sketch. But even Piranesi, in order to reach complexity, stratified one sketch onto the other, using an already carved plate and stratifying new visions, often contaminating one perspective logic with another, creating ambiguity and new possible overlapping reading keys that follow different temporal and emotional moments contaminating one another but that are not contradictory.
Complexity is always the result of progressive paths of contamination and stratification. It is generated from the dynamics of a process and often from its non-linearity. That's not all. Complexity also emerges from the ability of an idea/hypothesis to confront unforeseen events within a process of temporal transformation. If the idea, considered as visionary of the future, comes across obstacles, overcoming these obstacles and constraints creates knots of complexity in the system. At the same time, this increases the recognizability of the idea, that is, the complex identity of every single event." (Generative Design Visionary Variations. Morphogenetic processes for complex future identities, Celestino Soddu, Communication and Cognition Journal, 2003)
Complexity, as stratification of different and subsequent approaches, needs to have a process time. Also a subjective approach defined today is different from tomorrow's new one, the same if it belongs to the same human viewpoint.
Complexity is created by the simultaneous existence of different concepts and, in the same moment, of contradictory ones inside the same visionary approach.

If our aim is to design morphogenesis codes able to construct a contempoirary complexity, we need to stratify, inside generative project, a lot of different subjective concepts mirroring our personal history of designers, our different moods and the sequence of hypothesis belonging to our cultural viewpoint.
Doing that, we need to interpret each design occasion as a particular contamination way of our stratified morphogenetic codes. So we need to redefine a paradigm that will control the evolutionary path.
Following the concept that complexity rises only from a temporal path, we can manage a second possibility using evolutionary systems. This second possibility can be used only together with the first one because it can only consolidate the increasing complexity of a topological relationship.
In order to design this system of rules, we could also use Cellular Automata logical approaches. But such evolutionary structures don't succeed in satisfying the complexity as figuration proper of architectural events. In my generative architectural projects I used three-dimensional cellular automata for increasing the complexity of a topological system but not directly for shaping possible architectural events. Each of these architectural events follows genetic structures built considering the specificity of feasible buildings. This peculiarity is defined through rules of transformation.
Cellular Automata is really a generative phenomenon but only as a schematic support of possible configuration.
Cellular Automata define a progressive structure of different codes that are applicable to each event, at the different scales, considering the structure of relationships with the surrounding events. It is very important for the possible starting up of generative processes.
Each architectural event is identified and it is generated by considering what happens in the 26 surrounding positions. These relationships operate enhancing the rules of transformation already working in each single event and in its 26 interfaces shared with other events. This process occurs from the whole architecture until its details. My process uses logics similar to fractal systems. The difference with fractal systems is that the homothetic approach is applied not to forms but to transformations.



Sequence of increasing complexity in a 3d cellular automata experimental program by C.Soddu

2.3 Figuration and Idea

3dr factor. Like in nature, the constrains belonging to the increasing functional and technological factors that occur during the design life will increase the quality and natural character of artificial environment.
The strong relationship between figuration, feasibility and architectural concept can be managed in way that the feasibility don't reduce the idea but can be the key to gain complexity by opening a lot of parallel possibilities to develop the architectural concept until the implementation of final design results.

I defined, inside my generative projects, a structure of different, parallel and possible devices of transformation that represent a lot of different constructive approaches to the architectural shape feasibility. The choice among these possible evolutionary paths is done not only at a low level but with the purpose to enhance the idea/code during each increasing complexity process. The evolutionary process is managed by fitting the progressive results with different construction approaches and their progressive contamination in an open system. In this way, all the practical needs, that could seem to be bonds, are really used to enhance the architectural idea. As normally happens in nature, difficulties don't reduce the input but are the occasion for increasing the complexity implementation.
Like olive tree. More it is beaten from the wind and from the bad weather, more it has been marked by time history, more the quality of the result is amazing and fascinating. Time and constrains has enhanced its identity of individual, its being an exceptional and unique expression of the species code.

Olive tree aged of two thousand years in the Getzemani Garden, Jerusalem

In our town environment (and in architectural design processes too) the same process happens. More the town was passed through strong and different cultures, and, in sequence, different needs was applied to transform this reality, more its artificial environment has a high quality.
In generative processes happens the same. More the requests of the client are strong, contradictory and impossible, more the quality of the results can be high. The difficulties push the evolution and each step is an occasion to use an architectural code, using its ability to transform the request in increasing complexity and the first draft in a progressive good project.

Loa Angeles downtown, Visionary Variation. C.Soddu generative project 2003

3.0 Generative Codes and Visionary Variations.

Our aim is to construct Morphogenesis codes able to generate endless Visionary Variations. We can use, simultaneously, a set of different devices of transformation, made with the aim to represent the manifold faces of our architectural hypothesis.
As in nature, no one of this device of transformation is necessary or is exhaustive of our idea. We can use all them together. But we can also insert later other devices in order to upgrade our architectural idea during the time of our designing experience. The generated results will represent our subjective experience, our cultural references. Subjective codes in collective modality.

Chicago, one century ago. Visionary Generative scenario fitting City Identity.
C.Soddu generative project 2003.

My challenge was to design a generative code able to represent fascinating environments as historical cities. By representing the process and not the results, by constructing an artificial DNA.
I considered these subsequent issues and I used them to design an open system of generative codes:
1. In the historic cities everything seems always been so, that everything could not be anything else than so, but, at the same moment, everything is surprisingly unpredictable and complex, full of contradictions and of unexpected contaminations.
2. Everything is organically structured but every detail, every event is unique and unrepeatable. The codes of transformation, that I designed, manage opposite characters: uniqueness and recognizability, complexity and identity, unpredictability and organic system, order and chaos.
3. It is possible to find codes of identity and associations among characters and specificities of the events that compose these complex systems. But every code is interpretative code, is an hypothesis that represents the subjectivity of whom builds it.
4. The codes of reading are endless and each of these is like the codes that we use to recognize the objects surrounding us, the same codes that we learned to build when we was children and we needed to distinguish a chair from a table, an automobile from a truck, a picture of Van Gogh from one of Picasso, the teachers of mathematics from those of gymnastics.   Generative codes have to manage recognizability and clarity of possible scenarios.
5. The amazing thing is that, even if these codes are built so strongly by following our subjectivity, they perfectly work and are able to give us the ability to recognize unpredictable events. These rules of identification, also if they are different from the rules used by other people,

can fit the same results. This happens even if these subjective rules are founded on different lived events and on different logical associations. So, Identity codes can be written referring to our subjectivity. They will work well if these codes will be a lot inside an open system.

6. The codes of transformation that build the artificial DNA have to simultaneously fit our subjective way to read the surrounding environment and its transforming processes and, in the same moment, the inter-subjective feeling of how (in our interpretation) the inhabitants look at the past/future of the city environment.

7. The idea of city that springs from these subjective and inter-subjective approaches operates toward the realization of the city itself increasing its own fascinating aspects, its own characters, its own identity. This Idea represents an evolution and progressive stratification of complexity and it traces, unequivocally, the existence of a temporal run in action. The existence of the past, that is represented by the visible and by interpretable transformations gives the possibility of looking to a future. The need to interpret the existing town environment puts us into the game. We feel us inside the time, we feel alive, we feel well. A city without history is unliveable, because it is without time and therefore without future. At least until first transformations will be implemented, by opening the games to the creativeness and to the future.

The generative codes must be rules of transformation. Nothing has to be defined as form: this is a static approach. Everything has to be identified and to be designed as process of transformation, by following our need to feel alive. The more interesting and "natural" architectures were born by a transformation, not by a single act. The Pantheon too, one of the more perfect architectures, was born transforming a previous existing temple.


Shanghai. Visionary variation of city evolution. C.Soddu generative project 2003

1. *Artificial DNA*

IDEA AS ARTIFICIAL DNA

Idea: creative algorithms that define multiple paths from an existing world towards possible worlds. This is a ***set*** of ***transforming rules*** (transformation code like natural DNA) that identifies the designer's imprinting. These algorithms are used in every project and are upgraded after increasing experience.

2. Project Paradigm

SUBJECTIVE ACTIVATION OF EVOLUTIONARY PATH

This setup of the system is made for each specific design occasion, fitting the needs of the client

PLANNING CONTAMINATION

Evolutionary paradigm managing interactions, interferences, resonances and exceptions. It transforms the dynamic system into an auto-organizing system.

3. Artificial life

INCREASE THE COMPLEXITY WITH AL

Each artificial life begins at a different moment and it is the result of subsequent ***cycles*** of increasing complexity. Each generated event was not necessary before but becomes necessary after its generation. It is an irreversible temporal process, it is the clock of design evolution. The cycles continue until they reach the complexity that is requested by the architectural concept, and until they the client's needs.

4. Results

GENERATE ENDLESS SCENARIOS

Results are endless, unique and different. Although each result is ***unpredictable***, it can be recognized as following the IDEA/species and the client's needs.

5. Selection

CHOOSE THE RESULTS

The client can choose among different results. The selected scenarios will be used to upgrade the generative project and to generate a new set of results. The aim is to ***fit the client's needs and to develop the architect's concept***.

6A.Feedback for upgrading/increasing transforming rules

6B.Feedback for upgrading evolutionary paradigm

Table 1. ." (from: "Generative Design Visionary Variations. Morphogenetic processes for complex future identities", Celestino Soddu, Communication and Cognition Journal, 2003)

The generative process (cycle 1-2-3-4-5) uses algorithms managing the transformation and evolution inside a non-linear system, but not the evolution of the system itself. The IDEA **is** the evolutionary system. It uses generative algorithms for representing a particular subjective concept defined as process. Each generative project can generate, using a lot of parallel artificial lives, an endless sequence of possible parallel results for fitting the architect's imprinting with the client's needs. The system has not automatic upgrading (like genetic algorithms) because the aim is not optimising/homologising the idea-system but representing a subjective human creative identity with the fullness of all possible results. For this reason (cycle 6A, 6B) the upgrade is manually made by the architect. As in Renaissance, this upgrading activity is one of the most important human creative act during the design process. The only one that, following subjective interpretation, is impossible to emulate with AI and AL.

Nagoya. Visionary variation of the district of the harbor. C.Soddu generative project 2003

4.0 Visionary Variations

My last generative works have been characterized by the attempt to design the complexity of the urban-architectural environments of the modern tradition. While my first generative projects in the 80' have been characterized by the reconstruction of generative codes of the Italian urban tradition, from the Roman Empire to the medieval cities, from Renaissance to the Baroque, my last works focused the comparison with the urban environments of the modern tradition, as Chicago of the beginning of last century. This approach was enthusiastically performed and I found a good field to verify the possibility of using the generative approach directly in one of the most important design activity: the design of the quality of the urban environment, of the urban-architectural character and of its identity. Above all because in city as Chicago, Hong Kong and New York we can easily read the passage to the modern not only as innovation but also as construction of a cultural ideal shared among its inhabitants: the ideal city.
The challenge was to identify and build, with generative codes, visionary variations of ideal cities that are readable and interpretable in these real contexts and in their active and evolutionary processes.

Nagoya downtown, Japan. Visionary Scenarios of increasing complexity 2003

4.1 The Visionary approach

To implement a visionary approach we have:
1. To operate by generating variations and not permutations of pre-designed components (also if these components are parametric). My approach uses a set of parallel codes of transformation that represent a subjective vision, an interpretation of the reality as first step to implement possible worlds. Following that, my generative work don’t use databases. It is an open system able to generate endless results.

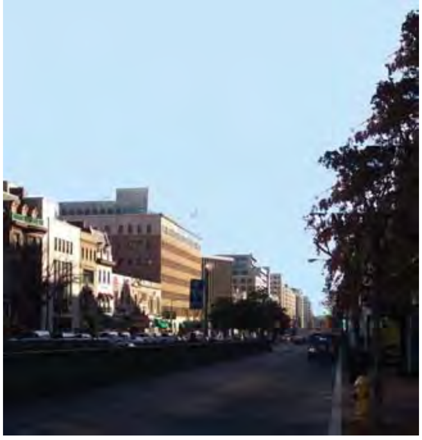
2. To reread the historical architectures but not to re-design their forms. The concept was to re-construct the complexity as harmony able to put, in only a scenario, the plurality of events that represents the natural multiplicity of the possible.

Washington DC, Inter American Development Bank Visionary variations. C.Soddu generative project 2003

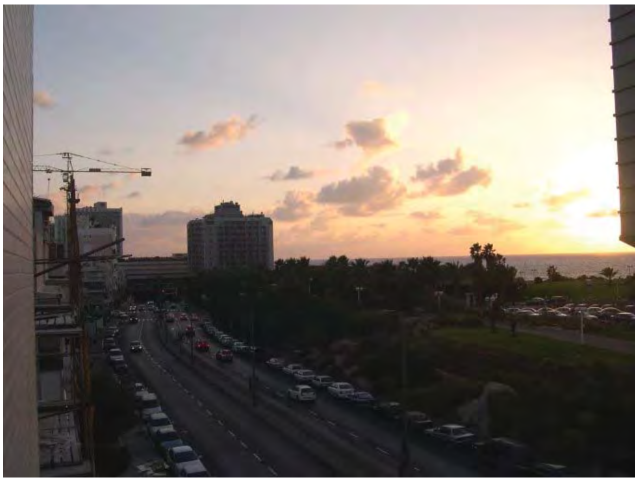
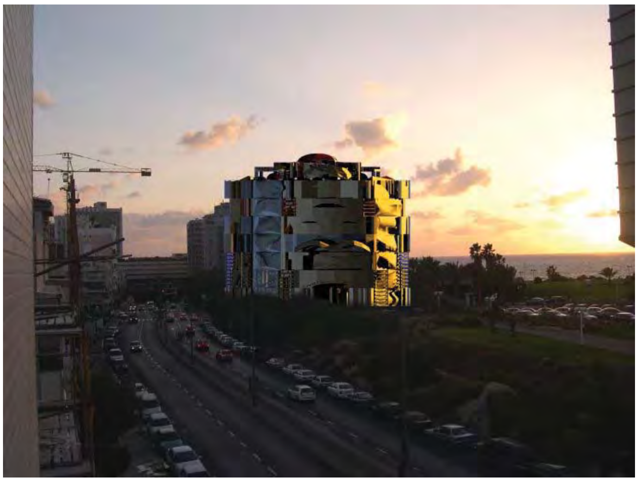
3. To build an artificial DNA that can be, at the same moment, innovative, contemporary, and the mirror of the architectural tradition of Renaissance. Where the generated scenarios, also if they mirror the tradition, they consolidate themselves in complex forms constrained by rules, they overcame the limit of these rules by using them. These scenarios have to deny the constrictive aspect of these rules to find again, in the constrain, the occasion to explain the concept and run the process of discovery. We are working, as in the Renaissance, in the field of art and science.
4. To maintain, rather to amplify the recognizability of each of these cities, also operating through architectures whose image is strongly linked to contemporary concepts of architecture.

5.0 Conclusion. Generative Art: technology or philosophy ?

The results of this challenge are the visionary variations of cities like Chicago, Nagoya, Shanghai, Washington, Los Angeles, Tel Aviv, and Rome.
These visionary approaches trace not the solution but the process toward a possible, a look toward possible variations of the environment that we are living. The aim is to design an idea of artificial objects that mirror nature, of architecture as plot of endless variations, of simultaneous uniqueness, of complexity that suddenly appears as existing from a long time, as natural character that we was looking for a long time, as mirror of our life.



Washington DC, Dupont street. Visionary variation of town evolution. C.Soddu generative project (IDB exhibition 2003)

TelAviv. Visionary variation of seafront. C.Soddu generative project of a new hotel, 2003

The generative approach overcomes the technology, it goes beyond the limits of the tools and it is the occasion of deep evaluations on the structure of the environmental systems surrounding us, occasion of discovery of creative spaces that we, for a long time, were looking for.
The idea can be concretised in a project of ideal city without having the necessity to represent it as solution, but only as code of the possible, as process of transformation that we can run: this is the Generative Art. Opening unexplored roads to the creativeness redefining the concept of design GA is, more than a technology, a philosophy.
Generative Art is not (only) a technology also if it uses information technologies. It is not only a tool that we can use to generate forms. It is a philosophy with a strong and humanistic imprinting: each generative project can be implemented only starting from a hypothesis, like all scientific

discovery paths, from a subjective vision of possible worlds, of possible rules, of possible increasing complexity.

Rome. Visionary variation of Ghetto-Trastevere new link. C.Soddu, E.Colabella, A.Sonnino Generative project 2003

References

C.Soddu, "L'artificiale progettato ", (the designed artificial world) Casa del Libro Publisher, 1979.
C.Soddu, "La patina del tempo" (the time patina) in "Recuperare" magazine n.9 1984.
C.Soddu, P.A.Rossi, "Il calice di Paolo Uccello uno e senza limite", (the goblet of Paolo Uccello, one and without limit) with a referee of C.L.Ragghianti, in "Critica d'arte" magazine n.8 1986.

C.Soddu, "L'immagine non euclidea" (the not euclidean image), Gangemi publisher, 1987.
C.Soddu, "Simulazioni per immagini tridimensionali computerizzate della dinamica di evoluzione formale dell'ambiente urbano", (3D simulation of dynamic evolution of urban shape), proceedings of the conference "l'immagine nel rilievo, Sezione L'immagine Computerizzata", Roma 1989.
C.Soddu, "Rappresentazione e rilievo per immagini tridimensionali computerizzate della morfogenesi storica urbana" (computer 3D representation of the morphogenesis of urban evolution), in the proceedings of the conference "il Rilievo Tra Scienza e Storia", Perugia 1989, then published in the magazine XYZ 1991.
C.Soddu, "Identita' come specie: la morfogenesi dell'immagine urbana con sequenze di modelli 3D di citta' aleatorie", (Identity as species: the morphogenetic evolution of urban image using 3D models of random cities), in the proceedings of the conference "Identita', Differenza, Fraintendimento", Palermo 1989.
C.Soddu, "Nuovi metodi di rappresentazione della configurazione urbana: la specie", in the book "La Configurazione dell'Immagine Urbana" (Designin the urban image), Gangemi publisher 1991.
C.Soddu, "Citta' Aleatorie", (Unpredictable cities), Masson Publisher. 1989 .
C.Soddu, "Citta' Aleatorie: strumenti di rappresentazione della dinamiche dell'immagine urbana", (random cities, representation tool of town shape dynamics), in the magazine "Territorio" n.3, 1989
C.Soddu, "Citta' Aleatorie", in "Computer and Art", Exhibition 1990, Lugano Swiss, , Fondazione dalle Molle Foundation for the quality of life, George Mason University.
C.Soddu, "Il progetto di specie. Strumenti propositivi e di controllo delle potenzialita' dell'acciaio nell'architettura e nel design", (the design of species. The creative tool to increase the possibility of using steel in architecture and industrial design), in the magazine "Acciao", April 1990.
C.Soddu, "Progetto di specie", (design of species) in the magazine "Sinopie" n.4 1991.
C.Soddu, "Simulation tools for the dynamic evolution of town shape", in "Global change and local problems", Oxford Polytechnic 1991.
C.Soddu, "La simulazione della dinamica evolutiva della forma, dagli scenari metropolitani al design morfogenetico", (The simulation of the shape evolutionary dynamics. From urban scenarios to the morphogenetic industrial design), in the proceedings of the conference "La citta' interattiva", Milano, June 1991
C.Soddu, "Simulation tools for the learning approach to dynamic evolution of town shape, architecture and industrial design", in "Proceedings. International Conference on computer aided learning and instruction in science and engineering", published by Press Polytecniques et Universitaries Romandes. Lausanne 1991.
C.Soddu, E.Colabella, "Il progetto ambientale di morfogenesi", (the environmental design of morphogenesis), Progetto Leonardo Publisher 1992
C.Soddu, E.Colabella, "Spatial and image dynamical models for controlling and planning the development of differences in an increasingly international and interdependent world", in the proceedings of the conference "Planning in a time of Change", Stockholm 1992
C.Soddu, E.Colabella, "The project of morphogenesis to design the DNA or architecture", in the proceedings of "CIB'92, World Building Congress", Montreal 1992.
C.Soddu, "Il progetto ambientale attraverso i codici morfogenetici del naturale artificiale", (the environmental design using morphogenesis codes of natural/artificial systems), in the book "Poiesis, l'informatica nel progetto euristico", Citta' Studi Publisher, Milano 1993.
C.Soddu, "Morphogenetishes Design Architekture " in "New Realities - Neue Wirklichkeiten II ArchitekturAnimationenInstallationen" 27 Jan/4 Apr 1993, Museum fur Gestaltung Zurich.
C.Soddu, E.Colabella, "The morphogenetic design as an artificial intelligence system to support the management of design procedures through the total quality of the built-environment", in the proceedings of "The management of Information Technology for Construction. First International Conference" Singapore, 17/20 August 1993.
C.Soddu, "The design of morphogenesis to design the genetic code of the artificial environment", in 33rd European Congress of Regional Science Association, Moscow, August 1993.

C.Soddu, "Human machine interaction in design processes. New search software to generate the simulation of the increasing complexity of an idea about architecture, environment and industrial design". In the proceeding of the congress "Computer Science, Communications and Society: A Technical and Cultural Challenge " Neuchatel, 22/24 September. 1993.
C.Soddu, "Progetto di morfogenesi per un'architettura dei componenti. I pannelli metallici di copertura e di parete", (The morphogenetic architectural design using steel components), in the proceedings of the congress AIPPEG at SAIE, 22 October 1993, Bologna, published in the magazine Rassegna AIPPEG n.1 1994.
C.Soddu, E.Colabella, "Experimental CBL original software to teach project approach and designing procedures in architecture and industrial design", in the proceedings of the International Conference of Computer Based Learning in Science", Wien 18/21 September 1993.
C.Soddu, "Il progetto di morfogenesi / Design of morphogenesis", in the magazine Demetra, n.5 December 1993. (In Italian and English)
C.Soddu, E.Colabella, "La progettazione morfogenetica dell'ambiente urbano", (Morphogenetic environmental design) in "Ridisegna la Citta'" catalogue of the exhibition Casaidea 1994, Roma 1994.
C.Soddu, "Intelligenza Artificiale e progetto di architettura. Dai vecchi CAD a nuovi strumenti che incrementano la creativita' progettuale come pensiero del possibile", (AI and architectural design. From old CAD to new tools that increase the creativity as thought of possible events), in the magazine Archimedia n.4, 1994
C.Soddu, E.Colabella, "Tre tesi di disegno industriale", (3 student's thesis work of Industrial Design), in the magazine Area, September 1994
C.Soddu, E.Colabella, "The project of morphogenesis. A way to design the evolution code of the environment", AESOP congress, Istanbul 23-26 August 1994.
C.Soddu, E.Colabella, "Artificial Intelligence in the teaching of architectural design", in the proceedings of the conference Hypermedia in Sheffield, Sheffield 1995
C.Soddu, E.Colabella, "Recreating the city's identity with a morphogenetic urban design", International Conference on Making the Cities Livable, Freiburg 1995.
C.Soddu, E.Colabella, "Artificial Intelligence and Architectural design", CAAD Futures '95, Singapore 1995.
C.Soddu, "Lavoro e Internet", (Job and Internet), conference at the Rotary Club Milano Porta Design – Design in Contexts", The European Academy of Design, Stockholm 13-15.4.1997 Vercellina, 3.2.1997, publisher in Rotary magazine.
C.Soddu, E.Colabella, "Argenic design", paper at the International Conference "Contextual Design – Design in Contexts", The European Academy of Design, Stockholm 13-15.4.1997
C.Soddu, "Argenia, il progetto genetico dell'auto naturale" in the proceedings of the congress "Mobilita' ed evoluzione dell'ambiente del XXI secolo, Motor Show Bologna 1997. Published in the book "Mobilita' del XXI secolo", Promotor publisher, Bologna 1997
C.Soddu, E.Colabella, "A Natural Approach to Industrial Design: Argenic Design", New Simplicity?, International furniture design conference, Helsinki Aug 1997.
C.Soddu, E.Colabella, "Pantheon", CDRom Multimedia, Poligrafico dello Stato publisher 1996.
C.Soddu, E.Colabella, "I percorsi della mente" (mind paths), CDRom Multimedia, Alea Design 1996.
C.Soddu, "Internet", in the magazine AIPAI, 1997
C.Soddu, Gege' Telesforo, "100% pure live funk and generative art", TV movie, STREAM, Italian network.
C.Soddu, "Arte Generativa, nuovi prodotti per l'uomo", (generative art, new products for the human beings), 1998, Rotary magazine.
C.Soddu, "Argenia, the natural approach to Architecture and Industrial Design" in the proceedings of Mecatronic workshop at the Universtity of Lancaster, 27/28 May 1998. (ISBN 1-86220-057-2).
C.Soddu, "Argenia, una citta' naturale", (Argenìa, a natural city) at the conference Piazze

Telematiche, The proceedings are published in the book "Piazze telematiche", Rome 1998
C.Soddu, "Recognizability of the Idea: The evolution process of Argenìa", in the proceedings of AISB99 Edinburgo 6-9 April 1999.
C.Soddu, "Argenìa: codici dell'identita' artificiale", Digitalcity - International Biennale Cybercultura, Parma 25-27 March 1999.
C.Soddu, "GENERATIVE ART", proceedings of GA'98, Editrice Dedalo Publisher, Rome 1999
C. Soddu, "Recognizability of designer imprinting in Generative artwork". Proceedings of Generative Art Conference GA'99, Milan December 1999.
C. Soddu, "New naturality: a Generative Approach to Art and Design" in Artificial Life 7 workshop proceedings, Carlo C. Maley and Etlis Boudreau Editors, Portland, Ontario, USA, 2000
C. Soddu, "Argenia, Art's Idea as Generative Code", in 2000 Genetic and Evolutionary Computation Conference proceedings, Annie S. Wu, University of Central Florida Editor, Las Vegas, Nevada, 2000
C. Soddu, "Basilica, an Architectural Generative Virtual Office based on Italian Renaissance Code's interpretation", in Mosaic 2000 proceedings, University of Washington Editor, Seattle, 2000
C. Soddu, "From Forming to Transforming", proceedings of Generative Art Conference, Milan, Ale Design Publisher, December 2000
C. Soddu, "Argenia, naturality in Industrial Design", in proceedings of 3rd International Conference on Computer-Aided Industrial Design and Conceptual Design, CAID&CD'2000, International Academic Publisher, World Publisher Corporation, December 2000
C.Soddu, “Recognizability of the idea: the evolutionary process of Argenia” in P.Bentley & D. Corne (edited by), "Creative Evolutionary Systems", Morgan Kaufmann Publisher, San Francisco US, 2001
Duncan Graham-Rowe, Design Genes, Blueprint Magazine, August 2001
C. Soddu, "Generative Natural Flux", proceedings of Generative Art Conference, Milan, AleaDesign Publisher, December 2001
C.Soddu, “Generative Art, Visionary Variations”, Catalog of the exhibition at Visual Art Centre, Hong Kong Museum, 2002
C.Soddu, “New Naturality: a Generative approach to Art and Design”, Leonardo Magazine 35, MIT press, July 2002
C.Soddu, E.Colabella, “Generative Art, Preludi natural mirrors”, proceedings of ISEA2002, Nagoya, Japan, published by Inter Society for the Electronic Arts, Japan.
C.Soddu, “”Clarity, complexity harmony and safety: Identity’s Generative codes build liveable cities”, Proceedings of Cities Asia Summit, Singapore 5-6 Nov. 2002, PSA Pub., Singapore
C.Soddu, “La Citta’ Ideale, generative codes design identity”, Proceedings of GA2002, GDL Pub., December 2002, Milano
C.Soddu, ““Generative Art, Visionary Variations of Washington DC”, catalogue of the exhibition DigItalyArt, IDB Cultural Center, Washington DC, 2003.
C.Soddu, Generative Design Visionary Variations. Morphogenetic processes for complex future identities, in Communication and Cognition Journal, 2003 (incoming printing)

C.Soddu, "Human machine interaction in design processes. New search software to generate the simulation of the increasing complexity of an idea about architecture, environment and industrial design". In the proceeding of the congress "Computer Science, Communications and Society: A Technical and Cultural Challenge " Neuchatel, 22/24 September. 1993.
C.Soddu, "Progetto di morfogenesi per un'architettura dei componenti. I pannelli metallici di copertura e di parete", (The morphogenetic architectural design using steel components), in the proceedings of the congress AIPPEG at SAIE, 22 October 1993, Bologna, published in the magazine Rassegna AIPPEG n.1 1994.
C.Soddu, E.Colabella, "Experimental CBL original software to teach project approach and designing procedures in architecture and industrial design", in the proceedings of the International Conference of Computer Based Learning in Science", Wien 18/21 September 1993.
C.Soddu, "Il progetto di morfogenesi / Design of morphogenesis", in the magazine Demetra, n.5 December 1993. (In Italian and English)
C.Soddu, E.Colabella, "La progettazione morfogenetica dell'ambiente urbano", (Morphogenetic environmental design) in "Ridisegna la Citta'" catalogue of the exhibition Casaidea 1994, Roma 1994.
C.Soddu, "Intelligenza Artificiale e progetto di architettura. Dai vecchi CAD a nuovi strumenti che incrementano la creativita' progettuale come pensiero del possibile", (AI and architectural design. From old CAD to new tools that increase the creativity as thought of possible events), in the magazine Archimedia n.4, 1994
C.Soddu, E.Colabella, "Tre tesi di disegno industriale", (3 student's thesis work of Industrial Design), in the magazine Area, September 1994
C.Soddu, E.Colabella, "The project of morphogenesis. A way to design the evolution code of the environment", AESOP congress, Istanbul 23-26 August 1994.
C.Soddu, E.Colabella, "Artificial Intelligence in the teaching of architectural design", in the proceedings of the conference Hypermedia in Sheffield, Sheffield 1995
C.Soddu, E.Colabella, "Recreating the city's identity with a morphogenetic urban design", International Conference on Making the Cities Livable, Freiburg 1995.
C.Soddu, E.Colabella, "Artificial Intelligence and Architectural design", CAAD Futures '95, Singapore 1995.
C.Soddu, "Lavoro e Internet", (Job and Internet), conference at the Rotary Club Milano Porta Design – Design in Contexts", The European Academy of Design, Stockholm 13-15.4.1997 Vercellina, 3.2.1997, publisher in Rotary magazine.
C.Soddu, E.Colabella, "Argenic design", paper at the International Conference "Contextual Design – Design in Contexts", The European Academy of Design, Stockholm 13-15.4.1997
C.Soddu, "Argenia, il progetto genetico dell'auto naturale" in the proceedings of the congress "Mobilita' ed evoluzione dell'ambiente del XXI secolo, Motor Show Bologna 1997. Published in the book "Mobilita' del XXI secolo", Promotor publisher, Bologna 1997
C.Soddu, E.Colabella, "A Natural Approach to Industrial Design: Argenic Design", New Simplicity?, International furniture design conference, Helsinki Aug 1997.
C.Soddu, E.Colabella, "Pantheon", CDRom Multimedia, Poligrafico dello Stato publisher 1996.
C.Soddu, E.Colabella, "I percorsi della mente" (mind paths), CDRom Multimedia, Alea Design 1996.
C.Soddu, "Internet", in the magazine AIPAI, 1997
C.Soddu, Gege' Telesforo, "100% pure live funk and generative art", TV movie, STREAM, Italian network.
C.Soddu, "Arte Generativa, nuovi prodotti per l'uomo", (generative art, new products for the human beings), 1998, Rotary magazine.
C.Soddu, "Argenia, the natural approach to Architecture and Industrial Design" in the proceedings of Mecatronic workshop at the Universtity of Lancaster, 27/28 May 1998. (ISBN 1-86220-057-2).
C.Soddu, "Argenia, una citta' naturale", (Argenìa, a natural city) at the conference Piazze

Checking interactive generated design against distributed objectives

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Abstract

The demand for low cost houses is increasing along with the technical demands imposed by national building code and regulations. The above outlined problems raise the following questions: 1) Is it possible to generate a draft from these initial design goals; 2) Can the same tool indicate what the best alternatives are; And 3) can the tool indicates what the consequence are of the design changes. Goal of this research is to develop a design tool, based on an integral design strategy, with respect to engineering and spatial layout, which generates different dwelling layout concepts, ‘optimized’ to specific design goals.

1. Introduction

Goal of this research is to develop a design tool, based on an integral design strategy, with respect to engineering and spatial layout, which generates different building concepts, optimised to specific design goals.

Solving a multi-objective problem mostly involves several incommensurable and often competing objectives. Usually there is no single optimal solution but rather a set of alternative solutions. These are optimal in the wider sense that no other solutions in the search space that are superior to them when all objectives are considered.

Its robustness and similarity with human design process is the reason we use a genetic algorithm to solve the multi-objective problem. Because of the 'nature' of the genetic algorithm, we have to code the building into an array of numbers, the so-called genotype. To implement the genetic algorithm in our tool we face an information problem. Is it possible to decode a string of (random) numbers into information, which tells us how to “construct” the phenotype (= a building)?

2. Designing, a multi-objective goal oriented task

Before the architect can start to design, he must inform himself about the 'client's brief'. The owner/client states for instance the relationships between the rooms, the desired area of the rooms, the orientation, the location of the site, etc. These functional requirements, performance goals and constraints are the task, which the designer has to fulfill.

After describing the requirements, the architect makes a first draft design. In the final design he has to evaluate the design in order to check if the building is designed according to the client's brief, the ruling national building codes and last but not least his own 'beliefs'. If this is not the case, the designer has to redesign his initial design. In many cases only a few 'items' are changed after the evaluation. This iterating process of designing-evaluating-designing goes on till the design meets all the objectives, and then the process is stopped.

We can look at a building as a collection of 3D objects, namely spaces and masses. The consequence of this view is that designing has become the geometrical and topological organization of a set of 3D objects in such a way that is fulfils a certain set of constrains. In other words designing is the search for a set of 3D objects that fulfills the described task, in a multi objective space.

2.2. A genetic algorithm

A genetic algorithm is started with an initial set of random "solutions" (represented by chromosomes) called population. Chromosomes from one population are manipulated to form a new population. This is motivated by the expectation, that the new population will be better than the old one. Chromosomes that are selected to form new chromosomes (offspring) are selected according to their fitness - the higher the fitness, the more suitable they are and the more chances the chromosomes have to reproduce. This is repeated until some end condition (for example number of generations or improvement of the best solution) is satisfied (see table 1)[GOL 88].

[Start] Generate random population of *n* individuals
[Evaluation] Evaluate the fitness $f(x)$ of each individual x in the population
[New population] Create a new population by repeating following steps
[Operators] Manipulation of genetic code to form new offspring.
[Accepting] Place new offspring in a new population
[Test] Stop if the end condition is satisfied, or continue to step **[Evaluation]**

Table 1 A Genetisch Algorithm

2.2.1. Operators

In our genetic algorithm we use the three standard operators:

- *Selection*: Selection of an individual in the population for reproduction. The 'fitter' the individual, the more it is likely to be selected for reproduction, this is called the roulette wheel method.

- *Cross-over*: A locus is randomly chosen that exchanges the subsequences before and after that locus between two "parent" chromosomes to create two "offspring's";

- *Mutation*: The building genetic code may be changed, in some random way before or during reproduction. A random bit in the entire genetic code or in chromosomes is changed. Mutation is the source of variation in the appearance or characteristics of an individual building from one generation to the next.

2.2.2. Fitness Evaluation

The selection operator uses the outcome of some function. This so-called fitness function or objective is used in the evaluation process to generate fitness values. These values are a fitness measurement of an individual in comparison to the other individuals. As mentioned, a design problem consists of many objectives. If we want to use a genetic algorithm, we have to 'translate' the set of objectives into one fitness value, which the genetic algorithm can handle. There are many different methods developed for that purpose, our system uses the Pareto method [AZ 2002].

3. The building genome

The complete set of genetic material (all chromosomes) is called the genome. DNA, the blueprint of an organism, is a sequence of base pairs; more generally said it is sequence written in a specific alphabet. In our case the 'DNA' serves as a model for the whole building and is written in the binary alphabet. This abstract representation of an "object" (organism or building) is called the genotype; the real "object" is called the phenotype. The genes that form the DNA-structure (see figure 1) are first decoded into a sequence of integer numbers, the so-called RNA structure. This RNA-structure is an intermediate step between Genotype and Phenotype, which makes the 'building-data-model'. With this sequence of integers we can build the phenotype.

[0011000000001010000010101010000001010....]

[1,2.4,5,6,7,8,4,5,43]

Figure 1 The Building Genome (on top the DNA profile, beneath the RNA profile)

In our building genome we recognize two types of chromosomes, construction-chromosomes and space-chromosomes.

3.1. Construction chromosome

A construction chromosome stands for a wall construction. A wall is coded into a sequence of material layers. Each gene stands for a typical material layer. In table 2 a construction is build up from 9 "genes". The 'first' gene is the inner layer and the last gene is the outer layer.

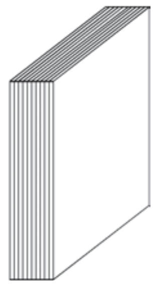
Genotype		Phenotype	
DNA	**RNA**	**Meaning**	**Construction**
0011	3	Material ID of the outer layer	
0000	0	Material ID of 1st layer	
0000	0	Material ID of 2nd layer	
1010	10	Material ID of 3rd layer	
0000	0	Material ID of 4th layer	
1010	10	Material ID of 5th layer	
1010	10	Material ID of 6th layer	
0000	0	Material ID of 7th layer	
1010	10	Material ID of the inner layer	

Table 2 Construction chromosomes

Each layer represents a material, because an ID is related to a specific set of material properties in a material database (see table 3). Each property-set maps onto a specific material or product in the real world.

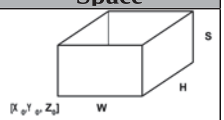
ID	Name	D [m]	σ [N/mm^2]	λ [W/m.K]	ρ [kg/m^3]
0	Empty (cavity)				
1	Wood	0,1	20	0,17	800
2	Brick -1	0,1	2	0,4	800
3	Brick_2	0,1	2	0,6	800
4	Brick_2	0,1	2	0,6	800
5	Concrete_1	0,1	30	2	2300
6	Concrete_2	0,1	30	0,7	1600
7	Concrete_3	0,1	30	0,12	300
8	Insulation_1	0,0	0,0001	0,033	35
9	Insulation_2	0,0	0,0001	0,033	35
10	Insulation_3	0,1	0,0001	0,033	35

Table 3 the material dBase (example)

For simplicity we recognize only two wall types, wall type I, which separates a space from the outside, and wall type II, which separate two spaces. The first two chromosomes, in the building genome, represented the two wall-types; the other ones are space chromosomes.

3.2. Space chromosome

The space chromosomes represent the rooms. The area of a room is coded as a rectangle. In table 4 a space is build up from 5 "genes".

Genotype		Phenotype	
DNA	**RNA**	**Meaning**	**Space**
0011	3	Floor index (=S)	
0000	0	x-point corner (=X_0)	
0000	0	y-point corner (=Y_0)	

1010	10	Width (=W)	
0000	0	Height (=H)	

Table 4 Space chromosomes

The first gene is decoded into the floor index; the next pair of genes corresponds with the angle (rho) and length (lt) of the (polar-) coordinate of the first corner. The next 2 genes are decoded into the width and height of a rectangle. The coordinates of the 3 other corners can be calculated with this information. For the coordinate of the first corner of the rectangle the polar notation is chosen. The reason is that with only positive numbers the whole x-y plane is covered. In the current implementation each space has the same height, 2600 mm. This height is chosen because it is the minimum room height according to Dutch building regulations.

4. Transforming a genotype into a phenotype

As mentioned in paragraph 3, the building is represented by a sequence of “1” and “0”. This sequence is translated into a sequence of integers, which can be translated into construction types and space. The translations from genotype to phenotype isn’t a one to one translation, there are some ‘problems’ that will be discussed in the next sections, which has to be solved before a building can be modeled.

4.1. Rooms

There are many ways two rooms can be adjacent [BAY 03]. We can easily recognize 4 main categories of room-adjacency, see figure 2. From these four categories our system recognized three as “well-designed” (figure 2 a, b, c) and one as “ill-designed” (figure 2 d).

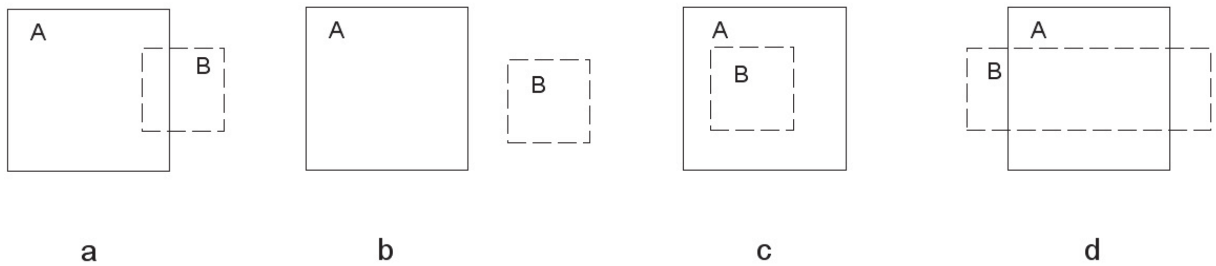


Figure 2 Adjectives spaces

In one of the well-designed solutions (figure 2 a) the both rooms will be redesigned by the system so that they are along side one another. In the ill-designed solution (figure 2.d) two rooms overlap each other. This solution is considered as ill designed because of the indistinctness what to do with the “intersection” part. Does it belong to one of the two rooms, or are there 5 rooms. Because of this indistinctness this solution will get a very bad fitness scores, thus this solution will not propagate through newly formed populations.

4.1.1. Circulation space

The height of the circulation space needs special treatment, because this space must be accessible from every floor. The height h is the outcome of the multiplication of the numbers of floor by the standard room height (=2600 mm).

4.2. Floor indices

Because of the nature of the phenotype it is possible that some floor/floor-spaces do not exists, say, we have spaces on the ground floor, second, third, sixth and eight layer (see figure 8 a). In the data model we reorganize the data that need re-ordering to get a consistent model. In that case layers on which the spaces are located are renumbered to become consecutive (see figure 3 b).

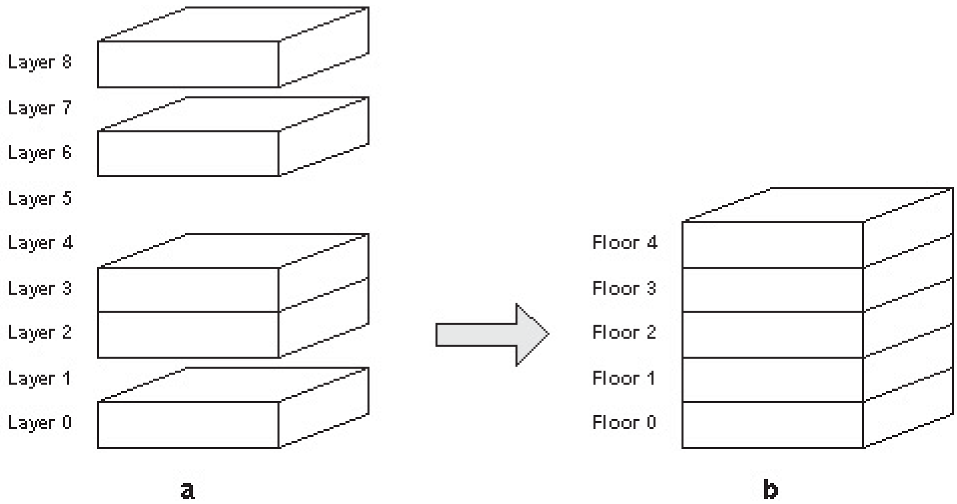


Figure 3 Floor layers

4.3. Wall layers

For simplicity we don't' merge layers as in real world construction sometimes is done. For example it is good practice to place, in a timber frame construction, the insulation between the timber posts. In our model we keep the insulation and timber posts in separated layers. As a consequence an inaccuracy is introduced in the outcome of the fitness calculation of some objectives. Since layers sometimes in practice can be integrated, the wall thickness can be smaller than calculated (see figure 4).

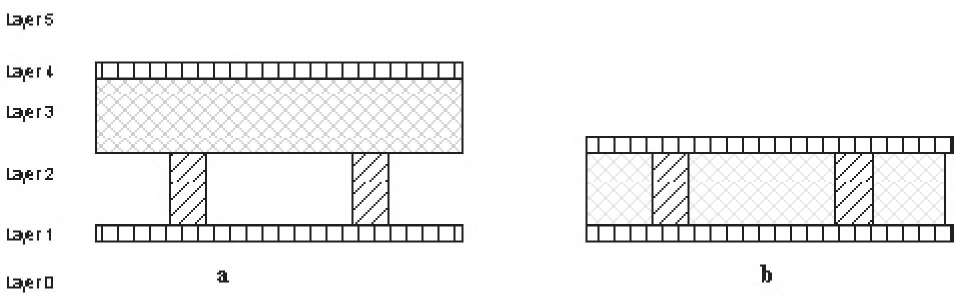


Figure 4 Wall layers

If the inner and/or outer layers of a wall are made of material “cavity”, they are deleted. From Table 3 we learn that a material ID with the value of 0 maps onto a ‘cavity’.

5. Objectives

The outcome of the generation process depends heavily on the number of objectives the phenotype must fulfill. If there are to many objectives the search space will be to small and the algorithm can't find a solution. If there are there too few objectives there will be too many possible answers to inspect.

As indicated earlier, a design is evaluated in order to check if the building is designed according to the ruling national building codes, the client's brief and the designer intention. All these different rules of evaluation form the total set of objectives, which must be fulfilled by the design. The whole set of objectives can be divided into 3 levels (see table 5), according to the imposing party of the objectives.

Level	Example	Imposing party
Primary	Every building has to fulfill a minimal number of structural en physical demands, for example, the building has to stay erected, give protection against the forces of nature etc.	Government
Secondary	A building most also fulfill some specific demands, such as: number and size of the rooms, the function of the rooms etc.	Client
Tertiary	These demands consisted of mostly immediate subconscious knowledge, unwritten rules, etc.	Designer

Table 5 Level of demands

Most of the primary objectives are based on national rulings, and can easily translated into formulas. The secondary objectives are mostly prescriptive rules and can also easily be translated into formulas. The last category consists of the objectives, which deal with the beliefs of the designer and therefore are difficult to translate into formulae.

5.2. Distributing objectives

The ‘owner’ of each of these categories is different. As a consequence different people maintain each category. The objectives, which are imposed by the government, have a different status in comparison to the others, they have to be fulfilled otherwise the designer can’t get a building permit. These objectives or norms are the tools for the government to enforce designers to design according some minimum requirements. Governmental institutes develop these norms. In our digital era most of these institutes develop computer applications which help the user by their ‘calculations’. However, these norms are not static, they change in due time, because of 1) gain in knowledge, 2) change in insight and last but not least 3) accentuation of requirements. These governmental institutes must also look after the distribution and ‘maintenance’ of these norms.

Every designer and every conformance checking application must use the ruling norms. Before one can start conformance checking, there has to be a search for the ruling norms. In order to overcome this problem we introduce the capability of remote access of primary objectives. In this way the "owner" of the objective stays responsible for the objective, it improves the validity of information, because it remains under control of the provider. In this case the user is always certain of using the latest version of the norm.

6. Implementation

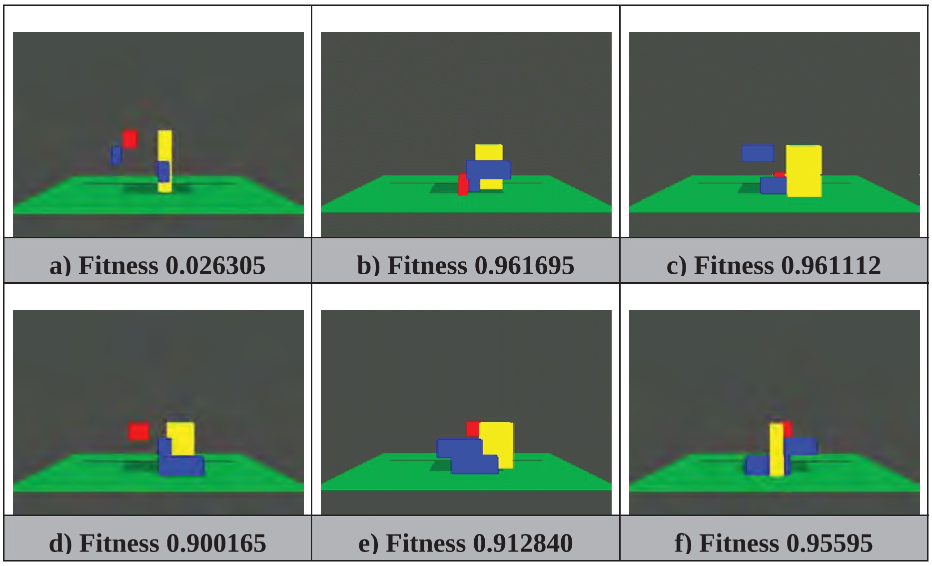
6.1. Client's brief

In order to test the application we use a simple test design project, consisting of 4 rooms, each with a minimum and maximum area. The relations and areas of the rooms are presented Table 6.

Rooms			**Relationship between rooms**					
Name	**Min. area**	**Max. area**		**V1**	**V2**	**V3**	**V4**	**B**
Circulation space	5 m^2	10 m^2	**V1**					
Living	20 m^2	25 m^2	**V2**	*				
Kitchen	10 m^2	15 m^2	**V3**	*	*			
Bedroom	15 m^2	20 m^2	**V4**	*				
Outside	- m^2	- m^2	**B**					

Table 6 Client's brief

In our current system implementation we have used only the 'relation objective' and the 'area objectives'. After this information is entered into the GA, the GA is started. During its run, alternative solutions are generated. The following images (see figure 5) show the outcome at some time during one run of the GA.



a) Fitness 0.026305 | **b) Fitness 0.961695** | **c) Fitness 0.961112**

d) Fitness 0.900165 | **e) Fitness 0.912840** | **f) Fitness 0.95595**

Figure 5 Examples

In Figure 5 a few snapshots are shown which are made during the run of the system. The three rooms are swirling around the circulation space. From this circulation space the other rooms has to be accessible, which is the case in solution b, e and f. During the process the shape and location of the spaces changes, this overall change is also notable in the fitness score. The higher the fitness the better the solution fulfills the objectives.

7. Some conclusions from the project

The building, geometry and material use is represented in one complex chromosome that evolves in time. A genetic algorithm allows for interpretations of multiple design objectives that up to now only could by studied in isolation.

8. Further research

We have to implement more objectives in order to get a more realistic outcome of the process. Special attention is required to implement windows into the model. There are a few problems concerned with windows, 1) in which wall a window or windows have to be located 2) how many windows in a wall; 3) how tall a window must be. This has rather a big influence on the genotype. The genotype of a building with 2 wall types and 4 spaces has a length of 2 x 9 + 4 x 5 = 38 integers. A rectangle can be described by 4 integers (see also paragraph 3.2), therefore if in every wall a window is located; the original genotype has to extend with at least 4 x 4 x 4 = 64 integers. This extension has a big influence on the performance of the system, and the time it takes to find a sufficient solution.

A genetic algorithm, as proposed by Holland, has one big shortcoming for using as a design 'generator'. It lack's the ability to direct the evolutionary process. By implementing a feedback method into the genetic algorithm we intend to manipulate the process. As a result the evolutionary process will be directing towards a preferred outcome. The extended algorithm will give the designer better control over the design generation process.

9. Bibliography

[BEN 96] Bentley, P. J.: 1996, Generic Evolutionary Design of Solid Objects using a Genetic Algorithm, Ph.D. Thesis, University of Huddersfield, Huddersfield, UK

[BAY 03] Baykan, Can (2003) Spatial relations and architectural plans, Layout problems and a language for their design requirements, in B.Tunçer, S.Özsariyildiz and S. Sariyildiz (eds), E-activities in design and design education, Europia Productions, 2003

[COH 78] Cohon, Jared L (1978) Multi-objective programming and planning, Academic Press London

[GOL 88] Goldberg David E.: 1988, Genetic Algorithms in Search, Optimization & Machine Learning, Addison Wesley

[HOL 92] Holland, J, H. 1992 Adaptation in Natural and Artificial Systems; MIT-press, Cambridge, Massachusetts

[ZEE 02] Zee, van der A. and Vries, de B. (2002) Computer Aided Evolutionary Architectural Design, in Celestino Soddu(ed.): Proceedings of the 5th International Conference on Generative Art 2002. Milaan. pp. 9.1 - 9.13.

[ZEE 03] Zee, van der A and Vries, de B (2003) Evolutionary development of early stage design alternatives for buildings, in B.Tunçer, S.Özsariyildiz and S. Sariyildiz (eds), E-activities in design and design education, Europia Productions, 2003

Image driven sound generation

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Abstract

With the object of creating abstract computer graphics animation with electroacoustic sound, an automatic image-driven sound generator was developed. Image sampling methods, which in principle sample one datum from each animation frame、 was tested as being effective for generating pitch, dynamic structure and stereo image. Wavelet transform, which provides multi-resolutional information of the signal made of data from image frames, was useful for determining other modulation signals including temporal cues. The generative method of creating music for animation also involves human judgement. At the system development stage, special attention was taken regarding pitch and loudness, since our perception of these factors varies depending on the register and it is not always proportional to what we read in the values of frequency and amplitude. Knowledge on orchestration proved useful for creating tangible and effective melodic and harmonic structure. One script file proceeds all the way, from making an animation clip, generating CD quality sound track and combining image and sound into a movie file for the final product.

1. Introduction

Sound plays an important role in films and video works by providing space environment for the audience. It also enhances the visual message and adds reality to animation films. Many film masterpieces are remembered for their theme music. In most cases, sound creation and image making are separately developed and ordinarily a composer starts to work after receiving the screenplay or seeing dailies. This is so that the composer understands the atmosphere and the theme of each scene.

Animation clips often have a human voice, a concrete sound, or some electronic music on the sound track. With our animation clip of flying geometric objects, composer referred to the design charts, which involve timings of object spin and changing view positions[1].
"The timing chart made the compositional work easy, because it could be used as the on/off chart for musical events. All I have to do was to determine the suitable sound to be triggered at each point accordingly (Ishijima)." How do you start sound-making for algorithmically generated abstract video clips? Unlike films, there is no script, no studio scene, or no actor/actress on screen. Images you've never seen are there. Just the impression you have is the material for your creative work.

This paper presents the second phase of the research on computer generated animation with abstract images. This time, we tried to generate a whole sound stream by using data sampled from each image frame without any involvement of a video/sound editor console. An image

clip is generated first. Then the visual data is lead up to sound generation. Finally, the image and the sound are combined into a movie file. We have tested some methods to sample data from a computer generated animation which has uncompressed 640x480 images.[Fig.1]
In the attempt of making sound with sampled data of image, the first confrontation is data file discrepancy.   While sound requires to be a continuous data file, video consists of a sequence of discrete data of image frames.

Image[2]		Sound	
Image format	TARGA	Sampling freq.	44100Hz
Image size	640x480	Sampling res.	16bits
Colour depth	24bits	Channels	2
Frames/sec	30	Num of Data	2,646,000/min/ch
Frames/min	1800	Bytes of Data	10,584,000 Bytes/min
Data size/frame	921,600 Bytes/frame		
Data size/sec	27,648,000 Bytes/sec		
Data size/min	1,658,880,000 Bytes/min		

Fig.1 Specifications of image and sound files.

2. Sound

2.1 Music Parameters

In any music, pitch is probably the most significant element which creates tangible musical impression. Although other elements such as rhythm and timbre also play important roles, which we discuss later, pitch creates melody and harmony, and is considered the most essential element for any organised sound. In this sense, the most basic information required for musical sound are Pitch, Amplitude and Note length. Colour data, which represent the visual impact of each frame, are a suitable source for generating both pitch and amplitude information. In order to define note length i.e. duration of each pitch, values are defined by the duration derived from the varied levels of the wavelet transform.

In order to express a pitch, one sine wave is enough but for more interesting timbre, a single sine tone is too simple.   To achieve rich sound, layers of sine waves which have different pitch and duration are superimposed.   Tracking events in left, centre, right areas of the image in respective audio channels would produce coherent spatial emphasis in the visual and audio material.   For the purpose of capturing spatial property of the image material, various combinations of sampling positions are tested.[Fig.2]

```
+-----------+-----------+  +-----------+-----------+  +-----------+-----------+  +-----------+-----------+
|                       |  |                       |  |                       |  |                       |
|                       |  |                       |  |                       |  |                       |
|                       |  |                       |  |           o           |  |                       |
|     +           *     |  |     +     o     *     |  |     +           *     |  |  +   +   o   *   *    |
|                       |  |                       |  |           o           |  |                       |
|                       |  |                       |  |                       |  |                       |
|        type 1         |  |        type 2         |  |        type 3         |  |        type 4         |
+-----------+-----------+  +-----------+-----------+  +-----------+-----------+  +-----------+-----------+
+-----------+-----------+  +-----------+-----------+  +-----------+-----------+
|                       |  |                       |  |                       |
|  +   +   o   *   *    |  |                       |  |     o     o     o     |   + left
|                       |  | +  +  o  o  o  *  *   |  |                       |
|  +   +   o   *   *    |  |                       |  |     o     o     o     |   o left+right
|                       |  | +  +  o  o  o  *  *   |  |                       |
|  +   +   o   *   *    |  |                       |  |     o     o     o     |   * right
|        type 5         |  |        type 6         |  |        type 0         |
+-----------+-----------+  +-----------+-----------+  +-----------+-----------+
```

Fig.2   Sampling positions

For sound to be recognised as music, there must be tangible temporal progression such as melody and rhythm. Harmony is a preferable element which enriches music both momentarily and progressively. A regular beat is not necessary but useful to create sense of speed and progression. Dramatic visual development such as change of scene, or irregular movement ought to be synchronised or in some sort of causal relation to accentuation in music.

2.2 Parameters for Digital Sound

Above discussion is based on the psychological variables of musical sound. For the sake of clarification, conventional terms such as note or melody were used, but they are not of central concern for the composer. The goal is to generate a spectromorphological sound track rather than note-based composition. For digital, or any electronic sound, information which describes physical variables of phenomena of sound is required. Fig.3 shows correspondence between music and physical properties. Digital sound data consists of a series of amplitude values of sound measured at the sampling frequency of 22.05 kHz, 44.1 kHz, or 48 kHz. Ordinary dynamic range is 16 bits for each channel.

Music property	Physical property
Pitch	Frequency
Loudness	Amplitude
Note length	Duration
Timbre	Waveform=Sum of multiple sine waves

Fig.3

3. Sampling Image Data

For making 44,100Hz CD quality sound, 1470 data samples are required for one image frame duration, or 33 milliseconds. While there are some methods to collect this number of data from one image, the safe way is to apply one-sample-from-one-image rule because you have to avoid overtones of 30Hz produced by the 33ms repetitive data sequence. This rule is also effective to keep consistency of trans-frame events. This time, our solution is simple linear interpretation of colour data into pitch value, which is held for the duration of one frame, for the main pitch stream. One of the major advantages of this method is that it is free from 30Hz pattern repetition. The length of a frame provides enough time for our ears to recognise the frequency as a pitch. At the same time, it is short enough for creating impressions of continuous pitch slide. In order to keep the audio transition smooth, the program checks the phase angle at the end of 33ms segment and makes the next to waveform to start in-phase by adding offset phase value. This is a must to design a smooth tone shifting when you synthesize a waveform.[Fig.4]

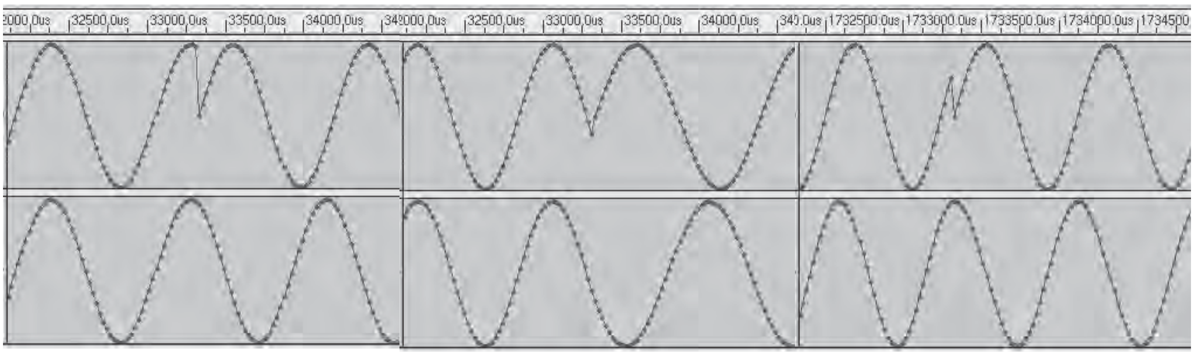


Fig.4 Phase matching. Same signal without(upper) and with(lower) phase matching.

4. Data Transformation

What can be obtained from visual image in any case is a set of pure data which then will be transformed to a sound file. To construct Image-to-Sound transformation, it is important to find suitable source for suitable audio parameters. We used wavelet analysis of the whole length waveform for the material of some sub tracks of this work[3].

4.1 Pitch and Harmony

Once a list of frequency are obtained, each frequency can be harmonized by adding partials expressed in ratio of integers such as 1/4, 1/2, 3/4, 2, 3, 4, 5, etc. relative to the original frequency. Problem here is how to define the harmonisation algorithm so that the result would become audible and musical. First thing to pay attention to is that the audible frequency range for human ears is roughly between 20Hz and 20kHz, so that the resulting frequency should fall into this range. Secondly, our perception of loudness and pitch separation is not linear. Traditional idea of instrumentation is helpful. Contrabass part is often doubled by cellos playing in an octave(2nd partial). Violas might be playing in 5th(3rd partial) or an octave(4th partial) above the cello. This means, sound harmonized according to the natural harmonic series creates impression of harmonic stability. Building up a harmony on a lower frequency also helps to enhance the perceived level (loudness) of low pitched sound against the fact that our perceived loudness is lower than the actual signal intensity in low frequency region.. Regarding stability, another important principle is that the longer the note, the more stable the music.

In order to extract a principal pitch movement, colour data are taken from the image area of "type 4" [Fig.2]. What is translated to higher frequency has more meaning than what became lower frequency, since the frequency values reflect impression level of the image. 0Hz means no colour. Thus, we employed a method of harmonising 'downwards' rather than upwards. The frequency obtained is interpreted as the 8th partial of a natural harmonic series, and harmonised with 7th, 5th and 3rd partials. The amplitude of each partial is controlled by the density of Red, Green and Blue respectively. High pass filters is applied to cut off inaudible signals below 20Hz. In this way, an upper structure is created from the main pitch movement. Octave intervals are omitted here, because it will be used for constructing a lower structure. Partials used for the harmonisation are summarised as below.

Upper Structure				3	5	7	8
Lower Structure	1/4	3/4	1				
Example	C1	G2	C3	G4	(E5)	(Bb5)	C6
Frequency(Hz)	32.7	98.1	130.8	392.4	654	915.7	1046.5

What is interpreted as the fundamental frequency, that is 3octaves lower than the initially obtained frequency, is harmonised with the 3/4 and 1/4 partials. This provides harmonically stable base for the upper structure. 20Hz – 200Hz band pass filter is applied so that the final frequency range for the lower structure becomes equivalent to the range of contrabass. Different sampling frame rate were applied to create rhythmic variety. Duration information for longer sound is obtained from 4th to 6th level wavelet transform.[Fig.5]

When the upper and lower structure are mixed, the resulting sound shows good separation in terms of pitch and frequency range. When an audio event is happening in higher register, mid to low range is suppressed except for one or two partials supports the overall harmonic structure. In the middle-range frequency, where our ears are most sensible, most partial elements are present to provide rich harmonic structure. Pitch separation between each harmonic element is good throughout.

Fig.5 Waveforms. From top to bottom, S4:sampled image data(type 4), H1-H6:wavelet level 1-6 (HPF), L6:wavelet level 6(LPF), L6s:sliced L6, S5:sampled image data(type 5), S5xL6s, H4s: sliced S4, H6s: sliced H6, S1+S4, S1:sampled image data(type 1), S4(similar to the top waveform). The waveforms of H1-H6 and L6 are stretched to the original signal's length. H1-6 and L6 are transformed S4 by Daubechies' wavelet, N=2.
S4=H1+H2+H3+H4+H5+H6+L6

4.2 Stereo sound

All sampling types produced good results which reflect significant visual events involving object movement and colour change across the screen. As number of sample location increases, sampled data include more visual events but averaging results in relatively lower resolution of event.
In order to capture minimal movement across screen type 2 and 4 are suitable since the most visual information is concentrated in the central area of the screen.

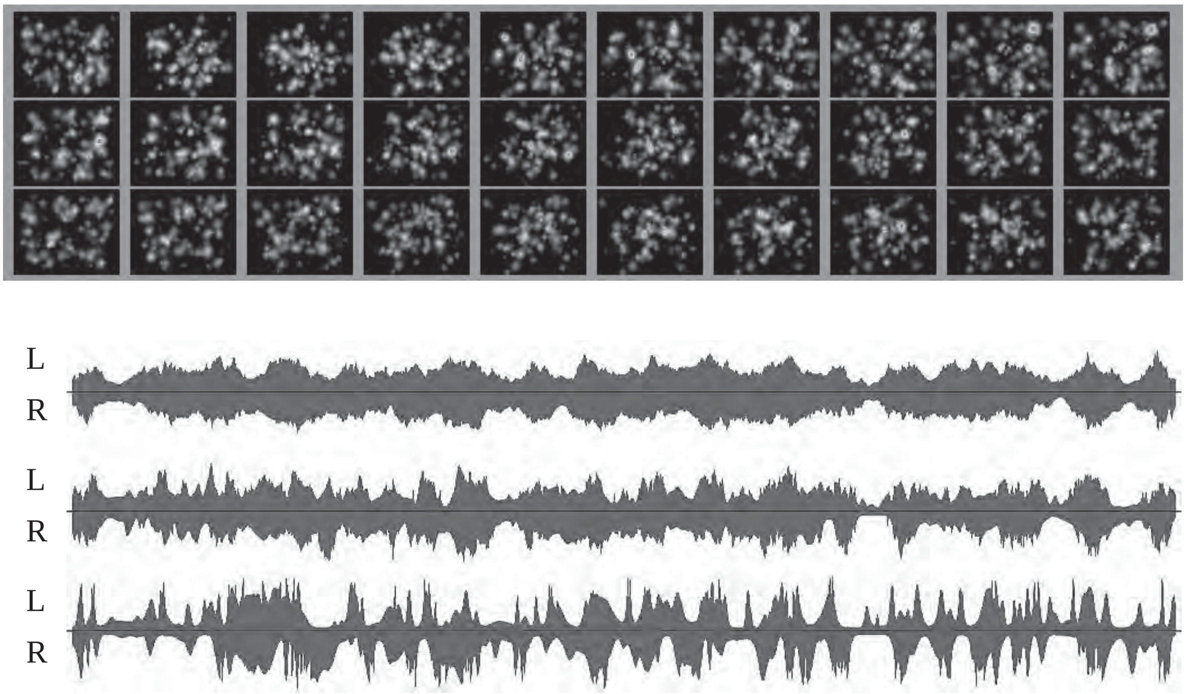


Fig.6 Animation with random abstract images. Channel data are type 6(top), 4(middle) and 1(bottom). Type 1 results a good channel separation and is used for sub channel data. Because it misses events on the central part, the most important area, it is not used for the main signal.

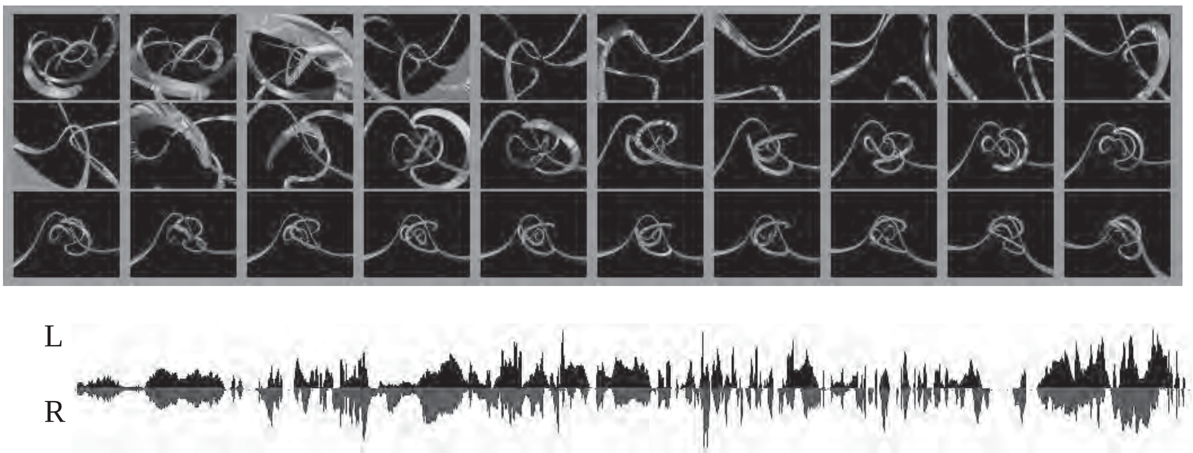


Fig.7 Animation used geometric surfaces. Channel data(type4) shows clear channel separation

and variety of image data levels.

4.3 Synchronisation and Alienation

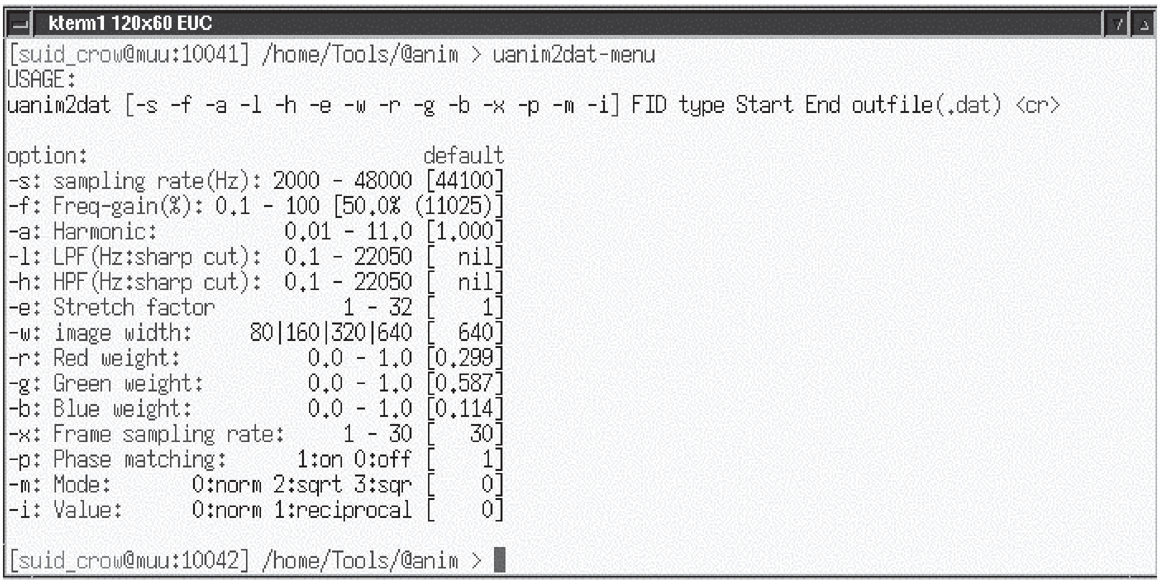
Transforming data into sound is not sufficient for sound design required for animation. For a quality animation, sound must not always follow the images. That means we need to detect visual events and have to decide whether the sound should cooperate or alienates from them. It is very hard to give a rule to such a highly creative process. As an attempt, we used other image data and AND OR XOR process for the decision making. In the test version, we set a rule for switching the sound track between synchronisation and alienation modes. The cue sheet is made of derivative data chart of wavelet transform.

5. Process Flow

This research developed all the necessary tools for the processes discussed above. A script file proceeds all the way from generating image list to integrating the image and sound data into a movie file.
[Fig.8][Fig.9]

```
#/bin/sh
umkga2003b gaa 22 640 480 100 2000          # generate gaa00 .. gaa21, 640x480 image size
apol_light gc4 22 99 gaa00...gaa18          # gaa(22 files) --> gac(2101 files)
utga-ga2003v                                # raytracing
uanim2dat ggg 4 0 2048 ggg                  # .tga --> ggg-4.dat(type 4)
ufwt2 gc4.fdat fwt1                         # ggg-4.dat   -->   fwt.lpf|fwt.hpf (level 1 wavelet)
ufwt2 fwt1.lpf fwt2                         # fwt1.lpf    --> fwt2.lpf|fwt2.hpf(level 2 wavelet)
ufwt2 fwt2.lpf fwt3                         # fwt2.lpg    --> fwt3.lpf|fwt3.hpf(level 3 wavelet)
ufwt2 fwt3.lpf fwt4                         # fwt3.lpg    --> fwt4.lpf|fwt4.hpf(level 4 wavelet)
ufwt2 fwt4.lpf fwt5                         # fwt4.lpg    --> fwt5.lpf|fwt5.hpf(level 5 wavelet)
ufwt2 fwt5.lpf fwt6                         # fwt5.lpg    --> fwt6.lpf|fwt6.hpf(level 6 wavelet)
udat2env fwt4.hpf fwt4.env                  # fwt4.hpf    --> fwt4.env(envelope file)
udat-mod ggg-4.dat gwt4.env ggw-4.mdat      # .dat + .env --> .mdat (modulation)
udat2aiff ggw-4.mdat 44100 16 2 ggg4        # ggw4.mdat --> ggg4.aiff
umkavi gg4 0 2048 gac gc4                   # .tga + aiff -->gg4.avi
echo "finished"
```

Fig.8 Script file



```
ktem1 120x60 EUC
[suid_crow@muu:10041] /home/Tools/@anim > uanim2dat-menu
USAGE:
uanim2dat [-s -f -a -l -h -e -w -r -g -b -x -p -m -i] FID type Start End outfile(.dat) <cr>

option:                               default
-s: sampling rate(Hz): 2000 - 48000 [44100]
-f: Freq-gain(%): 0.1 - 100 [50.0% (11025)]
-a: Harmonic:           0.01 - 11.0 [1.000]
-l: LPF(Hz:sharp cut):  0.1 - 22050 [  nil]
-h: HPF(Hz:sharp cut):  0.1 - 22050 [  nil]
-e: Stretch factor           1 - 32 [    1]
-w: image width:     80|160|320|640 [  640]
-r: Red weight:          0.0 - 1.0 [0.299]
-g: Green weight:        0.0 - 1.0 [0.587]
-b: Blue weight:         0.0 - 1.0 [0.114]
-x: Frame sampling rate:    1 - 30 [   30]
-p: Phase matching:      1:on 0:off [    1]
-m: Mode:       0:norm 2:sqrt 3:sqr [    0]
-i: Value:      0:norm 1:reciprocal [    0]

[suid_crow@muu:10042] /home/Tools/@anim >
```

Fig.9 *uanim2dat* generates a data file of animation images.

6. Conclusion

It is possible to create a sound track from data obtained from a succession of abstract images. We have produced a full animation without interactive editing. To create the music, data which represent impression of the images were collected. Sampling colour data from different areas of the image also proved effective to create stereo sound.

For a composer, this method of generating sound directly from images is an attractive alternative to MIDI and sampling since it gives the composer a wider and flexible range of frequency free from ordinary 12 note chromatic scale restriction. Composers can also be freed from lengthy manual endeavour of reshaping sample files with waveform editors.
The challenge of the present system is that it is still difficult to create realistic sound whose waveform has overtone-rich transient at the attack. To further the variety and quality of sound, we need to investigate methods of creating different timbre. Establishing a method to extract figurative and textural impression would enrich timbre quality and correspondence between sound and image.

We recognised that only very experienced composers and artists can control this kind of system at current stage, otherwise it can easily become a junk footage generator. This project gave us an opportunity to rethink why we make art. We need to understand an image can provide material for sound design, but it also limits the freedom of creation, a double edged sword.

7. Notes and References

[1]Ishijima, A. and Abe, Y., "Algorithmic process for time based arts," GA2002, Milan 2002.

[2] NTSC video system has interleaved 50.94 fields per second and frame rate is 29.97 fps. PAL and SECAM for 50/25.

[3] Wavelet provides time-frequency representation. Computation cost(AxN) of Fast Wavelet Transform is less than that of FFT(NlogN) in theory, where constant A depends on the chosen filters and N for number of samples. The analysis([X]) is a set of LPF and HPF'ing process and you can analyse a signal on time-freq basis, or more exactly it's a time-scale basis because of its relative frequency resolution is constant, by cascaded filtering process on the LPF results as shown below.

```
Signal-->[X]--(lf1)-->[X]--(lf2)-->[X]--(lf3)-->[X]-->lf4
          |            |            |            |
         hf1          hf2          hf3          hf4
Signal= hf1+hf2+hf3+hf4+lf4
```

[4] Ingrid Daubechies' web site has references on wavelet at http://www.princeton.edu/~icd/publications/

IMAGINED ARCHITECTURE via MATERIAL IMAGINATION
A Matter of Trans-Formation

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Abstract

The pedagogical intent of this design lab was to provide a means for interactive dialogue to occur between the formal and the material modes of imagination in order to approach a tripartite structure of form, content and function. It acted as a 'bridge' between the design principles of space and form to issues of materiality, structure and modes of representation inherent in the 'process of making'. We began with several design exercises as investigations to explore the expressive potential that material can achieve in light and mass as well as in structure and detail. The students explored and emphasized the ways in which structure and materiality can supplement and compete with the notions of form and space. The primary modes of representation were plaster casts, charcoal analytiques, structural models and sectional drawings as interpretive texts. They became the vehicle--hereafter refered to as 'artifice'--to develop visual acuity in response to formal cues and to demonstrate the affinity of technique and materiality with the construction of an idea.

Introduction

Creativity in architecture can be based on the process of transformation of matter. This transformation occurs in the realm of perceptive imagination where to generate and develop new ideas means to pre-figure matter in the course of the idea's realization. Two types of imagination can be engaged in this process, a *formal imagination* and a *material imagination.* (1) Formal causes tend to stem from intuitive and associative image production. These images derive from psychological projections and picturesque forms. They usually provide an analytical reading to create an object. Yet besides these images of form a certain type image is provoked solely and directly from our immediate confrontation, interpretation and manipulation of matter. These images may be assigned category by the eye but only the hand truly reveals them. They depend on visceral readings that are projected through qualities such as mass, material surface or texture, light, space and time. Of course, it is only artificially that we can separate formal and material imagination in the process of making.

Since matter remains itself despite the transformational metamorphosis it undergoes, the meditation upon and manipulation of it tends to cultivate an open imagination. This allows the architect as 'maker' to possess a kind of openness for 'wonder', preparing oneself for the amazement of unconscious manipulations that give rise to creativity and the art of invention. It is through a sense of wonder that one can initiate a critical beginning to the acquisition of knowledge. Wonder is an action--an impassioned verb. It forces one to think, to go beyond, to ponder in a world of constructive imagination. By seeking cues and wandering through curiosities, one becomes involved in a play of interpretive procedures until paradox becomes intelligible in an image of conception. Through this process of making--*a techne&poesis*---we gain an intuitive knowledge of the structure of the reality within which we dwell.

In the act of making one must engage memory at one end and imagination at the other; memory as the recollection of one's experiences, and imagination as the mechanism of transforming seemingly insignificant things into meaningful forms of re-creation. Through this dialectic the formal imagination embraces and transforms the material and allows one to read into shapes, marks, light and colors, a symbolic or representational meaning that is our fundamental form of language. This form of discourse allows the roles of subjectivity and objectivity to freely interrelate in order to discover *new orders* inherent in the active process of material transformation. The process starts from a persistent inquiry into the ways of natural creation, the becoming, the functioning and the individual resolution to associate oneself with the matter in which we live. John Locke said that what gives each person his or her personal identity is that person's private store of recollections, and I might add re-creations. "Imagination is not merely a faculty for forming images of reality but it is the faculty for forming images which go beyond reality, which sing reality."(2)

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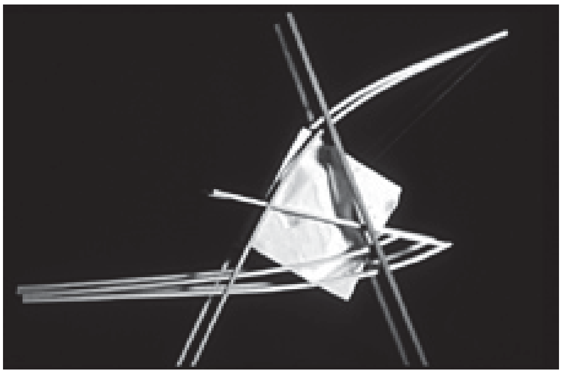
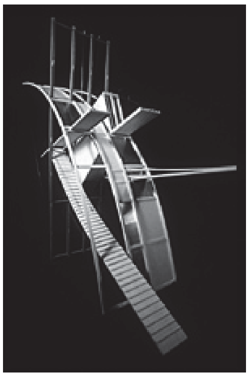
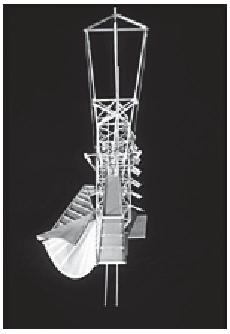
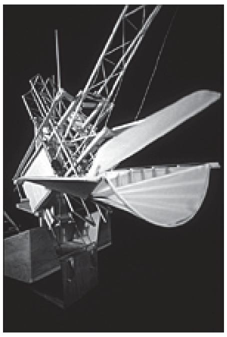


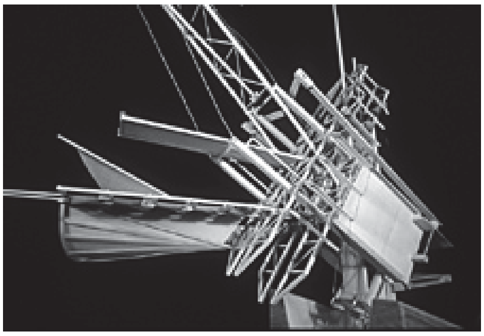


The Three Acts of Play

The three notions of *form, content, and function* have always been bound together as the three important components of architectural design. In the current heterogeneous state of the architectural design studios in academia, these hierarchical prescriptions or sequence of these notions have been freed from the strict boundaries of former theoretical paradigms. As educators though, we need to delineate optimum design sensibilities for beginning design students to weave together these sometimes artificially autonomous components in the making of architecture. If we begin to view these components as metaphorical portals that the student opts to pass through, their order becomes particular to the personal design route for the project at hand. Thus one can choose form; via content, via function or via form itself. This becomes a point of departure that frames a particular perspective with which the student can proceed in his or her design process. Dr. Alberto Perez-Gomez calls this theorizing the inventing of an 'enabling theory'; it enables the designer *to make*, serving as a rationale for ideation and fabrication.(3)







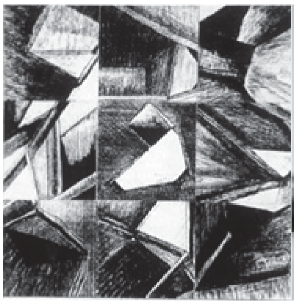
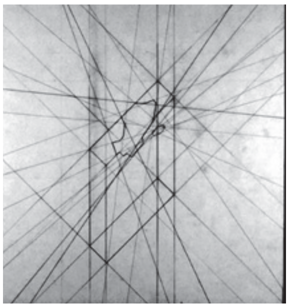
'Artifice' as An Enabling Theory

Normally 'artifice' denotes the skill and ingenuity one uses in the making of an artifact. There is a second connotation though that points toward trickery and craft. These compound notions of *artifice* for this discussion are seen as a means to the articulation of form for the beginning design student; it encompasses skill and ingenuity as well as craft. I will refer to a project called, "A Place for One's Daydreams" to demonstrate *form* generating techniques, artificially divorced from content and function, to be used as initiators in the development of an enabling theory for the final production of an architectural project. This artificial separation of form from content and function provides a portal to design and allows the student to focus primarily on a tangible vocabulary in the manipulation of the constituents of form. These techniques act as vehicles in an architectural pedagogy that open the imagination to formal and material causes and establish orders that will eventually lead to habitable forms of architecture. The artifice then is a device--a particular point of view--to appropriate the functional program and provide meaningful content to an architectural production.

The Communication of Meaning through the Design of Structure

Each student would begin their individual exploration by deriving their own "enabling theory" through an active process of making an object--what I refer to as 'opening an artifice'. Through a creative means of playful inquiry the artifice becomes the mediator to guide the student in making conscious and unconscious discoveries in his or her design process. These discoveries would then lead to analytical and interpretative modes of categorization defining formal and material orders inherent in the newly made artifact. As subsequent questions are imposed an effort is made to find new resolutions that provide ways to interpret the conventions of architecture. By artificially isolating the individual levels of design resolution the student immerses him or herself into the activity of the moment, cultivating an open imagination. As each consecutive proposition is given the previously made artifact becomes active in the form of the new artifice that now actively directs design thought. The design actions take on a conjugational character described semantically by Paul Klee in his Pedagogical Sketchbook as, *active-medial-passive*. (4)

Early design exercises challenged the students to question the nature of matter through shape, form and value, testing their ability to 'see' and react manually to formal cues. They focused on the relationship between mass and light and incorporated the use of large charcoal analytiques as the visceral and manual means of *seeing*. This exercise acted as the point of departure for the next series of studies dealing with structural transformations into frameworks for the suspension of objects and eventually enclosure systems for the habitation of their body.

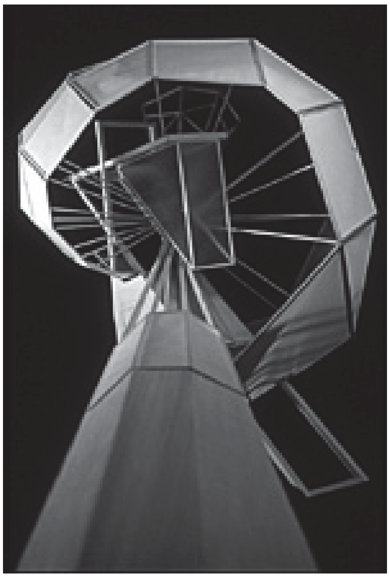
  

To begin, students constructed several plaster casts to act as templates for study in light; each 1" deep by 4"x4" plaster cast contained the impression of an object. As mass and light studies, these tablets were viewed gesturally through a series of large charcoal drawings to elicit a visceral and material mode of imagination. In these drawings the students were to isolate and focus their vision into small areas (1"x1") of the cast and enlarge them onto 18"x24" paper filling the field. This forced them to acutely examine the nuances of light and shadow as a means of articulating form. Simultaneously, through the use of sectional figures of pochè, the students produced ink drawings on mylar focusing on formal analytical skills in visual perception. The resulting dialogue generated imaginative pluralities that challenged their perception and manipulation of architectural conventions. Architectural drawings as interpretive texts--palimpsests of geometry in plan and section--established foundational orders in form-making. These maps would lead to 3-D frameworks exploring structural suspensions of objects; scaffolding to explore notions of the 'container as contents' versus the 'contents as container'. Axonometric drawings were constructed from the orthographic projections in order to inform a structural framework that would support and enclose these plaster casts raised 4 inches from a ground surface. Through playful experiments in tension and compression, each student wrestled with the forces of gravity to compose a structural framework that amplified the internal void left from the embedded object in their cast while also reflecting the 4"x4" dimensions of its container. The constructions were derived from direct formal extensions and material explorations of their initial artifact; the tablet. The tablets became the artifice to explore; light and mass, solid and void, and structure and gravity through drawings and models simultaneously--construing and constructing as an act of making. They were now to imagine the solid mass of their plaster tablets as a void or as the container of space.

The play of ARCHITECTURE/The architecture of PLAY

Each student now possessed an armature to support the two acts of play to follow: *function and meaning*. It was after the completion of these formal and material exercises that I introduced several architectural propositions and asked the students to explore their meaning in relation to their unconventional structures. The students were now challenged to transform their models, through rigorous architectural probing, to function as a habitable space for thought and experience. They were asked to use their working model, as developed to this point, to design "A Space for One's Daydreams." This space would be for one person and be derived from the mass/void within the spatial framework of their individual construct (the plaster cast). The architectural conventions of *wall, stair, window, light and gravity* were to be the focus of their next formal transformations. The meaning and function of these elements should be revealed through an interpretation of their previously built working model and be driven through a personal means of inhabiting their space of daydreaming. The existing model should be viewed as being at 1/4" scale, i.e., 16'x 16'x 4' deep and 16' above the ground. Their final model would be built at 1/2" scale, primarily out of bas wood, to a high level of craft articulating joint and connection details.

A SPACE for One's DAYDREAMS



> "... the house shelters daydreams, the house protects the dreamer, the house allows one to dream in peace. Thought and experience are not the only things that sanction human values. The values that belong to daydreaming mark humanity in its depths. Daydreaming even has a privilege of autovalorization. It derives direct pleasure from its own being. Therefore, the places in which we have experienced daydreaming reconstitute themselves in a new daydream, and it is because our memories of former dwelling-places are relived as daydreams that these dwelling-places of the past remain in us for all time" [Gaston Bachelard- The Poetics of Space](6)

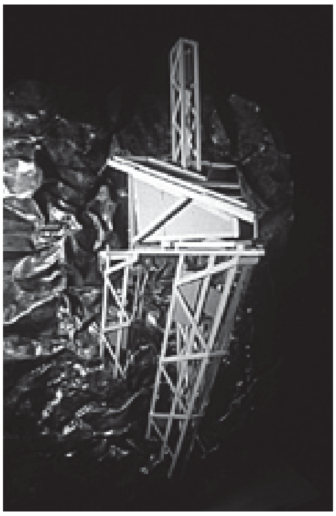
The content or meaning of the project would come in the form of a phenomenal proposition. Gaston Bachelard poetically describes the phenomenology of the daydream as being a place that "can untangle the complex of memory and imagination... for in daydreaming we are revisiting a memory in the present and through the power of our imagination engraving a newly formed image--an imagined recollection." (7) Bachelard assigns this place to the oneric house that constitutes a body of images that give oneself proofs or illusions of stability--a place of constant re-imagining of its own reality. Although this theme was very abstractly stated the students were to work hard to recognize its psychologically concrete nature. Through their specific use of the functional and spatial architectural elements assigned, each student confronted the challenge of making an architectural machine "that transports the dreamer outside the immediate world to a world that bears the mark of infinity."(8)

Each student aggressively imposed their individual identities upon their constructions through a constant dialogue between the individual space-images of the world within their daydream, or one's *core-space*, and the natural space-images of the world without as a *shell-space*. In order to start their design development, it was important for them to inhabit their construct. Through steadfastly engaging each of the assigned architectural elements *(wall, stair, window, light and gravity)* as related to their structure and appropriating their meaning as an extension of their body, geometrically as well as phenomenologically, these architectural conventions were each allowed to generate new and informative roles in the development of an idea. As stated in the closing quote by Alberto Perez-Gomez, each architectural element became a mechanism "to identify poetic intention with architectural means." A window became a watchful eye, a stair a way to transcend into a world apart, light a cosmological projection of time or the protagonist to gravity. The products of these imagined realities were real, buildable architectural constructions in a concrete language of architectural elements. Affording the freedom to interpret the phenomenal proposition within the stricter constraints of the architectural program proved to convince each student that they could build almost anything they could constructively imagine. It allowed for memory and imagination to playfully intertwine affording individual interpretations and inventive applications of some basic architectural conventions. Through a play of architecture, one was freed to examine, to interpret and to re-configure the basic constituents of architectural design and order them into imagined recollections--or daydreams.

> "The primary meanings of architecture are sought in making,in bringing into being things, places, sensations, perceptions; not in symbolizing meanings originating elsewhere, or in the responsive product of requirements. We work with wall, window, stair, light and gravity, in order to identify poetic intention with architectural means, but without accepting any type or a priori order. The uncertainties lying between high-sounding intention and beautiful work are freely admitted; that is what the struggle, panic and thrill are about." (9)

The nature and goal of these design lab experiments were to explore two divergent paths of inquiry: beginning with the communication of meaning through the design of structure and concluding with the design of meaning through the communication of structure. The paradoxical nature of this affirmation would become clearer as the students accounted for the ways in which they had been asked to construe and construct. Phase two of this experimental studio would attempt to form a conclusion that could produce a negotiation between the reading of an object to design meaning (the plaster tablets) verses using a reading to design an object. Their previous imaginative constructs have enough constituents to say that they are 'architectural', but what makes it architecture? Their former constructions were now viewed as 'conceptual models' that would direct analysis, interpretation and the appropriation of a new architectural project. They were to build upon their previous architectural discoveries and allow them to act as the catalyst for the design of more conventional building tasks. The students would endeavor to elicit and transform the complex ideas, techniques and situations of their previous architectural design project, architectonically into conventional building tasks, complete with site, program and parti.

The Design Of Meaning Through The Communication Of Structure



The objective of this studios' transformation process would be to understand more fully the conventions and conventional tools of architecture too; however, in this case, each student would be in charge of deciding precisely *how, why,* and *under what conditions* these conventions and tools are to be put into practice in relation to the specificity of their former site machine, now viewed as a conceptual model. This would necessitate serious reflection on the formulation and application of a building theory. Each individual must justify how, why, and under what conditions the practical issues such as 'wall', 'floor', 'roof', 'aperture', and 'stair' address the communication of meaning in their project. In both studios the exercises of the first half of the semester produced several 'tangible' products. The exercises were cumulative, in the sense that each built upon cues from its predecessor and transformed simple issues of form into complex readings of situations. The next phase of this studios' project required a transformation and distillation of the abundance of tectonic and semiotic causes and effects represented in their conceptual model into specific design criteria for individual building types that respond to the specific nature of the conceptual model and the design methodology initiated in order to construct it.

Each student was asked to reflect on the communitive opportunities of 'meaning' that are implicit in their concept model as well as the formal and spatial characteristics they possessed. As a class we tried to isolate the potentials for design strategies that would encapsulate both content (meaning) and container (building) simultaneously. This resulted in thirteen individual project statements to be developed architectonically into a building, complete with program and parti. Each project had a 'project title' or name, a 'building task' or functional frame, historical or literary references if applicable, and a series of specific questions for the student to ponder in their design process.

END NOTES

1. Gaston Bachelard, *Water and Dreams* , The Introduction- Imagination and Matter, pg. 1, 1983, The Pegasus Foundation , Dallas, Texas.

2. Ibid., pg. 16

3. The articulation of the notion of 'artifice as enabling theory' was developed through several ongoing dialogues with a good friend and former student of mine named Kristopher Takacs. This began after we attended a lecture by Alberto Perez-Gomez at The University of Pennsylvannia and continued via our theoretical discussion of one of Kristopher's former studio projects.
I want to thank him for his contribution to this paper and the ongoing discourse of architectural design pedagogy.

4. Paul Klee, *Pedagogical Sketchbook,* pp. 16-20, Frederick A. Praeger, New York, 1953

5. Kathleen Dean Moore, *Riverwalking* , "Winter Creek," pp.36, A Harvesy Book, Harcourt Brace & Co. ,1996

6. Gaston Bachelard, *The Poetics of Space,* pg. 6, The Orion Press, Inc., 1964

7. Ibid., pg.26

8. Ibid., pg.183

9. Alberto Perez-Gomez, Carleton Univ. Catalogue, 1983, Introduction

Genetic Algorithm for the Evolution of Feature Trajectories in Time-Dependent Arts

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Abstract

Especially in generative art, the creation of perceptible and compelling large-scale forms and hierarchical structures that unfold over time is a nontrivial challenge. Nonetheless, this is an important goal for artists, such as musicians and video artists, who work in time-dependent mediums. In my work as a composer, I often sketch curves and lines that plot the trajectories of how musical features will develop throughout a given piece of music. For example, I might imagine a piece that exhibits a timbral evolution moving from bright to dark and a density trajectory from dense to sparse. I have found that the design and implementation of multiple, independent musical feature trajectories allows for complex musical structures to emerge, and I have worked to design this capability into generative systems for the composition of music. In this paper I describe the motivations and goals associated with the design and implementation of a hierarchical, coevolutionary genetic algorithm comprised of a population of musical components. I concentrate on the aspects of the algorithm which enable the automated generation of feature trajectories through the use of artificial intelligence and an expanded definition of the genetic feature.

Keywords

Generative Art, Music, Computer Music, Genetic Algorithm, Evolution, Music Theory, Music Cognition, Music Perception, Algorithmic Composition

1. Introduction

In my work as a composer, I often sketch curves and lines that plot the trajectories of how musical features will develop throughout a given piece of music. For example, I might imagine a piece that exhibits a timbral evolution moving from bright to dark and a density trajectory from dense to sparse. Simultaneously, the amplitude level might rise from low to high, and return to a moderate level toward the end.

I hope to create structures such as timbral motives that evolve along an extended contour. I hope to create sequences of rhythmic distortions as defined by a subdivision value's contour. I want to be able to create meta-contours that drive the overall form of the music as well as local gestural contours which can serve as motivic structures. Furthermore, I want to be able to define independent contours for rhythm, timbre, amplitude, and frequency for any given level of the musical structure. Using sharp contours I want to be able to probe the extremes of each feature of the system and control the extent to which these extremes are reached.

I have found that the design and realization of multiple, independent musical feature trajectories, such as those described above, allows for complex musical structures to emerge. Such structures can support large-scale forms of durations ranging from ten to thirty minutes. I have worked to design this capability into a generative model for the creation of music. In this paper I describe the design and implementation of a hierarchical, coevolutionary genetic algorithm comprised of a population of musical components. I concentrate on the aspects of the algorithm which enable the automated generation of feature trajectories through the use of artificial intelligence and an expanded definition of the genetic feature.

I will first discuss my motivations and musical goals for creating the model. I will explain my reasons for implementing a genetic algorithm. I will illustrate the hierarchical organization of musical population. I will then discuss the expanded scope of the genetic feature and describe how this allows for the emergence of sophisticated feature trajectories over time. I will explain the role that artificial intelligence plays in the interactions between musical components, and finally, I will conclude with a discussion of the musical results and how this methodology can be applied to other domains of time-based creation.

2. Motivation and Goals

2.1 Formal Metaphor and Inspiration

As an artist working in a time-based medium, I am naturally intrigued by time cycles that occur in my life and the world around me. Many composers in particular have utilized this inspiration in their work. Igor Stravinsky provides a stunning example in his composition, *Symphony of Psalms* [3], which conveys the grandeur of the metaphysical world through the repetition of musical cycles.

The motivation and inspiration for my design of this generative model comes from my experience of watching the play of light against the ocean. In an afternoon on the beach I am drawn to the trajectory of the sun throughout the day, and the slow progression of clouds across the sky. Simultaneously, winds blow across the water, causing ripples and chop on the water, while the repetition of tidal patterns shift in a meta-rhythm. At the nexus of these intersecting forces is the play of light against the water; a shimmering surface that is slowly changing in tone and intensity with the influence of each of these cycles. The particular manifestation of these interacting forces on any given day is always unique. Nonetheless, the generative process is always the same.

In this generative model for the creation of music, I am trying to capture this essential nature of independent cycles that unfold over different time scales and contribute to defining a musical surface, that is guided by the underlying structure. Capturing this sense of flux and process is a critical musical goal.

2.2 Musical Goals

With this motivation in mind, I have defined two broad musical goals that I hope the system can achieve. They are open in that they can accommodate many different surface-level characteristics, but restrictive to the extent that they define the basis of music that I hope the generative system will produce.

1. I hope to generate large, slowly evolving forms that are balanced by local variety.

2. I hope to generate musical processes that unfold over time independently for each musical feature. The surface of the music is the composite resulting from the interaction of these otherwise independent processes.

3. The Generative Model

This generative model for the automated composition of music utilizes a coevolutionary genetic algorithm [1, 2]. The algorithm is hierarchically organized, and it is comprised of a population of musical components including *Notes*, *Gestures*, *Phrases*, *Sections*, and *Metasections*.

I chose to implement a genetic algorithm for this work because the computing paradigm is sufficiently flexible and open-ended to allow for manipulation and enhancement to suit the musical purpose. Additionally, it is possible to leverage features of the genetic algorithm that are well suited for organizing music.

- An unlimited genetic feature space can be defined for each member of the population.

- Each genetic feature evolves independently to yield virtually unlimited combinations.

- Members of the population will mate with one another to produce children which are a hybrid of the two parents. For example, two musical Sections can mate to produce a third Section which will exhibit musical features such as frequency and amplitude which are drawn from both parents. In this manner, the genetic algorithm affords the possibility for repetition and distortion in time. This fact allows for the cross-pollination of salient musical features at various hierarchical levels.

- A genetic algorithm is a complex nonlinear system and one cannot predict the outcome of the evolutionary process without actually running the simulation. Genetic mutation and the infinite variety of combinatorial possibilities, allow the algorithm to generate novel and unpredictable results. I want to build a generative system that is capable of producing musical results that are not explicitly built into the system and could not have been anticipated. New forms and musical ideas can emerge from the system which adhere to the goals outlined above, but are not 'composed' in a traditional sense.

3.1 The Evolutionary Process

The genetic algorithm described in this paper does not require any feedback from the author. Unlike selective breeding models [1] that require feedback to steer the evolutionary process, fitness evaluation is accomplished by upper level components within the hierarchical structure.

The population hierarchy and all genetic features are initialized with random variables. The topmost level of the hierarchy does not mate with any peer components, and as a result, the initial seeding of this component will dictate the overall form of the evolved piece. However, all details regarding the fleshing out of this form are determined entirely within the algorithm itself. Each evolved piece of music is unique and I cannot predict nor alter its particular features.

A difficult challenge in any genetic algorithm is to simply determine when the evolutionary process is finished. In this algorithm, through extensive experimentation, I have found that a population will stabilize after several thousand generations. This stability is indicated by a reduction in the percentage of deaths and ill-fit members of the population. Consequently, in most examples discussed in this paper, the evolutionary process is terminated after three thousand generations.

3.2 The Musical Hierarchy

In order to generate musical works which are hierarchically organized and contain feature trajectories that unfold at different timescales, I have implemented a hierarchically organized, coevolutionary genetic algorithm. *Metasections*, *Sections*, *Phrases*, *Gestures*, and *Notes* comprise the musical population. In the system, an upper level component, such as a *Section*, contains a sub population of organisms, such as *Phrases*. Throughout this paper I will refer to such an upper level component as a 'parent' and will refer to its sub components as 'children.'

A given parent component sets the fitness function for its children, and as these children evolve and change and interact with each generation, they are also redefine the fitness functions for their children. Section 3.4 describes the role of components in different hierarchical levels of the system.

Though the number of tiers in the population architecture is fixed, each population is randomly initialized, and the details of the resulting tree structure are always unique. Figure 3.1 diagrams a possible realization of the hierarchical structure wherein *Metasections* can contain *n* levels of other *Metasections*. At the terminal *Metasection* level, *Metasections* contain *Sections*. *Sections* contain *Phrases*, which contain *Gestures*, which contain *Notes*. The *Note* is the fundamental component of the structure.

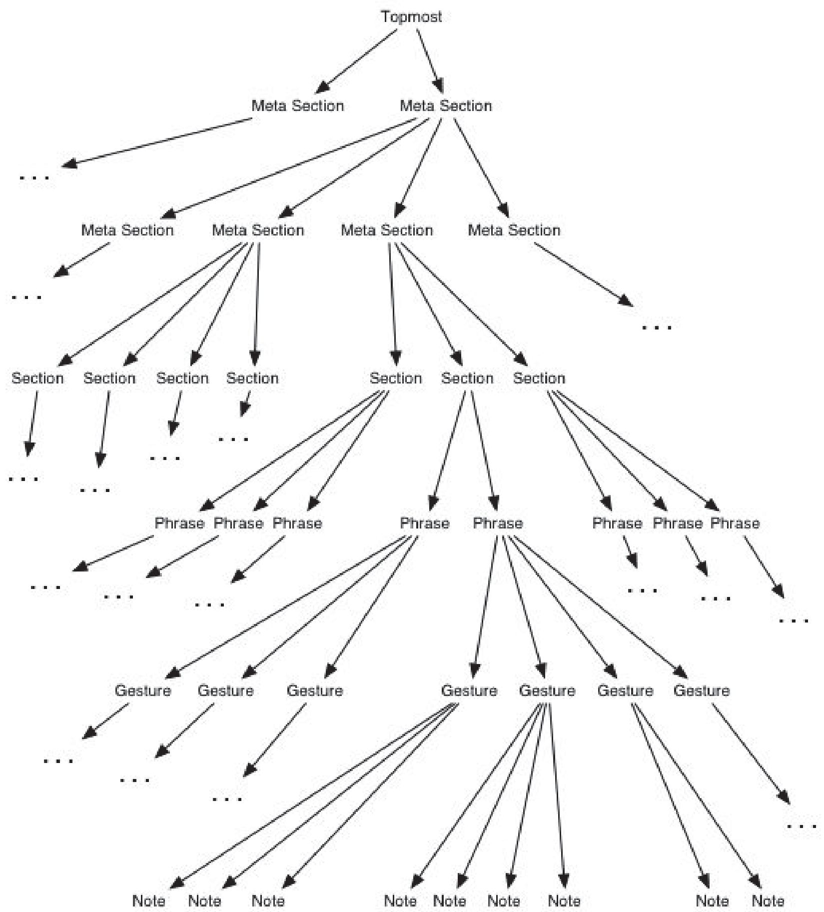

Figure 3.1

3.3 Role of Components in the Hierarchy

3.3.1 Note

The Note is the terminal level of the musical hierarchy. Notes are realized as musical events at the final stage of the generative process.

3.3.2 Mid-Level Components

Mid-level components, including *Gestures*, *Phrases*, *Sections*, and *Metasections*, are not directly realized as music. Their primary role is to shape the feature trajectories and bandwidths for their child components.

3.3.3 Topmost Level

The topmost level of the hierarchy does not mate with any peer components, and as a result, the initial seeding of this component will dictate the overall form of the evolved piece. The evolutionary process leads toward a realization of the global structure that is fixed in the initialization of the topmost level.

4. Expanded Scope of the Genetic Feature

A given *Phrase* could evolve a population of *Gestures* that simply cluster at random around some specified value. However, I want the system to generate groups of components that are organized in such a way that they yield discernable trajectories over time. I want *Phrase* groupings to emerge that contain groups of *Gestures* moving from low to high, and returning to a medium level. Similarly, I want a sequence of adjacent *Phrases* to yield a perceivable progression of feature trajectories with each new *Phrase*. Consequently, a number of additional dimensions have been added to each genetic feature to facilitate the generation of independent feature trajectories at each level of the hierarchy. Exactly as with the basic genetic values, these additional dimensions are exchanged, mutated, and inherited through the process if reproduction, and as a result, the genetic pool for these additional dimensions is perpetually varying and evolving with each passing generation.

Each genetic feature of a component is defined by this expanded set of dimensions. Some of these dimensions govern the component itself, and some define contours that dictate the relationships between child components. In this section I will describe these additional dimensions and explain how they contribute to the creation of sophisticated feature trajectories.

4.1 Fundamental Dimensions

4.1.1 Primary Value

The essential dimension of a feature is its *primary value*. This dimension plays three important roles in the genetic algorithm.

1. This feature dimension sets the expressed value of the feature when the component is realized in the generative process. For example, if a *Note* has an amplitude with a primary value of 0.5, the *Note's* amplitude will be set to 0.5 when it is realized by the generative system.

2. The primary value dimension is used to evaluate the fitness of a member of the population.

3. The primary value is inspected and modified as components interact and organize themselves along the trajectory skeleton defined by their parent.

4.1.2 Bandwidth

Each feature has a *bandwidth* dimension. This dimension in a parent component governs the range of feature values that its children can exhibit.

The bandwidth is centered around the primary value of a given component. For example, if the primary amplitude value of a component is 0.5 and the bandwidth dimension is set to 0.5, the bandwidth of that feature will span from 0.25 – 0.75. Consequently, any child of this component can have a primary amplitude value from 0.25 – 0.75 and still be well fit along the amplitude axis.

A parent’s bandwidth dimension plays a key role in defining the fitness function for its children. However, the bandwidth dimension does not have a function for *Notes*, because they are at the terminal level of the population hierarchy.

4.2 Contour Defining Dimensions

The primary role of upper level components in this system is to shape feature contours for their child components. *Gestures*, *Phrases*, *Sections*, and *Metasections* are not directly realized as sound events, but their genetic features shape the trajectories that drive the music generated by the algorithm. In this section I will describe the genetic feature dimensions that have been implemented to allow the generative system to create musically compelling feature trajectories.

4.2.1 Anchor Points

In conjunction with the primary value and bandwidth dimensions, four additional feature dimensions frame a skeleton trajectory for a given feature. These dimensions are the *start value*, *middle value*, *middle value location*, and *end value*. Figures 4.1 a & b illustrate two trajectory skeletons which could be defined by three anchor points.

Squares mark the anchor points of the trajectory, and these points are connected by lines. In Section 5, I will describe how components of the generative system interact with one another to create an infinite variety of lines and curves that flesh out this basic structure.

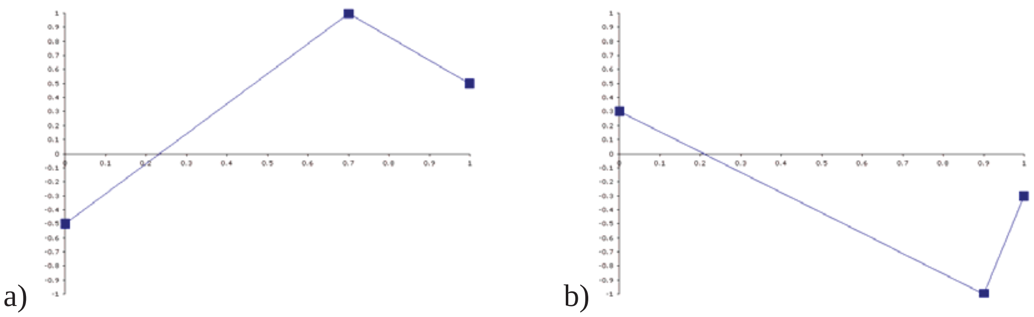

Figure 4.1

4.2.1.1 Start and End Values

The start and end values define the underlying direction and shape of the feature contour. This feature contour is always centered about the axis of the primary value dimension of the feature. If the *start value* is less than the *end value* the overall trajectory of the feature will move from low to high. If the *start value* is higher, then the overall trajectory will move from low to high. The plots in Figure 4.1 illustrate each condition.

4.2.1.2 Middle Value

Two feature dimensions, a *value* and *position*, define the middle point of the feature contour.

The value of the middle point is a function of the contour direction. This value is derived from subtracting the start value from the end value. As illustrated in Figure 4.1, trajectories which move from low to high, as defined by the start and end values, will have a positive middle direction, while contours that move from high to low will have a negative middle direction. Thus, the *middle value* is set to either +1.0 or –1.0, but as with all trajectory anchor points, this value is scaled according to the bandwidth dimensions of a genetic feature. This scaling function is described in section 4.2.2.

4.2.1.3 Middle Value Position

The above method is used to calculate the value of the middle point, but this middle point is not necessarily assigned to the centermost member of a peer group. The *middle value position* determines the point at which the middle peak of the contour will occur. The middle value position is a percentage that scales across the number of child components contained within the parent to determine which child component will be assigned as the middle value anchor. In figures 4.1a-b, the middle value positions are 0.7 and 0.9 respectively.

4.2.1.4 Assigning and Fixing the Anchor Points

Once the *start*, *end*, and *middle* points have been calculated, they are assigned to the child components of the parent. For example, a *Phrase* might contain seven *Gestures*. These *Gestures* are arranged in ascending order beginning with the *Gesture* which starts at the earliest time and ending with that *Gesture* which starts at the latest time. The features of the first and seventh *Gestures* in this example are assigned by the start and end anchor points. Using the *middle value location* as a percentage, one of the child *Gestures* will be assigned the *middle value*. It is also possible for the *middle value position* to supplant a *start* or *end* point to yield a trajectory defined by only two anchors, a *start* and *end*.

In Section 5, I will discuss the process by which adjacent, non-anchor components can organize themselves along the basic trajectory established by these three anchor points. Nonetheless, these three components are rigidly fixed as anchor points, and they will not deviate until the parent's feature dimensions change.

4.2.2 Bandwidth Scales the Trajectory

In section 4.1.2 I introduced the bandwidth dimension of a genetic feature. In addition to regulating the fitness function for child components, the bandwidth of a given feature scales the trajectory range for its children.

Figures 4.1a-b chart trajectories with peaks at 1.0 and –1.0 that are centered about the axis of a hypothetical primary value. If a given feature's bandwidth value is 1.0, these full value ranges will be preserved. However, a bandwidth value of 0.5 will scale the trajectory range such that the peaks would reach 0.25 or –0.25. If this trajectory is centered about a primary value of 0.5, the peak anchor point in figure 4.1a, with the same bandwidth value, would reach 0.75, while the peak anchor point of figure 4.1b would dip to 0.25. Bandwidth values which exceed the global 0.0 – 1.0 range are truncated at either bound.

4.4 Bandwidth Contour Dimensions

A feature's bandwidth value is critical in the organization of feature contours. Given that this dimension plays such an important role in defining the generated forms, I want to provide the generative system with the facility to construct meaningful bandwidth trajectories that unfold over time. This was accomplished through the implementation of an additional array of bandwidth dimensions.

Figure 4.3 illustrates a *Phrase*, containing four *Gestures*, which exhibits a gradually diminishing bandwidth trajectory. Using these additional feature dimensions, the genetic algorithm can potentially generate a shape where the first *Gesture* has a very wide frequency bandwidth that narrows over time before reaching a very narrow width by the fourth *Gesture*. Concurrently, the amplitude bandwidth might begin very broad and similarly grow narrow by the fourth *Gesture*. Thus, over the course of this *Phrase*, the music would start with diverse amplitudes that are spread over a full frequency range, and would gradually focus toward a narrow frequency band at a nearly uniform amplitude level. Such a bandwidth contour would provide a striking musical result that unfolds along with the other independently evolving feature contours for these *Gestures*.

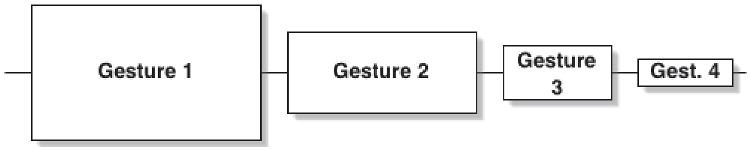

Figure 4.3

4.3.2 Bandwidth contour dimensions

Just as a component defines the trajectory of primary values of its children, it also defines a contour of bandwidths. Two variables are used for this purpose, *bandwidth start value* and the *bandwidth end value*. The *bandwidth start value* acts as an anchor point and sets the bandwidth for the first child contained within the component. The *bandwidth end value* sets the bandwidth anchor for the last member. Note that only two points, a beginning and end value, are used to define the bandwidth contour of a component.

4.4 Secondary Trajectory Dimensions

4.4.1 Secondary Trajectory Control

Thus far, I have described the expanded feature dimensions that define feature and bandwidth trajectories for each genetic feature of the system. There is yet another way in which component feature trajectories are organized, *secondary trajectory control dimensions*. These *secondary trajectory dimensions* control the trajectory of anchor points for a sequence of child components of a given parent.

Imagine again that a given *Metasection* contains six *Sections*. Each of these *Sections* defines a feature trajectory for each of the *Phrases* it contains as describe above. While the feature dimensions described thus far are sufficient for generating compelling trajectories within each of the child *Phrases* in this example, I want to ensure that the trajectories contained within each of the *Phrases* are not simply repeated. I want the model to generate sequences of musical structures that contain meaningfully shifting trajectories. Consequently, I have implemented an array of additional feature dimensions that define trajectories for the anchor points of child components. These dimensions define starting and ending values for each of the three trajectory anchor points, and are evolved by the genetic algorithm in the same fashion as all feature dimensions described in this paper.

Figure 4.4 illustrates a sequence of trajectories for six *Sections* in which the *middle* anchor point moves later and later with each successive component.

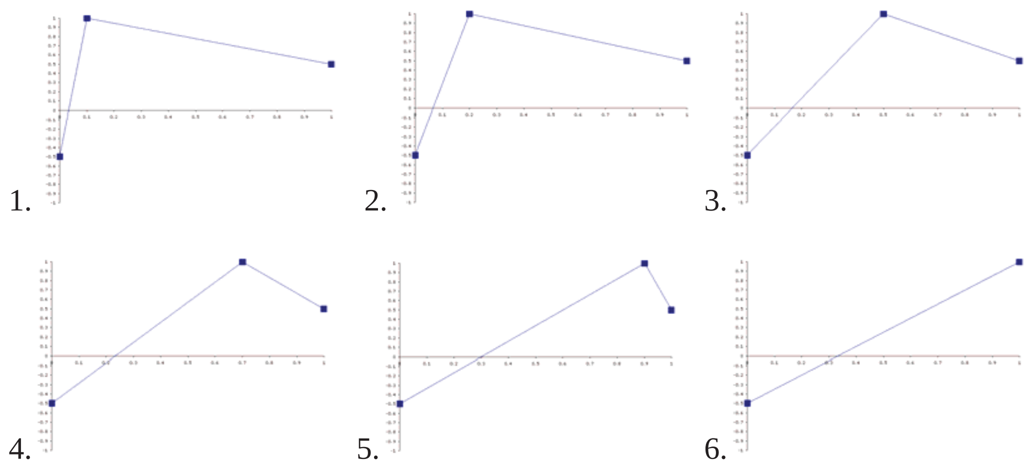

Figure 4.4 – 6 Sequential Sections

With the implementation of secondary trajectory dimensions, a given parent component can set trajectories for the *start*, *end*, and *middle* values of its child components. In the above sequence, only the middle value position is shifted. However, if all three values were to be shifted over a component sequence, the transformation would prove more dramatic. A secondary trajectory could be very small such that a sequence of contours would not change much at all, or the system could generate secondary trajectories where the trajectory is radically transformed over the span of just a few components.

4.4.2 Feature Dimension Depth Limit

The need for increased variety and control over feature trajectories is mitigated by the fact that this process of deeper and deeper nested levels of control must stop at some point. I have decided to stop at this secondary level. There are no tertiary levels that govern how the secondary levels will change over the duration of a musical component. Furthermore, I did not define additional middle values to act as targets for these secondary control values.

This balance is guided by the feeling that this level of trajectory manipulation and variation yields results that are discernable to listeners. A shifting trajectory as described in Section 4.4.1 defines an arc that a listener can still readily detect. Through experimentation with the system I have determined that the implementation of more levels of control would risk destroying the sense of meaningful progression, and might rather cross into a perceptual realm where feature trajectories seem to be generated at random. This limit on the nesting level ensures that the trajectories defined by a family of peer components will not grow stagnant and preserves a perceptible level of continuity between them.

5. Component Intelligence for Contours

I have described feature dimensions that enable the genetic algorithm to generate a wide variety of skeleton trajectories that can independently steer trajectories for each genetic feature of the system. Figure 5.1 illustrates a potential skeleton trajectory for a given feature of a component.

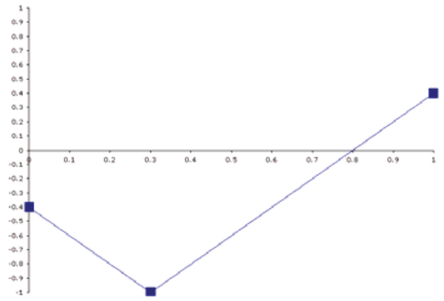

Figure 5.1

Though this basic shape is fundamentally satisfactory, I want the generative system to be able to generate trajectories that include curves and lines that allow for even greater control, variety, and subtlety in the generated forms.

For example, in composing a section of music, I might begin with the notion that the rhythmic activity should move from very still, to a frenetic peak toward the end, suddenly returning to a middle intensity at the end. However, these three points would rarely be linked by a simple linear rise or fall in activity. Rather, an exponential curve might link the first two points, followed by a shallow logarithmic curve between the second two points. Any variety of curves might potentially join two points, and this is a vital formal feature that I want to the system to generate.

In order for the algorithm to generate a great variety of connecting curves I have implemented a system of low-level intelligent interaction between adjacent components so that the organisms themselves can work together to generate compelling feature trajectories.

5.1 Component Intelligence

In the generative system, complex, curved contours arise from local interactions of intelligent musical components. In addition to the global cycle of life, death, and reproduction that drives the evolutionary process, each component in the hierarchy has an awareness of the state of adjacent members in its peer group. For example, if a *Phrase* contains nine *Gestures* arrange in ascending order according to their start times, the first and second *Gestures* can relate their feature sets to one another. Similarly, the second and third *Gestures* are aware of one another just as the third and fourth members of this group are aware of each other. This local awareness allows a group of components to fit themselves loosely along the contour skeleton that is defined by their parent.

To illustrate how these local interactions contribute to the construction of feature contours, I will refer to the contour graph in figure 5.1 and assume that nine *Gestures* are to fit themselves along this amplitude contour defined by their parent *Phrase*.

As discussed in the previous section, there are three anchor points in this group. The first Gesture of this group, $Gesture_1$, will have its amplitude set to –0.4 (scaled according to the bandwidth of the containing Phrase). The middle Gesture is the third member, $Gesture_3$, and will thus have its amplitude set to –1.0 (also scaled of course). The ninth Gesture, $Gesture_9$, will be anchored at an amplitude value of +0.4. The remaining, non-anchor Gestures use local intelligence to organize themselves along the basic trajectory specified by the parent Phrase. Thus, $Gesture_2$ must position itself somewhere between $Gesture_1$ and $Gesture_3$ to link the first two points. Between $Gesture_3$ and $Gesture_9$, five Gestures must sort themselves along any ascending curve from –1.0 to +0.4. With each generation of the genetic algorithm, each Gesture will make minor adjustments to its features until all nine gestures are sorted into the proper order that fleshes out the underlying skeleton trajectory. The feature distances between adjacent members of this group are not set by the parent Phrase. This low-level, intelligent sorting process yields any variety of curves which could join the three anchor points, and Figures 5.2 a-d illustrate solutions that could result from this component interaction.

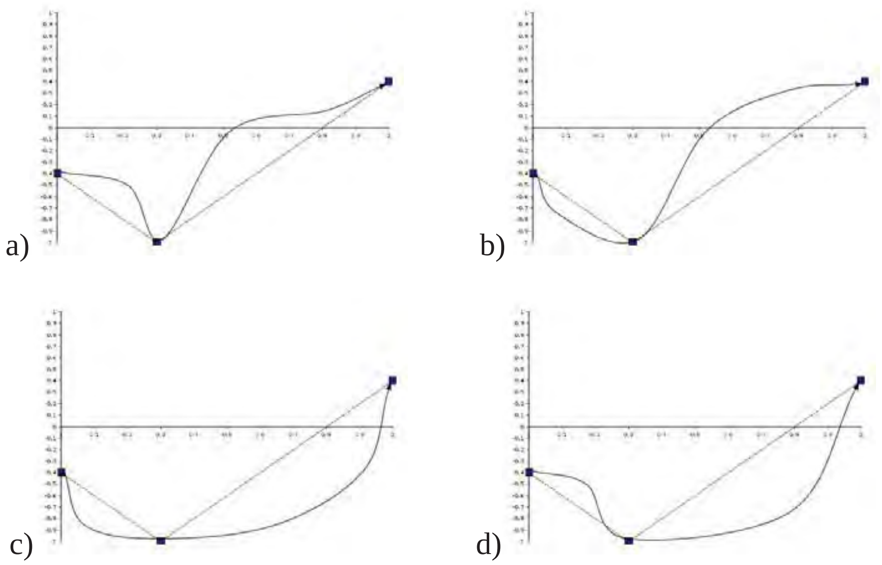

Figure 5.2

Figures 5.2-d illustrate contour shapes that are musically compelling and familiar. Imagine that these contours govern the amplitude shape of a *Phrase*, or the rhythmic acceleration of a *Gesture*. Imagine that they shape a fall and rise in frequency over the duration of a long *Section*, or that they steer a timbral motive across a *Phrase*.
By evolving a population of intelligent musical structures, the system itself can explore the creation of an infinite variety of feature contours, and thereby generate complex and discernible musical forms.

5.2 Bandwidth and Secondary Trajectory Intelligence

In previous sections I have described how anchor points for bandwidth and secondary trajectories are used to define contours for bandwidths and skeleton trajectories. Exactly as described for feature contours, local intelligent interactions between adjacent components will generate a great variety of curves to link these bandwidth and secondary trajectory anchor points.

6. Musical Results

The true measure of the success of the generative algorithm is the quality of the music it generates. 'Quality' is defined according to adherence to the points described in Section 2. Over the course of working on this project I have been encouraged by the steady improvement in the quality of the resulting music. The first musical outputs were undifferentiated from one another, and exhibited flat trajectories at the formal and local levels. As the feature dimensions were enhanced, more varied trajectories began to emerge. As the feature list was expanded, the generated pieces grew in sophistication and clarity. This improvement in the musical results is evidence of an increased understanding of the critical features of the music I hoped to generate and my ability to quantify their influence.

As the project progressed, I also felt that as a listener I was increasingly able to navigate the musical structures that emerged and could more clearly recognize my own musical biases in the pieces. This ability to grow more conditioned to the musical style of the genetic algorithm provides further evidence of the increasing sophistication of the generated music.

Another musical goal of the project was to generate music that exhibits large-scale, slowly evolving forms and addresses the passage of time on multiple levels. The genetic algorithm produces pieces that exemplify such forms.

7. Conclusions

The evolutionary framework described in this paper provides an effective means of generating an unlimited number of independent feature trajectories that unfold over time. These trajectories are musically compelling at every level of the hierarchical structure, and they contain sufficient variety and sophistication to support the creation of large-scale musical forms.

7.1 Other Time-Based Media

This paper describes the implementation of a generative model for the creation of music. Nonetheless, this methodology for using a genetic algorithm to generate independent feature trajectories that unfold over time in a hierarchical structure is applicable to any time-based media.

The genetic features described in this paper are used to drive features such as amplitude trajectories and harmonic progressions. These trajectories could also be mapped to drive video filtering parameters in a generative model for video art. They could drive actuators in a kinetic sculpture, or could shape the environment of an active installation. The generative model is intentionally flexible to allow for extrapolation to other domains.

8. References

[1] Holland, J., Adaptation in Natural and Artificial Systems, University of Michigan, Ann Arbor, 1975.

[2] Husbands, P., Distributed Coevolutionary Genetic Algorithms for Multi-Criteria and Multi-Constraint Optimisation. Evolutionary Computing, AISB Workshop 1994: 150-165

[3] Stravinsky, I., Symphony of Psalms. Boosey and Hawkes, London, rev. 1948.

ames Coincidence as the ase of Casino Atmosphere Design Using enerati e Approach

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Abstract

After the introductory reflections about the casino games concept, the basic idea how to increase gambler's sense of being really inside the game is explained. In the next section several applications of informational technology in the area of creating environments are presented. Furthermore generative art method is described as a possible approach to creating images as elements of environment. Follows my personal experiences on developing generative programs using algorithms based on mathematical formula. In the last section are listed some static and dynamic applications of generative art which can be used in casino environment design.

Introduction

There are two types of games with different degrees of chance in the result. Some of them (roulette, slot machines, craps, bingo) are extremely dependent on casual events or chance and the gambler in reality has no chance to calculate the result. Other games with playing cards produce results that are a combination of human ability and chance. But more or less, gambling means having the fortune to be in the right place at the right time and to profit from such good luck. Introducing slot machines, automatic roulettes, blackjack and other such games, computer support becomes very useful in applying random number generators to simulate chance events.

The basic question is how to apply gambling and chance philosophies to the planning of casino environments. Some authors argue that gambling equipment should be the only decoration around casino rooms. The concept of thematic casinos using world-famous stories, destinations, and exotic places brings the furnishings very far from the philosophy of gaming. The success of thematic casinos is very great and impressive at first, but it also becomes tedious and ignored by regular guests. Changing the interior means investing new money and also breaking common and natural connections between the outside and inside design concept. A third way might be somewhere in the middle, and could be connected to games and chance events that can influence the visual and audio effects inside gaming areas.

This approach means introducing computer technology using a close connection between science and art expressed as images and sounds. The Generative Art approach, a world-famous method to generate visual solutions on the base of mathematical algorithms might represent a very useful and non-expensive way to satisfy varying requests to create a casino atmosphere reflecting "the feel of game". The primary goal of the generative approach is to produce absolutely unpredictable results, and this is the point of departure for the concept under discussion. It is the principle of the transformation of the mathematics into visual art using random number generators and mathematical algorithms – the same way as in games of chance.

Games of chance were studied in connection with probability theory in the seventeenth century by Pascal and Fermat[1]. This research was conducted in the form of the mathematical study of randomness. Probability theory deals with the possible outcomes of an event, in our case the result of the game. The result of the game of chance is absolutely unpredictable and this is of course the main charm of gambling. To introduce the same feature into the room's decoration has the ability to increase gamblers' sense of being really inside the game.

Computer Technology and the Design of Casino En ironments

Typical applications of new technology in the area of creating environments using visual and audio effects have been developed under the name "Demo"[2]. Demos are visual shows designed to be seen on big screens, video walls and other such equipment capable of supporting video projections. Productions run in a linear form similar to a film, but possess a generally abstract approach to story-telling. In computer language, demos are programs which produce engaging computer graphics and music in real time. Programming art and music composition skills are stressed and require significant knowledge of computer science and entertainment. Currently the term "Real Time Environment" is used, a conceptual label deriving from real use to project a film created in real time using computer technology and running a generative program. A program is technically defined as "running in real time" if it produces results at a reliable speed. The common use of the phrase "real time" implies that the work is being done fast enough to avoid waiting, while the animation is produced for you while you watch. A video game is a typical real time process, given that you can give it commands and it responds immediately.

The entertainment industry focused on how to make a business out of the population's free time, and uses every possibility to attract and to retain visitors-customers inside its facilities, even encouraging guests to return. One of the most important encouragement features is the environment of the entertainment place, which plays a significant role in the strategy of guaranteeing customer satisfaction and the decision to return. The gaming industry in particular offers thematic casinos to introduce more and more new computer technology to create a pleasant and attractive ambience. Exterior design elements draw customers inside, a beautiful interior environment keeps them there. Inside the casino each element works on visitors to reduce their resistance to the environment, with the lighting, color, carpet patterns, directional patterns, design themes and temperature balanced between relaxation and arousal [3].

One of the principal rules of the entertainment industry is to diversify and change programs and ambience. Designing environments using classical materials and technology represents an excessive investment, too great to be changed frequently. Computer technology uses various possibilities to produce sound and images in an artificial way is perhaps a better solution. To change the casino design theme one need only change generative software. To support the casino theme design pragmatically-designed generative programs are more convenient because the motif resulting from the generative process is predictable. Using this approach it is possible to create abstract images that symbolize for example a warm sea atmosphere, constantly new and different, with characteristic elements of the chosen environment. The message of an unusual abstract image is specific to each person and has a different influence on the individual guests, thus satisfying a greater part of the population.

enerati e Art as a Possible Approach to Creating Images

The most accepted definition of generative art is offered by Philip Galanter: "Generative art refers to any artistic practice where the artist creates a process, such as a set of natural language rules, a computer program, a machine, or other mechanism, which is then set to motion with some degree of autonomy contributing to or resulting in a complete work of art."[4]

We can describe generative art as a method for developing ideas and creating new solutions in all fields of human creativity. The basic principle is human creation. The main problem is how to "explain" to the computer the elements of the idea, and this represents the next human creation: the program code. There are two programming types using pragmatic or mathematic instructions with different effects on the unpredictability of the results. Pragmatic designed programs are more useful for design purposes where we need to create only variants of a defined object. The area of art is absolutely free, so the program based on mathematic instruction producing unexpected colored shapes can satisfy completely different types of artistic points of view.

The most essential part of the generative method is the process that means "to set in motion the computer program" producing results without any kind of programmer or other human influence. Time is the only factor to have the right to enter into the process and to cause the creation of a DNA code, which is of critical importance and greatly influences the final result. This is typical of what is happens in nature at the beginning of a live organism's existence: the moment the association of two cells causes a new genetic combination as the formula of a future organism. Association in the next moment would combine different DNA formulas. So the starting moment of the generative process is a fatal parameter for the final result. Not knowing the exact time value of the start, nobody can foresee the path of the generative process.

The selection of generated results is the creative role of the programmer or any other person who starts the program or orders art for their office, for example. The importance and enchantment of the selection phase is connected with the non-repetition of the generative process. Any kind of results of the generative method are lost forever if they are not saved as a file or realized as a print or material object. The responsibility of choosing is manifested as a kind of hazard because the next cycle of generating algorithms might create better solutions than what was chosen. A fantastic solution might be lost in this way, and humanity would never have the opportunity to experience it again.

Applications of the generative approach involve different research and development areas, including: architecture, industrial design, visual art, generative music, poetry, visual grammar, design, virtual environments, artificial life, artificial intelligence, cellular automata, entertainment, artificial behaviours, communications, generative robots and other mechatronic applications [5].

Transforming Mathematics into isual Images

I have developed many generative-designed programs. In the beginning, I applied the pragmatic approach, and some examples from my earliest periods are displayed on my web site [6] (see link history). Later, I introduced the algorithmic concept as a much more effective and powerful approach to creating interesting and unusual images. My recent program is based on algorithms using mathematical expressions. The main characteristic of the program developed in the Visual Basic programming language is its modularity, making it easy to insert any kind of additional algorithms to improve "creativity". Currently, there are 225 different complex mathematical expressions built in, using algebra, trigonometry and logarithms defined in an empirical way to experiment with the results. Each cycle of the running program chooses one algorithm randomly, calculating the first step of the pixel color value out of a list of constants and variables. Values of constants and variables are defined randomly at the beginning of the cycle using random number generators and start time values. The next step is defined using one of the 227 types of coloring algorithms also chosen randomly. The final results are three components representing red, green and blue values for the RGB color command. Introducing the same formula and the same type of coloring algorithms, the program creates a sequence of always different but recognizable images because of the different and randomly chosen values of constants and variables that represent the DNA code of the evolving image.

Transforming mathematics into images using the method described above assures a highly aesthetic visual image without willful care. This ascertainment conforms to the fact that mathematics has a built-in aesthetic. There are many scientists and mathematicians who defend the thesis of a profound connection between mathematics and aesthetics. Max Bense called attention to these links while writing many books and essays explaining his aesthetic research [7]. What is important is to recognize that there are already aesthetics in mathematics and computing. Mathematicians talk of beautiful proofs, physicists talk of symmetry and their group structures, and computer scientists talk of well-crafted programs and algorithms.

Improving my generative program while developing complex algorithms there began to appear more and more beautiful images. To demonstrate how this works, I have prepared some examples of computer-generated images. Using the same mathematical formulas, I wanted to demonstrate the diversity of results while introducing the maximum level of “decision limitations” of the program. In the first case the program created three images using the same formula and the same coloring algorithm; in the second case the coloring algorithms varied using the same formula from case one.

Images produced in case one: figure1, figure2, figure3

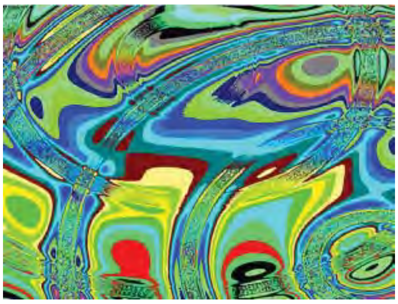
figure1

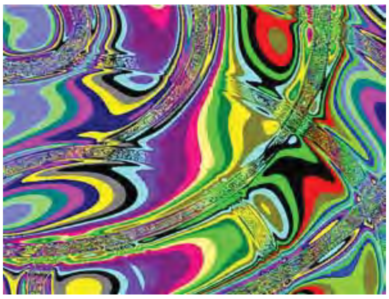
figure2


figure3

Images produced in case two: figure4, figure5, figure6

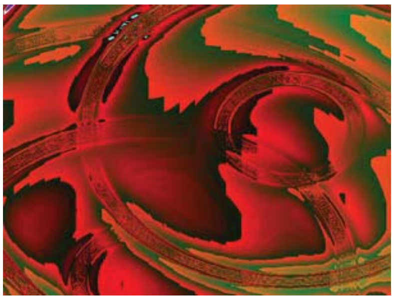
figure4

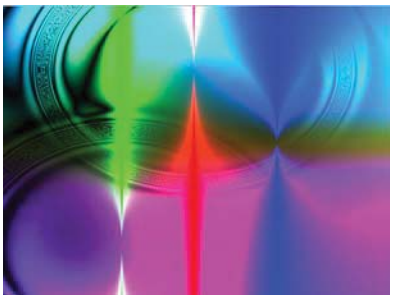
figure5

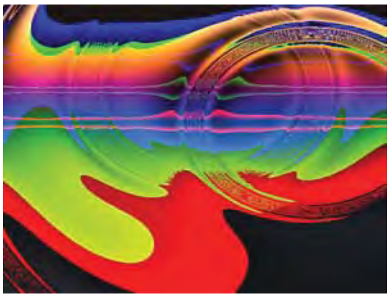
figure6

Possible Casino Applications of the Results of my Program

The results of my program are abstract images, which have no specific message and can symbolize different themes using selected mathematical formulas and algorithms. Everything depends on the definition of the parameters before running the program. The program can create images on the screen in different ways: cover right, left, up and down, random vertical or horizontal bars, box in, box out, dissolve and other. Those possibilities are useful for different types of live projections.

There are two typical groups of applications: static and dynamic. Static application means using a computer-generated image as framed artwork or as a design for floor carpeting. Dynamic application refers to any kind of live projection in real-time, and is much more convenient for creating casino atmospheres.

Possible static applications:

- framed artwork in casinos, hotel rooms or office decoration in different dimensions
- exterior design of buildings walls and other informational or promotional elements
- interior design of floor materials, walls and ceilings
- design of slot machines and other casino equipment decoration
- various printed promotional materials, tickets and cards
- design for textile material of staff uniforms

Possible dynamic applications:

- indoor big screen projections
- live stage projection as background for different shows
- live projection to create a pleasant atmosphere in fitness facilities
- background of outdoor or indoor advertising displays
- outdoor projections onto building walls as a dynamic floodlight

Conclusion

Unusual and pleasant decorative elements are most important to encourage guests to enter inside and influence guests to return. Most static solutions become tedious over time and are not effective in the long term. A key to the problem lies in the possibility of changing continuously, but at the same time remaining recognizable. Classical approaches are quite expensive, and the only way out is to use new technological solutions. The next step is to use the philosophy of chance games to create furnishings: ever-new, unpredictable and unrepeatable images that lead gamblers to feel inside the game. The Generative Approach could resolve the greater part of these problems and improve casinos' competitive advantage.

References

[1] Probability Theory, http://thinkquest.org/11506/ptheory.html
[2] Ashton Simmonds, Decoding Art – A Critical Analyses of the Demo Scene, www.cfxweb.net
[3] Walt Lockley, The Psychology of Residential Space, www.placeperformance.com/features/chap01.htm
[4] Philip Galanter, Definition of Generative Art, www.philipgalanter.com/pages/acad/index.html
[5] www.generativeart.com, official web site of the 5th International Conference of Generative Art
[6] Generative Art by Bogdan Soban, www.soban-art.com
[7] Elisabeth Walther, Max Bense's Informational and Semiotical Aesthetics, www.das-deutsche-handwerk.de/s/bense.html

Web Interface Design based on Cognitive Maps: Generative Dynamics in Information Architecture

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Abstract

The paper is aimed to introduce the application of the Cognitive Maps concept to the web design interfaces. Cognitive Maps allows the graphical representation of the information architecture highlighting the hierarchies, the nodes the physical (hypertextual) and conceptual connections between site contents.
The interaction with the Information is based on a generative dynamics of ryzomatic connections where the cognitive and perceptive richness Human User is evident, giving a more direct representation than the usual static structure tree.
Multimedia Authoring software tools are exploited to produce Multimodal cognitive Maps.
The experimental Project Designing-X (design of a biomorphic Web Site) shows a practical, specific realization of the concepts the paper is based on.

1. MUI and *cognitive maps: new paradigms in interface design*

The navigation through the hypertextual Web space can be easily performed if the user can benefit from visual and conceptual tools. Based on efficient tools, the user can search and explore the information. In the same time the user will build up a mental model of the site, in order to understand and to learn how the site works.
The user does not read the text exposed in a Web page, as Krug [1] states; he is going through (scanning) the page looking for the information he is interested on. Then the information shall be reached easily and in a short time. However the design of the GUI presently used in Web navigation is based on visualization tools that are using a communication model derived directly from the publishing and paper world.
The web page is organized by columns and boxes, in the same way a newspaper is and the text and the navigation menu lines are predominant. In order to support the user interaction with the Web, the interface shall communicate the site typology, its richness and complexity. The difficult usage of the hypertextual system must be kept hidden.
It is clearly difficult that a structure based on the concept of direction , of exploration and of the navigation dynamics can be represented by a text.
The application of Multimodal Interfaces, based on the simultaneous exploitation of a multiple communicative channels and on a spatial and visual representation of the information is an emerging challenge to the presently used GUI and a possible future

evolution.
Cognitive Maps allows the multimodal representation of the information architecture highlighting the hierarchies, the nodes the physical (hypertextual) and conceptual connections between site contents. The interaction with the information is based on a generative dynamics of ryzomatic connections where the *cognitive and perceptive richness Human User* is evident, giving a more direct representation than the usual static structure tree [2].

2. Cognitive maps as learning tool

Asubel introduced the *cognitive* (or *conceptual*) maps investigating the human learning [3]. The concept of *meaningful learning* is the opposite of the mechanical learning, say as mnemonic and instructional. The *meaningful learning* indeed produces a connection between the new information and the previous knowledge; it produces an improvement of conceptual and proactive kind to the subject. Following this approach, the maps are a metacognitive tool to mark up the meaningful connections between the concepts used to build up propositions (or semantic units) composed from many concepts linked by words.
Conceptual maps are a tool to schematize and articulate those units; the maps also make evident the connections used to organize the units on hierarchy and pertinence criteria.
Furthermore they make evident the key concepts and the prepositions linking the concepts; the maps use the visual communication channel to improve the learning and the retaining of the concepts. Verbal communication and the related verbal transcription are a sequential, linear process.
The cognitive maps have a mesh-like and hierarchical structure, where the typical hierarchical structure of an hypertext is reproduced. The learning principle stated by Asubel can be transferred also to the dynamical cognitive model for the learning the Website exploration: this is a continuous, dynamical and interactive process.
The concept has been revised and developed by Novak and Gowin in the seventies; the proposed and developed the application in order to produce a graphical representation of the knowledge. As a geographical map allows to be directed inside an unknown land, in the same way a conceptual map allows the interpretation, the transmission and to revise the knowledge, the information and the data. The visualizations of the links between the different concepts makes evident the path of the possible reasoning.
The cognitive maps then are: *a graphical representation of concepts synthetically described (words, concepts) inside a geometrical form (a node) and linked together by lines showing the relations by means of words-links.*[5]

3. Web Information Architecture and cognitive maps

The evolution of the discipline of the Information Architecture is developing methodologies for the search and for the information organization and systems for the visual representation of data. his proposed solutions are always closer and more similar to the *complexity of the human cognitive approach* [4] less based on the navigation hierarchy through hypertextual structures, more based on the richness of the cognitive and conceptual maps.
If we examine the tools used in information Architecture, maps are used to give a spatial, visual presentation; they are used also to convey a detailed description for a synoptic, parallel perception of information , replacing a conventional, serial communication.
The application of cognitive maps as representation systems for the web produces a better

interpretation and a more effective support for the user associative logic, exploiting a non mediated learning of informative elements and of specific relations between elements. In some aspects this solution is more efficient than the tree structure usually applied in many Web Sites.
The maps indeed:

- produce a visual hierarchy simple and evident
- allows the visualization of thematic nodes in the hypertext, and more mark up the logical and physical connections, say the links
- allows the visualization of many nesting levels of information at the same time in the same page

The solution based on the application of conceptual maps, as proposed by Novak and Gowin, overcomes the simple translation of contents to maps; a new interpretation of the method for setting up map is introduced, suggesting a critical approach to the structuring and to the navigation of the site.
The site interface can be designed as a single structured map, where the user can navigate to the full extent. The map is able to produce the information when explored and to develop the contents starting from the main sections, in some way conceptually equivalent to the key concepts of the structural maps. Applying the map method, the site is getting a visual, synoptic representation where all is shown at the same time, and the structure, the branches, the connections and the links will be easily perceived.
At every time the user is able to get a complete knowledge about the kind of information contained in the site and about the number and the type of the sections inside the site.
He is directed to understand how the sections will be structured and how the sections will be connected; furthermore he will learn how the proposed contents are linked and why.
The activity of the user is not limited to the basic navigation searching for contents; starting from this navigation model, the user experiences a total cognitive commitment and is driven toward the discovery of the site and of the services provided by the site.
The user experience is justified because: *the visual characteristics of the map produce the activation of the right side of the brain and the lateral thinking , which integrates with the left side brain, the side of the logical, linear processes. The understanding, the learning, the communication will be empowered* [5].
The site map is not exposed since the very beginning of the process; the map is produced and developed gradually as the user makes its own choices and grows in the interaction with the contents of the site sections.

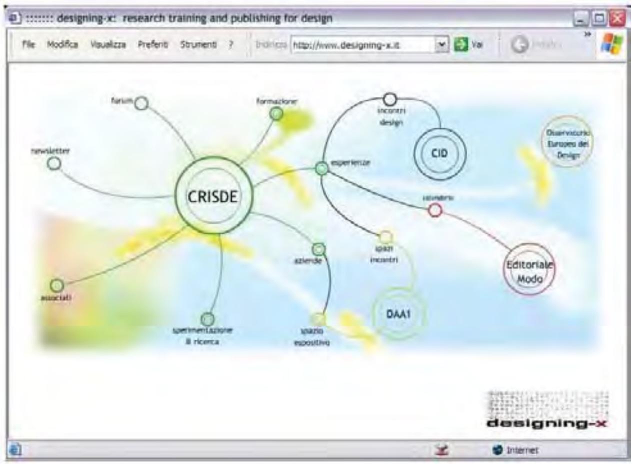
4. Designing a cognitive site: *Designing*-X a case study

The *Designing_X* project represents an experimental design for the realization of a cognitive, experiential Web site . User does not interact act only using a GUI, but can also exploit a tool for the exploration of a complex reality: a site *container* of a five different realities relating to the design world. The site collects contents, services, databases, papers, research reports in an homogeneous, complex and structured context. This site is not a “simple” portal hosting design news and information, neither is a concept association to collect other associations. The site is more a “common place” of realities sharing a strong interest for the education and for the information; they are *virtually associated* in an effort to *create a room of contents useful to (to support) a designer continuing his education* [6].
The aim of *Designing_X* is to develop inside a coherent project all the services proposed by the formation actors (professional associations) using a relational modality. That is, the contents will be presented as a part of a homogeneous proposal, highlighting the relations

existing between the contents outlined in the different sections. Lesser evidence will be given to the formal division in sections and to the consequent structuring in subsections.
This choice is aimed to produce a direct and necessary perception of the complexity of the contents structure inside the sections and between the sections; at the same time a simple and direct content navigation can be produced, and an efficient use of information.

1. homepage: www.designing-x.com/demo.htm

In the Home Page, only the key concepts of the site are present, say five sections. With the *mouse_over* event further information will be presented: the activity *declaration* of the contents of the selected section. Using this tool, the first elements will be exposed and the user can start a personal elaboration of the *Designing_X* concepts. The *mouse_over* can be repeated on every section and supports the user during the navigation. At the *mouse_click* event the displayed structure of the map will change. Every content in the selected section is displayed providing a complete structural map, where relations between the contents-menu items contained in the section will be visually presented.



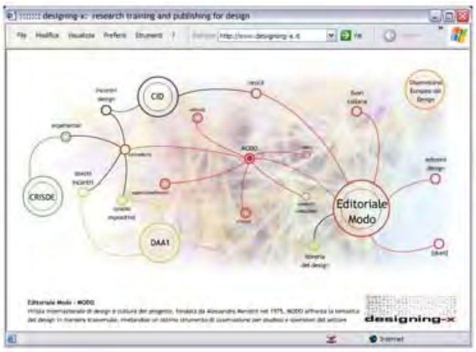
2. first level page

Once the section is opened, on the display is present the map of the contents which compose the section. The relations they have with the contents (or some of them) of the different site sections are visualized. In this level an eventual *mouse_over* has a twofold function: it displays the content of every menu item *or* it displays the relations existing between a content of the section we are at the present exploring and the content of the section where the element is contained.
Once upon one of the possible section has been entered, the *mouse_over* steers the user during the choice for the different menu items present in the section.

Unnecessary informations do not be displayed at every time; they will be exposed only at the time they are needed on user demand.
It is necessary to mark up that only two *mouse_click* selections are necessary to explore contents on the site: the first to enter one of the main sections, the second to select an option displayed inside the selected section. We have proceeded to the second level of interaction; at the same time it looks as if we are in the first one. However this is the deepest level of interaction with the map; not withstanding that we can perceive on the display all the site structure. A clear advantage is that we can master at any time all the site contents , and we do not risk to get lost in our navigation.

3. contextual information in pop-up window

As soon we *mouse_click* , we will get all information we are interested on. The information will be displayed in a *Pop_Up Window*, based on a simple HTML page, overlaid to the site map. This way we can get full control over the *Window* (we can move, resize, reduce to an icon or simply close without dismissing the display of the complete site map).
Inside the *pop_up Window* information will be presented by two different lecture level. On the left a *Visual menu*: in example if we choose the menu item *Calendar*, place and time of any proposed meeting (Event) will be given.
This allows a fast search by eye flash in order to select meeting I can possibly attend. On the right side a description is presented to evidence subjects and contents expected. On the upper right side we can easily select inside *a pop_up menu* a further presentation of the meetings classified by subjects. When the requested information has been collected, the *pop_up menu* can be closed, and we can go back to the site sections map.



4. visual relations between contents

Once the section is opened, on the display is present the map of the contents which compose the section. The relations they have with the contents (or some of them) of the different site sections are visualized. In this level an eventual *mouse_over* has a twofold function: it displays the content of every menu item *or* it displays the relations existing between a content of the section we are at the present exploring and the content of the section where the element is contained.
Once upon one of the possible section has been entered, the *mouse_over* steers the user during the choice for the different menu items present in the section.
Going back to the main Sections map, we can proceed to a further navigation to the contents of the other sections along the links of the actual section.
We know that *for a conscious building of a conceptual map, to allow the final user, which is not involved in the production of the map, to understand the meaning of the map, is necessary to make clear and explicit what relations can be possibly represented inside the map. If this fails, the reasons linking the different concepts will be difficult to be perceived* [5]. This difficult problem has been solved by the *mouse_over*: the event makes visually explicit the relation between the content of the selected section and the linked contents of an external section.
A last remark: in *Designing_X* it is useless to provide the usual "*go back to the Home Page*" feature; in every Windows of *Designing_X* is always allowed the possibility to go from the present Window to a new one. The *mouse_over* produces the same information displayed in the Home Page.
Inside this project has been decided that *go back to the Home Page* is not provided because is

useless in navigation , harmless in cognition: an holistic vision of the contents and of the links of the sections will be lost.

5. Conclusion

Cognitive Maps are tools to represent the knowledge and to support learning and retaining.
The maps are organized by means of conceptual-semantic nodes interconnected by prepositions-links; they can be used in order to represent the learning and the knowledge using a non linear processes.
The network structure of the maps is very similar to the information hypertext, based on information nodes, say communications unit self sustaining, autonomous and correlated.
The application of the cognitive map concept to the Web interfaces supports the user with a tool simple and direct for the site exploration.
The maps presents a simultaneous visualization of the site macroareas and at the same time the different layers of information nesting.
The maps visualize the connections and the hierarchy between the contents; they allows to reach in a short time the information core the user is interested on.
Exploiting the visual-hypertextual-relational structure the are more efficient than the usual hierarchical-verbal tree structure in order to cope with the human cognitive processes to explore and to learn in an complex, rich information structure.

References

[1] Krug, Steve. 2000. *Don't Make Me Think! A Common Sense Approach to Web Usability*, New Riders, Indianapolis.

[2] Bollini, Letizia. 2003. “MUI: design of the Human Computer Interfaces as a directing of communications modes targeted on human senses”. *Senses and Sensibility in Technology*, IADE, Lisbona: 182-186.

[3] Ausubel, David. 1968. *Educational Psychology: a Cognitive View*. Holt, Rinehart, and Winston, New York.

[4] Bollini, Letizia. 2001. “Multimodalità vs. multimedialità”. *Il Verri*, 16: 144-148

[5] Novak, J.D. and Gowin, D.B. 1985. *Learning How to Learn*, Cambridge University Press, Cambridge

[6] Palma Giuseppe, 2003. *Designing-X. Designing a cognitiv site*, Dissertazione di Tesi, Politecnico di Milano.

Using Cellular Automata to Challenge Cookie-Cutter Architecture

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Abstract

While economically efficient and easy to plan, over-simplistic residential “cookie-cutter” architecture – ubiquitous in high-density urban environments - results in obvious deficiencies for inhabitants including lack of individual adaptability in the immediate living environment as well as of larger-scale urban identity. This paper investigates into the possibility of applying cellular automata systems to the planning of high-density architecture. Following a review of previous approaches to cellular automata systems in architectural design, I aim at examining more concrete strategies of mapping dynamic processes in cellular automata to residential building morphology in high-density architecture. I discuss the possible use of various forms of cellular automata to generate emergent patterns based on local activity and identity within larger networks and the mapping of automata to aspects of designing and building architectural form. Because of her high living density, her extensive use of cookie-cutter architecture and her richness in emergent illegal building patterns, I use the city of Hong Kong as a case study for this investigation. The paper concludes by outlining possible strategies for developing cellular-automata-based alternatives to the pervasive monotony of commonplace high-density cookie-cutter architecture.

1. Introduction

High-density residential architecture accompanies the development of high-density living environments where land for development is scarce and where large numbers of inhabitants have to be accommodated. With urban population densities growing rapidly, the provision of housing is constrained by efficiency of production and cost, with extensive regulatory prescription to guide designers to desired results. Symptomatic for architectural solutions to this kind of need is large-scale planning that typically uses repetition with little variation – resulting in “cookie-cutter” architecture. The results are monotony and lack of identity in the built environment on different levels of scale. As a possible architectural design approach to this challenge, this paper outlines the potential of applying Cellular Automata (CA) as a generative design tool that aims at creating variance and identity while attaining performance goals within a high-rise residential building framework.

In the context of increasing density of urban development, generative design approaches are becoming potentially more relevant. Generative design proposes ways to create and structure design output with the help of design tools or systems instead of the continuous intervention of a human designer. In generative design strategies, problems are typically approached through the development of a generative design tool, which is used to generate solutions for a given design task. Generative design tools are often variations of techniques developed in sciences other than architecture – e.g. mathematics, physics and biology. CA have played a more prominent role in fields of study other than architecture: in Mathematics, CA have been studied as an alternative to differential equations, in Physics CA are used to model gas behaviour and in Urban Planning, CA are employed in the simulation of urban development (see for instance [13]). In the field of architectural design, however, CA have not yet been studied exhaustively – I outline key examples of CA related architectural research below. High-density residential architecture and CA can both be described as expressions of logic in space (see [5], p.45) determined by the massively parallel dynamics and interactions of individual units or cells, and grid structures that facilitate their interaction and provide general framework functions. These parallels can be taken as a starting point to apply CA to various aspects of planning in mass housing architecture, for which I propose Hong Kong as a high-density urban test bed. This paper positions further research in the topic and is intended to lay out a framework for more detailed studies.

2. Approaches to Cellular Automata in Architectural Design

Stanislaw Ulam, who is said to have initiated scientific interest in "cellular automata games" before the availability of suitable computational facilities, has used physical models for his early investigations into the field [1]. Otherwise, mathematical CA research was more interested in computational outcomes and the possibility to produce "chaotic" structures from simple rules and less interested in form finding and physical manifestations. Later developments, such as Conway's Game of Life and various subsequent CA applications in the Artificial Intelligence field, did not change this until Frazer [5] began to pioneer CA in the field of architecture and developed various physical digital cellular automata models to visualize dynamic architectural processes.

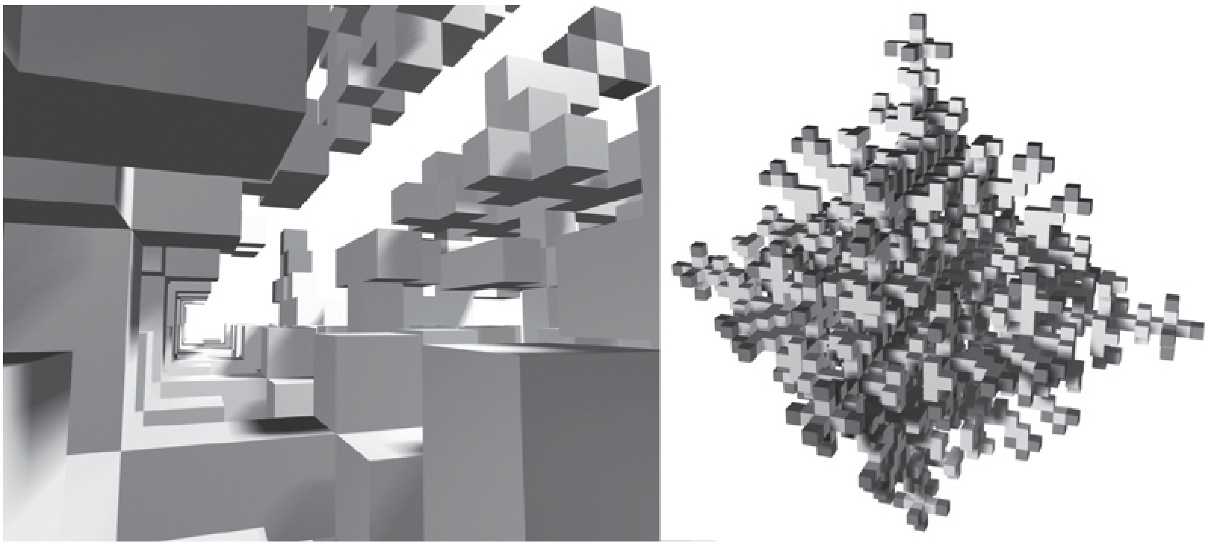

Figure 1: Reconstruction of a three-dimensional CA system designed by Schrandt and Ulam

The Generator Project, designed by Price (see [10], pp. 84-89) in 1976, was an early attempt to bring architecture closer to the spatial and logical versatility of a CA system. The design intention behind the project was to enable buildings to perform as catalysts and facilitators to dynamically encourage social and spatial interaction. The Generator Project consisted of a set of volumetric units, screens and barriers that could be freely arranged on a grid with the help of a mobile crane. Each unit was to be fitted with a logic circuit that would communicate with a central computer, which would keep track of configuration changes and even suggest possible alternatives. Never having been built, the project nonetheless gives an excellent example of a design that relies on dynamic reconfiguration to suit changes in user needs as well as on digital processing of spatial logic. However, though each unit contained a logic circuit, they would still depend on central computer control.

More recent discussions of CA applications to pattern-formation in architecture can be found in Coates [3] and Krawcyk [8]. Whereas Coates emphasises the role of CA as a tool for exploring function-driven generation of architectural morphology, Krawcyk focuses on the spatialisation of CA-generated volumetric clusters. Fischer et al. [4] describe applications of cellular automata to model morphogenetic and developmental form finding processes in architecture and construction. These examples indicate the potential versatility of CA in the architectural field. The possibility of structural design with cellular automata however has not yet been extensively explored despite existing related approaches in the engineering field, as in Finite Element Analysis (for example see [12]).

3. High Density Residential Buildings in Hong Kong

Accommodating some of the highest population densities in the world, Hong Kong houses a variety of exemplary residential building types, which demonstrate the problems of high-density architectural design. While elements of some building types are partly based on local conditions such as land ownership patterns, plot sizes and building regulations, they also demonstrate problems that other cities with rapidly increasing population densities might also encounter in the future. Rapid urban development in the future will not only have to deal with problems of density and identity. It also requires the development of highly time-efficient and competitive construction and design methods. China's plan to urbanise the populations of twenty counties per year for the coming two decades [2] for example illustrates the scale of future requirements. Increasing project sizes often result in increased architectural monotony, as large-scale, post-war modernist housing developments in Europe have shown. The Hong Kong case study demonstrates how similar building types also exhibit a lack of variation on the individual residential unit level. In this section I outline the characteristics of what I believe to be the most relevant types of high-density housing in Hong Kong.

The *monolithic block* is an early example of mass housing, with an overall building form mostly restricted to a rectangular box shape for space efficiency, structural and construction reasons. Buildings of this type, shown on the left of figure 2, were mainly built during the 1970s and early 1980s, both by private investors and the Hong Kong Government and are typically inhibited by roughly 1500 inhabitants each. In private developments, it occurs generally as a singular building, with repetition limited to the level of the individual unit. In larger government housing projects, estates can contain as many as a dozen blocks. While the simple form provides an efficient use of the land available for construction, it also reduces building surface areas that provide inhabitants with sunlight and air. A monolithic block's building facades usually do not show any architectural articulation apart from occasional crude ornaments. Inhabitants, however, very often change the building façade adding plants, individual clothes drying racks, commercial signage or entire balconies and room extensions. This phenomenon has lessened since building regulations have been enforced more strictly during the past few years.

Figure 2: Monolithic block and cookie-cutter high-rise buildings in Hong Kong

More recent examples of high-rise residential buildings in Hong Kong are based on plans that are geometrically less simplistic. This is mostly due to recently introduced building regulations that require every bathroom and kitchen to have direct external ventilation. This more recent type of building, shown on the right of figure 2, is just as rigid as the monolithic block, but significantly taller: the plan is extruded to up to sixty floors without much variation. Economically efficient for the developers and/or government, this type of building is rarely built as a single instance – in most cases, it is copied several times to form an urban unit of a larger scale. Several *self same high-rise* buildings often share one common podium that occupies an entire urban block and houses commercial uses such as shopping malls and restaurants as well as car parking spaces. With the need for residential quarters ever increasing, the Hong Kong Government has focused on the development of *new towns* – large-scale developments extending smaller towns outside of the inner city. New towns typically consist of a small old village centre surrounded by massive residential identical high-rise buildings. As a result of this development, newly added city blocks do neither connect well to the existing urban fabric nor exhibit any local identity. New developments all over Hong Kong are disconcertingly similar. The recent public housing design competition (in fact the only one in the history of Hong Kong to date) in 2001 for Shui Chuen O has acknowledged this deficit in declaring diversity and identity of character as one of the central aims of the competition, next to improved building sustainability [9].

In older urban areas, where land ownership is constricted to small lots, a further building type has developed out of the need to make use of very expensive land: the *pencil tower*. Buildings of this type are developed in older urban districts, on areas as small as 10m x 20m, with a podium of two to four floors for commercial use and a high-rise tower of twenty to thirty floors on top. The residential pencil tower floor plan typically consists of only one or two apartments, and its outer shape does not vary on different floors. Even though pencil towers are high-rise buildings, their small footprint has little effect on the urban pattern at the ground level. Given the highly monotonous and extremely small unit footprints – typically inhabited by families with 4-6 members, inhabitants of large-scale residential architecture frequently customise their individual living environments. Since changes or additions to buildings contravene building regulations, they are generally referred to as *illegal structures* [11]. The individualised changes of apartment interiors and building facades are motivated by a need for additional living space as well as the desire for a garden or simply the wish to convert the anonymous unit into an individualised home. Inhabitant-initiated changes occur only slowly, as the inhabitants' needs and preferences change over time and give rise to building activities to adjust the living environment accordingly. Thus, illegal structures as those shown in figure 3 most often appear on the facades of older buildings. While illegal structures often alter the appearance of monolithic buildings and inside living conditions to the better, they are being targeted by recently enforced government policies. Governmental mass-media campaigns encourage owners of illegal structures to remove them. The elimination of illegal structures ensures safety and proper building maintenance, but it also removes the occupants' ability to live in a personally adapted living environment.

Figure 3: Balcony conversions and illegal structure in Hong Kong

The factors determining the shape of residential architecture in Hong Kong are mostly related to aspects of regulation, economy and efficiency. Since much of Hong Kong's housing development has been in reaction to the rapidly increasing population during the previous decades, it is argued there has been little room for alternative developments in residential architecture. Unplanned building activities have been a significant feature of urban architecture in Hong Kong, for example, but high-density residential architecture has neither sought to address the problem of urban monotony nor utilised the potential dynamics resulting from the individual inhabitants' activities. With improving standards and increasing expectations of individual inhabitants, though, one key design challenge of the future will be to tackle the problems of efficient, high-density housing while at the same time providing high-quality, diverse living environments.

4. CA and Architecture

Numerous architectural proposals for the design of large building projects have diverged from the conventional approach to design homogeneous, monolithic monuments. During the 1960s, the fascination of architects with the aesthetic appeal of fine-grained conglomerates resulted in design proposals that featured cell-like units in large numbers – as in the extensively published projects of *Archigram* or the *Metabolists*. Many of these projects were concerned with residential architecture, reacting against the large-scale development of mass-produced identical residential buildings built all over Europe and North America after the Second World War. Cell-type residential structures were assumed to provide the inhabitant with greater flexibility in choosing a living environment and relocating it according to changing needs. Residential cells were conceived as elements within a larger structural framework that provided structural support as well as infrastructure, often extending far beyond the scope of individual buildings. Most of these projects are well known and have significantly influenced architectural theory, but they have nevertheless remained at proposal stages. A rare built example is *habitat 67*, a residential complex designed by Safdie in Montreal for the 1967 Expo. *Habitat 67* consists of cell-like, prefabricated concrete residential units that are stacked on top of each other in an irregular way, leaning against a supporting concrete structure. Since residential units can stretch across several concrete cells, unit plans are varied throughout the building and mixed with gardens and verandas on the roofs of lower units. While the cells of *habitat 67* are immobile, the building nonetheless manages to provide a diversity of residential units, individual living conditions and neighbourhoods.

The influential architectural design paradigm proposed by Habraken [6] in the early 1960s relates to both efficiency and inhabitant-oriented diversity in residential architecture. His *open building* approach divides buildings into support (structure) and infill (interior fittings and removable parts). Since infill elements are more related to the immediate way of inhabiting a building, Habraken suggested that these parts of the building were to be changed and improved by the inhabitants over time, while the support elements are designed to last for a long time without interfering with the changing infill. This type of structure allows more dynamic buildings that adapt to their inhabitants and give them opportunities to bring in their own personal preferences. The open building approach is only slowly gaining momentum, and it is remains widely ignored in the context of high-density architecture.

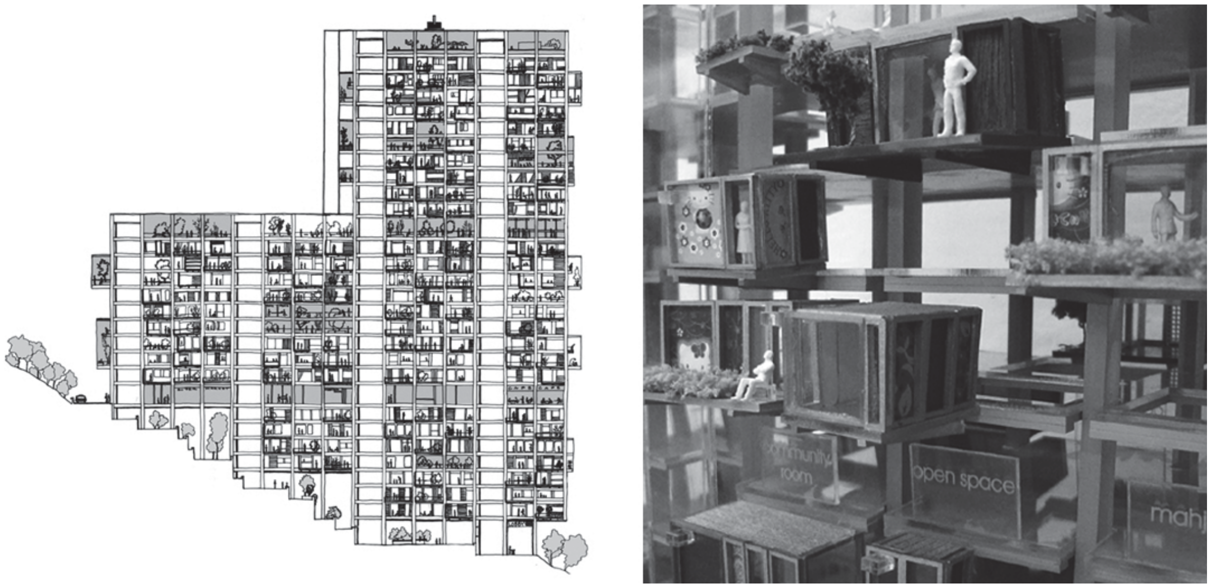

Figure 4: The *vertical village* project, elevation and model

As an alternative to current residential architecture in Hong Kong, I have proposed a *'vertical village'*: a high-rise structure that provides a rigid frame structure with completely flexible internal spaces and external additions (see figure 4). The building is seen not only as a stack of residential units, but also as a community similar to that of a village. Flexible unit sizes, removable floors and walls as well as a reconfigurable service infrastructure provide the basis for spatial diversity within the building. On the exterior, inhabitants can change the façade of their flat or add semi pre-fabricated extension modules to their living space using a crane that forms an integral element of the constantly changing building. Within the overall structure, a network of small community spaces provides the platform for local neighbourhoods, enabling communication between inhabitants. The ‘vertical village’ relates to many aspects of architecture that CA can be applied to in a generative design approach such as small-scale variance replaces top-down planned repetition, building form is seen as a process over time, and community spaces are an outcome of neighbourhood negotiation.

While the need for individual character and local expression of identity seems to become an issue in the context of high-density residential developments in Hong Kong, current architectural design practice is primarily concerned with efficiency. For example, the organizers of the Shui Chuen O public housing competition, who initially asked for individual character in residential developments, awarded the first prize to the entry with the most efficient and economic proposal, not the greatest variation and individualisation. One reason for the monotony of current residential high-rise design is that designing for variety usually requires increased design effort of the human designer as well as increased complexity of the design that is harder to manage and might easily cause complications during construction. Alternatives to simple repetitiveness can be developed by addressing individual unit layouts, three-dimensional building form as well as structure and services. While each aspect can be considered in separate generative design scenarios, their interactions can also be addressed. Such an approach can lead to greater variation while conforming to multiple performance criteria. The relationship of structure and inhabitable space in residential buildings, for example, typically results in one element dominating over the other due to sequential human planning. In an integrated generative design tool, however, structural and spatial aspects can be linked together with mutual feedback relationships, adjusting one to the other during the development of the building. Such simultaneous developments can be implemented in CA systems and interconnections made between a variety of scales, enabling integrated growth of structures similar to that observed in natural growth processes. Researchers in the generative computer-aided design field have recently begun to aim at integrating building performance apects with generative computation (see Kolarevic [7]). The research described below addresses in particular this issue of integrating and complying with multiple performance criteria within one generative process. This more organic view on residential building design results in architectural design that is less prone to the monotonous homogeneity resulting from rigid structural frameworks. It also allows to see large-scale, high-density residential buildings not as monuments, but as dynamic systems that harbour sub-systems on smaller scales while still maintaining an overall coherence. Diversity in high-density residential buildings should not result in an unrelated conglomerate of individual units, but rather in architecture that takes individual differences into account while supplying efficient infrastructure and a sense of overall identity.

Figure 5: Three-dimensionally mapped game of life variations

5. Applying Cellular Automata to High Density Architecture

In high-density residential buildings, variety can be generated either by the dynamics of the inhabitation process over time based on a homogeneous initial condition, or it can be a characteristic of the initial architectural design. Both approaches can certainly also be combined. In both cases, decentralised development of a large number of parallel units is essential – for simulation as well as for building design purposes. As with CA systems used in other sciences, architectural applications can and should be adjusted to the problem they focus on, which means they can be based on non-homogeneous, non-linear or even mobile cell systems. Furthermore, individual cells can be enabled not only to determine their states within their neighbourhoods, but also to initiate state changes in other cells. This relates closely to the dynamics commonly observed in the growth of illegal building structures in Hong Kong: while global rule sets (regulations or the feasibility of a particular type of addition) define the overall development conditions, inhabitants initiate building activities, influencing surrounding residential neighbourhoods.

To address the challenges of designing high-density residential architecture, two areas appear to be of particular interest. Firstly, the issue of monotony in plan and three-dimensional configuration, and secondly, the problem of designing inhabitable spaces, structure and services in an integrated way. Apart from potentially supporting the automation the design process to some extent, generative design techniques are well suited to develop variety at scales of high detail resolution that might otherwise be neglected by human designers for pragmatic reasons. The simplicity of CA systems might provide a handle to complex patterns arising from the interaction of large numbers of elements needed to describe the diversity potentially contained within large-scale residential building. The simplest means to achieve variety in high-rise architecture is to consider only the building exterior: building facades can be designed to allow for changes on the individual unit level. If this process is governed by a set of simple rules, it closely resembles classic two-dimensional CA systems like the Game of Life. While ornamental patterns have been used on facades before to alleviate the austere expression of highly monotonous building exteriors (see left on figure 6), I also suggest the integration of functional and structural aspects as well as to address the human desire for variance. In many Hong Kong buildings, similar processes – balcony conversions and added cantilevered structures - have already resulted in generating individualised building facades (see left on figure 6).

Since high density residential buildings usually come in clusters, massing studies of building forms within larger urban frameworks need to be considered as well. Seen as volumetric representations, generative CA systems can be useful in spatial composition tasks on the building massing level as well as in generating unique floor plans on every floor. As typical high-density residential projects often house as many as thousands of inhabitants, decentralised zoning within a building is required. Where buildings become mega-structures, taking on the role of city quarters rather than traditional homes, urban-scale zoning for housing people of similar needs becomes important: clusters of special-needs residences, for example, need to be located within a specific neighbourhood, allowing shared use of facilities. The Ulam model shown in figure 1 gives a simple demonstration of how CA can be used to develop consistent density while simultaneously differentiating building mass into connected zones of use.

Figure 6: Façade ornament (Bunka Gakuen Campus in Tokyo, Japan) and illegal balcony conversions (Wan Chai district, Hong Kong)

I intend to investigate the potential of CA in developing structural and spatial aspects together in decentralised, massively parallel systems of cells using cellular rule sets that encompass various aspects of overall architectural design considerations. In a similar way, infrastructure and services within large buildings can be developed simultaneously with building massing and internal organisation. This process has analogies to growth in Nature where cells develop together with support networks that provide the necessary nutrients for growth. Natural processes have a fundamental bottom-up logic, which inspire the use of CA in generative design of residential structures. Structures like the support skeletons in open housing designs could be modelled to perform in ways that are similar to the supporting and connecting functions of extracellular matrices in biology. CA also have the potential to complement traditional top-down design strategies with localised, decentralised bottom-up design generation, which I intend to explore through the development of interactive experimental generative tools.

4. Conclusions

Up to now, generative, cellular-automata based design strategies have primarily been applied to ornamental design aspects, producing visual pattern variations. They have rarely addressed basic building design issues, common problems of high-density architecture or applied functional or integral structural aspects. I propose the use of CA as a design platform for generative design processes using large numbers of massively parallel cells, facilitating the design of structures that are characterised by local variation as well as coherence within a larger context. Apart from two-dimensional variations on building facades, CA units can represent volumetric or relational aspects of individual units within buildings. Generative architectural design using CA can also enable the emergence of decentralised bottom-up processes within top-down design frameworks, facilitating processes that focus on local neighbourhood relationships within predefined frameworks. They are applicable to a broad range of architectural design scales from interior design issues to the layout of individual residential units up to the planning of urban structures. In my further research I plan to focus on the integration of structural, spatial and functional aspects as well as the design of problem-specific cellular automata, hoping to develop alternatives for overly pragmatic mass housing designs.

Acknowledgements

I gratefully acknowledge the kind support of Prof. Kvan of the Hong Kong University. I also acknowledge Sheila Cooke's friendly permission to reproduce her photograph on the right-hand side of figure 6, and Catty Chan Fung Yin's friendly permission for reproducing her photograph of an illegal building structure in Yau Ma Tei, Hong Kong in figure 3.

References

[1] Burks, A. W. (ed.): *Essays on Cellular Automata*. University of Illinois Press, Chicago 1970.

[2] Cering, D.: Wèi lái èr shí nián wǒ guó huì zēng duō shǎo xīn shì zhèn? *Outlook Weekly* No. 3, August 14th 2000.

[3] Coates, P., Healy, N., Lamb, C. and Voon, W.L.: The Use of Cellular Automata to Explore Bottom-Up Architectonic Rules. Paper presented at *Eurographics UK Chapter 14th Annual Conference* held at Imperial College London/UK, 1996.

[4] Fischer, T., Burry, M. and Frazer, J.: How to Plant a Subway System. In: Chiu, Mao-Lin et al. (eds.): *Digital Design - Research and Practice. The Proceedings of The Tenth International Conference on Computer Aided Architectural Design Futures*. Kluwer Academic Publishers, Dordrecht, Boston and London 2003, pp. 403-412.

[5] Frazer, J.: *An Evolutionary Architecture*. Architectural Association, London 1995.

[6] Habraken, N. J. et al.: *Variations: the systematic design of supports. Cambridge*, Mass.: Laboratory of Architecture and Planning at MIT 1976.

[7] Kolarevic, B.: Computing the Performative in Architecture, In: Dokonal, Wolfgang and Hirschberg, Urs (eds.): Digital Design. Proceedings of the *21st International eCAADe Eonference*, Graz University of Technology, Austria, 2003, pp. 457-464

[8] Krawcyk, R.: Architectural Interpretation of Cellular Automata. In: Soddu, C. (ed.): *The 5th International Conference on Generative Art 2002.*Generative Design Lab, DiAP, Politectnico di Milano University, Italy 2002, pp. 7.1-7.8.

[9] *Shui Chuen O Architectural Design Competition*. Published by the Hong Kong Housing Authority, Hong Kong 2001.

[10] Spiller, N. (ed.): *Cyber Reader – Critical writings for the digital era.* Phaidon Press Limited, London and New York 2002, pp. 84-89.

[11] Wojtowicz, J.: *Illegal Facades*. Privately published, Hong Kong 1984.

[12] Xie, M. M. and Steven, G. P.: *Evolutionary Structural Optimization*. Springer, London 1997.

[13] Yeh, A.G.O. and Li, X.: Urban Simulation Using Neural Networks and Cellular Automata for Land Use Planning. *Symposium on Geospatial Theory, Processing and Applications*, Ottawa, Canada 2002.

Motion Representation and Evolutionary Architectural Spaces

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Abstract

As we spend more time immersed in the virtual spaces of the computer world, the creators of the artificial environments attempt to synthesize principles for the virtual space design. Depending on the specific medium they address (Internet, multimedia etc.), these principles tend to show specific differences determined by the characteristic freedoms and limitations offered by each medium. Nonetheless, there is a clear trend towards solutions related to human everyday experiences. These attempts define the digital environments as extensions of the natural world, and aid the user's orientation in the virtual space based on behaviours acquired through interactions with the natural environment.

The present paper starts from the premise that most of the visitors already have an extensive experience interacting with the computer medium or, alternatively, that there exists a clear trend towards this situation. This may suggest that synthesizing design principles for virtual world development must combine the human orientation skills acquired in the real world with the specifics of virtual spaces, their capabilities of change and interaction with the human or intelligent agents. The specifics of artificial motion, the freedom of movement, and the necessary limitations to avoid an alienating experience represent an essential component of the evolutionary environment design combined with the principles of virtual architecture design.

Based on these, the present paper advances the idea that virtual architecture should be developed considering the transfer of human motion and architectural composition principles as the basis for the design of evolutionary architecture in virtual environments. It also looks into how these combined principles have to be adapted to the characteristics of the virtual world.

The possibility of rapid changes in the virtual environment provides a basis for qualitative analysis of virtual architecture in interaction with represented motion in computer applications.

The project is in incipient development at the present time. During the first stages, interactions in real-time applications between evolving virtual architecture and artificial motion will be analysed. These will gradually develop towards immersive virtual reality experiments, allowing hybrid experimentations with real and represented movement.

1. Introduction

Accompanying the technological developments, an active dynamics of the surrounding environment has emerged in the information society. Daily interactions with computers make digital spaces an important part of this dynamics; the ability of humans to accommodate with virtual environments becomes a factor in the way the real, outer world is perceived.

The present paper concentrates on issues related to human integration with the actively changing character of the digital environments. Human motion principles and their translation into represented motion are analyzed as an important issue to be considered in virtual space design. Various approaches to evolutionary architecture are considered from the viewpoint of their impact on human integration with the real and artificial architecture. As evolutionary architecture is essentially related to change and development, it represents a vital element to be considered in the analysis of the impact on human behaviour.

In order to support a case study analysis, an experimental artificial environment combining the representation of human motion within a changeable virtual architectural space has been developed to a representation stage. This project is developed around Palladio's villa "La Rotonda" (figure1, figure2, figure3). This attempt to make possible experiential ways of investigation during preliminary stages of the research, provides the grounds for formulating a solid hypothesis regarding human behaviour in relation to changeable virtual architecture. Further development of the research is expected to be based on simulation research methodology for the analysis of human integration with modifiable virtual architectural structures.

Figure 1. Experimental artificial environment developed around the Palladio's villa "La Rotonda." View 1. Author: Daniela Sirbu, University of Lethbridge.

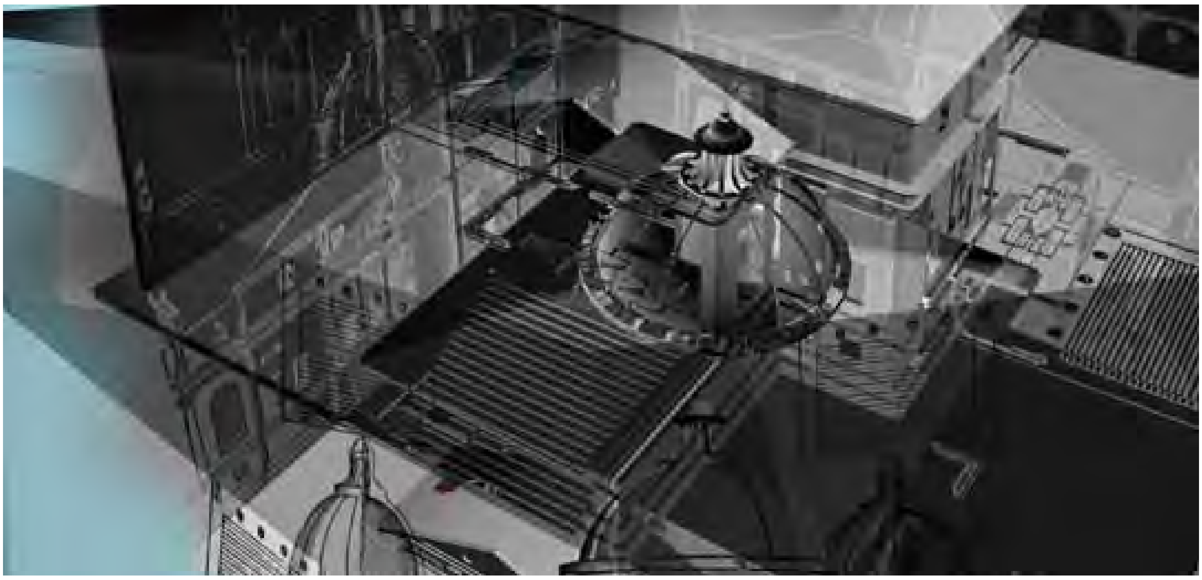

Figure 2. Experimental artificial environment developed around the Palladio's villa "La Rotonda." View 2. Author: Daniela Sirbu, University of Lethbridge.

Figure 3. Experimental artificial environment developed around the Palladio's villa "La Rotonda." View 3. Author: Daniela Sirbu, University of Lethbridge.

2. Background: Changeable Built and Virtual Environments

The mobile character of the virtual worlds has already been acknowledged by different new media theorists and various conceptual frameworks have been developed in order to define and relate to the dynamics of changeable digital architectural spaces.

The concept of liquid architecture introduced by Marcos Novak[1] characterizes the infinite variability of the cyberspace information spatialization and underlies Novak's idea of aesthetics of navigation in the digital space. Novak introduced the concept based on the analysis of the digital mechanisms of cyberspace. The modifications of the "normal mapping from data to representation" make cyberspace a "habitat for imagination." Novak is presented by Zellner as a “visionary architect, theorist, intermedia artist, who has actively developed strategies to address how physical space have been transformed by the virtual space.”[2] For Marcos Novak, digital architecture is the proper medium for the expression and experimentation of the architectural thought unbound to the confinements of the real life construction requirements.

The full definition of the concept of liquid architecture makes necessary the reference to historical precedents of unbuilt projects as “manifestos for the premonitions of an architecture of cyberspace.”[3] Marcos Novak’s concept of “liquid architecture” serves to define a framework for architectural experimentation. Novak’s work continues the line of investigation opened by the visionary architecture of his predecessors. The declared program of his work resulted in a full restating of McLuhan’s idea that “the medium is the message”. Continuing this line of thought, further analysis brings to forefront the idea that the use of digital tools in architectural design resulted in buildings that directly mirror the specific geometric character of the digital world.

The emergence in the real world of the digital aesthetics is mainly due to the utilization of rapid prototyping and computer aided manufacturing technologies.[4] These directly make use of 3D digital models for the production of full-scale building components. The flexibility of digital customization of the building modules intensified even further the process of extending the digital aesthetics into the real world. Peter Zellner[5] defines the new trend: “Architecture is becoming ‘firmware,’ the digital building of software space inscribed in the hardwares of construction. Soft-complex-curved surfaces, modeled in data space will be transmuted to real space…”

Frank Gehry’s Guggenheim Museum in Bilbao is one of the most significant examples to illustrate this idea,[6] especially through its final appearance if not entirely through its design and production. Zellner presented Gehry’s building as “the most spectacular (and publicized) example of the extent to which the new technologies are influencing architects, production and aesthetic practices” by the use of “complex-curve generation software, digitization devices and numeric command-machining.” The Spanish contractor built Bilbao Museum[7] based on the technical data provided through accurate 3D models, which were used for the description of external surfaces and of the interior structure as well. The basic concept of the building came, however, in the traditional paper form. From there, it took the form of traditional models. These have been converted in digital format by the use of 3D scanning. The digital models have been adjusted for further refinement, and the contractor used the information directly from the 3D models for the construction stages. Gehry’s original drawings express an architectural vision specific to the computerized culture of the present days. Although not a direct user of the computer technology,[8] the architectural practice exposed Gehry to the new digital aesthetics, and he responded with a design concept closely related to it.[9]

In a historical perspective, the reflection of digital aesthetics in the build environment was a step to precede the reflection of the flexible mobile character of the computer environment into real architectural spaces. In chronological sequence, two other projects describe important steps towards mobile built environments as reflections in the real world of the changeable character of the digital medium. These projects are freshH_2OeXPO and House_n: The MIT Home of the Future

The freshH_2OeXPO[10] project developed for the Dutch Ministry of Transport, Public Work and Water in collaboration with Nox Architects,[11] provides an example to further illustrate a crossbreed between architecture and new media. The architectural project expands real architecture into a multi-dimensional space by the addition of motion, sound, a special treatment of light and interactivity. The logic and aesthetics of the computer medium have been translated into a complex combination of mobile architecture and installation in the real world. However, the mobile character of the architecture still remains of a speculative nature in the freshH_2OeXPO project.

A significant step towards a true translation of the changeable character of the digital medium into real projects is illustrated by the project House_n: The MIT Home of the Future.[12] This project aims to produce a small prototype home as a basis for experimentation and testing with the purpose to synthesize strategies meant to ensure the experiencing of the house as a much larger space through “the use of transformable multi-use spaces, the close integration between interior and exterior, expansion of perceived space via axial views, etc.”[13] Further developments of the project could lead to building the house based on client participation during preliminary design based on the modular structuring of the building.

An important development is brought in by evolutionary computing offering alternative architectural design strategies to the traditional methods. A significant example is offered by Celestion Soddu’s generative approach to town and building design.[14] The proposed evolutionary method develops a design idea into a population of possible design solutions generated through mathematical formalization of design parameters and their interference with various evolving factors characterising the considered urban space. A number of projects illustrate this approach, and we mention here the Basilica project. Soddu describes this generative software as being “able to produce an endless sequence of architecture, all different but all belonging to the same idea.”[15] The Basilica software has concrete applications to the enlargement of the Prado Museum in Madrid and to the multimedia urban stand and multimedia square in Milan.[16] The numerous possible solutions evolved during design stages may strongly influence the creative architectural process. Celestino Soddu’s generative design process is geared towards real architecture.

Considering the historical line of development in the area of changeable real and virtual spaces and the relationships between the two, the present paper is concerned with the idea of the possible development of generative spaces as evolving 3D virtual worlds adapting to patterns of human behaviour. While this seems to be a logical continuation of previous developments, and the purpose would be to aid human orientation in virtual spaces, the main question raised is how does the human being adapt to changeable virtual architecture.

3. Hypothesis

In accordance with Christian Norberg-Schultz,[17] “architectural space may be defined as a ‘concretization’ of existential space. ‘Existential space is a psychological concept, denoting the schemata man develops interacting with the environment in order to get along satisfactorily.” Norberg-Schultz goes on and assumes that man’s interaction with the environment will not produce a final fixed image, but an evolving image modeled on man’s “wishes and dreams.” As predicted by Norberg-Schultz, the surrounding environment is being modified in accordance with these internal processes in order to define the relationship between man and the environment as a “real interaction.” A satisfactory relation between existential and architectural spaces is difficult to achieve, mainly because man usually deals with architectural spaces that are a concretization of others’ existential space.

The research hypothesis is that if we transfer this theoretical development to the domain of digital architecture, most of the assertions remain true. Although digital architecture remains a concretization of others' existential spaces, the digital architecture is not always a fixed given space, but it can be programmed to interpret human behaviour and redefine itself to adapt to the user's specific behaviour patterns. Limited implementations of such adaptive digital spaces are already available.[18] Hence, a further development of the basic hypothesis is that adaptive digital architectural space may provide a better relationship between the human existential space and its concretization in the form of digital architecture.

The present research is concerned with the verification of the hypothesis for the case of navigable 3D spaces for architectural research and design, and for the implementation of architectural structures as interface solutions for Internet portals.

The present paper is limited to introducing the main research issues, the hypothesis and research methodology, and to briefly describing the development of experimental artificial environments for the experiential analysis of the hypothesis in preliminary research stages.

4. Research Methodology and Preliminary Case Study

In order to study subjective dimensions of human behaviour in relation to the digital environment, the present research relies on simulation research techniques. It is important to emphasize that for the present research an important degree of overlapping with experimental research occurs due to the fact that simulations in the form of digital architectural spaces may provide the actual objects of study with application to particular cases. Simulation/experimental research results will provide material for qualitative analysis.

The proposed project comes in the form of an experimental artificial environment combining the representation of human motion within a changeable virtual architectural space. The evolving digital architectural space is developed taking as a starting point Palladio's villa "La Rotonda." This is intended as a simulation space, but the present project is in a very incipient stage, and only a representation phase could be reached in the development of the experimental artificial environment. The architectural space is first exposed as pure geometry, then it is investigated as a growing abstract construction evolving from a nucleus pattern provided by "La Rotonda,"

Principles of architectural composition will be expressed in future developments as generative rules at the basis of form-generation in the virtual space. Motion representation is planned to take full advantage of virtual freedom, but it will develop within a set of rules extracted from mechanics of movement in real life and adapted to the virtual environment so that the artificial motion is believable to the visitor. Computer models are intended to provide the basis for developing a spectrum of prototypical architectural forms that will be analysed in correlation with motion representation issues.

A more detailed description of the project can be found in the art projects section of the present conference.[19]

5. Conclusion

The pure representational level of the experimental artificial environment does not provide sufficient information to draw a definitive conclusion regarding the validity of the advanced hypothesis. In this preliminary stage, the changeable character of the virtual architecture seems to be a central problem for the proposed research with a strong impact in two directions. One direction of study is represented by the original hypothesis. The second direction of study refers to the human ability to adapt to evolutionary virtual media. The representational level reached in the development of the experimental artificial environment allows seeing that differences induced in the development of our existential space in interaction with stable and mobile environments may raise problems that can be a separate extensive object of study.

6. Acknowledgements

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References

Anders, Peter. *Envisioning Cyberspace. Designing 3D Electronic Spaces.* New York: McGraw-Hills Companies Inc., 1999.

Soddu, Celestino.“Recognizability of the Idea: The Evolutionary Processes of Argenìa.” In *Creative Evolutionary Systems*. Edited by Bentley, Peter J. and David W. Corne, San Diego, CA, Academic Press, 2002.

Kolarevic, Branko. “Digital Fabrication. Manufacturing Architecture in the Information Age.” In *Reinventing the Discourse: How Digital Tools Bridge and Transform Research, Education and Practice in Architecture. Proceedings of the 21st Annual Conference of the Association for Computer-Aided Design in Architecture*, p. 268-279. Buffalo, October 11-14, 2001.

Manovich, Lev. *The Language of New Media*. Cambridge: MIT Press, 2001.

Norberg-Schulz, Christian. *Existence, Space & Architecture*, New York, Praeger Publishers, 1971.

Norberg-Schulz, Christian. *Architecture: Presence, Language, Place* Milano: Skira, Editore Sp.A, 2000.

Novak, Marcos. “Liquid Architecture in Cyberspace.” In *Cyberspace. First Steps*. Edited by Michael Benedikt. Cambridge: MIT Press, 1993.

Novitski, B.J. “Digital Architect. New 3D Modeling merges the flexibility of clay with the precision of computers to create extraordinary forms.” Architectural Record 6 (1999): 49-50.

Osman, Yasser. The Use of Tools in the Creation of Form. In *Reinventing the Discourse: How Digital Tools Bridge and Transform Research, Education and Practice in Architecture. Proceedings of the 21st Annual Conference of the Association for Computer-Aided Design in Architecture*, p. 44-52. Buffalo, October 11-14, 2001.

Zellner, Peter. *Hybrid Forms. New Forms in Digital Architecture*. London: Thames and Hudson Ltd., 1999.

Zevi, Bruno. *The Modern Language of Architecture.* Seattle: University of Washington Press, 1978.

Notes

[1] Novak, Marcos. "Liquid Architecture in Cyberspace:" In *Cyberspace. First Steps*. Edited by Michael Benedikt (MIT Press, 1993), 255.

[2] Ibid, 250.

[3] Manovich, *The Language of New Media*, 246.

[4] Kolarevic, *Digital Fabrication. Manufacturing Architecture in the Information Age*, 268-279. Kolarevic investigates the development of digital tools into digital design and fabrication processes. The use of rapid prototyping (RP) and computer-aided manufacturing (CAM) technologies allow the production of both small-scale models and full-scale building components on the basis of information directly provided by the 3D models.

[5] Peter Zellner, *Hybrid Forms. New Forms in Digital Architecture* (Thames and Hudson Ltd., London, 1999), 13.

[6] Ibid, 12-13.

[7] Osman, Yasser. *The Use of Tools in the Creation of Form*. Proceedings of the 21st Annual Conference of the Association for Computer-Aided Design in Architecture, October 11-14, 2001, Buffalo, New York, p44-52.

[8] Cited by B.J. Novitski from an interview with Frank Gehry in "Digital Architect. New 3D Modeling merges the flexibility of clay with the precision of computers to create extrordinary forms" *Architectural Record* 6 (1999): 50.

[9] Zellner, *Hybrid Forms. New Forms in Digital Architecture*, 49-50.

10 The Fresh Water Pavillion (Fresh H_2OeXPO) is located in Neeltje Jans Island, Zeeland, the Netherlands. It was designed by NOX Architects and it is described in New Forms in Digital Architecture by Peter Zellner ed. (Thames and Hudson Ltd., London, 1999) and in *Architectural Record* 5 (1999):202-206.

[11] NOX Architects is a design practice founded and directed by Lars Spuybroeck and it is located in Netherlands (see *Architectural Record* 5 (1999):202-206.

[12] Kent Larson, principal research scientist at the Massachusetts Institute of Technology, currently directs the consortium House_n: The MIT Home of the Future (http://architecture.mit.edu/~kll/).

[13] Ibid.

[14] See "Recognizability of the Idea: The Evolutionary Processes of Argenìa." In *Creative Evolutionary Systems*. Edited by Bentley, Peter J. and David W. Corne (Academic Press, 2002), 109-128.

[15] Ibid, p.116.

[16] Ibid, p.116-118.

[17] Norberg-Schulz, Christian. *Existence, Space & Architecture* (New York, Praeger Publishers, 1971), p37.

[18] See for an example http://www.amazon.com which adapts to a user profile while she is interacting with the interface. Numerous other examples are available.

[19] The project title is "Imaginary Palladian Spaces."

The roningen T ister
An e periment in applied generati e design

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Abstract

This paper describes a collaborative project between the design team of Kees Christiaanse Architects & Planners (KCAP) in Rotterdam, an engineering team of Ove Arup & Partners in Amsterdam and the chair for Computer Aided Architectural Design (CAAD) at the ETH Zurich. The project was initiated in February 2003.

The aim of the project was to develop a CAD-tool which would help the architects of KCAP to solve a complex design task: Underneath a pedestrian area that links the main station to the city center of Groningen/NL, there was a need for parking space for approximately 3000 bicycles. To support the concrete slab of the pedestrian level, the desired design called for more than one hundred columns of different sizes to be placed in a random pattern, but to be then sized and controlled according to structural, functional and aesthetic needs.

To solve this problem, a software was developed at the chair for CAAD that simulates a growth process for the columns. The distribution of the columns is defined by structural rules, provided by ARUP's engineers, as well as functional and design rules provided by KCAP's designers. The results are presented to the user as a three dimensional, dynamically evolving model. At any time during this process the user is able to control the model on the screen interactively. The user can control the process in two distinct ways, on the one hand by directly controlling the placement of single columns, on the other hand by adjusting various parameters that define the properties of the columns and the environment. The system provides real time feedback, as the column distribution tries to adapt to the changed configuration. This allows the user to test various alternative solutions in very short time. After a stable and satisfactory condition is achieved, the resulting column locations can be exported for construction documents in various digital file formats.

The final architectural design, based on the output of the software, has been approved and construction work in Groningen is about to start.

Introduction

In the year 2000 Kees Christiaanse Architects & Planners (KCAP) [1] and the University of Kaiserslautern started the "Kaisersrot" project [2] to develop new methods of urban development based on "bottom-up" principles. To allow rapid testing of design rules, various CAD software tools were programmed which allowed to describe inter-dependencies in urban structures and iteratively generated urban plans according to rules and user interactions. In 2001 the project was merged with the Chair for Computer Aided Architectural Design (CAAD) at ETH Zurich [3] and the fruitful cooperation resulted in a number of successful applications, particularly the "Schuytgraaf" project in Arnhem/NL.

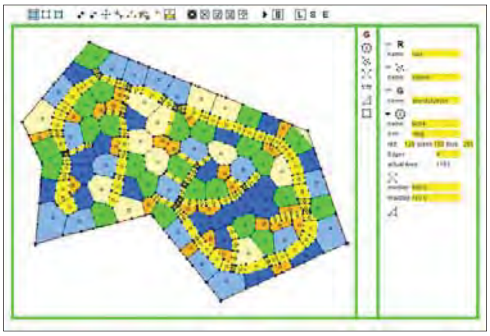

Fig. 1: Kaisersrot Software for urban planning

Early in 2003 a design team of KCAP approached the CAAD chair with another, different problem. This time it was not an issue of urban design but a complex architectural design task to be solved. The following text describes – in the manner of a workshop report – the solution of this task, which was achieved by a specifically developed generative standalone CAD-Tool – the Groningen Twister.

Ho to design a forest of columns

Fig. 2: Model view of the Groningen Stadsbalkon

In the city of Groningen, in northern Holland, KCAP is redesigning a public square in front of the train station: the Groningen Stadsbalkon. In order to achieve a better link between the city center and the station, a bus terminal was moved to the side and gave way for a spacious new pedestrian area and a semi-subterranean parking lot for 3000 bicycles underneath.

The final design consists of a concrete flat slab with large holes for letting light down to the basement and to enable two large trees to grow up. It has a number of incisions for ramps and stairs. Some edges of the slab rest on the ground, others loom in the air, flexing the pedestrian area into a long sweep over the whole length.

To give the whole structure an additional notion of lightness, the design called for it to be supported on a field of slim concrete columns. The complex outline of the slab and the already defined paths and bicycle stands in the basement made it difficult to place the columns on a regular grid. As a result, it was decided to locate the columns randomly, giving the impression of a "column forest". To re-enforce this impression, the design called for the columns to

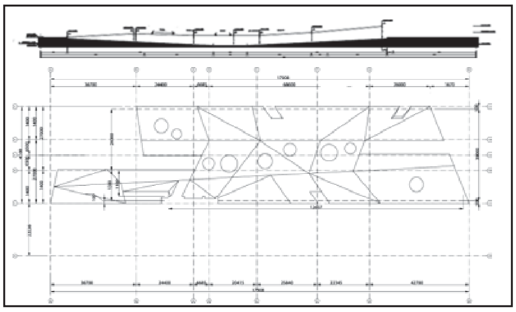

Fig. 3: Longitudinal section and outline

be made with different diameters and random degrees of tilt.

In a first rough calculation, the engineering team at Ove Arup in Amsterdam estimated that it would take about one hundred columns to hold up the slab and stay within the budget. But then the problem was: where to place the columns? There were too many degrees of freedom (column location, tilt angle, column size) and at the same time too many restricting rules (holes, incisions and paths to avoid, bearing capacities, optimum column distances) influencing each other and preventing to design a structurally and aesthetically working solution in reasonable time. A brain twisting task, at least if you tried to do it by hand.

Letting them gro

There has been much research into the use of artificial intelligence in design and architecture since Bill Mitchell stated in 1977 that a “comprehensive CAAD system” had to perform the function of automatic generation of solutions to well defined problems[4]. Recently, research into the principles of artificial life (such as cellular automata, swarm systems, and genetic algorithms) has proven to be a very reasonable way to deal with the ill-defined (or not adequately definable - due to aesthetic demands) problems of architectural design [5, 6, 7]. The chair for CAAD at ETH Zurich has gained some very positive experiences in the field of generative bottom-up principles with the already mentioned Kaisersrot project. So it was clear that a similar solution could be the answer to this problem: A software simulation of “living columns” that are able to grow on the best locations within a common habitat.

The habitat

The living space for the columns is well defined by the functional and conceptual constraints described in chapter 2: The top ends of all columns have to be located within the outline of the slab while avoiding the holes and incisions. In some areas the slab is lying on the ground, so no columns are needed there. The bottom ends of the columns should seek the areas of the bike stands to get out of the way of pedestrians and bikers. As a result, the habitat actually consists of two layers: the slab where the top ends of the columns have to find their locations, and the floor plate where the bottom ends have to do so. Fig. 4 shows the habitat with the slab outline, the attracting areas in green, and the repelling areas in red.

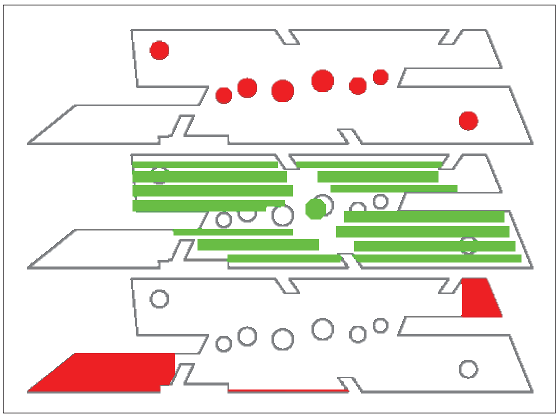

Fig. 4a-c: slab outline with holes, bike stands and areas without cellar (top to bottom)

The organisms

The columns represent particles in a swarm system: Each column in the system is an autonomous individual, exploring the habitat and reacting to its neighboring columns.

According to the two layers of the habitat (see 3.1), the column model consists of two independent parts. The bottom end can move freely within the ground plane of the model, whereas the top end can move in the plane described by the slab. The actual column position, length and tilt is defined by the connecting line. It has to be assured, that the tilt angle stays below the assigned maximum.

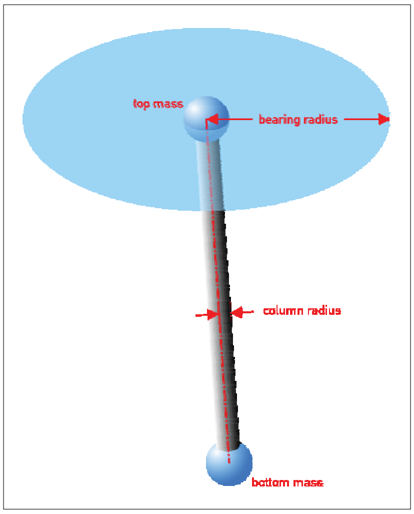

Fig. 5: column model

This behavior is easily described by a spring-mass-system: punctual masses are connected by a virtual spring that pulls depending on the distances between the masses. In our model each organism is composed of two masses which describe the top and bottom end of the column and a spring in between. The force of this spring is proportional to the horizontal distance and, since the move of the masses is confined within the two planes of the habitat, they are drawn to positions above each other.

Interaction

The columns are interacting with their adjacent columns as well as with the surrounding habitat following the same simple principles of attraction and repulsion by virtual springs. If they come to close, the top masses of each column are repelled by the slab outline, the holes, and the areas without cellar. The bottom masses are attracted by the closest bike stand.

To get the desired effect of distributing the columns, they seek to stay at a certain “social distance” to each other. This distance is defined by the maximum spanning distance of the slab and the bearing capacities of the respective columns. The bearing capacity of a column defines a circle around the top end marking the area where column is able to support the slab (see Fig. 5). Neighboring columns therefore have to be aligned so that their radii touch or overlap slightly. This is also accomplished by virtual springs that push or pull between their respective top masses.

The result is a complex system of masses and springs that can be analyzed in a non-linear time-step simulation, as described by Martini [8]. To prevent resonance catastrophes and to promote a termination to the process, an additional damping factor is introduced which induces a certain friction on the movement of column masses.

Implementation

One of the main goals of the project was to create a highly interactive application that would allow the architects to directly influence the outcome of the simulation process and see immediate feedback on the decisions they took. Therefore it was necessary to have a graphical representation of the whole model, preferably in three dimensions, and very short response times. Since the application had to run in a multitude of different environments (at the CAAD chair, at KCAP and at ARUP), it was also necessary to address compatibility issues. Development time for the project was also very short, and it was necessary to quickly exchange new versions of the software over long distances, so after a few tests it was clear that the software could and should be programmed in Java. The Java 3D API provides a very powerful and effective 3D programming interface which at the same time is very clearly structured and easy to use. It runs on Sun, Windows and Linux systems with OpenGL and DirectX graphics adapters, and the Java executables – especially in the Java-Archive format (JAR) - are very lightweight, so the compiled programs could easily be exchanged via email. [9]

Column Specifications

The specifications of the columns were given by Arup as shown in Tab. 1. There are three types of columns with different diameters and bearing capacities. The maximum radius of the column results from the bearing capacity and defines the distance between the columns as shown in 3.2. The tilt angle of the columns was limited to 10 degrees so that this factor could be ignored in structural calculations. Also the height differences between the ground plane and the slab were not cared for and an average height of 3.0 meters was used throughout the habitat. The approximate number of columns needed was estimated by Arup based on the maximum radii and the building budget which would only allow for a certain number of columns.

diameter [mm]	max. rad. [m]	approx. number
150	2.0	15
250	3.0	35
300	4.0	50

Tab. 1: column specifications by Arup

Prototype arranging columns

The first version of the software was a simple particle system: the columns as described in chap. 3.2 could be “thrown” into the middle of the habitat and immediately started to arrange themselves according to the definitions. The user could pick and drag a single column and change various parameters influencing the interaction amongst the columns and between the columns and the habitat (slab, bike stands, holes). The viewpoint could be changed via mouse dragging, keyboard navigation and various preset viewpoints. The results could be exported as two dimensional SVG graphics and as comma separated lists of column locations.

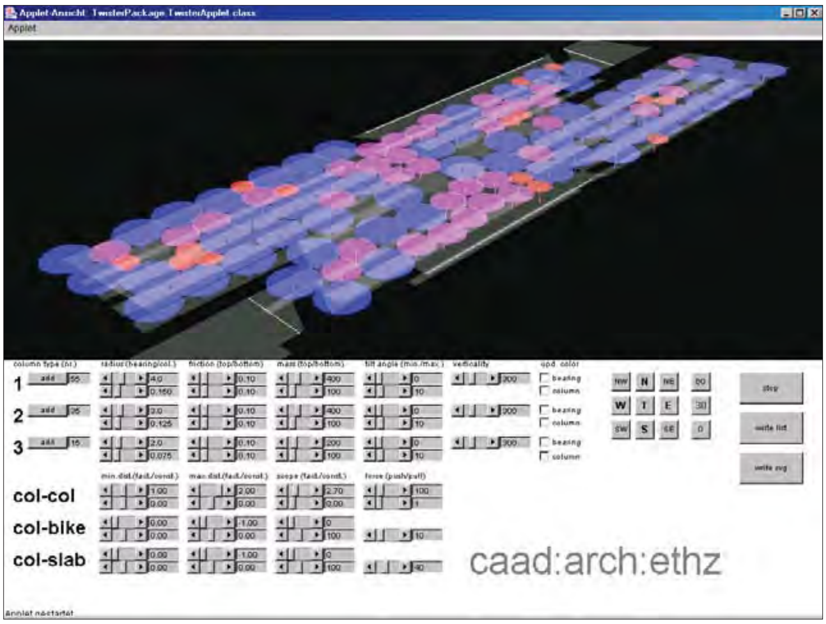

Fig. 6: Screenshot of the Groningen Twister prototype

Results

The results achieved with this first version were very encouraging. The columns managed to arrange in very reasonable patterns, as is shown in Fig. 6. With some tweaking of the parameters, stable conditions could be reached in very short time. The frame rate of the simulation was high enough to directly interact with column numbers up to 150 on an average notebook without hardware graphics acceleration.

But there still were some flaws. Besides pushing each other there was no real interaction between the columns, and they were not reacting on their environmental situation. Once assigned, a column could not change its type anymore. So the arrangement of the column-types was only dependant on the random placement in the beginning and the user who could drag single columns to new (better) locations. There were also big structural problems in the center of the slab where no bike stands were planned, so the columns had no place to position themselves. Furthermore, after they had been shown the first version, the engineers at ARUP came up with some additional structural constraints. So the next version of the Groningen Twister was planned with some major changes.

inal ersion ro ing columns

While testing the prototype, construction details appeared which had not been part of the initial considerations: Two expansion joints across the middle of the slab were necessary. Parts of the slab were interspersed with glass blocks which influenced the spanning capacity and therefore the maximum column distance in the affected areas. Some the edges of the slab, the edges of the holes, and the expansion joints, also required different structural responses with regards to cantilevering and column distances.

e model of the slab

To integrate the new structural rules into the system, a different model of the slab was necessary: It now consisted of five independent partitions, separated by the joints and the border line between areas with and without glass blocks. In reaction to the differing structural demands in various regions of the slab, the partitions, their edges and the holes were grouped into five categories with independent parameters as shown with different colors in Fig. 7.

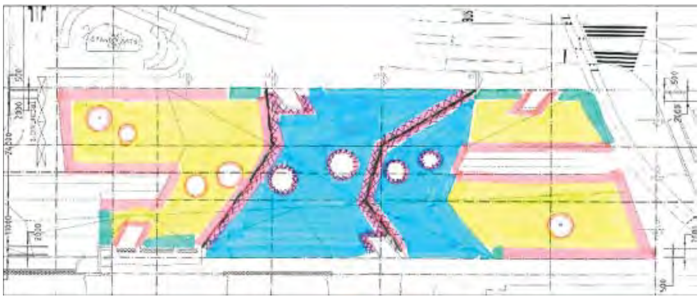

Fig. 7: ARUP sketch of the different regions of the slab. Expansion joints run vertically through the middle of the slab. The blue area contains glass blocks, green edges are supported on walls or the ground

Paths instead of column areas

To avoid the column-less area in the middle of the slab, the criteria for the placement of the lower column ends was changed completely. The task – to keep columns from obstructing the paths – was now modeled directly: Instead of being attracted by the bike-stand areas the columns now are repelled by the paths, which are defined by their center lines. According to their traffic volume the paths are grouped in three categories with different repelling forces, ranging from the main bike route through the center, to the secondary paths at the stairs, and the small access paths between the bike stands.

ro ing columns

The most important change from the prototype was the completely different approach in distributing the columns. By making them pressure sensitive and able to change their type, an actual growth process was possible. Instead of assigning a column diameter and bearing radius from the beginning, the columns were now able to adapt to their surroundings by changing their size autonomously.

A column that is too far away from its neighbors detects a low surrounding pressure and starts to grow in discrete steps, matching the column types defined in chapter 4.1 (see Fig. 8a). If it reaches the largest possible state and still has no close neighbors, it splits into two small columns which both start growing again (see Fig. 8b). If a column gets to close with its neighbors or the edges of the habitat the resulting pushing increases the pressure and it starts shrinking in just the same way (Fig. 8c). And if it reaches the smallest state while the pressure remains high, it finally dies (Fig. 8d). Thus, by "seeding" a single column the whole area of the slab is filling up with columns over time.

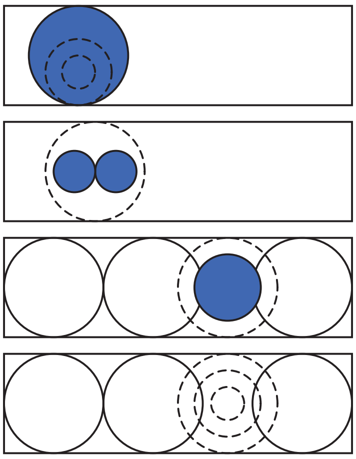

Fig. 8a-d: A column is growing, splitting, shrinking and dying.

The pressure threshold values for the growing and shrinking can be adjusted for each column type independently, so it is possible to influence the distribution of columns to the three types. In some regions of the slab where the spanning capacity is lower due to glass inlays, the growth is restricted to the two smaller column types.

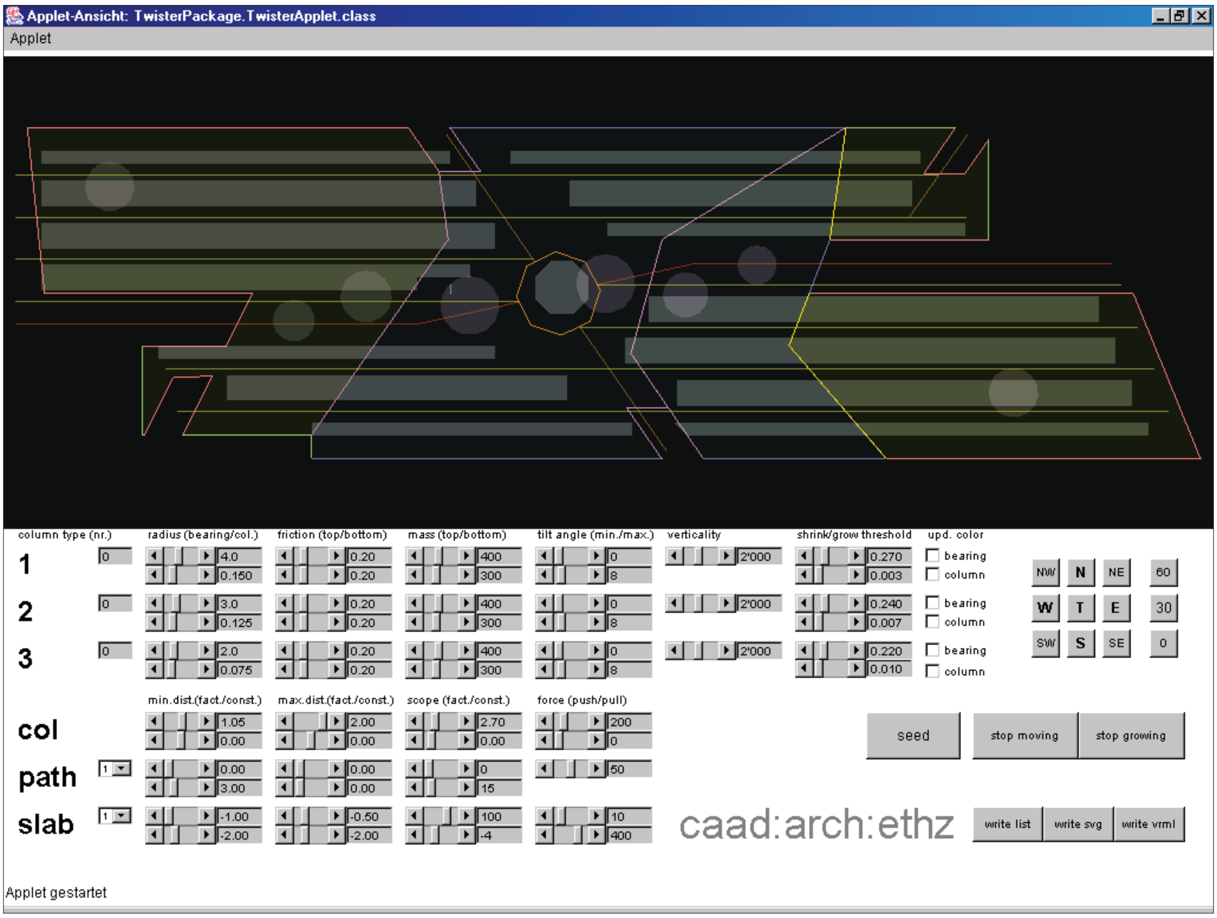

Fig. 9: Screenshot of the Groningen Twister before adding columns

Results

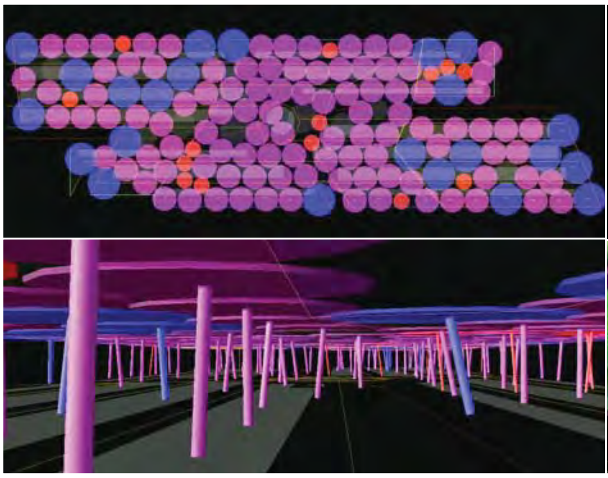

Fig. 10a-b: Twister in action, color coding by column type

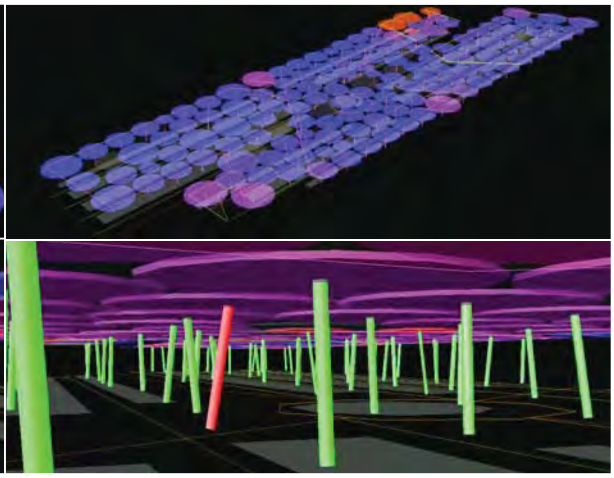

Fig. 11a-b: Color coding by kinetic energy (top) and excessive tilt angle (bottom)

The results of this version proved to be much better than that of the prototype. After "seeding" a single column into each of the five slab partitions, they start growing, splitting and eventually filling up the whole area. The column types adjust to the necessities of their location (see Fig. 10). After a few tries it was possible to adjust the default parameters so that the structural constraints were fulfilled to a high degree. Various color coding schemes proved to be helpful. It is for example possible to tint the columns relative to their kinetic energy (see Fig. 11a) or mark those columns which exceeded the maximum tilt angle (see Fig. 11b). In very short time the architects at KCAP were able to handle the various parameters quite well and produced numerous versions of the column layout. The best version was exported to AutoCAD and used as a basis for the further development of the final design (see Fig. 12).

A few problems turned up in the working phase, which could not be completely solved due to lack of time: The discrete growth of the columns caused the phenomenon that the total kinetic energy of the system increased every time a column changed its type. Either a growing column applied a greater pushing force on its adjacent columns, or the neighbors of a shrinking column suddenly had more room to move and therefore a higher potential energy to be turned into velocity. In tight situations (like in the upper right corner in Fig. 11a) this lead to very unstable conditions with high velocities and a high type-change rate. Also it was difficult to prevent columns from exceeding the maximum tilt angle when their lower ends came too close to a path. The linear increase of the erecting force was sometimes much lower than the accumu-lated pushing and pulling forces the attractors and repellors applied to the column ends.

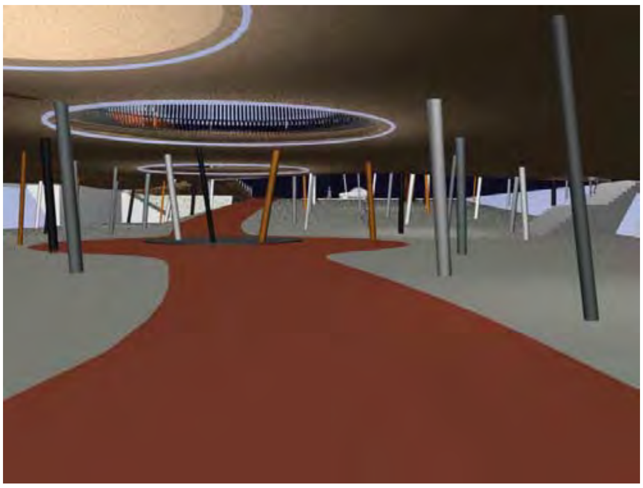

Fig. 12: Rendering of the final layout (by kind permission of KCAP)

Summary and future or

The basic concept for this generative tool is direct interaction. The software is looked upon as an interface which maps the different views of the project participants onto a single model and therefore allows a very different mode of communication about the project. In this case the architects at KCAP stated their design idea based on a flat slab and the notion of a "column forest" and the engineers at ARUP provided a set of rules of thumb which would ensure that the design stayed within structural possibilities, based on their notion of a concrete structure. Programming these rules into a plain simulation system and allowing the user only to start and stop the process would reduce the task to a mere optimization problem with a probabilistic outcome based on the quality of the software design. But if the simulation is highly interactive, so that the user can influence the process at any given time, it becomes a true design tool. This tool allows the architect the freedom to decide about the aesthetic and functional aspects of the design, while steadily, but uncompromisingly, pushing the results to a state that satisfies all of the structural rules.

There have already been requests for studies on similar projects. To be able to rapidly develop further simulation studies it is planned to develop a software toolkit based on the most valuable insights gained from this experiment.

Steady gro th

The sometimes explosive increase of kinetic energy in the system as described in 4.3 poses a big problem. The system never reaches a stable equilibrium as long as the deceleration by damping is lower than the acceleration by type-change of columns. To simply turn up the damping parameter only leads to suboptimal states because the columns are handicapped in arranging their positions. To turn off the growing and shrinking on the other hand prevents them from adjusting their size. The dilemma could be resolved by the introduction of a continuous growth of the bearing radii. The resulting column diameters could still be discrete, some of the columns would then simply be over-dimensioned.

User Interface

Since the target user group of design tools like the Groningen Twister is architects in a professional environment, the software has to become more user friendly and ergonomic. It has been criticized by the users that there was no possibility to save intermediate states of the evolving structure to be able to start later explorations from there on. To be able to quickly react on design changes, import filters for CAD files are needed. Also a direct output to CAD formats is highly desirable.

Statistics and measurements

In the current version, the designer has to rely on the software to deliver "correct" solutions without having a detailed control mechanism to see whether structural needs are fulfilled. What the Groningen Twister is lacking up to now is a quantitative "fitness measure" of the achieved solution. Fitness measures could, for example, be a comparison of the number of columns required to cover the whole slab, the amount of "overlapping" bearing radii, the exceeding of tilt angles, and so on. This would allow a precise identification of the structurally and functionally best solution and leave the aesthetic judgement to the designer. The inclusion of this quantitative evaluation would also make automatic parameter testing possible or the evolvement of solutions by genetic algorithms.

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References

[1] Kees Christiaanse Architects & Planners Website: www.kcap.nl
[2] Kaisersrot Website: www.kaisersrot.com
[3] CAAD Website: www.caad.arch.ethz.ch
[4] Mitchell W.J. 1977, *Computer-aided architectural design* - New York : Petrocelli/Charter.
[5] Coates, P.; Healy, N.; Lamb, C.; Voon, W.L. 1996: *The use of cellular automata to explore bottom up architectural rules*. Eurographics
[6] Frazer, J. 1995: *An Evolutionary Architecture* , AA Themes no 7, London, The Architectural Association.
[7] O‘Sullivan, D.; Torres, P.M. 2000: *Cellular models of urban structures*, in Bandini, S. & Worsch, T. (eds.) 2001: *Theoretical and Practical Issues on Cellular Automata*, Proceedings of the Fourth International Conference on Cellular Automata for Research and Industry (ACRI 2000), pages 108–116.
[8] Martini. K. 2001: *Non-linear Structural Analysis as Real-Time Animation*, in de Vries, B. et al. (eds.): *CAAD Futures 2001 Proceedings*, page 643-656, Dordrecht, Kluwer
[9] Sun’s Java Website: java.sun.com. Versions used for the development of the Groningen Twister: J2SDK 1.4.3 and Java3D 1.3.1.
[10] Kennedy J.; Eberhart R.C.; with Yuhui Shi 2001: *Swarm intelligence*, San Francisco, Morgan Kaufmann.

Feature-Based Design of Building Forms Using an Improved CSG Tree

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Abstract

Evolutionary technologies can be effectively used for architectural design supporting innovation, optimisation and planning. In this paper, we introduce a method of generating building forms using an improved Constructive Solid Geometry (CSG) tree. In this method, an abstract building form is represented by the makeup of its main body and its exterior features. Traditional CSG tree is modified for the representation of diversity building forms. In this paper, this method is described with the presentation of the preliminary results of the implemented system.

1. Introduction

From the perspective of computing, an architecture form can be viewed as a combination of many distinctive features related to the environment. To formally define the style of a building in a CAD process is difficult. However, it is easier to work at a level of abstraction of building style in terms of geometric features. In [2], for example, the style of a building is interpreted using hierarchical levels with syntactic and semantic mapping from concept to form. Semantics are derived from the forms and result in important decisions in the design process. In this paper, we represent the style of a building using features from which different build forms are generated.

Feature-based design has a long history originating from the engineering domain, where the gap between design and manufacturing must be bridged. In such a domain, features are meaningful elements for designers and the use of them can speed up the design process as well as provide a means for standardisation, thus reducing the cost and time to market. Generally, a feature is considered as:

- a specific geometric configuration formed on a surface, edge or corner of a work piece [3],
- distinctive or characteristic part of a work piece, defining a geometrical shape, which is either specific for a machining process or can be used for configuration and/or measuring purposes [4], or
- a generic shape which carries some engineering meaning [5].

In our method, we express the style of a building with the characteristics of its main body construction and exterior elements. The main body of a building can be obtained using 3D modelling method. The exterior building elements, such as roof, wall, window, gate, and so on, are represented as compound features. In light of this, the generation of a building consists of two steps: (1) generating the main body with a 3D modelling method, and (2) adding building elements to the main body (fig 1).

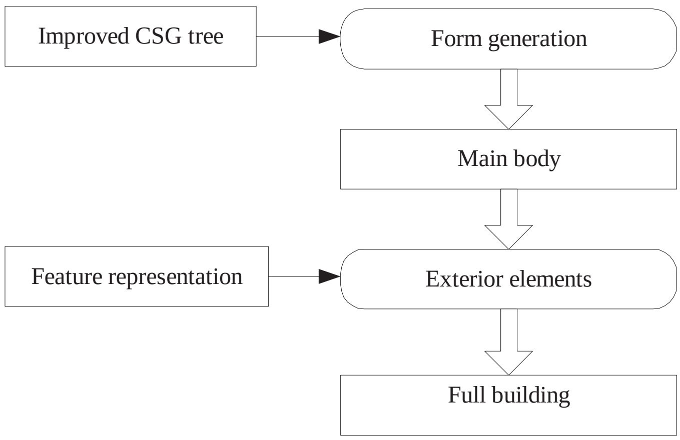

Fig 1 Steps to generate a building

In the following text, we give a brief review on solid modelling representations in section 2. In section 3, we introduce our improvements on traditional CSG tree to meet the requirements of generating diversified building forms. Section 4 introduces our idea to represent building elements with feature technology. Section 5 presents the preliminary implementation of the proposed method. Finally, we conclude this paper in section 6.

2. Solid modelling representations

Solid modelling is a rapidly growing area of research and development in the CAD domain. As a field, solid modelling spans several disciplines, including mathematics, computer science, and engineering. Three major representation schemes used in generative design are spatial partitioning, boundary representations (B-rep), and constructive solid geometry (CSG).

In spatial-partitioning representations, a solid is decomposed into a collection of adjoining, non-intersecting cells that are more primitive than the original solid. The most common spatial partitioning representation schemes include cell decomposition, spatial occupancy enumeration and cctrees. In cell decomposition, each cell decomposition system defines a set of primitive cells that are typically parameterised. Cell decomposition is not necessarily unique. Spatial occupancy enumeration (also called exhaustive enumeration) is a special case of cell decomposition in which the solid is decomposed into identical cells arranged in a fixed and regular grid. These cells are often called voxels. Octree is a hierarchical variant of spatial occupancy enumeration. The essential property of octrees is that they record the shape information of an object in a spatially ordered manner, and the highly hierarchical nature of them suggests the use of divide-and-conquer recursive paradigms.

The boundary representation, or B-rep, represents solids in terms of bounding surfaces, with a convention to indicate which side of boundary is inside. It is based on complete topological information as well as geometry. Topology (fig 2) provides mathematical basis for complete definition of well-formed solid. A solid object is represented by a complicated data structure giving information about each of the object's faces, edges and vertices and how they are joined together. With B-bep, the description of the object can be into two parts: topology records the connectivity of the faces, edges and vertices by means of pointers in the data structure, and geometry describes the exact shape and position of each of the edges, faces and vertices.

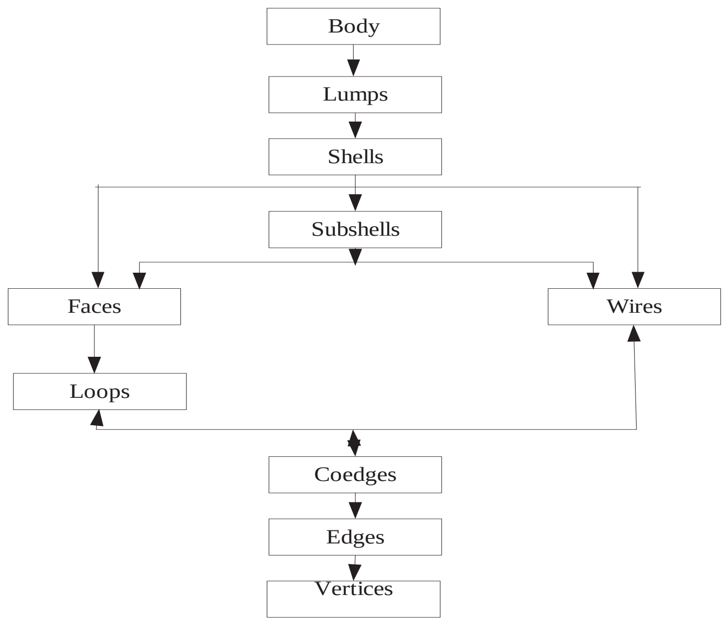

Fig 2 Topology of boundary representation

In CSG, a solid is represented as a combination of primitives, or building blocks. Typical primitives include rectangular blocks, cones, cylinders, spheres, tori and prisms. Primitives are first scaled based on specified dimensions, then moved by a rigid motion, or a combination of translations and rotations, and finally merged together by regularised Boolean operations. There are three typical Boolean set operations: union, intersection and subtraction. Because the final geometry changes depending on the order of the operations performed, the order of operations can be stored in a binary tree structure, which is called a CSG tree. Fig 3 gives an example of using CSG tree to represent the design process of a mechanical part.

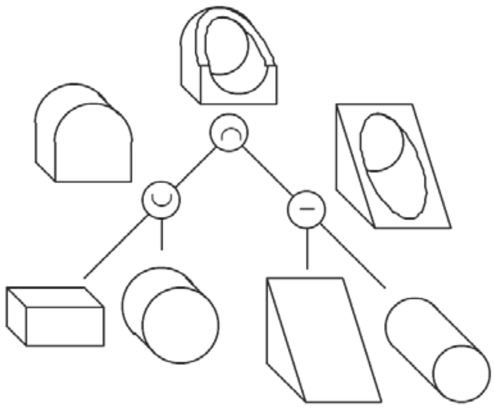

Fig 3 A CSG tree example

In reference to generative architectural form design, various methods have been explored to generate novel building envelopes. A number of computer models are used to simulate the development of prototypical forms that are then evaluated on the basis of their performance in a simulated environment. In [7], optimisation functions are integrated with the form generating processes in order to generate new forms responding to varied design environments to be created and determined through a series of complex mathematic transformations.

3. The Improved CSG Tree

Among the three solid modelling representation methods mentioned in section 2, CSG tree is highly recommended in generative design systems because of its conciseness and easiness for genetic encoding. But the primitive numbers and Boolean operations in a traditional CSG tree severely impair its ability in generating diversified building forms. To address this issue, we improve the traditional CSG tree in two aspects: primitive representation and operation set.

3.1 Uniform representation of CSG primitives

Most CSG modelling systems provide just a few standard primitive shapes of a unit size, whose position, and orientation are initially set within the primitive's local coordinate system. The designer chooses appropriate primitives, then sizes, positions, and combines them to form complex shapes. A primitive's size, shape, position, and orientation are controlled by specifying the values for a small set of variables. For example, rectangular solids, or blocks, are almost always available in a CSG system. A particular instance of a block is produced by specifying its length, width, height, and subsequently its location and orientation within a world coordinate system. In our method, we do not intend to provide a specific number of primitives. Instead, we propose a uniform representation for a wide range of primitives.

Definition 1 A primitive is represented by a modelling method, two curves and four parameters, which can be expressed as:

$Primitive = (m, draft, step, twist, portion, c_1, c_2)$

Where

- *m* is a creation method such as sweeping, revolving or lofting,
- *c1* and *c2* are two curves,
- *draft* represents the angle with which the swept profile is to draft out (positive) or in (negative) while sweeping,
- *step* converts a circular sweep path into the specified number of linear segments. The results are polygons, and the intent is to create simpler geometry by keeping faces planar. The default is 0. This option may only be used when specifying the path as a position and axis of revolution,
- *portion* specifies the angle to sweep around another, given in radians. The default is 2π,
- *twist* represents how much the profile twists in total as the profile is swepting along the path, regardless of the length of the path.

In the above definition, a primitive solid can be created with three methods: sweeping a curve along another, revolving one around another or lofting one to another. Four parameters specify how the solid will be created in more details.

Definition 2 A curve is defined by a type, a flag indicating whether the curve is closed, and a collection of control points, such that

$Curve = (t, f, p_1, p_2, ..., p_n)$

Where

- *t*: the curve type, which can be line, arc or spline,
- *f*: flag indicating whether this curve is closed,
- P_i, i = 0, 1, …, n: pairs of float numbers, representing the coordinates of control points,

Note that different curve types need different numbers of parameters, and the flag is not always necessary. For example, a straight line needs two control points; an arc needs three points and a line strip or a spline usually needs variable number of points.

When generating a primitive solid, if the method of a primitive is sweeping, the resulting solid will be created by sweeping curve c1 along curve c2. In this case, c1 should be a closed curve, while c2 can be either an open curve, e.g. a line, or a closed curve. If the method is lofting, then both c1 and c2 should be closed curves.

Some modelling tools support an even more complex sweeping method called Variable Section Sweep (VSS). A VSS allows for the creation of some very complex geometry by controlling how the section will change along the trajectory for the feature. For example, in ACIS, a law provides symbolic representations of equations that are parsed in much the same way that equations are. A law is represented internally by a tree of C++ classes that know their dimensions, how to evaluate themselves, and how to take their exact (symbolic) derivatives with respect to any combination of variables. In addition, law utility functions numerically integrate, differentiate, and find roots. Such a method usually uses mathematical functions to control the changing of a section. It's too complex to be applied in the generative design process.

It is obvious that all primitives in the existing CSG methods (say, block, cone, wedge, cylinder, torous, etc.) can be represented by this uniform method.

3.2 Extended CSG operation set

CSG is a method for describing the geometry of complex models by applying set operations to primitive objects. Traditionally a CSG tree contains two kinds of operations, i.e. rigid Boolean operations and transforming operations. However, a feature based generative design system should be flexible so that the generation process can not only add new instances of feature primitives to the model, but also can modify various aspects of the existing features.

In our method, operations involved in the improved CSG tree include three categories of operations: Boolean operations, transformations and feature operations. We list the operations of each category as follows.

1) Boolean operations
   - Union,
   - Intersection,
   - substraction.

2) Transformations
   - Translating,
   - Rotating,
   - Scaling.

3) Feature operations
   - Creation,
   - Deletion,

- Modification.

By providing a uniform expression of primitives and extending the operation set, our improved CSG tree can now generate a much wider range of building forms than that of a traditional one. In light of the above description, now we give the formal definition of our improved CSG tree.

Definition 3 An improved CSG tree recursively expressed in Backus-Naur Form as:

CSG tree ::= <CSG tree> < Op> <CSG tree> | <CSG tree>
| <Transformation> | <Primitive Solid>
Op ::= Boolean operation | Transformations | Feature operation
Boolean operations ::= Union | Intersection | Substraction
Transformation ::= Translation | Rotation | Scaling
Feature operation ::= Creation | Deletion | Modification
Primitive ::= <Method><Curve><Curve>
Method ::= Sweeping | Revolving | Lofting

4. Representing building elements with features

Many different kinds of features have been proposed in the development of CAD systems, such as functional features, assembly features, mating features, physical features and even abstract features. All of these features have to be associated with the basic shapes to which they are attached. Shah defined the requirements a feature should at least meet [6]: a physical constituent of a part, to be mapped onto a generic shape, engineering significance and predictable properties.

To represent building elements, it is important to give a feature taxonomy to classify all features in a structured way. By doing this, we can also define features with the notion of inheritance, i.e. properties of super classes can be inherited by subclasses without explicitly being repeated.

In our method, we adopt the feature taxonomy scheme presented by Wilson and Pratt based on the overall shape of features and the assumption that features will be incorporated in solid modelling systems [8]. Wilson and Pratt distinguish explicit and implicit feature taxonomies which are related to form feature representation. Fig 5 illustrates this taxonomy.

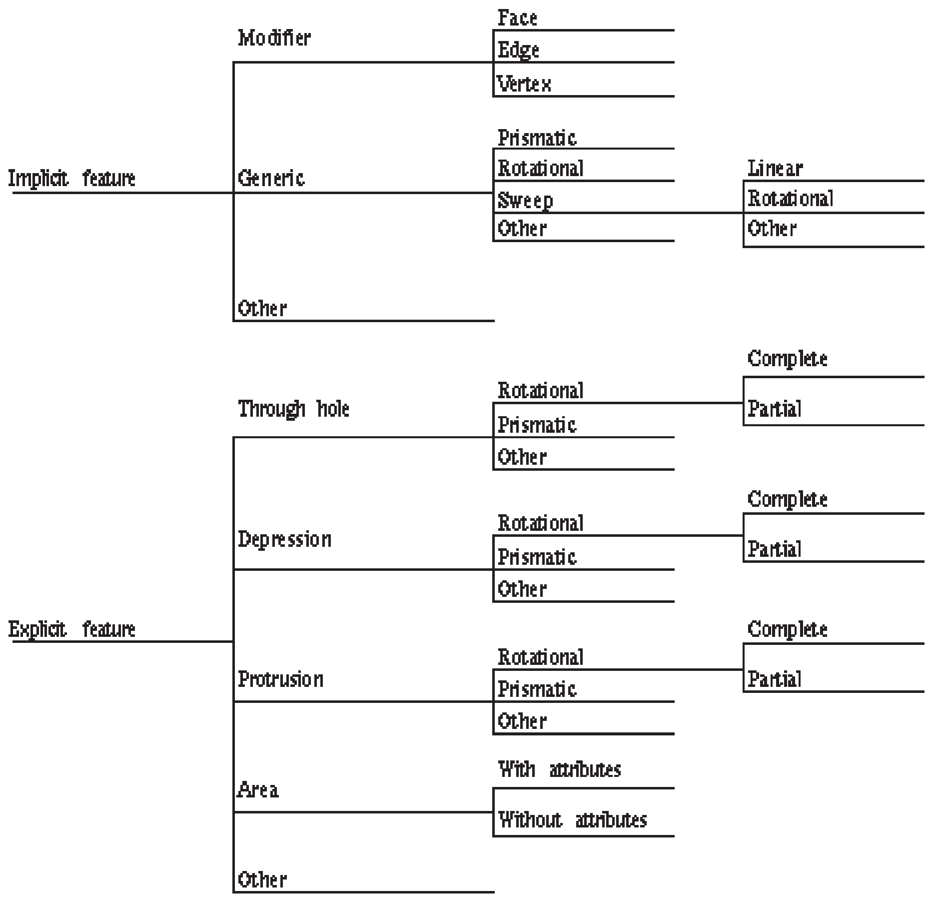

Fig 5 the taxonomy proposed by Wilson and Pratt

According to this taxonomy, features can be represented either implicitly or explicitly. In the explicit representation all geometric details of a feature are fully defined. In the implicit representation, sufficient information is supplied to define the feature, but the full geometric details have to be calculated when required. A cylindrical window for example may be defined implicitly in terms of its radius and depth or explicitly in terms of the set of faces which compose it in a boundary representation model.

In our implemented system, we represent the building elements, e.g. roof, door, window, podium, column, and so on, as compound features. A compound feature is defined as a group of sibling primitive features. It is useful to treat some features as a single entity because for example they might perform a single function or may be machined by the same manufacturing procedure. The members of a compound feature are treated internally as primitive features with relationships, but externally a number of most commonly used compound features are defined, so that designers can generate instances by simply supplying the parameters. Choices are also given for creating new compound features by defining the relationships between the existing primitive features.

It should be stated that in addition to building elements, special modelling techniques for the design of building forms are also considered in our method. Most of these techniques are related to the construction of the main body of buildings. We view these techniques as special features and represent them explicitly in the form of our improved CSG tree.

5. Implementation

Present feature based CAD systems generally do not offer a facility to easily define one's own features. Feature definition usually consists of some kind of programming interface to the geometry modeller. In Knowledge Based Engineering (KBE) systems, the programming interface as well as the access to the geometry modeller is better when compared with "traditional" CAD systems. Nevertheless, even within KBE systems, feature definition is difficult and error prone, requiring extensive programming skills as well.

We employ the so-called Object Oriented Technology to develop our software system. Features are viewed as design objects, belonging to some general class, inheriting properties from their parent classes. A single feature is defined in terms of the feature name or ID code, the feature class, profile type, faces, parameters, a list of relationships and the feature location and orientation. Each face of a feature is described by the face name or ID code, the face type, face shape type, the face normal, its parent face and surface finish. The parametric representation of features provides a powerful way to change features with respect to their dimensions.

Fig 6 shows some preliminary results generated by the software system.

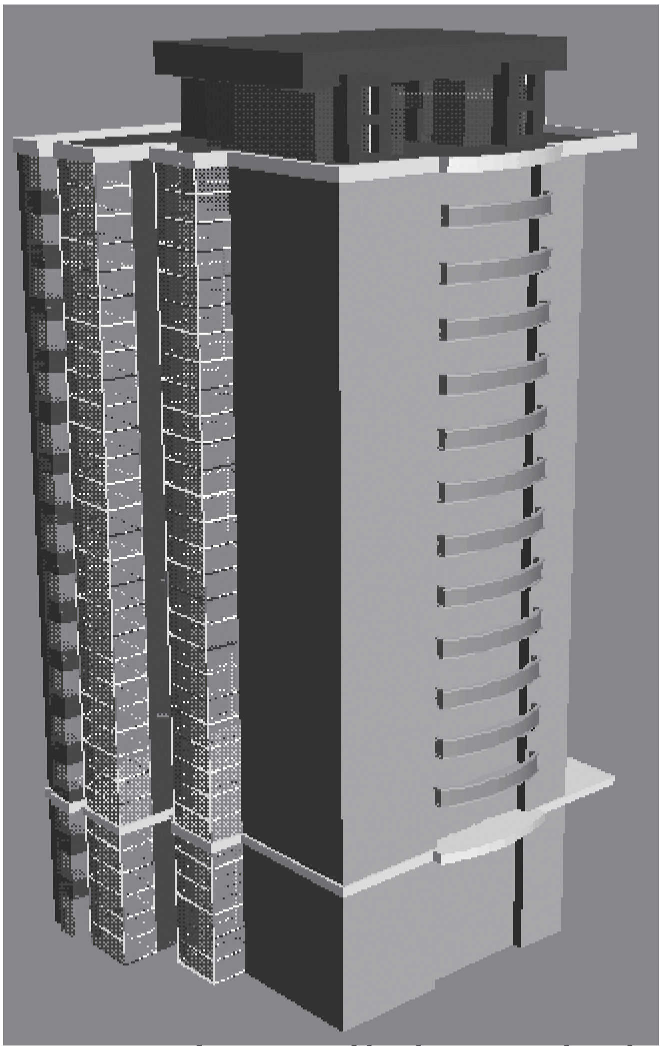

Fig 6 Some results generated by the proposed method

6. Conclusions

This paper presents a new idea of generating building forms using an improved Constructive Solid Geometry (CSG) tree. The traditional CSG tree is improved with a uniform representation of primitives and an extended operation set.

Future work of this research will be concentrated on applying domain knowledge to the generation of architectural forms. The generative design of building groups using co-evolutionary technologies is also a direction of our future endeavour.

References

[1] Tang M. X., Frazer, J. H., "An Artificial Intelligence Approach to Industrial Design Support", Generative Art, 1998, Milan, Italy, December, 1998.
[2] Gero, J. S. and Ding, L. (1997). Exploring style emergence in architectural designs, in Y-T. Liu, J-H. Tsou and J-H. Hou (eds), CAADRIA'97, Hu's Publisher, Taipei, Taiwan, pp. 287-296.

[3] CAM-I's illustrated glossary of workpiece form features, R-80-PPP-02.1, 1981.
[4] Erve A.H. van't, Computer Aided Process Planning for Part Manufacturing, an expert system approach, PhD thesis, University of Twente, 1988.
[5] Wingerd L., Introducing form features in product models, a step towards cadcam with engineering terminology, Licenciate Thesis, Dept. of Manufacturing Systems, Royal Institute of Technology, Stockholm, 1991.
[6] Shah J.J., Philosophical development of form feature concept, CAM-I report P-90-PM-02 , 1990, 55-70.
[7] Liu X. Y., Frazer, J.H., Tang M. X., “A Generative Design System Based on Evolutionary and Mathematical Functions”, Generative Art 2002, Milan, Italy, December, 2002.
[8] Wilson P.R., Pratt M.J., A taxonomy of form features for solid modeling, in Geometric Modeling for CAD applications, eds. Wozny M.J., McLaughlin H.W., Elsevier Science Publishers B.V. (North Holland), IFIP., 1988, 125-135.

Very small Elements in very large Arrays

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Abstract

Embarking on a minimalist concept of algorithmic generation, pen-plotter-drawings have been generated, which use very small elements in very large arrays. The calligraphic quality of the drawings relies on a massive repetition of "standards" within a matrix. Random processes are used to disturb and to contaminate the regularity of this matrix. The resulting drawings are complex and unique. They demonstrate the power of a simple concept, based on a minimal set of easily identifiable elements.

1. Generative Processes and Design

In any kind of generative design process, answers must be given to two important questions:

(a) What is intended (what is the pursued concept, the idea)?
(b) Which system of generative rules - which generators – are suited to produce (a)?

Naturally, the generative system employed should meet the designers intentions as precisely as possible. This is not always simple for different reasons. All design problems have specific and well-known characteristics, and since generative design - despite its heretic and radically different approach - is within the realm of design, it will still face these very same problems, which are characteristics of design and which are responsible for the difficulties and dilemmas of designing at large. Some of these difficulties, which we find in all design problems, are for example [1]:

(1) There is no definite problem formulation
(2) There is no stopping rule
(3) Solutions are not true-or-false, but good-or-bad
(4) There is no immediate or ultimate test of a solution
(5) Every solution is a “one-shot operation”; because there is no opportunity to learn by trial-and-error, every attempt counts significantly
(6) There is no enumerable (or exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations, that may be incorporated into the plan
(7) Every design problem is essentially unique
(8) Every design problem can be considered to be a symptom of another problem
(9) The existence of a discrepancy, representing a design problem can be explained in numerous ways. The choice of explanation determines the nature of the problem’s resolution
(10) The designer has no right to be wrong

The invention of a generator (the design of a design machine) represents the actual challenge within generative design. Any such generator is not objectively right or wrong, it is more or less good or bad in the eyes of a respective viewer, inspecting the results it generated. The ideologies, value systems, aesthetic views, etc. which are hidden within any generator, represent very personal forms of knowledge, and the designers of these systems carefully lock this knowledge away from any public access.

2. Performance of Generators

As a measure of performance p of a generator (with regard to the quality of the generated output), we may use the ratio of the number n of good (useful, acceptable, spectacular, unexpected etc.) outputs generated over the number N of attempts to generate them:

$$p = n / N \tag{1}$$

A goal is to get close to the value 1 for p; e.g. to produce for each generative run a “good” (useful, acceptable, spectacular, unexpected etc.) result. What we regard as good and how we measure the quality of a generated output, is a different question of its own. In a favorable case, the generator contains sophisticated measures, acting like filters through which only the “good” solutions are allowed to pass. In an unfavorable case, the evaluation of generated results is a separate, post generative process, where for each generated output it is to be decided, whether it will be rejected, or accepted as useful. For the drawings discussed here, p is approximately 1 / 3.

When we analyze generators with reference to their evaluative schemes we find an open list of approaches, for example:

(1) an explicit performance function (like greatest velocity, lightest weight, greatest stability etc.) is employed. Such performance functions are widely employed in optimization techniques

(2) a large number of assumptions and of personal preferences are elevated to the status of axioms and parameterized for manipulation in various ways

(3) ad hoc input from the context of the problem space is used to feed a generator

(4) a set of procedural rules is operating on a carefully constructed morphological structure

(5) a set of transformations is applied to an arbitrarily chosen input (traffic data, weather forecast, my left shoe, the sound of an engine, the sequence of cigarette brands in a vending machine, a song, movements in a video clip, an image drawn from the environment, etc.)

(6) a set of variables resulting from a strict rational analysis is manipulated by a player following specified rules

(7) etc.

Whenever judgment comes into play, our decisions are grounded on “Weltanschauung”. We unavoidably disembark from objectivity and have to resort to argumentative persuasion. And judgment (evaluation) is everywhere in generators. The seemingly trivial selection of a pair of coordinates x,y for further processing may draw on a preference structure which is hidden further down in the generator, where allowable ranges may have been explicitly stated as a consequence of some other chain of considerations.

But this is no harm as long as no claim of “optimum”, rightness or truth is made. It is one of the astonishing experiences encountered in the generative approach that surprisingly unexpected results may pop up, which trigger our fantasy and our imagination and which are leading to unexpected new viewpoints.

3.Small Elements in large Arrays

I talk about drawings, which are produced with a generative program, and which are executed on pen plotters. Pen plotters, a type of first generation computer periphery, have become extinct and they have been replaced by other, more efficient printing technologies. There is however reasons to prefer them to printers, particularly for art motivated output. The calligraphic quality of a line produced mechanically by a pen is of special interest for the type of drawings discussed here.
The experiments generating such drawings, and the generative systems, which have been designed to produce them, are regarded, as exemplary models for the design of generative systems as such, because they display all the difficulties of such systems, but they do this in a comprehensive, easily understood manner.
It is regarded an important goal of these experiments, to program generators which produce results with a minimum of effort, and I like to categorize this approach as “Generative Minimalism”. The resulting drawings should be of high calligraphic quality and leave ample room for associations and interpretations. As a justification for choosing the topic “Small Elements in Large Arrangements” I refer to the following list:

(1) Such elements are found in many different forms and on many scales of our environment such as: In views into a landscape, the grasses on a meadow, in the branches of trees, in the leaves on trees, the pebbles on a beach, in the asphalt cover of roads, on walkways, in the tiles of roofs, as stones in old and new walls, etc. Small elements in large numbers and arranged in endless varying patterns are very frequent in nature and in man-made environments, and they are familiar to us.
(2) “Repetition” is an interesting generative operation. To generate a structure of order using identical elements is possible with a very simple generative rule. The application of such a principle is in line with the intended “Generative Minimalism”
(3) The use of small, simple shaped elements in large arrays is an experimental scheme, which can be easily extended to complicated arrangements with any number of elements (of any complexity)
(4) For the design of the generators, no natural limit is in existence. Modeling such generators sheds light on the design problem of generative systems in a very general sense
(5) Arrangements of elements, which we find in nature, are rarely “geometrically clean”. More frequently, they are disturbed and contaminated, which is exactly one of the appealing aspects to us, when viewing such semi orderly structures.
(6) For the generative production of disturbances in the arrays, coincidental shifts of the elements are performed. Shifting elements may also be considered a minimalist generative operation, which again is in line with the intended goal of to follow a “Generative Minimalism”.

The illustrations [1], [2], [3] show some examples of small elements drawn from nature, where they are found in large numbers.

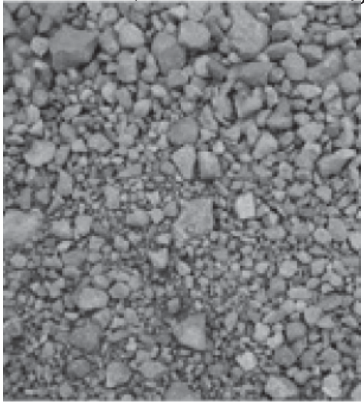

Fig.1 Stones in a river **Fig.2 Trees against sky** **Fig. 3 Leaves on the ground**

The illustrations [4], [5], [6] show some attempts to derive abstractions from the above for use in the drawings.

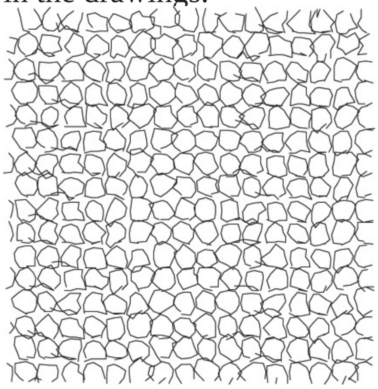
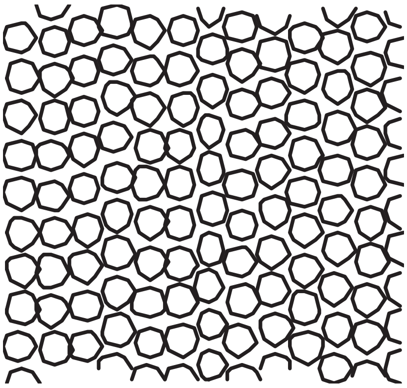
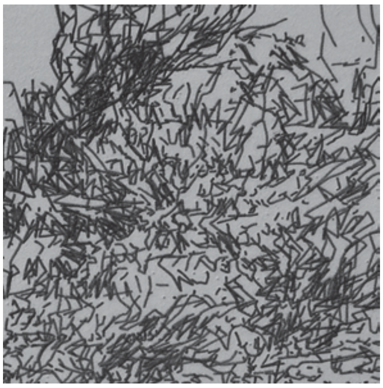

Fig. 4 "Potatoes" **Fig.5 "Circles"** **Fig. 6 Short strokes**

The illustrations [7], [8] and [9] show some examples of generated drawings, which use such elements.


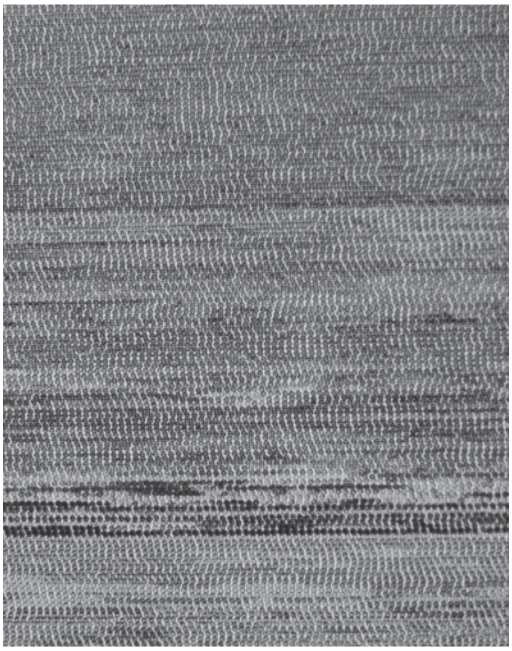

Fig.7 Example of drawing **Fig. 8 Example of drawing**

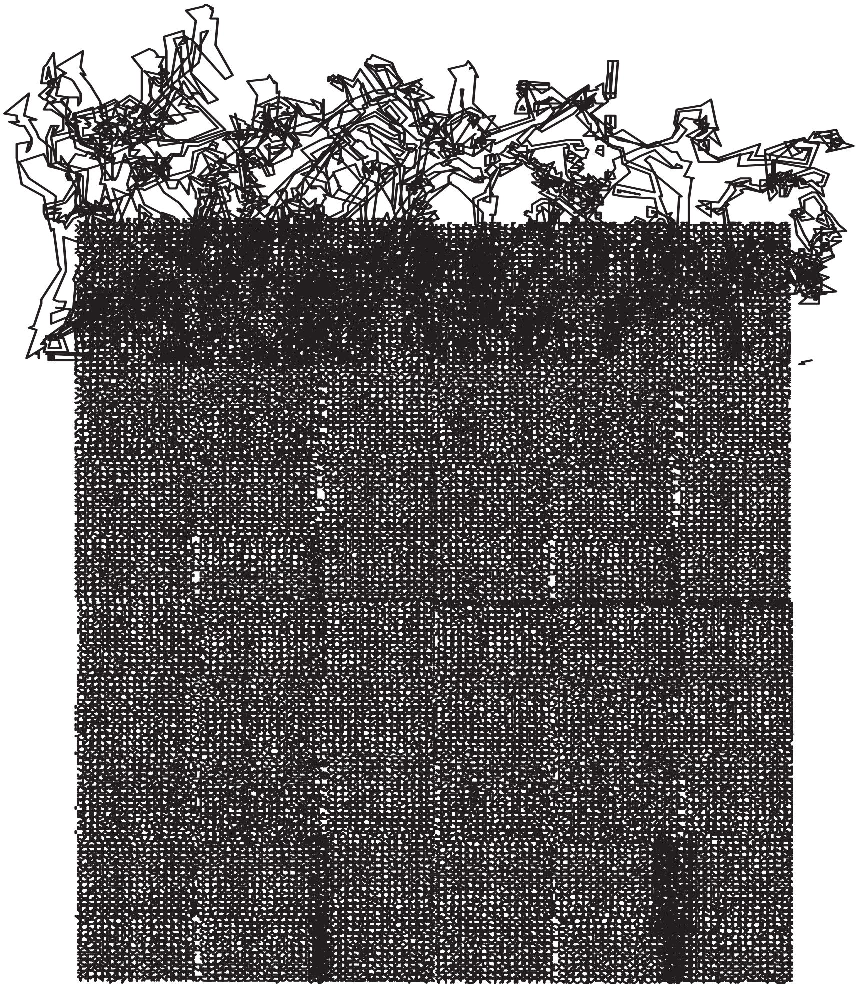

Fig. 9 "Cheer" (2003)

4. Summary

A summary of the discussed approach and its results is formulated in the following statements:

(1) small, identical or slightly varying elements in large numbers are placed in dense, contaminated arrangements
(2) elements and arrangements where collected from nature (environment), stored photographically, converted and abstracted, then used as suggestions for experiments
(3) Generators for arrangements were programmed in Spitbol [2], which generated the HPGL-code [3] for the plotter drawings.

References

[1] Horst W. J. Rittel, Melvin M. Webber, *Dilemmas in a General Theory of Planning*, Policy Sciences 4 (1973), 155 – 169.

[2] Robert B.K. Dewar, Mark B. Emmer, Robert E. Goldberg, *MaxSpitbol*, The SNOBOL4 Language for the Apple Macintosh Computer, Tutorial and Program Reference Manual Catspaw Inc., 1989.

[3] Hewlett-Packard Company, Interfacing and Programming Manual, San Diego, 1983.

Generation of Three-dimensional Cellular Automata

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Abstract

Cellular automata (CA) are mathematical models for complex natural systems containing large numbers of simple identical components with local interactions. Some researches have demonstrated how to apply this form-making methodology on architectural design, visual design, and even music composing. This paper attempts to introduce some new generative ideas about three-dimensional CA, especially on architectural and music interpretations. For the purpose of generating three-dimensional forms in the computer environment, AutoCAD software and AutoLISP language serve us as a visualization tool.

1. Introduction

Following Wolfram's original idea [1], CA can be extended to two-dimensional and three-dimensional structures in time sequence. Schrandt [2] and Mar [3] had given some interesting researches on these topics. Emphasizing on its application about form making, Krawczyk [4] demonstrated several architectural interpretations of CA. From such organized patterns, which derived automatically from a computer-aided CA system, we may give suggestions about architectural forms to designers. Particularly in the digital era, we may need a kind of mechanics to generate free forms and to transform the orthogonal facades for architects. Therefore, in this paper, I try to use a professional architectural drawing software to build CA models. It would be helpful for transferring these models to architectural elements.

CA own the power to produce huge amounts of patterned data and very profuse information could be assumed as formats of art. For example, music composition can be thought of as being based on pattern propagation and formal manipulation of its parameters. No wonder researchers started to suspect that cellular automata could be mapped into musical representation in order to generate compositional material [5]. Musical and architectural interpretations are two major interests in this paper.

2. The basic concepts

2.1 One dimensional CA

The research of cellular automata based on computer is one of the earliest forms of artificial life research. Conway's game of life, which sets rules about cells in a grid being on or off, is an original study. In the game of life there is a matrix of cells, and each cell can be alive or dead according to specific rules. We may call it one-dimensional CA. Owing to the similarity to the binary logic of 1s and 0s; it attracts early researchers' attention about the possibilities for computing.

The rules try to simulate the social relationship and the growth of the natural life. For example, if a cell has too many or too few neighbours it dies, from over crowding or lack of support. If it has a moderate number it lives or comes to alive. Each iteration of the game results in a new pattern of dead and alive cells. The patterns of cells can be mapped to various physical and artistic elements.

2.2 Three dimensional CA

Three-dimensional CA is an expansion of one-dimensional and two-dimensional CA. It deals with more complicated information about the relationship between cells; however, it also provides more spatial data to us. The basic concept of three-dimensional CA constitution in this paper is described as follows. A cell is concerned with its lower-layer neighbours; the amount of its neighbours makes it alive or dead. We overlap the several cell-grid layers and build a 3D-structure. In this computer system, the user may specify a first floor plan or generate the first floor plan by random number. Every upper-floor grid is checked by the sum of its nine lower-floor grids. The rule describes how many lower-level solid cells (0-9) can compose a upper-level cell. Users may specify a rule or let the random number make a rule. The first iteration of first floor life-power was transferred to upper floors, and we even can trace back up side down. With the benefit of computer, this study is built in the environment of AutoCAD and AutoLISP. That's the reason why we can try many cases using different rules and different sizes of the first floor plan and even different three-dimensional viewpoints very quickly.

2.3 Generation of form and music

The pure mathematical translation of cellular automata into architectural form includes a number of issues that do not consider built reality [6]. The interpretation or translation to a possible built form can be made after the form has evolved. Figure 1 is an example that designers create architectural forms with CA.

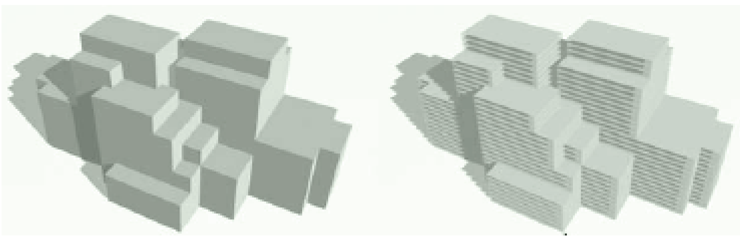


Figure 1. Architectural forms derived from CA. (source: Krawczyk [4])

To transform CA into architectural forms is easier to be realized than to map CA with music, because cells themselves have composed a solid and void space-structure. Some musical questions still could be remained as undetermined "black boxes"; for example, how can a configuration of cells represent a sound granule, and how can the relations between cells represent melody and rhythm? Researchers need mapping methods for translating CA into music composing. Recently, Miranda [7] proposed a Cartesian model in CAMUS to represent a triple, that is, a set of three notes. The model tries to transform spatial data into music; it has two dimensions, where the horizontal coordinate represents the first interval of the triple and the vertical coordinate represents its second interval (Figure 2). It's one of the known methods to interpret CA into music.

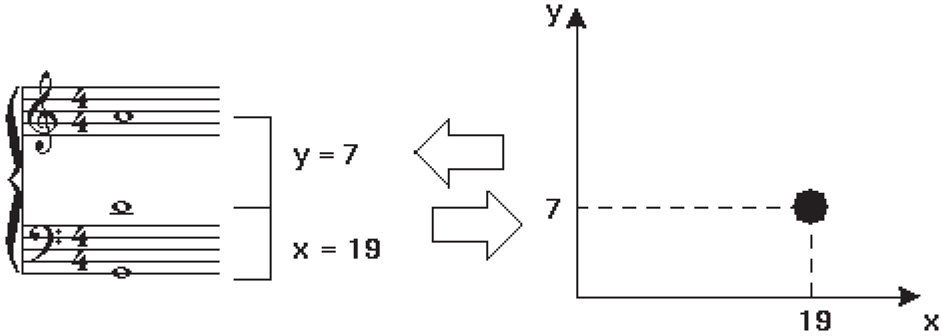


Figure 2. Mapping between music and Cartesian space. (source: Miranda [7])

3. From forming to transforming

In this section, let's discuss how to create forms and therefore to transform them. The first step is to compose the space structure; in other words, we need a method to use generative rules to create forms. The second step is to transform the structure derived from the first step.

In our computer presentation and simulation, we apply a life and death rule to generate the second floor, third floor, fourth floor and so on. The rule could be denoted as: "0D1L2D3D4L5D6L7D8D9L", L for life and D for death. V and X also represent same meanings in Figure 3. The number, from 0 to 9, stands for under-level solid neighbour cells in total. For example, 4L means it will survive when there are 4 solid or occupied cells at lower floor; 2D means it will be dead when there are 2 solid or occupied cells at lower floor. The colours represent the amount of cells. We use AutoLISP programs to generate 3D structures. We may use AutoCAD command to see this basic structure from different view-angles, and to "shade" this structure (Figure 4).

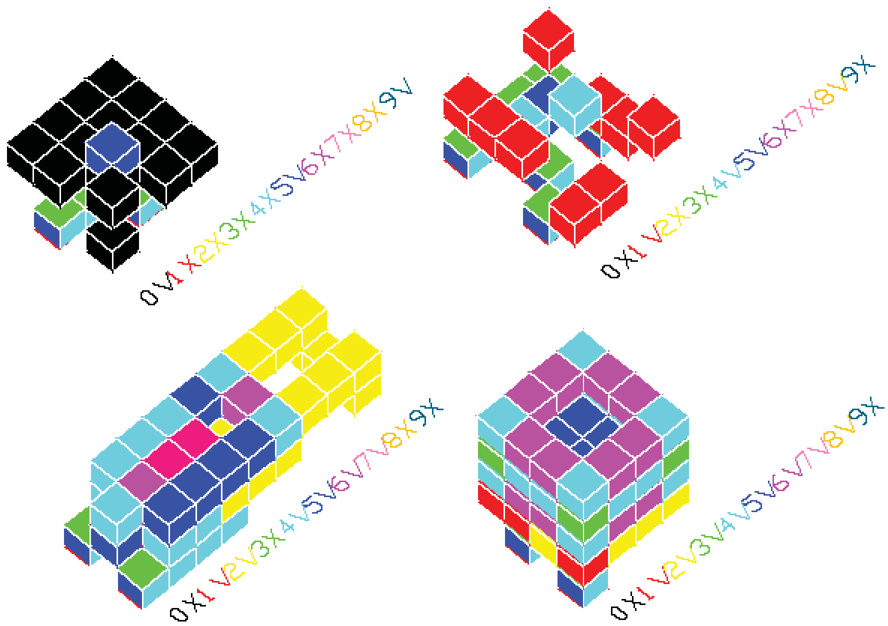
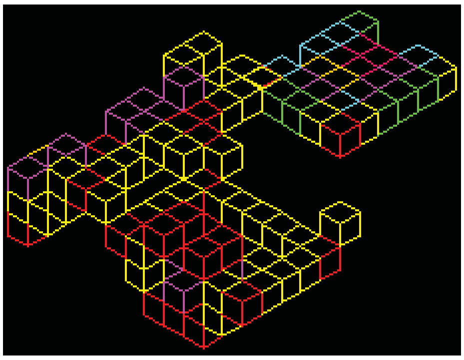


Figure 3. Basic examples of three-dimensional CA derived from different rules.



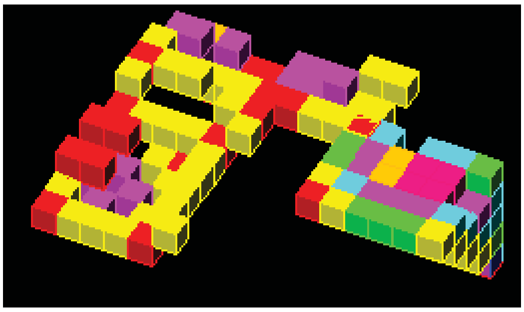


Figure4. A basic structure (left) and a shaded structure (right).

We give every cubic cell different colour for representing its total lower-level neighbours. For example, red stands for one solid cubic under it's lower-level neighbours (within 3 x 3 grids); yellow for 2, green for 3, bright blue for 4, dark blue for 5, magenta for 6, pink for 7, brown for 8, grey for 9, and white for zero.

3.1 Architectural form

Our CA system provides a basic construction of solid and void space. It could be an interesting inspiration for designer to create the composition of space. Like Figure 5, we embed columns in a cellular structure, and make it look more like a real construction. Here, allow me to explain again, the colour of every cube has its meaning. The colour is determined by the total of its lower level solid cells; therefore it is not just for fun. The ground level has no lower level; therefore, we give the 6 faces of a cell different colours.

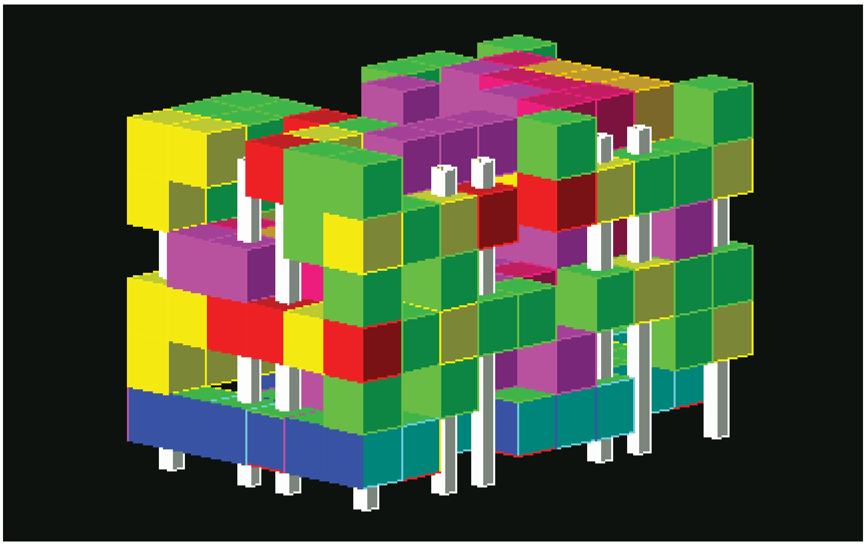


Figure 5. Embed columns in a cellular structure.

3.2 Transforming

Following is an idea of transformation. I put two strings into every cell for stretching its cubic-box contour (Figure 6). The strings connect four diagonal corners of a box. When a generate program runs, the simulation system will stretch the lengths and change the directions of these strings based on random numbers; therefore the whole structure could be transformed into a kind of "free" form. It is able to break the original orthogonal boxes when this program runs. The facades of a structure will be twisted seriously if we use this transforming rule many times. That's the reason why I put only two strings inside a box, because more strings stretched in a box will destroy this box and make it unrecognisable.

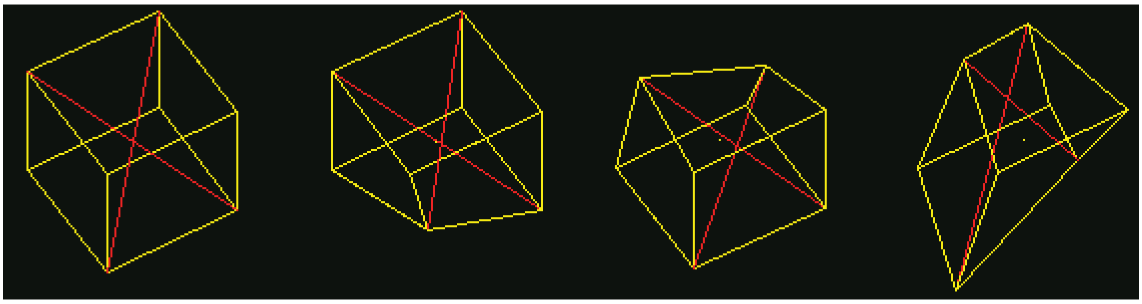


Figure6. A box with normal strings and three boxes with stretched strings.

In fact, when the simulation system stretches a string, it will stretch all the boxes whose corner is connected with this string's two ends. Therefore, the whole wire-frame structure is transformed. Figure 7 is an example to explain the original orthogonal structure and two transformed structures after applying different times of stretching-rules.

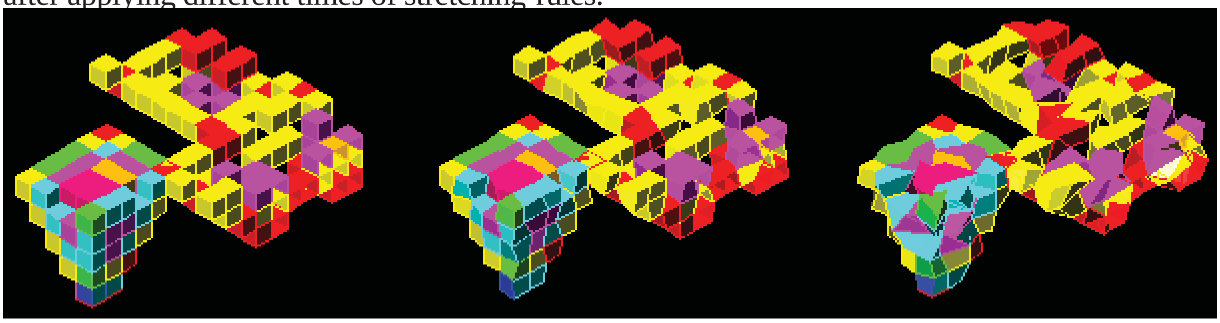


Figure7. An orthogonal structure and two transformed structures.

3.3 Generating different size cells

We may change the size of these cells with random numbers, which give the boundary of maximum and minimum lengths of every box (Figure 8). It vivifies the composition of a structure, too. This kind of expressions could be a good suggestive composition for designers, and for further manipulation.

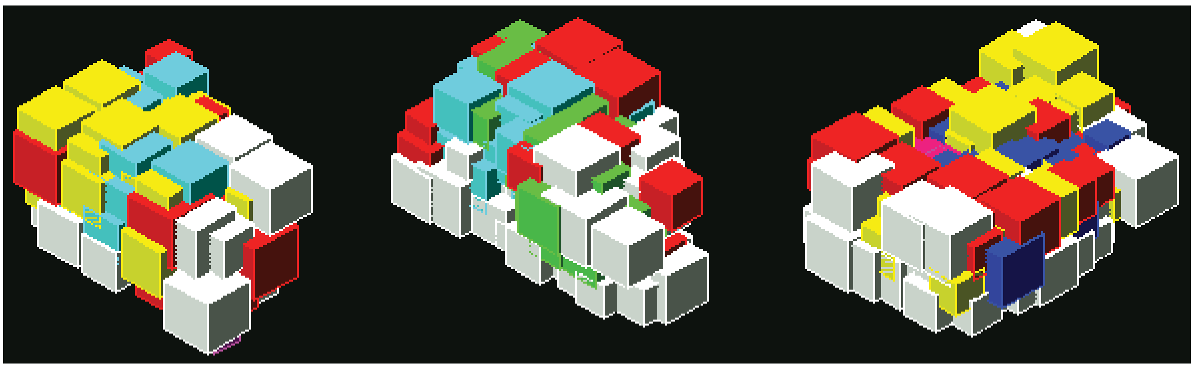


Figure 8. Random cell size structures.

On the other hand, it may give some suggestions and inspirations to design building's elevation. (Figure 9.) In this section, we may realize the diversity and creativity of three-dimensional CA. With the assistance of AutoCAD and AutoLISP program language, we may generate many space structures, and test interesting solid/void possibility in computer.

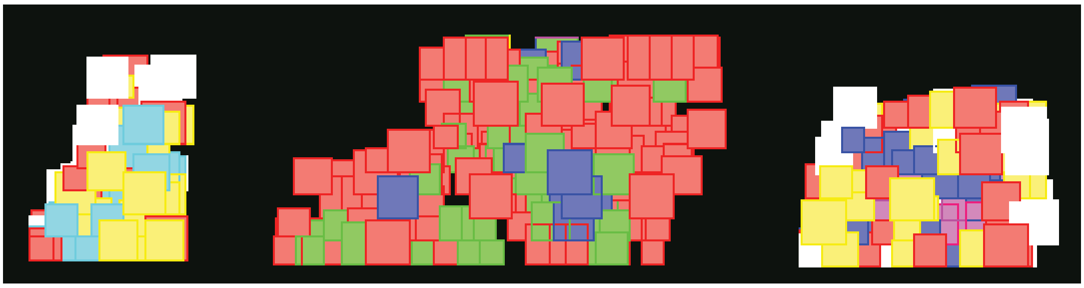


Figure 9. Simulation of architectural elevations.

As we know, a box has six faces. In the above-mentioned examples, all boxes are closed. However, we may open some faces of these boxes, or even erase some boxes in a structure if you do not like so many boxes, to create an open-faced structure. Demonstrating the inner composition of cells, we may display a construction with cubes and plates (Figure 10).

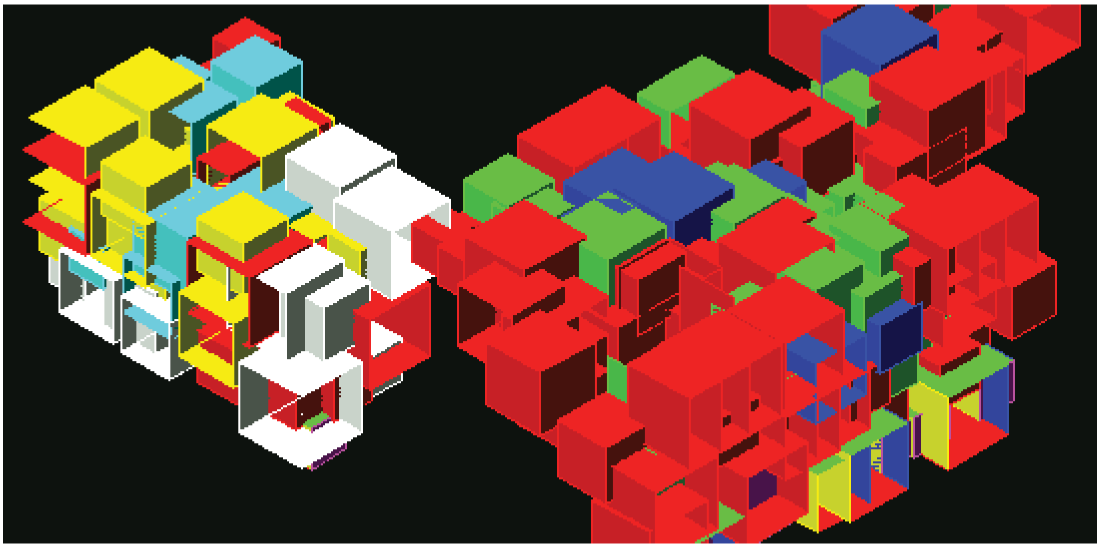


Figure 10. A structure with some opened boxes.

3.4 Random-sized cell structures

In this section, we use two above-mentioned methods together to create free-form random-sized cell structures. Obviously this generation can transform the original form a lot; the result seems more similar to natural organizations than artificial works (Figure 11). For example, it may look like villages that are located on a hill. Figure 12 has two pictures of Greek villages, Fira and Oia. There are some interesting similarities between our generative cell structures and these natural grown villages. For example, they both have cubic contour, plane roofs, vertical walls, horizontal layers, hierarchy and organic organization in particularly.

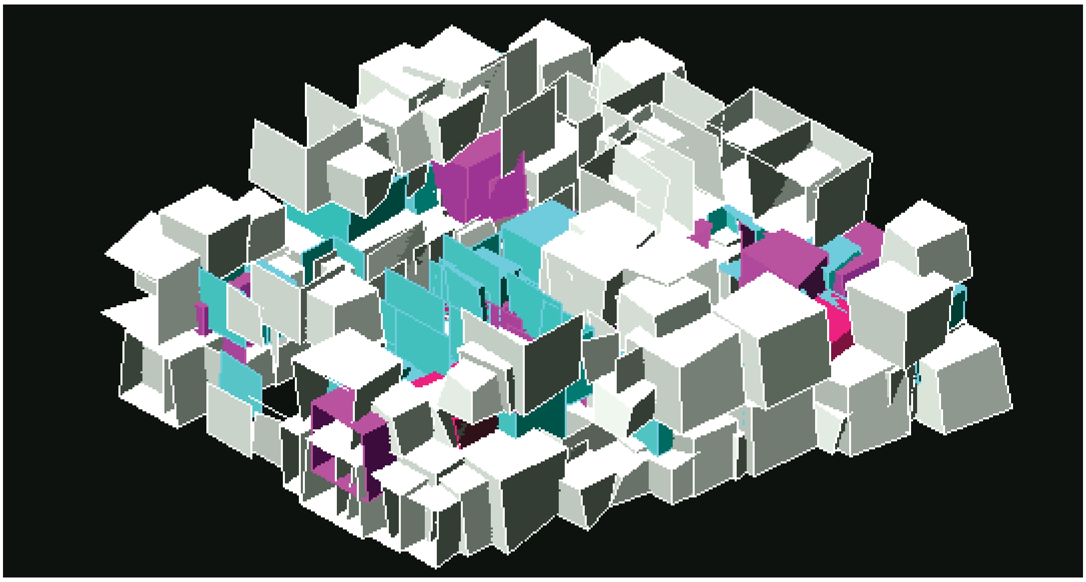


Figure 11. A structure with random-sized and twisted and opened cells.

Figure 12. Two organic cubic structured villages. Left: Fira, Right: Oia; Santorini, Greek.

4. Musical interpretations

Modern music has become an interesting discipline for the application of new scientific discoveries inviting composers to combine artistic creativity with scientific methods [7]. Based on the development of computer techniques, more and more composers turn to the sciences to supplement his or her compositional models. Particularly, artistic creations share the same sources of mathematics, nature, and biology, etc. By the same token, scientists also seem to show interest in the organisational principles to be found in music and other arts.

CA are computer modelling techniques widely used to model systems in which space and time are discrete, and quantities could be displayed as a finite set of discrete values. Therefore, the proposed three-dimensional CA could be a generative machine, which is able to create multi-layers cells. If we regard these cells located at ground level as fundamental tones, then we may apply generative rules to create upper levels. Take Figure 13 for example, we translate a piece of music into cells, and the location of cells match their melody and rhythm. In other words, we may see the ground-floor plan (left-up) as a piece of music. The second floor (3,4), third floor (5,6) and fourth floor (7,8) are generated from ground floor (1,2).

In theory, we may derive as many levels as we wish. Finally, these cell-plans composed tones, chords and melodies. If we use another rules, perhaps the results of generation and the melody will be very different. In this case, maybe it is not a good piece of music for everyone; however, it's an interesting way to generate not only cubic boxes but also music.

We may use it in another way. If we take a whole piece of music as a very long ground-floor plan, we may generate a whole piece of music at one time. With the assistance of computer techniques, it would be a quite interesting way to compose new music.

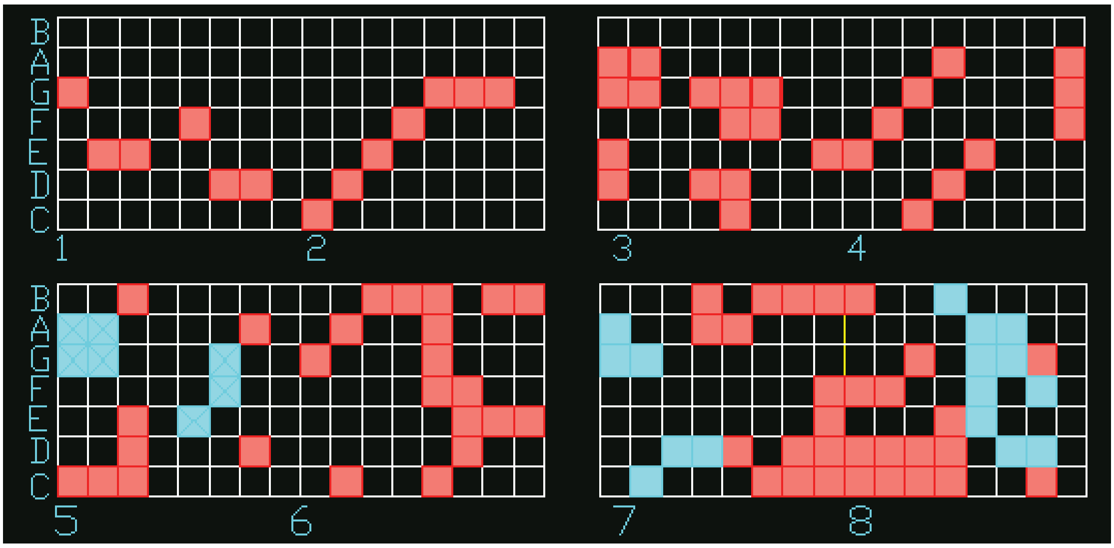


Figure 13. Floor plans representing a piece of music.

5. Conclusions

The results of the cellular automata interpretations are very encouraging. They are good evidences that both architectural and musical forms can be successfully modelled by using cellular automata. Nowadays designers probably have learned to shift their issues from forming to transforming [8], and from designing one artificial product to creating a family of art [9]. However, we still need more ideas about generative design methods in various artistic domains. In architectural experiments, this paper provides several ideas about space transformation and construction. In musical experiments, this paper tries to translate spatial relations to compose music. It should be noted that it is not the only way or correct way to utilize CA. There ought to be many interesting or global principles creating both architectural and musical forms. Perhaps the next step would be to integrate CA and neural systems in order to study the relationship between form making, design thinking, and behaviour controlling. In general, we found that a CA system could produce profound data sources until the next cell generation dies. We think that in this case it might need a kind of rebirth or regenerative model for continuing to grow cells. As architecture and music are primarily cultural-related phenomena, sometimes we need to think about how to employ CA techniques that can produce results sensible, content, or at least reasonable. Otherwise it is just an interesting computer game.

References

[1] Wolfram, S.: 1984, Cellular Automata as Models of Complexity, *Nature*, 311, pp. 419-424

[2] Schrandt, R. and Ulam, S.: 1970, On Recursively Defined Geometrical Objects and Patterns of Growth, in A. Burks (ed), *Essays on Cellular Automata*, University of Illinois Press, Urbana, pp. 232-243.

[3] Mar, G. and Denis. P.:1996, Real Life. *International Journal of Bifurcation and Chaos*, Vol. 6, No. 11, pp. 2077-2086.

[4] Krawczyk, R. J.:2002, Architectural Interpretation of Cellular Automata, *Generative Art Conference*, Milan, Italy. pp. 7.1 – 7.8

[5] Miranda, E. R., CAMUS-- A Cellular Automata Music Generator, http://website.lineone.net/%7Eedandalex/camus.htm#intro

[6] Krawczyk, R.: 1997, Programs as Pencils: Investigating Form Generation, *ACADIA 1997 Conference*, Association for Computer-Aided Design in Architecture.

[7] Miranda, E. R. Evolutionary Music Research -- Sound Synthesis and Composition, http://website.lineone.net/~edandalex/celautom.htm

[8] Soddu, C.: 2000, From Forming to Transforming, *Generative Art Conference*, Milan, Italy.

[9] Fischer, T. and Herr, C. M.: 2001, Teaching Generative Design, *Generative Art Conference*, Milan, Italy.

Reflections:
The Creative Process of Generative Design in Architecture

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Abstract

This paper explores the connections between cognitive design processes and the composition of software code which generates architectural forms autonomously. Similarities are drawn between the pedagogic process (teacher – student) and the crafting of applications to generate forms (programmer/designer – computer). Through an interactive iterative process of generative design and programmatic intervention, architectural forms evolve and are refined.

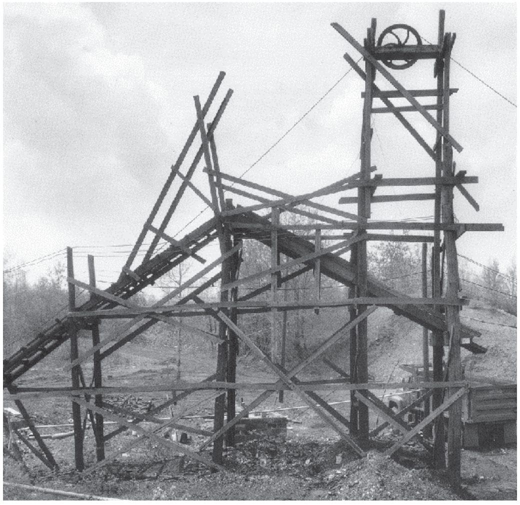
Background

One can argue that the architectural design process—pen/paper or CAAD—is driven by a process of communication which is part of an iterative loop where feedback, interventions, and reflection occur. The process is framed within the realm of multiple goals or challenges: the communication between the goals and the physical manifestation of the design allow the design and its intentions to emerge, fortified and refined. Creativity within the design process is a complex play of conversation, variation of shapes, and ideological notions within certain determined limits [1]. Within design education, an instructor (architecture studio professor) works under similar circumstances with design students. While not advocating any position on design education or the principles taught within, the position this paper takes describes the instructor's role as instantiator of a working framework. Within this framework, the instructor influences and challenges the student in an environment open to the questioning of all ideas, encouraging the student to explore their own design sensibilities, methodologies, and craft [2]. Similar open environments can be designed within the realm of generative design and the interaction between a designer and a computer program. This paper explores the potential of mapping instructor based feedback into an iterative generative design process.

Within the realm of architecture and design, technology interactions are becoming more sophisticated. Traditionally, computer/architect interaction centered on models of efficiency and documentation. Recently, this interaction has shifted away from productivity tools and moved towards design exploration and experimentation. One of these fields of exploration is generative design. Within architecture generative design can be defined as the approach of developing applications, or systems which can develop, evolve, or design architectural structures, objects, or spaces more or less autonomously depending on the circumstance. This paper shows that generative design has great potential for uncovering new avenues of research within creativity and computation.

Within this paper, all forms (and by-products of forms, images, rendering, etc.) are generated entirely by programmatic output. The experiment is set up to use the process of studio exploration or a studio charette as an analogy for the generative design process. The two processes were explored in parallel from concept, exploration, refinement, to final design. Ultimately, the experiment is an exploration of creativity, aesthetics, and the creative process. It embraces the expansion of a problem's solution space rather than the traditional computational approach of optimizing a solution.

Inspiration and Process – Development of the Framework

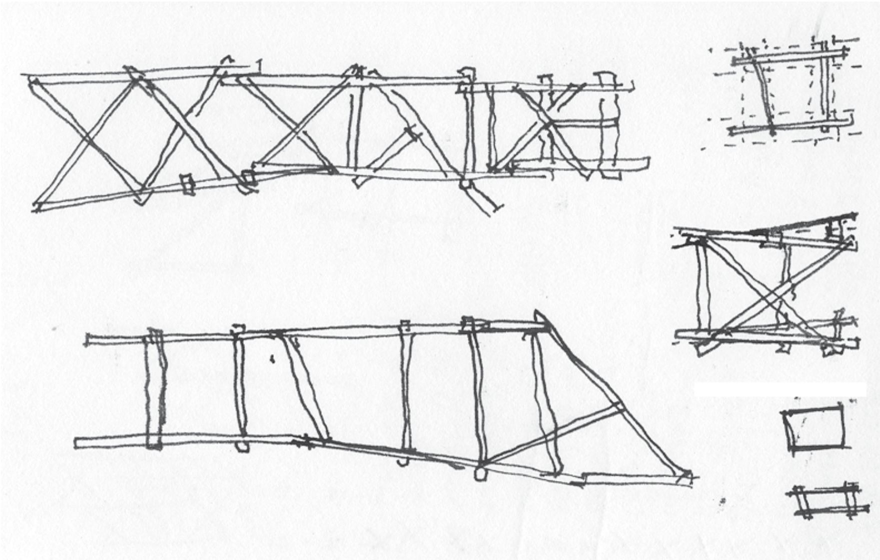


Okay Coal Co., Tremont, Schuylkill County, Pennsylvania, USA 1975 [3]

Start with a Goal

In this experiment, the challenge is to generate structures informed and inspired by Bernd and Hilla Becher's black and white photographs of Mineheads. The underlying experiment directive is the investigation of the aesthetic cohesiveness of the Minehead forms as opposed to the physical or functional attributes of the structures. Looking more closely at the photographs from an aesthetic viewpoint, one notices a haphazard yet purposeful interaction of the structural elements: a minimal subset of items form a bricolage of structural members whose sole function is to support coal extraction and rock movement.

With the definition of the project challenge and internal conceptualization of the Minehead aesthetics, the process of developing a framework initiates a series of traditional representational sketches. These sketches become conversations with one's self—in-depth investigations of forms, repetitions, patterns, emerging and diverging relationships, similarities, and differences.



Exploration sketches

Describe Consistencies

To determine the generalized code framework, one must first study the Minehead structures, looking for descriptors: potential classifications, hierarchies, general material interactions, and member placement. These descriptors are possible routines or procedures which may be formalized and transformed into generative algorithms. One notices while looking at the structures that they are made from multiple nominal structural elements. One also notices that the elements are not cut to size, but are cut to an approximate size. The elements, some longer than their joining counterparts, slip past intersection endpoints. The general compositional shape of the system, principally driven to accomplish a functional task, is also influenced by the imprecision of construction resulting in slight shifted angles which make up smaller orthogonal units, or triangulated shapes.

Formalize Code Parts

Once descriptors have been created, they need to be developed into generalized code (functions and routines) to produce visual output. Generalized code within this experiment is defined as a structured system for output which is generated entirely from random input. For example, if a routine is set up to make 2 points, those points can be in an entirely random (X,Y,Z) coordinate position.

Below are two different outputs from the same set of basic functions in the system; both outputs use four random coordinate points to set up a frame structure. A few things to note about the output: the members (single structural units) are different random sizes within a visually constrained system; the members extend beyond the initial four-point system; and the points are not coplanar, but close to existing within the same plane (once again, constrained by visual interaction). All three of these examples express the aesthetic characteristics of the Minehead structures.

Four-point structures. Two different frame-like outputs from the same set of basic functions.

Set Range Potential

Generative code is typically executed (or called) many times during the generative process. To create a meaningful output range, one needs to develop systems with range potential. These systems are built in accordance with the challenge aesthetic from the initial form analysis. The ranges relate to the general tolerances accepted for conditions like slipped members or modified angles. The systems are also driven by random number generation within certain tolerances. In addition to set range potentials, occasionally it may be necessary to break out of preset ranges to allow for unexpected, and potentially illuminating, outputs. Therefore, it is important to code scenarios where unpredictable outcomes can occur, even if they are statistically unlikely.

Evaluate Output

As the code begins to generate visual forms, one needs to study the output of multiple iterations. Through multiple iterations one begins to see patterns, potentials, and unexpected conditions. These discoveries and learnings are then used to modify the code iteratively to generate forms fitting within general (visual) aesthetic expectations. This is a significant point to reflect upon: the most common misconception about generative architecture is that the system is entirely random. In an experiment such as this there are an infinite number of potential solutions, but these solutions will fall within certain groupings of visual and contextual appearance because the range of randomness is carefully coded into a variety of algorithms and managed by subsequent generations.

Add Complexity

Once generalized code has been developed to work at a fundamental level, it can be augmented to accept additional directions. For example, the structure below extends the development of the simple “frame” by combining it with another “frame” which shares a common structural member with the original as well as formal extensions at the joints.

2 four-point structures sharing a common structural member.

Increase Tectonic Potential

Once the fundamental algorithms have been created, the next stage is to develop and refine the concept by applying architectural and formal conditions. This is accomplished with the introduction of other tectonic elements, planes, structural systems, and surfaces. This phase of the process becomes more influential as one departs further from the initial design inspiration.

2 four-point structures with additional structure. creates a more complex frame-like form

Iterate

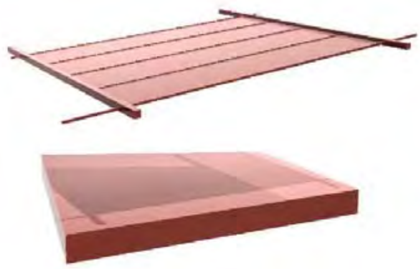
As one learns more about the underlying code, and the aesthetics which emerge, the entire process and its stages are usually repeated in order to refine the code, the visual outputs, and the system capabilities. The user-computer/teacher-student interactions grow more complex as the iterations of the proceeding process steps increase. Throughout the process, one needs to look for new design opportunities or unexpected inspirations to explore. These are the critical junctures in the teaching/coding process.

Departure from the Initial Inspiration

Generative design within a multi-output space has the potential to promote a greater degree of novel creativity. Boden suggests the transformation of conceptual or generative space allows for new mental structures to arise which simply could not have been generated from the initial set of constraints [4]. Within this generative experiment, viewing a variety of distinct forms prompts one to ponder and explore future possibilities and developments.

While working with the frame-like forms one could imagine alternate architectural possibilities. What if the frame was a roof structure? What if a floor could be generated from the frame, but be related at the same time? What about other structural elements? These spatial musings lead the experiment through unexpected turns.

2 frames, one with plane



frame with plane, and floor plane

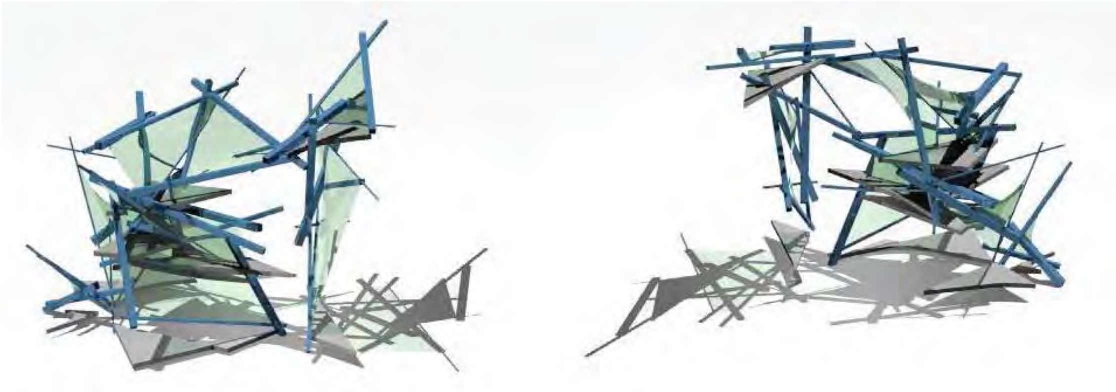
Framework Experimentation

The entire experimental process outlined in this paper is comparable to the interaction between architecture studio instructor and design student. Mapping a simplified version of the instructor/student interaction onto the generative design process, we see the computer outputs as student works in progress and the generative designer in the instructor role investigating the output, looking for potential or conditions which allow the design to progress further. Often the output of this mentor relationship yields surprises and refreshing new paths of inquiry—conditions and interactions of form not previously explored while working solely with the Mineheads aesthetic. These “aha” fragments, appearing throughout the process, allow the design to progress and the solution space to broaden, encompassing new threads of thought. In this experiment, the breakthrough in understanding occurred upon realization of the architectural and spatial potential of the Mineheads code aesthetic.

Putting the Framework to Use

Using the fundamental algorithms described in the “Inspiration and Process” section above and applying, combining, and modifying these over multiple generations of interaction, structures begin to emerge from the system. In general, the visual density of the output makes it difficult to evaluate looking at a single rendering. To view the entire 3D object, the forms are visually analyzed and interpreted through animations (turntable to see all sides), or through OPENGL visualizations in environments where the form can be rotated and investigated manually. The images represented in this paper are snapshots from simple animations; these animations and larger images can be viewed in more detail at the website.

First Output



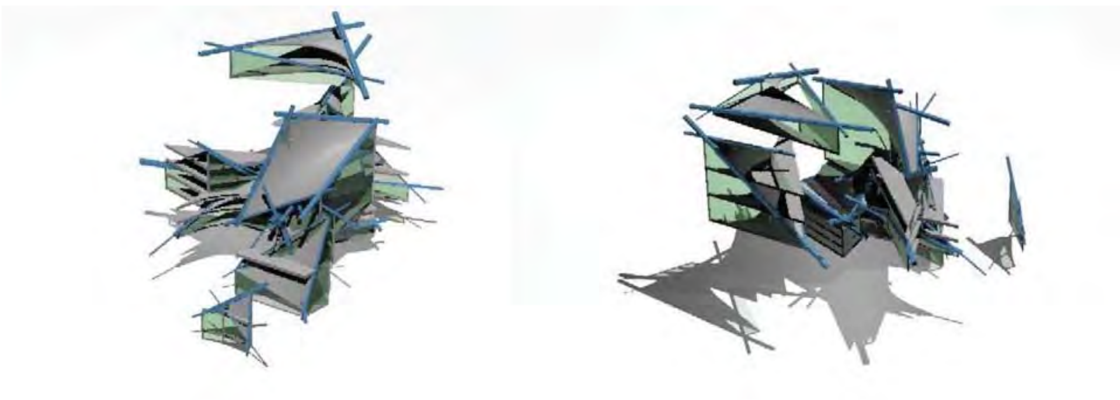
First output of program struct01, 2 views [5]

The complexity and richness of the structures which emerge derive from the formal interaction of multiple tectonic elements generated simultaneously. Running the simulation several times reveals compelling spatial arrangements grouped within a similar aesthetic family. After viewing several generations, the next logical step of the process is to introduce more architectonic textures and features.

Over subsequent generations, the form takes on different characteristics with the introduction of other elements and through progressive refinements. Once the basic algorithms for generation have been established, the next phases reflect the concept of real-time design. Forms are generated, assumptions are made from the output, and the code is influenced once again with more architectural modifications and new directions.

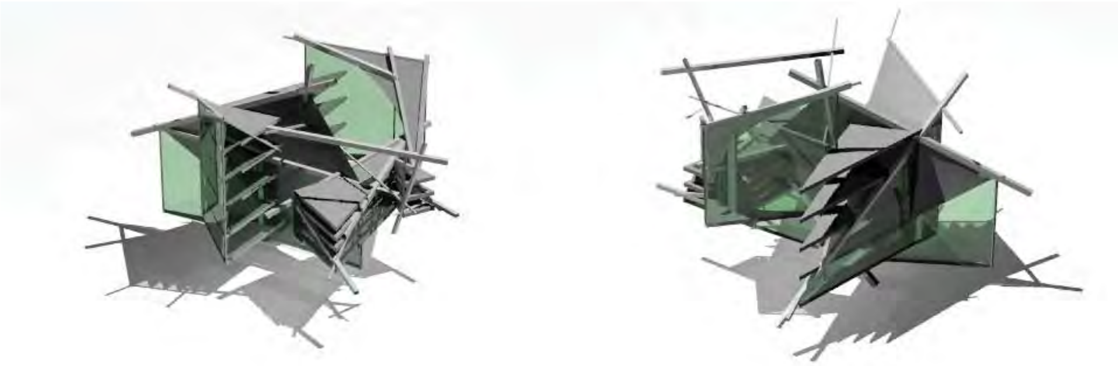
Moving Towards Architecture

The next generation reflects the first significant architectonic intervention with the introduction of horizontal planes and the addition of solid roof-like membranes. The horizontal planes beneath the frames immediately convey a semblance of scale. Vertical planes are also introduced as transparent walls to resemble glass.



Output of struct02, introduction of planes, 2 views [6]

After the introduction of planes, the next generation attempts to introduce variability into the fundamental structural elements such as the generation of frame systems without related planes. Below one notices “roof” structures that contain planes and “roof” structures that are open. Floor structures are also unpredictable both in terms of the number of floors and in their relative distances.



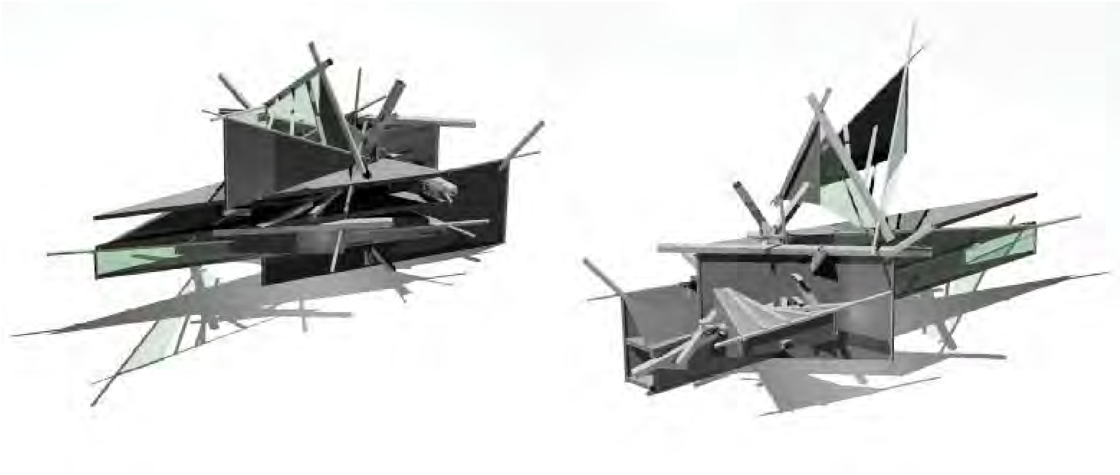
Output of struct03, introduction of variability, 2 views [7]

In addition to variability in the “roof” structure; options are selected for vertical wall structures, allowing the potential for both transparent and opaque vertical surfaces.

Output of struct04, variable planes, 2 views [8]

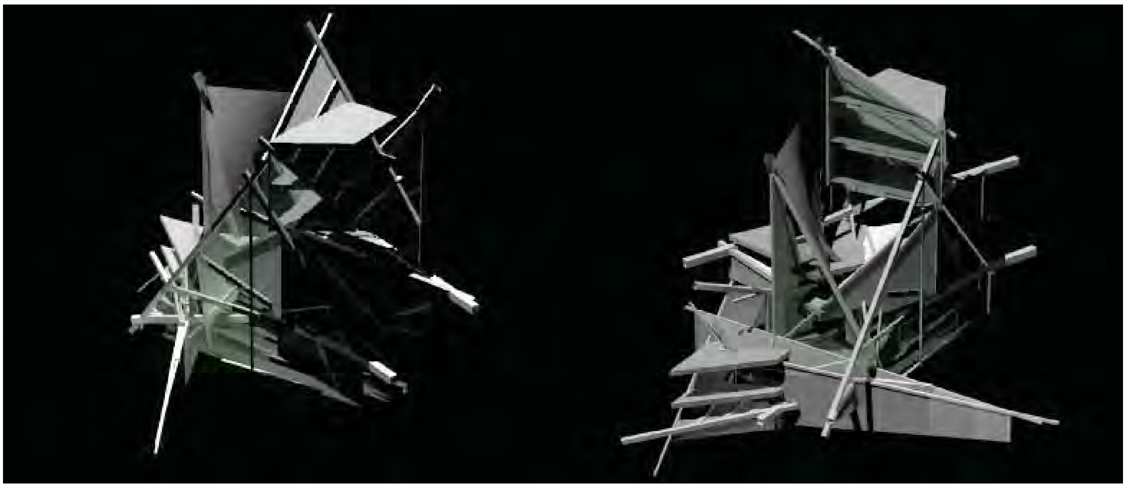
Adding Refinements

Generations are examined to explore refinements such as structural elements which connect roof and floor members. Other refinements include architectonic features such as mullions within the transparent planes to break up the homogenous surfaces.



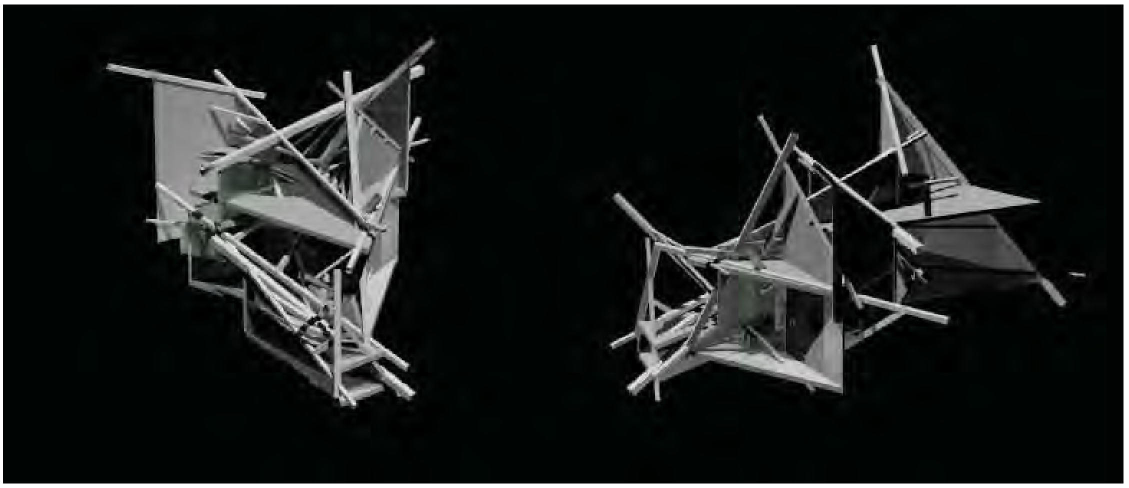
Output of struct07, additional architectonic features, 2 views [9]

Alternative spatial arrangements are introduced with stacking of elements near or on top of each other, creating distinct "pod-like" units, or "clusters". Each arrangement technique is investigated, exploring the spatial richness of the open space between forms as well as the complexity of interactions within the intersecting forms.

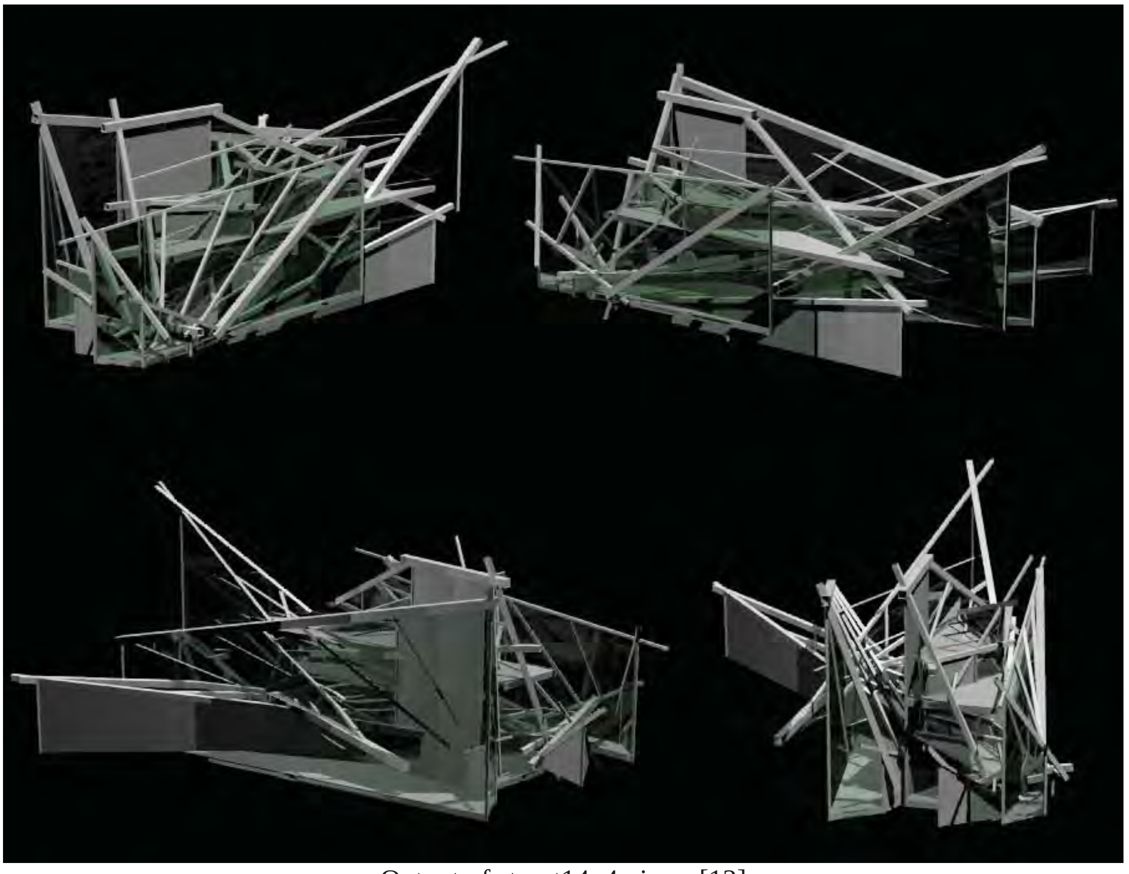


Output of struct10, pod-like clustering, 2 views [10]

Below is an example of a more horizontal or linear progression of the frame forms. Positional variation was superficially explored in this experiment and explored in more detail in other experiments.

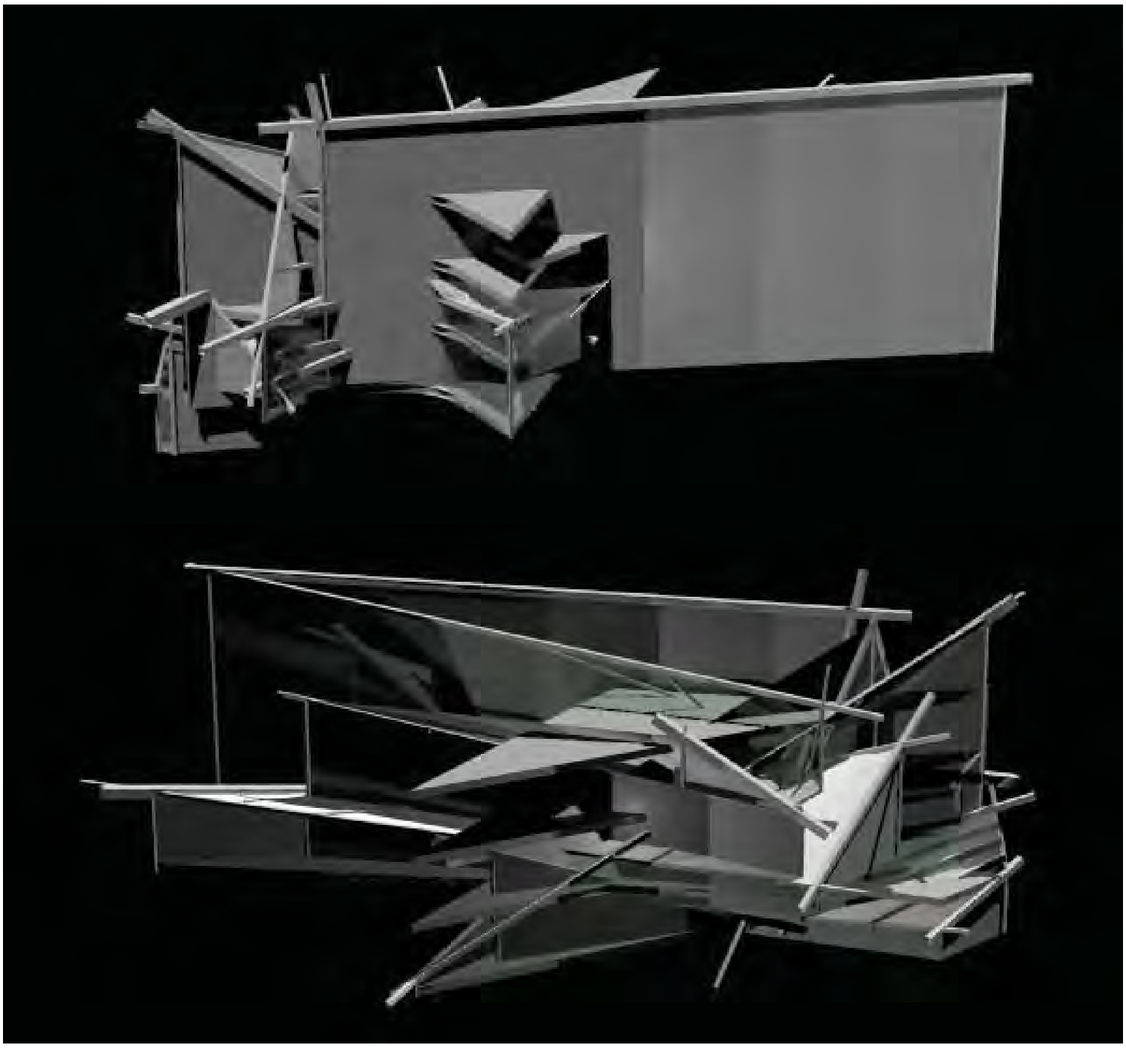


Output of struct13, linear progression, 2 views [11]

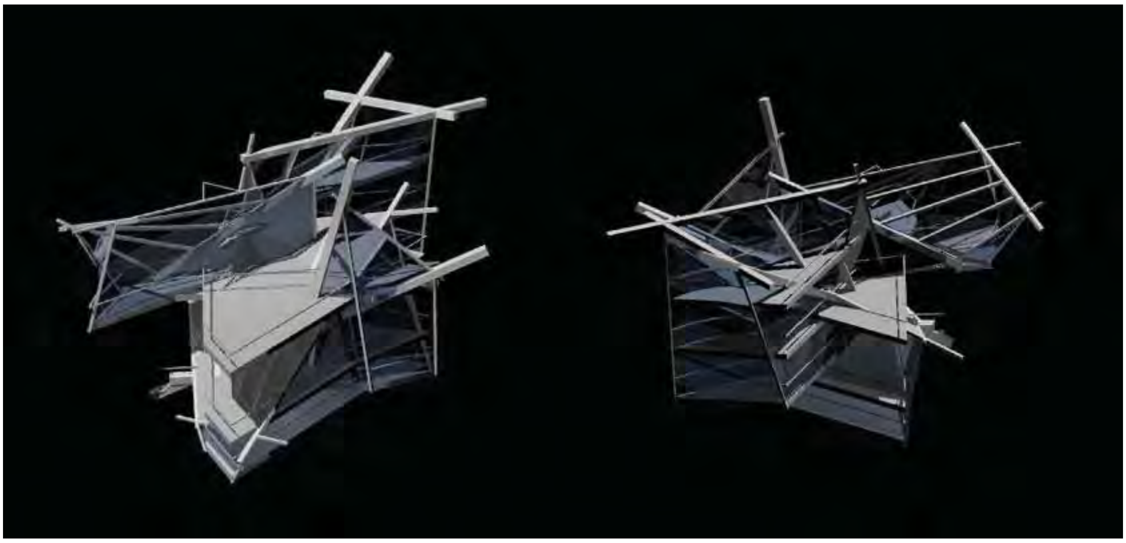


Output of struct14, 4 views [12]

Another generation applies refinements of more delicate architectural elements such as railings along planes or lighter structural elements in planes and in the transparent objects.



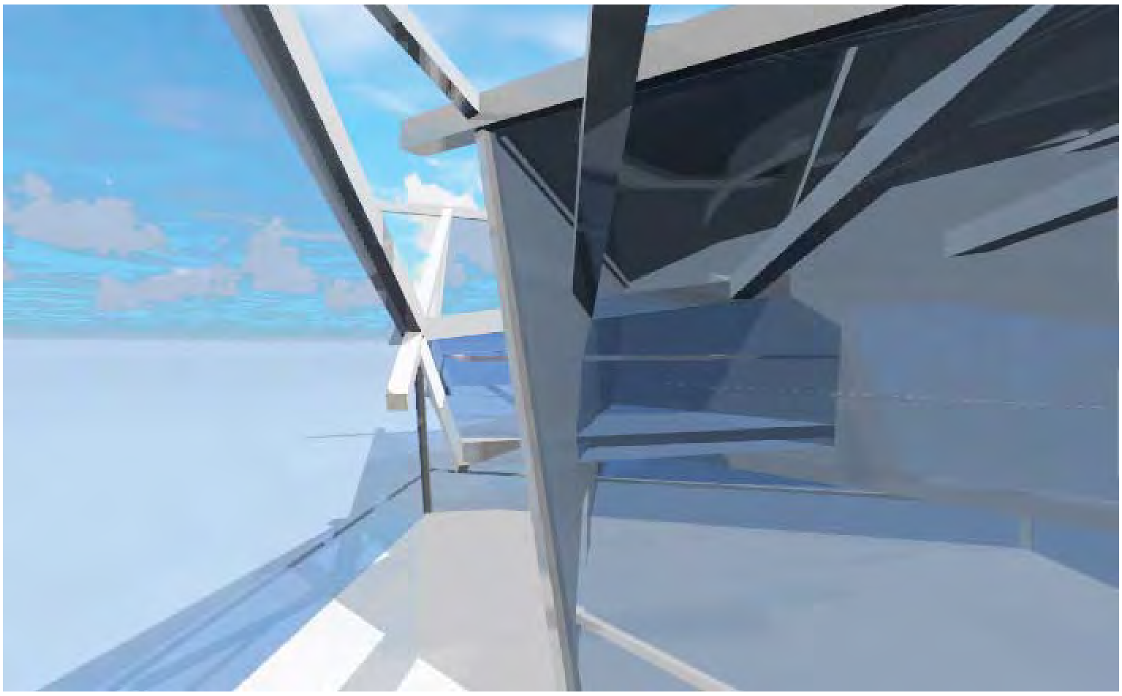
Output of struct17, addition of lighter elements, 2 views [13]



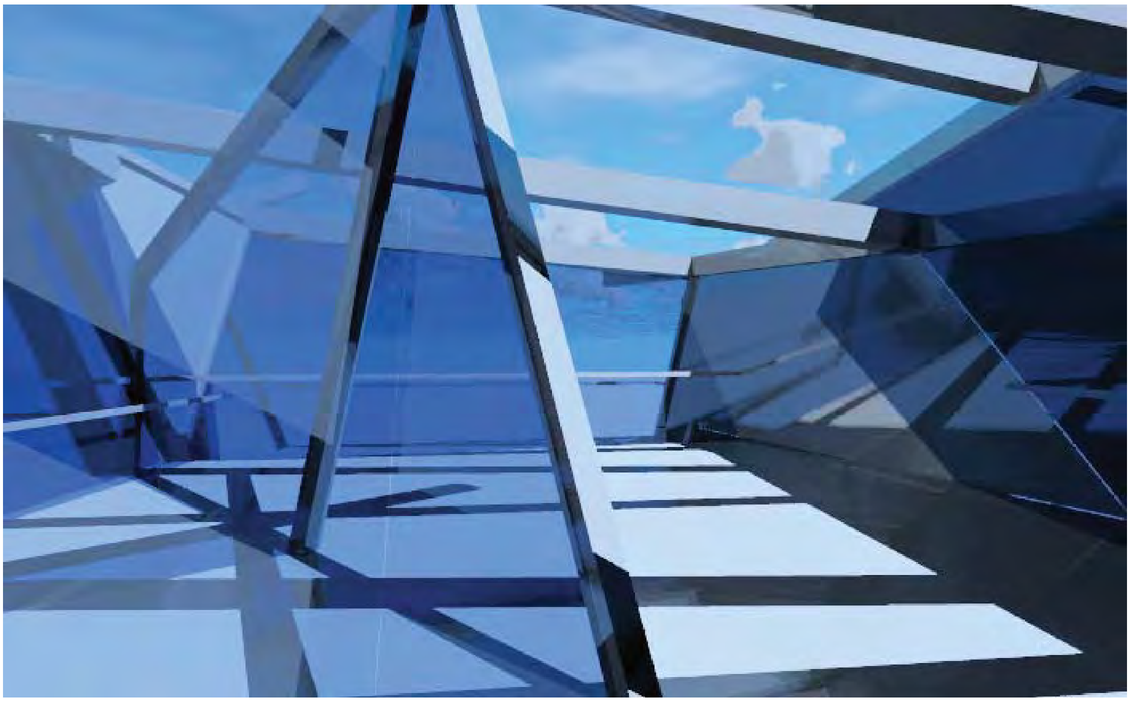
Output of struct20, railings and more refinement, 2 views [14]

Inside Out

The final experiment positions the viewer within the generated structures, evoking the feeling of being inside the virtual spaces and forms.

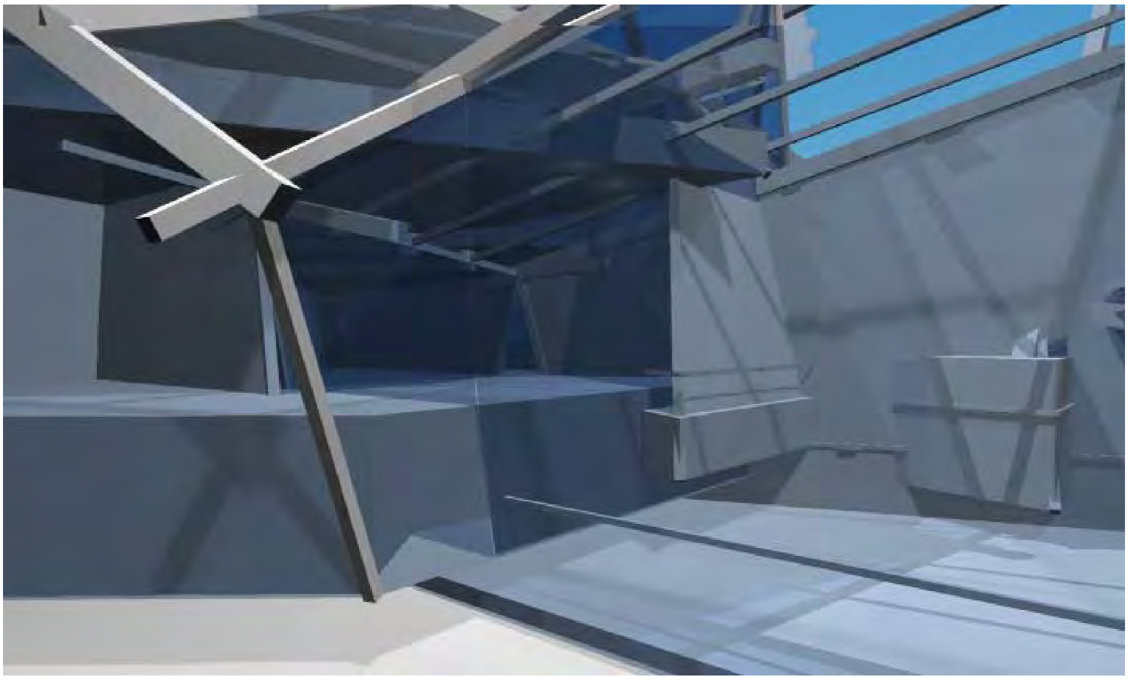


interior view [15]



interior view [16]

The examples shown within this paper are only a few of the thousands of images which were generated, based on hundreds of generations, and 20 code versions. More examples, images, and animations can be found on the website.



interior view [18]

The goal within experiments of this type is to gain insight into computer and human design interaction and allow us to explore the cognitive processes involved in acts of creativity. The generated objects are not meant to be inhabitable or functional but are explorations of creativity between a designer and interactive computer code. One needs to be facile in both design comprehension and in computer programming in order to see the process as an improvisatory, inspired sketch rather than a tedious programming experiment.

Conclusion

Human and computer interaction within the design realm exists on many levels, occupying coexisting methodologies and working processes. This paper describes one experiment which uses generative design as a conversation, a sketching tool, and a working relationship akin to a professor and student. In the process, communication and understanding exist, and Knuth's statement that "a person doesn't really understand something until he teaches it to someone else. Actually a person doesn't really understand something until he can teach it to a computer" [17] is explored. Ultimately, the experiment itself represents a personal approach to visual form generation in purely interactive and aesthetic terms, as a visualization tool for "sketching" formal occurrences within the realm of controlled random possibilities.

References

[1] Nesbitt, Kate (editor) “Theorizing a new agenda for architecture”, Princeton Architecture Press, 1996
[2] Schon, Donald, “Educating the Reflective Practitioner”, Jossey – Bass Publishers, 1989
[3] Becher, Bernd and Hilla, “Mineheads”, MIT PRESS 1997
[4] Margaret Boden, Oxford University Press, The philosophy of artificial life, 1996
[5] Krause, Jeffrey, struct01; seed: {DC81BB46-8BAF-40e4-95B4-81D1EC84582E}, 2003
[6] Krause, J, code: struct02; seed: {25CB3495-CBDC-48ca-82DA-0CBDA6039116}, 2003
[7] Krause, J, code: struct03; seed: {10744C57-652A-4f25-81B4-577DDDD13D72}, 2003
[8] Krause, J, code: struct04; seed: {B9BF5FF5-1AC7-47b9-B48D-A8EADA1C748D}, 2003
[9] Krause, J, code: struct07; seed: {44431F71-C233-4abb-BCC6-17C3868CD157}, 2003
[10] Krause, J, code: struct10; seed: {69025635-F6F9-4183-B6F1-AA186E29EA7B}, 2003
[11] Krause, J, code: struct13; seed: {42125D96-F7E3-4fed-B616-1E7C00E772BF}, 2003
[12] Krause, J, code: struct14; seed: {D8033853-3009-40bf-816B-23EF9F29B500}, 2003
[13] Krause, J, code: struct17; seed: {0BF5883C-E0F3-460f-BB80-42FF0C7E5F85}, 2003
[14] Krause, J, code: struct20; seed: {04F9A71D-FE96-43ba-9C11-701E10F78C83}, 2003
[15] Krause, J, code: bstruct; seed: {F3F36937-6496-4430-8E07-E264A7622CD5}, 2003
[16] Krause, J, code: bstruct; seed: {6A101162-0D10-4638-89BA-DF807A0E92A2}, 2003
[17] Knuth, Donald, “Computer Science and Mathematics", American Scientist, 61, 6, 1973
[18] Krause, J, code: bstruct; seed: {0DE6B6D5-B121-41f2-A018-96CE54DAA280}, 2003

Artificial Music Critics

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Abstract

This paper proposes a framework for the simplification of the development of Artificial Art Critics. We provide two basic elements: an architecture that consists of two main modules for the pre-processing and classification of an artwork, and a validation methodology that consists of several stages, such as the objective evaluation of an artwork (with targets like author or style identification) and a dynamic evaluation that implies the integration of the Artificial Art Critic into a multi-agent environment. We also present some experimental results concerning the first stage of the validation methodology. The results show the ability of the system to identify the author of a musical piece and its adaptive capacity to determine the relevant features of the musical piece.

1. Introduction

We believe that every artist, or in general every creator, has to act as a critic during the creation of a product, because he must judge whether or not it can be considered innovative or aesthetically pleasant. The creative process necessarily involves a phase of critique, parallel to the creative process but also an integrated part of it, that progresses at the same time as the creation itself.

The role of the critic as a key component of the creative process seems to have been forgotten by most of the artificial artwork generation systems developed over the last years. These systems ignore both their own generated artworks and external creations. In our opinion, the critic role of an artificial artist may not be neglected in a system that is really capable of acting as its human counterpart.

This paper describes a general framework for the development of an Artificial Art Critic (AAC) that consists of an architecture and a validation methodology, and it presents a series of experimental results concerning the application of this validation methodology.

The proposed architecture has two main modules. The *feature extractor* perceives the artworks and measures their characteristics. The *evaluator* generates an output based on these measurements and on additional feedback information. Depending on this feedback, the *evaluator* provides an objective assessment of the artwork (e.g. a style or author recognition task), or a "subjective" assessment (e.g. an evaluation task).

One of the main problems in the development of Artificial Artists or Artificial Critics is the validation of the fact that the system is behaving correctly or as expected: it is extremely complicated to specify what the system is expected to do. For an Artificial Artist, these expectations are very vague: we expect our system to create an innovative, aesthetically pleasant artwork.

The proposed multi-stage validation methodology intends to tackle this problem. Each stage of the methodology focuses on a different validation task: the first stage allows the objective and meaningful assessment of the system; the latter stages add more subjective criteria, and include testing the system in a hybrid society of humans and artificial agents.

This paper presents a series of experimental results in the first stage of the validation methodology.

2. Framework

We want to provide a basis for the validation and development of AMCs that allows the integration of contemporary critics and promotes collaboration between groups in the creation of AMCs. The overall framework is based on the following set of characteristics:

- Adaptability: an AMC should adapt to a changing environment. It must replicate a commonly accepted characteristic of human critics, namely evolution.

- Sociability: this can be seen as a concretion of the adaptability characteristic. AMCs will be integrated into a society with certain cultural and aesthetic trends, so they should be able to behave according to these trends. When performing in a hybrid environment – one that incorporates humans and artificial systems – the AAC must be validated by the society of artificial and human "agents", in the exact same way that human critics are validated in purely human societies [1].

- Independence of representation: the AMC should build its own internal representation of the artwork, shaping its assessment from the artwork itself; and it should only have access to the piece of art, not to any sort of higher level or external representation of the piece.

In addition, as the task of criticizing or expressing an opinion about an artwork is of the same nature, be it a music or whichever other kind of art, we have generalized the architecture in order to allow handling different artistic domains, adding a new characteristic to the list above:

- Generality: the AMC should be easily adaptable to different domains – becoming an Artificial Art Critic – so domain-specific tasks should be carried out by specialized modules, enabling the whole system to easily change from one domain to another.

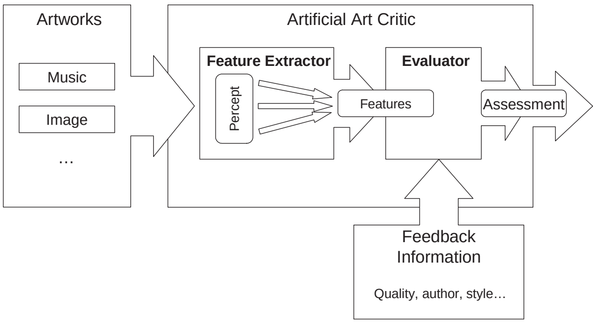

Figure 1. Outline of the proposed architecture

2.1 Architecture

If it intends to take into account the abovementioned characteristics, the architecture must allow the development of adaptive AMCs that will be easily adaptable to different domains (becoming a generic Artificial Art Critic, AAC), taking into account the particularities of each artistic domain. For instance, the way of dealing with music and with visual art is visibly different: whereas music follows a predetermined temporal sequence, the art viewer has a less constrained and more direct access to the piece of art. Hence the need to divide the system into various modules, providing specific ones that deal with domain particular tasks and allow the generality of the others.

Usually, artworks contain a huge amount of information. In visual art, for instance, even a relatively small picture can consume a large amount of memory. As one can infer from a state-of-the-art analysis of current adaptive systems (e.g. neural networks, genetic algorithms), such vast amounts of information cannot be handled reasonably. Some researchers try to tackle this problem by reducing the size of the artworks fed to the adaptive system (e.g. [2]). However, this approach implies an important loss of information and detail, and the experimental results are, typically, disappointing.

We believe that there is a more adequate approach, which consists of some kind of pre-processing of the artworks in order to extract relevant features, which can then be used as an input for the adaptive part of the system. This reduces the amount of information that has to be processed.

The proposed AAC architecture (roughly outlined in Fig. 1) includes two modules: the feature extractor and the evaluator. Each module has a concrete and different purpose. The feature extractor performs an analysis of the artwork and provides a set of relevant features to the evaluator. The evaluator makes an assessment of the artwork based on the previously extracted features.

The features extractor module performs two specific tasks: perception and analysis.

During the perception task the system builds some kind of internal representation of the artwork. Then, in the analysis task, this representation is analyzed and provides a set of relevant measurements. While this partition between perception and analysis is mainly conceptual, the idea behind it is that, in a first stage, the features extractor acquires information about domain-specific parameters which are then analyzed.

The internal representation is not constrained, nor are the techniques used on the feature extractor.

The evaluator module is an adaptive system that accepts, as an input, the features measurements carried out by the previous module, and processes this input so as to obtain, as an output, an assessment of the artwork.

The evaluator module must adapt to different tasks according to the feedback information provided. Depending on the task, this feedback can be an indication of the desired answer or an evaluation of the performance of the AAC, which must adjust its behaviour in order to maximize the performance. Also, the adaptive evaluator module provides information about which characteristics or measurements are relevant in the assessment of an artwork. The weights of an ANN, for example, give an indication of which characteristics are more significant when criticizing a piece. It is also possible to test the evaluator with different sets of features so as to find the minimum set needed for a particular evaluation task.

With this architecture, the search for new relevant features and evaluations remains independent: a system can include a set of different feature extractors and evaluators from different authors in order to test which combination of extractor and evaluator is preferable to characterize a piece of art.

We shall now present a validation methodology that allows us to test the developed AAC.

2.2 Validation Methodology

The validation of our AAC presents two main difficulties: the subjectivity involved in the evaluation of artworks, and the fact that large training sets are needed to train the evaluator module (hundreds of man-evaluated artworks).

The answer to these complications is the use of a multi-stage validation methodology. The AAC is presented with a different task in each level, starting with tasks in which the correctness of the ACCs output can be objectively determined and which do not require a training set of human evaluated artworks. We then move on to tasks that require more subjectivity and complexity. The response of the AAC is supposed to be static in the first levels; in the last levels, the AAC must adapt to the environment and change its evaluation over time according to the surrounding context.

At this time, the validation is divided into three levels: Identification, Static Evaluation and Dynamic Evaluation.

In the Identification level, the AAC recognizes the style or author of a given artwork.

During the Author Identification task, the AAC is presented with several artworks by different authors. Its task is to determine the author of each piece. The evaluator module can be trained by giving it feedback information that indicates the correct answer. This validation is easy to perform, the compilation of training instances is simple, and the test is absolutely objective. The main difficulty involved in this level of testing is the construction of representative training and test sets.

This validation step is limited in scope but it is useful in determining the capabilities of the feature extractor module. A failure during this test may indicate that the set of extracted features does not suffice to discriminate between authors: this prevents us from moving on to a more complex task, bound to fail due to the lack of meaningful information. The analysis of the features used by the evaluator to determine the correct author can help determine the relative importance of each of the extracted features. In fact, it is possible to perform specific tests to determine the predictive power of each measurement or set of measurements.

During the Style Identification task, the AAC must identify the style of an artwork. This type of validation allows the testing of AACs that may be used in a wide variety of tasks, such as image and music retrieval (and allowing, for instance, style-based searches).

It may be more difficult to discriminate between artists of the same school than to distinguish styles that are radically different. However, discriminating between artists that have characteristic signatures (in the sense used by Cope [3]) is easier than discriminating between closely related styles, so the difficulty of these tasks depends on the chosen artists and styles.

During the analysis of the experimental results, it is important to take into account what is reasonable to expect. For instance, if the testing set includes atypical artworks, the AAC will most likely fail. This does not necessarily indicate a flaw of the feature extractor or evaluator, but simply the fact that the artwork is atypical.

The Static Evaluation is the second level of validation. In this case, the AAC must determine the aesthetic value of a series of artworks previously evaluated by humans. To this effect, it needs a representative database of consistently evaluated artworks, whose construction is one of the major difficulties in the performance of this test.

The training of the AAC requires positive and negative examples, and, paradoxically, it is quite difficult to obtain a representative set of this type of examples.

The use of complexity appraisers in the feature extractor module may prove useful to rule out this type of items: representative samples of items that do not even meet the necessary requirements to be considered a piece, such as images in which the pixels are totally uncorrelated, and, as such, are nothing more than noise. The relation between complexity and aesthetic value has been pointed out by several authors (see, e.g., [4]); complexity appraisers have successfully been used as a way to filter images that do not meet the necessary pre-requirements to be considered artworks [5].

We could use a generative art tool to create the training set. This would yield a relatively high number of pieces in a reasonable amount of time. However, the set would only be representative of the pieces that are typically created by that generative art tool. Moreover, the degree of correlation between the created pieces may be high, making the task of the AAC artificially easy.

Another option would be to diminish the scope of application of the AAC: create an AAC that is able to assess the aesthetic quality within a well-defined style. This results in a validation step that is somewhat closer to the task of “Style Identification”, and as such less subjective. The difference is that the AAC is assessing the distance to a given style instead of trying to discriminate between styles.

The analysis of the experimental results can be challenging: one needs to make sure that the AAC is performing the expected task and not exploiting some flaw of the training set.

This type of problem is detected using the trained AAC to assign fitness to the pieces generated by an evolutionary art tool, and thus guide the evolution process. Evolutionary algorithms are especially good at exploiting holes in the fitness evaluation (see, e.g., [6]). Therefore, one can check if the evolutionary algorithm is able to generate abnormal pieces, which are highly valued by the AAC in spite of their poor quality.

The Static Evaluation step poses many difficulties, both in the construction of the test and in the analysis of the experimental results. It is, however, necessary in order to assess an AAC.

The last step in the methodology is the Dynamic Evaluation. The value of an artwork depends on its surrounding cultural context (or contexts). As such, the AAC must be aware of this context, and be able to adapt its assessment to changes in the surrounding environment.

To perform this validation, the “Hybrid Society” (HS) model is proposed. HS is a paradigm similar to Artificial Life, but with human “agents” at the same level as the artificial ones. HS explores the creation of egalitarian societies populated by humans and artificial beings in artistic (or other social) domains; as such, HS is adequate to validate the AAC in a natural and dynamic way. In the Dynamic Evaluation step, the success of the AAC depends on the appraisal of its judgments by the other members of the society. This type of test introduces a new social and dynamic dimension to the validation, since the value of an artwork varies over time, and depends on the agents that compose the society.

This validation level presents the problem of the need to incorporate humans in the experimentation. The experiments are difficult to plan and organize, and strong time limitations exist. Moreover, the adaptation capacity of the critics must be high in order to adapt to a dynamic and complex environment. In spite of the inherent difficulties, these critics can be valuable and easy to integrate in the “information society” as assistants of users or as part of general composers.

It is possible to assess the performance of the feature extractor and evaluator module independently, since the output of the feature extractor (in conjunction with the feedback information), can be seen as a training instance to the evaluator, and only in the first two levels of validation.

At the third level this is no longer possible since the feedback information does not directly reflect the quality of the artworks, but only an appraisal of the AAC actions by society, which changes dynamically in time.

The validation methodology presented here tries to find a compromise between automated and human-like validation.

3. Experimental Results

The experiments related to the development of an AAC are focused on the musical field. They distinguish the authors by means of their works and represent the first validation level of an artificial critic.

We have used 741 scores with an ample variety of music styles (prelude, fuga, toccata, mazurka, opera…) composed by a total of 5 different musicians: Scarlatti (50), Purcell (75), Bach (149), Chopin (291) and Debussy (176).

The system consists of two modules: the static feature extractor, presented by Manaris et al. (2003) [7], is based on a set of musical metrics and on the distribution of Zipf in order to obtain a series of values that represent each theme. The metrics surge from musical attributes (pitch, duration, melodic intervals, harmonic intervals,...) and are divided into simples (simple note and interval) and fractals (fractal note and interval). The Zipf distribution of each metric generates two numbers: the slope and the square average error (R2), which indicates the adjustment of the trendline to the value. This means that the output of the feature extractor is a set of numbers, two for each metric. We have used a total of 81 values: 40 metrics and the corresponding notes.

The adaptive evaluator consists of a feedforward ANN. We use the Backpropagation learning function, with a learning rate of 0.2 and a moment 0; the neuron activation function is the logistic function, whereas the output function is the identity function. Where the topology is concerned, the input layer consists of 81 units or neurons that correspond to the 81 values obtained in the previous stage. These values are normalized between -1 and 1 for their presentation to the network. We consistently used one single hidden layer, whose amount of units is variable (some tests have 6 units, some 12) so as to observe their influence on the final results. The output layer also varies according to the analysis that is being carried out (discrimination between two authors, three, five…). We use the SNNS application to construct, train and test the network. And in order to optimize the learning of the different patterns, we have presented them in a different order within the different cycles.

We use a high percentage (85%) of patterns in the training set (the test set consists of the remaining patterns), and two ANN architectures: one with 6 neurons in the hidden layer, the other with 12 neurons. Within each architecture we carry out an exploration with 10.000 cycles (a cycle is a training unit in which the file patterns are presented once to the network); after observing the error graphic (MSE, Medium Square Error) and their results, we analyze a different amount of cycles, which is usually smaller.

3.1. Experiment 1: Scarlatti vs. Purcell

The aim of this experiment is to check the efficiency of the network in distinguishing between two authors who belong to the same musical period (Baroque), and both to their initial years, which is an additional difficulty.

Architecture 81-6-2:

81 neurons in the input for the different metrics, 6 neurons in the hidden layer and 2 neurons in the output layer with the following representation: (1,0) to indicate that it is a work by Scarlatti and (0,1) by Purcell (Figure 2).

After 10.000 learning cycles, and in a test set of 19 patterns, the ANN identified all the authors except one, which indicates a success rate of 94,8% . The MSE was 0.00003 in the training set, and 0.04109 in the test set. After 3000 cycles, the ANN identified the authors of all the pieces of the training and test sets (100%). The MSE was 0.00021 in the training set and 0.00987 in the test set.

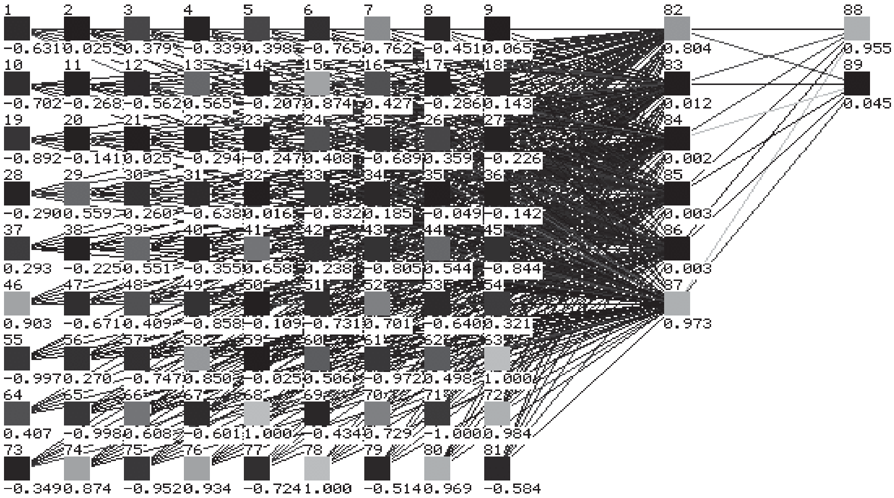

Figure 2. Architecture of the trained ANN

Architecture 81-12-2:

In this case, the number of units in the hidden layer amounts to 12. After 10.000 cycles, and as in the previous case, the ANN identified all the authors except one (95%). The MSE was 0.00003 in the training set and 0.08408 in the test set. After 4000 cycles (this amount allows us to see the evolution of the test set; in cycle 3000 it reaches its lowest value, 0.03353), we find the same situation, with a success rate of 95%. The MSE was 0.00020 in the training set and 0.06573 in the test set.

3.2. Experiment 2: Scarlatti vs. Purcell vs. Bach vs. Chopin vs. Debussy

Our aim is to check the efficiency of the network in distinguishing between these five composers. To this effect, we have carried out a more exhaustive analysis by identifying the most relevant features for the author recognition.

The results are as following:

Architecture 81-6-5:

In this case, the output layer contains 5 neurons and the activation of each neuron corresponds to a different author: (1,0,0,0,0) to identify Chopin, (0,1,0,0,0) for Bach, (0,0,1,0,0) for Scarlatti, (0,0,0,1,0) for Purcell, and (0,0,0,0,1) for Debussy.

After 10.000 learning cycles, the ANN made 6 mistakes in a test set of 106 patterns, which indicates a success rate of 94,4%. The training MSE was 0.00005 and the test MSE 0.07000. After 4000 cycles, we found 6 errors, as was the case with 10.000 cycles, which indicates the same error percentage. The training MSE was 0.00325 and the test MSE 0.10905.

Architecture 30-6-5:

In order to detect the importance of the metrics involved in this experiment, we checked the contribution of each metric to the network through the sum, in absolute terms, of the weights between the input units and the successor neurons (in this case, those of the hidden layer). This means that we added up the weights that connect neuron 1 with all the neurons of the hidden layer, neuron 2 with all the neurons of the hidden layer… and so forth until 81. Among all the obtained results, we chose the 30 heaviest weights, since they contribute more to the final result of the network.

During the training of the ANN with 30 neurons in the input layer (the rest of the architecture remains unchanged) and during 10.000 cycles, the results were the following: we observed 7 errors among the 106 patterns of the test file, which means that the ANN reached a success rate of 93,4%. The training MSE was 0.00319 and the test MSE 0.12876. The similarity in percentages between this experiment and the one with 81 neurons clearly shows the importance of certain metrics (Figure 3).

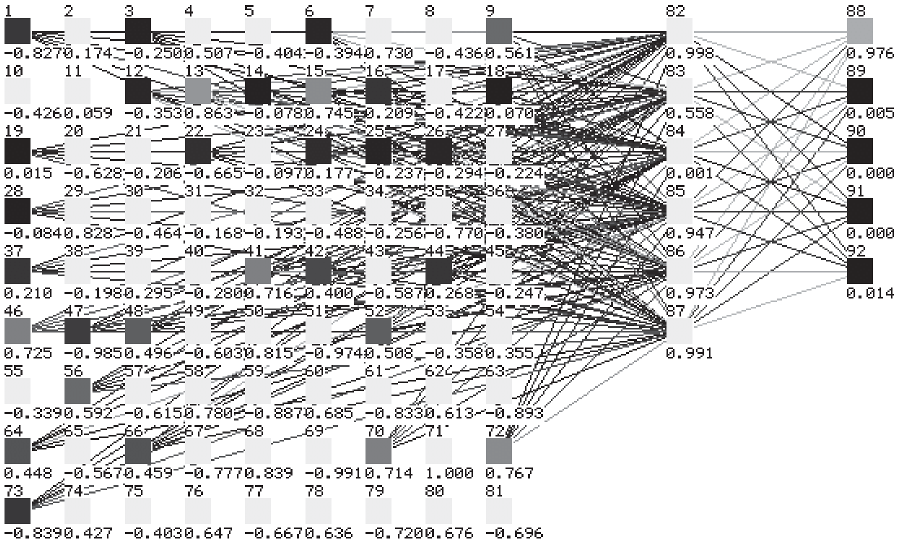

Figure 3. Architecture of the trained network with an input of 30 neurons. The image shows all the neurons (81), but only the 30 selected neurons have connections with the hidden layer (darker shade).

Architecture 15-6-5:

The selection took place in the same way as in the previous experiment, but the input layer counts 15 neurons. In this case, the results were less positive: we observed 15 errors (more than twice the previous amount), which amounts to a success rate of 85,9%. The training MSE was 0.01131 and the test MSE 0.26105.

Several representative metrics were excluded from the selection, and the 15 selected metrics were not enough to distinguish among the authors.

4. Conclusions

This paper describes a generic framework for the development of artificial art critics, including an architecture and a validation methodology.

The proposed architecture separates generic from domain specific components, allowing an easy adaptation to different domains. It also proposes a multilevel validation methodology that allows a structured testing of artificial art critics and enables the comparison of different approaches.

We have built a system that uses the proposed architecture through the combination of a static model, that analyzes the musical pieces, and an adaptive model, based on artificial neuron networks that predict the author through the output of the first model. This output corresponds to a set of 81 features that includes harmonic consonance and distance of note repetitions. We use fractal metrics to recursively applying simple metrics at decreasing resolution levels.

A high success rate shows that the system has proven its efficiency in the performance of the proposed task, which is the identification of the author of a given piece of music. The task was relatively complex, because in several cases the authors belonged to similar schools and periods.

The ANN has shown its capacity to detect the relevant metrics:

- Among all the neuron selections, the ANN always maintained more than 85% of the relevant metrics. This means that if two tests used 30 relevant metrics, approximately 25 metrics were the same in all the cases.

- We obtained similar results in the tests carried out with only 30 metrics. This shows that it is not necessary to use 81 metrics; however, the less positive results of the experiments based on 15 metrics indicate that there is a minimum of relevant metrics.

This mechanism makes it possible to incorporate metrics obtained by several research groups: the adaptive system (such as the ANN-based system used in this article) discerns the metrics that are relevant to the identification of the author.

We are carrying out more experiments to verify the ability of this system in the identification of visual arts; and we are about to test this system by means of the second level of the methodology, the subjective appraisal.

References

[1] A. Pazos, A. Santos, B. Arcay, J. Dorado, J: Romero, and J. Rodríguez. An Application Framework for Building Evolutionary Computer Systems in Music. Leonardo, 36(1), 2003

[2] S. Baluja, D. Pomerleau, and T. Jochem. Towards Automated Artificial Evolution for Computer-Generated Images. In Connection Science 6, No. 2, pp. 325–354. 1994.

[3] David Cope. Experiments in Musical Intelligence. Madison, WI: A-R Editions, 1996.

[4] Rudolf Arnheim. Entropy and Art. University of California Press, 1971.

[5] P. Machado and A. Cardoso. All the truth about NEvAr. Applied Intelligence, Special issue on Creative Systems, Bentley, P. Corne, D. (eds), Vol. 16, Nr. 2, pp. 101–119, Kluwer Academic Publishers, 2002.

[6] L. Spector and A. Alpern, Criticism, Culture and the Automatic Generation of Artworks. In Proceedings Twelfth National Conference on Artificial Intelligence (AAAI-94), August 1-4, pp. 3–8. AAAI Press. 1994.

[7] B. Manaris, D. Vaughan, C. Wagner, J. Romero and R. Davis. Evolutionary Music and the Zipf-Mandelbrot Law: Developing Fitness Functions for Pleasant Music. In Lecture Notes in Computer Science, Applications of Evolutionary Computing – EvoWorkshops 2003, LNCS 2611, pp. 522-534, Springer-Verlag, 2003

Breaking the Type

Considerations Toward the Production of Innovative Architectural Designs by Evolutionary Design Models

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Abstract

Evolutionary architectural models often show only variation of a theme. They thus misrepresent the design process in architectural practice that eventually results in some innovative designs over the years. It seems that this misrepresentation arises from the analogy between biological and design models. The objective of this paper, then, is to shed light on the similarities and differences between the models, in particular on the notion of purpose and species, and on the use of precedents (as instructions) in both models. With the notion of purpose and species, we intend to question how architects “break” types and create innovative designs by recombining their parts. The ultimate objective of this article is to provide ideas for the improvement of evolutionary design models for architecture.

1. Introduction

Evolutionary Design Models have their origins in an analogy between biological evolution and design. We argue in this article that some differences between the two models were not well explained, causing misunderstandings in the representation of design practice. We argue that evolutionary architectural models often only show variation of a theme, thereby misrepresenting the design process in architectural practice that in the long run produces some innovative designs.

It is not necessary to mimic the mind (even if it were possible) or the behaviour of the architect to develop a tool, or even to make perfect analogies with other fields (an analogy cannot be used as justification of a claim), because a model does not need to be true or false, but fruitful and this depends of the objective of the model. In our case, the interest is not only in the production of variation of a typ, but also in the production of creative and innovative designs, which is the main concern of this paper. By innovation, we refer not only to the production of different forms, but also to technological advances in the field. We wish to contribute toward developments in this context.

Variation is a means toward and necessary condition for the development of new species in nature and for the development of innovative designs. However, we noted that there are important differences in the production of variation and selection in both fields. We wish to present two notions that are probably the key in expounding the differences. These are the notion of intention in design and the concept of species in nature.

We shall explain our arguments by means of examples. First, we shall concentrate on the use of precedents in design, focusing on the transference and adaptation of Le Corbusier’s piloti and Santiago Calatrava's arch. Here we shall discuss the notion of intention and the concept of species. Second, we shall describe the creation of an innovative design from recent history: the creation of the Unité d'Habitation by Le Corbusier. With this example we will briefly show the origin of certain precedents, questioning the idea of species in design and trying to describe the possible mechanism in design.

To conclude, we shall pose a series of questions that may lead toward a better representation of the architectural process: a representation that supports the production of innovative designs or at least leads toward a re-evaluation of the actual research results in the field of evolutionary designs.

2. Designing with Precedents

Architects often explicitly make use of design precedents, such as Le Corbusier, James Stirling and Jo Coenen; and others less explicitly, such as J.J.P. Oud, Santiago Calatrava and Aldo van Eyk; both ways frequently lead to efficient, effective, and/or innovative results" (Moraes Zarzar 2003). We argue that in architectural practice, the use of design precedents as a source of knowledge is often considered to be a more efficient strategy in developing designs than initiating a project from tabula rasa." Evolution in nature takes place based on the transference of genes from one generation to another and eventually on erratic copies of genes that generate novelties and more variation. Looking this way they are very different models, however, it is implicit in both models that there is use of past information in the ontogeny of a new generation and in this way we can follow with our analogy. We also assume that by using this analogy, evolutionary design models depart from the use of a certain kind of design precedents.

Genes are instructions and copies of other genes. Organisms are the expression of those genes (phenotypes). By analogy, we could say that design precedents/projects/cases are the expression of design genes. A design gene then expresses a feature in a project/case: features are then the "material of the architect". Architects transfer features (and their hidden instructions), which may derive from other architectural projects or vernacular buildings as well as by analogical reasoning, even from bottles and bottle racks (Tzonis 1990).

In general, one can observe two kinds of transference. On the one hand, one may be interested only in the configuration of certain elements, such as Le Corbusier and the piloti of the savage hut. On the other hand, the designer may be concerned with the use of certain structures irrespective of the original use that the structure had, such as Calatrava's use of similar structures for different kinds of project; for example the "arch and hangers" of Lusitania Bridge (1988-91) in Mérida, Spain, and the "arch and hangers" of the roof of Tenerife Exhibition Hall (1992) in Tenerife, both to be described later in this paper. In this manner, Instructions from a feature are isolated from their original design and transferred.

The configurational and/or structural instructions of a certain feature of an artefact must obviously fit its corresponding part in the new design. In other words, it must fit with the other configurations of the new design as well as its own structure. Once separated from the original design, they may evolve by acquiring more meanings, such as in the case of Le Corbusier's piloti. They may also become a principle, as in fact the piloti did in becoming part of Corbusier's "five points for a modern architecture". At that point, it was no longer the savage hut that was essential to be recalled, but the principle.

3. Purpose and "Inheritance" in Designing

We are trying to mimic some aspects of the architect's behaviour to get insights into his/her creative mind when generating innovative designs based on design precedents. In turn, we want to improve the evolutionary design models that support the use and adaptation of design precedents.

Architectural design is an ill-defined kind of problem. However, this does not presuppose that designers have no purpose or that they may go freely in all directions. It seems unlikely that designers would go through their memories in a purposeless way collecting precedents and randomly changing them to see afterwards whether they fit or not. It would take millions of years to find a suitable solution. Designers have performances in mind that they want to match, although they could change their minds through the design process and aim for new or additional performances. When using precedents, they seem to examine them for configurations and structures that could help them to achieve a desired performance. It seems that the more experience an architect has, the more precedents he or she would find to match the same performances – at least if we excluded the power of biases that could block the actual search (Bay 2001).

We are thus led to an *artificial selection* rather than *natural selection.* In this sense, "evolution in design" is closer to breeding than to evolution in nature. Breeding refers to artificial selection, i.e. to purpose. Breeders have an intention and select by phenotype plants or animals, each having a particular desired performance to improve the quality of their grains or animals in the generations to come. More than one generation will be necessary, but eventually the breeder will have a generation that approximates or matches his/her goal.

In nature, but also in breeding, there is an important constraint: species. Once new species are formed, their descendants will evolve departing from the set of genes they have. The offspring of two different species are mostly unfertile. Based on case studies, we argue that this barrier is not so strict in design as it is in nature (Moraes Zarzar 2003). It seems that putting characteristics of other orders of objects together helps architects to generate innovative designs. Therefore, to approximate even more from design practice, one should provide architects with "genetic engineering knowledge"; i.e. architects should be able to isolate the genes that express the desired performance from any species, transfer them and adapt them to the new design. In this way, architects would have an "open" design gene pool rather than a perfect closed system.

This kind of transference seems to be a bottleneck in developing an evolutionary design tool since, besides the continuous recognition of new features over the years; it involves the use of analogy in the process of recognition.

Next we will present examples of two kinds of transference of features from precedents used by Le Corbusier and Santiago Calatrava.

4. Transmitting Characteristics in Design: species constrained?

If an intention exists, then we have stumbled over one of the principles of Darwinism. however, we may instead use breeding and artificial selection as analogues for architectural design based on precedents. Next, we shall show these ideas through two examples of the use of precedents from architecture. We question the validity of a closed system that randomly mutates its genes dealing with ill-defined problems in the very constrained field of architecture. We will describe Le Corbusier's transference of the piloti from the savage hut to his work and his subsequent re-use of it. Second, we will describe the possible transference of the arch and hangers of Lusitania Bridge to the Tenerife Exhibition Center. It goes without saying that they are described as a possible reconstruction of the facts based on the analysis of designs and on written material.

4.1. Le Corbusier: piloti and savage huts (Moraes Zarzar 2003)

The first time that Le Corbusier used the piloti was during the design of his Citrohan house of 1922. In his article "Hutten, Shiffe, und Flaschengestelle", Alexander Tzonis suggested that it was at this point that Le Corbusier would have asked himself: "Do I know any products which do not disrupt the natural continuity of the terrain (Tzonis 1992)?" Le Corbusier would search through his memory to find a precedent that would fulfil his intention of not disrupting the continuity of the terrain and came up with the "savage hut" which, being supported by stilts, did not disrupt it. A process of recognition of characteristics of the stilts (piloti) took place. Further analysis of the element would suggest that the piloti could suit other purposes as well, such as that the piloti allowed air to circulate without obstruction under the buildings, thereby protecting it from humidity; for this reason it was also environmentally good. This feature was then used in his Citrohan of 1922, stored in his memory and archives for later re-use in most projects.

As Tzonis asserted, Le Corbusier was selective in what he transferred. He was neither interested in the 'body' of the hut (room) nor in its 'top' (roof), only in its stilts. Looking deeper, we would claim that Le Corbusier was also not interested in all of the information of the piloti, but in its pattern of arrangement. When challenged to find some precedent that did not disrupt the natural continuity of the terrain, he considered the overall configuration of the piloti and some of its operations. However, at that stage, he was not interested in measure, material, technique or technology.

In the (as he himself termed it) "40 years of gestation" of the Unité d' Habitation, Le Corbusier's piloti first appeared in the Maison Citrohan, and through use and adaptation it changed from slender stilts to gargantuan columns, and from the individual domain to the collective domain.

Structurally, the piloti is in general a part of a building's structural framework formed by columns and beams or slabs. While each storey contains a set of columns mostly wrapped up by a "skin" (walls, glass etc.), the piloti is mostly exposed. Le Corbusier used it in reinforced concrete but also in steel, for example in the double Maison Citrohan of Stuttgart. It functions by distributing the structural forces from the "body" and "top" to the building's foundation.

The piloti is not just a set of columns; it is a set of columns at the ground floor, which in addition to supporting the artifact, should permit cross-ventilation to protect the building against humidity. Therefore, it should have few or no enclosure elements. Morphologically, it is composed of columns that do not touch each other, and it is at least one storey high to permit the circulation of people. The space generated by the columns may function as access to the building as well as a garden, garage, and/or recreation area. In the Unité d'Habitation, the piloti was supposed to be used on a large scale (several buildings in an environment), and was intended to permit the view of an open landscape from the ground floor level and be used collectively. In other words, the notion of piloti evolved from the private domain to the collective, first because of its potential to meet other needs on a larger scale, and second because it was compatible with other innovations.

Together with the rest of the structure, it was intended to free façades and plan layouts. This formed a chain of links which could be read as follows: to enhance the design of façades, neither the piloti nor the columns of the framework should be placed within but behind the façades' planes; to enhance a stable structure, the piloti needs to be linked to the total structural framework; and to enhance the design of free layout plans, the piloti and framework should allow partition walls to be freely placed in the layout, thereby freeing the layout of the units as well as, in the case of the apartments, permitting varying house sizes.

In summary, in the case of the piloti, Le Corbusier was not directly concerned with the rest of the structure of the savage hut; he was also not concerned with the use of timber and the technique used to put the parts together. He was concerned with the quality that this configuration would provide if he were to use it in his buildings. This configuration acquired more meanings over the years. It was used to free buildings from humidity, to free ground for private and later also collective activities, and to liberate the view of the horizon.

We could conclude that the recognition process of the piloti of the savage hut is intrinsic to Le Corbusier's creativity. He recognized in this configuration some qualities that could be interesting in his projects, a process that was carried out many years before the architect became involved with the creation of the Unité d'Habitation. In fact, many precedents used by Le Corbusier were collected on journeys in his early years. In the work of Corbusier it is clear that once a specific part of a precedent was recognized and separated from the whole, it could be part of his "d-gene pool" and eventually become enriched with new meanings as well as transformed.

4.2. Calatrava: Tenerife Exhibition Center and Lusitania Bridge (Moraes Zarzar 2003)

Through careful observation of Calatrava's Tenerife Exhibition Center and Lusitania Bridge, one may see the use of the arch and hangers of Lusitania Bridge adapted to hold the roof of the Tenerife Exhibition Center. Next, a structural description of Lusitania Bridge and the Tenerife Exhibition Center is given in a way that makes a comparison possible between the arches of these two projects.

Lusitania Bridge, 1988-1991, Mérida, Spain. The 34-meter deep arch is composed of two bases in reinforced concrete and, connecting these bases, three braced steel-arches (Figure 1). The steel arches are connected by linear rigid elements forming a truss, thus taking material out the center to give the whole a certain rigidity that prevents the arch from buckling as a consequence of, for example, wind load working on the structure (Figure 2). The cables are brought in pairs into an element pinned in the lowest of the three steel arches of the truss[1].

Like most Calatrava bridges, this bridge also presents a four-level structural hierarchy: dead and sometimes live loads carried by the roadways are transferred to the cables. These 23 pairs of steel cables transfer the loads to the arch, and thereafter the loads are transferred via the truss-like arch to its bases in reinforced concrete, and finally, to the abutments (Figure 3).

[1] The first and the last pair are fastened inside the reinforced concrete basis.

According to Frampton et al., the central load-bearing element of the bridge – the box girder or torque tube – is constructed from post-tensioned, pre-cast concrete elements (Frampton, Webster et al. 1996, p. 87). This is Calatrava's solution for dealing with the horizontal forces originating from the arch in the direction of the banks of the Guadiana River. In other words, the cables crossing the girder longitudinally generate a horizontal force opposed to that of the arch preventing the arch from collapsing.

Post-tensioned concrete wings supporting the road decks cantilever from the 4.45 meter-deep concrete box girder (Frampton, Webster et al. 1996, p. 87), i.e. there are cables crossing the box girder to connect each pair of opposed concrete wings.

The motorways on top of the wings are not directly in contact with the torsion box; they transfer the symmetric loads (Figure 4) to the structural wings. Horizontal components of the live and dead loads acting on both decks and transferred through each pair of wings counter-balance each other via cables because the forces are similar at both sides of the girder. Vertical components of these forces are transferred through the cables to the arch.

The asymmetric loads – loads that are only applied on one of the decks due to potential traffic on one side of the torsion box – are solved by adding another set of slanted beams that suspends the motorway transferring forces also to the top of the torsion box. These beams are placed between the torsion box and each roadway at regular intervals (Figure 5). The same elements also seem to prevent the whole from excessive vibrations generated by the friction of the wheels of the vehicles in the direction of their movement.

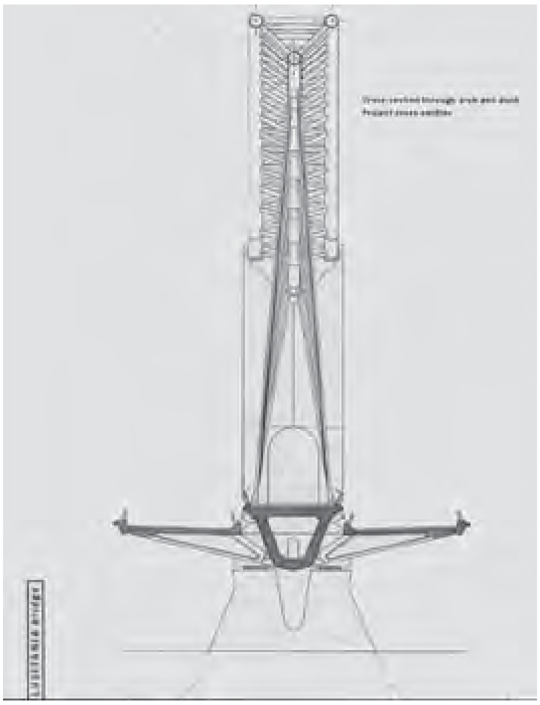

Figure 1: Section

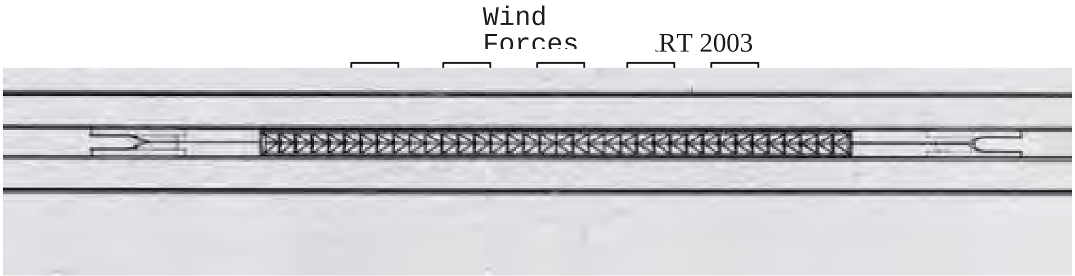

Figure 2: Truss Supporting Wind Forces

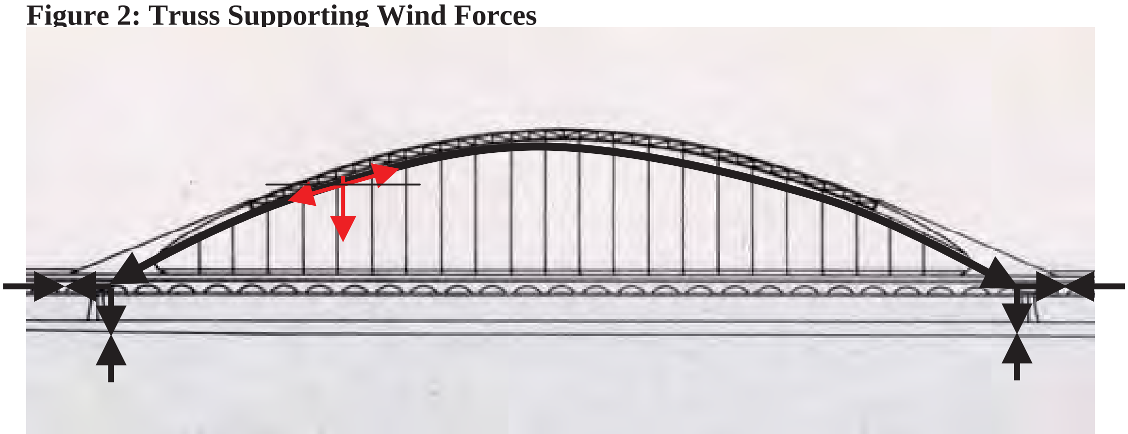

Figure 3: Diagram of Forces

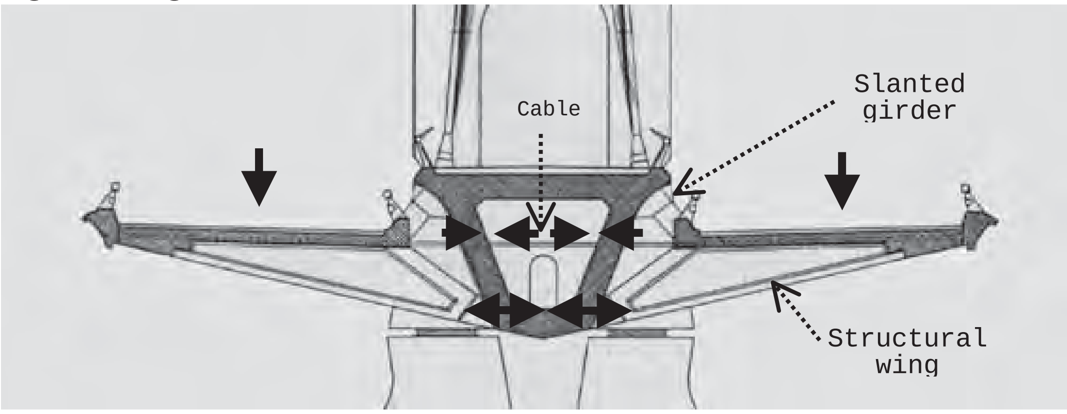

Figure 4: Symmetric Load Case

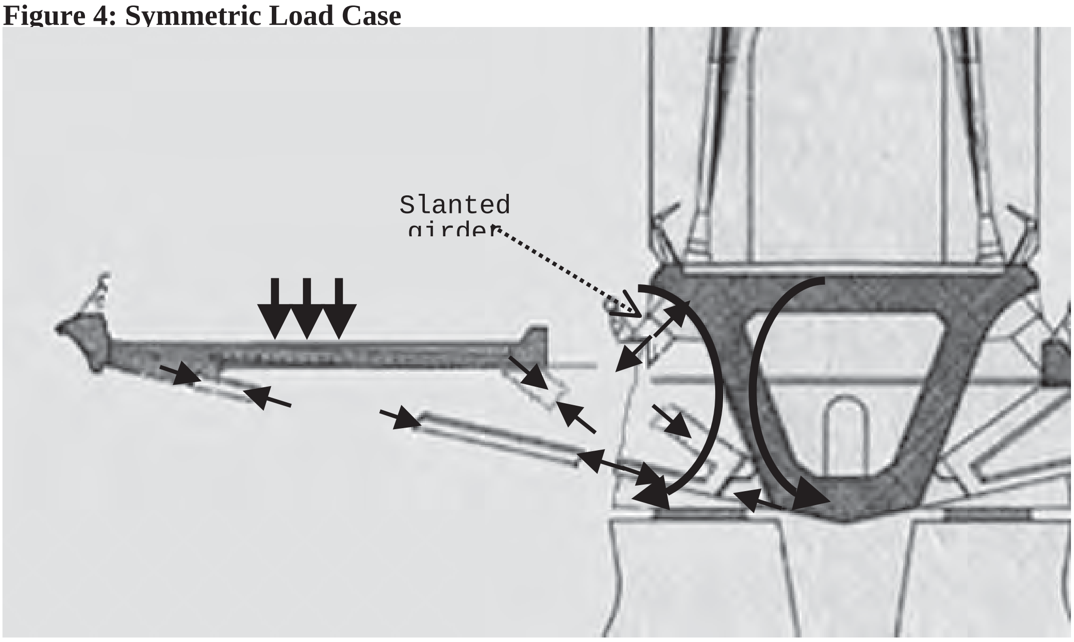

Figure 5: Asymmetric Load Case: torsion box comes to action

Tenerife Exhibition Center, Tenerife, 1992. The main function of the Tenerife Exhibition Center was to be to house fairs as well as carnival parties (Figure 6), and thus Santiago Calatrava's main task was to design a multipurpose space. For this purpose, Calatrava designed a hall that did not have any structural obstacles within it. A steel arch was used to span the 142-meter hall between two concrete, splayed buttresses at each end of the curved plaza slab. This 39-meter high arch suspends a shallower arch, whose apex is 30 meters high above the floor slab.

This arch is intended to hold the roof in its center together with the outside slanted columns. The transference of vertical loads, whether from the roof weight or from wind loads, is solved with the arch and slanted columns (Figure 7, Figure 8).

The shallower arch is linked to 18-meter long curved and triangulated latticework trusses that hold the roof weight. Through their form – slightly curved toward the middle – the trusses resist the moment created by loading this beam. These lattice trusses are held together in such a way as to resist the horizontal component of wind loads in two important ways: first, each two lattice trusses form a triangle that provides stiffening for the roof structure; and second, the binding of these beams creates shear forces between them which together produce a force equal and in an opposite direction to the horizontal component of wind loads (Figure 9).

Figure 6: Tenerife Exhibition Center, 1992

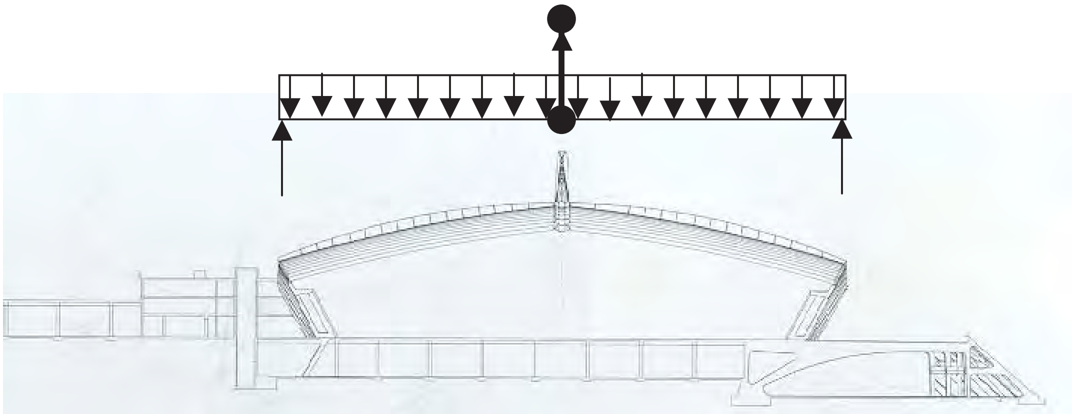

Figure 7: Cross Section, Symetric Loads (dead loads), Tenerife Exhibition Center, 1992

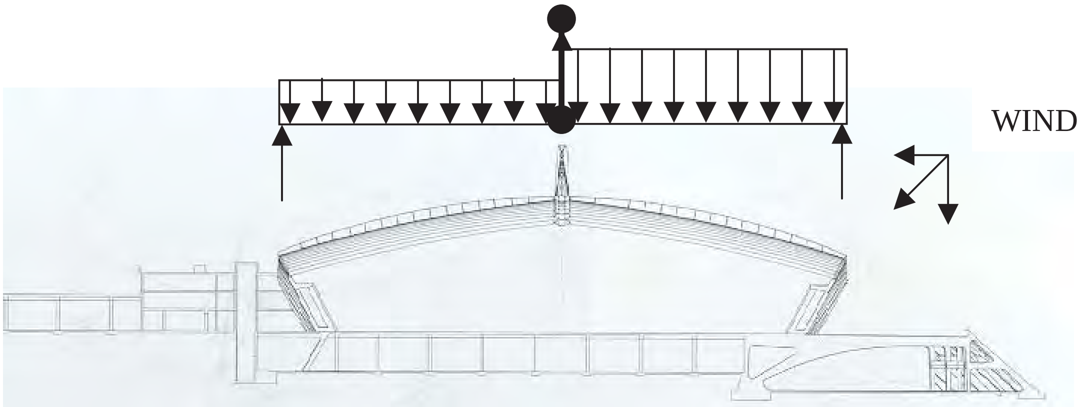

Figure 8: Cross Section, Asymetric loads (vertical component of wind loads), Tenerife Exhibition Center, 1992

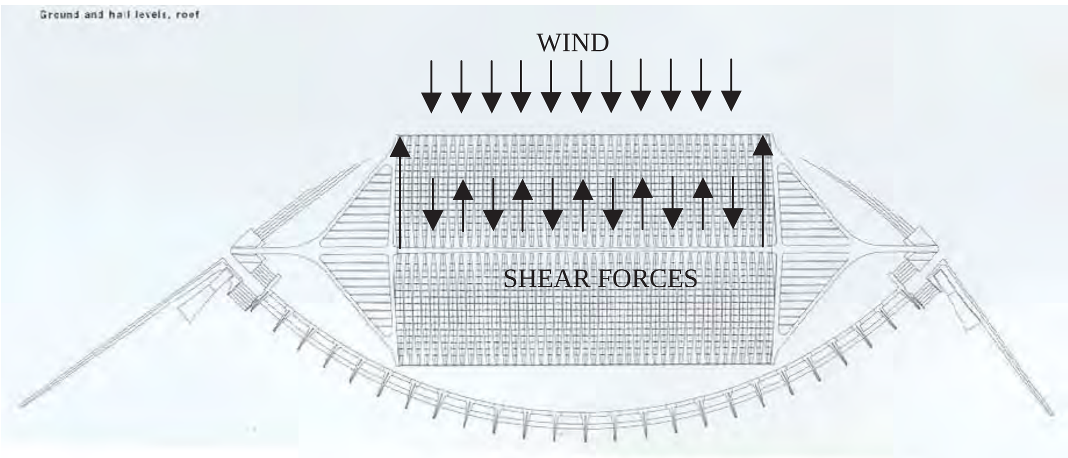

Figure 9: Roof Plan, Asymetric Loads (horizontal component of wind loads) Tenerife Exhibition Center, 1992

Comparison. Comparing the use of the arch in both the above projects, we may come to similarities that give support to our thesis of transference and differences that point to necessary or desired adaptations in the transference of the arch from the bridge to the Tenerife Exhibition Center.

Proceeding from the thought that bridges as well as roofs are beams, we provide several similarities and differences making it possible to exchange the explicitly similar data from one design to the other. However, in this case, it is the structure that is being transferred rather than just the configuration. These artifacts show topological dissimilarities. A bridge refers to the crossing of people, goods and vehicles from one point to another, surmounting an obstacle. These live loads are extremely changeable (e.g. the traffic of trucks and other vehicles exerting asymmetric loads on the carriageway) and are reflected in the structural solution. The roof of the Tenerife Exhibition Center is a means of protection against climate or environmental circumstances; there is no human traffic on the roof; and there is no vehicle traffic over the top of it. The structure of this roof is thus more straightforward than that of the bridge allowing the modifications that we observed on the morphology of the later arch.

This case provides an example of a second kind of transference of features from a precedent to another design. It is interesting to note that the arch structure seems to carry instructions of its configuration, in particular the geometric configuration, while it left the intentional function (topology) behind.

Obviously the configuration and structure (with its technique and materials) have a strong interdependency in the precedent. The transference of the first or the later alone can only succeed if the part transferred fits the corresponding part in the new design.

5. Breaking the Type: The Ontogeny of the Unité d'Habitation

The creation of the Unité d'Habitation by Le Corbusier was primarily the creation of a new housing type which reflected the architect's ideals for a new life-style: healthier and more enjoyable; an innovation in the production of housing for the worker class.

How was it achieved? It seems that it was created by "breaking" earlier types in the manner as illustrated above by Le Corbusier's use of the piloti and Calatrava's use of the arch.

Le Corbusier's inventions, such as Maison Dom-Ino and Maison Citrohan, combined numerous concepts within a fascinating network that involved different levels and domains. Concepts were carefully translated into architectural elements and vice-versa, often evolving a (re)combination with others, such as the elements that compose the "five points for modern architecture" or the elements of his "architectural promenade". Le Corbusier had a very peculiar way of looking at the object of design: on the one hand he proceeded from extremely general concepts trying to provide solutions for the primary needs of lodging, work, cultivation of body and mind, and traffic; on the other hand, he claimed to have proceeded from the concept of the kitchen as a modern hearth, from which the rest followed naturally.

Proceeding from the earlier examples of transferences of the precedent features, this section will present aspects of a possible "ontogeny" of the Unité d'Habitation of Marseilles.

The Grand Plan (Moraes Zarzar 2003). Le Corbusier claimed that the Unité d'Habitation was the result of "40 years gestation". We suggest that this "gestation" was not a question of development (ontogeny) but of lineage (phylogeny). The Unité was not the result of a consecutive combination of two design precedents or, in other words, a direct descent, from two parents to offspring, through the generations.[2] The creation of the Unité seems to be the

[2] This also seems to be the case with other designs carried out in architectural practice.

result of the use and modification of specific elements, often in small chains of linkages such as the aforementioned “five points for a modern architecture”, or Le Corbusier’s bottle, bin and bottle rack (linked features). At that moment he had a huge gene pool at his disposal, ready to be used.

In designing the Unité, Le Corbusier’s task was to provide a housing scheme for workers in the bad economic situation after the Second World War in France. His solution grouped 330 units to house a community of roughly 1600 inhabitants in an 18-storey building providing extensive services to the community. This was a unique opportunity to put all his ideas concerning multi-familiar housing schemes into practice. He had already developed the Maison Dom-Ino, the Maison Citrohan and the Immeubles Village as well as concepts at city planning level such as the concept of the vertical garden city. The Unité d’Habitation for the workers of Marseilles was the result of all these studies. In designing the Unité, he had certainly recalled many of those concepts; some of a general order (light, sun, greenery) but also others that could be more straightforwardly translated into architectural elements (the piloti, the roof garden, the free façades, and so forth).

In fact, many parts of this building block were already developed in detail through experiments in other designs. However, before he could use these precedent features, he needed to have an overall framework. Le Corbusier had to assemble the right features into a whole to match the new desired configuration. In his world full of metaphors, he then placed bottles (dwellings) into the bins (neutralizing walls) and the bins into the bottle rack (structural framework); a collective roof garden on top of the structure with activities for all inhabitants, and a piloti freeing the whole block from the humid ground, providing the whole community with parks, schools and other extensions of the home.

It was not only a question of assembling the existent elements, i.e. recalling them and putting them together. They needed to be adapted to the new constraints and available technology. By constraints, we mean the particularities of a commission such as the budget available, the particularities of the site such as its landscape and climate, and also the selected technology and materials. Due to these constraints and possibilities, “mutations” occurred.

Some features changed their physical expression, i.e. their pattern or structural configuration changed such as the change of the slender piloti of the houses of the 1920s to the gargantuan piloti of the Unité. Other features changed from domain level, meaning that the resultant element acquired uses different to the original one, such as the roof garden that was originally a family garden; after its recombination with the deck of the ocean liner (a precedent of a later date than the vernacular houses of Istanbul). It became the square, the club, the gymnasium of the building block community. Some of the linked “five points of a modern architecture” from 1927[3] were used in a “mutated” form. In other words, the initial linkage was broken; some features “mutated”, and were recombined and re-used in the Unité.

As an independent structure, the bottle rack allowed the creation of maisonettes of 23 different sizes and shapes to house[4] different types of families as well as the creation of a whole infrastructure of services for the block community. The roof garden, the bottle rack and piloti gave the primary or general structure of the Unité (Figure 10). This primary framework enabled Le Corbusier to use many of his precedents, some of them with further “mutations”.

[3] When Le Corbusier designed House 13 of Stuttgart

[4] The variation of the maisonettes was, however, based on the addition or subtraction of cells (rooms) of a prototype (Type E). The cells did not vary in size or layout.

Accordingly, in the Unité d'Habitation, not only the roof garden, but also the piloti and the free façade concepts changed their domain level: from the private (the dwelling) to the collective (the building). The free façade concept was initially tried out at the level of a Citrohan house as well as at the level of the apartment unit of his theoretical multi-familiar building, and then to a free façade at the level of the building block, where the façades of the units are standard and its freedom resides in the combination of the parts to make the whole.

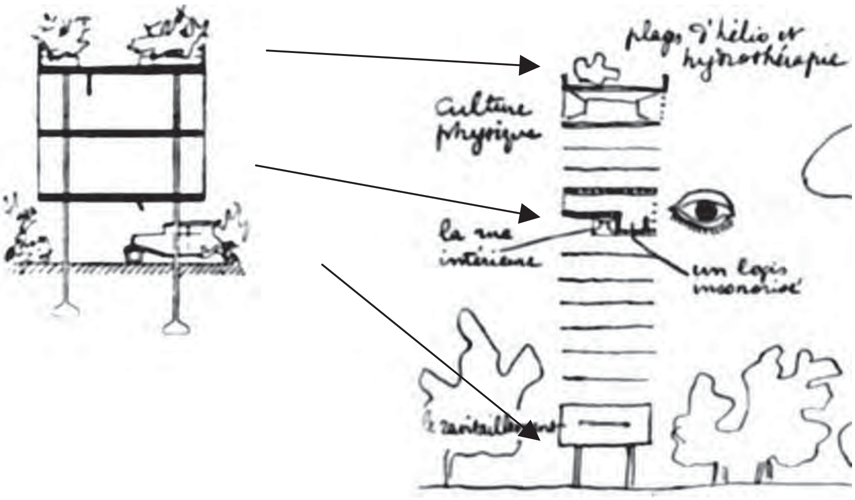

Figure: 10: The Mutated "Five Points of a Modern Architecture"

6. Conclusions

As mentioned in the introduction of this paper, it is not necessary to mimic the mind or the behaviour of the architect to develop a tool or even to make perfect analogies with other fields, because a model does not need to be true or false, but fruitful. However, proceeding from our interest in the production of innovative designs, it can be said that actual approaches are not tackling the problem accordingly. Models are not proving fruitful in the production of innovative architectural designs.

Indeed, variation is a means toward and necessary condition for the development of new species in nature and for the development of innovative designs. But variation occurs not only in form, but also in structure; and innovative designs, as far as the use of precedents is concerned, are a product of the accumulation of these small changes as well as of the recognition of different features and the introduction of them into the architect's vocabulary.

We can say that features are continuously identified within and outside the architectural field bringing small innovations to architects' own "d-gene pools" over the years. These small innovations are selected by architects when searching for precedents to help them to meet certain performances that fit the new design, instead of starting from tabula rasa. These features have their own evolutionary path through the use and adaptation that they go through to fit new situations. New types are often produced by recombination and adaptation of the features already found in the architect's "design gene pool", which is continuously renovated by the architect's creativity in the aforementioned process of recognition and transference of features from a precedent to a new situation, and which is searched purposively by artificial selection.

How, then, can evolutionary models for architecture cope with the need for "outside" information derived from new feature recognition? How can evolutionary models run by computers purposefully select the right precedent and adapt it so as to fulfil the multifaceted constrained world of architecture? Is it realistic to try to build a tool to substitute the architect? Is a support-tool not a more powerful tool toward the development of innovative designs in architectural practice?

By ending this article with these questions we hope to bring other frames of thought which may redirect future evolutionary design research in architecture.

References

Bay, J. H. 2001. *Cognitive Biases in Design, the case of tropical architecture.* Delft: Faculteit Bouwkunde, Technische Universiteit Delft.

Frampton, K., A. C. Webster, et al. 1996. *Calatrava bridges*. Basel; Boston; Berlin: Birkhauser Verlag.

Moraes Zarzar, Karina. 2003. *Use and Adaptation of Precedents in Architectural Design, Toward an Evolutionary Design Model*. Delft: DUP, Technische Universiteit Delft.

Tzonis, A. 1990. "Hutten, Shiffe, und Flaschengestelle." *Archithese* 20(3): pp 16-27.

About the Author

In 1985, Karina Moraes Zarzar obtained her Bachelor's degree in Architecture at the UFPE University, Brazil. Between 1989 and 1991 she followed the OPB post-graduate course at Delft and Eindhoven Universities of Technology in The Netherlands and obtained the title Master of Technological Design (MTD). On June 11th, 2003, she received her doctoral degree at the Delft University of Technology, and is currently lecturing at the same university.

survivor: emulating human behaviours in an animated artwork

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Abstract

Survivor is an artistic creation, aimed at expressing the horror of landmine-inflicted wounds on innocent people.

The behaviour of a human who finds him/herself in such situation is affected by several factors: some are due to the objective difficulty of using the new legs, and some are due to emotional factors, that include fear, “shame” of being in such situation, pain, etc.

In order to attain such characteristics in an artificial device we combined the mechanical structure, which was strongly conditioned by artistic requirements, with a control system that exhibits appropriate behaviours. Behavioural control, a technique developed for the control of mobile robots, was used in *survivor*, and it was implemented over a modified version of the traditional Brooks’ subsumption architecture. This technique makes it possible to emulate normal behaviours such as the need of avoiding obstacles and typical animal feelings such as curiosity, hunger, fatigue and fear.

The paper describes how such results were attained, discusses in detail the implemented behaviours, and presents some ideas for the application of the same architecture to other artistic creations.

1. Introduction

Women and children are the main victims hit by mines.

How does art relate to a humanitarian problem?

Can ethics be a meeting and exchange point among art, technology and other aspects of human knowledge?

Is it possible to develop, trough cooperation among art and technology, objects and art processes that can become understandable symbols or metaphors?

From such questions the *survivor*-walking chair, and subsequently the *survivor*-project were born.

More specifically, the goal was to realize a mobile, relational object that would implement the concept of “remembering pain”, meant as the psychological threshold that marks the transition from the dramatic situation of a victim to the more optimistic one of a survivor.

Survivor-walking chair is a common primary school chair that walks moving its front legs in a way that recalls the uncertain and shaky movements of a person that has just learned how to use crutches and artificial limbs.

The project aims at building an object that can be a recognizable metaphor through its shape, its behaviour, and its capability of establishing relations. This object should be easily recognizable by the majority of individuals, thus being able to awaken the public opinion through emotions and personal feelings. In the final implementation, five of these devices should be placed in various symbolic places around the world, connected via a video-conferencing system, in order to superimpose virtual and actual perceived images, thus reducing the psychological perception of distance.

Survivor is not, by any means, a robot. Its mechanical structure is highly defective, as defective is the structure of a human body that has been deprived of its legs, substituted by some rough mechanical devices such as prosthetic limbs.

Some sensors gather information from the surrounding environment, to understand if people and obstacles are present and if they can threaten *survivor*, and some monitor the internal status of the chair: for instance, the remaining battery charge is acquired as a measure of the “hunger” of the device, and the elapsed time from the beginning of the last movement sequence is used as a measure of the fatigue of the machine.

The resulting actions of the chair are a compromise among the various emulated feelings, and its overall performance, that ranges from quietly walking when no one is around to quickly trying to escape from fast-moving objects, usually triggers surprise and desire to interact in the audience. The system is also capable of recognizing unmanageable situations, such as being trapped in a dead end, and emits a sound that signals the need of human intervention.

At the time of writing, a first version of *survivor* has been built and is now operational. Due to the existence of a previous prototype, this version will be referred to as version 2. In the meantime, a modified and augmented new version is being implemented. This paper shortly describes version 2, and extensively discusses the improvements and additions that are being applied to version 3.

2. Structure

Artistic building elements

Chair: From a primary school

Easily recognizable: an everyday object in all western countries and an object known worldwide – Has several purposes and serves different needs – Refers to children and to childhood

Old: perceived in western countries as a no-value object because it is not "brand new"

Hanging bag: Under the chair, it contains bomb debris from Afghanistan:

When the chair walks and for some time after it has stopped, the bag keeps swinging – memory, recall – collect and order the debris

Fully visible mechanics: show a defenceless body

Perception of disorder, incompleteness, restlessness

Walking chair: A movement that will represent the interior image.

Alternate movements of the front legs – avoids contact with people and objects – if an object comes too close the artwork emits a sharp sound, as alarm and distress call

The artwork is autonomous, and there are no cables or other connections to the outside world

Error, fortuitousness, uncertainty, inaccuracy as fundamental element pertaining to the work of art

Electro-mechanical

The mechanical structure, that is the same for both versions, is very simple (Figure 1). It is based on the consideration that a four-legged vehicle can maintain its stability while lifting either one of a couple of adjacent legs, provided that its centre of gravity is located in a suitable position. It is impossible to maintain stability if more than two legs must move, unless complicated mechanical systems are used to displace the centre of gravity of the vehicle during its movement. This forced us to have the chair move only the two front legs, while the two rear ones are equipped with wheels and are almost always in contact with the ground.

Figure 1 - *survivor* version 2

In order to attain a suitable position of the centre of gravity, the batteries were placed in the rear part of the chair, and some lead counterweights were added to the rear legs.

Loose and quite inaccurate mechanical couplings were chosen for all moving parts, in order to attain a "shaky" and uncertain movement. The "step" derives from the movement of a DC motor with a gear speed reduction system (a car windshield wiper motor was used for each front leg). Such motors provide enough power for moving the chair, and are equipped with the auxiliary contacts used to stop the motor after each step.

Given these mechanical implements, the control of the chair is quite simple. In section 4 details on the control strategy will be given. If the chair has to move along a straight line, both legs must perform an equal number of steps, i.e. steps must be alternately performed by both legs. Having one leg perform more steps that the other one causes the chair to move along a curve.

In version 2, it was decided that no step could be initiated before the previous one had come to an end. The only available feedback is the contact that signals the end of each step, but, since it has been seen that the speed of the motor is quite constant regardless of the load conditions, a slightly more sophisticated control can be implemented if needed, that also allows moving both legs at the same time if a sort of "fall down" is required.

3. Sensors

The other important issue was the sensory aspect. Clearly, *survivor* needs some sensory input to detect fixed and moving obstacles. Furthermore, an indication of the distance and of the direction of obstacles is needed, as it occurs in humans, to determine the appropriate reactions.

As in humans, no precise measurement is necessary or desirable. It was decided that a number of infrared active sensors would solve the problem.

The chosen devices are based on a triangulation principle, where the IR beam reflected by the obstacle is focused on a photodiode, whose output is roughly proportional to the position where such spot falls on its sensitive surface.

These sensors, currently manufactured by Sharp under the catalogue number IGP2Y0A02YK, exhibit very good characteristics at a relatively moderate price. Their output is an analogue signal, whose characteristic can be considered roughly linear for distances ranging from 30 to 120 cm.

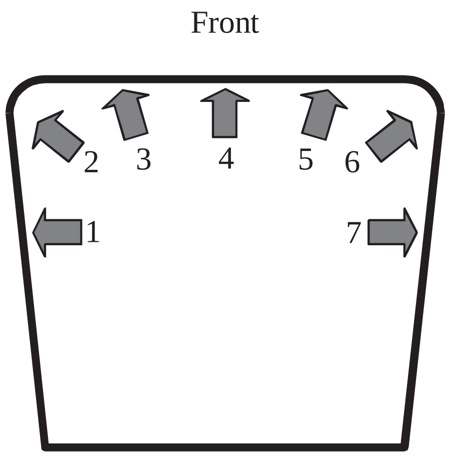

Figure 2 - Arrangement of distance sensors (top view)

As far as the placement of sensors is concerned, the five sensors originally used soon had to be augmented to seven, because since their viewing angle is quite limited, some small obstacles (and even human legs) were undetected. *Survivor* version 2 uses seven sensors, whose placement is shown in Figure 2. Since the original software was designed to handle only three sensors, namely left, front and right, the seven sensors were grouped as follows: sensors 1 and 2 constitute the "left" group, sensors 3, 4 and 5 the "front" group, and sensors 6 and 7 the "right" group. For each group, the smallest reading is taken as the correct reading for the whole group. In *survivor* version 3 this grouping will be removed and all the sensors (including one additional sensor in the rear part of the chair) will be used in a more effective way.

4. Control system

In the first implementation, a deterministic approach was used to drive *survivor*. A PIC microprocessor handled all functions, receiving analogue signals from sensors and sending the appropriate movement commands to motors. A simple program continuously converted data from the range sensors, and took decisions according to the measured distance. Some parts of the behaviour were based on random quantities, whose seed was derived from the readings of all sensors.

Given the simplicity of the mechanical part, electronic circuits are also very simple. It has been decided that a single PIC, namely a component of the Microchip 16F876 series, would be enough to handle all the required functions. The only additional hardware is an analogue multiplexer used to provide enough analogue inputs for all the sensors, and an interface circuit for the RS232 serial line.

Motor control was also kept to a minimum, using only one "intelligent" power CMOS transistor to provide the PWM current for each motor.

5. The behavioural approach

It turned out very quickly, however, that *survivor* would be best driven by some kind of behavioural architecture, and that a fuzzy logic based control would allow obtaining the desired performance from the system.

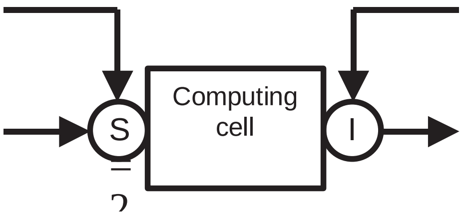

Figure 3 - Basic component of a subsumption architecture

The architecture that best suits the needs of *survivor* is the so-called *subsumption architecture* 0. Basically, a subsumption architecture is composed of a number of interconnected cells (Figure 3), which form layers in the control system. Each cell has an output that depends, according to some fixed law, to its input. Inputs can be suppressed and outputs can be inhibited when some conditions are met. A detailed description of subsumption architectures and of their use can be found in 0.

In our implementation, a slightly modified version of the original Brooks' architecture has been used. Conceptually, cells are analogue computers that process analogue inputs and produce analogue outputs. They may or may not possess memory, according to the function they must perform.

For those who are not familiar with subsumption architectures, an example of how the whole architecture can be used in *survivor* is the following: given a normal walking behaviour that would make the chair walk at a constant speed in a given direction, one can imagine a "fatigue" cell whose output increases as time passes. This output inhibits the input to the legs control cells, resulting in a slower motion. But, if for any reason a panic status is triggered, the output of the fatigue cell can be suppressed, and the chair will again walk at maximum

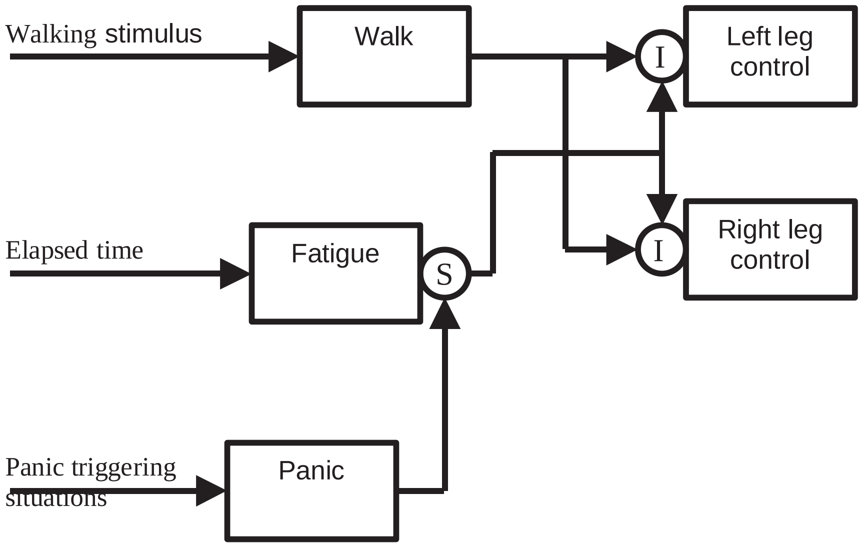

Figure 4 - How panic suppresses fatigue in a subsumption architecture

speed, just as a tired human being would do in a distress situation (Figure 4).

6. Interfacing with the environment

This section deals with the interaction means of the chair with the surrounding environment

External sensor inputs

Survivor receives information about the surrounding environment through a very simple sensory system. Only range sensors are used in version 3, although the information they provide is treated in a slightly more sophisticated way than in the first prototype.

Range values from sensors are converted at a rate of about 30 readings per seconds, and their values are stored and averaged in order to filter out the noise that affects such signals. Furthermore, the following pieces of information are extracted, and treated separately from each other:

- Contact (the presence of an obstacle closer than a preset threshold (around 200 mm) is considered as a contact with an obstacle in the direction the sensor is pointing to;
- Distance (the actual range from the sensor, averaged over several successive readings, in the direction of the sensor);
- Relative speed: successive readings on each sensor are used to evaluate the relative speed of moving obstacles. Only the radial component of such speed is

evaluated, resulting in the approach-departure speed of moving obstacles with respect to the chair.

Internal sensory inputs

Internal sensors are also quite limited: the battery voltage is acquired as a measure of the "hunger" of the device, and the elapsed time from the reset and from the start of the last movement sequence are used as a measure of the fatigue of the machine.

Each leg is equipped with a mechanical switch that indicates the end of each step. In order to keep things simple, no other feedback is provided from the movement mechanism. The mechanical switches are also used to provide an indication of a possible blockage of a motor. Since this can occur simply because the characteristics of the floor change as the chair moves, a sophisticated self-calibration routine has been implemented.

For safety reasons, a watchdog system has been implemented, that resets the whole control system if the microprocessor appears to be stuck in a loop.

Outputs

Outputs include a PWM output for each leg. This allows a rough control of the speed of the motors.

Other outputs were provided for a red LED signalling the need for the battery to be recharged, and a buzzer intended to signal a distress situation, such as *survivor* trapped in an unmanageable cul-de-sac.

Auxiliary I/O

In order to simplify the debugging of the developed software and the fine-tuning of parameters, a serial channel has been implemented that allows connecting a terminal, or a PC running a terminal emulator program, to *survivor*. All constants that can require adjustments during the setup of the device are stored in EEPROM, and can be changed without the need of reprogramming the device.

Also, some statistical values are stored in EEPROM and can be accessed using the aforementioned terminal.

7. *survivor*'s behaviour

The need for emulating the behaviour of an injured human being that is undergoing such a dramatic experience has suggested the creation of a behaviour that is subject to the following (fuzzy) rules:

1. If there are no obstacles close to *survivor*, or people around, the chair will stand still, and occasionally move to another location starting with a random rotation followed by a straight movement.

2. If, during such movements, a fixed obstacle is approached, the chair will avoid it, adding some extra steps with the leg facing the obstacle. If the obstacle is exactly in from of the chair, it will randomly turn 90 degrees to the left or to the right. In general, the turning radius will become smaller as the distance from the obstacle decreases.

3. If a moving obstacle is detected that can be identified as a human being, the chair will modify its direction in order to move towards the obstacle.

4. If a fast approaching obstacle is detected, a “panic” situation will be triggered. The following actions will be turning away from the obstacle, and running in a straight direction for a given amount of time. During this phase, all behaviour modifiers (hunger, fatigue, etc.) will be suppressed, and only obstacle avoidance will remain in effect.

5. During normal movements, a “fatigue” register that affects movement speed. This indicator is simply a timer, that counts upwards when motors are moving, and backwards when they are still. If a panic situation is triggered, this counter will be authoritatively set to the maximum value.

6. Another indicator is “hunger”. This timer starts running when the battery voltage falls below a given threshold, and causes a slowdown of all movements as the fatigue register does. When the battery voltage falls below a second threshold, the red “charge battery” lamp goes on, and no further movements are possible, unless a panic status is triggered. In the latter case, the hunger signal is suppressed as the fatigue signal.

7. If the chair gets stuck, i.e. it has close obstacles in front and on both sides, since it cannot go backwards, will enter the “dead end” situation, activating the buzzer and stopping all movements. The only possible exit from this situation is a global reset, or the removal of obstacles in at least one direction.

8. The same status, but signalled with a different buzzer tone, is entered if any hardware malfunction or motor blockage is encountered.

8. Software structure

The architecture that implements these functions is being developed.

Although the software that drives *survivor* is simple, its implementation on a small PIC posed some technical problems that had to be solved.

The structure of the program is a classical interrupt-driven one, where a real time clock dictates the scheduling of all processes. The tasks that have to run concurrently are:

1. Left motor control
2. Right motor control
3. Range measurement for the eight distance sensors
4. Speed measurement based on range readings
5. Battery voltage measurement
6. Elapsed time measurement
7. Behavioural logic computations

8. Serial I/O control (debugging and setup only)

A real time clock generates an interrupt every 10 ms that triggers execution of the aforementioned tasks. A simplified *crontab* states the periodicity of each task.

9. Experimental results

During 2003 the project has undergone a number of tests, where *survivor*-walking chair was brought in everyday places, such as marketplaces, shopping centres, streets, art galleries. Each performance lasted about one hour, and each time people passing by stopped and formed a circle that kept a distance of approximately three meters from the chair, making comments about the display.

Later, more structured actions were performed, with the aim of modifying the perception of the common space.

The last performed action is *the perfect survivor* installation that was shown at Bangkok World Trade Centre mall from September 16th to 21st, 2003, during the 5th Meeting of the State Parties of the International Campaign to ban Landmines.

In this case the chair was shown together with some large pictures taken by Giovanni Diffidenti, a photographer that reports since ten years landmine victims throughout the world. The installation was in a transit area and was structured in such a way that no privileged viewing points existed. People were invited to enter the installation and to become a part of it, interacting with *survivor*.

This activity resulted in a substantial number of visitors, and in a great interest of national and international communication media.

10. Conclusions and future developments

At the time this paper was written, *survivor* version 3 was close to completion, while version 2 is fully operational and almost constantly on display in art exhibitions and in mine action-related activities.

As it has been said, the full programme includes the realization of five *survivor*-walking chairs, operating in particularly symbolic places scattered around the world (weapon industries, hospitals, political and economical organizations headquarters, museums and art galleries, etc.). The five chairs should be operated concurrently, and all the exhibitions should be connected with each other via videoconference system.

Aside from the artistic aspect, however, the behaviour of *survivor* is interesting also from a general robotics point of view, and we are planning to replicate and to augment its control structure in a more traditional robot, using the resulting behaviour as a base for a more sophisticated (and useful) behaviour-based operation.

The techniques employed in *survivor* will also be investigated as the basis of other machines designed to emotionally interact with men and women.

Credits and Acknowledgements

Giovanni Diffidenti stimulated the artistic creation through his human experience and the photographic materials gathered during his journeys in mine-affected countries.

Virgilio Fidanza, photographer, provided the picture of *survivor*.

The undergraduate students Pierpaolo Apollonio, Giulio Del Bono, Raffaele Ippolito, Marco Negrini and Alessandro Zanacchi did hardware and software development as part of the fulfilments required for their degree study course.

The Educational Robotics Lab and the Electronics Lab of the University of Brescia provided logistic support, computing means and electronic instruments.

The Town of Verdello (Italy) sponsored the installation “*survivor*-spazio relazionale”

The Italian CBL, ICBL and Power sponsored the installation “the perfect *survivor*”

Bibliography

[1] Brooks, R.: “A Robust Layered Control System For A Mobile Robot”, IEEE Journ. Of Robotics and Automation, Vol. RA2, N. 1, March, 1986.

[2] Connelly, J.H., “A Colony Architecture for an Artificial Creature”, MIT AI Memo TR-1151, 1989.

Aesthetic Analyze of Computer Music

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Abstract

The improvement of the aesthetic of the melody line of the music generated by the computer is a big challenge for the scientific world today. The research presented in this paper is trying to give a solution to this problem. A first experiment consisted on the following: 1) a tool for music generation was created; 2) some simple melodies for Bass were created and all the possible solutions for Tenor, Alto and Soprano were generated;a musical analyze from an aesthetic and musical form points of view was made; 3) a set of rules were derived from the analyze such that the aesthetic of the melody line of the music generated by the tool would improve.Out of this first experiments we derived a theory for feelings based music generation. Examples generated according to this theory will be also presented in this paper .

1. Introduction

The improvement of the aesthetic of the melody line of the music generated by the computer is a big challenge for the scientific world today. There are programs and mathematic theory [1] for computer music generation. Usually, this music is produced in conformance with the laws of harmony [3]. But when a computer scientist gives to a musician some music originated from the computer too often the musician is saying: I do not want only a music which is harmonic good, but also a music which will sound good. On another hand, for a mathematician, only employing the harmonic laws for the computer music generation still leaves a lot of freedom for the notes generation, and, consequently the number of possible solutions (for a simple leading melody) is usually very big. For example, when Bass is given, and its melody has a small size (13 notes), the computer can still produce millions of solutions for the melodies of Tenor, Alto and Soprano (all the solutions being harmonic good).

The research presented in this paper is trying to give a solution to the problems above mentioned. The team was formed by researchers from music and computer science. In main the experiment consisted on the following: 1) a tool for music generation was created; the tool implements the laws of classical harmony; 2) some simple melodies for Bass were created and all the possible solutions for Tenor, Alto and Soprano were generated; a musical analyze from an aesthetic [2] and musical form points of view was made; the principles of the classical music for a choir were engaged in the analyze; 3) a set of rules were derived from the analyze so that the aesthetic of the melody line of the music generated by the tool would improve.

This was a first experiment concerned with the computer music aesthetic. In our later experiences we took into account the set of rules derived from our first experiences. From this experiences we derived also a theory for feelings based music generation. The concepts of this theory are also applied and presented in this paper.

The paper is organized as follow. Section 2 briefly presents the harmonic laws implemented by the tool. Section 3 describes the tool. Section 4 presents the first experiment related with the aesthetic music analyze. Section 5 deals with the theory of feelings based music generation. Section 6 gives examples of applications of this theory. These examples are analyzed also esthetically. Section 7 outlines the conclusions.

2. The harmonic law

The music is a revelation higher than any wisdom and philosophy (Ludwig van Beethoven)

The music (the sound art) revealed in the time of the centuries to be a main component of the human culture. The musical art has a theoretical system which is composed by a number of disciplines with different visions. In this way the musical theory, the harmony, the polyphony, the forms, the instrumentation and orchestration, the musical aesthetic and the composition, treat step by step the aspects studied by this art. From the multitude of disciplines enumerated above, the present paper is willing to `touch' only some aspects of the classical harmony, aspects which today can be used by the computer.

The chord -- the principal element of the harmony The chord is a sonorous unit formed by more simultaneous sounds [5] with a sonorous structure and aesthetic structure well organized.

In the natural resonance of the sounds the fundamental is repeated the most, the third is on the second place and the fifth is on the third place. It is not an accident that the sounds *do* (the fundamental), *mi* (the third) and *sol* (the fifth) represent the constitutive elements of the major chords.

The chords and the harmony are linked to the occurrence of the tonal system.From the necessity that the musical sounds must support each other, must have a weighting center, the idea of tonality was born. From the sounds of a tonality, a chord can be built on every musical degree. A chord is formed from third overlaps. Every sound takes the function given by its correspondent degree.

From the point of view of their functions, two kinds of chords can be distinguished: principal and secondary. The degrees of the principal chords are: the tonic (I), the subdominant (IV) and the dominant (V). The rest of the degrees are secondary : the supertonic (II) , the mediant (III), the submediant (VI), the leading tone (VII).

The harmony for four voices The present work treats the human voice harmony, especially the harmony of the principal voices -- Soprano, Alto, Tenor and Bas. According to their setting in the choir assembly the voices are divided in external voices (Soprano, Bas) and internal voices (Alto, Tenor). Usually, the melody is given by Soprano. Sometimes the other voices contribute also to the melody. The most used chords are the ones with 3 sounds (triads) which are distributed to 3 voices. The fourth voice doubles the tonic or the fifth (the third is doubled rarely).

In some chords some elements can be omitted. The tonic can not be omitted because it is the one which generates the chord. The same holds for the third because it gives the scale: minor or major. Consequently, the only element which can be omitted is the fifth.

The distance between voices For ensuring a homogeneous and balanced sonority a maximal distance should be respected among neighbour voices. For example, among Soprano and Alto the maximum distance is of an octave.

The melodic movements of the voices For having a cantabile song, some intervals, difficult to be singed, are not allowed:

- *The octave* is allowed especially for the external voices.
- *The seventh* and all the intervals greater than an octave are in general not allowed.
- *The leading tone* plays an important role. It is attracted by the tonic.It has a special treatment: its doubling is not allowed. The leading tone goes immediately to the tonic.

The harmonic movement of the voices In the melodic movement we observed the horizontal development of one voice, but in the harmonic one we will observe two voices which moves simultaneously.The following movements between voices exists (self-explanatory by name): the direct movement, the parallel movement, the oblique movement, the counter movement and the counter-parallel movement.

The direct fifth and octave For the external voices, the direct fifth and octave are allowed if and only if the superior voice goes gradually.

The parallel unison, fifth and octave It is not allowed to have two voices which go in parallel in unison, fifth and octave when the voices go through two different chords.

The counter-parallel fifth and octave The succession of fifth and octaves between the same voices are not allowed for a counter-parallel movement.

3. A tool foor music generation

In this section we will present the tool for music generation. The tool which is especially built for our experiments can be used in the following way: a Bass melody is given as the input for the tool and the melodies of Tenor, Alto and Soprano are generated such that the constraints imposed by the harmonic laws are respected. However, the tool can easily be updated so that it will help the user to compose melodies for all the voices (Bass, Tenor, Alto and Soprano), melodies harmonically good. The tool can be easily be adapted to be an interactively process in which the user gives notes for Bass, Tenor, Alto and Soprano to the tool and the tool tells to the user whether his/her choice is correct or not harmonically.

The main engine of the tool is the procedure *Verify*. This procedure has as parameters four arrays of notes (for Bass, Tenor, Alto and Soprano). The procedure verifies whether the musical composition formed by the notes of Bass, Tenor, Alto, Soprano is harmonically good. First it checks whether the distances between the notes of Bass and Tenor, Tenor and Alto, Alto and Soprano are in the allowed intervals (see Section 1). The next steps is to apply the procedure *VerifyVoices* to all the possible combinations between the four arrays of notes for Bas, Tenor, Alto and Soprano. The first 3 steps of the procedure *VerifyVoices* is to verify that there is not a direct octave, fifth or unison between two voices. After that it checks that there is not a parallel octave, fifth or unison between two voices, at the end it looks for counter-parallel octaves or fifths.

As explained above the constraints imposed by the harmonic law are checked out by the procedure *Verify*. The generation of the notes Tenor, Alto and Soprano is done by a back tracking procedure. The algorithm generates notes for Tenor, Alto and Soprano in a size equalling the length of the Bass melody. First, it fills the first position by generating three notes for Tenor, Alto and Soprano. After that it goes to the next position and generates again notes for Tenor, Alto and Soprano. This is done till a complete melodic solution is constructed. At each position the back-tracking algorithm verifies whether the melody generated is harmonic good (this is done by using *Verify).* After a first solution, the algorithm generates other solutions. It stops only when all the possible combinations for every position are tried and, consequently, all the possible solutions for the melodies of Tenor, Alto and Soprano are produced.

The tool have also the possibility to accept pattern functions for the Soprano voice. An example of such a pattern is: the voice is moving gradually. A first use of the patterns is to generate music when the pattern and the Bass are given. Another possibility is to ask the tool to generate all the voices when a pattern of the Soprano is given. This option was used for the feelings based music generation experiment.

4. The first experiments

The melody is the most expressive way of communication of the music. The melody is a general reference for the compositional, aesthetic, theoretical and historical characteristics of the sound art. The melody is the center to which all the characteristics of the musical image converge.

A melody can be well composed harmonically but, sometimes, it does not sound well. In the work presented here, there are many musical examples which confirm this truth. The same Bas can generate, on the basis of the harmonic laws, melodies which are correct from an harmonic point of view but which do not sound well. More precise, these melodies do not have a beginning, a culmination and an end.

The Bas given (imposed) is in a pedagogical style, arranged in such a way to make easy the analyze of the melodies generated. The harmonic laws of the classical style are used. From this reason the analyze of the melodies are made also from a classical point of view. The Bas of each of the three melodies which are used in the first experiments is formed from the principal degrees of the do major scale. The rhythm is the element which differentiates the melodies.

Because the number of solutions generated was too big we considered randomly the same number of solutions for each melody, we made observations related with the aesthetic problems encountered. What is interesting for us is to observe whether the melodies created for Soprano (and for Alto and Tenor) can be interpreted and whether the aesthetical melodical curve which keeps the idea of a beginning, a culmination and an end exists. We call *correct melodies* (37% in our case) the ones which correspond to the harmonic laws and the aesthetic laws.

There are exceptions from the aesthetic rules, melodies which do not respect strictly the `melodic-aesthetic` curve which gives the criterion of correctness. In a number of cases, the culmination is at the beginning, or at the beginning and at the middle, or at the middle and at the end, or at the end (46% exceptions). It is common to have the culmination only once (around the middle of the melody), for such a small size.

Another problem encountered is that some melodies from the exception group can not be easy interpreted, are not easy-cantabile because the culmination (the notes in the acute register), bypasses the admitted limit (goes too high), and, consequently, the other two support voices, Tenor and Alto, go also too much in the acute.

So called *non-correct* melodies can not be called melodies, because they consist of one or two sounds which are repeated continually and we can not speak about a beginning (in the medium register of the voices), a culmination (in acute) and an end (in medium).

5. Feelings based music generation theory

In the previous chapters we presented a tool, aesthetical and classical musical form analyses and general rules of improvement (derived from the analyses performed) for the computer music. In the current chapter we propose a new theory for the music generated by the computer. We experimented with it on the tool presented in this paper.

When a composer is involved in his compositional process, especially when he/she tries to compose music for different texts, the composer wants the music to awake different feelings in the hearers of the music. The feeling can be decided by the composer or can be derived from the text. For example, a piece of text expresses joy, another one violence or peace, etc. On another hand it is a known fact that using some general rules for composing music can produce in the audience some reactions. For example, repeating a small sequence of notes many times make a hypnosis state to be induced. The joy can be produced in many ways; for example by a melody which goes upwardly and gradually.

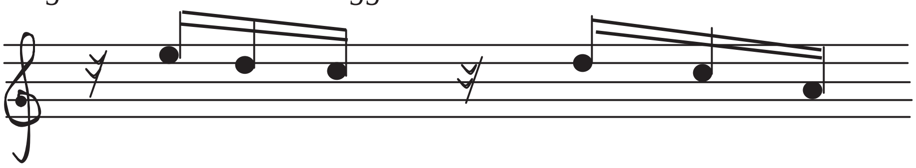
We propose to generate music according to a similar process used by the composers. Our method applies especially for texts which need to be sustained by melodies. When looking to the text, the human (a composer or a non-specialist) decides each portion of the text which feeling needs to awake. The feeling can be derived from that portion of text or can be decided by the human. The computer receives as an input data the set of feelings and for each feeling the length of the melody which needs to be generated. Now, from its data base, for each feeling from the set, the tool will choose rules or a pattern which express that feeling and will generate music, till the whole melody is constructed. The human will receive back the set of melodies generated and he/she can choose one of these or get inspiration from this set in his/her compositional process.

Of course a key element of the whole process is the knowledge (the data base) which the tool have related to the melodically patterns which induce a given feeling. In the current paper we worked out a list (which is not exhaustive) containing feelings and their associated pattern. One important observation is that one feeling can be awaked by more patterns. The tool has the possibility to choose from more patterns for a given feeling, therefore its creativity is enlarged.

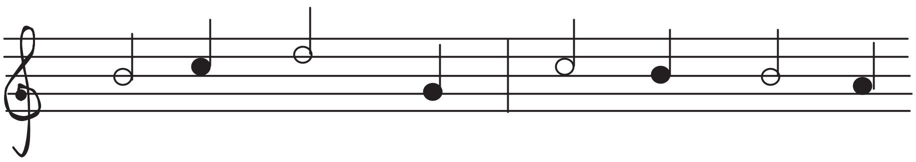
The list of sentiments and their correspondent patterns are given below. This list is not exhaustive and it was worked out by the authors of this article with the help of the existing literature (see for example [5]).

1. Restlessness:

a) *Gradually descendent movement combined with ascending movement having short breaks which suggests the restlessness idea.*

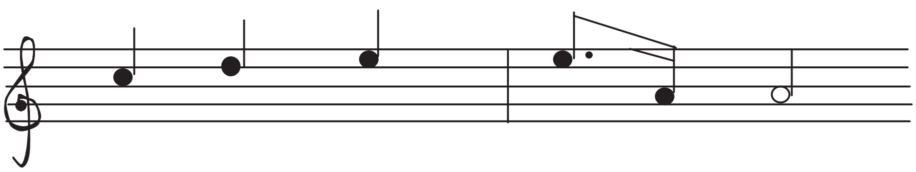


b) *At the beginning of the melodic sequence gradually movement followed by jumps of fifths or sixths; the melody is formed by the repetition of this melodic sequence.*

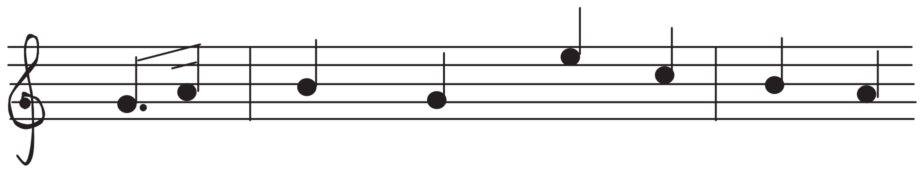


2. Peace

a) *Gradually ascending movement combined with a descendent jump of a fifth*

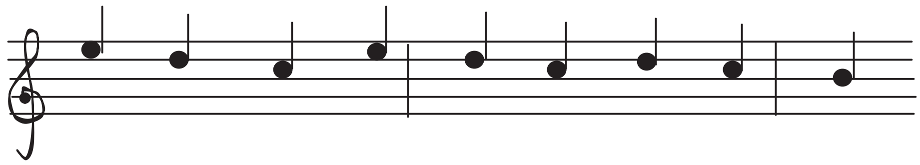


b) *Gradually ascending movement followed by a descendent jump of a third combined with a ascending jump of a sixth and after that again a descending jump of a third*



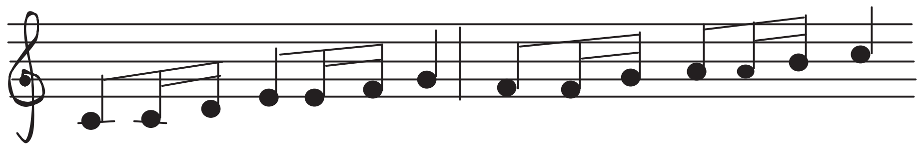
3. *Consolation*

a) Gradually ascending movement combined with gradually descending movement

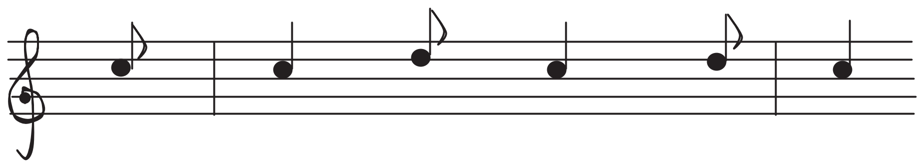


4. *Innocence*

a) Gradually ascending movement which contains a short musical proposition which will be combined with the same musical proposition transposed to a range of a fourth.

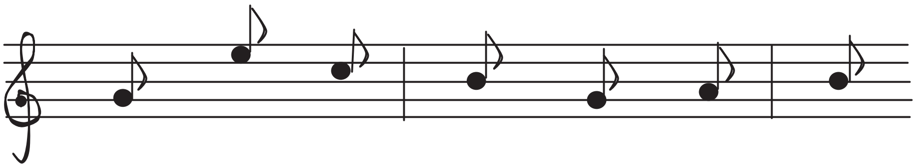


a) Gradually ascending movement combined with a gradually descending movement and everything repeated (short values for the times of the notes)

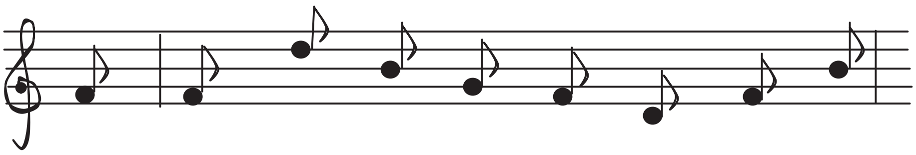


5. *Delicately*

a) Jump of a sixth at the beginning followed by a gradually descending movement combined with a gradually ascending movement (short values *for the times of the notes)*

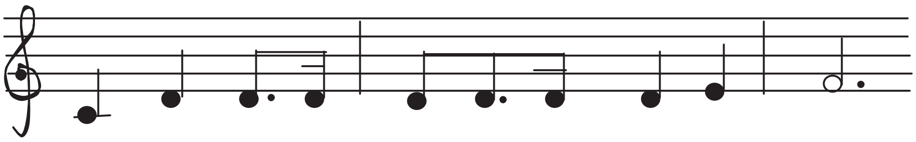


b) *At the beginning the repetition of the sound once followed by a jump of a sixth combined with descending jumps of thirds and ascending movement in jumps (short values for the times of the notes)*

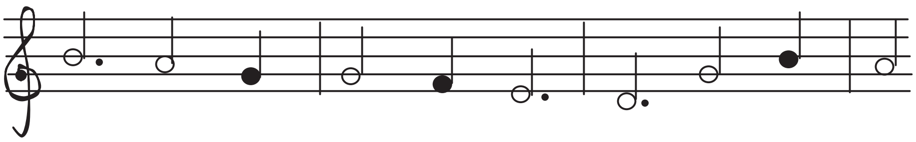


6. *Sadness*

a) *The first sound repeated five or six times combined with gradually ascending movement*

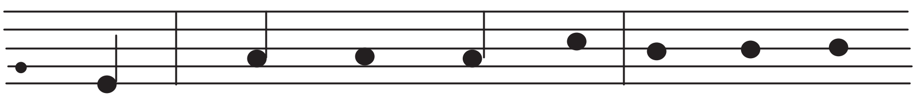


b) *Gradually descending movement followed by descending movement in jumps combined with ascending movement in jumps (large values for the times of the notes)*

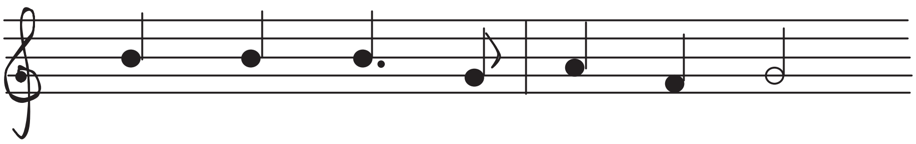


7. *Trust*

a) *Ascending jump of a fourth followed by a repetition of the same sound (three or four times) combined with the repetition of a sound obtained from a ascending and gradually movement (middle values for the times of the notes)*

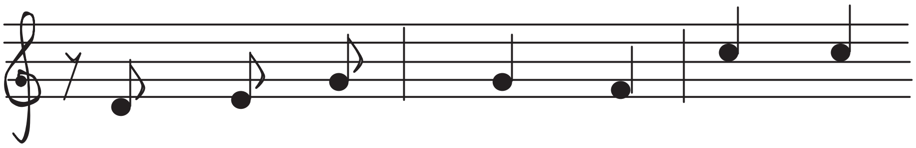


b) *The first sound repeated twice or three times combined with an ascending and descendent movement with jumps of thirds (middle values for the times of the notes)*

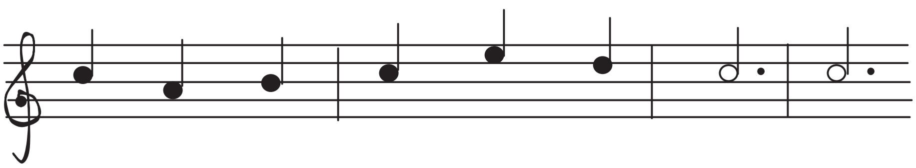


8. Love

a) *Gradually ascending movement followed by gradually descendent movement combined with jumps of fifths and followed by the repetition of the same sound*

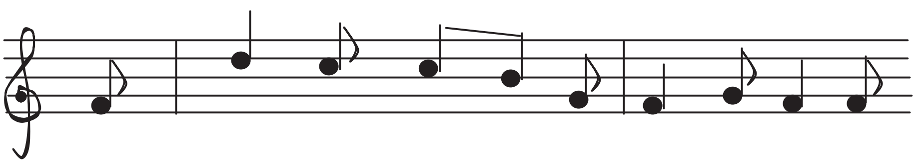


b) *Descendent movement in jumps of thirds combined with ascending movement in jumps of thirds followed by large values of times on the same sound*

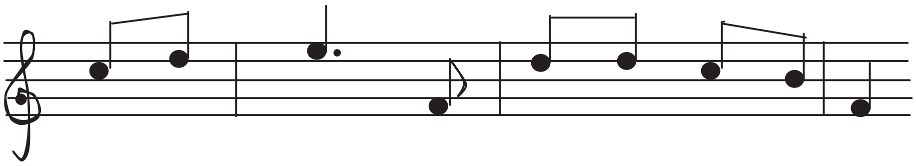


9. Joviality

a) *At the beginning jump of a sixth followed by gradually ascending movement combined with an gradually movement or movement with jumps of thirds*

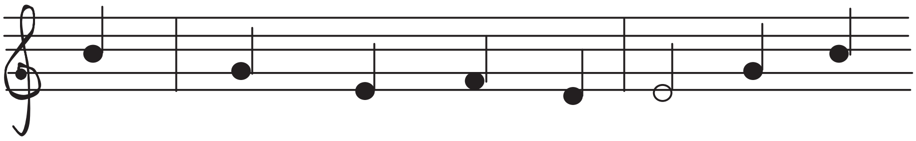


b) *Gradually ascending movement followed by descendent jumps of sixths or sevenths combined with jumps of fourths followed by a gradually descending movement*



10. Joy

a) *Descendent movement with jumps of thirds (unison for all the voices) combined with ascending jumps of thirds.*



The music is a strange and subtle form of art. It is formed from different ingredients: rhythm, harmony, melody, their mixture, etc. In function of the presence and the equilibrium of each of these ingredients the music can be peaceful or invigorating, profane or noble, philosophical or orgiastic. The music aims to influence the systems of our emotions.

It is interesting to observe and to analyse from a medical point of view how the musical patterns listed above induce their correspondent feeling (listed also above). But the way in which the musical sound from its entrance in the external hear induces the feeling production is not in the focus of the current article. Therefore we will explain this only for the variant a) of point 1) above: how the musical pattern induce the feeling of restlessness.

This musical pattern has short breaks at the beginning of the three cumulated values which go always from the acute register to the grave register. Another characteristic is the syncope which is used repetitively. The syncope reverses the natural rhythm of the body which induces a sensation of anxiety which conduct to restlessness.

According to the medical experts [4], this musical pattern modifies the respiration and the blood circulation. This can lead also to the modification of the percentage of the sugar in blood. Under the influence of this music the pupil reflexes and the brain circumference can be changed. These modifications provoke anxiety, agitation, leading to restlessness.

We worked out examples according to this theory with the tool described in the previous chapters. In the examples worked out, we choose some texts, we decided the feelings and we gave them to the tool together with the associated lengths. The tool produced music, which was analyzed from an aesthetical and musical form point of view. These are presented in the next chapter.

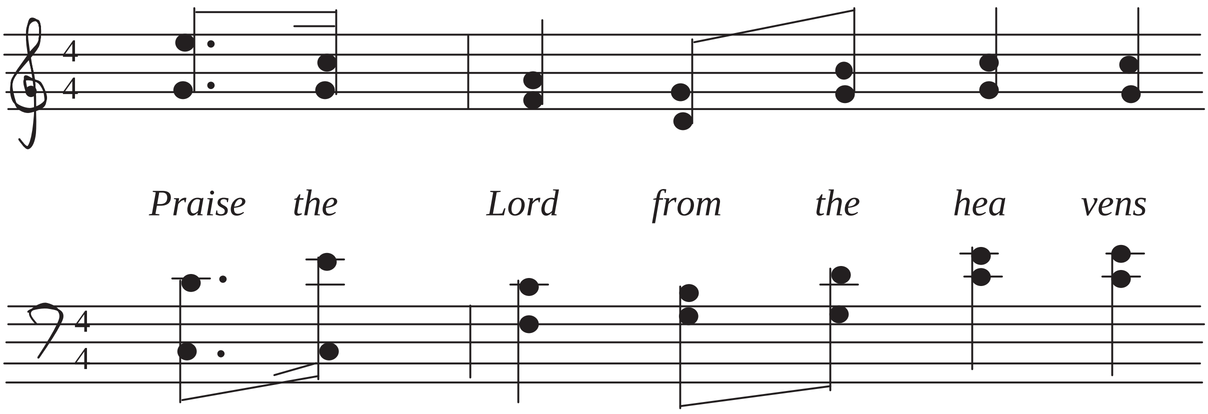
6. Implementing the feelings based music generation theory

In the current article we showed musical patterns based on ten types of feelings. For every feeling we presented two musical variants which induce that feeling. For the feeling of happiness we worked out an example. This is based on a text from the book Psalms of the Bible (Ps. 148, 1)

'Praise the Lord from the heavens'

This text expresses feelings of praise for the Lord, happiness from the deepness of the heart. These feelings can be induced by different patterns. A first pattern is one in which the melody of Soprano has a jump of a fourth in the beginning followed by a gradually and descendent movement. The second pattern for Soprano has the culmination at the beginning of the melody (in acute) followed by a movement which has jumps of maximum of thirds.

The jump of a fourth for the first variant expresses the joy found in the text. The gradually descendent movement suggests the trust in the Almighty God which embraces gradually the soul of the composer (listener). The culmination of the second variant expresses an explosion of joy. This is followed by a gradually stabilisation of the trust in God (expressed by the movement which has small jumps).



We succeeded to generate melodies for both patterns. Both melodies has a nice sonority. The harmonic law implemented by the tool are respected. We did not encounter aesthetic problems.

7. Conclusions

We created a tool for music generation. The tool is based on a backtracking algorithm which explores all the possible solutions and chooses the only ones which respects the constraints imposed by the harmonic laws. When the melody of Bass is given it can generate all the solutions for the melody of Tenor, Alto and Soprano. This functionality of the tool was used for the aesthetic music analyze of our first experiences. The tool can be used also for imposing a pattern to the Soprano voice and to generate all four voices for a given pattern (or sets of patterns).

In our first experiments we used melodies of small size (8 -- 13 notes) which were made in a pedagogical style, with imposed bass. For this experiment, we used chains of major principal chords. Many solutions given by the computer were distributed in the acute register which for a professional choir is not always easy to be intonated; for an amateur choir this is almost impossible. We also observe from the examples generated that the melody does not have a musical form with introductive part, culmination and ending of the musical phrase. So we found the culmination in the beginning and sometimes remaining in the melody movement. In many examples, the soprano voice remained on the same notes which does not correspond from the aesthetic or musical form points of view. These are only some negatives aspects met in the examples produced by the computer.

Out of these experiments we derived a theory feelings based music generation. We employed the principles of this theory for generating music and we analyzed it from an aesthetic point of view.

We will continue the study of the quality of the music generation in other domains (such as for a specific instrument). We will implement also other kind of harmonic laws such as the modern and contemporary harmonies and improve the quality of the computer music. Another possible fellow-up of this research is to observe how such tools can be used efficiently in the domain of education, by teachers and students.

References

[1] **Jackendoff, R. S**. and **F. Lerdah**l (1996). *A generative theory of tonal music*. Publisher: MIT Press.

[2] **Leopoldo, H.** (1971). *Introduction a la estetica de la musica*. Publisher: Editorial Paldos, Argentina.

[3] **Schoenberg, A.** (1900). *The theory of music*. Germany.

[5] **Schullian, D.** and **Schoen, M.** *Music and Medicine*. USA.

[5] **Wyatt, K.** and **Schroeder, C** (1998). *Harmony and Theory*. Publisher Hal Leonard, USA.

Beyond the mechanical stage-hand: Towards an Aesthetic of real-time Interaction between Musicians, Dancers and Performers and Generative Art in live performance.

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Abstract

The authors have recently developed generative content as part of collaborative pieces presented in venues in the UK and Europe. In each performance the generative content was created to respond to live performance from dancers and musicians. By using microphones, sensors and video-based motion detection, contextual information was used to influence the direction and evolution of generative algorithms that were controlling 3D moving-images, sound, and video processing. Additionally some of the source material that was used in the generative content was acquired in real-time from the performance, such as video (used for 3D texturing) and sound. In the development of these works the authors have started formalising ways to analyse sets of real-time captured data and extract information that can be used extensively.

1. The Background

The search for an "expanded theatre" or an "expanded cinema " is not new. Writings from Richard Wagner in the first half of the nineteenth century call for a "total theatre" in which all of the art forms involved – lighting, sound scenery and performance - combine together. This is echoed nearly a century later in Lazlo Moholy-Nagy's writings on a Bauhaus approach to theatre which reflect a fascination with mechanics and a desire to incorporate technology into performance. It was Moholy-Nagy who wrote that the "Theater of Totality with its multifarious complexities of light, space, plane, form, motion, sound, man – and with all the possibilities for varying and combining these elements – must be an organism."

Over the last century we have seen mechanical, recorded material used to represent the virtual contrasted with the live performer in the work of Samuel Beckett and virtual dancers generated by computer interacting with real dancers on stage in Merce Cunningham's choreography. In Film, the writing of Gene Youngblood on expanded cinema has pointed the way towards a medium which emulated a synaesthetic experience rather than that of a passive distant observer.

In all of our experiments we have been searching to create theatrical experiences which use the computer and computer generated imagery in a manner which goes beyond a simple "stage-hand" effect. A more appropriate analogy would be that we are attempting to create instruments with which the musicians, dancers, actors, etc… can perform. They are ideally however, more than simply a passive instrument in that they have an intelligence that will continue to act and react without cues from the performers or technicians. They are both another instrument and a performer in their own right.

2.1. The Software

Most of the generative work was executed with the open-source free software PD (pure-data) with GEM, an openGL library for PD, with the rest of the work developed with Macromedia Director. PD is real-time software programming environment for live performance of music and multimedia. The software was chosen because of its robustness and performance, but also for the ease of programming changes in real-time during rehearsals or performance.

2.2 The Performances.

Each performance piece was created as a collaborative exercise. In each case, all parties involved exchanged ideas and experimented with modes of interaction in order to achieve a full and balanced integration of the generative and interactive content with the "human" performance. This was deemed especially important to avoid the multi-media content added on as an afterthought. Furthermore, the range of possibilities was not known by all parties beforehand, which made the dialogue and exchange of idea challenging, but exciting.

2.2.1 "Where Do We Go From Here?"

"Where Do We Go From Here?" was an interactive, non-linear film written and directed by Barbara Hawkins. It is a conventionally shot, black and white movie focusing on a relationship between two lovers. The film was written for live performance with the saxophonist Andy Sheppard playing an improvised soundtrack and controlling the playback and order of the scenes of the movie. While the actual time-based film sequences were shown on the main screen, two side screen displayed each 4 sequences that were further controlled by the saxophone in such a way that playback speed, size, cropping, colour, rotation, etc of each sequence responded in real-time to various parameters of the saxophone sound, such as amplitude, base frequency, and spectral richness.

This was achieved by using sound input from the saxophone into a first computer running a PD program in which we derived data from the sound input. This program essentially monitored the amplitude and spectral content of the signal and sent contextual messages over a LAN network to a second computer on which the video was manipulated with GEM. The input data was essentially interpreted by the first computer to send contextually meaningful messages to the second computer, such as the amount of activity, the richness of the spectrum and a rough fundamental frequency. This allowed us to control the side sequences with parameters that made the sequences respond to the music in ways that were clear to the audience.

We have found that the most critical aspect of the system, in order to achieve high quality “symbiosis” between music and images, was the latency of the system. The video processing was displayed at 50fps per second, rather than 25fps, and the whole latency of the system, from sound input to image manipulation was in the order of about 25-30ms. The authors found that the audience seems to intuitively understand the relationship between sound and image manipulation, and enjoy the experience better with as short a latency as possible.

2.2.2 “Dead East, Dead West”

This piece, performed at the ICA (London) on 1 August 2003, was written by Sue Broadhurst as a live, semi-improvised performance piece involving two dancers/actors and a drummer, with live stereoscopic video processing and 3D image manipulation providing an ever shifting setting in which the performers evolved. The images were in a way illustrating the points of view and feelings of the two main performers, and the changing dynamic of their relationship.

The 3D image processing was realised using two computer, one doing sound input analysis (similar to the one developed for “Where Do We Go From Here?”) and sending network messages over a LAN to a second computer, which was receiving live video input from a DV camera, and displaying the 3D visuals using GEM. Motion detection was used on this computer to infer the amount of movement and direction of the performers. This was used to control 49 3D objects in a virtual 3D space onto which the input video was mapped as a live texture. Several aspects of the 3D objects, such as size, rotation, colour, and their spatial organisation were controlled by the data derived from the motion detection. The 3D virtual “set” was then displayed with two LCD projectors through polarising filters on a silver screen, which also displayed stereoscopic video of the performance seen from different vantage points. The members of the audience were wearing stereoscopic polarised glasses which enabled them to see the whole performance in 3D stereoscopy.

The piece was performed by Tom Wilton (Dancer), Katsura Isobe (Dancer) and Dave Smith (composer/percussionist), choreographed by Jeffrey Longstaff, and the 3D video was realised and performed by Brian McClave.

2.2.3 Interaktions-Labor, Saarland Germany.

This piece was realised in collaboration with Lynn Lukkas, University of Minnesota (USA), Marija Stamenkovic, dancer (Barcelona, Spain) with programming in Macromedia Director by Paul Verity Smith. The programme read the amplitude level of the dancer’s breathing so that she could improvise and control the playback speed of a video (of herself) projected behind her. Additionally a heart rate monitor attached to her body controlled a drum track programmed in MAX-MSP by Mark Henrickson.

3. Development and approach

The nature of collaborative work meant that in each instance, the authors had to do most of the work *in situ* during the writing and rehearsal stages of the “human” performance parts. This implied the need for an approach where experimentation and prototyping can be done quickly. The authors felt that it was necessary to develop many modular algorithms that could be used and modified quickly and easily. Thus, much the work went into creating contextual representations of data to easily interface the different algorithms together. This meant that complex, yet consistent real-time interaction was achieved. For instance, the amplitude of the sound input was derived to produce a variety of data, which resulted in messages which translated to concepts such as “sudden change”, or “very noisy” (as opposed to very pitched).

The advantages of this approach were two-fold. First, it did mean sending relatively small amounts of data over the network, thus allowing us to preserve very low-latency. Secondly, it meant that the algorithms could be developed around significant perceptual changes, which enabled us to better design the algorithms with the goal of achieving a perceived closeness between performance and generativity.

4. Conclusion.

A clear development in our work has been the use of open source software in preparing the parches for performances. We have used PD and GEM extensively. This has enabled us to create specific applications tailored to the precise performance needs, as opposed to having to adapt or subvert commercial applications for purposes to which they were not intended.

Further experimentation will be in the field of using live sampling of audio directly from the performers and musicians, creating a relationship between pre-recorded video and sound and the movement and speech of performers and dancers and further developments in responsive environments where the virtual stage setting responds to the performers and the audience.

Objecter

A Step towards a General Tool for Generative Design

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Abstract

This paper introduces a general approach to be able to use generic procedures for a wide range of design problems. Therefore we regard a certain product exponent as an instance of a product class, which contains well-defined degrees of freedom. The formal model of the product class is developed out of the product analysis results and is noted in a specific modeling language. For this we define the geometrical structure and relevant shaping characteristics of the product including variable parameters, dependencies and constraints. The modularity of the system permits the encapsulation of individual units, which can be reused as autonomous components in other models. The software *Objecter* parses the formal model, assigns concrete values to the parameters, propagates dependencies and so generates different representatives of the product class. For the variation of the parameters a choice of automatic procedures (i.e. Constant, Random, Mutate...) as well as interactive modes are provided. As a prototype of a design-supporting tool *Objecter* shows promising potentials in its latest state of development.

Introduction

When implementing generative approaches on computers, there is the question for the suitable environment. One can choose one of the specialized tools on the market like Maya, Illustrator, Flash or even Mathematica and use their scripting languages to integrate the generative idea. However, these tools are often very complex and demand intensive study of the whole software package. In many cases they do not offer the required methods for a certain approach.
Another strategy is to use a common, multi-purpose programming language like, Java, C++, Basic or others. But are these algorithmic programming languages ideal for solving construction and design problems in a generative approach? For the average designer, architect or artist the additional job of a software developer is quite strange, likely too technical and a too big effort – all in all: a different world. As a result, we see a variety of different individual implementation approaches, a mixture of used tools, programming environments and frameworks.

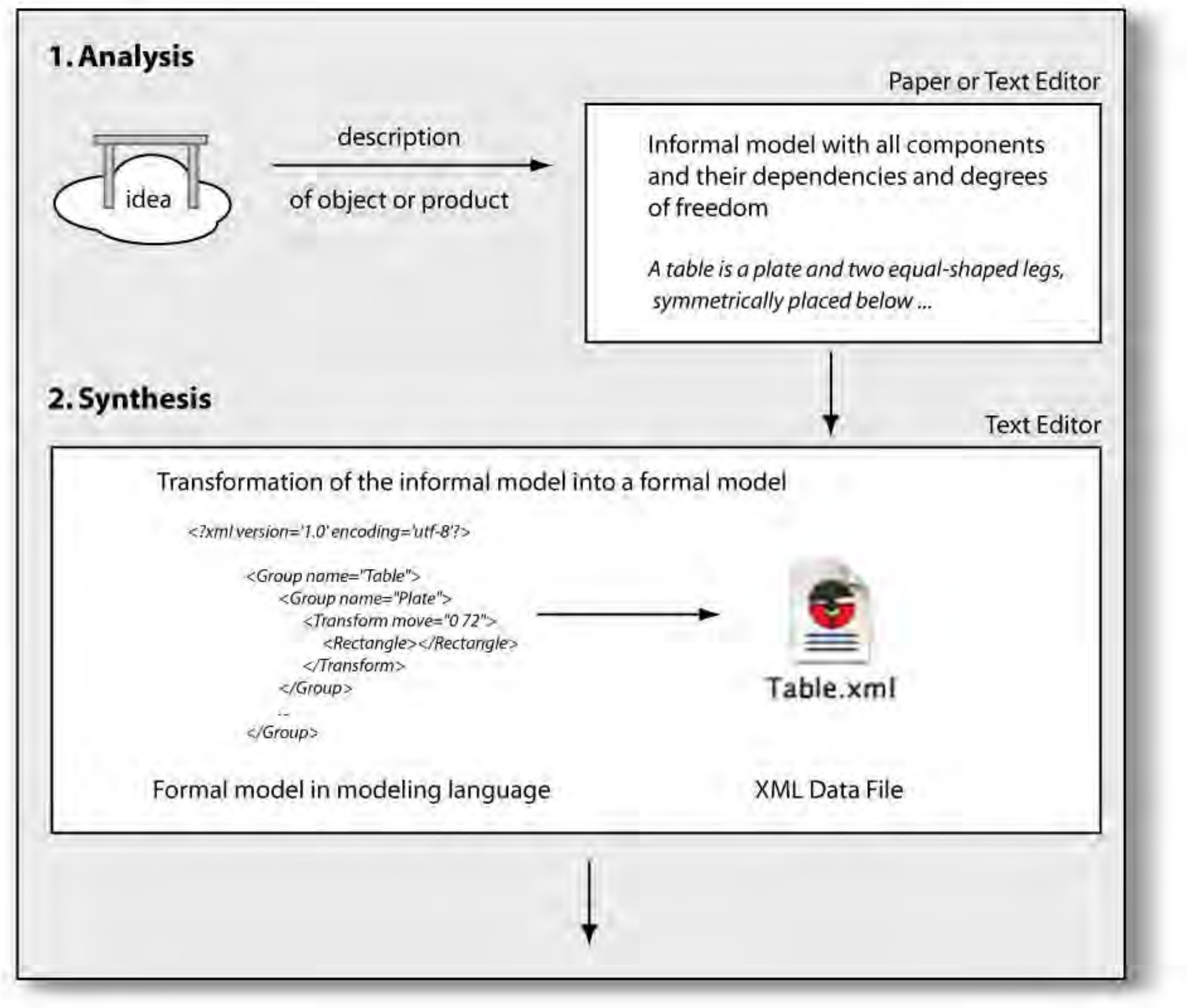
From this background we asked ourselves if there could be an environment more oriented to the goal of implementing generative ideas.
It should have the following characteristics:

- Generators for a wide range of applications should be implemented easily and straight- forward in the scope of an underlying model.
- Not only the results, but also the generators should be exchangeable and modular.
- Common generative methods like cellular automats, L-Systems and others should be integrated from the scratch.

The software *Objecter* we introduce here is our first step towards such a common environment for implementing generative ideas.

Methods

At the beginning of the *Objecter* workflow there is the idea of an arbitrary product or object. As the result of the process we want to generate many designs of this product.
We regard the designs as instances of our product class, they are all representations of the initial idea. On the one hand, they all show the same common product characteristics. On the other hand they vary in many aspects to cover the field of creative freedom.



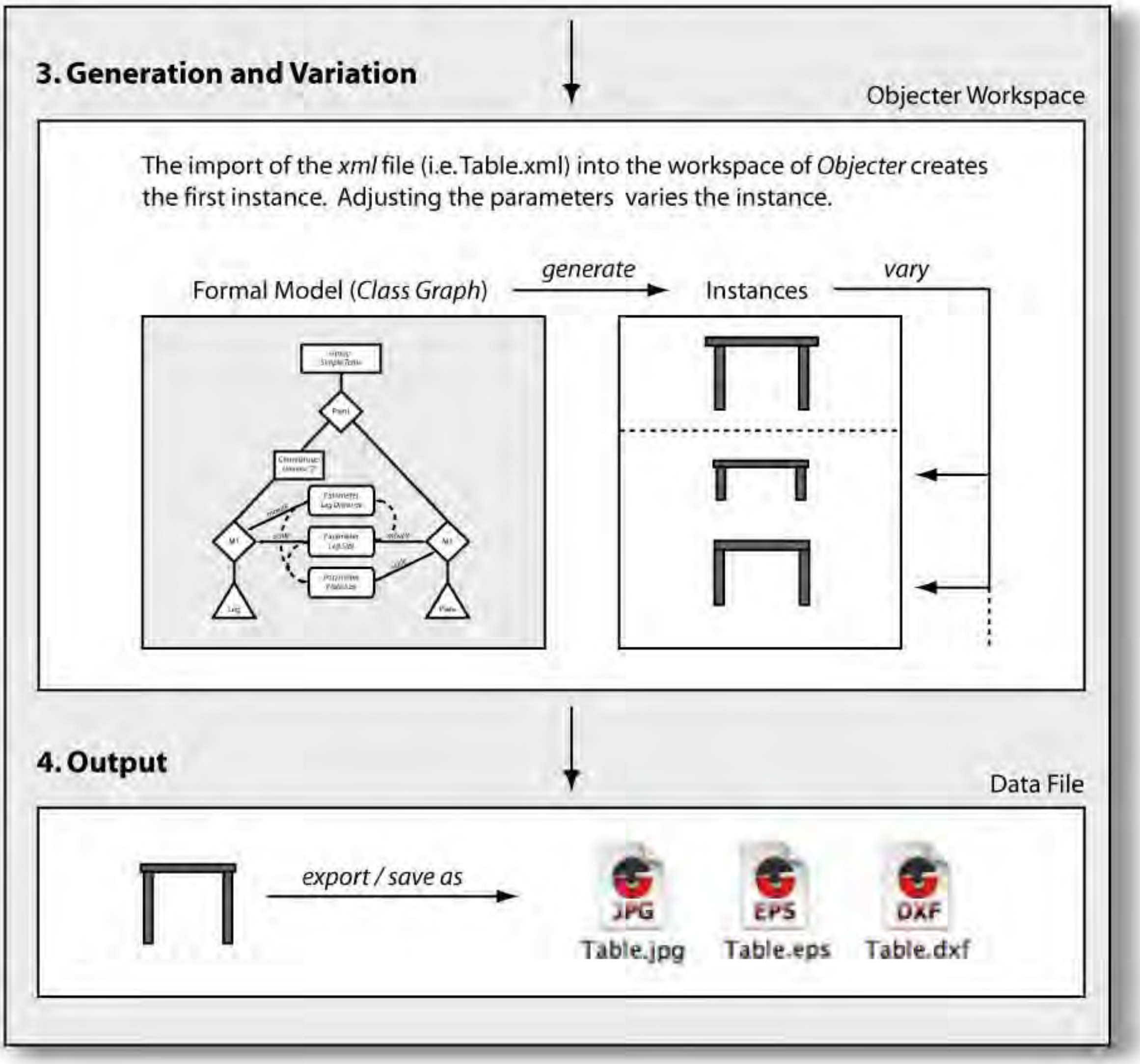


Fig. 1: Workflow steps in *Objecter*

To illustrate the workflow steps we want to introduce the example “SimpleTable” here. Although a table of course is a 3D-Object, we just generate a 2D side view here to keep the things simple.
In the “2D side view scope” we could define for example: “A table is a plate and two equal-shaped legs, symmetrically placed below.” This describes the common characteristics of all instances of the product class “table”. As the degrees of freedom we find the width and height of the plate and the legs, and also the arrangement of the legs at the bottom of the plate. Aspects of the materials or the color are not to be regarded here.

Analysis

In the analysis phase, we extract the basic characteristics of our product class. Therefore we have to answer the following questions:

What are the Product Components?

In our “SimpleTable” example, we can identify the following components:

1. Plate
2. Two equal-shaped legs

The term “equal-shaped” for the legs implicates that we actually have to define just one leg and then produce the other leg by cloning.

How are these Components Geometrically and Logically Related?

We can have at least two different views of logical relationships: either the legs are arranged at the bottom of the plate or: the plate is located on top of the legs. Both views will produce similar results here, however it is essential to have at least one point of view of the logical structure of the object.

What are the Variables, the Degrees off Freedom that Form a Creative Space?

The “SimpleTable” definition leaves out many aspects of our product. We use these “unanswered questions” to establish variation: These are the degrees of freedom in our model space.

We can find:

1. The size of the plate
2. The size of the legs
3. The distance between the legs

What are the Constraints of Variation?

In our example, the distance between the legs is not totally free. The plate and the legs must stay connected somehow. In addition the elements should not overlap.

Model Synthesis

From the knowledge we gain in the analysis phase we are able to create a model of the product class using *Objecter*. At the current development state models are notated in an XML-Language called “*Objective*”. Later, models could also be created using a graphical editor.

Modeling means, creating a class graph for the product class using a set of given nodes.

Class Graph Nodes

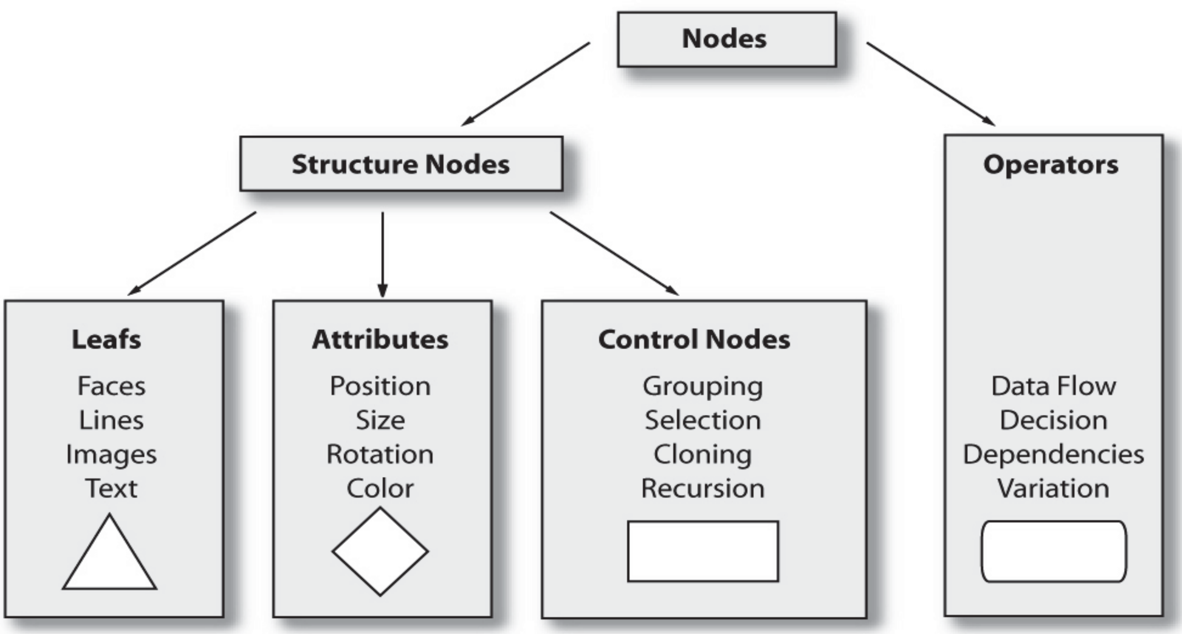


Fig. 2: Types of node and their symbols.

There are nodes for different purposes. Altogether the set can cover the following demands:

- Primitive shapes can be combined and grouped to model more complex shapes
- Shapes can be scaled, moved and rotated regarding their group structure
- Shapes can be added, intersected or subtracted
- Text and Images are considered as shapes
- Degrees of freedom can be modeled by adding variant parameters for size, position, amount, color or any attribute
- Limitations, constraints or any other kind of logical or geometrical relationship can be modeled by expressions
- Special operators help simplify common tasks like arrangement and alignment of shapes
- Models can be based on themselves to create recursive models

Some parts of the model are independent from the chosen 2D or 3D workspace, others have to be defined in a given representation space. For example, a shape in 3D has a different type of coordinates than a shape in 2D. So the available nodes are organized in libraries for 2D or 3D modeling. However, many core features are implemented independently from a representation space.

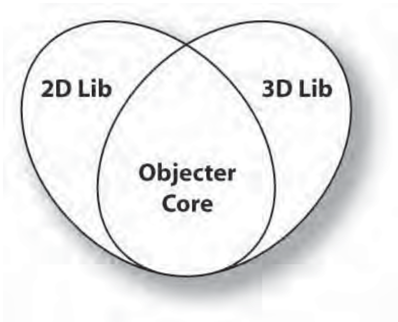


Fig. 3: Common Architecture for different modeling spaces

At the current state of development, the 3D library is not implemented yet. This is partially justified by the lack of a Java 3D environment on some platforms (e.g. Mac OS X).

The next figure (*Fig. 4*) shows the Class Graph for our example "SimpleTable". In the center you can see the three operator nodes "Leg Distance", "Leg Size" and "Plate Size". These are the degrees of freedom in our model we identified during the product analysis phase. For instance "Plate Size" has a data flow connection to the "MultiTransform"-node (MT) for the plate, it is used to scale the plate shape. However the values of "Plate Size" are not totally free. You can see that there are constraints given by "Leg Distance" and "Leg Size": The plate width is never chosen smaller than the leg distance plus the leg width.

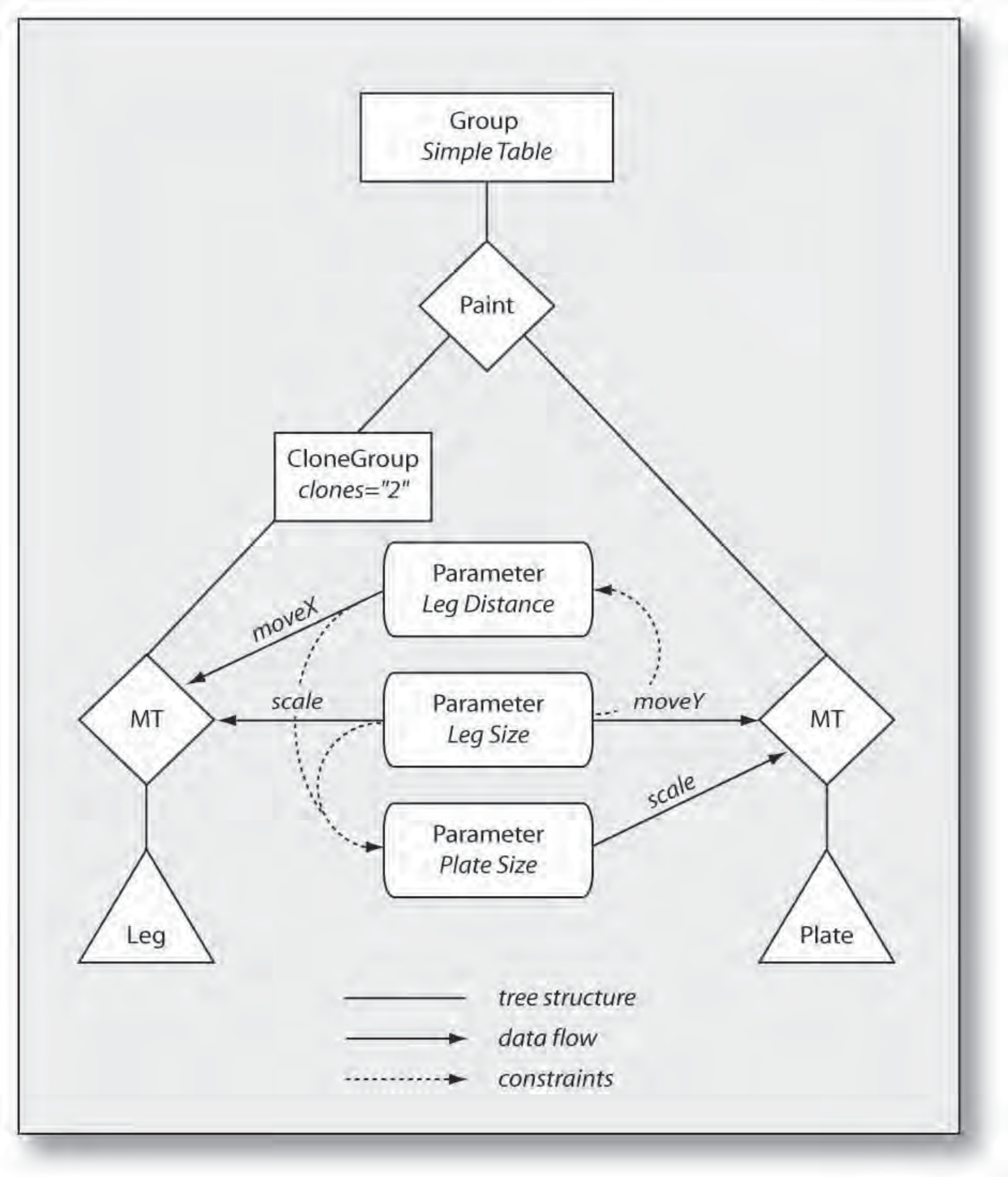


Fig 4: Class Graph for "SimpleTable"

Generation and Variation of Instances

After loading the XML-notation to the *Objecter* workspace, the parameters "Leg Distance", "Leg Size" and "Plate Size" immediately appear on the left side and a first instance of our "SimpleTable" is drawn in the "Render" area (*Fig. 5*). The value fields of the parameters reflect the chosen min/max-intervals and display the current value in this range.

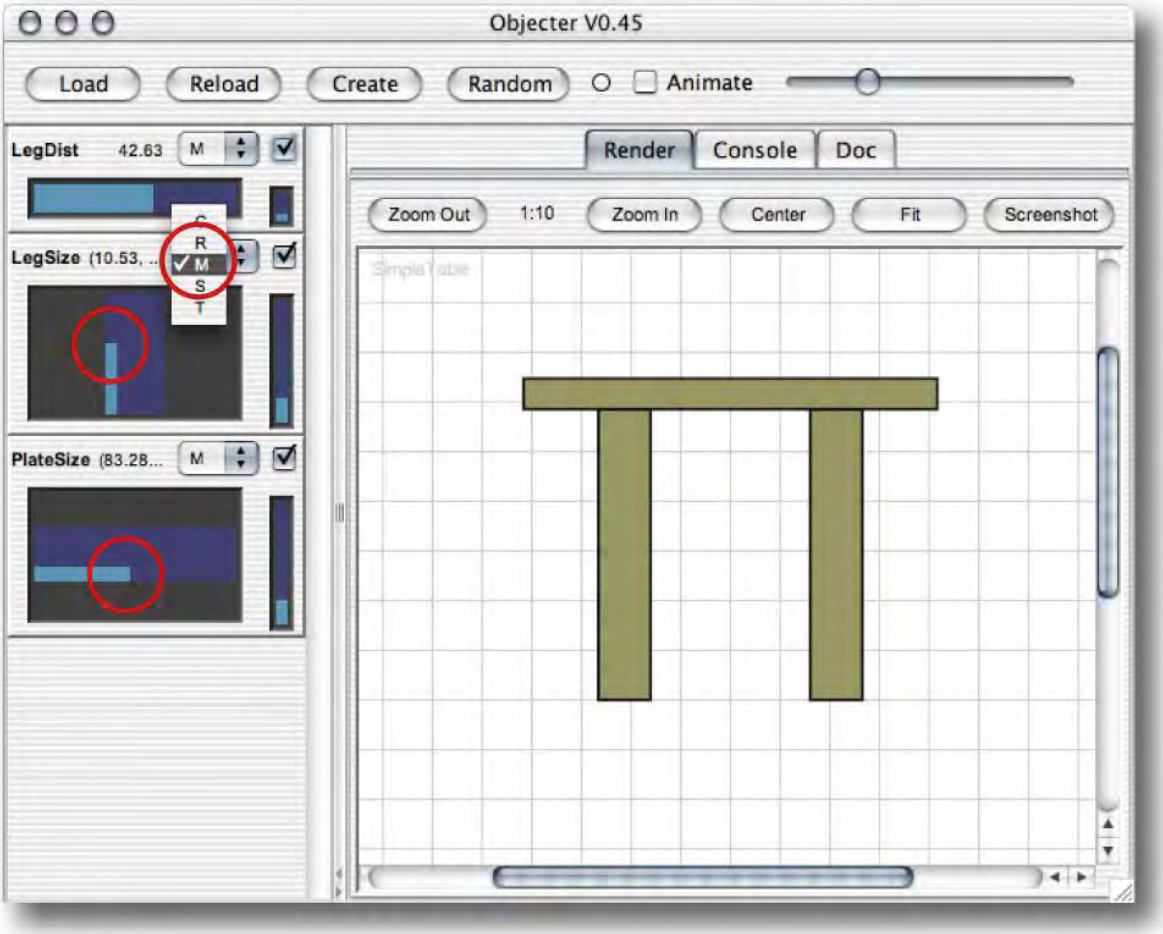


Fig. 5: Screenshot of "SimpleTable" loaded to the *Objecter* workspace

The user now has several possibilities to vary one or more parameters:

Manual Parameter Variation

By dragging the mouse in the value field of a parameter, the changes of the instance are applied in real time. This manual variation is a suitable method to explore the effect of a single parameter.

Automatic Parameter Variation

By clicking on the button "Random", a new instance is created with all parameter values chosen randomly in their definition range.
By clicking on the button "Create", the values for the next instance are chosen by using one of the variation rules specified in each parameter:

Mutate	The next value varies from the current one by a small, random offset
Random	The next value is completely random
Tweed	The value slides from the current value to a randomly selected target value, after it is reached, a new target value is chosen

Sweep The value oscillates through the complete definition range

Constant The value does not vary at all and can only be changed manually

Applications

In this section we briefly introduce some example generators in different fields of application.

Furniture Design

Furniture is a quite good field of application, because the industry and handicraft uses mainly simply shaped profiles.

A Table Generator

The following example illustrates the range of designs of another more advanced table generator. All in all, this generator has 21 parameters.

Fig. 6: A series of instances of a more advanced table / sideboard generator

This generator uses style definition tables for different wood textures and fill colors.

Fig. 7: Instances with style definitions "Cherry-Style" and "Oak-Style"

The drawer handle bars are the output of a separate generator which is embedded in the main generator.

A Recursive Shelf Generator

Another furniture example demonstrates a recursive model implementing a "divide and conquer" algorithm. Beginning with the given outer size, the generator divides the shelf into smaller areas and finally decides to insert a solid or glass door element, a compartment or an empty unit.

Fig. 8: Results of a recursive shelf generator

Industrial Design

"The Watchmaker"

The example "Watchmaker" is a completely image based generator. It uses a library of predefined graphics and recombines them on different layers.

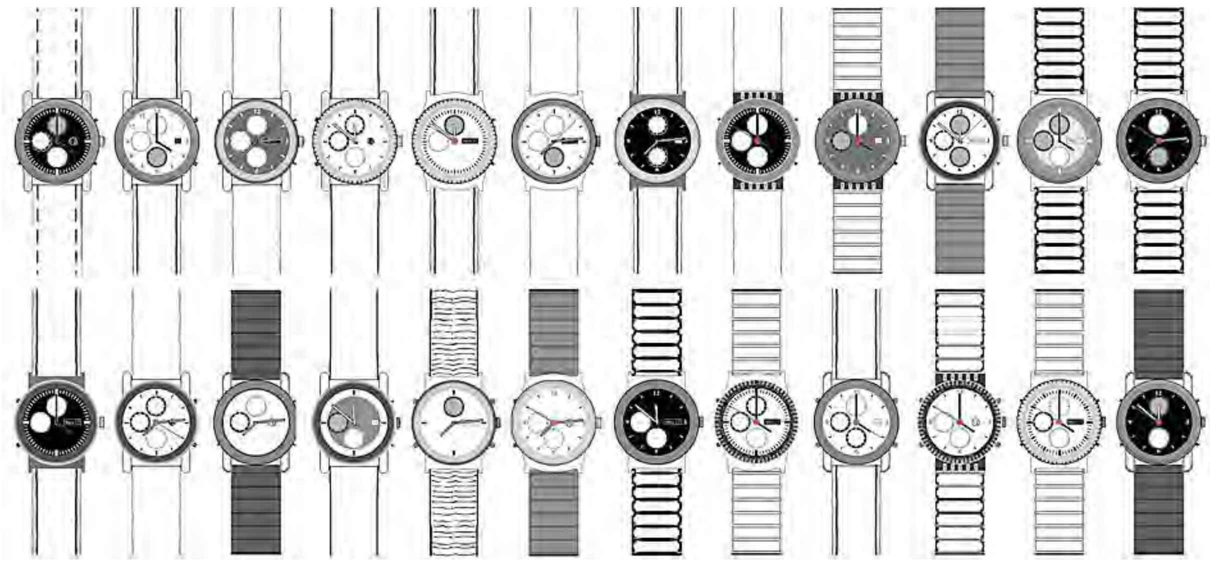


Fig. 9: Random "Watchmaker" results.

Science

Lindenmayer-Systems

Lindenmayer-Sytems are a wide spread method for simulation of natural growing structures. As a proof of feasibility we created models for many classic L-Systems in *Objecter*.

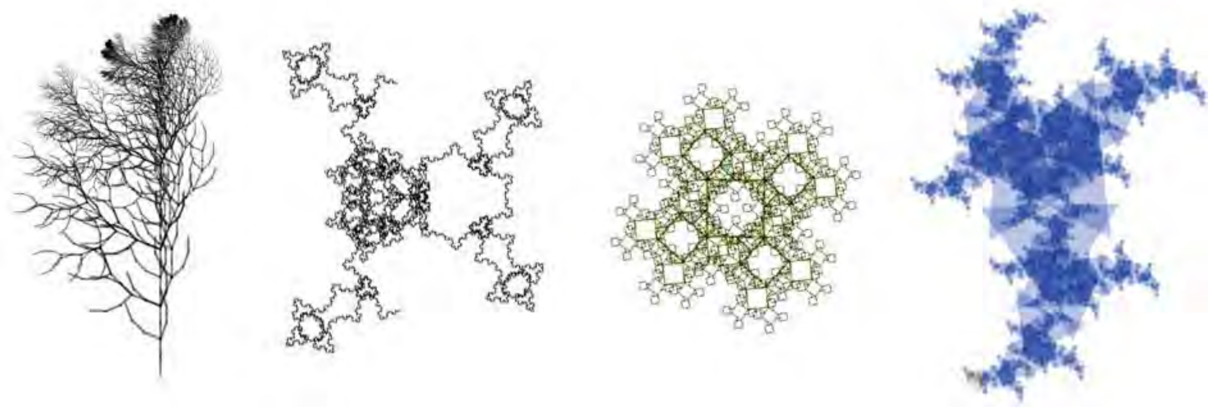


Fig. 10: Some L-Systems modeled in *Objecter*

Graphics - Arts

A 2D Pattern Generator

Using a single quadratic image as a tile, we create 2D-patterns by flipping and rotating in 90° steps. The tile used in the example below has only 4 different orientations due to its inherent symmetry. Generally 8 different orientations are possible.

Fig. 11: Single tile in its 4 possible orientations

Our pattern generator combines **n** x **m** tiles in variant orientations to create larger tiles for filling rectangular areas by repeat patterns. Instead of using images, one could also insert a tile generator into the pattern generator.

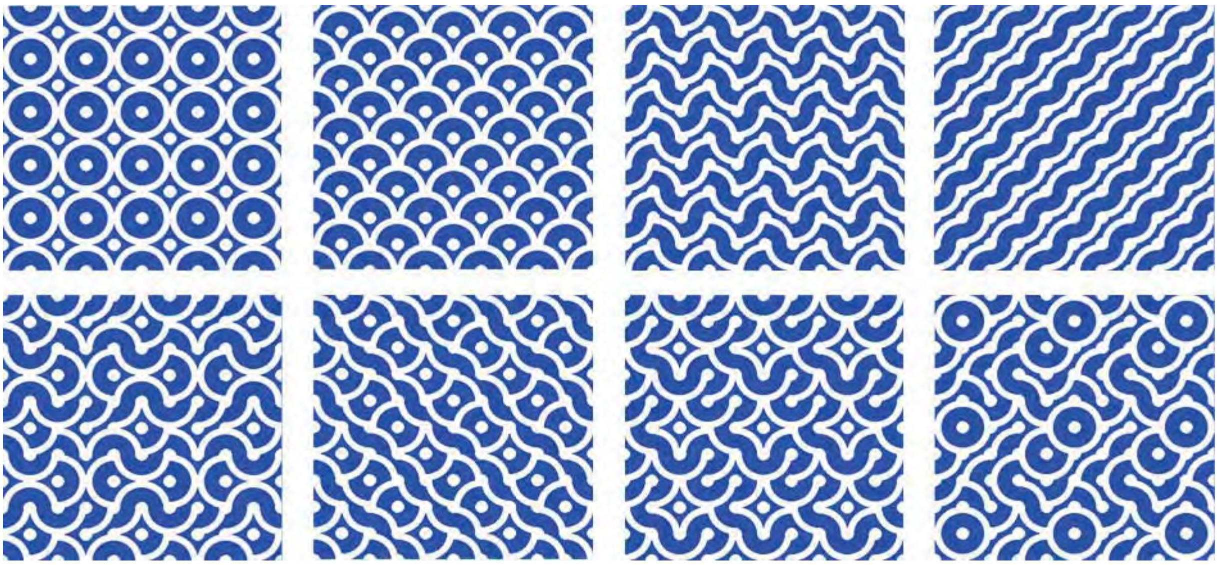


Fig. 12: Tile patterns with different complexities

A Comic Face Generator

75 Parameters distributed over 12 single generator templates (e.g. eye, nose, hair) are producing an uncountable amount of individual characters. In the animation mode you will see them being transformed one into the other.

Fig. 13: A comic face generator creates instances of "Mr. M. U. Tate"

Summary

Objecter is a suitable platform to develop generators for a wide range of objects. It could be a valuable tool for professionals in the field of design, architecture, engineering and arts. With *Objecters* ability of animation and direct user interaction it could also be used for visualizing complex issues and so applications in the e-learning market could be found.
Due to the modularity of class graphs, models could be exchanged and libraries for different trades could be built up by a user community. A future user forum on our web site will initiate this process and give us the desired user feedback for our development.

At the current state of development we see room for various improvements:

- Developing an *Objecter* class graph is not always straight-forward and can be tricky in some cases. More special operators for common modeling problems will be added
- A graphical editor for modeling could replace the current necessity of a formal scripting language
- Algorithms for solving optimization problems are not implemented yet. All expertise has to be defined by the user
- The implementation of the 3D-library will open up new perspectives

BioSonics – Interactive Growth System

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Abstract

BioSonics is an interactive art installation that explores the transformation of human interaction into spatial and temporal patterns by a dynamical and self-organized system. It both looks at aesthetic qualities of pattern formation processes and explores means of intuitive interaction with complex systems. In BioSonics, users interact with the growth processes of an organism. These processes are controlled by a chemical reaction network whose underlying dynamics eventually leads to changes in the organism's appearance and behavior. BioSonics produces both visual and acoustic feedback. Each chemical in the system controls its own sound synthesis engine whose acoustic output depends on the characteristics of the chemical, its concentration and its spatial position. Users interact with the organism by means of several microphones. The sounds picked up by the microphones are converted back into chemicals, therefore leading to changes in the dynamics of the chemical reactions and the growth processes they control. By using an acoustic interface, the user's influence on the system is embedded within the acoustic properties of the environment of which the interactive system as well as other users are a part. Interaction therefore becomes a collaborative endeavor to which the growing organism continually responds by changing its appearance as well as by modifying its acoustic feedback and sensitivity.

1. Introduction

Complexity theory has become one of the most influential scientific disciplines since the end of the 20th century [2]. As a result, complex system research nowadays plays an important role in many scientific disciplines. More recently, application oriented areas such as engineering, entertainment and art are becoming influenced by this research. Of particular interest to art and entertainment are the capabilities of complex systems to create patterns at a variety of spatial and temporal scales that constantly change, adapt and evolve [8]. The highly dynamic aesthetics of these patterns form an important motivation for artistic explorations. Complex systems respond to external influences in a variety of ways ranging from an immediate return to the previous state to a drift into a qualitatively different regime. In an interactive setup, complex systems therefore tend to respond in non-trivial and surprising ways to user input. This fact renders interactive complex systems both attractive and problematic at the same time. Interaction can quickly become frustrating and boring for an inexperienced user if no causality between input and feedback seems to exists. Consequently, one of the major challenges in applying complex systems to interactive art and entertainment consists in the development of a suitable combination of feedback and interaction. The system BioSonics which we present in this paper tries to address these issues.

2. Concept

BioSonics explores both the aesthetics of a particular complex system as well as means of intuitive interaction with such a system. It draws inspiration from biological principles and concepts in Human Computer Interaction (HCI).

Biological systems represent particularly interesting complex systems with regard to their flexibility, robustness, adaptivity and wide range of morphological and behavioral patterns. All biological organism arise through a process of growth which in itself is a combination of several complex systems acting in parallel on different organizational levels (molecular, cellular, tissue). Some of these processes are sensitive to environmental influences. This sensitivity results in the formation of a complex adult morphology which is adapted to the properties of its habitat. BioSonics implements an abstract form of a growth process by combining an artificial chemistry [3] with a simple physical simulation of a body morphology. Growth results from the mutual influence between these two organizational levels. The chemical system is sensitive to user input. Therefore, the user activity forms part of the dynamics which ultimatively controls the appearance of shape.

In HCI research a body of literature exists that looks at issues of interaction with artificial systems. The exploration of adequate forms of sensory feedback constitutes an important aspect of HCI research. The concepts of direct manipulation [7] and multimodal interaction [10] try to transform abstract representations into direct sensations. In many situations the interactive experience benefits from the combination of several sensory modalities that complement each other [1]. Dynamic visualization and computational steering concepts [5] address issues of real time interaction with computer programs that generate a large number of temporally changing data. BioSonics tries to combine some of these HCI concepts. It does so by providing simultaneously visual and acoustic feedback about the ongoing growth process. The artificial chemical system is transformed into sound whereas the organism's morphology is visualized using 2D graphics. These two modalities complement each other: vision excels at discriminating spatial details while audition is particularly good in the detection of temporal patterns. Interaction with the system happens in real time and relies on input via several microphones. This input directly affects the chemical system. By this way acoustics is used as the same modality for both interaction and feedback.

3. Implementation

The implementation of BioSonics involves the following aspects: installation hardware, morphological model, chemical model, growth , visual and acoustic feedback, and interaction.

3.1. Installation Hardware

BioSonics was developed as an interactive art installation. As can be seen on figure 1 the installation consists of a horizontal plexiglas plate held in position by four aluminum rods and a black cube. The plate is positioned at about 1.3 meters above ground and has a size of one square-meter. The cube contains all electronic components such as a computer, a beamer and

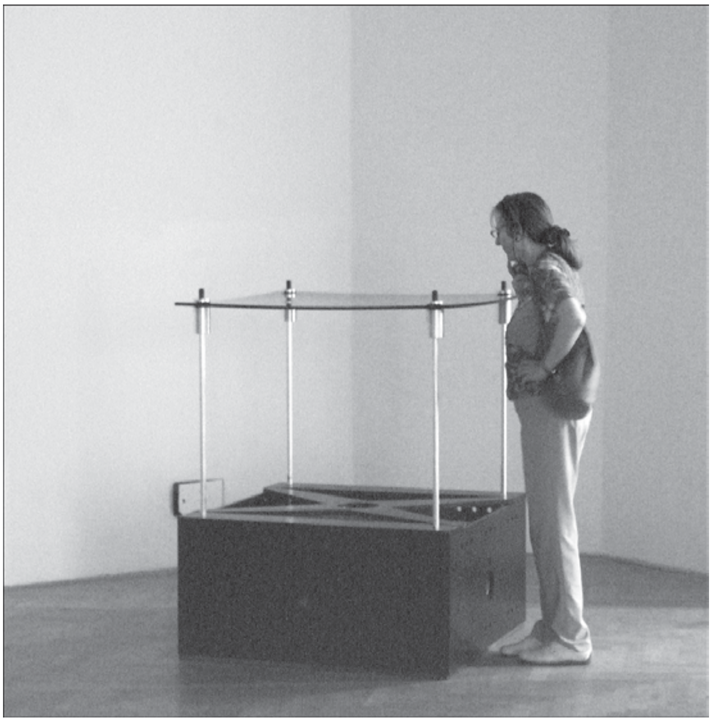

Figure 1: BioSonics Installation. Depicted is the installation which was shown at the exhibition "Abstraction Now" in Vienna.

two acoustic mixers. One set of speakers is built into each vertical face of the cube. These four speakers constitute a quadraphonic sound system (see 3.6). The computer generated image is back-projected through a circular hole in the cube's top face onto the plexiglas plate. Since the plexiglas plate is slightly transparent the displayed image seems to float in midair. This gives spectators the impression of looking down into a pond containing a growing organism. A microphone protrudes from the upper end of each aluminum rod. These four microphones serve as acoustic input devices for interaction with the growing organism (see 3.7).

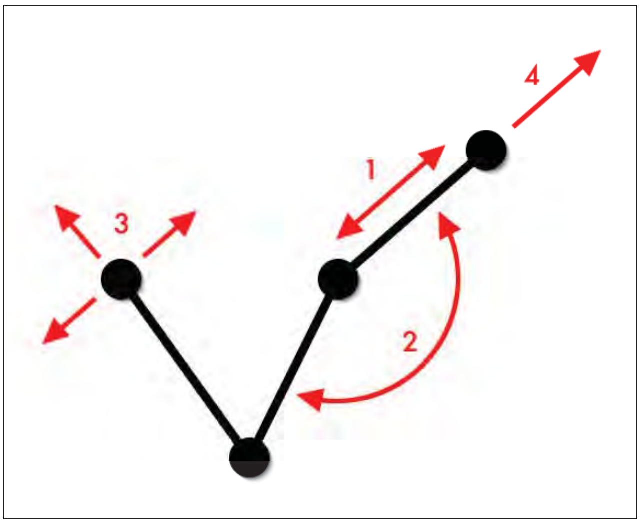

Figure 2: Extended Mass Spring System. Mass-Points are indicated by filled circles. Lines between these circles represent springs. The following forces are indicated in the figure: 1) spring force 2) angular force 3) Brownian force 4) chemotaxis force.

3.2. Morphological Model

The structure of the artificial organism is implemented as an extended mass-spring system (see figure 2). In addition to the spring and damping forces modeled in standard mass-spring systems, BioSonics implements an angular, Brownian and chemotaxis force. The angular force causes two successive springs to assume a preferred relative orientation. The Brownian force contributes a random component to the overall force vector. The chemotaxis force points into the direction of a chemical gradient (see 3.3). The simulation of the morphological model proceeds by using a simple Eulerian integration scheme. The paper should be completed (if possible) using Microsoft Word . The paper size should be A4 (210 mm x 297 mm). Line spacing should be 1.

3.3. Chemical Model

BioSonics implements a very simple artificial chemistry consisting of a total of six different types of chemicals. These types differ with regard to their diffusion coefficients, their initial concentration at the beginning of the simulation, the current concentration and the reactions they participate in. Reactions are always of the following type:

$$chem1 + chem2 \rightarrowtail chem3$$

Reactions are unidirectional. The direction of the reaction depends on the sign of the reaction rate. The three reaction partners can be the same chemical, a different chemical or a null chemical (e.g. no chemical). Therefore, any of the following reactions can be represented:

$$\begin{array}{lcl} chem1 \rightarrowtail null & : & decay \\ chem1 \leftarrowtail null & : & production \\ chem1 \rightarrowtail chem3 & : & transformation \\ chem1 + chem2 \rightarrowtail chem3 & : & polymerization \\ chem1 + chem2 \leftarrowtail chem3 & : & cleavage \end{array}$$

Each reaction is specified by the three chemicals involved, its rate, yield, threshold and saturation. Chemical concentrations and reaction parameters are in arbitrary units and always range either between 0 and 1 (concentration, yield, threshold, saturation) or between -1 and 1 (rate). Chemical concentration changes are calculated as follows:

$$\theta = rate * (chem1 * chem2 - threshold)$$

$$\frac{dchem3}{dt} = \begin{cases} 0 & chem1 * chem2 < threshold \\ saturation & \theta \geqslant saturation \\ \theta & \theta < saturation \end{cases}$$

$$\frac{dchem3}{dt} = -\frac{dchem1}{dt} * yield = -\frac{dchem2}{dt} * yield$$

Each structural element contains either one (spring) or three (mass-point) chemical compartments. Every compartment stores its own set of chemicals. Chemicals can be exchanged between neighboring compartments by diffusion (see figure 3). Reactions between chemicals occur within these compartments. This chemical system represents a sophisticated variant of reaction diffusion systems [9] in which the organization of the organisms morphology determines the shape and neighborhood relationships of the chemical dish grid.

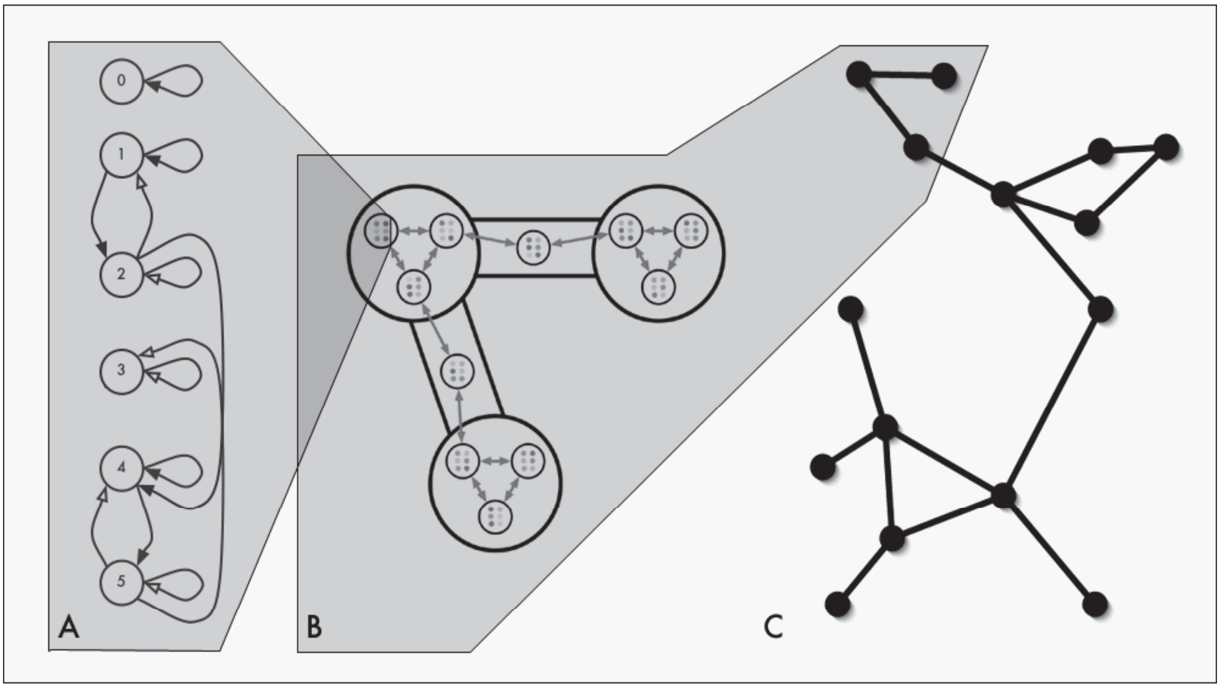

Figure 3: Chemical System. Part A depicts reactions among chemicals. Circles represent the different types of chemicals. Positive reaction rates are represented by filled arrows, negative rates by outlined arrows. In Part B chemical compartments are indicated as small outlined circles containing a set of six chemicals each. Arrows between chemical compartments indicate diffusion of chemicals. Part C hints at how the arrangement of chemical compartments in Part B forms a small subset of all the chemical compartments which are embedded in the entire structure.

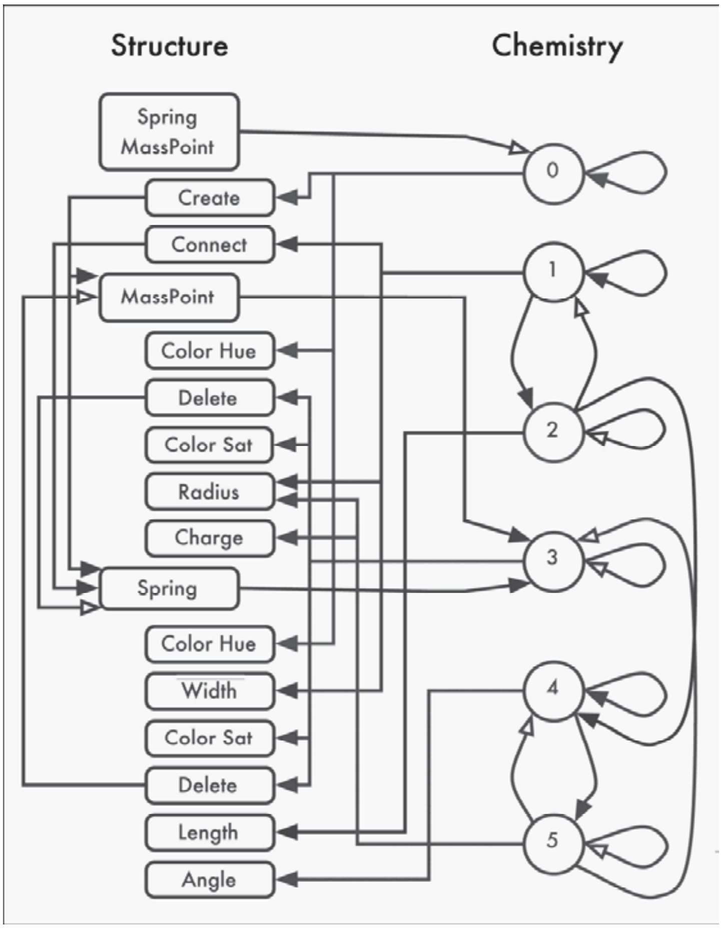

Figure 4: Reaction Network. Each compartment contains the same reaction network. Circles represent the different types of chemicals. Structural elements are depicted as rounded rectangles. Arrows represent reactions: filled arrows indicate positive effects, empty arrows negative effects.

3.4. Growth

Growth of the simulated organism results from the interactions between its artificial chemical system and its body morphology. These interactions are implemented as a special kind of reactions in which both chemicals and structural components form the reaction partners.Essentially, any chemical parameter can control any structural parameter and vice versa. By this way the structure and the chemicals form a reaction network (see figure 4). Possible reactions include: creation and deletion of structural elements, consumption of chemicals in order to sustain structural elements, modification of structural parameters, and fusion of structural elements due to proximity. Growth always starts from an single mass-point containing a set of initial chemical concentrations. In the absence of any user input the internal dynamics of these chemicals lead to a mostly deterministic growth process (see figure 5).

For the moment all reactions are hard-coded and somewhat arbitrary. The intention in designing the reactions was to create a system that shows both a fairly interesting behavior when left on its own but at the same time is very responsive to user input.

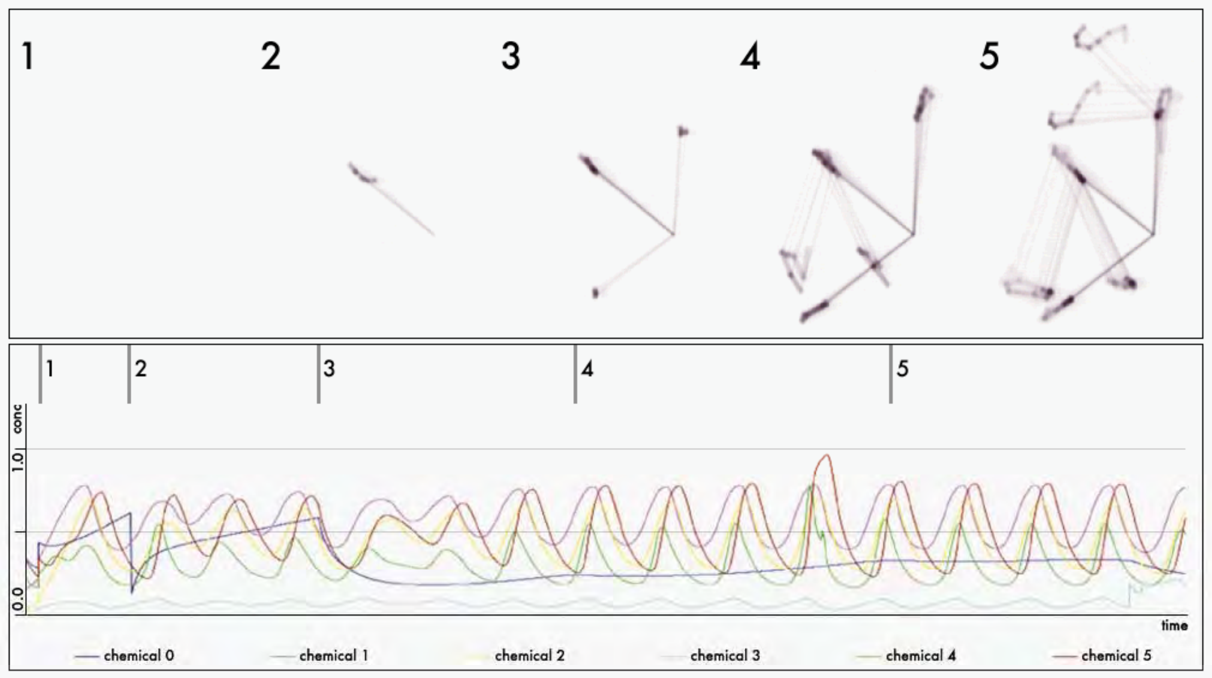

Figure 5: Growth Process. This time sequence depicts the graphical representation of the structure (top) and the spatially averaged chemical concentrations (bottom). Time runs from left to right. Numbers indicate corresponding positions in simulation time. For information concerning the visualization of the structure refer to 3.5.

3.5. Visual Feedback

BioSoncis displays the structure of the growing organism graphically as a collection of simple 2D shapes such as rectangles for mass-points and lines for springs. Each mass-point and spring possesses in addition to its physical parameters a set of values controlling its display characteristics (color hue, color saturation, color alpha, diameter and line width). These characteristics are subject to change based on the reactions that take place between chemicals and structural parameters (see figure 4). To convey the spatial dynamics of the growing structure, corresponding mass-points between consecutive time frames are connected by lines. The length and direction of these lines visualize the direction and magnitude of the structure's motions. At the same time successive images representing consecutive structural states are displayed on top of each other with older images gradually fading into the background. . Depending on the amount of fading applied BioSonics displays a more or less densely entangled meshwork of points and lines. This mesh-work creates the illusion of a highly complex morphology despite the fact that due to computational performance issues the actual morphology is never larger than about 100 mass-points and springs. During the visualization the simulation automatically switches between different fading values. These fading values in combination with the changing display characteristics of the structure create a wide variety of graphical patterns (see figure 6).

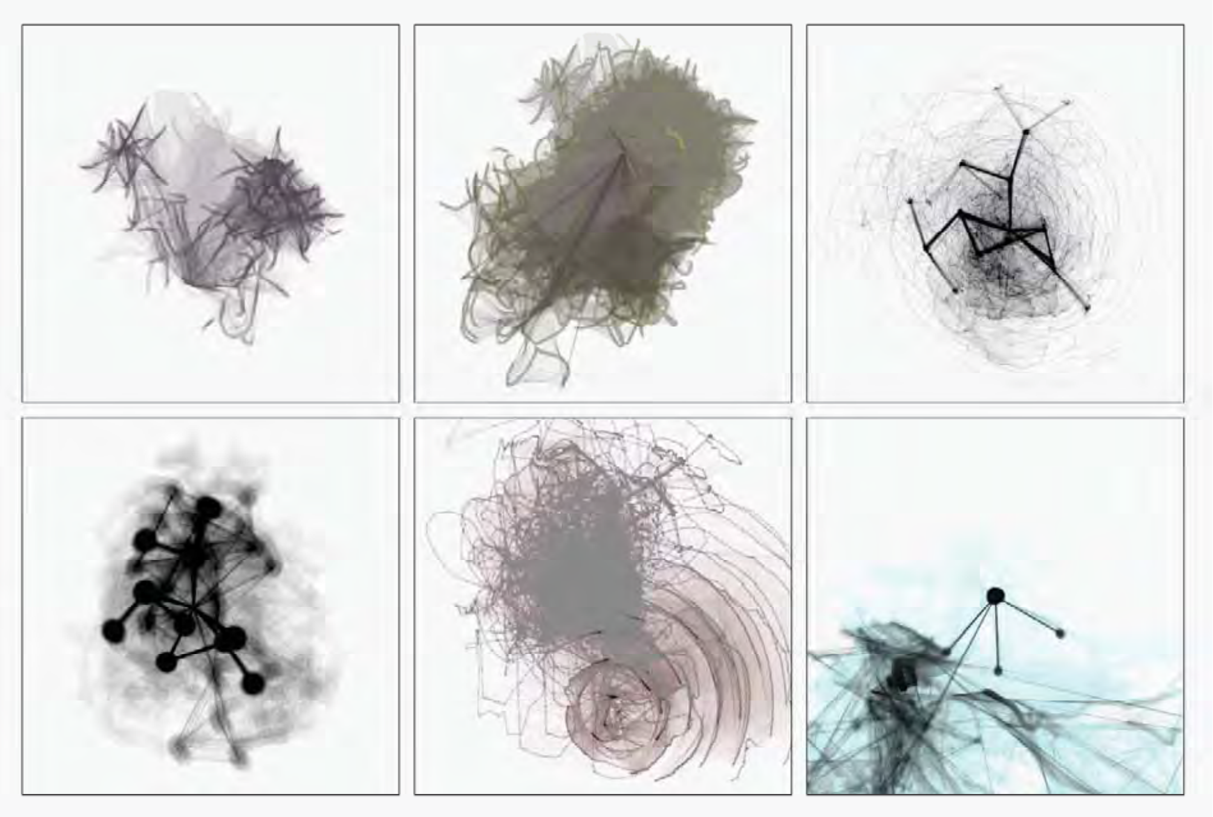

Figure 6: Visual Representations of the Growing Organism. During the growth process it is not only the body structure of the organism that changes but its graphical representation as well.

3.6. Acoustic Feedback

BioSonics relies on acoustics in order to render the dynamics of the simulated chemical processes perceivable. The acoustic output is generated by means of additive synthesis [6]. The frequencies and amplitudes of the combined sine waves are characteristic for each type of chemical. Each visible chemical compartment continuously plays all six chemical sounds at an amplitude which is proportional to the concentration of these chemicals within the compartment. In the current setup (see 3.7) a quadraphonic sound system is built into the installation. Chemical sounds are positioned within the quadraphonic sound space depending on the relative screen position of the corresponding compartments. Compartments at the center of the screen play their chemical sounds at equal loudness on all four speakers. Shifting a compartment away from the screen center results in an equally asymmetric spatial audio output. By this way the temporally and spatially changing sound patterns directly reflect changes in the chemical system.

3.7. Interactivity

Interaction with a complex system constitutes one of the key aspects of BioSonics. Since BioSonics relies on sound both as a means of providing feedback and modality of interaction, it implements a unique form of the direct manipulation concept [7]. In the current setup, four microphones pick up all the sounds provided by users and the environment. The frequency spectra of the recorded sounds are compared to the sounds associated with the various chemicals. If the similarity is sufficiently hight a certain amount of the corresponding chemical in fed into the organism thereby changing the state of the chemical system (see figure 7). The dynamics of the chemical system is therefore both the result of its internal reaction network and the activity of the users and the environment. The amount of chemical which is infused in a particular compartment depends sound similarity, amplitude and distance between compartment and sound source. Each microphone acts as a chemical source possessing its own position in screen coordinates. The distance is calculated according to the following formula:

$$dist = \left(\frac{|CP - CM|}{|S - CM|}\right) * ((S - CM) \cdot (C - CM))$$

and clipped to positive values. In this equation, CP is the position of the chemical compartment, CM is the center of mass of the organism and S is the position of the chemical source. The chemical concentration infused into the chemical compartment is multiplied by the squared inverse of this distance. By this way the effect of interaction on the chemical processes is strongest within those compartments that are closest to the interacting user. By choosing a particular microphone users decide which parts of the organism are exposed most strongly to interactivity related changes. When interacting with BioSonics, users not only infuse chemicals into the growing organism but also create chemical gradients within the simulated environment of the organism. These gradients result from the differing amounts of chemicals which are produced by each chemical source. The organism exhibits chemotactic behavior within these gradients. Each type of chemical possesses a certain attractiveness for the organism. Chemicals which lead to an increase in the growth rate of the organism have a positive attractivity value. On the other hand, chemicals that delay growth or cause a reduction in the size of the organism have negative attractivity values. Depending on this attractiveness a force vector pointing towards or away from the steepest gradient slope is applied to all mass-points of the organism’s structure (see figure 8). The sum of all these force vectors is multiplied by the squared distance of the organism center of mass to the edge of the screen. The resulting chemotaxis force causes the organism to move towards users which cause the production of attractive chemicals.

Apart from exerting influence on the dynamics of the chemical system interactivity also affects the acoustic properties of the chemicals. Whenever the system evaluates the spectral similarity between the recorded sounds and the chemical sounds it tries to improve the best match by slightly changing the additive synthesis parameters of the corresponding chemical sound. Over an extended period of time this mechanism causes the acoustic feedback of BioSonics to match the acoustic properties of its environment. As a result, the growth process becomes increasingly sensitive to frequent environmental sounds.

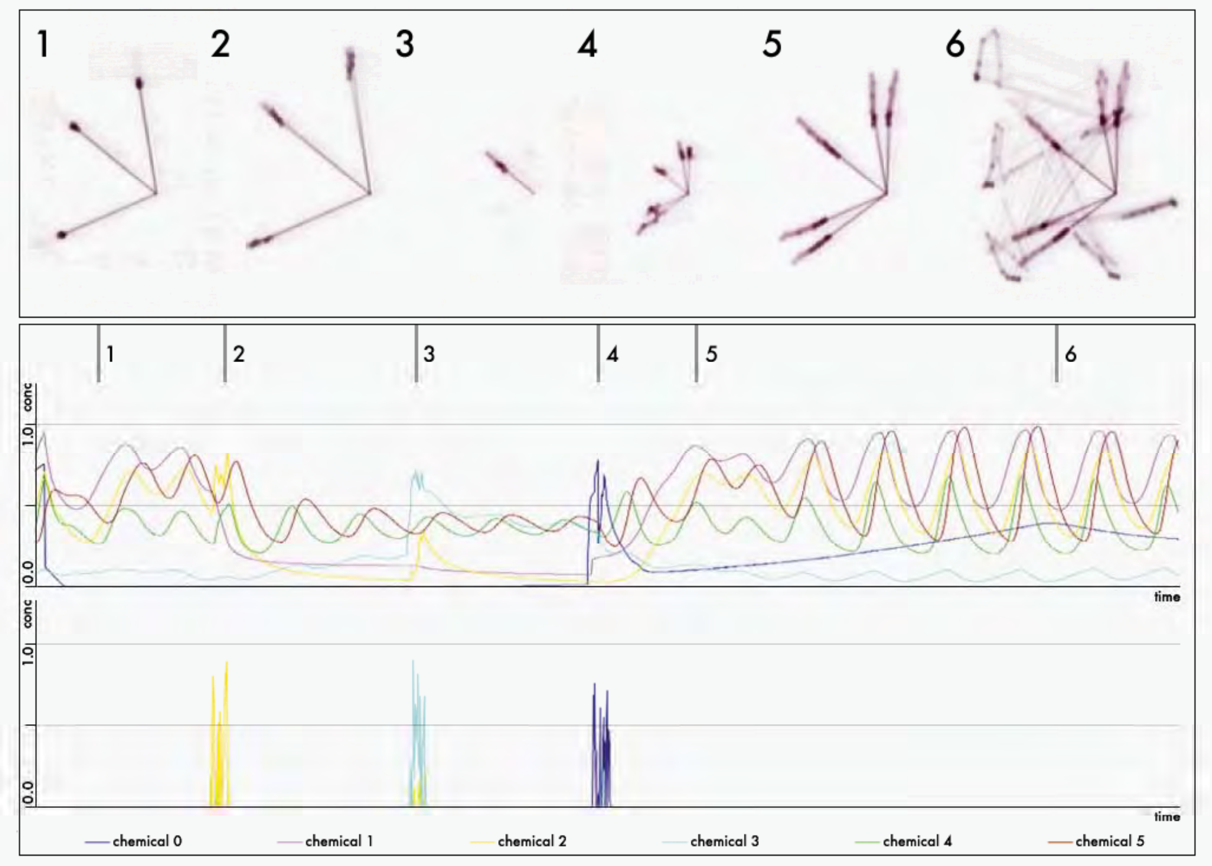

Figure 7: Interaction. This time sequence depicts the graphical representation of the structure (top graph), the spatially averaged chemical concentrations (middle graph), and the interactively produced chemicals (bottom graph). Time runs from left to right. Numbers indicate corresponding positions in simulation time.

4. Results and Discussion

The project BioSonics has been presented to various people both at the Artificial Intelligence Lab of the University of Zurich and during an exhibition entitled “Abstraction Now” which took place from August to September 2003 at the Künstlerhaus in Vienna, Austria. During these presentations we were mainly interested in informal feedback concerning the aesthetics and interactivity of the system.

The aesthetics of the visual feedback has provoked very positive feedback. Both the somewhat unorthodox display system as well as the abstract nature of the visuals contributed to this positive response. In a newspaper article [4] the visual representation is described as almost pictorial in appearance. The smootsh motions of the continuously rearranging structure were appreciated as well. It was mainly this constant metamorphosis which reminded spectators of living systems. Surprisingly, nobody considered the combination of abstract graphical elements with smooth live-like motions to be of contradicting aesthetical value.

The acoustic qualities of the system have received more critical feedback. Some people appreciated the slowly changing timbre of the sound. For other people its was exactly this sound quality which they considered to be monotonous and boring. Regardless of musical

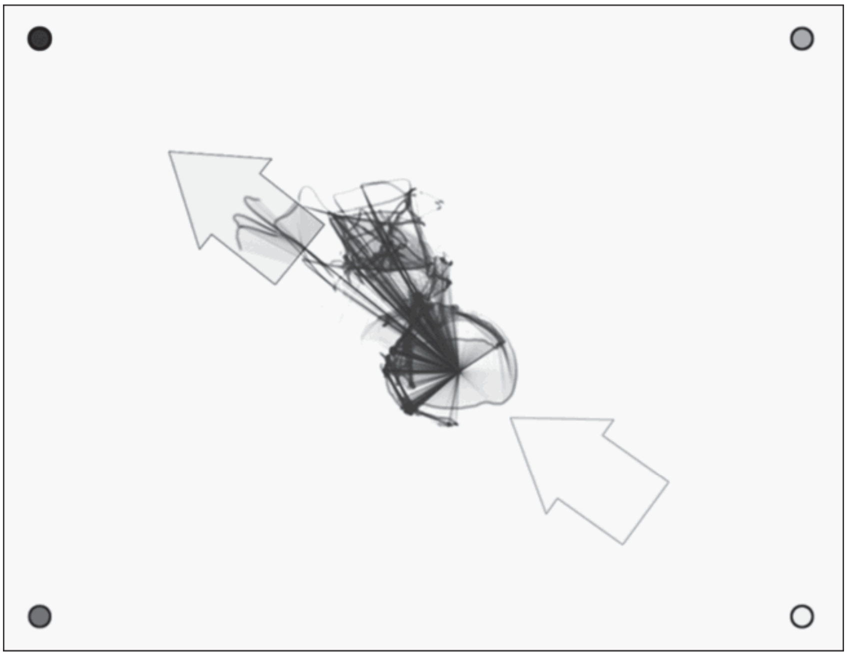

Figure 8: Chemotaxis. This figure illustrates the concept of chemotaxis implemented in BioSonics. The four microphones which act as chemical sources are indicated by large circles. In the extreme situation depicted here each microphone produces exactly one chemical at maximum concentration and none of the others. The organism is highly attracted to the chemical produced by the top left microphone, it dislikes the chemical produced by the bottom right microphone, and it is indifferent to the chemicals produced by the other two microphones. For this reason the overall motion of the organism is towards the top left microphone.

taste we think that in the current implementation the acoustic output is flawed for two reasons. Firstly, by having hundreds of chemical compartments produce chemical sounds of identical timbre but slightly different dynamics at the same time leads to a blurring of the acoustic output. This effect becomes more pronounced as the organism gains in size. Secondly, the aesthetics of temporal change is not necessarily the same for visual and acoustic feedback. In BioSonics, the temporal characteristics of acoustics and visuals are very similar because both the chemical system and the structure of the organism are tightly linked. In order to produce a slowly changing visual appearance the accompanying acoustic output is necessarily slowly changing as well. By using a more indirect and complicated relationship between chemical processes and structural changes this problem could possibly be solved. On the other hand, highly indirect chemical effects will impair the interactivity of the system since both the system's response and predictability is lowered. It remains a challenge to find a proper balance between these two conflicting goals.

Our evaluation of interactivity comprised the following aspects: the ability of the system to catch a user's interest, whether this interest is maintained by providing an engaging interaction, and the amount of intuitive understanding the users acquired by simply interacting with the system. For obvious reasons, feedback concerning these issues was restricted to users who didn't know the system in advance and did not possess any background in the field of complex systems.

Initial interest was generated through the changing feedback of the system and because of the fact that these changes were not immediate. This interest was further supported by the perceived degree of synchronization between acoustic and visual output. The fact that synchronization was neither total nor totally absent, mediated the impression that both outputs are coupled by a non-trivial algorithm. Interactivity played an important role in generating continued interest. It became clear that users had to overcome two obstacles to engage in interaction. First of all, users are not accustomed to interact with an installation by using acoustics, in particular in a museum setup. The default form of exploring an art installation is to stare at it in silent astonishment. Secondly, despite pictographic labeling most users didn't recognize the microphones as such. For these two reasons we explicitly had to tell users to produce sounds in order to have them realize that the system responds to acoustic input. It quickly became obvious that different users interacted in very different ways. Some users were happy to expose the entire organism to very noisy sounds which usually resulted in large bursts of growth. In order to cause smaller and more diverse changes in the growth process users had to produce strongly pitched sounds. In this case, the sound input matched only one or two chemicals which were consequently infused into the system. Users that interacted in this way quickly realized, that they could recreate structural changes they had previously observed by mimicking the acoustic feedback the system provided. This type of interaction was therefore a prerequisite to create a longer lasting interest in the system and to promote an intuitive understanding of the system's behavior.

5. Conclusion and Outlook

BioSonics has been conceived and designed as an interactive art installation that explores the aesthetics of pattern formation by complex systems as well as issues of intuitive interaction with such systems. In its current implementation, the system allows users to interact in a playful and exploratory way with an artificial growth system that provides both acoustic and visual feedback. The informal user feedback concerning the aesthetics of the system's feedback and its interactivity has been mostly positive.

For this reason we believe that the current approach to the creation of an interactive complex system for art and entertainment is sufficiently promising to justify further research. This research will mainly concentrate on improvements in the systems acoustic feedback and its interactivity.

The mostly monotonous characteristics of the acoustic feedback results from a possibly inadequate acoustic synthesis technique and a too simple relationship between chemical dynamics and structural effects. By increasing the complexity of the underlying chemical system a wider variety of temporal patterns could be produced. The relationship between the chemical system and the morphology needs to be carefully redesigned in order to maintain the slow paced life-like metamorphosis of the organism. In an improved version of BioSonics the number of chemical compartment whose chemicals produce sound should be reduced. Such a subset of sound producing compartments could either be interactively selected by the user or be specified automatically based on the proximity of the compartments to the microphones. In this way the compartments which are most likely to be affected by the users interaction are the ones that provide acoustic feedback. Finally, the acoustic output could be rendered more interesting by employing a different method of sound synthesis. In such a setup not every chemical would necessarily produce its own sound but could rather act in combination with other chemicals to control sound synthesis.

Interactivity could be improved by giving users means of navigating within the morphological structure. Instead of drawing the entire structure at a constant magnification users could choose to zoom in on particular details of the growing organism. This sort of control could be achieved by tracking the users hand on top of the display.

Finally, we would like to move to 3D graphics for representing the structure of the organism. The added dimension allows the display of a wider variety of structures and improves the immersiveness of the interactive experience, in particular when combined with 3D spatial sound.

5. Acknowledgement

The interesting discusssions with Dale Thomas on technical and conceptual topics pertaining to this work are highly appreciated. This research is part of a project entitled “Embodied Artificial Intelligence” that is funded by the Swiss National Science Foundation.

References

[1] Lynne E. Bernstein and Christian Benoît. For speech perception by humans or machines, three senses are better than one. In Proceedings of the International Conference on Spoken Language Processing, pages 1477–1480, 1996.

[2] Peter Coveney and Roger Highfield. Frontiers of Complexity. Faber and Faber, 1995.

[3] Peter Dittrich, Jens Ziegler, and Wolfgang Banzhaf. Artificial chemistries - a review. Artificial Life, 7(3):225–275, 2001.

[4] Malewitschs erben im digitalzeitalter: «abstraction now» in wien. Westdeutsche Zeitung, 2003.

[5] Jurriaan D. Mulder, Jarke J. van Wijk, and Robert van Liere. A survey of computational steering environments. Future Generation Computer Systems, 15(1):119– 129, 1999.

[6] Curtis Roads. The Computer Music Tutorial. MIT Press, 1996.

[7] Ben Shneiderman. Direct manipulation for comprehensible, predictable and controllable user interfaces. In Intelligent User Interfaces, pages 33–39, 1997.

[8] Christa Sommerer and Laurent Mignonneau. Modeling complex systems for interactive art. In Applied Complexity - From Neural Nets to Managed Landscapes, pages 25–38. New Zealand Institute for Crop and Food Research, 2000.

[9] Alan Turing. The chemical basis of morphogenesis. Philosophical Transactions of the Royal Society, (237):37–72, 1952.

[10] Alex Waibel, Minh Tue Vo, Paul Duchnowski, and Stefan Manke. Multimodal interfaces. Artificial Intelligence Review, 10(3-4):299–319, 1996.

What is Generative Art?

Complexity Theory as a Context for Art Theory

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Abstract

In this paper an attempt is made to offer a definition of generative art that is inclusive and provides fertile ground for both technical and art theoretical development. First the use of systems is identified as a key element in generative art. Various ideas from complexity theory are then introduced. It is noted that systems exist on a continuum from the highly ordered to the highly disordered. Citing examples from information theory and complexity science, it is noted that highly ordered and highly disordered systems are typically viewed as simple, and complex systems exhibit both order and disorder. This leads to the adoption of effective complexity, order, and disorder as organizing principles in the comparison of various generative art systems. This inclusive view leads to the somewhat surprising observation that generative art is as old as art itself. A number of specific artists and studies are discussed within this systems and complexity theory influenced paradigm. Finally a number of art theoretical questions are introduced to exercise the suggested generative art definition and implicit paradigm.

1. Introduction

I teach a course titled "Foundations of Generative Art Systems" [1] and the most frequent question I am asked is "what is generative art?" Generative art often seems like a fuzzy notion, and most students don't seem to "get it" until very late in the semester. And indeed, in forums such as the eu-gene mailing list (http://www.generative.net) this very question has sparked considerable controversy. In opening this paper I would like to gratefully acknowledge the many discussions on this topic I've had with both my students and the eu-gene online community.

Some might wonder whether the attempt to define generative art is an empty pedantic exercise. I hope that this paper will show that it is not. First clarity of language enhances any discussion, including those about art and specifically generative art. Additionally the discussion of what generative art is stimulates the discussion of other art critical concerns.

2. Two Views of the Term "Generative Art"

First a quick look at the term "generative art" from the bottom up, and from the top down.

2.1 From the Bottom Up – Clusters of Current Generative Art Activity

With regard to the "what is generative art?" question one is often reminded of the parable of the blind men and the elephant. One blind man feeling the leg of the elephant says, "Surely an elephant is like a mighty tree". Another blind man, holding the trunk of the elephant says, "Surely an elephant is like a large snake". Yet another blind man, placing his hands on the sides of the elephant, exclaims, "Surely an elephant is like a great whale". And so on. In a similar way artists seems to all too often define generative art as being most like the work that is closest at hand, namely their own generative art.

And indeed there are clusters of contemporary generative art activity that are, in many ways, worlds onto themselves. Some of these include:

Electronic Music and Algorithmic Composition - Dating at least to the seminal paper by Brooks, Hopkins, Neumann, and Wright in 1957 [2], those in the electronic music community have explored all manner of generative processes for the creation (at the macro level) of musical scores and (at the micro level) the subtle modulation of performance and timbre. This activity has not been limited to academic music. A recent article in Electronic Musician, a magazine for working musicians, notes more than a dozen programs using techniques as varied as cellular automata, fractals, a-life, L-systems, chaos, and of course randomization. [3]

***Computer Graphics and Animation* -** Well documented in the vast body of literature published by the ACM SigGraph organization and others, computer graphics researchers have contributed to the realm of generative art for decades now. Examples of generative breakthroughs would include Perlin Noise [4] for the synthesis of smoke, fire, and hair imagery, the use of L-systems to grow enough virtual plant life to populate entire forests and valleys [5], and the use of physical modeling to create animations that depict real world behavior without requiring the animator to painstakingly choreograph every detail. These efforts have yielded results that reach far beyond the research community. Examples include animated feature length films such as those by Pixar and the hugely popular realm of video game machines.

***The Demo Scene and VJ Culture* -** Borrowing from the above, youth culture movements are taking generative technology out of the well funded labs, recording studios, and animation companies, and adapting low cost alternatives for use in nightclubs and other social settings. For such artists and enthusiasts generative art is no longer obscure or esoteric, but rather an everyday method of creation. Randomization is the most frequently discussed technique, but others are working their way into the scene as well.

Industrial Design and Architecture **-** Design practice has always included the iterative process of creating numbers of samples, selecting among them, making incremental improvements and hybrid samples, again evaluating the results, and so on. This manual practice is quite reminiscent of the evolutionary process of genetic variation and natural selection.

It was seemingly inevitable that soon after the adoption of the computer by designers as a manual tool for CAD, there would follow the adoption of genetically inspired algorithms for the creation and selection of variations. In fact the generative artist William Latham initially used an evolutionary system that existed purely on paper, and only later did he move to computerized versions. [6]

Clearly any attempt to define generative art would have to include all of the above, as there is no obvious reason to privilege one form of contemporary generative art practice over another. And few would want to stop with just the above. One could also include, for example, robot art and math art as clusters of generative art activity.

The fine arts offer a number of challenges in this regard. For example, in the 20th century a number of artists such as John Cage, William Burroughs, and Marcel Duchamp embraced randomization as a fecund generative principle. Minimalists such as Carl Andre, Mel Bochner, and Paul Morgenson used simple mathematical principles to generate compositions. The conceptual artist Sol Lewitt uses combinatorial systems to create complex works from simple components, and conceptual artist Hans Haacke explored physical generative systems in his early work.
And indeed some have wondered whether a painter like Kenneth Noland should be considered a generative artist given his “systemic art” practice, or whether Jackson Pollock's drip and splash method qualifies as the kind of randomization that would place his work in the realm of generative art. I, in fact, don't consider Noland and Pollock to be generative artists. But given the dizzying variety generative art offers it is an entirely legitimate question to ask

2.1 From the Top Down – Generative Art Considered Literally

The term generative art can also be explored from the top down by considering its literal abstract meaning.

I often joke with my students that it is easy to tell if something is generative art. First it must be art, and second it must be generative. The joke here is, of course, I am begging the question. One difficult question is replaced by two difficult questions. What do we mean by art, and what do we mean by generative?

The "what is art?" question is often brought up to mock and sound a cautionary note about the perils of intellectual discourse rather than to pose a serious question. But this is mostly unfair. The discussion spawned by the question "what is art?" can in fact be productive and useful. It has perhaps been best considered by specialists in aesthetics in the analytic school of philosophy found primarily in the U.S. and U.K. A recounting of this debate is beyond the scope of this paper but is well-summarized elsewhere, for example Carrol’s book “Philosophy of Art”. [7]

Viable contemporary definitions of art generally include a notion akin to fuzzy set theory so that some things may be considered more fully art than others. In a similar way we can expect that some works are more fully generative art than others. In addition current notions about art recognize it as a social and historical notion that changes over time. To the extent generative art is art surely this must apply there as well. But I hope to show that the generative aspect can be fixed in a more stable way.

The word "generative" simply directs attention to a subset of art, a subset where potentially multiple results can be produced by using some kind of generating system.

It is important to note here that if generative art also included art produced by any kind of generating idea, then generative art would include all art, and it would loose its utility as a distinct term.

3. Generative Art Defined

So a useful definition of generative art should (1) include known clusters of past and current generative art activity, (2) allow for yet to be discovered forms of generative art, (3) exist as a subset of all art while allowing that the definition of "art" can be contested, and (4) be restrictive enough that not all art is generative art.

Whether considered from the top down or the bottom up, the defining aspect of generative art seems to be the use of an autonomous system for art making. Here is the definition I've been using in my class:

> *Generative art refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art.*

The key element in generative art is then the system to which the artist cedes partial or total subsequent control. And with this definition some related art theory questions come quickly to mind. A hint as to how that conversation might go will be offered at the end of this paper.

For now here are some observations about this definition. First, note that the term generative art is simply a reference to how the art is made, and it makes no claims as to why the art is made this way or what its content is. Second, generative art is uncoupled from any particular technology. Generative art may or may not be “high tech”. Third, a system that moves an art practice into the realm of generative art must be well defined and self-contained enough to operate autonomously.

So if systems are in a sense the defining aspect of generative art, it is worth asking if all systems alike, or if there is a useful way to sort them out and thus, by implication, sort out various kinds of generative art. This is the topic of the next few sections.

4. Complexity Science as a Context for Understanding Systems

Over the last 20 years or so scientists have attempted to create a new understanding of systems. Under the general rubric of "complexity science" and “complexity theory” various systems, and various kinds of systems, have been studied, compared, contrasted, and mathematically and computationally modeled. An abstract understanding of systems is beginning to emerge, and given that systems are a defining aspect of generative art, complexity science has much to offer the generative artist. And indeed a great deal of the work presented at this very conference in past years is, explicitly or implicitly, rooted in complexity science.

Science generally proceeds in a reductive manner, the thinking being that by breaking down complicated phenomena into its figurative (or literal) atomic parts one gains predictive and explanatory power. The problem with reductionism, however, is that it is often difficult to put the pieces back together again.

This is especially true of complex systems. When scientists speak of complex systems they don't mean systems that are complicated or perplexing in an informal way. The phrase "complex system" has been adopted as a specific technical term. Complex systems typically have a large number of small parts or components that interact with similar nearby parts and components. These local interactions often lead to the system organizing itself without any master control or external agent being "in charge". Such systems are often referred to as being self-organizing. These self-organized systems are also dynamic systems under constant change, and short of death or destruction, they do not settle info a final stable "equilibrium" state. To the extent these systems react to changes in their environment so as to maintain their integrity, they are known as complex adaptive systems.

In common language one is reminded of the saying that “the whole is greater than the sum of its parts.” Local components will interact in “nonlinear” ways, meaning that the interactions do more than merely add up…they exponentiate. Examples of complex systems are familiar to everyone. The weather, for example, forms coherent patterns such as thunderstorms, tornados, and hot and cold fronts, yet there is no central mechanism or control that creates such patterns. Weather patterns “emerge” all over and all at once. In the near term weather can be predicted with some accuracy, but beyond more than a few days the weather becomes quite unpredictable.

The stock market is similarly a complex system with emergent properties. Billions of shares and transactions are linked in a finite chain of cause and effect, and patterns such as booms and busts emerge from the overall system. Yet no one factor dominates or “plans” the market, and even with all of the relevant information available to the public, the stock market generates surprising and unpredictable behavior.

Additional examples of complex systems include the brain (as studied by biologists) and the mind (as studied by psychologists), the predation and population cycles of animals in an ecosystem, the competition of genes and resulting evolution of a given species, and the rise and fall of cultures and empires. Each of these systems consists of many components (such as cells, chromosomes, citizens, etc.) that interact with other nearby components, and form a coherent pattern or entity without any central control or plan as to how that should happen.

Thus complex systems often develop in ways that are dramatic, fecund, catastrophic, or so unpredictable as to seem random. Complexity science is a relatively new, and at times controversial, attempt to understand such systems by bridging a number of traditionally distinct disciplines. The ambition is to understand the commonalities systems exhibit across all scales and hierarchies.

Note that the study of complex systems also provides context and perspective for understanding simple systems. And the notion of generative art offered here includes both complex and simple systems.

5. Chaotic Systems and Random Systems

Generative artists often use randomization. Complexity scientists often speak of chaos. In many cases a chaotic system may seem random because its behavior is so unpredictable. But it is important to keep in mind that there is a difference.

Complex systems often include chaotic behavior, which is to say that the dynamics of these systems are nonlinear and difficult to predict over time, even while the systems themselves are deterministic machines following a strict sequence of cause and effect. The nonlinearity of chaotic systems results in the amplification of small differences, and this is what makes them increasingly difficult to predict over time. This is usually referred to as sensitivity to initial conditions or "the butterfly effect", from the notion that a butterfly flapping its wings in Hawaii can result in a tornado in Texas. [8]

It is important to remember, especially within the context of generative art, that chaotic systems are not random systems. Natural chaotic systems may be difficult to predict but they will still exhibit structure that is different than purely random systems.

For example, even though it is difficult to predict the specific weather 6 months from now, we can be relatively sure it won't be 200 degrees outside, nor will we be getting 30 feet of rain on a single day, and so on. The weather exists within some minimum and maximum limits, and those expectations are a sort of container for all possible weather states. This is what scientists call the phase space, and it describes a sort of consistent general shape the chaotic system eventually traces out even though it remains unpredictable in precise detail.

What about day to day weather transitions? The best predictor of tomorrow's weather is today's weather. Even in my hometown of Chicago, known for its crazy weather, a cold day is usually followed by another cold day. And a hot day is typically followed by a hot day. And so on. The transition from one weather state to another can be thought of as a path within the state space. Those paths are continuous (no instantaneous jumps are allowed) and exhibit this form of local auto-correlation. In other words unlike purely random systems chaotic systems have a sense of history.

I find life to be more like a complex chaotic system and less like a simple random one. There is uncertainty, but there is still a sense that cause and effect are at play. I may not be able to make a specific prediction for a specific time, but I can know how things tend to go. And I can often consider some things as impossibilities. There are surprises, but not at every single turn because there are also correspondences.

In a related way, artificial chaotic systems seem more like nature, and more like real life, than artificial random systems. There is likely a lesson there for generative artists.

6. Notions of Order and Disorder in Information Theory

While we have an intuitive sense of what we mean when we refer to a system as "simple" or "complex" developing a formal technical measure of complexity that corresponds well to our intuitive sense is not easy.

An earlier related attempt to better understand communication systems was initiated by Claude Shannon in the form of information theory. [9] For the purposes of analyzing the capacity of a given communication channel, the core idea is that the more "surprise" a given communication can exhibit the more information it contains.

For example, consider a channel that can only send the letter "A" at regular intervals.

A A A A A A A A A A A A A A A A A A A A A

Every transmission is the same and allows for no modulation of the signal. It is, in a sense, a highly ordered signal to the extreme. But even more, if all a channel can carry is the letter "A" there are no surprises, and thus no information can be transmitted.

A channel that allows the sending of English language words like so:

I LIKE GENERATIVE ART

contains variation from character to character, and thus allows information to flow. It should be noted that information theory is not fundamentally about the transmission of meaning, but rather the capacity to transmit symbols. The following nonsense sentence sent via the same channel:

PAPER BIG WORK I CATS

is about the same amount of information even though it is meaningless.

Natural language contains redundancy, which is another way of saying that the text has consistent patterns, such as statistical frequencies of letter combinations that can potentially be compressed out. For example, since we can anticipate the structure of the English language we might send the following compressed string with relative success:

I LIK GENART

In the limiting case a signal in a channel that sends random letters is at maximum information. For example:

F O E V Q K M V K D Y P Q X C I H R S N W

A truly random stream of characters is maximally disordered and has no underlying structure. Thus there are no patterns and redundancy to take advantage of, and no compression is possible.

While saying a highly ordered sting of repeating characters has low information seems intuitively correct, saying a highly disordered string of random characters has maximum information seems peculiar. In terms of our human ability to extract meaning from a given experience we require a mix of surprise and redundancy, i.e. a signal somewhere between extreme order and disorder.

In his 1958 book "Information Theory and Esthetic Perception" Abraham Moles applies these notions, along with findings from the realm of perceptual psychology, to analyze the arts. [10] In line with the above, he attempts to apply various statistical measures to classify musical works on a spectrum from "banal" to "novel" corresponding to the relative order versus disorder of the given information. And indeed one can easily intuit that forms such as, for example, traditional folk music are more ordered and banal than, say, free jazz which encourages more disorder and novelty.

At the extremes, however, highly ordered music (e.g. playing the same note over and over again) is of no greater intrinsic aesthetic interest than highly disordered music (e.g. playing entirely random pitches and durations). In terms of the pure esthetics we will quickly lose interest in both. (Such performances might, however, be perfectly legitimate given an appropriate conceptual framework providing context and thus meaning).

Working artists understand that an audience will quickly tire of both a highly ordered and a highly disordered aesthetic experience because both lack any structural complexity worthy of their continued attention. The intuition that structure and complexity increase somewhere between the extremes of order and disorder leads us to the consideration of "effective complexity".

7. Algorithmic Complexity and Effective Complexity

Complex systems stand in contrast to simple systems, and attempts have been made to invent measures that quantify the relative complexity of given systems. One approach is to consider the algorithmic complexity (AC) of a given system. Algorithmic complexity is also called the algorithmic information content (AIC), and was independently developed by Kolmogorov, Solomonoff, and Chaitin.

It is known that in principle any system can be mapped into a smallest possible program running on a universal computing machine generating a growing string as output over time. Some systems, such as fractals, require infinite time to generate because they have infinite detail. But that is not to say that fractals have infinite complexity. They are simple in the sense that they exhibit self-similar structure at every scale. And, in fact, a fractal algorithm can be very compact indeed. [11]

One might hope that AC or AIC is a good candidate for a measure of what we intuitively consider complexity. Perhaps the larger the algorithmic complexity the more complex the system.

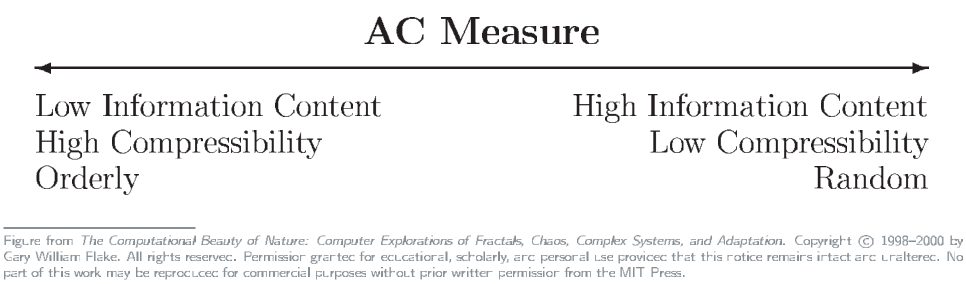

Figure 7.1

Unfortunately, in the case of random processes we run into the same paradox as we see in information theory.

For our low information example the AIC would be very small, and independent of string length, because the algorithm could be very small. For example:

```
loop:   print "A"
        go to loop
```

For our intermediate information, English language, example the AIC would be a bit larger. The redundancy of natural language allows the use of an algorithm that carries a compressed version of the string and then expands it. For example the algorithm:

```
print( expand( "NIFNEPOLDFIMDMEUMN" ) )
```

might result in the string:

HERE IS THE MESSAGE AFTER IT HAS BEEN UNCOMPRESSED

Unfortunately in the case of a system that generates a purely random result the AIC will be quite a bit larger. Without redundant information in the string, in other words without structure, no further lossless compression is possible. The smallest algorithm would be a program that is a single "print" statement that includes the literal string in question. Thus for a random string the AIC is at least as long as the length of the string.

```
print("APFUYWMVPBXTWLFMCRORNBHTEIYBCMIBUNEPMVU")
```

Similar to what was previously shown, the AIC becomes larger the more random the message is, and this conflicts with our intuitive sense of complexity. As Murray Gell-Mann, one of the founders of the Sante Fe Institute and complexity science, puts it:

> *"This property of AIC, which leads to its being called, on occasion, "algorithmic randomness," reveals the unsuitability of the quantity as a measure of complexity, since the works of Shakespeare have a Lower AIC than random gibberish of the same length that would typically be typed by the proverbial roomful of monkeys."*

What is needed is a measure of "effective complexity" (EC) such that systems that are highly ordered or disordered are given a low score, indicating simplicity, and systems that are some where in between are given a high score, indicating complexity, Gell-Mann goes on to say:

> *"A measure that corresponds much better to what is usually meant by complexity in ordinary conversation, as well as in scientific discourse, refers not to the length of the most concise description of an entity (which is roughly what AIC is), but to the length of a concise description of a set of the entity's regularities. Thus something almost entirely random, with practically no regularities, would have effective complexity near zero. So would something completely regular, such as a bit string consisting entirely of zeroes. Effective complexity can be high only a region intermediate between total order and complete disorder"*

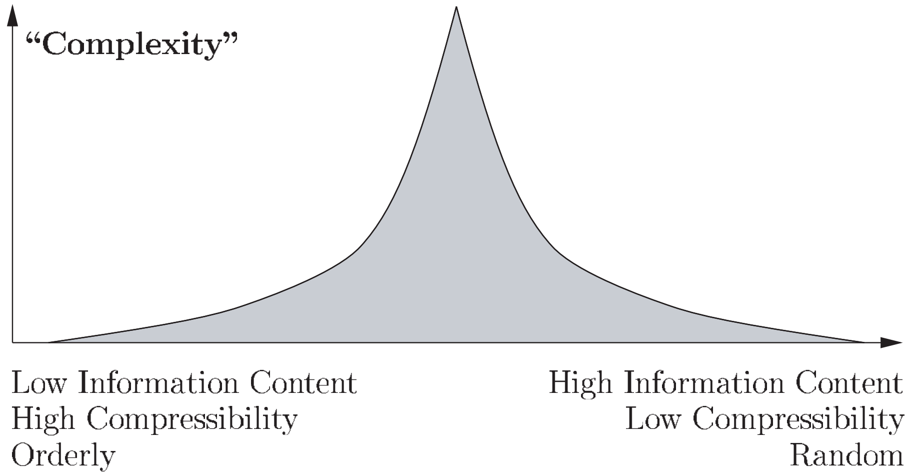

Figure 7.2

To measure EC Gell-Mann proposes to split a given system into two algorithmic terms, with the first algorithm capturing structure and the second algorithm capturing random deviation. The EC would then be proportional to the size of the optimally compressed first algorithm that captures structure. There are objections to this approach, for example some maintain that this notion of structure is subjective and remains in the eye of the beholder. And indeed there are competing proposals as to the specifics of effective complexity. [12]

The important point for the purpose of this paper is that complexity science has produced a robust general paradigm for understanding and classifying systems. Systems exist on a continuum from the highly ordered to the highly disordered. Both highly ordered and highly disordered systems are simple. Complex systems exhibit a mix of order and disorder.

8. Generative Art Systems in the Context of Complexity Theory

Earlier I offered a definition of generative art where the key is the use of systems as an indirect production method. This, taken in combination with the new paradigm for systems suggested by complexity science, results in a paradigm for understanding and sorting though generative art systems.

This paradigm for generative art systems is captured in the following figure, a variation on the previous figures from Gary Flakes wonderful book "the Computational Beauty of Nature". [13]

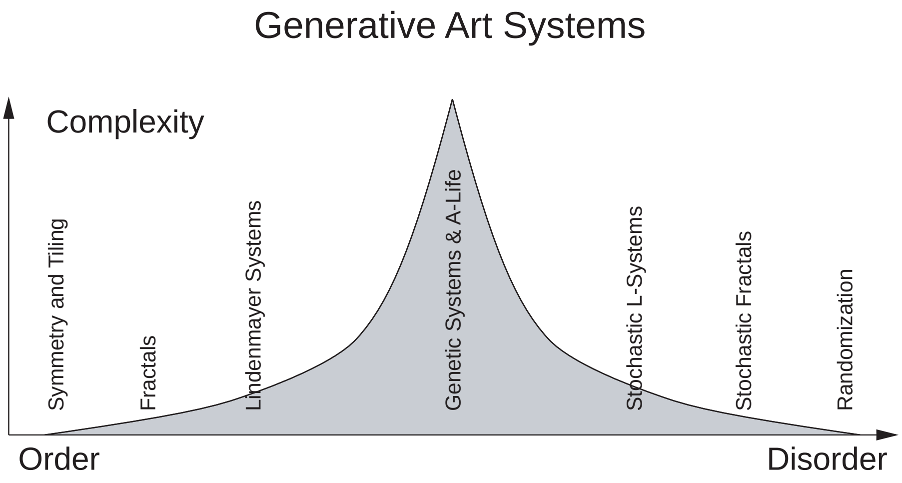

Figure 8.1

First one should note that complexity is specific to a given system, and the classifications shown here are generalities. Not all genetically inspired evolutionary systems are going to be equally complex. Some L-systems are going to be more ordered than others, and some stochastic L-systems are going to be more disordered than others. Also some L-systems are equivalent to fractals, while others using parametric and contextual mechanisms are more complex (as shown). [5]

But if we accept this paradigm, that generative art is defined by the use of systems, and that systems can be best understood in the context of complexity theory, we are lead to an unusually broad and inclusive understanding of what generative art really is.

And while it shouldn't be terribly surprising that the earliest forms of generative art used simple systems, some will find it surprising and perhaps even controversial that generative art is as old as art itself.

8.1 Highly Ordered Generative Art (and Generative Art as Old as Art Itself)

In every time and place for which we can find artifacts, we find examples of the use of symmetry in the creation of art. Reasonable people can disagree as to at what point the use of symmetry can be considered an autonomous system. But even among the most so called primitive peoples examples abound in terms of the use of geometric patterns in textiles, symmetric designs about a point, repeating border designs, and so on. Many of these are well documented in books by authors like Hargittai and Hargittai [14] and Stevens. [15]

The artistic use of tiling, in particular, is nothing less than the application of abstract systems to decorate specific surfaces. Leading the most notable examples in this regard are perhaps the masterworks found in the Islamic world. It is no coincidence the Islamic world also provided one of the significant cradles of mathematical innovation. It is also worth noting that the word "algorithm" has its roots in the Islamic world.

Highly ordered systems in generative art also made their appearance in innovative

20th century art. A popular contemporary tile artist, and student of the Islamic roots, is M. C. Escher. While lacking in formal mathematical training, it is clear that he had a significant understanding of the generative nature of what he called "the regular division of the plane". Without the use of computers he invented and applied what can only be called algorithms in the service of art. [16]

In addition, minimal and conceptual artists such as Carl Andre, Mel Bochner, Donald Judd, Paul Mogenson, Robert Smithson, and Sol Lewitt used various simple highly ordered geometric, number sequence, and combinatorial systems as generative elements in their work. [17] [18]

In my class I frequently remind my students that you don't need a computer to create generative art, and that in fact generative art existed long before computers. With tongue only partially in cheek I also sometimes comment that generative art lead to the invention of the computer!

A highlight in the history of generative art was the invention of the Jacquard loom. Manual textile machines long allowed weavers to apply repetitive formulas in the creation of patterned fabrics. With the industrial revolution some of these systems were automated, but it was Jacquard's 1805 invention that introduced the notion of a stored program in the form of punched cards that revolutionized the generative art of weaving. Interestingly one of Jacquards primary goals was to allow the automation of patterns of greater complexity. Later both Charles Babbage and Charles Hollerith leveraged Jacquard's method of punch card programming in their efforts to invent the computer.

But is generative art really as old as art? Many are familiar with the discoveries of representational cave paintings some 35,000 years old that depict animals and early mans daily life. But in 1999 and 2000 a team led by archaeologist Christopher Henshilwood of the South African Museum in Cape Town uncovered the oldest known art artifacts. Etched in hand sized pieces of red ochre more than 70,000 years old is an unmistakable grid design made of triangular tiles that would be clearly recognizable as such to Escher or generations of Islamic artists.

While the etchings, like all ancient archaeological finds, are not without controversy, many find them compelling examples of abstract geometric thinking with an artistic response. In a related article in Science anthropologist Stanley Ambrose of the University of Illinois, Urbana-Champaign says "This is clearly an intentionally incised abstract geometric design...It is art." [19]

Obviously two stone etchings alone cannot make the case that generative art is as old as art itself. But around the world, and though out history, there is overwhelming evidence of artists turning to systems of iterative symmetry and geometry to generate form. Early generative art may seem unsophisticated because it is highly ordered and simple, but our complexity inspired paradigm for generative art has an important place for highly ordered simple systems

8.2 Highly Disordered Generative Art

The first use of randomization in the arts that I am aware of is an invention by Wolfgang Amadeus Mozart. Mozart provides 176 measures of prepared music and a grid that maps the throw of a pair of dice, and a sequence number (first throw, second throw, etc) into the numbers 1 through 176. The player creates a composition by making a sequence of random dice throws, and assembling the corresponding measures in a sequential score. Perhaps Mozart knew intuitively that purely random music isn't terribly interesting because he found a primitive way to mix order and disorder. The short pre-composed measures provide order, and the throw of the dice provide disorder.

Randomization in the arts came into its own primarily in the 20th century. As a young artist Elsworth Kelly used inexpensive materials such as children's construction paper along with chance methods to create colorful collages. He was inspired to do this after observing the random patchworks that would develop in the repair of cabana tents on the French Rivera. [20]

The writer William Burroughs famously used his Dada inspired “cut-up” technique to randomize creative writing. Less well known are Burroughs experiments in visual art using shotgun blasts to randomly scatter paint on, and partially destroy, plywood supports. [21]

Occasionally Carl Andre would use a random spill technique rather than his more typical highly ordered assembly system. [18]

Certainly one of the most famous advocates for the random selection of sounds in music was John Cage.

In the era of computer-generated art the use of pseudo-random number generators becomes perhaps the most popular digital generative technique.

As mentioned earlier, generative art is a long-standing art practice, but different artists may choose the same generative technique for wholly different reasons. For John Cage the motivation for randomization was a Zen inspired acceptance of all sounds as being equally worthy. For Andre the intent was to somewhat similarly focus attention on the materials, but also to assault art-world expectations regarding composition. For many contemporary electronic musicians performing in a club context the use of randomization isn't so theory laden. It's simply an attempt to add an element of surprise to make things more interesting.

It is important to remember that what generative artists have in common is how they make their work, but not why they make their work, or even why they choose to use generative systems in their art practice. The big tent of generative art contains a diversity of intent and opinion.

8.3 Complex Generative Art

One need only survey the proceedings of this very conference to see that the bulk of those working on the cutting edge of generative art are working with systems that combine order and disorder. These artists are exploring many of the same systems that are the very meat of complexity science. Examples include genetic algorithms, swarming behavior, parallel computational agents, neural networks, cellular automata, L-systems, chaos, dynamical mechanics, fractals, a-life, reaction-diffusion systems, emergent behavior, and all manner of complex adaptive systems. It would be difficult to summarize all of this work in a single paper, and indeed there is no need to here.

The point I would like to emphasize here is that while complex systems dominate our current attention, and in many ways represent the future of generative art, complex systems are not “better than” simple systems. Each has a historical and contemporary place in art practice. Both the ordered and the disordered, and the simple and the complex, are needed to complete an account of systems, and to complete an account of generative art.

9. Complexity Theory as a Context for Generative Art Theory

It is my hope that bolstered by the view of systems that complexity theory provides, a fecund context for generative art theory will result from a broad and inclusive systems oriented definition of generative art. Towards that end I will close by raising some common questions I hear regarding generative art. While some initial answers are provided here, my primary intent is to suggest that the paradigm suggested in this paper is an inviting context further discussion.

9.1 Is generative art a subset of computer art?

Because contemporary generative art is so very often computer based many assume it is a subset of computer art. I’ve tried to show here that generative art preceded computer art, and in fact is as old as art itself. Equally important is the virtual certainty that new forms of generative art will come after the computer as well. Nanotechnology, genetic engineering, robotics, and other technologies will no doubt offer generative artists some wonderful opportunities.

9.2 Isn’t generative art a subset of abstract art?

Generative art refers to a way to create art rather than an art style. Consider the work of Harold Cohen who creates software that autonomously designs stylized representational works depicting people in lush tropical settings. [22] And of course there is the growing use of genetic and other generative systems in the design of practical and decorative objects.

9.3 How can handmade art be generative?

A given work being generative is a matter of degree, i.e. generative art is a fuzzy set. Generative art practice is really the key, and a given work might be created only partially via the use of an autonomous system. In principle any computer based generative method could be carried out by hand. More practically, if an artist creates a system and then hands it off to an artisan for use in laying tiles, how different is that from using a generative art robot? And how different is that from the artist choosing to do it himself? What is key is that a system is applied with some degree of autonomy, whether or not the construction happens by hand. Handmade generative art is still quite different than other handmade art where the artist is making intuitive design judgments from one moment to the next throughout the entire construction process.

9.4 Why do artists choose to work using generative methods?

Generative art is a method of making art, but it carries with it no particular motivation or ideology. In fact the use of generative methods may have nothing to do with the content of the work at all. For example, filmmakers may use generative methods to synthesize imagery for purely economic reasons. At the other extreme some generative artists create works where there is no distance at all between the generative production method and the meaning of the work. These are generative artists exploring systems for their own sake. And of course there are numerous artists somewhere in between. There are as many reasons to use generative methods as there are generative artists. Perhaps more.

9.5 Is generative art an art movement?

Generative art as described here is simply systems oriented art practice, and it has roots in the oldest known art. Various generative systems have been used by those in assorted art movements over the years. Generative art as a systems oriented art practice is much too large to be claimed by any single art movement.

There is, however, an earlier and somewhat obscure use of the same phrase in the context of a specific art movement. Our discussion here should not be confused with this narrow art historical technical homonym.

> *“Generative Art - A form of geometrical abstraction in which a basic element is made to ‘ generate' other forms by rotation, etc. of the initial form in such a way as to give rise to an intricate design as the new forms touch each other, overlap, recede or advance with complicated variations. A lecture on 'Generative Art Forms' was given at the Queen's University, Belfast Festival in 1972 by the Romanian sculptor Neagu, who also founded a Generative Art Group. Generative art was also practiced among others by Eduardo McEntyre and Miguel Ángel Vidal [1928-] in the Argentine.*"[23]

This same source also defines “Systemic Art” which is at times confused with our contemporary understanding of generative art.

> *"Systemic Art – a term originated by the critic Lawrence Alloway in 1966 when he organized an exhibition 'Systemic Painting' at the Solomon R. Guggenheim Museum, New York, to refer to a type of abstract art characterized by the use of very simple standardized forms, usually geometric in character, either in a single concentrated image or repeated in a system arranged according to a clearly visible principle of organization. The Chevron paintings of Noland are examples of Systemic art. It has been described as a branch of Minimal art, but Alloway extended the term to cover Colour Field painting."* "[23]

9.6 Isn’t generative art about the issue of authorship?

Certainly when one turns the creation of a work of art over to a machine, and part of the work is created without the participation of human intuition, some will see a resonance with contemporary post-structural thinking. Some generative artists work specifically in the vein of problematizing traditional notions about authorship. But the generative approach has no particular content bias, and generative artists are free to explore life, death, love, war, beauty, or any other theme.

9.7 Was Jackson Pollock a generative artist?

Partially because Jackson Pollock’s best-known work seems “random”, and partially because his “drip and splash” technique seems to be a retreat from conscious artistic control, many wonder whether Jackson Pollock can be considered a generative artist. I don’t consider his work to be generative art because there is no autonomous system involved in the creation of his paintings.

There is, however, an interesting link between Pollock’s most famous work and complexity theory. Physicist Richard Taylor has shown that Pollock’s drip and splash marks are fractal in nature, that they are likely the result of Pollock learning how to “launch” the paint with his wrist and arm so as to induce chaotic fluid flow, and that as Pollock’s work progressed he was able to achieve higher and higher degrees of fractal dimension. [24]

Perhaps it is this fractal look that encourages the knowledgeable observer to try to connect Pollock to generative art. In any case Pollock applied the paint manually without the use of any external system. The work was a hard earned intuitive creation requiring physical discipline, and requiring many sessions and constant reworking. However, the fact that his manual practice rests on underlying physics that happens to engage contemporary notions of fractals and chaos theory shouldn’t sway one to think of these paintings as generative works. All artwork has underlying physics, and if that were the measure then all art would have to be called generative art.

9.8 Is Hans Haacke a generative artist?

Han's Haacke is a prescient artist whose work critiques both physical and social systems in a bold way that precedes by decades the similar attempts now underway in complexity science. It is important, however, to differentiate between works that are about systems and works that use systems in their creation. Haacke has produced both.

As curators for the exhibit "COMPLEXITY – Art and Complex Systems" Ellen K. Levy and I were thrilled to be able to present Haacke's 1963 piece "Condensation Cube". A simple acrylic cube with a bit of water at the bottom and sealed shut, "Condensation Cube" becomes a miniature weather system as an ever changing display of condensation forms on the cube's walls. This work anticipated meteorologist Ralph Lorenz's discovery of chaotic strange attractors, and stands as a wonderful example of generative art. [25]

The following artists statement written by Haacke in 1965 could stand today as a manifesto for generative artists exploring complex adaptive systems.

> *HANS HAACKE Statement*
>
> *...make something which experiences, reacts to its environment, changes, is non-stable...*
>
> *...make something indeterminate, which always looks different, the shape of which cannot be predicted precisely...*
>
> *...make something which cannot 'perform' without the assistance of its environment...*
>
> *...make something which reacts to light and temperature changes, is subject to air currents and depends, in its functioning, on the forces of gravity...*
>
> *...make something which the 'spectator' handles, with which he plays and thus animates...*
>
> *...make something which lives in time and makes the 'spectator' experience time...*
>
> *...articulate: something natural...*
>
> *Cologne, January 1965* [26]

9.9 Is Sol Lewitt a generative artist?

Most of Sol Lewitt's work is generative, and as a conceptual artist much of his attention is focused on exploring systems for their own intrinsic value. In his "Paragraphs on Conceptual Art" from 1967 he says, "The idea becomes a machine that makes the art" and refers to the actual construction of the work as "a perfunctory affair". His combinatorial drawings and sculptures demonstrate the continuing viability of highly ordered systems in generative art.

9.10 Shouldn't all generative art exhibit constant change and unforeseeable results?

There is much to be said for the creation of complex systems as installation art that exhibits dynamics in real time for an audience. It is a wonderful way for an artist to share his explorations of complex systems, and especially complex adaptive systems, with an audience. However, an art practice that uses a dynamic complex system to create what is ultimately a static object or recording is still generative art. As is, for that matter, works resulting from the use of simple generative methods.

9.11 Is generative art modern or post-modern?

Generative art is ideologically neutral. It is simply a way of creating art and any content considerations are up to the given artist. And besides, generative art historically precedes modernism, post-modernism, and just about any other "ism" on record.

Certainly one can make generative art that exhibits a postmodern attitude. Many do. But one can also make generative art that attempts to refute post-modernism.

Two of the most significant impacts of post-modernism on art are (1) the proposed abandonment of formalism and beauty as a meaningful area of exploration, and (2) the proposed abandonment of the notion that art can reveal truth in any non-relativistic way. Form, beauty, and knowledge are held to be mere social constructions.

Generative art can be used to attack these fundamental points head on. First, generative artists can explore form as something other than arbitrary social convention. Using complex systems artists can create form that emerges as the result of naturally occurring processes beyond the influence of culture and man.

Second, having done this, generative artists can demonstrate by compelling example reasons to maintain faith in our ability to understand our world. The generative artist can remind us that the universe itself is a generative system. And through generative art we can regain our sense of place and participation in that universe.

References

[1] Galanter, P. *Foundations of generative art systems – a hybrid survey and studio class for graduate students*. Generative Art 2001: Proceedings of the 4th International Conference. Generative Design Lab, Milan Polytechnic, Milan 2001

[2] Schwanauer, S. M. and D. A. Levitt (1993). Machine models of music . Cambridge, Mass., MIT Press.

[3] Miller, Dennis, *Game of Chance*, Electronic Musician, p 53-64, November 2003

[4] Perlin, Ken. *An Image Synthesizer*, Proc. SIGGRAPH '85, ACM Computer Graphics, Vol.19, No.3, pp.287-296.

[5] Prusinkiewicz, P., A. Lindenmayer, et al. (1990). The algorithmic beauty of plants . New York, Springer-Verlag.

[6] Todd, S., Latham, W. (1992) Evolutionary art and computers. London, Academic Press Limited

[7] Carrol, Noel. (1999) Philosophy of Art, London, Routledge

[8] Casti, John L. (1994) Complexification, New York, HarperCollins

[9] Shannon, Claude E. *A mathematical theory of communication*. The Bell System Technical Journal, 27(3):379--423, 1948.

[10] Moles, A. A. (1966). Information theory and esthetic perception. Urbana, University of Illinois Press.

[11] Bar-Yam, Y. (1997). Dynamics of complex systems. Reading, Mass., Addison-Wesley.

[12] Gell-Mann, Murry. *What is complexity?* Complexity – John Whiley and Sons, Vol 1 No 1, 1995

[13] Flake, G. W. (1998) The computational beauty of nature, Cambridge, The MIT Press

[14] Hargittai, I., Hargittai, M. (1994) Symmetry: a unifying concept, Bolinas CA, Shelter Publications

[15] Stevens, P. S. (1981). Handbook of regular patterns: an introduction to symmetry in two dimensions. Cambridge, Mass., MIT Press.

[16] Locher, J. L., ed. (1992) M. C. Escher: His life and complete graphic work, New York, Abradale Press

[17] Alberro, A. and B. Stimson, ed. (1999). Conceptual art: a critical anthology. Cambridge, Mass., MIT Press.

[18] Meyer, J. (2000) Minimalism: themes and movements. London, Phaidon

[19] Balter, Michael. *Oldest Art – From a Modern Human's Brow - or Doodling.* Science, Vol. 295 pp 247-249

[20] Bois, Y. A., J. Cowart, et al. (1992). Ellsworth Kelly: the years in France, 1948-1954 . Washington, D.C. [München], National Gallery of Art; Prestel-Verlag.

[21] Sobieszek, R. A. and W. S. Burroughs (1996). Ports of entry: William S. Burroughs and the arts . Los Angeles New York, Los Angeles County Museum of Art ; Distributed in the USA by Thames and Hudson.

[22] McCorduck, P. (1991). Aaron's code: meta-art, artificial intelligence, and the work of Harold Cohen . New York, W.H. Freeman

[23] Osborne, Harold, ed. (1988) The Oxford Companion to Twentieth-Century Art. Oxford, Oxford University Press

[24] Taylor, R., Micolich, A., Jones, D. *The constructtion of Jackson Pollock's fractal drip paintings.* Leonardo, Vol 35, No. 2, pp. 203-207

[25] Benthall, J. (1972). Science and technology in art today. New York,, Praeger

[26] Cotter, S., Douglas, C. ed. (2000) Force fields: phases of the kinetic. Barcelona, Museu d'Art Contemporani de Barcelona

New methods for the three-dimensional representation of high-dimensional objects

Philip Van Loocke

Abstract. The paper develops new methods for the visualization of high-dimensional objects. An algorithm minimizing different kinds of error functions is described. The contrast between metric and structural adequacy is illustrated. Aesthetic representations of hypercubes are obtained in the metric domain if different types of structure are integrated, and in the structural domain when spatially bifurcating curve sets are taken as a point of departure. Then, a weighted sum of vertex-based transforms is associated with the visualization of a hypercube. These transforms construct map from R^n onto R^3 on basis of the visualization of a hypercube. This is illustrated for four-dimensional objects generated by a function familiar from fractal contexts.

1. Introduction

The question how high-dimensional structures can be visualized in three dimensions has been raised since the advent of non-Euclidean geometry and of modern physics (Kaku, 1994; Barrow, 2003), and has inspired several artists (Henderson, 1983). Toward the end of the nineteenth century, knowledge about the conceivability of a fourth dimension spread, among others, in England and in France. From about 1910, cubist art was often explained as a means for the artist of expressing a four-dimensional reality. Artists such as Duchamp explicitly tried to develop new methods for visualizing the fourth dimension. They embedded their practice in a more global philosophical view on a four-dimensional universe. It was influenced by Russian authors and artists (such as Ouspensky and Malevitch), who linked four-dimensional concepts with a mystical attitude, which was linked with platonism. In the United States, ideas about higher dimensions widely spread through literature, such as the science fiction of Wells. Through the work of Bragdon, four-dimensional concepts found their way to the design of ornaments. In the twenties, Buckminster Fuller brought these ideas into the field of architecture. But although there are notable exceptions, the four-dimensionalist artistic/philosophical inspiration and interest faded after 1920.

In the past few decades, this interest gradually re-emerged, because computer technology gave new opportunities for visualizing high-dimensional objects. Popular work on computer graphics, like the book of Banchoff (Banchoff, 1990), brought these possibilities under wider attention. Digital architecture included the concept of higher dimensions in its design process, such as in the work of Novak or Lalvani (Lalvani, 2003).

In this paper, new methods for obtaining computer generated visualizations of high-dimensional objects are constructed. In section 2, a stepwise algorithm for visualizations of n-dimensional hypercubes is explored. The algorithm is run for metric constraints, and for structural constraints that are cast in metric terms (section 2). Subsequently, the algorithm is reformulated in terms of branching structures. This yields representations in which different types of three-dimensional spatial structures are combined. Section 3 comments on the difficulty of reconciling structure and metric in the representation of high-dimensional objects. As an alternative to a stepwise procedure, section 4 describes a structural approach that generates forms of a more organic nature. Finally, section 5 describes how the visualizations of hypercubes can serve as a basis for a transform of the entire space R^n onto R^3. The transform is illustrated with visualizations of some four-dimensional structures defined in quaternion space.

2. A stepwise algorithm for two and three dimensional visualizations of hypercubes

Consider a hypercube in n dimensions. It has 2^n edge points or 'vertices', which are denoted P_i. Suppose that the hypercube is mapped on a two- or three-dimensional visualization. The point on which P_i is mapped is denoted Q_i. The vertices P_i are supposed to have coordinates equal to –1 or +1. The coordinates of Q_i take continuous values and are adapted in the course of the stepwise algorithm.

Suppose that the coordinates of Q_i are initialized randomly. The Euclidean distance $d(Q_i,Q_j)$ for all couples of points (Q_i,Q_j) is determined, and this quantity is normalized by division by the largest value found for it: $d^*(Q_i,Q_j)=d(Q_i,Q_j)/d_{max}$, where d_{max} is the maximal distance between points Q_i and Q_j. Similarly, in the hypercube, all n-dimensional Euclidean distances $d(P_i,P_j)$ between edge points are determined, and normalized by division by $2.n^{(1/2)}$:

$d^*(P_i,P_j)=d(P_i,P_j)/\ 2.n^{(1/2)}$ (for the given choice of coordinates, $2.n^{(1/2)}$ is the largest distance between different edge points in the hypercube). Then, the error measure E_1 = $_{i,j=1,\ldots,n}$. $(d^*(Q_i,Q_j)–d^*(P_i,P_j))^2$ can be used to measure the metric resemblance between the hypercube and its visualization. It is proportional to a measure known as 'stress' or 'Sammon error' in the literature on data visualization.

A stepwise algorithm minimizing this error can be defined as follows. The points Q_i are give random initialization. At each step, one point Q_j and one dimension in the visualization are selected randomly. The quality ˜ is added to the coordinate of Q_j along this dimension; is the stepsize of the algorithm, and is a random number between –1 and +1. If the new coordinates of Q_j lead to a lower value of E_1, the change in coordinates is kept; else, the old coordinate values are restored. Different runs of this algorithm generally yield different visualizations, though the final value of E_1 is often the same. Figure 1 shows a two-dimensional visualization of a three-dimensional cube (with E_1=1.904); Figure 2 illustrates a two-dimensional visualization of a four-dimensional cube (with E_1=11.946).

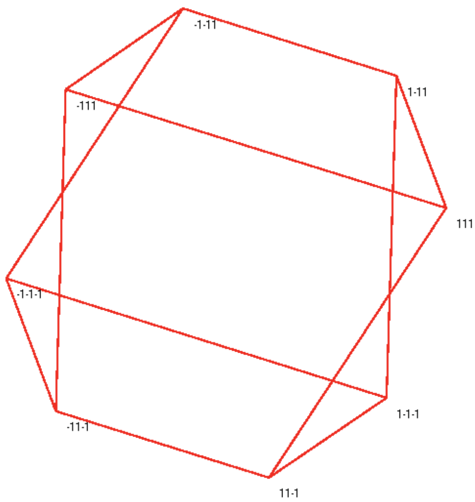

Figure 1. Two-dimensional visualization of a cube by minimization of E_1

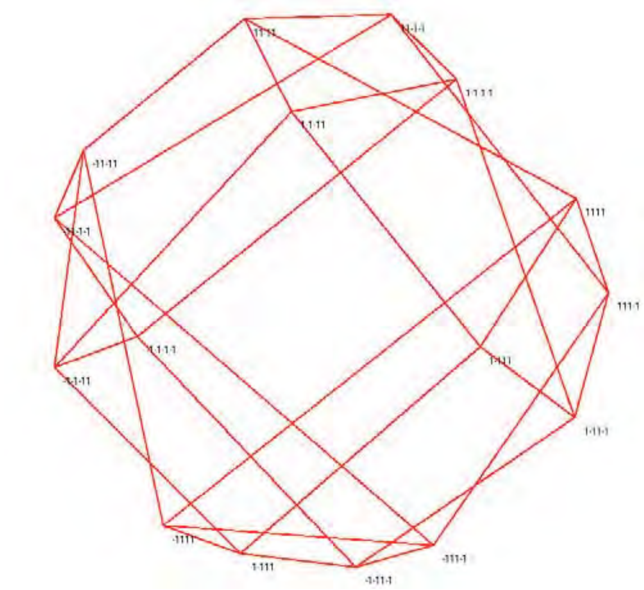

Figure 2. Two-dimensional visualization of a hypercube with n=4 and for minimization of E_1

The visualization of the hypercube in Figure 2 lacks symmetry. Symmetry is restored when the algorithm is applied for three dimensional visualizations. This is illustrated in Figure 3, where two representations corresponding to n=4 are shown (in both cases, E_1=3.769). The visualizations obtained show point-symmetry relative to the center of the Q_i-structure. The left and the right part of Figure 4 show a representation of a five, respectively a six-dimensional hypercube (with E_1=24.102 and E_1=120.378). The point-symmetry of the visualization remains for n=5 and n=6.

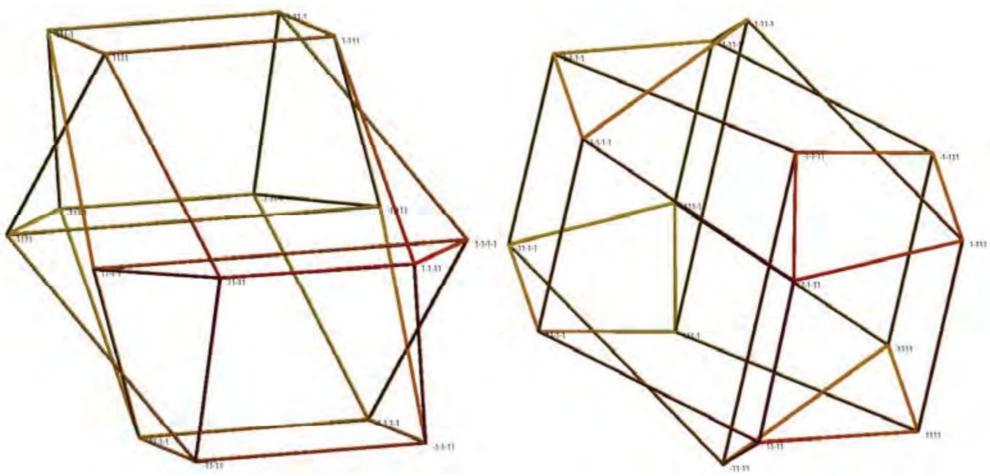

Figure 3. Two visualizations of hypercubes for n=4 and for minimization of E_1

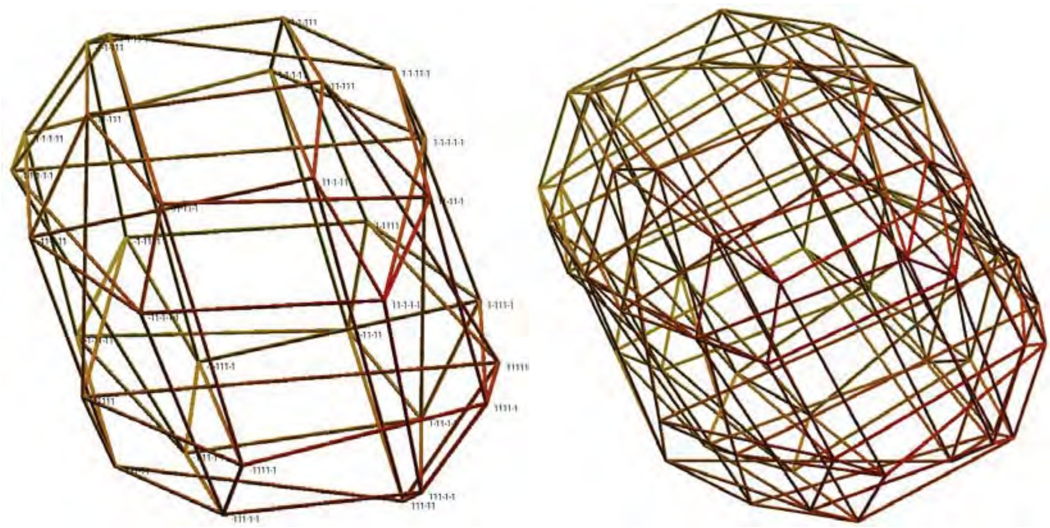

Figure 4. Visualizations of hypercubes for n=5 (left) and n=6 (right)

Consider the smallest squares on the surface of the hypercube. These squares are determined by edge points $\{P_{i1},\ldots,P_{i4}\}$ for which n–2 coordinates take the same value, and for which the remaining two coordinates form the four combinations (–1, –1), (–1,+1), (+1, –1) and (–1,+1). The number of such squares is equal to $s(n) = 2^{n-2}$. B(n, n–2), where B denotes the binomial value. Similarly, the smallest 3-dimensional cubes are formed by sets of different edge points $\{P_{i1},\ldots,P_{i8}\}$ which have the same value along one dimension. The number of such cubes in the hypercube is $c(n) = 2^{n-3}$. B(n, n – 3).

The four edge points of a smallest square define $(4^2 - 4)/2 = 6$ different distances. For the j-th smallest square, the k-th distance between edge points is denoted ds_{jk}. Similarly, for every smallest cube, the eight edge points define $(8^2 - 8)/2 = 28$ distances; dc_{jk} is the k-th distance relation associated with the j-th cube. The largest distance that occurs in a smallest square is $2^{(1/2)}$; in case of a cube, the corresponding value is $3^{(1/2)}$. Similar distances can be determined also for the images Q_i of the edge points P_i in the visualization. Suppose that $d's_{jk}$ is the k-th distance between the points in $\{Q_{j1},\ldots,Q_{j4}\}$ on which the square $\{P_{j1},\ldots,P_{j4}\}$ is mapped. Similarly, $d'c_{jk}$ is the k-th distance between points on which the edge points of the j-th smallest cube are mapped. The largest distance in $d's_{jk}$ (k=1,…,6), respectively $d'c_{jk}$ (k=1,…,28), is denoted $d's_{j,max}$, respectively $d'c_{j,max}$. With these notations, two additional error functions can be defined:

$$E_2 = \quad_{\{j=1 \text{ to } s(n)\}} \quad_{\{k=1 \text{ to } 6\}} (ds_{jk}/2^{(1/2)} - d's_{jk} / d's_{j,max})^2$$

$$E_3 = \quad_{\{j=1 \text{ to } c(n)\}} \quad_{\{k=1 \text{ to } 28\}} (dc_{jk}/3^{(1/2)} - d'c_{jk} / d'c_{j,max})^2$$

Error function E_2 measures how well smallest squares in a hypercube are mapped on squares in the visualization. E_3 measures how well the visualization preserves distance relations for smallest cubes. Figure 5 shows two examples of two-dimensional solutions found for minimization of E_2 and for n=3 (and with E_2=12.618 and E_2=8.657). For n=3, E_3 coincides with E_2. Figure 6 shows a visualization of a hypercube with n=4 and for minimization of E_2 (E_2=22.952). In Figure 7, E_3 is minimized (E_3=21.661). Three-dimensional visualizations are shown in Figures 8-11. Figure 8 has two examples of visualizations for n=4 and minimization of E_2 (E_2=12.394 and E_2=12.200). Figure 9 shows two examples for minimization of E_3 (E_3=12.629 and E_3= 12.618). The left, respectively the right, form in Figure 10 gives a visualization for n=5 and minimization of E_2, respectively E_3 (E_2=53.965 and E_3=80.735). Finally, in Figure 11, the left, respectively the right part, illustrates the case n=6 for minimization of E_2, respectively E_3 (E_2=173.245 and E_3=365.124).

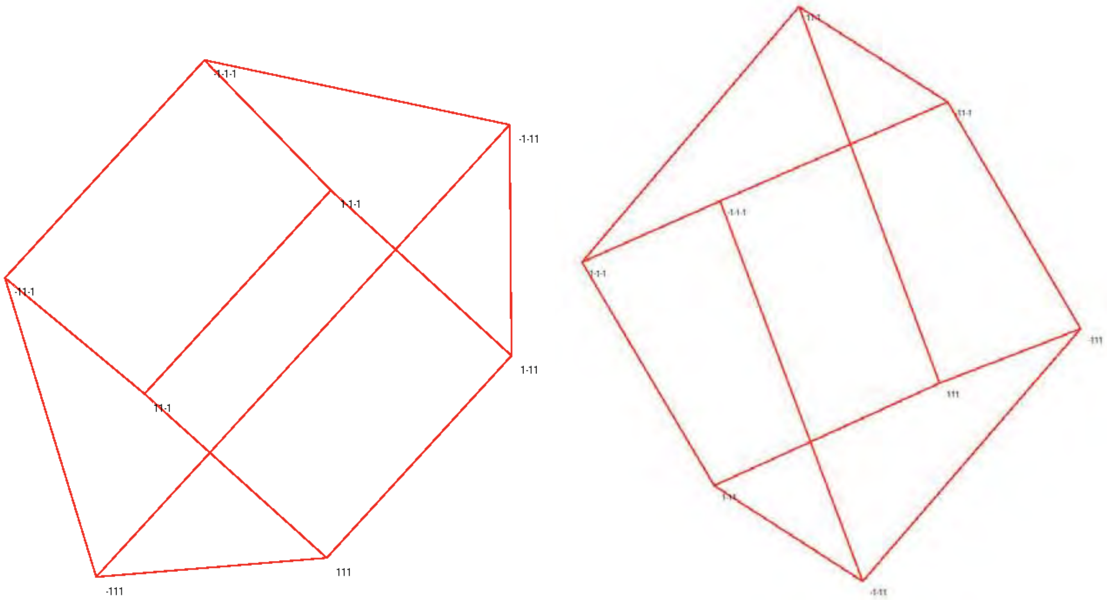

Figure 5. Two visualizations for cubes obtained by minimization of E_2

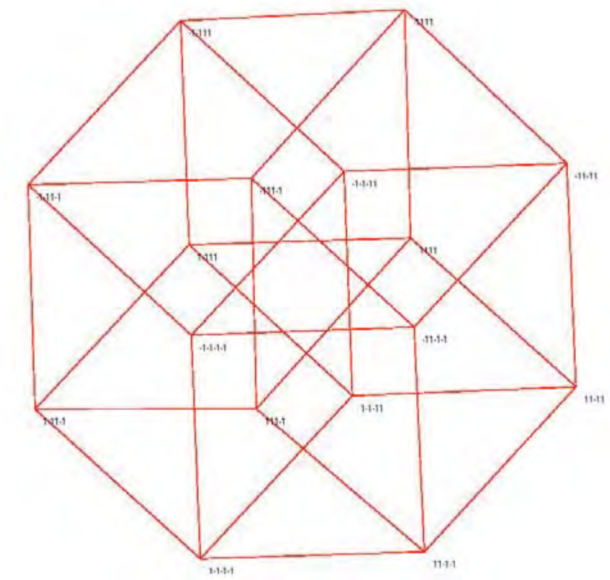

Figure 6. Two-dimensional visualization of a hypercube for minimization of E_2

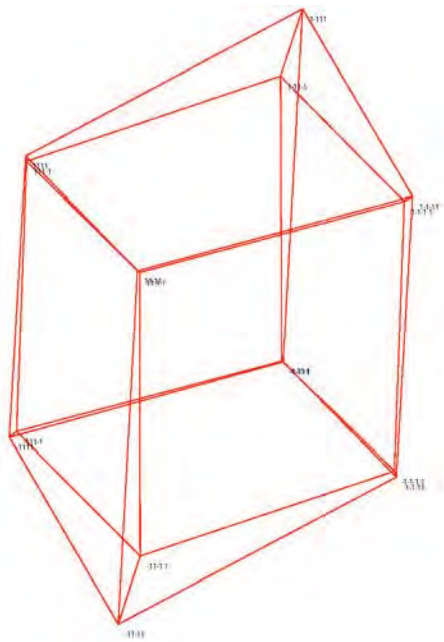

Figure 7. Two-dimensional visualization of a hypercube for minimization of E_3

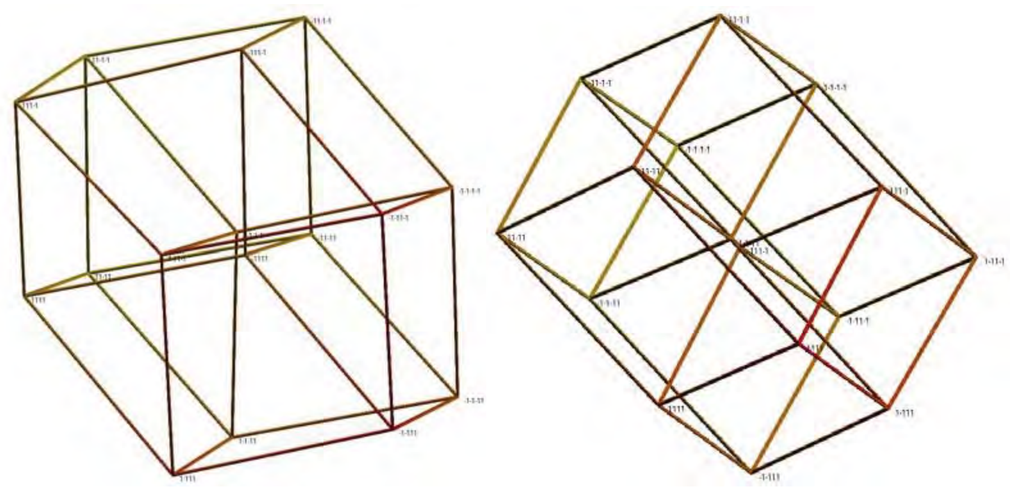

Figure 8. Three-dimensional visualization of the hypercube for n=4 and minimization of E_2 .

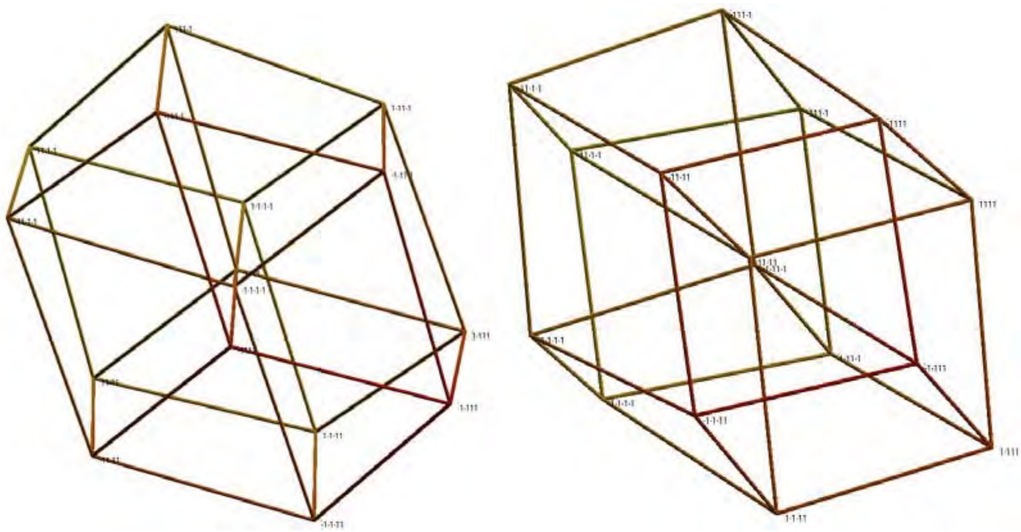

Figure 9. Visualization of the hypercube for n=4 and minimization of E_3

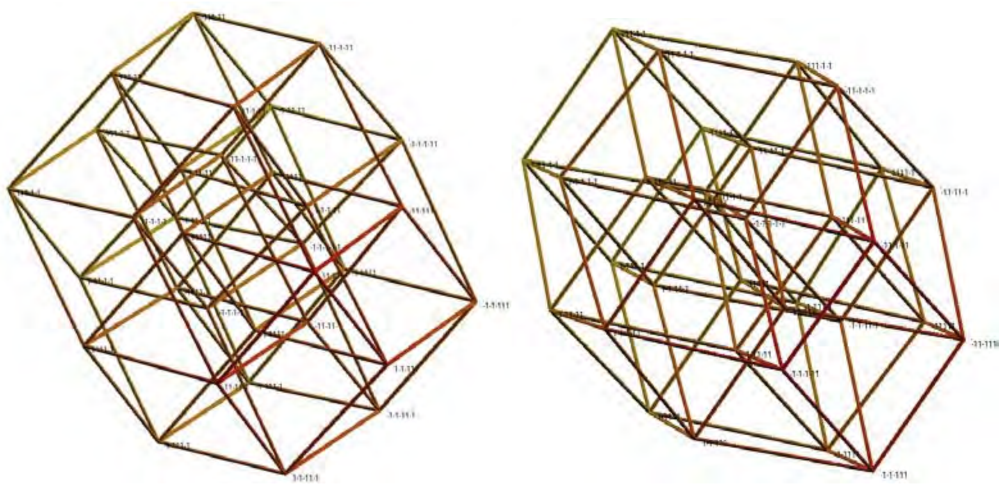

Figure 10. Visualization for n=5 and minimization of E_2 (left) and E_3 (right)

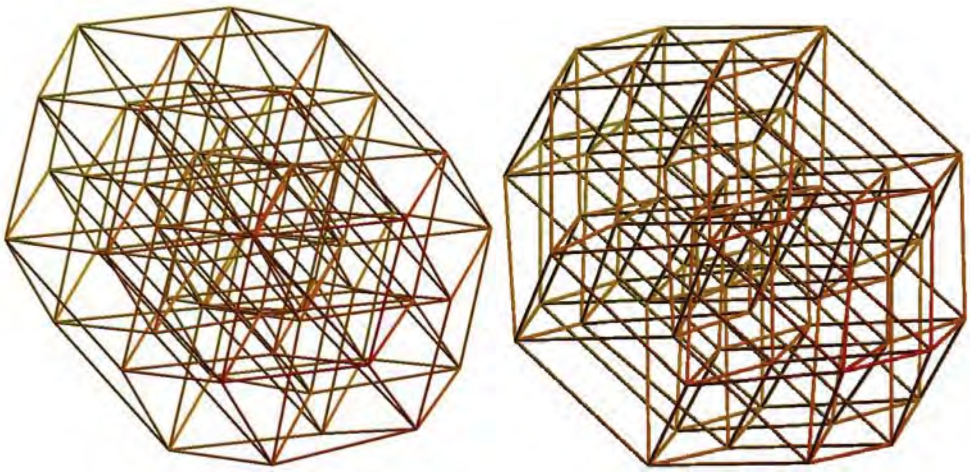

Figure 11. Visualization for n=6 and minimization of E_2 (left) and E_3 (right)

3. Angular variables corresponding to a branching process

In the previous section, the search algorithm varied Cartesian coordinates of edge points Q_i. For a different choice of variables, the points Q_i can be obtained by a spatial branching process consisting of n subsequent bifurcations. At the first stage of the bifurcation process, two branches with starting point in the origin are defined. The endpoint of a branch is the starting point for two new branches at the next level, until, at stage n, 2^n endpoints are generated. Each branch is characterized by two angles and .. and by a length , where is the angle between the horizontal projection of the branch and the x-axis, and . is the angle between the branch and the z-axis. The angles and can be adapted by the stepwise algorithm of the previous section, for any of the functions E_1, E_2 or E_3. This yields a system with 2. $(2+\ldots+ 2^n)$ angular parameters. In the examples in Figures 12-13, branches were given length inversely decreasing with the branching level.

The configuration to which the branching system converges lacks symmetry, but the endpoints of the branches have point-symmetry. This accords with the fact that the value of E_1 in these examples approximates the values found in section 2 (in Figure 12, E_1=3.801, and in Figure 13, E_1=24.503). The algorithm can be run for symmetrically constrained branching systems. In this case, half of the tree is constructed as a point-mirror of the other half, and the total number of parameters is divided by 2. Then, solutions with higher E_1-values are obtained. This is illustrated in Figures 14-15, where symmetry was imposed, resulting in E_1-

values 10.757, 12.624 (Figure 14) and 65.002, 48.916 (Figure 15). The illustrations are for branches of constant length (except for the first two branches, which were given shorter length).

These visualizations of hypercubes have a special aesthetic property. The tree-structure in itself has no clear interpretation to an observer not informed about its purpose. In Figures 14-15, the visualization of the hypercube, when drawn apart from the underlying tree-structure, is also of limited appeal (since the E_1-value is relatively high, the fact that a hypercube is being visualized is not apparent). But by matching the tree-structure with the with the visualization of the hypercube, each type of three-dimensional structure can be interpreted with help of the other.

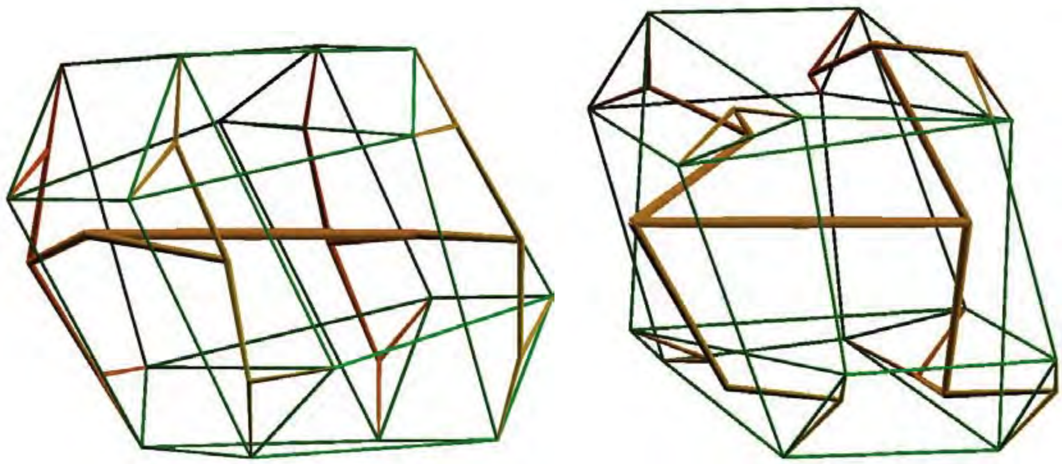

Figure 12. Two examples for angular variables and with branches of decreasing length

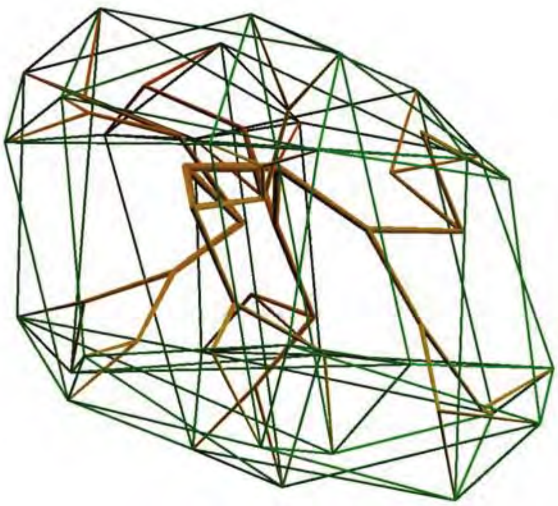

Figure 13. Visualization of the five-dimensional hypercube for angular variables

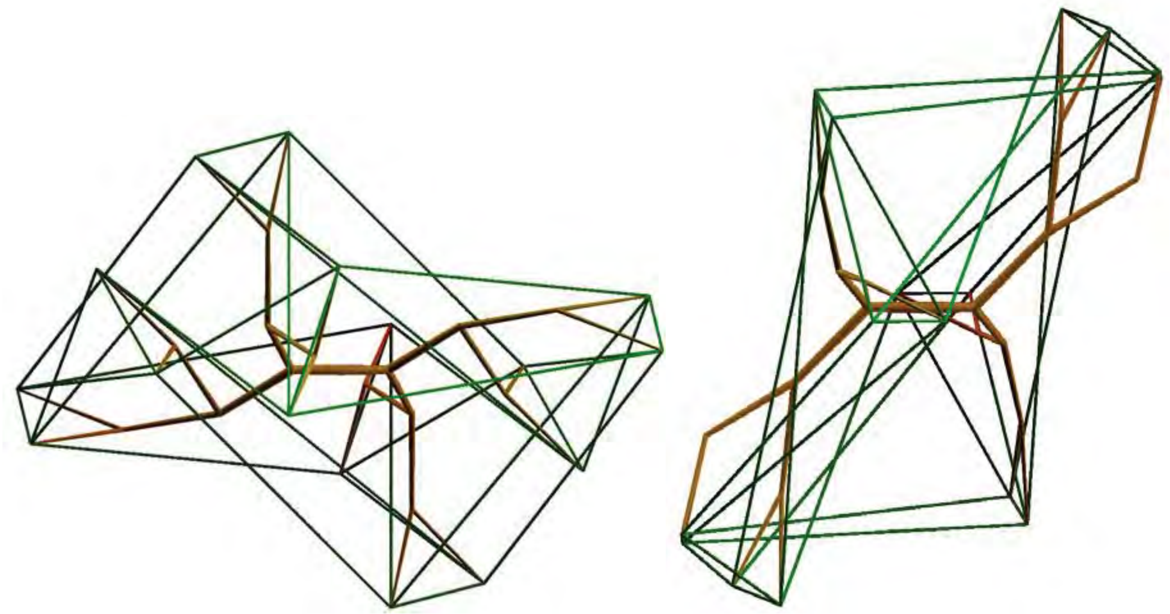

Figure 14. Visualizations of hypercubes with point symmetry imposed

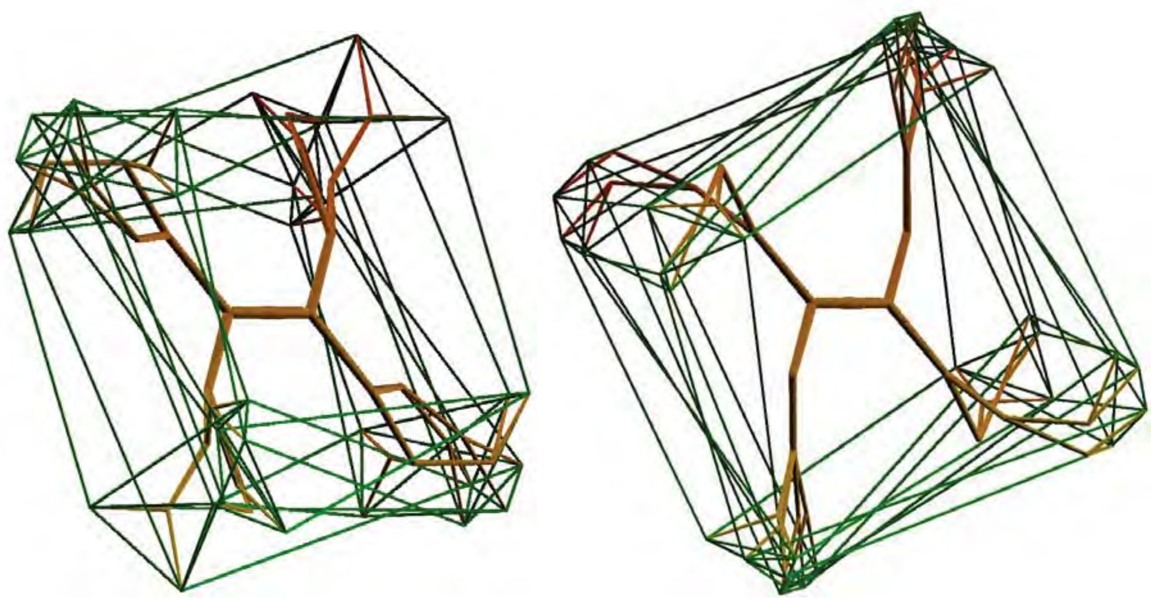

Figure 15. Visualizations of hypercubes (n=5) with point symmetry imposed

The branching algorithm can be run in a sequential way. First, a visualization for n=2 (corresponding to the visualization of a square) is computed. The 2^3 additional branches required for the visualization of the cube (corresponding to n=3) are attached at the endpoints of the branches corresponding to n=2. During the search corresponding to n=3, the latter are kept fixed. This process is continued. At the k-th step, the angles associated with the 2^k new branches are allowed to vary. This results in a fast algorithm when compared to a non-sequential procedure. Such an algorithm was run several times. Branching structures with systematicity were never found, in the sense that angles between branches at later stages were not related in any systematic way to angles between branches at previous stages. This was not helped if different dimensions were given different weight in the metric function. Suppose that the coordinates of P_i, respectively Q_i, are denoted x_i^k (k=1,…,n), respectively y_i^k (k=1,2 or k=1,2,3). In Figure 16, the error function $E'_1 = {}_{\{i,j=1 \text{ to } N\}} (d^n(P_i,P_j)/d_{max} – d^3(Q_i,Q_j)/d'_{max})^2$, with $d^n(P_i,P_j) = ({}_{k=1 \text{ to } n\}} ((1/k).(x_i^k–x_j^k))\ ^2)^{(1/2)}$ and $d^3(Q_i,Q_j) = ({}_{k=1 \text{ to } 3\}} ((1/k).(y_i^k–y_j^k))^2)^{(1/2)}$ was used. As a consequence, each additional dimension led to a smaller deformation of the metric relations obtained at a previous stage.

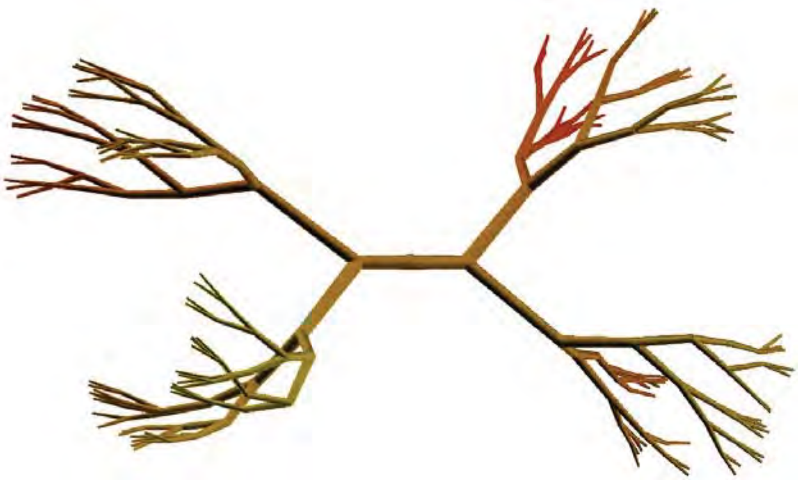

Figure 16. Tree-visualization for n=7 and with E'_1 = 126.390

The lack of systematicity limits the aesthetics of the branching forms. Structural properties appear to be hard to reconcile with metric constraints, and this difficulty increases as n increases. For values of n higher than 6, representations which are visually accessible, or which have aesthetic symmetry, can still be obtained if the metric procedure is replaced by structural considerations.

4. Structural visualizations of high-dimensional discrete spaces

The spatial branching process used in section 3 can be generalized into an alternative visualization procedure based on structural considerations. As a point of departure, a rectangular parallelepiped is constructed with sides ˜ , ˜ ^{2} and ˜ ^{3} (<1). This structure is turned into a visualization of four-dimensional hypercube by splitting the smallest side-surfaces into two smaller rectangles with sides ˜ ^{4} and ˜ ^{5} (see Figure 17). Then, the new rectangles split again in two smaller rectangles to yield a representation of a five-dimensional hypercube, and so on. For splitting processes with appropriate structural properties, aesthetic representations result.

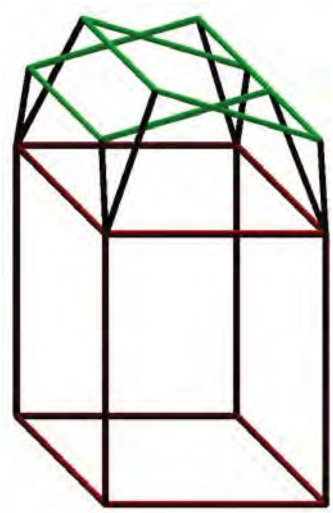

Figure 17. Splitting the upper side-surface of a rectangular parallelepiped

An instance of a splitting process is defined as follows. We confine the definition to the splitting process at the top rectangle of the cube (so that half of the visualization of the hypercube is generated; the other half is obtained by mirroring the resulting structure relative to the horizontal plane).

The first three binary dimensions of the n-hypercube are associated with the edges of the parallelepiped. Then, two curves are constructed, corresponding with fourth component values +1 and –1, respectively. The curves are defined as successions of line segments. The starting point of the curves is the middle of the upper rectangle of the parallelepiped. The angles and of the segments linearly increment according to the rule: d c.x_4 and d d.x_4, where x_4 is the fourth component value associated with a curve. The new rectangles are attached on top of these curves. They are obtained by scaling the top-surface of the parallelepiped, and are orthogonal to the segment on top of which they are drawn. The length of a line segment in a curve is multiplied with a factor (<1) at each step, so that the bifurcating curve structure has smaller branches after each new bifurcation.

After the rectangles corresponding to the fourth dimension are drawn, each of the curves splits into two new curves. The change in angles of the segments in the curves remains determined by d . . c.x_k and d . . d.x_k (k≥5). This process is continued until k equals n. In order to allow endpoints to be located in different horizontal planes, at each odd step in the bifurcation process, the value of is increased by an amount at the initial segment corresponding to $x_k = 1$ if $x_4 = 1$, and at the initial segment corresponding to $x_k = -1$ if $x_4 = -1$. In order to prevent the branching structure from curling too strongly onto itself, the parameter is defined as a decreasing function of k. More specific, in the illustrations in Figures 18-19, = $_c(n+1-k)^2$. Figure 18 shows the upper part of the visualization of a 13-dimensional hypercube for c=0.0175, d=0.0175, =0.993, and $_c$=0.125. Figure 19 shows the underlying curve structure for variation of one parameter in the construction (d=0.0105). Figure 19 was drawn with continuous circular contours in order to ease visual track of the bifurcation process.

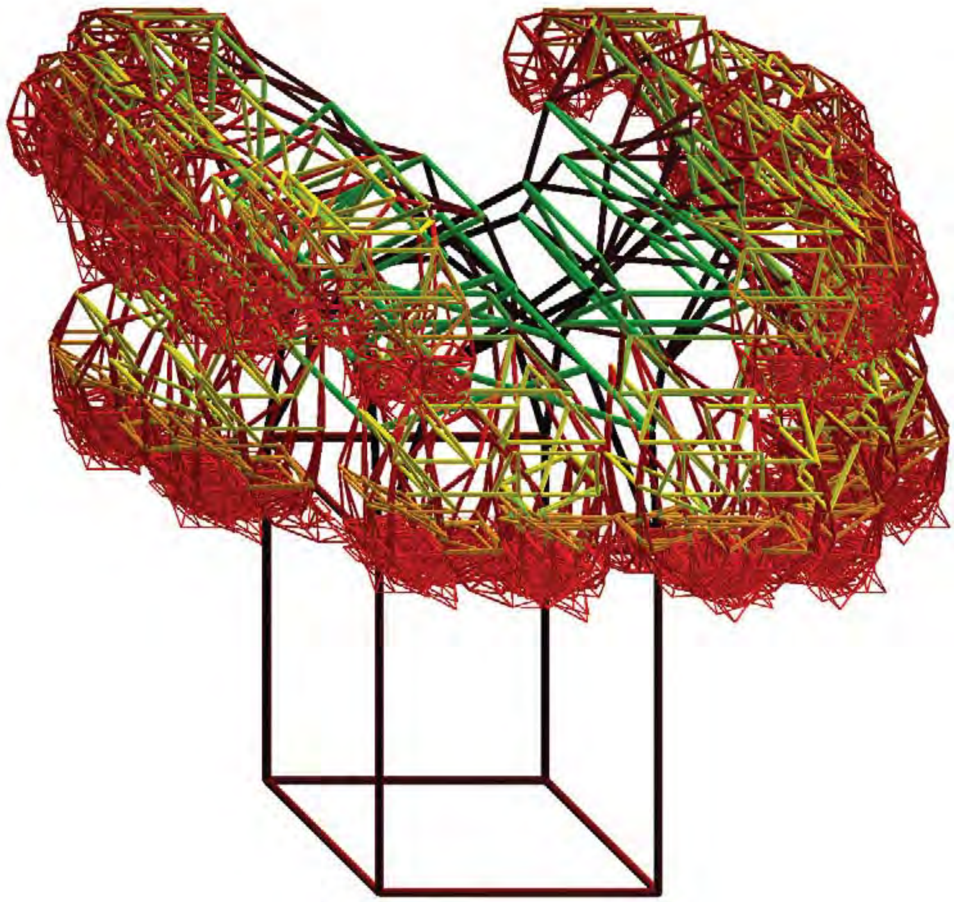

Figure 18. Upper part of a structural visualization of the thirteen dimensional hypercube

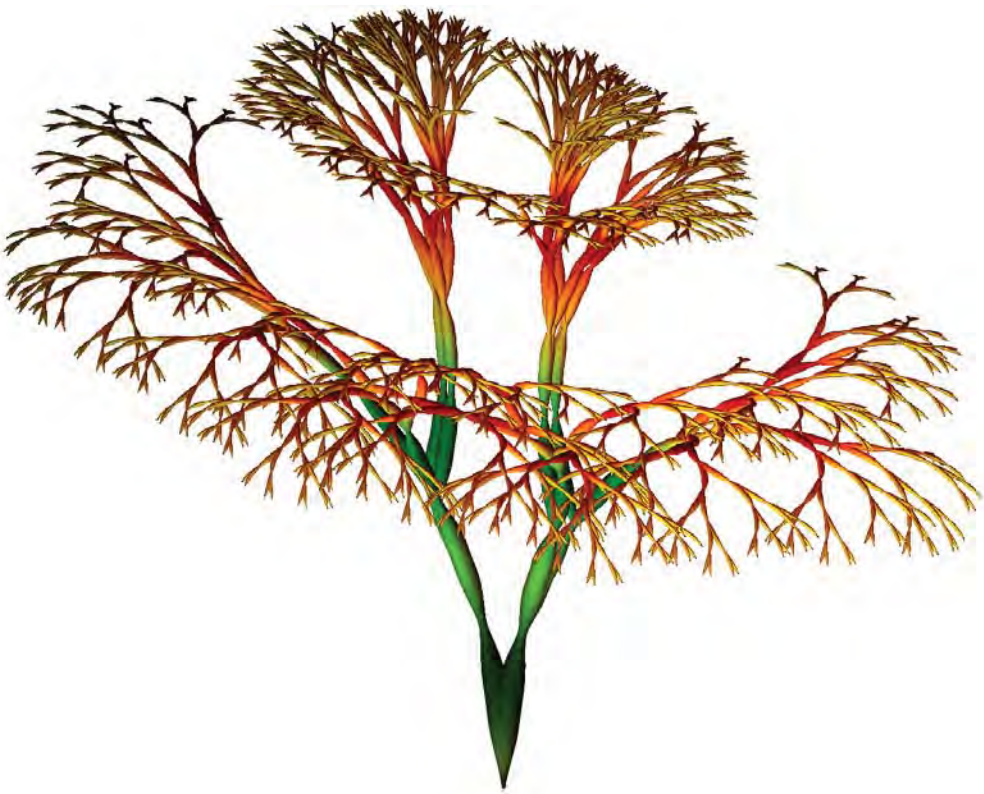

Figure 19. Example of an underlying bifurcating curve set

The aesthetics of bifurcating curve sets can be studied in its own right. For different parameters, and for a constant value of , a binary tree corresponding to ten bifurcations is shown in Figure 20. The end-points of this structure are associated with a binary, ten-dimensional space. The procedure can be defined for p-ary spaces. The nature of the curve sets generated can be made more general also by giving the rules for d and d a more general form. This is illustrated for a ternary space, and for which x_k can take values –1, 0 and +1 in Figures 21-25 (k=1,…n; since we only illustrate the branching curve structure, k can start at value 1 instead of at value 4). Suppose that d and d are defined in accordance with d . . c.f(,).x_k and d . . d.g(,).x_k (c and d are constants; also is kept constant in the illustrations which follow). If f and g are well chosen, end-points of branches develop in non-co-planar ways and with aesthetic spatial symmetry. The parameters and functions in these rules can be tuned toward a visually accessible representation of a p-ary space, or toward representations of aesthetic interest.

The definition of f and g is facilitated if the angles and are drawn into the interval [0, /2]. Two angles μ and are considered . μ is obtained from by subtracting iteratively /2 from Abs( ) until a number in [0, /2] is obtained; is obtained in the same way on basis of . Then, the form in Figure 21 is obtained for f=–μ and g= . Figures 21-24 show branching structures with endpoints corresponding to the points of a seven-dimensional ternary space). The form in Figure 22 results with $f=\mu^2$ and g=1– . Figure is obtained for $f=8\mu^{(1/2)}$ and g=– . Figure 24 corresponds $f=\mu^4$ and $g=\mu^4$. Figure 25 is made for a ternary eight-dimensional space and for f( )=– and g( )=8 $^{1/2}$

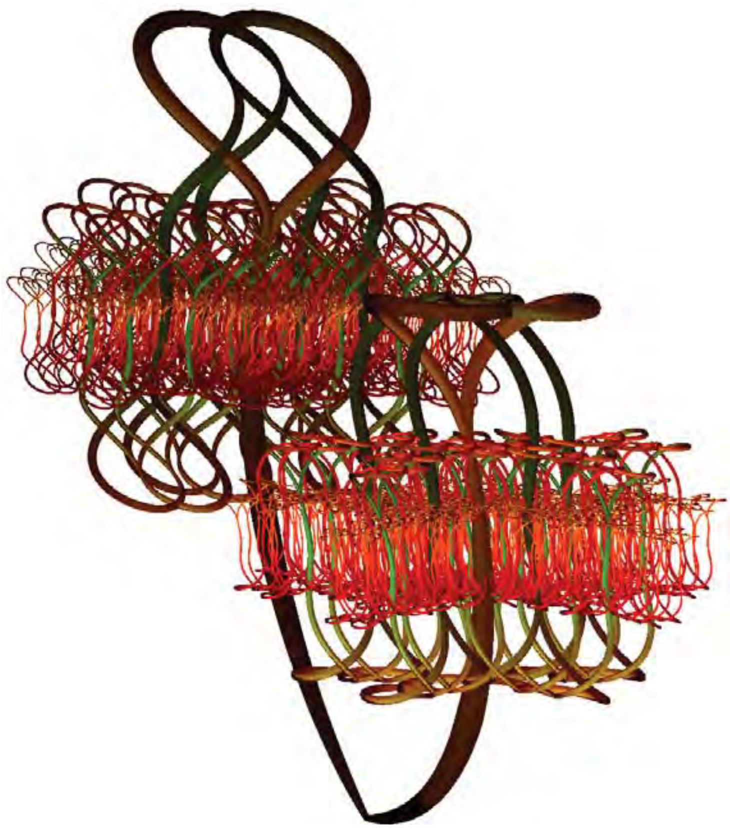

Figure 20. Form associated with a space of ten binary dimensions

Figure 21. Form with f=−μ and g=

Figure 22. Form with f=μ^2 and g=1−

Figure 23. Form with $f=8\mu^{(1/2)}$ and $g=-\ {}^{1}$

Figure 24. Form with $f=\mu^4$ and $g=\mu^4$

Figure 25. Form corresponding to an eight-dimensional ternary space

In Figures 20-25, the curve-structure was enveloped with non-circular volumetric elements. For each curve, circles were drawn around the end-points of all line segments, and orthogonal to the curve. In case of a ternary space, for each line segment, there are two corresponding segments on alternative curve-continuations and which belong to the same stage in the bifurcation process. An enveloping circle was elongated in the direction of these alternative continuations. The resulting contours were connected by lines.

5. Transforms constructed as weighted vertex-based functions

The previous section aimed to obtain visualizations for high-dimensional spaces by exploration of the structural instead of the metric domain. This section returns to the metric visualizations of section 2. Instead of visualizing hypercubes, a general transform $R^n \rightarrow R^3$ is described which visualizes arbitrary high-dimensional objects. The transform takes a visualization of the hypercube as its point of departure, and maps a point in R^n on a point in R^3 as a function of its metric and angular relations with the vertices (or 'edge points') and the edges (or 'side-lines') of the hypercube. The visualizations obtained by the algorithm of section 2 generally do not correspond to linear projections of the hypercube. Therefore, the function which embeds objects in the visualization is also not linear, although usually only 'weakly' so.

The transform . is defined as a weighted sum of angular vertex-based transforms. With each vertex of a hypercube, an angular vertex-based transform $f_k(x)$ is associated as follows ($k=1,\ldots,2^n$). The unit vector originating in the center of the hypercube and pointing to the k-th edge point is denoted e_k ($k=1,\ldots,N$). The components of e_k are equal to $1/n^{(1/2)}$ or $-1/n^{(1/2)}$. The unit vector pointing from Q_k to Q_r in the visualization is denoted v_{kr}. With these notations, f_k: $R^n \rightarrow R^3$ associated with vertex P_k is defined as follows:

$$f_k(x) = Q_k + \ . \ |x-P_k| \ . \ (\quad r \ \tilde{!} \ . \ r\neq k \ . \ (e_r . (x-P_k)/ |x-P_k| \ ) \ . \ v_{kr}) / c$$

with:

$$c = | \quad r \ \tilde{!} \ . \ r\neq k \ . \ (e_r . (x-P_k)/ |x-P_k| \ ) \ . \ v_{kr} |$$

The function $f_k(x)$ contains a distance factor $|x-P_k|$ and a directional factor ($r \ \tilde{!} \ .$ (e_r. $(x-P_k)/ |x-P_k|$) . v_{kr}) / c. Due to the normalization, the directional factor specifies a unit vector in R^3. The distance factor entails that the distance between f_k (x) and Q_k in R^3 is times the distance between x and P_k in R^n, from which it follows that $f_k(P_k)=Q_k$.

Figure 26 illustrates an edge-based transform for n=4 and for the point Q_1 in the Q_k-structure in the first form in Figure 8. The Figure shows the transform of a 12x12 grid defined over the four-dimensional hypercube. All points on the grid were transformed according to $f_1(x)$ (with =1.05. ˜ , where is the average distance between edges in the P_k-hypercube, and is the average distance between different points Q_k). It can be observed that, in the neighborhood of Q_1, the transformed grid approximates a linear grid structure coinciding with planes through Q_1 and the neighbors with which it forms a smallest square. The quality of the approximation decreases for points which are images of points removed from P_1 in the hypercube.

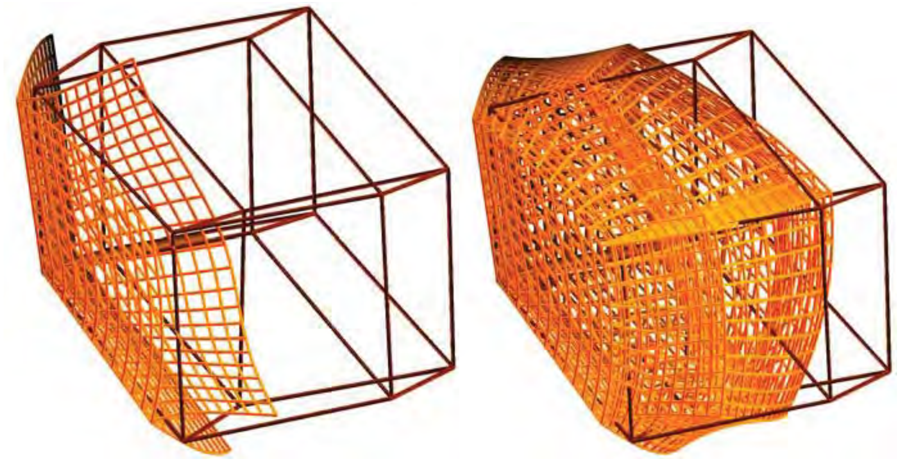

Figure 26. Vertex-based transform operating on the side-planes of a four-dimensional hypercube containing Q_1. The left figure shows the transforms of the side-squares containing Q_1. The right figure shows the transform of the entire side-square structure.

A good approximation of an overall linear structure over the Q_i-structure is obtained if vertex based transforms for all points P_i are summed into a weighted combination. The function is obtained if a transform f_k is given a weight proportional to a power of the inverse distance between x and P_k:

$$(x) = (1/c).\quad _{\{k=1 \text{ to } N\}}\, f_k(x) / |x-P_k|$$

with

$$c = \quad _{\{k=1 \text{ to } N\}}\ 1 / |x-P_k|$$

Figure 27 shows the result of (x) when applied to the same Q_k-structure as in Figure 26. It can be noticed that the voted sum turns local approximations into global approximations (the Figure was generated for =1; this property remains for other visualizations of the hypercube, and for values of n higher than 4; a study of this fact was carried out in Van Loocke, 2003).

Figure 27. (x) operating on the side-squares of the hypercube

The function (x) can be used to obtain visualizations of any n-dimensional form. In Figures 28-33, it was applied on a generalization of a function familiar in a fractal context.

Suppose that a four-dimensional point x has coordinates $x_1,\ldots,x_4$. Then, the quaternion expression $f(x)=x^2+c$ has four components $f_1,\ldots,f_4$ which are defined by $f_1(x)=x_1^2-x_2^2-x_3^2-x_4^2+c_1$, $f_2(x)=2x_1^2x_2^2+c_2$, $f_3(x)=2x_1^2x_3^2+c_3$, $f_4(x)=2x_1^2x_4^2+c_4$. The following procedure defines a function (x). First, f(x) is iterated t_1 times. The result of this function, but with the first component transformed in its negative, is used as input for t_2 additional iterations of f, after which the first component is changed into its negative again. The resulting point is uniformly contracted toward the origin, except for the first coordinate, which is displaced by an amount . This cycle of t_1+t_2 iterations is repeated t_3 times. The resulting point is $(t_1,t_2,t_3;x)$. In Figures 28-33, $(t_1,t_2,t_3;x)$ was applied to a square 27x27-grid defined over a structure defined over the four-dimensional hypercube which was contracted uniformly to the origin by a factor ˜ In Figure 28, $=0.333$, $t_1=2$, $t_2=1$ and $t_3=3$. In Figure 29, the same parameters are used, but is applied on basis of a different visualization of the hypercube. In the next Figures, these parameters were $=0.333$, $t_1=3$, $t_2=2$ and $t_3=3$ (Figure 30); $=0.333$, $t_1=3$, $t_2=4$ and $t_3=3$.(Figure 31); $=0.333$, $t_1=5$,$t_2=4$ and $t_3=4$ (Figure 32); $=0.0121$, $t_1=5$, $t_2=5$ and $t_3=6$ (Figure 33); $=0.0121$, $t_1=5$, $t_2=5$ and $t_3=8$ (Figure 34).

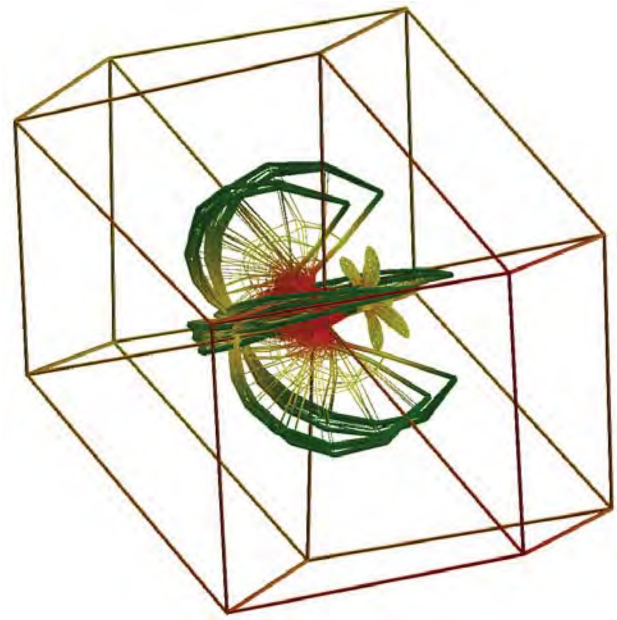
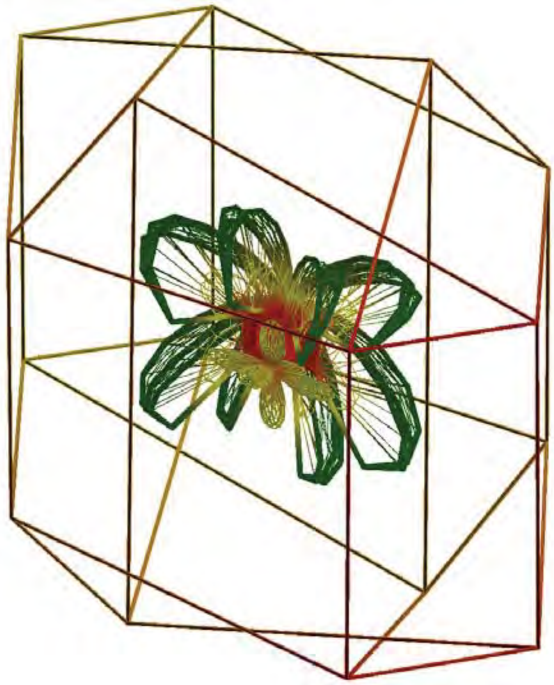

Figure 28 (left) **and Figure 29** (right)

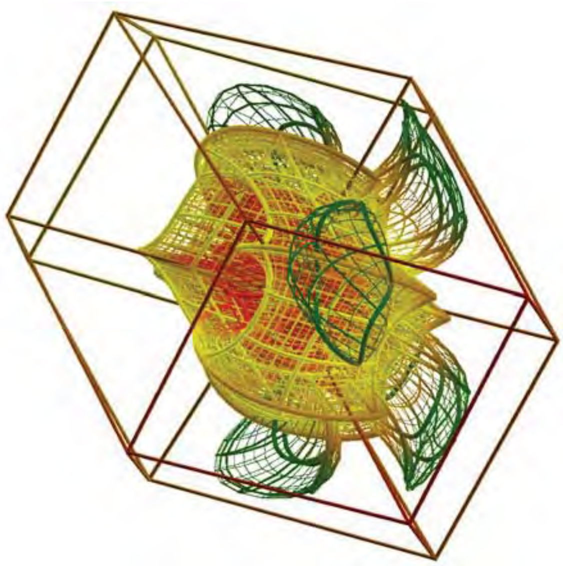
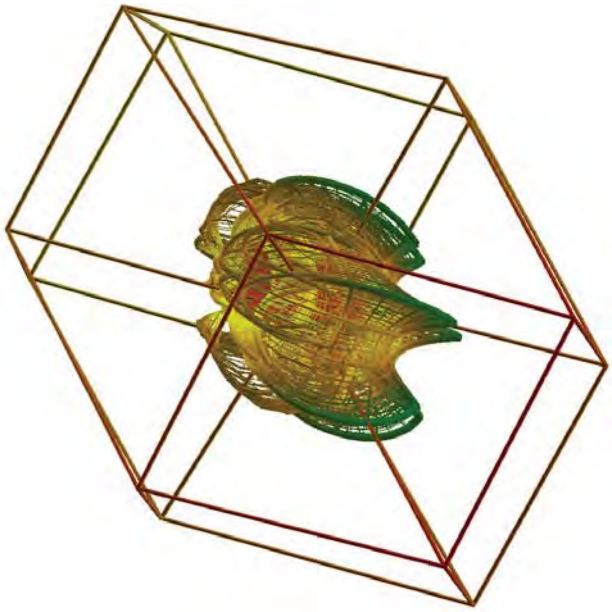

Figure 30 (left) and **Figure 31** (right)

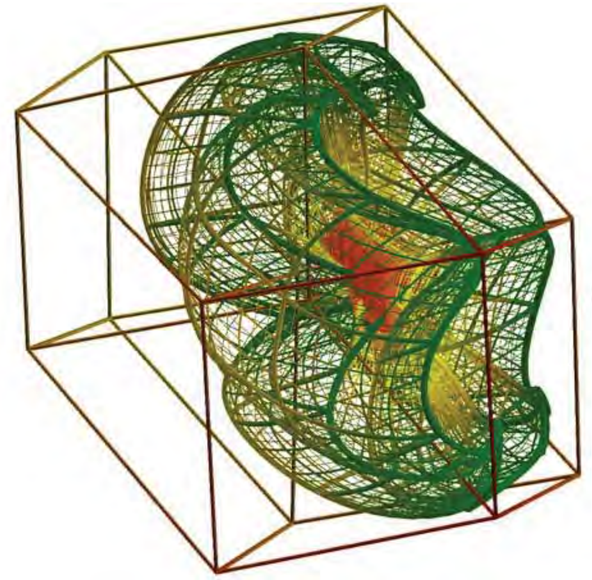
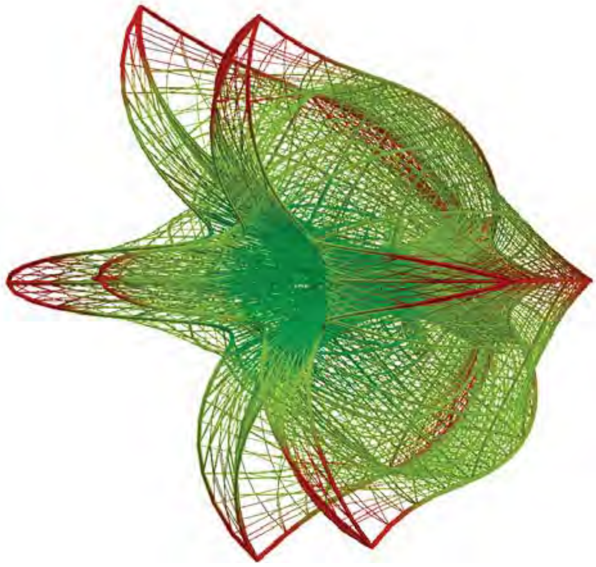

Figure 32 (left) **and Figure 33** (right)

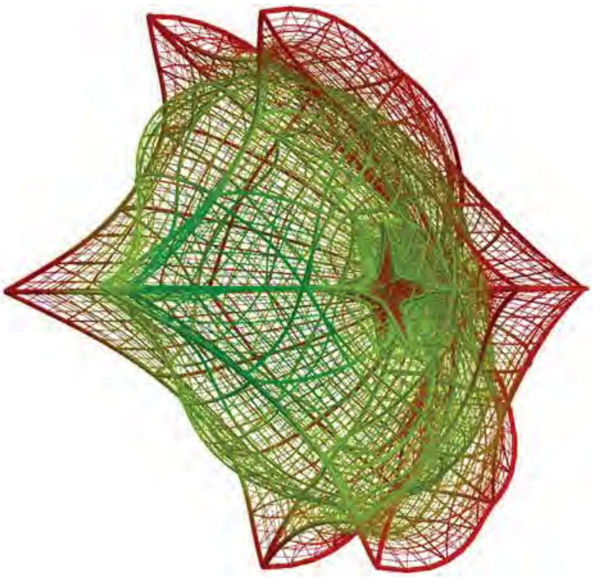

Figure 34 (left) **and Figure 35** (right)

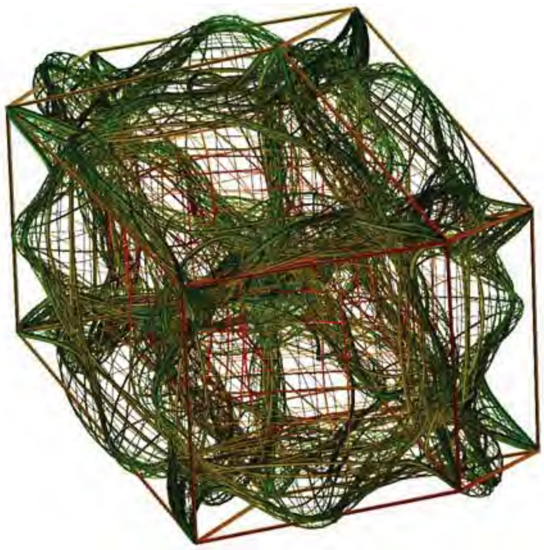

Figure 34 (left) **and Figure 35** (right)


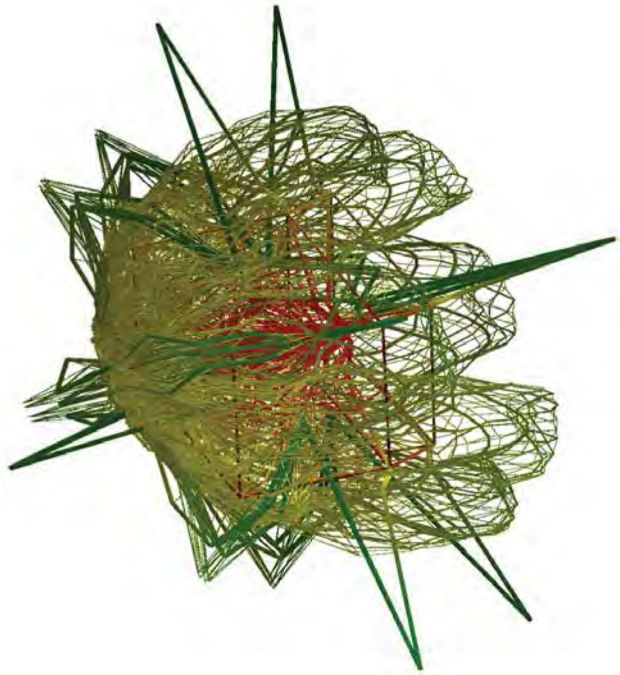

Figure 36 (left) **and Figure 37** (right)

Variations of (x) can be obtained in several ways. In Figures 35-36, (x) was applied on the side grid over the hypercube, but for functions $f_k(x)$ in which the factor $|x-P_k|$ was replaced with $|x-P_k|.(1+\sin(5|x-P_k|))$. In Figure 37, this strongly non-linear transform was used to map the side grid after it had been transformed by the procedure used in 28-34, and for =0.4, t_1=1, t_2=1 and t_3=4.

6. Conclusion

The paper considered visualizations of high-dimensional objects. As a point of departure, visualizations were used which came out of stepwise algorithms. The tension between metric accuracy and desirable structural properties was discussed. In section 5, a non-linear projection method was developed to obtain visualizations of high-dimensional objects matched in the visualization of a hypercube. In other work, the latter method was applied to data-visualization and was compared with principal component analysis, which corresponds to the selection of a well-chosen linear projection. It was pointed out that, for different real-world data-sets, the metric accuracy of a visualization based on the non-linear transformation was better than the metric accuracy of principal component analysis (Van Loocke, 2003). This is part of the motivation for using instead of linear projections in section 5.

References

Banchoff, T. (1990), *Beyond the third dimension*, New York: Scientific American Library

Barrow, J. (2003), *The constants of nature, from alpha to omega*, Pantheon Books

Henderson, L. (1983), *The fourth dimension and non-Euclidean geometry in modern art*, Princeton University Press

Kaku, M. (1994), *Hyperspace. A scientific odyssey through parallel universes, time warps and the tenth dimension*, Oxford University Press

Lalvani, H. (2003), Genomic Architecture. In (Eds. Gans, D. and Kuz, Z.) *The Organic Approach to Architecture*, Chichester: Wiley Academy, pp.115-126.

Van Loocke, Ph. (2003), Application of weighted vertex-based transforms to data visualization (submitted)

Exploring the Massing of Growth in Cellular Automata

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Abstract

In the investigation of cellular automata as an architectural massing generator, as a cell survives generations after generation, a question occurred if the survival property could be integrated into the final form so its history is not lost. One method that could be considered is color, single generation cells having a different color than ones surviving multiple generations. Another method is to increase the size of the cell as it survives over time. When both methods are considered they are able to add an interesting variety to the massing of an architecture that is basically made from the regular placement of single cells.

1. Introduction

Cellular automata is a computational method which can simulate the process of growth by describing a complex system by simple individuals following simple rules. An early example of three-dimensional cellular automata was the wooden block model created by Schrandt and Ulam [1]. Bays [2] further developed three-dimensional patterns, as did, Coates [3] for architectural applications, much in the same spirit as Bays. More recent investigation includes two methods developed by Wolfram [4], in which a stacking method is explored, as well as, one similar to Bays. Examples of all of these can be seen in Krawczyk [5]. The striking similarity in all of these is the explicit representation of the cellular automata, even though each had taken a different approach and had a different application as an investigative goal.

In a previous investigation, Krawczyk [5], the primary organizing element, the location of the cell, was interpreted in a variety of architectural elements. Concepts that were demonstrated included: horizontal and vertical connectivity, support structures, floor planes, envelope, and site boundaries. The rules and neighbour configurations were held constant and there was no attempt to research the variety of forms possible when these are considered.

One of the observations from this previous research was that the massing of the cells at any one time never included consideration for the cells that had survived from generation to generation. The question that resulted was: could this property be displayed in some fashion in the final form. Showing this property would increase the visibility of the underlying cellular automata method used. This current research addresses this question.

2. Recording Survival

The first method in recording survival was to simply display the surviving cells in another color. Figures 1a., b., and c. display three original results without color differentiation.

Figures 1d., e., and f. display surviving cells in a different color.

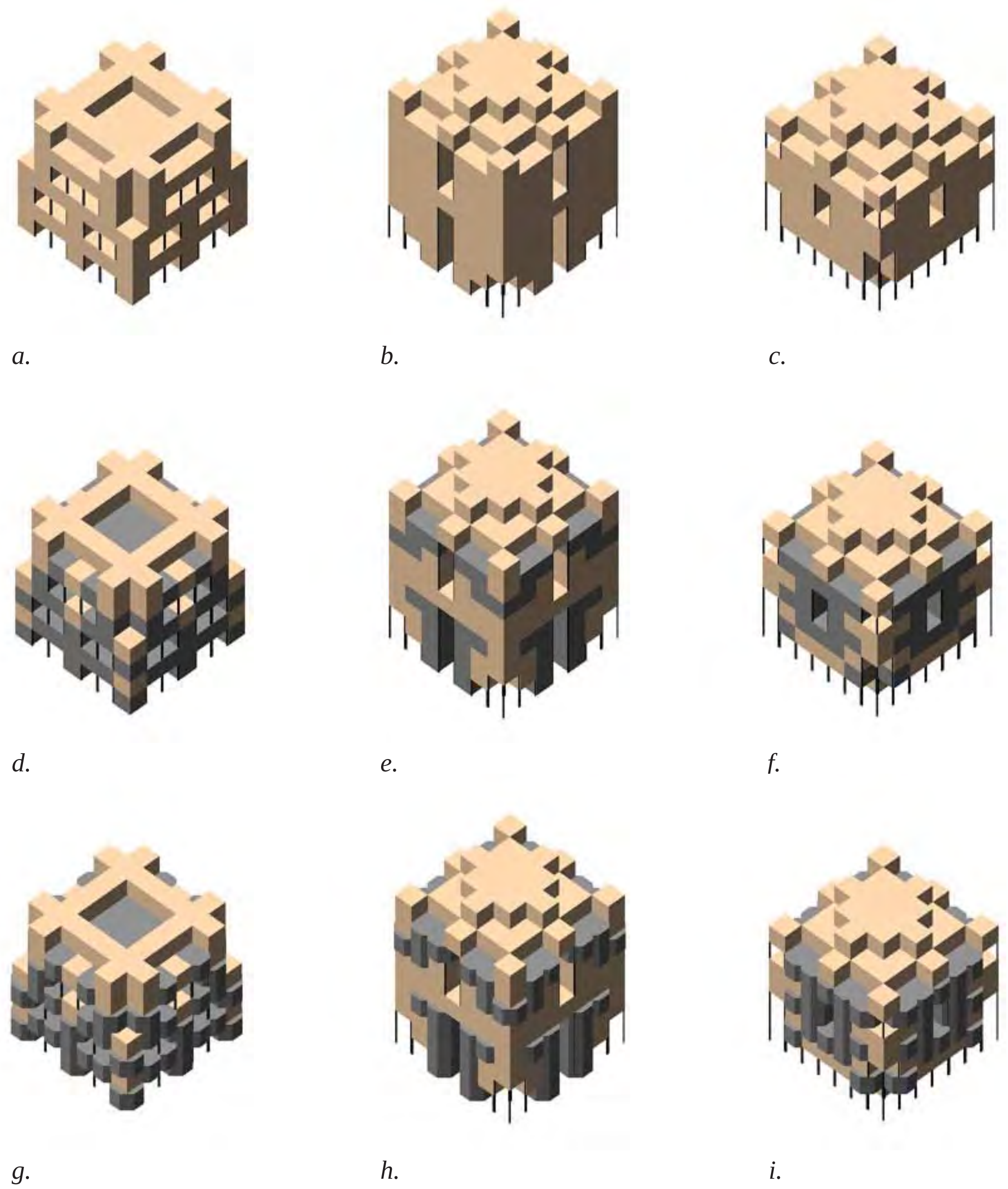

Figure 1. Survival as color and shape

The architectural patterns that were generated were interesting but the overall massing still remained the same. The next option was to represent the surviving cells in a different shape from the others. Figures 1g., h., and i. display one such variation, an octagon as the cell shape. These did further accentuate the surviving cells, but were not strongly integrated into the remaining square cells. The horizontal connections were much stronger than the vertical. These results lead to the concept of varying the cells not by shape but by size. Figures 2a., b., and c. display the same results with the surviving cells modified by only height. As the cell survives from generation to generation it increases its height by a small amount. This also enables survival to be represented as growth. Figures 2d., e., and f. display the same results by giving the cells only horizontal growth instead of vertical. Finally, Figures 2g., h., and i. display the results when both horizontal growth is included with growth in height. With growth in all directions, the architectural massing greatly deviates from the regular cellular one of simple square cells. This offers a variety of expression and also a visible history of the survival of cells.

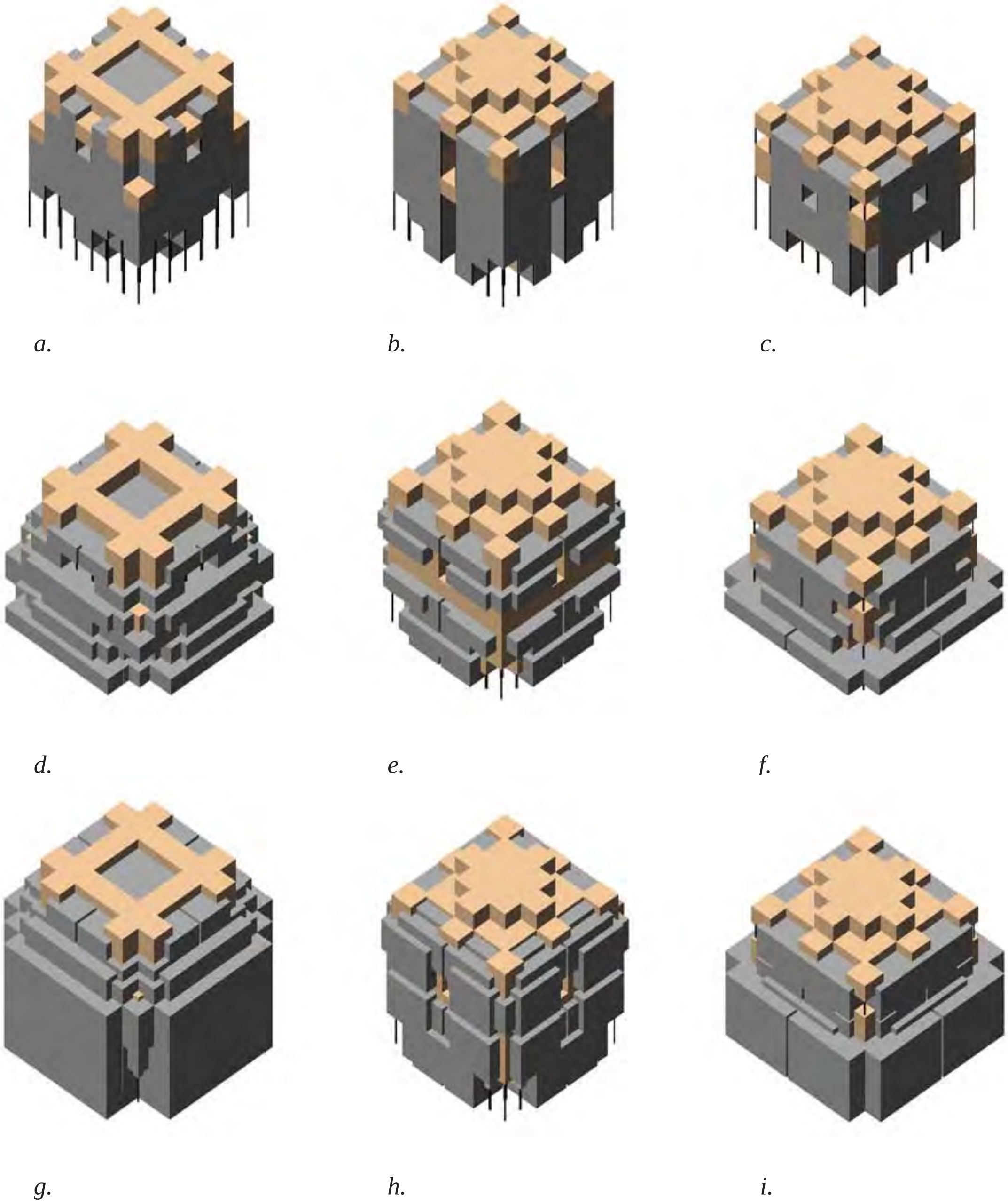

Figure 2. Survival as variation in size

A further investigation could include the rate of increase for each generation or the grouping of cells having survived the same number of generations, color-coded in some fashion. The original shape of the cells could also be varied. This research only considered the square and later the circle as possible plan layouts.

2. Generating Variation

To be able to investigate the possible variation that might be possible with the retaining of survival and displaying growth method, a series of experiments were performed. From previous research a series of parameters of boundary, survival/birth rules, neighbourhood definitions and number of generation was established. In the first series 1,144 trials were executed. This included all the results from two boundary conditions, one limited and the other unlimited; thirty-seven rules, based on a survival/birth neighbourhood count having a variety of combinations of a maximum of eight cells; four neighbourhood definitions: six locations, four on the same level, one above and one below; the classic twenty-six locations, all adjacent cells on the same level and all the ones above and below; seventeen locations, all the cells on the same level and all the ones below; fourteen locations, diagonals on the same levels and diagonals directly the level above and below. Each of these parameter sets was executed for five, six, nine, and fifteen generations. The initial configuration consisted of eight cells outlining a square arrangement, with the center cell empty. Selected results from this series are displayed in Figure 3.

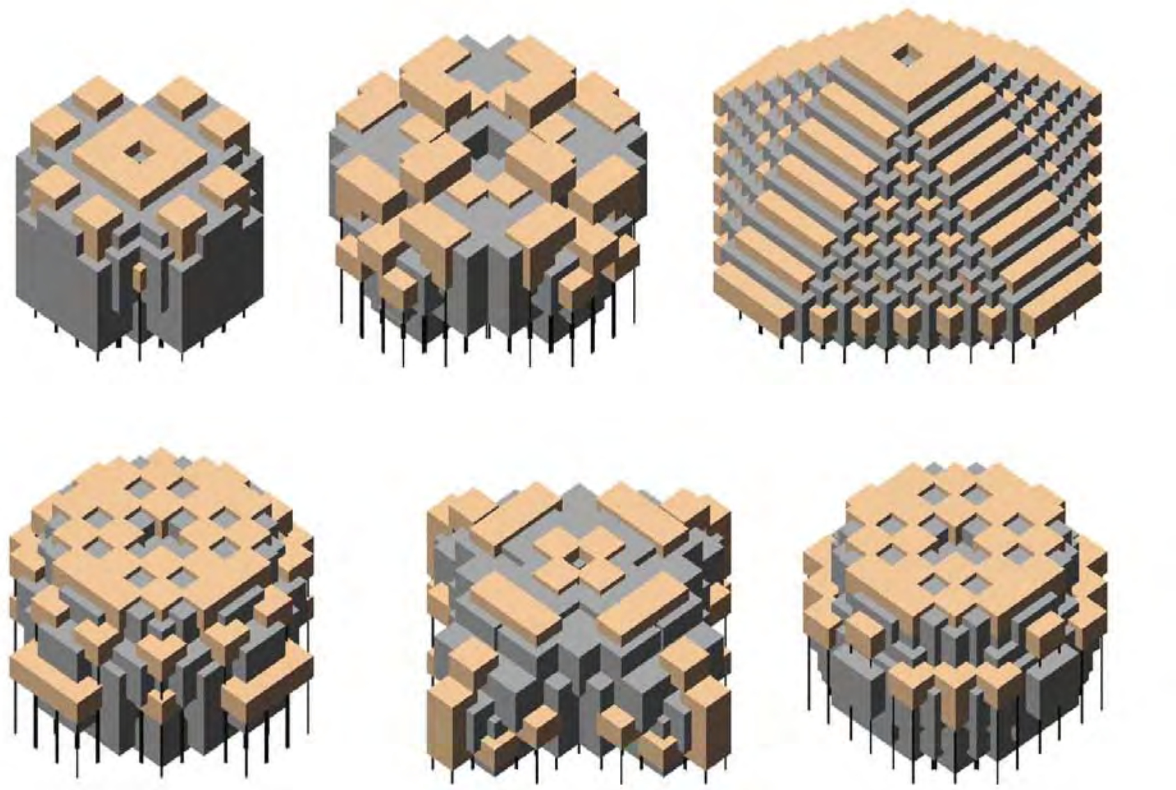

Figure 3. Regular survival series

In reviewing the generated results, some were eliminated; the arrangements that became extinct within the number of generations and the ones that became overly fragmented. Only the ones that retained a fairly connected mass were considered. Architecturally, the process developed connecting masses that further enhanced and highlighted the cellular automata method used to create them. The standard method treats all cells equally, this massing retains the survival history of the cells. When the total series was examined, the possibilities of interesting subgroup arrangements were observed. Further research could find the relationship of these arrangements with the generating parameters exploring the concept of natural occurring styles.

Another series was also investigated that further attempted to introduce a method to increase variety within the results. Figure 4. displays a sample of massings where at every generation a mutation is applied by randomly selecting a new survival/birth rule and neighbourhood count. Architecturally, the concept explores a method to break any evolving pattern so the forms are further unpredictable and offer an even wider range of massings without introducing a natural style. The boundary condition is set to unlimited throughout, with the random selection using all thirty-seven rules and all four types of neighbourhoods. In this series the life span is set to six generations and the space module is represented as a cube. The initial configuration consists of the same eight cells in a square arrangement as before. Over 2,000 random trials were generated.

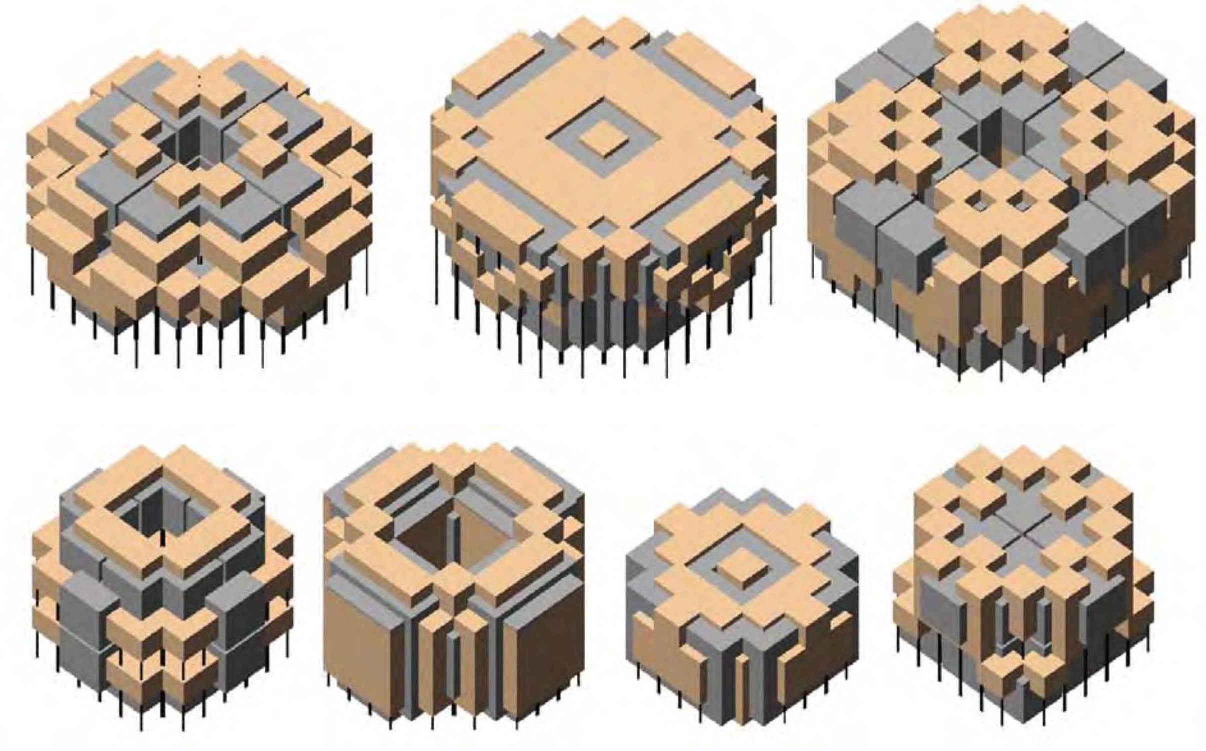

Figure 4. Mutated survival series

Figure 5. displays an initial sampling of massing developed in the same manner as described above except that the cells are represented as circular volumes and are limited to seven generations.

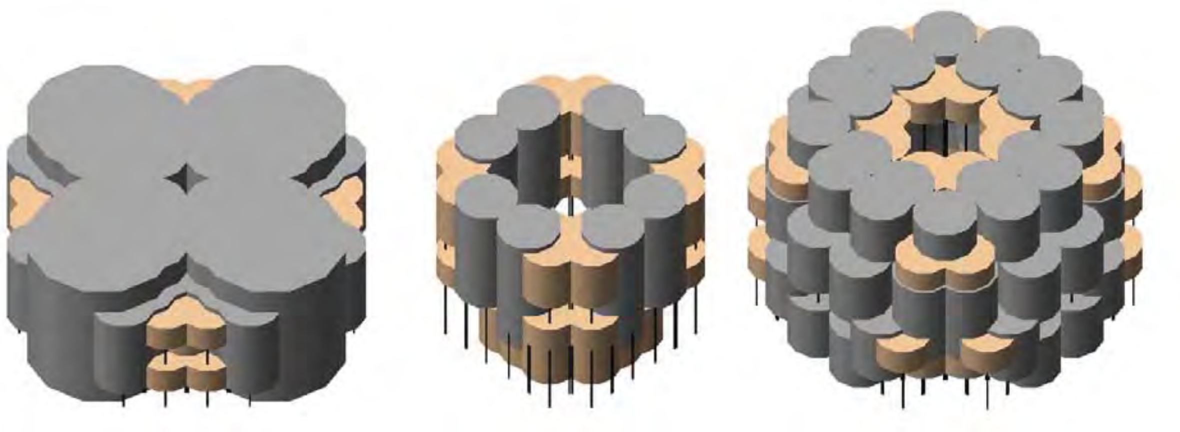

Figure 5. Mutated survival circular series

References

[1] Schrandt, R. and Ulam, S.: 1970, On Recursively Defined Geometrical Objects and Patterns of Growth, in A. Burks (ed), *Essays on Cellular Automata*, University of Illinois Press, Urbana, pp. 232-243.

[2] Bays, C.: 1987, Candidates for the Game of Life in Three Dimensions, *Complex System 1*, pp. 373-400

[3] Coates, P.: 1996, The Use of Cellular Automata to Explore Bottom Up Architectonic Rules, *Eurographics Conference, Imperial College of Science and Technology*, London

[4] Wolfram, S.: 2002, *A New Kind of Science*, Wolfram Media Press, Champaign

[5] Krawczyk, R.: 2002, The Architectural Interpretation of Cellular Automata, *Generative Art*, Milan

Generating Narrative Spaces from Events History

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Abstract

For a successful distributed teamwork it is vital to provide team-members with awareness on collaborative activities. One way of achieving this is through applying a narrative based approach to construct the events that have taken place on documents and folders in a project workspace, as various members make changes to its content. The research presented in this paper investigates the possibility of exploring the history of activities performed by team members. Past events are aggregated in the form of a three dimensional environment time tunnel, providing the team-members with a generative tool to visualize the project's events history in various configurations, in order to reveal the usually hidden relationships between separate pieces of events. Furthermore we provide a tool for managing and inspecting the folder's contents: the DocuDrama Timetunnel. Here we present preliminary findings showing how the visualisation of a sequence of connected actions and happenings using a temporal and spatial narrative based approach may lead to a better understanding of the project-related events history.

1. Introduction

Increased globalisation and teleworking have resulted in less of a need for everyone employed on a project to be at the same location. However a distributed team cannot provide the same level of collaboration as a co-located team [1]. For effective collaborative working it is essential for team-members to be able to access records of meeting minutes, document histories and decisions made. It is also essential that new members of teams are able to catch up with what has happened in order to get a clear picture of the state of a project. Although many systems are available for recording changes and amendments to documents, the information gathered from these sources can be very sketchy. It can also be very difficult for team members to fully understand the context in which decisions were made or documents changed [2].

We argue that an approach based on the generation and construction of stories provides a novel way of supporting awareness in distributed collaborative work. However, story generation from recorded events is difficult to achieve. In order to generate successful narratives of project event histories various issues need to be addressed including: collecting and selecting meaningful events, aggregating this data and deriving a meaning from the event sequences. Presenting the event data to the user in a meaningful way, and finally presenting the aggregated data in an entertaining way, which captures the user's attention and conveys complex information fast and effectively [3].

This paper describes the DocuDrama: Timetunnel; a generative tool, which constructs stories from past events data recorded in a given event notification infrastructure. A set of tools is provided to capture activity events that have taken place in folders within a workspace; for example, create, read or delete document. The log of user interactivity with the workspace generates over time a map of the folder's history. The DocuDrama prototype takes advantage of this to generate a time-space based configuration, in which past events are aggregated in the form of a three-dimensional environment. The three-dimensional environments could be built on various events and actions depending on user preferences, which would generate different results from the same data. Finally the prototype creates narratives based on events history captured in the collaborative virtual environment TOWER, a Theatre of Work Enabling Relationships[4].

In the following chapter we briefly describe TOWER, which allows project members to be aware of project-relevant activities as well as to establish social relationships that improve team coherence and social presence in virtual teams. We then introduce the DocuDrama prototype. The chapter on implementation specifies a range of interfaces available in the DocuDrama architecture. Finally, some early user experiences are outlined. This specification has been implemented as a full prototype, which forms one of the main components in the TOWER environment.

2. The Timetunnel as part of TOWER

TOWER, the Theatre of Work Enabling Relationships [5], is a European Commission-funded research project aimed at generating a shared environment to improve team coherence and social presence in distributed teams. The goal is to provide distributed teams with awareness environment of collaborative activities of team members and their shared working context, in addition to spontaneous communication capabilities for social encounters close to those of co-located teams through symbolic presentations in a from of three dimensional virtual model representing the Theatre of Work (Figure 1).

Fig. 1: Scenes from the TOWER world

The system of the Theatre of Work is based on collaborative workspaces and ambient interfaces. Its architecture consists of six main components (Figure 2). Sensors detect the operations and activities performed by users. The activities are then processed as events by an event notification infrastructure ENI [6]. The events and actions are aggregated according to space syntax rules in a three-dimensional multi-user environment [7]. Users' activities are embodied through avatars with symbolic action. Generating stories of past events forms an important part of TOWER. This is achieved through the Docudrama, which transforms sequences of event history information into a narrative of the past activities [8].

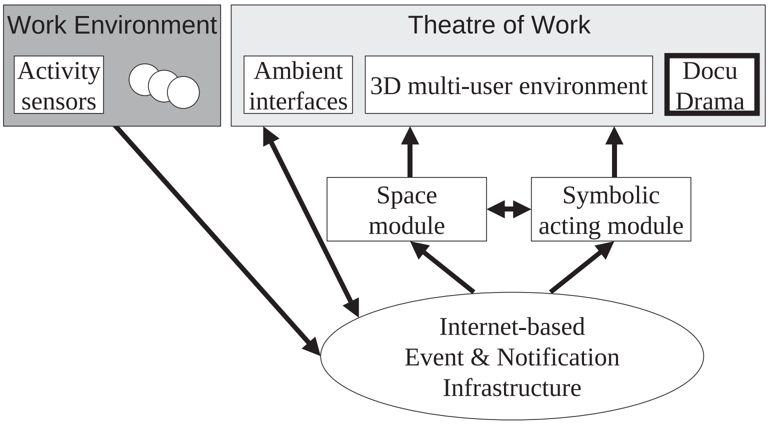

Fig. 2: Overview of the TOWER architecture

3. DocuDrama and Narrative

We see our life as sequences of events and actions. Everything we see, learn, and do becomes part of a story. This is the way we perceive the world around us and this is the way information should be presented to us [9]. A narrative may thus be seen as a way of making sense of the captured events by integrating them into a meaningful whole that makes the events comprehensible in relation to the context of what had happened.

In this paper we present an approach on DocuDrama: The Timetunnel, which tells a story of the team's workspace life cycle. Digital narratives are created in the DocuDrama Timetunnel from the events history, which is generated by a project team in a collaborative work environment. Hence past events and activities that have taken place in folders within the workspace (e.g. create document, read document and delete document) are captured in the form of a history file, which contains the events information as abstract data sets. The strategy that has been adopted by the DocuDrama prototype is to take advantage of this to generate a configuration, in which past events are aggregated in the form of a three dimensional environment, which gives the user a quick overview of past activities in the chosen period of time (Figure 3).

In this prototype a 'meaningful' symbolic representation of events history is constructed by implementing a spatial approach that aggregates events and elements together in a chronological sequence as a configuration of related events. Thus events that take place at the same time period will be interlinked and appear in the same time segment (Figure 3). The stories presented in the DocuDrama are dynamically generated and do not follow a story line

[10]. Depending on user's preferences, events are aggregated, providing team-members with a generative tool to visualize projects events history in various configurations. The three-dimensional models could be built on various events and actions, which would generate different results from the same data depending on user needs. Subjects of mapping in this case are events and their changes over a period of time.

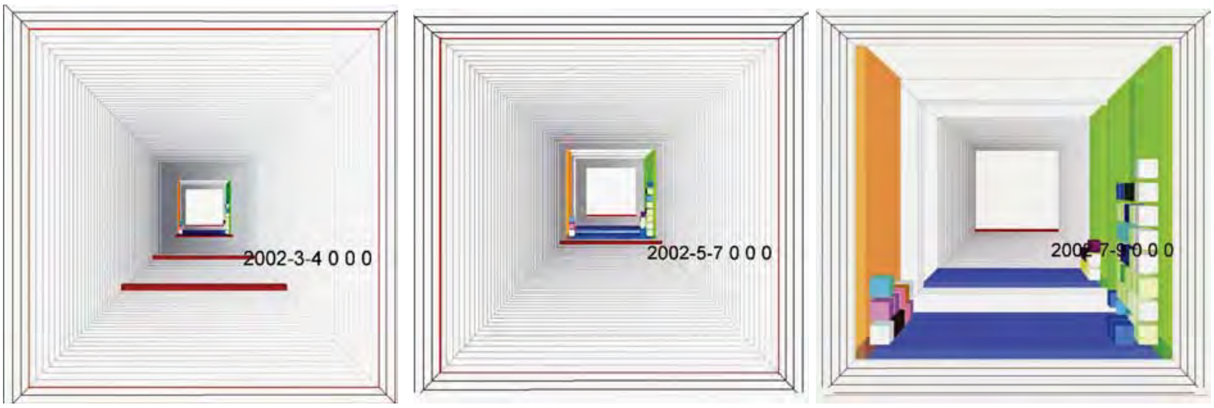

Fig. 3: Narrative spaces generated by the DocuDrama

To illustrate the function of the prototype, the following scenario explains one possible use of the tool in the TOWER context: An asynchronous scenario of what happened in the past:

Mike is back in his office after a short holiday. He needs to check the history of the management folder in order to get a quick overview of the past activities that were generated during his absence, for instance if there has been an important event that might affect the progress of the project. He clicks on the DocuDrama symbol in the TOWER portal (Figure 8). In the configuration interface, he selects '10 days' as the period to be examined, and defines a 'daily' level of detail. He then specifies that he wants to view the DocuDrama tunnel for the designated folder built on events producer and colouring the documents based on artefacts. Finally the DocuDrama three-dimensional model will be generated, visualising the selected folder including the activities and events with the project related deadline.

3.1 Components

The DocuDrama Timetunnel visualises the history of users' interactions with folders and documents, in relation to deadlines, within a project's lifetime. The aim of the DocuDrama Timetunnel is to offer an abstract view on project activities and to provide the project team-members with a functionality to manage the project's data by enabling them to visualise a project's events history in various configurations.

The DocuDrama Timetunnel went through different phases of evolution. The evaluation of the first prototype revealed the need to visualise events performed on folders instead of documents in order to get meaningful results. In addition, all time-segments representing a selected time period needed to be represented regardless of whether an activity was performed during the time-segment or not. Based on this, the final version of the prototype featured the following (Figure 4):

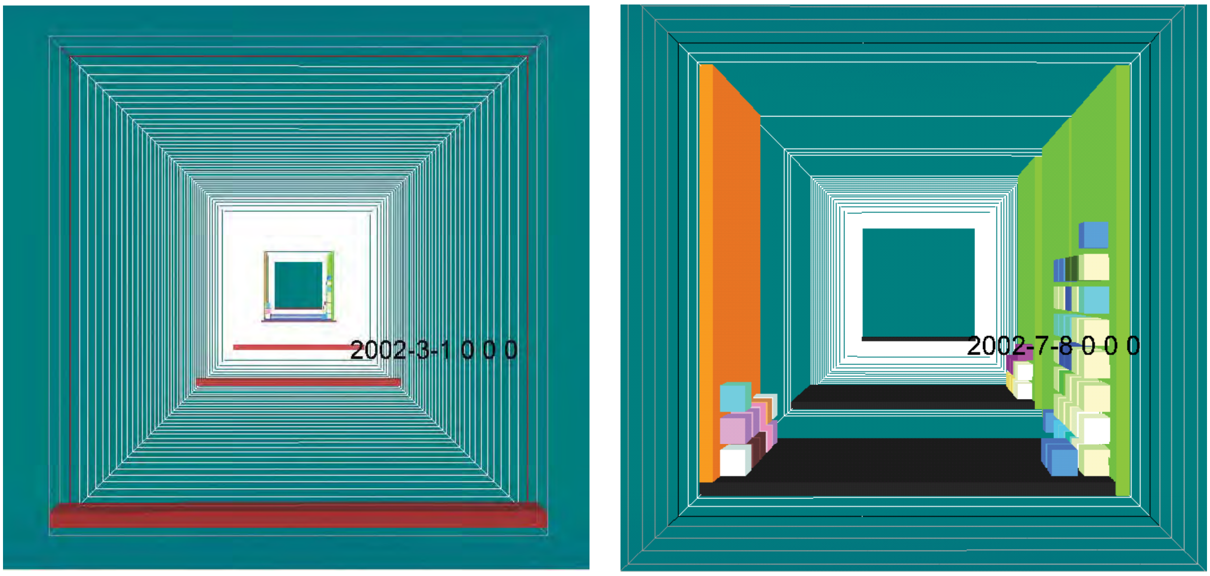

Fig. 4: Timetunnel components visualising, events, documents and milestones

The Timetunnel consists of different segments. Each segment represents a unit in the lifetime of the project. Depending on the required period of time for the DocuDrama visualisation, a time-segment might represent a year, a month, a day or even only an hour. In our example, a time-segment represents one day of the project's lifetime. The user selects a time period of project's lifetime for visualization, in our example, 10 days. In that case, the entry of the tunnel represents the start of the selected time period. Moving through the tunnel enables a virtual tour through the project's lifetime, from the furthest date to the most recent one. The closer the user gets to the end of the tunnel, the closer he gets to the end of the project's lifetime. Events, actions and milestones in the Timetunnel are organized around the axis of movement forming the four surrounding walls. Activities that have taken place on the same day are located in the same time-segment. The Tunnel's walls have different colours depending on the kind of actions they represent. These actions include read, create, modify and remove documents in a folder (Figure 5), which affect the state of that specific folder.

Fig. 5: Events type representation in the Timetunnel

Small cubes placed on the wall of a time-segment represent the interaction of the user with project's folders and documents. The location of the cube inside the time-segment indicates the form of interaction with the document. For instance, cubes piled up on the left side of the time-segment would represent documents that have been removed, whereas cubes on the ceiling show documents that have been opened for reading. Many cubes piled up on the walls indicate a time period with high activity whereas empty time segments represent a time period at which no action has been performed. The cubes could be coloured according to the document type. This would create a visual link between a document placed for instance on the "create event" wall and the same document placed on the "remove event" wall; for example, if they are placed in the same time-segment this indicates that the document was deleted shortly after it was created. Moving closer to the small boxes will reveal the producer of the action as an image mapped on the cube (Figure 6). The user is able to move back and forth in time along the time axis, and follow the project's activities over a period of time. Navigation through the tunnel is facilitated through the use of viewpoints that transport the user to the desired location (Figure 7). In order to retrieve the document's name and the date of the action, the user needs to click on the selected document [3,10].

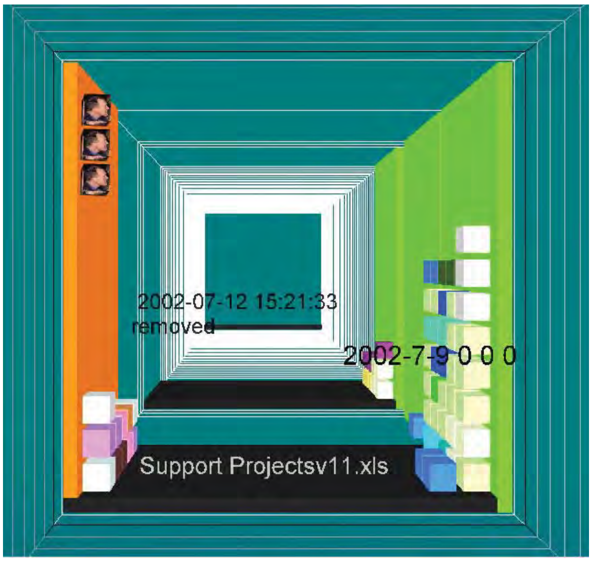

Fig. 6: The image of an event producer appears, when moving closer to the cubes

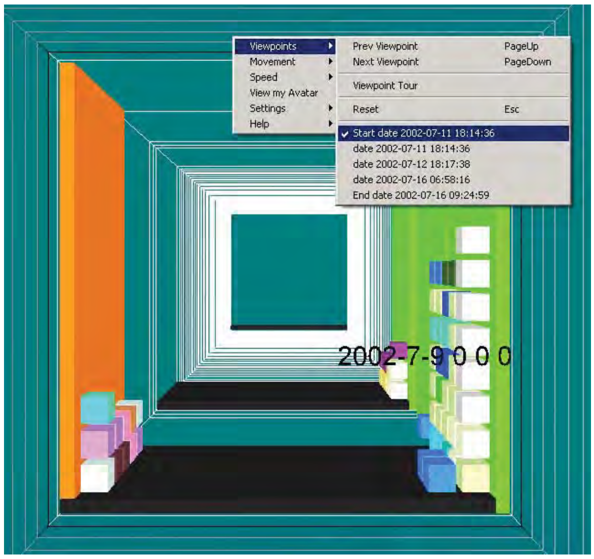

Fig. 7: Navigation through the tunnel is facilitated through viewpoints

4. Implementation

The DocuDrama Timetunnel is internet-based, using HTTP requests. It could be accessed either from the TOWER world (Figure 8) in the TOWER portal or via a web-based interface, which consists of a set of HTML forms that enable customisation of the VRML interface with associated Perl- and CGI-Scripts.

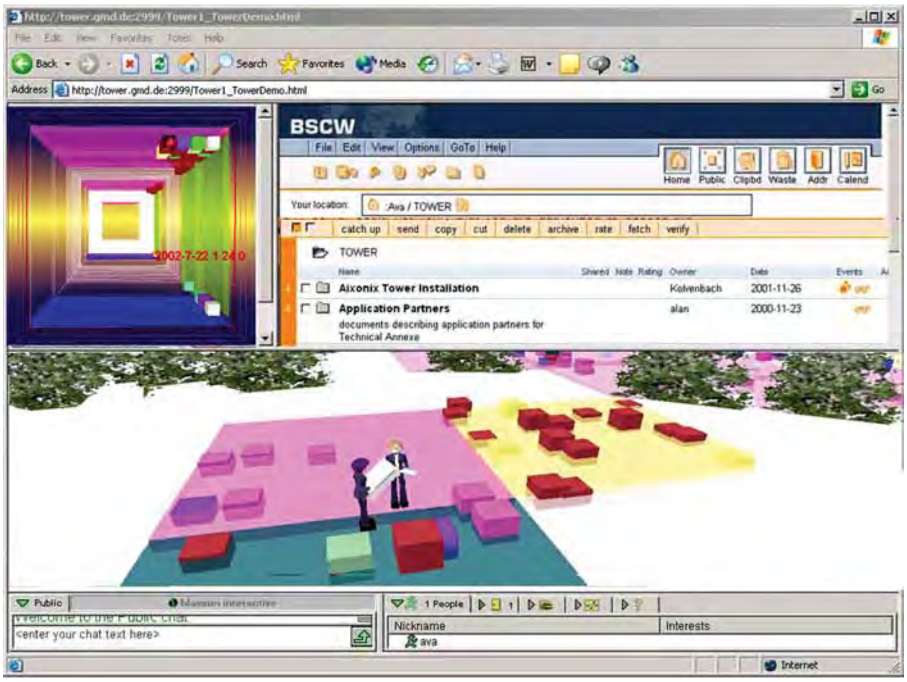

Fig. 8: Combined interface of BSCW, TOWER world and the Timetunnel

Figure 8 illustrates the integration of the Timetunnel with a BSCW shared workspace [11] and the three-dimensional TOWER world. The combined presentation of the three components enables the user to follow project activity at the same time from different angles. While TOWER world gives a view on the current state of the workspace and BSCW offers direct interaction with the documents, the DocuDrama Timetunnel provides the user with a quick overview of past activities [8].

The Timetunnel architecture consists of three different components: the WorldDatabase, the WorldMapper and the ConfigurationInterface. Figure 9 illustrates the relationship and interaction between the components:

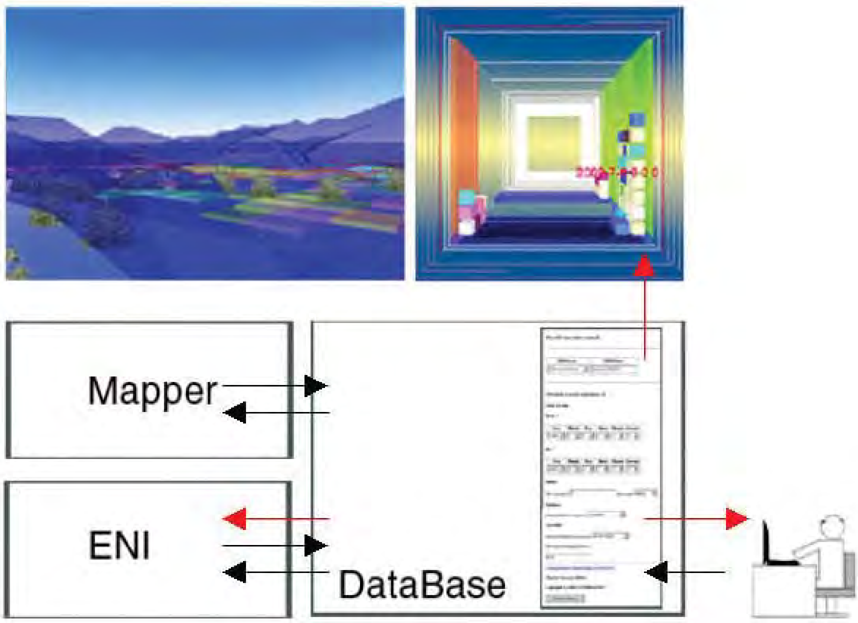

Fig. 9: Timetunnel architecture

The WorldDatabase stores the data sets of the event history in the collaborative-shared workspace. The WorldMapper realises the matching between the events context and the geometrical data, which results in the three dimensional representation of the prototype. Currently the mapping of the underlying information structure is executed on the basis of a fixed placement rule. This means that the number of the mapped events is predetermined, i.e. four actions, resulting in the shape of the tunnel. On the other hand, inside the predefined shape of the tunnel, different representations could be generated from the same data depending on user's preferences. The ConfigurationInterface. (Figure 10) allows the user to generate environments built on various aspects. In our example the tunnel is built according to the producer, which means that the tunnel will illustrate events history that were produced by a specific user within a desired period of time. The Software is written in VRML, Perl and C++ respectively. The DocuDramaInterface is implemented in Perl-CGI scripts and provides access in a Mysql backend database [10].

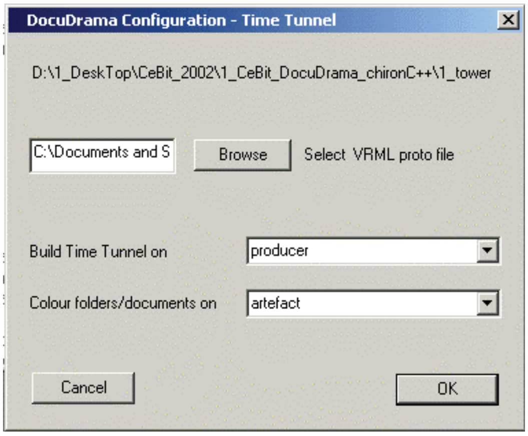

Fig. 10: DocuDrama ConfigurationInterface

5. Results and future work

In the first DocuDrama prototype, we experimented with a version that created a chronological visualisation of past events in the TOWER virtual environment. The user could choose to visualise only the time-segments in which events were performed and showing events that were performed only on documents. Although this approach looked interesting in the first place, practical usage revealed that a document's history would not be of a great importance to the users, as visualising folders would convey more information than visualising only documents. Hence a suggestion was made to develop the concept further into mapping a context-oriented events history rather than document oriented history. For example, visualising the events history related to a folder through mapping the events that were performed, such as creating or reading documents, within the main folder. Moreover it was pointed out by the user group that visualising the project related milestones and deadlines would give the user appropriate information to review and would make the Timetunnel very useful. In addition visualising the time-segments that show no activities with the ones that show activities turned to be useful as it provides the user with a better understanding of the change in the pattern of events through time. Consequently the prototype had to be improved with the new features. Experimental trials were conducted and the prototype was tested to visualise various events histories along with the related milestones.

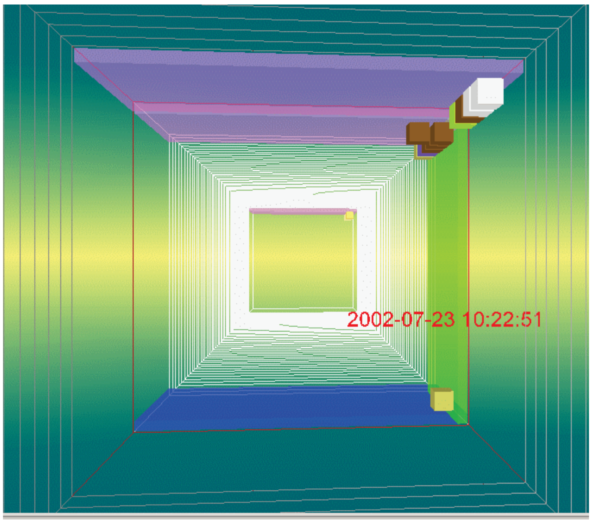

Fig. 11: Period of low activity

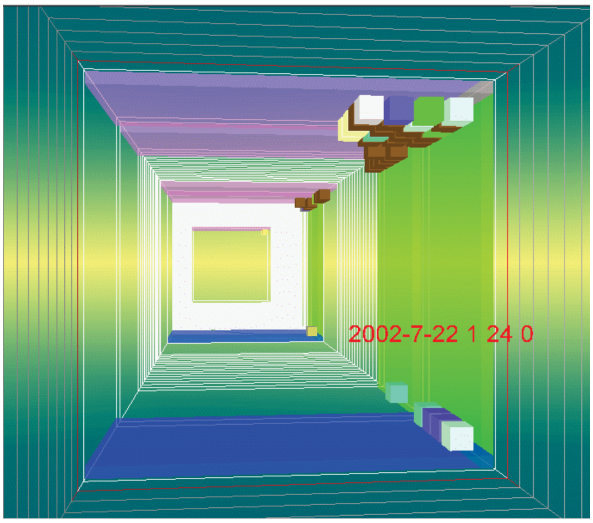

Fig. 12: Period of high activity

Our findings indicated that the three dimensional visualisation of events history is easier to understand than the two-dimensional pure textual list of the same data as the clustering of events is easier to detect in the three dimensional representation. The evaluation in discussion with possible user groups illustrated that the DocuDrama Timetunnel represents an excellent tool for task control of shared document production. The user group pointed out that the tool could prove to be especially useful in relation to deadlines, which would enable the user to monitor the activities and delays in a task. Currently, events mapping within the mapping engine is implemented on the basis of fixed placement rules representing only four types of events. Future research and development will focus on the handling and visualisation of large datasets in the Timetunnel. To improve the functionality of the model we plan to experiment with different types of spatial clustering in a form of a parametric mapping of past events. Consequently the shape of the tunnel would reflect the real number of events that were performed at the specific time-segment. In this way the user would be able to detect and identify the period of high activity at a glance, as the associated time-segment will be bigger than the time-segment defined during the period of low activity. Future work will include providing an automatic focusing on areas of interesting activity, which will simplify interaction with the Timetunnel and its content. The future Timetunnel will be useful to monitor tasks in relation to overall milestones and project deadlines. In particular it will provide the functionality to manage and organize folders [3,10].

6. Conclusion

This paper describes a novel approach for generating and visualising events history in a collaborative virtual information space. We introduced the DocuDrama Timetunnel; a new type of a dynamic interface based on a temporal and spatial narrative approach. A three-dimensional virtual model serves as a stage for visualising the history of project related activities creating meaningful relationships between separate strings of events. A set of tools have been realised to deal with different aspects of constructing and mapping events histories. At the same time the users will be able to visualise the same information in different ways according to their needs. The prototype provides an efficient and entertaining way of illustrating the history of project-related events and activities together with milestones and deadlines leading to a better understanding of the project-related events history. It is especially suited as a tool for inspecting project related folders and managing them. Finally in developing the DocuDrama Timetunnel we have created a narrative based folder management tool as part of TOWER, a Theatre of Work Enabling Relationships.

Acknowledgements

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References

[1] Thomas, D., 2003, “Virtual Environments help distributed project teams work more effectively”, in *Computer Weekly*. http://www.computerweekly.com/

[2] Schäfer, L., Prinz, W., Oldroyd, A., Gavin, L., 2001, “Virtual storytelling of cooperative activities in a Theatre of Work” in *Proceedings of the International Conference ICVS 2001: Virtual Storytelling*, Avignon, France. Berlin: Springer.

[3] Schäfer, L., Bokan, B., Pankoke-Babatz, U., Prinz, W., Fatah gen. Schieck, A., Oldroyd, A., 2003, “Symbolic activities in virtual spaces” in *Proceedings of the 3rd international conference on Computational Semiotics for Games and New Media: Cosign 2003*, University of Teeside, Middlesborough, UK.

[4] Prinz, W., Pankoke-Babatz, U., Gräther, W., Gross, T.; Klein, K.-H., Kolvenbach, S., Schäfer, L., 2003, “Presenting activity information in an inhabited information space”, in *Inhabited Information Spaces,* forthcoming.

[5] TOWER Project, 2002. http://tower.gmd.de.

[6] Prinz, W., 1999, “ NESSIE: An awareness environment for cooperative settings” in *Proceedings* of the 6th *European conference on Computer Supported Cooperative Work (ECSCW '99)*, Kopenhagen: Kluwer Academic Publishers.

[7] Penn, A., Desyllas, J. & Vaughan, L., 1999, “The space of innovation: interaction and communication in the work environment”, *Environment and Planning B: Planning and Design*, Pion, London, Vol. 26.

[8] Schäfer, L., Pankoke-Babatz, U., Prinz, W., Fatah gen. Schieck, A., Oldroyd, A., 2003, “DocuDrama” in *Virtual Reality*, Berlin: Springer, forthcoming.

[9] Schank, R., 1995, *Tell Me a Story: Narrative and Intelligence*, Northwestern University Press, Illinois.

[10] Fatah gen. Schieck, A., 2003, “Space-time configuration for visualisation in information space” in *Proceedings of the 4th international conference on Space Syntax*, UCL, London. UK. http://www.spacesyntax.net/symposia/SSS4/shortpapers-posters/FgSchieck-600dpi.pdf.

[11] BSCW: Basic Support for Cooperative Work. http://www.bscw.de/index_en.html.

Selectionist musical automata
Integrating explicit instruction and evolutionary algorithms

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Abstract

We describe an open, modular system for experimentation with algorithmic composition. It integrates evolutionary methods for implicit synthesis of complex hierarchical structures as well as a large library of software tools allowing user directed explicit object manipulation. The idea is to combine the generative potential of genetic methods with the instructive power of user control embedded in knowledge and culture. Melodic material is generated by viewing the rewrite rules of both L-systems and linear cellular automata as genotypes. The user creates cross-overs and mutations according to visual/auditory interactive evaluation. One can traverse genetic space by morphing one rule into another. Further, objects are visualised in a graphic interface and available for direct manipulation, analysis and structural assembly. A complex harmonisation module creates articulated chords to a given melody based on tension profiles and conventional pattern matching. An embedded interpreter allows the user to extend the functionality of the system which is fully operational and implemented in Object Lisp.

1. Introduction

Much recent work in algorithmic composition and interactive composing has turned to biologically inspired models for the synthesis of coherent yet unpredictable output. The design of programs with true creative impact no longer relies on explicit rules based on a known aesthetic tradition. In contrast, we speculate on the potential of genetic engineering for the synthesis of original musical constructs.

Composition becomes navigation in a virtually infinite search space inhabited by families of related musical objects. Large groups of genotypes are generated at random. A given fitness is attributed through interactive evaluation, and the DNA of a few selected objects is mixed using cross-over and mutation operators. Results may be stored to disk and sorted according a number of critical features. At a later stage, the composer can issue search commands over this database as well as embark on a new exploration from an earlier point of reference.

The process of gradual optimisation allows the composer to control intricate structures without necessarily understanding their underlying complexity. In addition, genetic algorithms provide a way to discover interesting structures that were not anticipated by the composer. Note that the human interactor actually samples a virtually infinite, non-linear search space. The composer conditions the system to favour interesting emergent functionality -- highly in contrast with compositional theories based on explicit structural design.We have applied the evolutive method in three implementations: a program that grows brains for interactive composing; real-time sensor-activator networks with evolved connectivity [Beyls 99, 00], a system which views the rewrite rules of L-systems (Lindenmayer Systems) as genotypes, implemented as Lisp functions of arbitrary nesting complexity and finally, cellular automata with evolved lookup tables. The present paper reports exclusively on the latter two.

However, it is understood that automation by itself seldom yields a complete musical composition. When considering larger musical movements, we often think in terms of development of germinal ideas, of shifting tendencies in time and the critical control of tension profiles i.e. compositions consisting of statements built according to a specific plan. Our system provides a desktop model to handle a pool of musical fragments visualised as boxes freely configured in a workspace. A box contains a figure of arbitrary complexity; a few notes to a complete musical gesture. Typically, melodies are generated from cellular automata or L-systems and imported into the current workspace for further treatment, analysis and assembly.

Our system also allows for genetic interpolation from the specification of two points in genetic space; the result is a shifting musical climate between two points of reference. In addition, we use a novel harmonisation algorithm based on a measure of psychological tension in the melody/chord relationship. Also, our musical workbench provides a large toolbox of functions to edit and transform generated musical material.

In summary, exploration and discovery are implicit to the current approach though the overall intention is the synthesis of scores for human performance, i.e. the system must incorporate knowledge of physical musical instruments.

2. Implementation

The main interface contains a family of musical objects under observation, visualised as an array of coloured and labelled boxes. One of them is selected and subject to manipulation by the user.
The top row is thought of as an assembly line; the user collects boxes into a sequence which can be retrieved into a single, new macro object. The events that constitute the top row are shown in the upper right pane in piano roll notation, the lower pane shows the currently selected object.

Figure 1a. Main interface, typical workspace configuration

Any workspace can be saved to disk and later retrieved, like a dynamic sketchbook for musical experimentation -- any interface in the present system provides tools to save and load objects. In addition, the interface provides access to a large set of operators, some of them quite exotic; operators include contrast-expansion, counter melodies according to user-specified intervals, simple rule-based multi timbral orchestration, a conditional filter, the generation of new objects from interpolating between two existing ones, chord generation by a ring modulator inspired function and many more.

The new object which results from a transformation can be appended, prepended or replace the current object. Operators feature appropriate default arguments as well as function-specific program suggested parameters. Since the system aims to be open and modular, we provide an imbedded interpreter where the user may write small Lisp programs and save them into a private library.

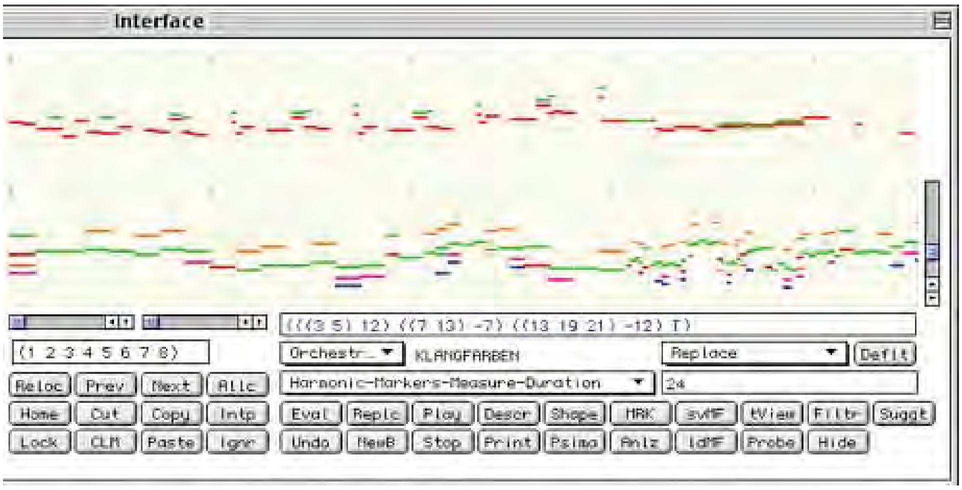

Figure 1b. Main interface, score visualisation

In view of harmonisation, the current melody is subject to segmentation according to 4 potential criteria:
- segmentation according to an explicit grouping parameter list
- segmentation by comparing melody durations to a user specified duration argument, create mark when the event-start-time modulo duration argument equals zero
- segmentation by scanning the melody for user-specified cadences
- segmentation according to values or intervals in melodic tension.

Tension plays an important role when considering the complexity of melodic material. Formally, we use a logarithmic scale [Jaxitron, 85] to compute harmonic tension: a minor-seventh contributes 1, major-second adds 10, major-seventh adds 100 and a minor-second adds 1000, all other intervals add zero. So a melody can be scanned with a certain window, say 5 wide, the local tension sums are collected in a list and subject to inspection. Information on how tension evolves in time is often taken into consideration in the harmonisation module; it may be used as a parameter to control automatic segmentation of melodies.

3. Melody generation by cellular automata

Cellular automata are discrete models of complex dynamical systems [Wolfram, 94]. We implement one dimensional linear automata and think of the rewrite rule as a genotype. Fig. 3 show nine automata with numeric fields for local parameters; lambda parameter in percent, noise value, nr of generations (up to 80), neighbourhood (3, 5 or 7) and nr of values (2 to 8). A CA grows from editable initial conditions. The complexity of a CA is said to belong to one of 4 families; CA evolving to a steady state (point attractor), CA moving into a cycle attractor, CA showing multiple types of relative periodicity and finally, CA featuring strange attractors. A clever tuneable complexity navigator, known as the lambda parameter, was suggested by [Langton, 86]. Basically, it specifies the density of positive values relative to zeroes in the rewrite rule i.e. how many values map to live cells. Thus, it offers a statistic measure of how active the automaton will be.

Visual inspection provides a first hint to the musical potential of a CA. Two automata are selected by mouse pointing to become the parents of a reproductive process; their lookup tables are applied to a cross-over operator and some percentage mutation; from here 9 new children are bred from these 2 parents. The lower pane informs about the current mapping; a melody follows from an elaborate mapping algorithm which uses a mapping neighbourhood of 2, 3, 4, 6 or 12 -- values applicable in a CA with 12 cells wide.

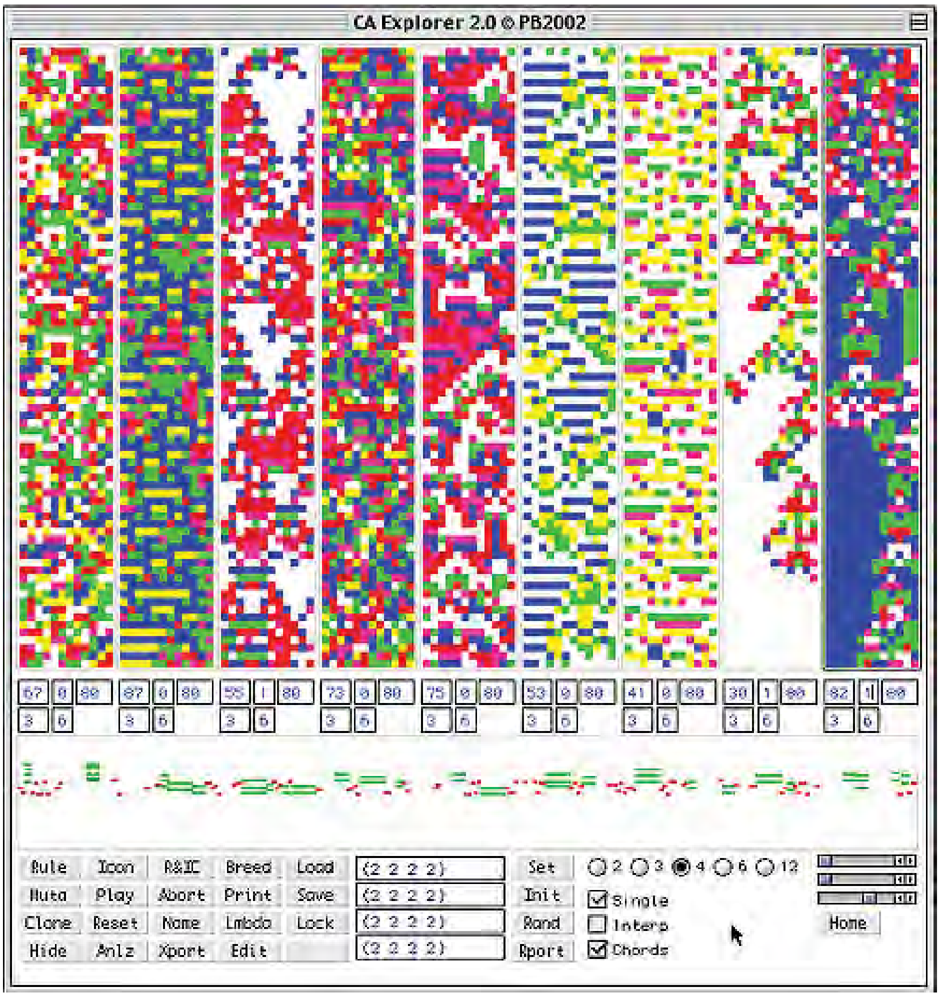

Figure 3. CA main interface.

CA genotypes may be cloned yielding identical structures yet a minimal amount of noise may be used to disturb the functioning of the CA; it may stimulate local structures in an otherwise stable automaton. In addition nearly identical CA can grow from the same rule with minor mutation. Genetic interpolation speaks to the imagination: what if we think of two rules as two points in a huge search space; these two points thought of as anchors of a clear and specific musical climate. So interpolating between the anchors in a few generations yields a trajectory and a potentially characteristic momentum. Any rule is accessible for analysis or explicit editing by the user when hitting the *Edit* button, in particular if we wish to study the implications of certain values in a rule.

It should be noted that while the combinatorial complexity of genotypes formulated as lookup tables is huge, it is also intrinsically limited. The nature of the rules does not evolve, so the system cannot move into regions of higher hierarchical complexity -- the genetic algorithm does not change the structure of the genotype. L-systems, described in the next paragraph, address this consideration.

4. Melody generation by L-systems

L-systems [Lindenmayer, 68] are prime examples of database amplification systems; a large structure is generated from a simple list of start-tokens and a rewrite rule that is applied recursively for a number of generations. L-systems are similar to type 2 (context free) grammars, they provide a computationally inexpensive way to represent complex patterns showing various degrees of self-similarity and developmental structure. For a formal description of grammars and L-systems in music, see [McCormack].

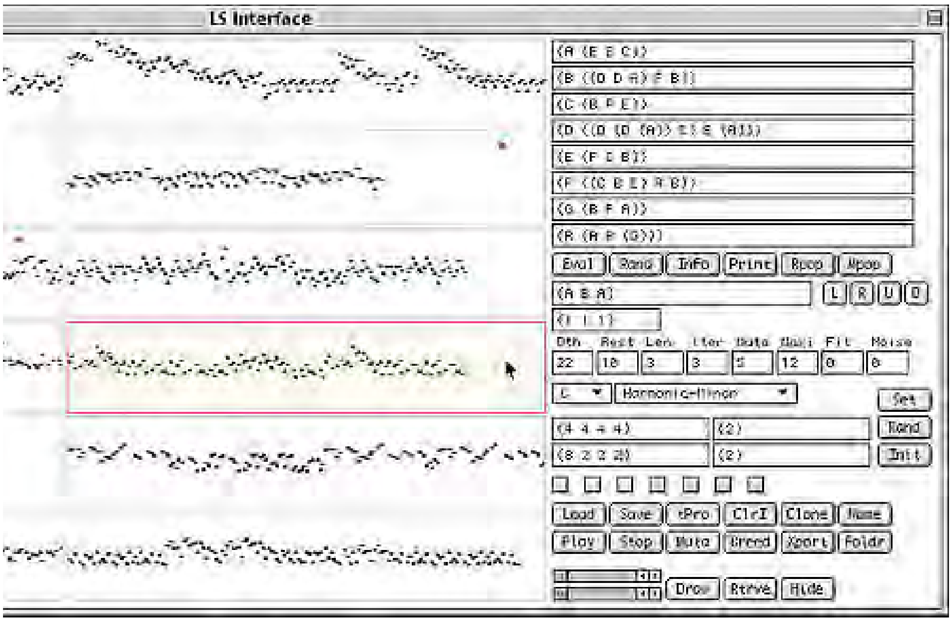

Figure 4. Snapshot of L-system interface.

The genotypes here are not lists but tree structures; cross-over is thought of as replacing local branches at some depth with other branches taken at some other depth from another tree. We have a vocabulary of 8 potential start-tokens; A to G (implies activity) and R (is mapped to a rest). The following editable parameters determine the nature of a rewrite rule:

- Depth: A recursive algorithm is used to compute a new rule; any branch in the nested Lisp structure may feed on itself and spawn additional branches at any given depth. The *Depth* parameter sets the chance, at any point in the tree, whether branching continues or aborts. Care is taken to avoid infinite feedback -- exit is forced at some given maximum depth. A typical rule is shown in the upper right corner of figure 4.
- Rest: the chance that the R-token is selected over an active token. This is similar to the lambda parameter used to determine the density of activity in cellular automata.
- Len: the maximum length of a rule-part.
- Iter: the number of iterations the rule is applied to the start-tokens.
- Muta: the mutation percentage.

- Maxi: used with the mapping algorithm; it specifies the maximum interval step in the resulting melody.
- Fit: the fitness attributed to the currently selected rule.
- Noise: the amplitude of a noise source set to interfere with the rule.

The start-tokens (‘A B A’ in the current example) are user editable; note that symmetric start-tokens will add coherence to the output, it is one way to balance novelty and unpredictability in the essentially self-contained automaton.
The genotype tree structures are metabolised into polyphonic MIDI patterns and organised into larger musical gestures -- additional interface elements apply to the mapping algorithm: the choice of a tonality, a scheme to select durations at 4 different depths in the resulting tree and a set of check boxes used to inhibit the use of tokens A to G.

The list containing ‘(1 1 1)’ specifies the intervals that will be used to compute melodies. Both the depth of a leaf and its content (A to G) is taken into consideration to compute a new pitch, the depth contributes an additional offset taken from that list (modulo the length of the list). The user proceeds by selecting two phenotypes from critical evaluation; visual inspection and/or by listening to the object. The cross-over operator mixes branches from both parent trees and applies some mutation in order to keep a certain degree of novelty i.e. to keep the system from evolving to a point attractor.

So here again, the system accommodates both generative processes and direct control by a human interactor. A delicate balance is maintained between implicit automation and explicit control. As an example, let’s have a closer, systematic look at a typically hand-crafted mapping algorithm. The L-system generates a tree containing the symbol of every leaf plus its depth. Each symbol is converted into a numeric pointer, pointers are collected in a linear list. Formally, a pointer equals:

```
(defun transpose-token (symbol interval)
   (if (not (eq ‘R token))                    ;; skip rest
     (+ (nth (position token ‘(A B C D E F G)) interval)
     token)))
```

The list of pointers becomes:

```
(defmethod compute-pointers ((self lso))
  ; outputs pointers for pointing in scale plus respective depth
  ; (starting from 0)
  (collect-grammar self)
  (loop with ic = 0
        with grammar = (grammar-output self)
        with d0 = (get-depth-zero grammar)
        with d1 = (get-depth-span grammar)
        initially (progn (format t "~%Zero depth is ~a and depth span is
             ~a." d0 d1) (format t "~%Sequence = depth, symbol"))
        for tok in (mapcar 'car grammar)
        for dth in (mapcar 'second grammar)
        when (atom tok)
        collect (list (- dth d0)
                      (transpose-token tok
                       (* (nth ic (intervals self)) (- dth d0))))
```

```
        when (and (not (unpack-flag self)) (listp tok))
        collect (list (- dth d0)
                      (loop for e1 in tok collect
                         (transpose-token e1
                                 (* (nth ic (intervals self))
                                   (- dth d0)))))
        when (and (unpack-flag self) (listp tok))
        append (loop for e1 in tok collect
                     (list (- dth d0)
                         (transpose-token e1
                                 (* (nth ic (intervals self))  (- dth d0)))))
        do (setq ic (mod (+ 1 ic) (length (intervals self))))))
```

The lowest depth value is not necessarily zero, so all depth values are transposed as to have the lowest depth at level 0, the depth span is used to determine pitches. If the unpack-flag is true, the tree is parsed up to the level of a leaf, otherwise the deepest list is considered the top of the tree -- the list is then interpreted as a parallel structure (later to be used as a chord). The algorithm cycles though the intervals. At this point, the resulting list yields a numeric interpretation of the tree, the next step is to provide musical meaning.
A 10 octave scale is created from an explicit selection of both key and mode from popup menus. In addition the user may edit the intervalic structure of any mode; it forms the basis of custom tonality design. The score events are computed as follows,

```
;; select a duration list from 4 potential ones, according to depth
(setq dur-list (nth (mod depth 4) (durations self)))

;; select a duration value by cycling through every list
(setq dur-value (nth (nth (mod depth 4)
                          (duration-counters self)) dur-list))

;; a single MIDI event becomes
        (when (and (numberp e)
                   (plusp dur-value)   ;; not a rest
          (not (nth (mod e 7) (inhibition-flags self))))   ;; token not inhibited
          collect (list start-time
                        ;; compute MIDI key number
                  (if (chroma-flag self)        ;; chromatic or diatonic use of depth
                   (+ bias (* 1 depth) (nth e (scale self)))  ;; bias = register of LSO
                   (+ bias (nth (+ e depth) (scale self))))
                  dur-value
                  (if (zerop (nth  (mod depth 4)  (duration-counters self)))
                   (+ 90 (random 30))     ;; articulate velocity
                   (+ 60 (random 20)))
                  1)                         ;; channel 1
```

5. Harmonisation

The harmoniser imports a segmented melody and finds appropriate chords according to constraints specified by the user, it does not incorporate genetic ideas. The central constraint is minimum and maximum harmonic tension between segment and chord, 36 tonalities provide a pool of 432 harmonic

alternatives. Harmonisation is viewed as a problem of constraint satisfaction; tension, intended root tone motion, required intersection count of melody and harmony, specific tonalities .. all contribute to the nature of the harmonic path.
An orchestration module is under construction, the goal is to output scores for human performers. An object-oriented database was created documenting the characteristics of acoustic instruments; this information is used to filter musical objects according to constraints in the database. Orchestration includes first, the critical distribution of polyphonic material over a number of instruments according to criteria that may shift in time and, second, the rule-based articulation of melodies assigned to particular instruments that may as well evolve during the life span of a given musical gesture. After some experimentation with a genetic approach (viewing orchestration as an array filled according to genetically derived functions) we adopted a text oriented interface; the user issues Lisp macros to orchestrate the current object. Direct functional expression was felt to be repeatable, reliable as well as flexible. By the way, we may in fact consider textual code as genotype, the approach was applied successfully in the pioneering work of Karl Sims [Sims, 91].
The pragmatic automata described here imply extensive selectionist user interaction; fit objects are selected for breeding new generations. This determines both the strength and weakness of the system; the user navigates a wealthy field of possibilities but that field is highly non-linear and it is very time consuming to evaluate all possibilities at every step in this selective process. So ways to automate selection -- given explicit complexity criteria -- would lower the pressure on the user. We have implemented functions to analyse the time-dependent complexity of CA in terms of periodicity, speed of change in (and acceleration of) periodicity, density in time, evolution of complexity measured using a Hamming window... The idea, then, is to adopt an unsupervised method: generate families of genotypes, evaluate the metabolism which follows and save the result to disk. The user could then explore that database with thousands of objects and issue sort commands -- structures would then be directly accessible given intended characteristics.

6. Conclusion

The methods described aim the combination of exploration and exploitation in a computational environment which stimulates creative decision making -- optimisation in selectionist automata mirrors the creative process of searching through the composers personal search space. Exploitation concentrates on the effective use of a certain momentary niches while exploration means moving on to potentially better, yet unexplored points in combinatorial space. Exploration is analogous to self-confirmation in the creative process while exploration is more like self-revision and seems closer to the heart of true human creativity. Gradual optimisation is extended through explicit stylistic input from a human interactor. The idea is to start from randomness and to grow a pool of related objects -- a field of reference is thus created; goals are identified in a gradual fashion. The user provides constraints, interferes with the functioning of the system by providing initial conditions and tuning parameters and thus complements the otherwise automatic, generative behaviour of the global system. Obviously, this type of intimate machine interaction yields results that could not be produced in isolation by neither man nor machine.

7. References

[Beyls 97] Aesthetic navigation: musical complexity engineering using genetic algorithms, Proceedings of the JIM97, Lyon, France 1997

[Beyls 99] Evolutionary strategies for spontaneous man-machine interaction, Proceedings of the International Computer Music Conference, Beijng, China 1999

[Beyls 00] Synthetic creatures in context, Proceedings of Intersens, Marseilles, France 2000
www.labo-mim.org/pdf intersens/Beyls.pdf

[Jaxitron, 85] Cybernetic Music, Tab Books Inc. 1985

[Langton, 86] Studying artificial life with cellular automata, Physica 2D, Elsevier Science Publishers 1986

[Lindenmayer, 68] Mathematical models of cellular interaction in development, Journal of theoretical biology 18, 1968

[McCormack] Grammar Based Music Composition
www.csse.monash.edu.au/~jonmc/ resources/L-systemsMusic.pdf

[Sims, 91] Artificial evolution for computer graphics, Computer Graphics, Vol.25, Nr. 4, 1991

[Wolfram, 84] Cellular automata and complexity, Collected papers, Addison-Wesley Publishing Co. 1994

Morphogenetic CA
69’ 40’ 33 north

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1 > abstract

We would like to present some recent work using cellular automata and agent modelling for the generative design of building configurations. The cellular automata is based on a 3d terrain model of a site (taken from the recent Europan competition) which is encoded with both topological and economic data, and agents that are light sensitive and which reconfigure the developing architecture by checking overshadowing and spatial occupation. The emergent pattern of development therefore results from an understanding of the programmatic and the spatial parameters of the task, and is intimately related to the site and its peculiarities.

2 > introduction

2.1 > generative modelling perennial problem:

Bridging the theoretical gap

This project is attempting to take the approach of digital generative design in architecture out of its *in vitro* academic context into the realm of industry’s design briefs. This undertaking aims at throwing open the limitations of such projects when it comes to the translation into an open design competition. We were anxious to find out when, at which stage of the design process, industry’s constraints would force us to dilute the integrity of the process. We chose this year’s Europan07 brief to set the constraints and to engender a generative approach we would base our design on.
Europan competitions take place every four years, sponsored by the EU, and comprise a series of sites across Europe that are in need of redevelopment.

2.2 > Europan 07: brief & analogy

69’ 40’ 33 north

Tromso in Norway, with its 60.000 inhabitants plus an extra 7000 students, is situated in a Fjord, 200 miles north of the Arctic Circle. It is surrounded by a sprawling rural countryside in a spectacular, pristine and vast arctic landscape. With 2 months of midnight sun in the summer and 2 months of no sun at all during winter, which lasts 7 months the climatic changes are dramatic.

Europan07 – site of Tromso

The site is an artificial piece of headland reaching into the strait of Tromso. It is delimited by a fjord towards West, a highway and its facilities (a gas station comprising a shop – the main social focus of the suburb) towards East, a creek and forest towards south and housing towards North. The highway towards East separates the existing suburb of Tromso, Kroken, from the site.

The design brief focuses on the development of diverse and innovative housing types for a variety of occupants. This housing should engage with the existing suburb. The surrounding housing consists mainly of post-war development designed without a sustainable approach to the climatic challenges.

One of the salient qualities and uses of arctic coastal regions has traditionally been the exploitation of peat-lands that stem from the setting of a combination of wet soil with remains of tree roots and trunks, into a compost type resource. Rich in carbon, it has been depleted for centuries as fossil-fuel for heating. The process of exploitation foresees the scooping out of this soil in cubic chunks. These cubes are deposited on nearby sites and sold. The deposits were not always entirely carried off and left new deformation in the landscape. Thus, peat has not only been transformed into other resources but also changed landscapes of coastal arctic regions.

peat-resources in coastal heath land

2.3 > CA & MAS & environment:

'However, sometimes it is necessary to study phenomena of such a great complexity, that their implementation with a single CA seems anyhow complicated or impossible. This is why it's useful to apply the concept of multi-cellular automata, which is: a system constituted by two or more automata linked together in sequence.'[4]

The brief displays a depth of interacting parameters and entities within a complex site over at least two different scales (urban and morphological) that are hard to meet with traditional top-down methodologies prevalent in architectural design. Thus, in order to widen the search and solution space we used a by now well-tested method of decentralized non-linear design, the cellular automaton (CA) coupled with a multi-agent system and environmental parameters.
Each of those autonomous systems has its strengths of application within the architectural scales whose combination we hope produce a solution space more differentiated than a singular use of one or the other.

Customized to the design brief, we believe that the CA can solve the continuity problem present in the context of the competition's site by diffusing information about the context locally.
Further, the multi-agent system – based on the swarm logic – will serve to communicate the dynamic environmental parameters – sunlight and wind direction – to the CA without having to program them as instructions into the CA. Thus, the swarm tests the fitness of the configurations of the CA in accordance to the environmental parameters.

Finally, we synthesized the interaction of the CA with the swarm to a morphogenetic process. CA so far has either been used as an analytical simulation tool or exclusively as a form-generation tool. The present approach attempts to combine the analytical and the morphogenetic into a continuous method.

3 > Precursors

3.1 > CA as analytical model

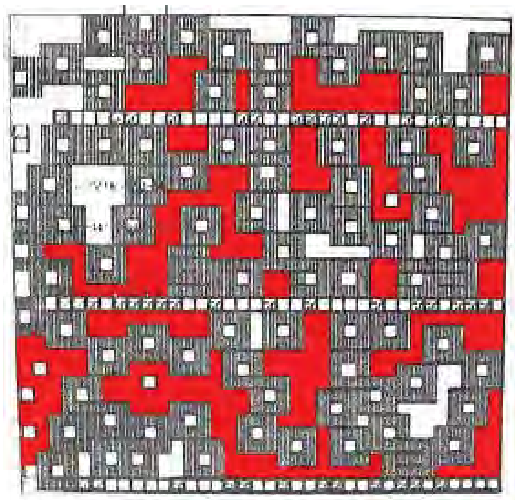
The Community land use game CLUG [1] of Cornell University was the precursor of all system models of urban development, using a tiled map and a team of human actors to execute the rules. The eventual transformation of this idea into a computer game - Sim City, illustrates how the development of computers has enabled more and more complex models to be developed.

Nearly all models of urban structure are based on a scale of development that never reaches down to the scale of architecture and architectural spaces, as one might find in a city. One of the major contributions to a generative theory of architectural space was that of Bill Hillier with his Alpha syntax model of space (Hillier & Leaman 1978)[2]. Following on from Steadman's (Geometry of Environment 1970)[3] exposition of the effect of geometry on configurations – what he likes to talk of as 'the topological necessities of space', Hillier explored the morphological outcomes of a set of simple syntaxes – simple grammars of form for developing agglomerations of buildings. The alpha syntax was the simplest, and generated spatial arrangements similar to typical small towns in Europe.

P. Coates – Alpha Syntax study of the Isle of Dogs

It is possible to dichotomise the debate between the morphologists – who believe that the shape of space (dictated by architectonic and material notions) influences the way it is utilised, and the economist/geographers who say that urban structure is the inevitable outcome of geographical and economic outcomes. While the morphologists are prepared to admit the obvious influence of global factors in locating and encouraging development, the economists are reluctant to concede any reverse feedback from the architectural necessities of settlement.

One example of the way micro morphology may influence global social organisation is that of the guild courtyards often found in pre-Islamic cities of the middle eastern type. In these ancient cities one often finds that culs-de-sac are occupied by single occupations (gold beaters court, leather sellers court etc). The conventional explanation is that these social structures have imposed the morphology on the city, by gathering together and closing off the street to through traffic. By exploring the morphogenetic system of these simple agglomerative cities, it is easy to observe that there is a tendency for all street systems to collapse into culs-de-sac, the one ended street is the natural state of equilibrium as it were. If this is true, then the courtyards are the inevitable topological outcome of the global agglomeration process and the guilds simply 'occupy' these pockets of space – or even stronger – they are themselves created by the morphological outcome.

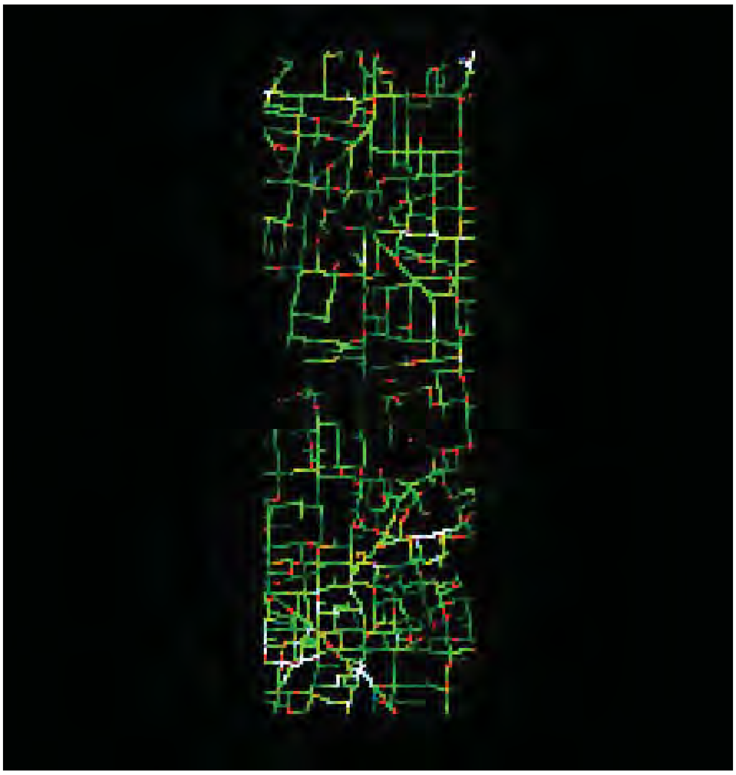


P. Coates – emergence of inner courtyard

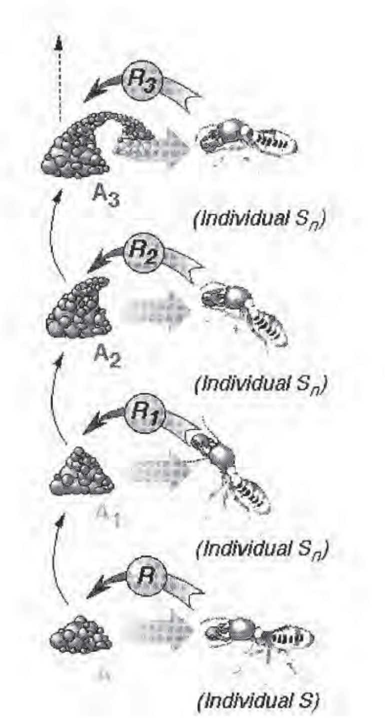
The researches at UCL have been developing a range of CA based models of urban development, mostly at the larger scales mentioned above as normal in the geographic field. The space syntax group (following on from Hillier's work mentioned above) have also developed models using agents at nearer architectural scales, to analyse emergent properties of urban space such as co-visibility, predictive pedestrian traffic and many other measures.

3.2 > multi-agent models

Using agents to analyse and construct urban morphology has been reported [13,15] by the authors. In such systems the agents are provided with means for sampling the existing morphology of an area and either reporting globally, or making interventions. As an example of multi agent analysis, take the case of a simple star-logo model [14], which analyses the spatial configuration of the Hoxton area of East London to predict relative accessibility of streets. A typical 'top down' analysis (Hillier etc) maps the street pattern into a network, which is then analysed for accessibility metrics using standard graph theory algorithms. The outcome labels streets (edges in the graph) with respect to their relative accessibility from all other streets. In Miranda's model however the streets are represented by small tiles, which are labelled as walk-able on or not. Agents are randomly placed onto these tiles and allowed to walk at random, with the only proviso that they must not walk on 'non street'- tiles. As the agents walk they update the tiles by one point, thus the tiles that have had the most traffic gain the most points. This is reflected in the colour gradient of the outcome. The result is a pattern of usage that is similar to that derived from the network analysis, but of course the method of obtaining it is quite different, in particular it provides a better model than the network version because it makes fewer assumptions about what is going on. In the network model the street pattern is arbitrarily decomposed into straight segments which are arbitrarily connected with identical weight. In the agent model they just walk about – the only assumption in the model is the shape of the space as described by the array of small tiles.

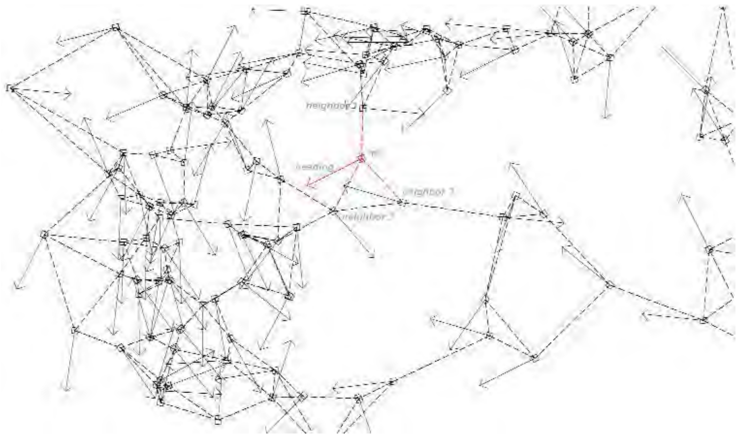


P.Miranda – accessibility study

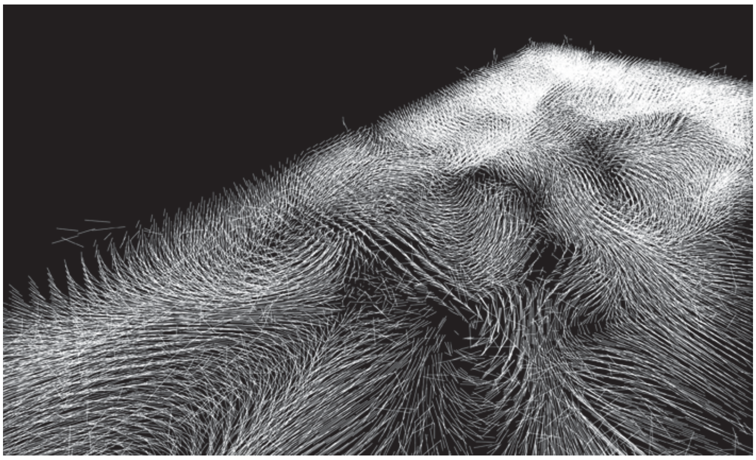


L. Grasse – stygmergic nest builders in wasps

Guy Theroulaz and Eric Bonabeu [8] were the first to develop models of morphology based on a detailed understanding of the complex relations between morphogenetic 'builders' (in their case of wasps nests) and the material they are using. This relation was dubbed 'stygmergic' by Louis Grasse in 1956 from stigma = sting: ergon = work. It develops the idea that, while the agents have morphogenetic desires and behaviours, these procedures are triggered and/or modified by the environment in which they are working. Since this environment is the very one they are building there is a feedback loop between the builder and the material of the environment. Stygmery allows for multi-agent systems to communicate indirectly through their environment rather than exercising direct feedback amongst themselves. Models of such behaviour can show complex morphologies, and students at CECA have experimented with termite architectonic models.
Swarming is a multi-agent behavioural phenomenon which is based on direct feedback between the agents. This model is - just like the CA -based on parallel computation and based on flocking behaviour of birds. Thus, information gleaned as perturbations from the context (whatever the context constitutes: the swarm topography itself, the CA (topology, etc) is distributed throughout the system due to local communication only. Unlike the CA however, the swarm is not fixed by topological constraints and has therefore a geometrically unbound search space – the CA constitutes an iso-spatial system, where all points within the spatial array can't change their relative position within each direction. Thus, swarming generates clusters of hotspots of interaction pointing to 'interesting' qualities within the environment.



P.Miranda - swarming

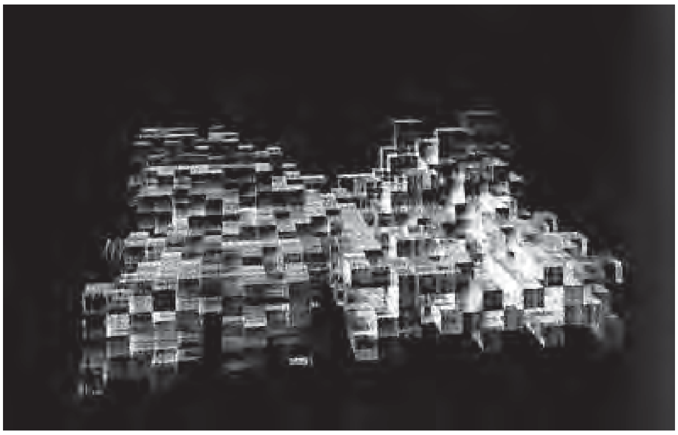


P.Miranda – stygmergic space

Other multi-agent systems include such where there is no feedback amongst the agents. Such systems don't take their fellow-agents into account when navigating the environment but act in isolation. (see Miranda above). This approach is of use when probing an environment via stochastics.

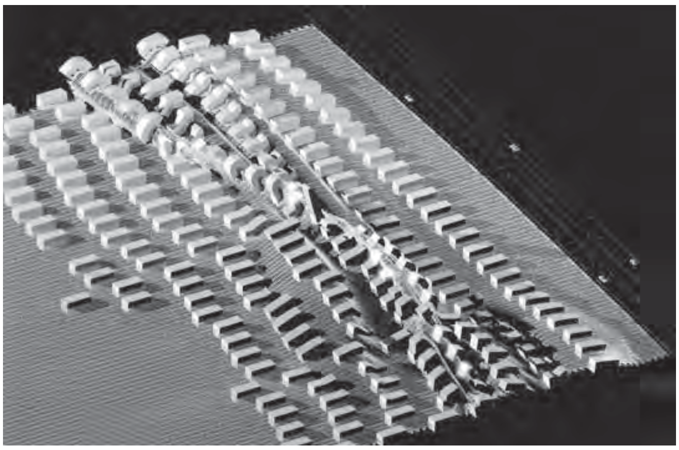
3.3 > ecologic feedback models

Termite algorithms can be seen to involve environmental parameters, both because of the direct feedback between material properties and the agent, but also in terms of external/global factors such as sun and wind. A more directly architectural example is that of Watanabe's 'Sun God City' where agglomerations of apartments are generated randomly, but with rules such as *'so many hours sunlight a day'* applied to delete/ promote individual cells. This method suggests a rich variety in external spaces providing new relations between function and space (openings, paths, terraces and common spaces), investigating conditions such as access and privacy.



Watanabe – Sun God City

Dutch architects Nox [17] used sound as a generator for their design proposal of a housing project 'Off-the-road' outside Eindhoven.
The profile of the noise barrier along the Autobahn has been transformed using animation software into a system of strings, 'playing' the noise of cars passing by. The vibration patterns have been recorded and added together to create a sound landscape. The resulting diagram represent/ maps the sound to be read in time (score) and in space (orchestra).
The form of the dwelling modules varies systematically following the wave patterns of the recorded traffic noise. The modulation of the noise patterns mirrors the variation of the volumes. Each housing unit is different reflecting the transformation of the neighbouring house. Hence, a global generator (sound) and a local geometric seed (initial housing layout) lead over time to morphology.



Nox – Off the road

Cellular automata perturbed by environmental parameters have been experimented with by Coates and Voon [6]). In order to generate sheltered open spaces with a particular orientation, Voon encoded the general assumption that sunlight is perceived from the south – cells in the direction of the negative Y-axis where treated differently from others. Additionally, specific ‘voting rules’ for the transition between states were introduced to differentiate between above, below and next to in different directions, allowing the cell in question to sense overshadowing.

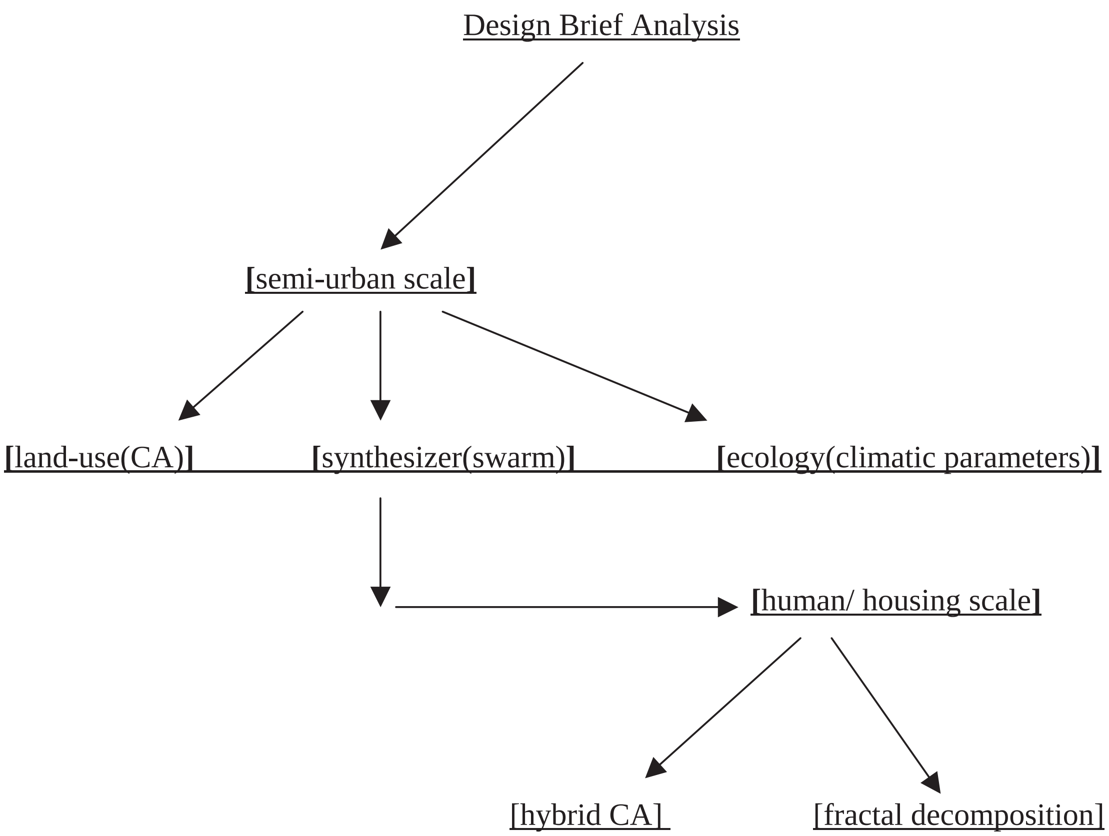
4 > a model for cooperation of parallel systems

4.1 > elements of synthetic construction

In order to integrate the main aspects of the brief of the Europan07 competition, we extracted the dominant features of the above mentioned models to suit the different problems on site.
The parallel local transition rules of the CA serve to determine the distribution and designation of land-use on site. The CA will not directly be accounting for climatic change.
The topological freedom that the members of the swarm enjoy serves to establish the validity of local congruence with the climatic parameters. Thus, the strength of the swarm to detect idiosyncratic geometrical features of the site serves to perturb the structure of the CA locally. The swarm as a whole functions as a global observer who enforces the dynamics of the climatic parameters. The unhinging of a direct mapping of climatic change into the states of the CA’s cells helps to keep each system as simple as possible while trying to reflect on all possible parametric combinations of the search space. By applying this fragmentation of the various programmatic fields we are trying to avoid what Paul Valery observed: ‘*if you examine the man-made object, you find that the form of the whole is less complex than the internal structure of the parts, and this suggests a disarrangement. In the sense, order imposes disorder.*’[11]

The climatic constraints are limited to the sunposition during the day at different times of the year and the prevailing direction of wind.

Generally, we devised a fragmentation of the overall brief into programmatic sub-fields that could be handled by autonomous systems, which in turn would be coupled to another. One discontinuity occurs though, at the point when we zoomed into the human/ housing scale of the brief. As previously mentioned, a synergy of CA/ swarm/ ecologic parameters generates the morphology on a semi-urban scale (the cell size as discussed below corresponds to a minimal housing unit). After having established the macro scale for housing clusters, a separate program reads the clusters into a new CA and performs a ‘fractal decomposition’ on the clusters. The CA changes into a hybrid of semi-globally/ semi-locally steered model of simultaneous interactions and can thus not be described as a CA in the orthodox sense anymore. On the other hand, we attempted an integrity over scales by using related techniques that would still base themselves on the same geometrical elements as well as related local evaluation processes (as described below, there are two types of transition rules for CAs; on both, the semi-urban scale and the human/ housing scale the voting rule as been applied as transition functions).



4.2 > linking site and models – the semi-urban scale

4.2.1 > CA

To start with we divided the site into three layers of cubic cells, the size specified to serve in later stages as minimum housing units. Each cell would be read in by the program and filled into an array position of the CA. The site boundaries are also translated into cells that form the static edge cells of the CA. The edge cells contain the existing information of land-use around the site whereas the cells covering the site itself are set to a generic neutral state.

Two types of transition rules exist for CAs: the counting rule and the voting rule. The counting rule needs pre-established values from its neighbours in order to instruct the transition of the state of the cell whereas the voting rule established proportions between the states of the neighbours and instructs the transition of the cell in question according to a resulting gradient. For our model we used the voting rule for state transitions since each cell carries percentages of various land-uses. Thus, the state of a cell depends on the proportion of the various percentages summed up.
The smaller the cell the more accurate its occupational value can be determined and the CA's *gestalt* on a global scale results more differentiated. Clearly, the size of cells generally relates to the overall size of the area of analysis in question and the statistical quality the cell should embody.

Four types land-uses have been identified for the gradients of the cell state:

- housing
- recreation (mainly outdoor activities)
- social infrastructure (kindergarten, shopping, etc)
- transportation (main roads)

Further a preferential matrix relates the types in an asymmetrical scheme to another:

housing:		+ recreation
		+ social infrastructure
		- transportation
recreational:	+ housing	
		- transportation
social infrastructure:	+ transportation	
transportation:	+ social infrastructure	
		- housing

During the evaluation phase of the CA, each cell sums up the total value of each land-use from all its neighbours and establishes the winning land-use. That final land-use will be the value the cell determines its state transition function upon. This transition is laid out in the above shown preferential matrix. If no preference is defined at all, the cell maintains its state.
Asymmetric preferences encourage emerging patterns of vicinity among occupation and reduce the amount of assumptions incorporated in the rules of the CA.

housing, social infrastructure, transportation, recreation

4.2.1 > swarm

The CA distributes locally information about land-use and sets up patterns of activity. However, it doesn't include transition functions based on climatic parameters, so as not to complicate the communication processes of the cells among themselves. Hence, we introduced the swarm as an equally parallel system that is synchronous to the dynamic update mechanism of the CA. On the other hand, the members of the swarm are not limited by the isometric array of the automaton and possess the ability to perceive global height, distance and direction (as a result of implicit local perception due to their relation to the swarm as a whole). Thus, they are capable of testing locations on the surface of the CA for exposure to sunlight and the rate of enclosure (used for protection against heavy winds predominant on the Tromso site).
The added-on capacity (since it isn't a basic quality of the simple swarm) is exploited to use the swarm members locally as fitness functions of the CA configuration. The swarm thus becomes a negotiator between the climatic global parameters and the local land-use preferential matrix of the cells.

Through the internal feedback of the swarm, idiosyncratic features of the site will be drawn out. Swarm members need to stay within 'visual' reach of their neighbours and average their direction of heading with these. Thus, if some members detect through deviant behaviour (i.e. 'being trapped' highlights difficulty of access or exit -> possible narrowness or enclosure of space) particular configurations in either morphology or neighbourhoods of cell states, these *problematic* configurations will be coupled with the climatic parameters more intensively, since the swarm would cluster its members in those locations [14]

4.2.2 > cooperative construction

To prompt a morphogenetic construction through the configuration of the CA, the ‘fitness’ tested by the swarm on the surface specifies what kind of transformation the swarm member will apply to the CA.
There is only one transformation the swarm member can exert which is the relocation of one cell of the CA. This transformation, or interaction with the automaton, is triggered by the occurrence of a combination of conditions on the surface:

If member situated on predominantly: housing cell
Then check for: shade condition

If member situated on predominantly: transportation cell
Then check for: wind condition

If member situated on predominantly: recreation cell
Then check for: shade & wind condition

If member situated on predominantly: social infrastruct. cell
Then check for: shade condition

If either of the conditions occur then the transformations will depend on the verification of a positive or negative outcome. Only if the outcome is negative (shaded or exposed to wind) will the agent perturb the automaton. In case of shading it will relocate the cell that is shading it to a new *lower* location within the cell’s three dimensional van Neumann neighbourhood. In case of exposure to wind, the member will ‘carve’ out a cell within its van Neumann neighbourhood and lift it to a new *higher* location. The shifted cell will carry its land-use percentages to its new location to preserve an informational balance within the automaton.
The aim of the shifting a cell downwards when in shade or upwards when exposed to wind, is the eventual emergence of an architectural configuration that will afford two key qualities of living in arctic landscapes

a) maximising the impact of sunlight when there is any during summer; also during winter, in complete absence of direct sunlight, a position is desirable which is surrounded by as many horizontal planes as possible because snow reflects light. Any light present in the context will be enforced by reflective surfaces. This observation allows us to test only months when sun is actually present since the same general (high) vertical positioning is aimed for.
b) minimising the impact of wind at any time. Cells will be shifted upwards since they will serve as wind shelters. If a irregular scattering of cells emerges, wind will be more successfully defended.

It is apparent that the swarm members are not directly communicating a coordinated sequence of spatial transformations but are prompted indirectly by the dynamic occurrence of a matter configuration combined with a climatic condition. Thus, the environment – here an architecture embedded in an ecology – becomes its own implicit indirect generator. As Theraulaz & Bonabeau reference Grasse: '*… in the termites, the regulation of the batisseuse activity did not depend directly on the insects, but of constructions themselves: the insect does not direct its work but is guided by him. Thus, any batisseuse activity of a termite in a point of space, producing a new material structure, involves the creation of a new stimulative form, which can direct and start in return a new batisseuse activity among other members of the colony. This process, called "stymergy" by Grasse, can lead to an almost perfect coordination of collective work,…*'[8].

Thus, the automaton and the swarm are mutually embedded while they are both situated in a local ecology. They constitute structurally coupled systems while remaining topologically/ organisationally invariant (Maturana & Varela, 1984).

4.3 architecturalizing clusters

At a smaller architectural scale, we are hoping to create internal configurations within the housing clusters that accommodate some qualities generally associated with good standard living quarters. These include privacy, yet platforms for social interaction with neighbours, well-being through light spaces, which encourages sanitary living situations.
Further, the clusters generated in the first stage are not to be dismantled and extensively fragmented since clusters promote structural adjacency. In other words, the more walls between housing units are shared, the lower the heat loss of the cluster. The housing schemes erected over the last three decades were not respecting the local climatic conditions. One of those conditions is the extreme cold during winter, spring and autumn months. One approach to energy conserving sustainability is the subdivision of wall surfaces.

Once the configuration of a site lay-out has been synthesized by the first program, a second program reads the housing clusters in and limits its search space to one constraint:

- accessibility of each cell within the cluster

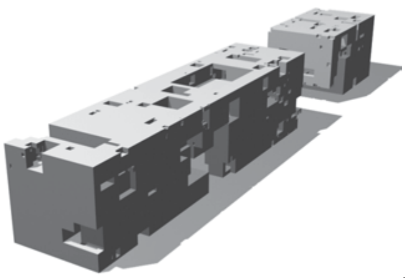
Since the clusters are made up of cells measuring minimal housing units (6*6*2.5 meters), a new iso-spatial array is populated with the solid cells. To achieve a reading and differentiation of accessibility of each cell in the array, we implemented two sequential processes that follow an initial investigation and establishment of which cells will serve as 'generators'.

4.3.1 decomposing the cluster

To establish the generators, which will serve throughout as a kind of local observes and determine for the neighbouring cells what kind of decomposition they will have to apply to themselves, the cluster will wrap itself with a layer of static cells that read as the perimeter due to their states.
The cluster then performs an evaluation of each cell that will count-up its neighbours relative density and stores the value as its own state. This density each cell calculates depends on the vicinity to open spaces, be they internal or external. The cells with proportionally the highest density values will be emptied (remove the solid but keep density value) and serve its neighbours as observers and instructors – the generators. The initial density is calculated based on a van Neumann neighbourhood function.

Next, a looped sequential process begins.
The first step calculates the relative accessibility of each cell based on Moore's neighbourhood function. Each cell's density value will be graded according to the number of empty neighbours.
The second step passes through the generator cells. Each generator checks the relative density of its neighbours in the Moore neighbourhood. The neighbour with the lowest density value constitutes the cell with the highest probability to an open and potentially external space. The cells with the highest probability of external access will be exploded into its six faces. The face adjacent to the generator will be decomposed.
Those two steps will be repeated until each generator's density value reaches a threshold. The threshold, a low value of density and therefore high probability of access for the neighbourhood, represents the halting function of the each generator independently.
If a cell has been decomposed more than three times it will become a generator itself and hence void.

The above described process forms a hybrid of a CA and the method of fractal decomposition. As in the CA a voting rule exists for each generator. The generators can only act locally and have no perception of the overall configuration of the cluster. Also, as in the CA both steps happen simultaneously. However, it is only the generators that are equipped with transition rules that they don't apply to themselves but to one neighbour in each generation. Therefore, the cluster can not be described as a CA.
The decomposition process is vaguely related to a paper given by Coates, Appels, Simon and Derix at the GA2001 entitled 'Dust, Plates and Blobs'[7].



T. Appels – fractal decomposition architecture

Appels generated architectural forms based on the formal position of the Belgian Theorist Van der Laan, using fractal decomposition. It has to be pointed out, that the decomposition process of the present work is not recursive yet creates self-similar resulting configurations.

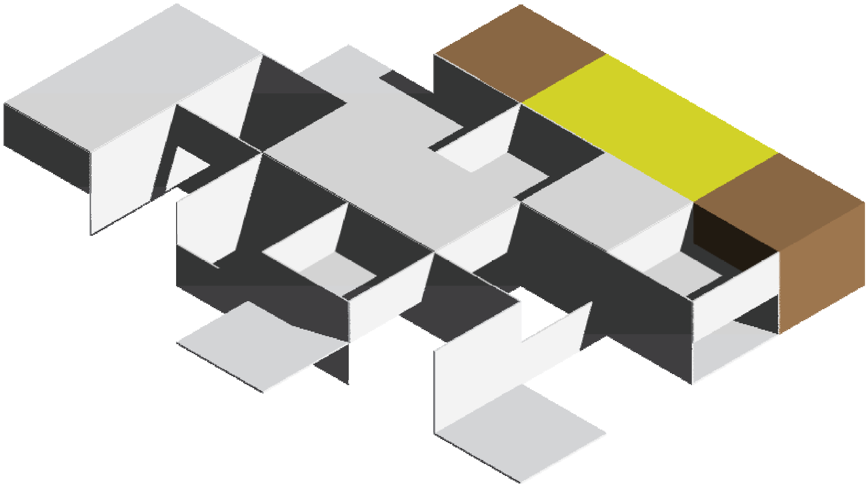
Apart from finding physical access to the cells and providing internal open spaces, this process entails qualities such private and public places within the clusters and allows for a hierarchy between them. It also generates interesting and varying light conditions inside the decomposed cluster. Thus, through interpretation of the emergent configurations we are able to compose living-space patterns of new typology, which on the other hand reflect the climatic and social conditions of the location (and the design brief).

5 > conclusion

The present work is in progress. The programs for either architectural scale are already in their final stages. Hence, we had the opportunity to test the first versions on generic sites.
One of the main intentions of the project is the incorporation of generative and evolutionary processes into the context of an industry's design brief without remaining at a very large and general scale. We are not necessarily interested in producing completely new tools or theories here but to check the validity of bottom-up design approaches to architectural and urban design. Clearly, the full range of constraints of the competition brief has not been applied and we are not under the illusion that every detail of a housing scheme could be resolved on the basis of generative processes.
The designer as in most generative design approach sets out the algorithms which the processes are based on. He needs to carefully determine which constraints are placed on the processes and of course which process is used. Finally, he slips back into the role of the observer and chooses which outcome to develop further. He therefore interacts with the processes and becomes part of the algorithm her/ himself.

As a first stab at working with a competition deadline, we had to find out how difficult the tuning between machine/ human processes is. It is very tempting to stop the machine when a result *looks* fabulous but the process hasn't finished yet, meaning the constraints have not been met. Only when the processes based on the fitness according to constraints come to a halt will the result be verifiable within the design brief… additionally checked by the observer's aesthetic perception.

Overall, emergent typological and topological configurations appear through the use of synergetic digital design, using the CA as a basis for morphological construction. In that sense a partial success. It remains to test the emergent typologies against the brief and to analyze the use and qualities of these generated spaces.



housing/ human scale hybrid CA initial test

7 > References

1. Prof Alan Feldt, ‘Community Land Use Game’, New York, Free Press, 1972
2. Hillier & Leaman, ‘Space Syntax’ in Environment And Planning B 3, 1978
3. Steadman & March, ‘Geometry of Environment, RIBA Press’, 1971
4. Cecchini & Rinaldi, ‘Building Urban Models With Multi-CA’, 1998
5. Haken & Graham, 'Synergetics - The theory of Cooperation', Umschau 6 (eds), 1971
6. Coates, Healy, Lamb, Voon, ‘The Use of Cellular Automata to Explore Bottom-Up Architectonic rules’, Eurographics 14th Annual Conference, 1996
7. Coates, Appels, Derix, Simon, ‘Dust, Plates & Blobs’, GA2001, Milan, 2001
8. Theraulaz & Bonabeau, ‘Coordination in distributed building’, Science 269, 1995
9. Bonabeau, Dorigo & Theaulaz, ‘Swarm Intelligence’, Oxford University Press, New York, 1999
10. Watanabe, ‘Induction Design – A Method for Evolutionary Design’, Birkhaeuser, Basel, 2002
11. Paul Valery, ‘Reflections on Art’ from Aesthetics vol. 13, New York, Pantheon, 1964
12. Maturana & Varela, ‘The Tree of Knowledge’, Goldmann, Munich, 1987
13. Coates & Schmid ‘Agent based Modelling’ ECADDE 1999 Liverpool
14. Carratza & Coates The use of swarm intelligence to produce architectural form’ GA 2000 Milan 2000
15. Coates & Thum ‘Parallel systems and architectural form’ Greenwich ‘Digital design studio conference’ Greenwich 2000
16. Nox Architecture ‘Off the road’ Arch+ 47 pp 78,79

Argenia Business Plan

Evaluation of opportunities in applying generative design approach for unique objects production

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Abstract

This business plan provides a blueprint for the launch and growth of Argenia concept. It will also serve to demonstrate the operational and financial viability of Argenia business.

- Argenia is the business of commercializing unique design objects by the means of generative design techniques applied to manufacturing and mass production.
- Argenia products will enter the market of fashionable design commodities where this technology can be applied immediately. The generative design technology will later be diffused throughout the entire range of design products as on going R&D and marketing analyses identify further avenues for profitable application of the concept.
- The generative design technology consists of software that can process and generate series of unique objects quoting every single part of the desired outcome. Once the design is complete all reference data can be wired to a numeric control machine which can be easily programmed to start up the production.
- The advantages of this technology include significant improvement in the design phase of the concept and the opportunity to quickly evaluate a possible set of solutions (kind of objects, not single objects) the producer wants to market. Nonetheless the uniqueness of the final product deployment, master database will always hold trace of the rolled out manufactured goods.
- This will lead to potential manufacturing cost benefits due to the reduction of time to market options and the scale production of artcrafts by the means of numerical machineries.

- The market for generative design objects spreads all over the commodity furniture to every other possible product used in the normal day time of a human being. Everything we use in our day by day activities can be turn into something unique and special.
- To serve this market by Argenia approach, we considered two strategic options: licensing and manufacturing. Manufacturing and marketing generative design products under the own banner involves considerable business risk and funding costs, which may be minimized by licensing and leveraging existing production channels (minimum start-up cost).
- We evaluated better to seek to license the patent to a major manufacturer in a mutually beneficial strategic alliance. Royalty income from this alliance will provide the necessary funding for ongoing R&D expenditures and patent protection. Year by year revenue flows are expected to grow from licensing due to higher sales volumes.
- Expected royalties total \$ 0,8 million for calendar 2004, with \$ 2,7 million in royalties expected over the first six years. This income can be applied liberally to R&D, a patent protection fund, and the commercialization of other products. Cash balances for the licensee manufacturer become positive after three years and cumulate to \$ 9,7 million over the six years.

1. Market Analysis

Economical key information

- In late 1978 the Chinese leadership began moving to a more market-oriented system;
- The result has been a quadrupling of GDP since 1978;
- In 2002, with its 1.28 billion people and a GDP of just \$4,600 per capita, China stood as the second largest economy in the world after the US (measured on a purchasing power parity basis);
- GDP: purchasing power parity - \$6 trillion (2002 est.);
- GDP - real growth rate: 8% (official estimate) (2002 est.);
- Inflation rate (consumer prices): -0.8% (2002 est.);
- Industrial production growth rate: 13.5% (2002 est.);

- Exports: $312.8 billion f.o.b. (2002 est.);
- Imports: $268.6 billion f.o.b. (2002 est.).

Import-Export with China

- Italy – China interchange:
    - Italian import: 8,3 billion Euro
    - Italian export: 4 billion Euro;
- Production cost in China is about equal to 1/3 of the Italian one;
- Labor cost in China is about equal to 1/10 of the Italian one;
- Electricity cost in China is about equal to 1/3 of the Italian one;
- Goods transportation cost for a container from Shanghai to Genoa is the same than from Genoa to Turin.

Most important evaluations

- Building and Construction is one of the leading Sectors for exports to China;
- Production of design objects can be made in China with a significant cost saving; transportation costs are not high for commercializing these products both in China and in Europe.

2. Strategic Options

Two main strategic options have been identified. Manufactured goods can be designed on the concept or license the technology to one or more current operators in the Chinese market.

2.1 Manufacturing

The manufacturing option would require Argenia to source large amounts of venture capital through equity or debt on the open market, or through a joint venture (perhaps with one of the current manufacturer). The capital would then be used to undertake the R&D necessary to identify the specific materials and associated requirements. The expenses of researching, designing and commissioning productions processes and tooling would be met. The manufacturing option would require that Argenia enter into a highly competitive arena with the current manufacturers, all keen to retain market share in a mature market. The business and financial risks of this option are substantial.

2.2 Licensing

Licensing, on the other hand, requires relatively little capital up front and would establish Argenia more in a strategic partnership than in an adversarial technology, with at least one of the Chinese manufacturers. Licensing will accelerate the spread of concept that soon can be seen as leading edge within the industry. It will also allow access to markets that would not be normally accessible. In other words, while it is possible to enter the market via the manufacturing option, it is not possible to introduce the technology to the major international markets and become a “must”. Licensing instead allows to simultaneously enhance the competitive position of its licensee while providing net gains to its owners. A licensee would build and stimulate demand, provide brand name recognition, share the costs of pioneering.

A large and financial strong licensee would also defend against the theft of intellectual property.

3. Marketing Strategy

Argenia marketing strategy is summarized in the following key points:

- Argenia acknowledges a primary and a secondary market for its technology.
- A company’s future primary market should be the one of manufacturers and wholesalers.
- The secondary market is the end-use consumer.
- The needs of the secondary markets have been discussed earlier in this report. In meeting secondary market demand, Argenia technology will be pulled through the primary market.

4. Risk Reduction Strategy

In defining Argenia market approach we paid attention to the risks that may threaten the viability of its operation. In the following the main risk reduction strategies are summarized:

- Intellectual property protection via patents, copyrights and design registration;
- Patent insurance and a patent defense fund developed income;
- Injunction readiness, with patent attorneys ready at a moment's notice;
- License structured to encourage rapid diffusion of the technology;
- Dividend policy to discourage exit of major shareholders;
- Continuing discussions with several designers to develop a diverse portfolio of technological innovations.

5. Financials

The following assumptions and facts impact the financial statements:

- All figures are shown in US real dollars;
- Revenues will begin to flow from licensing with a master contract agreement with a well established manufacturer. Steady growth of product sales will account for profitability of Argenia company and positive net income of licensee;
- Company policy is to avoid investment in substantial fixed assets, preferring to lease or hire such assets to enhance flexibility and conserve cash flow;
- Tax rates vary widely among jurisdictions and Argenia is presently unsure of its domicile for tax purposes. Argenia wishes to be a good corporate citizen but will nonetheless direct efforts to minimize tax payable. A conservative income tax rate of 40% is assumed payable once yearly;
- Argenia company will always have positive and substantial free cash flows from year one. Starting from year three even the licensee will perform positive free cash flows and positive Net Present Value (NPV) with Internal Rate of Return (IRR) as high as 63%;

5.1 Royalty income from licensing

It is expected that a commitment fee of $ 0,5 M will be received in 2004 upon contract sign up, followed by annually payments at the rate of $ 0.25 M per year for the remainder of years if licensee is selling up to 30,000/yr products (assumption) . Royalties will increase as the licensee exceeds the base sales levels of 30,000/yr (assumption) which have been established as part of the incentive royalty structure. The royalty structure is based on the licensee's wholesale sales and is designed to induce the rapid diffusion of the technology across a wide range of products i.e., the use of a high minimum payment with a reduced royalty rate as volume increases (over 50,000 sales/yr. While our research determined that license fees for proven technology vary from 5% to 8% of wholesale prices, the financial projections are based on more conservative royalty rate of 2%. These rates may be exceeded in negotiations with licensees.

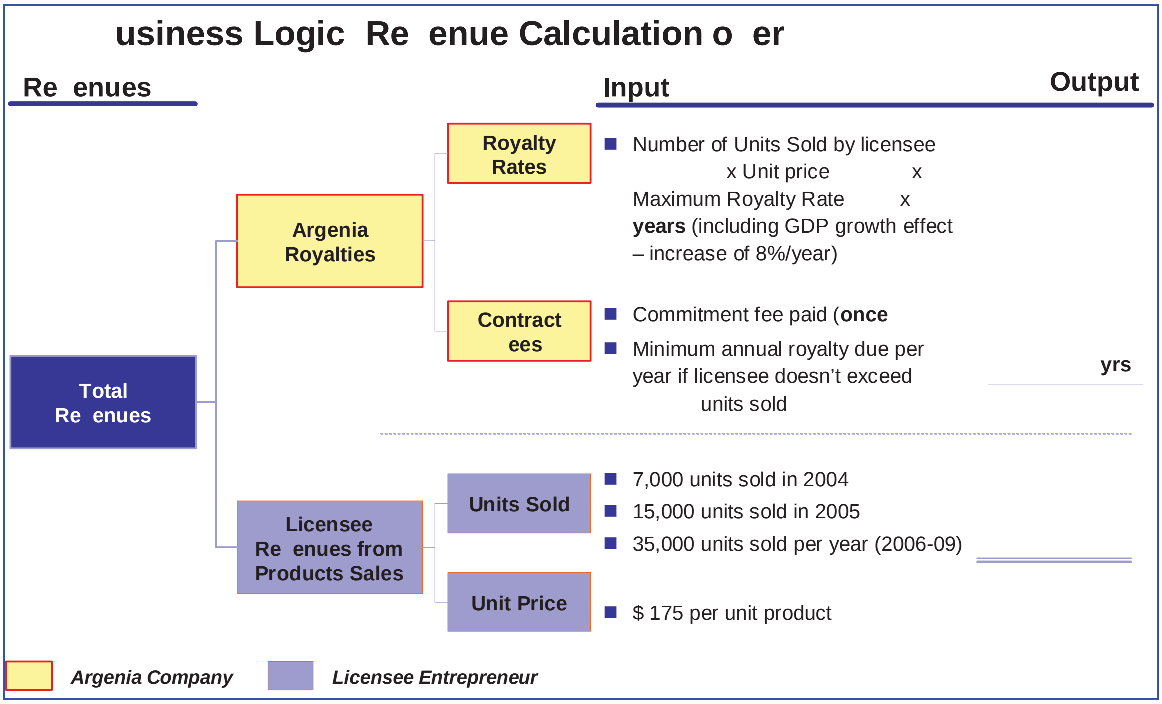
5.2 Income from manufacturing

- We found that the key drivers leading to manufacturing consistent revenues can be identified in:
    - Volumes of units sold;
    - Price per Unit.

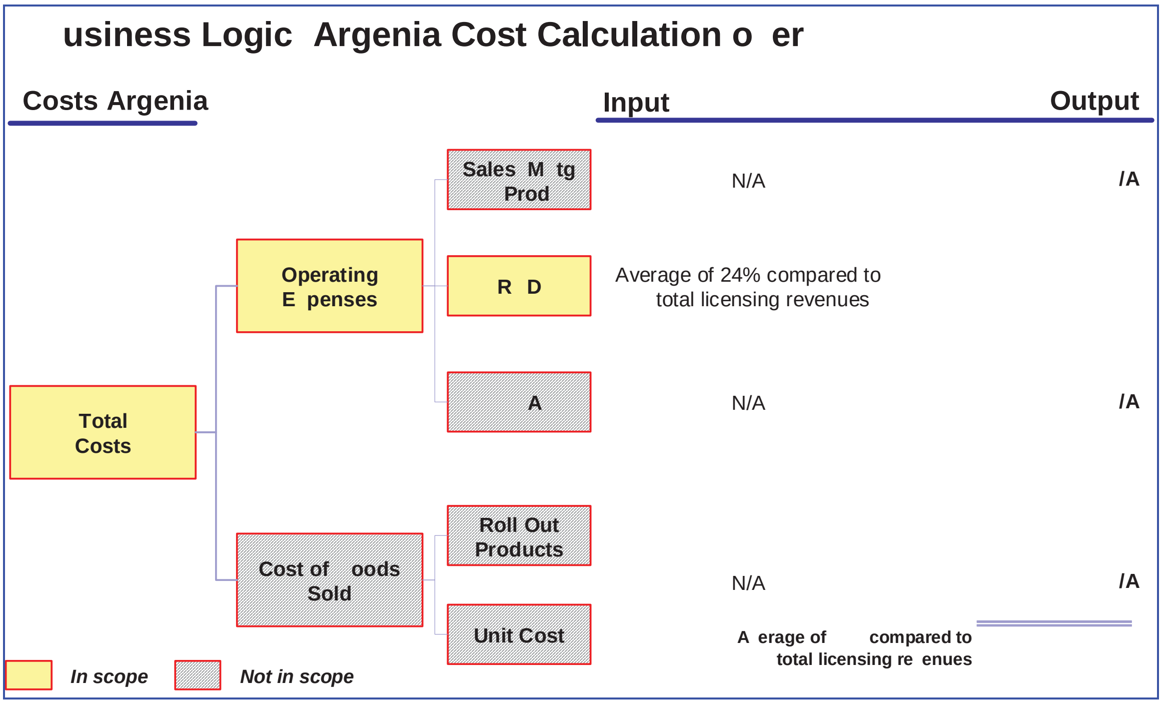
- In order to gain adequate and profitable positioning volumes should be as high as 35,000/year and the average wholesale price should be ranging from $ 150 to 200.
- We run a scenario driven analysis upon which it will be possible to target our production/marketing effort being reasonably safe on the financing side of business.

5.3 Revenue and Cost calculation

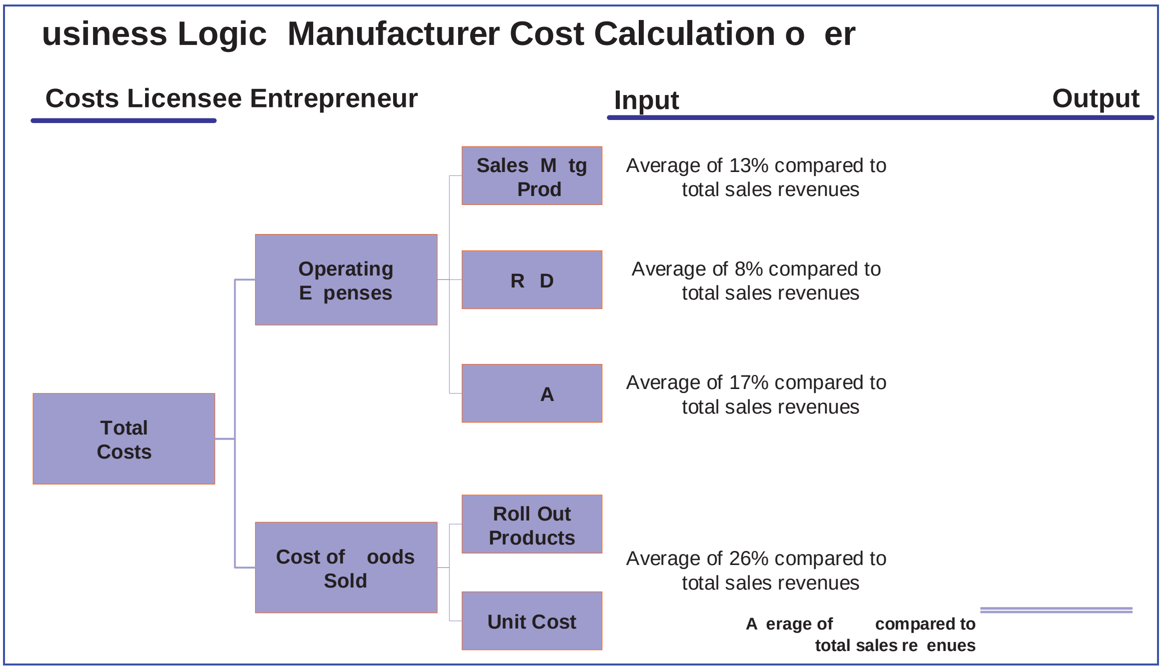
In the following picture Revenue Calculation over 2004-2009 is described, for both Argenia and Licensee Entrepreneur (Manufacturer).



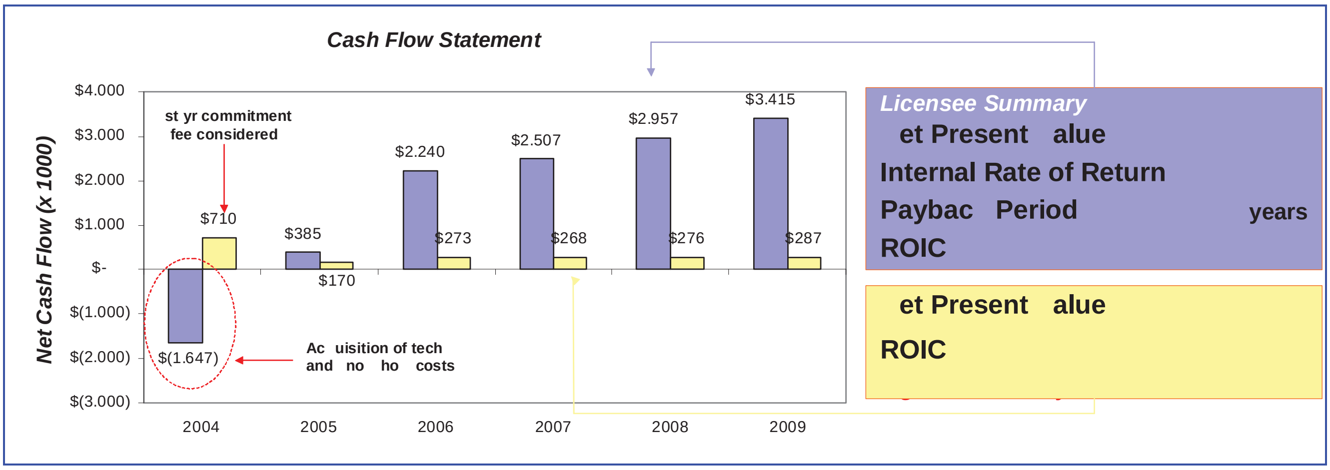
This second picture describes the cost structure for Argenia.



Licensee Entrepreneur will also have to manage start-up and operative costs as described below.



Our scenario analysis led to the results shown in the next picture in terms of net profits (revenues-costs) for the timeframe 2004-09. You can see both profits earned by the licensee who produces the Argenia objects and by Argenia company gaining the royalties according to the model discussed before (fixed plus variable royalties according to sales volumes).



Our estimation is based on the following **assumptions**:

- Pre tax Free Cash Flows (Revenues minus costs);
- 7,000 units sold considered in 2004;
- 15,000 units sold considered in 2005;

- 35,000 units sold considered in 2006 and growing for the subsequent years at GDP level;
- 191,000 units sold over six years timeframe;
- Unit Price $ 175;
- Licensee Investment: $ 2,2 M;
- Argenia Investment $ 0,41 M;
- Production costs decrease from 04 to 06 due to scale effect.

6. Business Plan Main Evaluations

This business plan provides a feasible option to start up the industrialization and commercialization of Argenia based products. Artwork may now be considered a possible generator of profitable business.

- Investment in Argenia technology can be profitable for both Argenia crew and licensee entrepreneur adopting a coupled licensing and manufacturing strategy.
- Conservative hypotheses on costs and revenues structures have been considered such as high start up costs and relatively small number of products to break even.
- Cash flows are positive for Argenia crew and become positive after three years for the Licensee and yield to positive NPV's and IRR's for a wide range of scenarios.
- China with its dynamic environment (8% annual GDP) and huge potential market definitely needs to be addressed to exploit Argenia based sales.

Dress Codes:
work environments – wearables – protective wear

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Abstract

In the age of digitalisation, knowledge and resources are stored in computers and available to anyone at any time, and workday rhythms as well as our work and leisure schedules have changed. But the effects of the digitalisation go far beyond just the modification of our workday. Significant social effects and the impact on the design of body environments – let it be fashion or the work space - are interacting with this changing society.
Yet, looking at the trends, discernable in interior and fashion design, we see a mixture of 50’s futurism and 70’s plastic flower power, with a dash of the 60’s for the “Average Consumer”.
It seems a contradiction: we live in an era where digital appliances and equipment dominate home interiors and the workplace, but our design reality obviously comes to be through the reproduction of the past.
In designing new utilitarian articles, we connect current thinking and culture with earlier generations of thinking and designing. Yet, the “digital way of life” is not merely restricted to the visual, but incorporates relationships of experiences. In this post-material cult of the “real self”, design focuses on two interfering phenomena: the multitude of real or visionary environments and trends touching the notion that the traditional formal and physical design has to be extended.
This paper deals with the question of materiality and virtuality.
By going back in time in a first step, I come to the roots of use and application. To explain the false materiality of things as a vehicle brings us to the “post material cult of the real self” of designs. Examples of developments throughout the ages - interior design and fashion design – underline the thesis of a new dress code.

1. Back to the roots

During the renovation of its main building, Weimar's Bauhaus University decided to restore Gropius’ Director’s Room as a usable working room. The Director’s Room only existed at its original location during the period between the great Bauhaus exhibition in the summer of 1923 and the departure of the Staatliches Bauhaus's teachers and students in April, 1925. Subsequently, the furnishings were removed with the furniture going along with the Bauhaus to Dessau.
In the art historical sense, this room represents an important achievement of Weimar's Bauhaus period since the room presents a new kind of what the Germans call “Gesamtkunstwerk”: a complete work of art.

The ideology of this modern architecture had a rather paradox character. It was created from a striving for the essential, with no aesthetic references to the past, though still giving the impression of being intentionally “stylish”.
In his book “From Bauhaus to our house” Tom Wolfe points out the crucial problem of this ideology [1]. The first Bauhaus postulate, being “non-bourgeois” can hardly be maintained in daily life. People tend to “personalize” space, as seen in the Gropius room as it was in its original state: with the table cloth and cushions.

This aspect is important when creating visions that have to be translated into the “now”. Then, talking about vision and reality, the first question is how many utopias have in fact become a reality. And for those that did, *when* did they become a reality?
A vision is not yet understood machinery, a desire. Tracing the roots of technology, it is useful to regard the Kapp theory in „Philosophie der Technik“ from 1877 [2]. Kapp states that every tool is an organ projection. Tools produce new tools and those tools include a projection that man cannot define any more. It is what Kapp and Freud call the „unconscious“. This „unconscious“ should be understood as „not yet understood machinery“. Freud adds that the fulfilment of this desire to perfection makes man to a prosthesis god, but that at the same time man has problems with those artificial organs.
Examples from the year 1883 show, that the design of those tools is touched by the fact that, in daily life, we attempt to adjust our environment to our needs and desires, but cognitively we adjust our expectations in order to orient ourselves in our world and survive in daily life.
This adjustment in two directions acts when designing new utilitarian articles. We connect current thinking and culture with earlier generations of thinking and designing.

The same development can be seen in the world of wearable computers.
Perhaps wearable computers are not as ground-breaking a technology as is commonly supposed. History gives us examples of a technology that evolved physically from immobile to portable to wearable, that employed a variety of user interfaces, and that revolutionized cultural conceptions.
An example for this is the „Berlin Golden Hat“. A prehistoric hat, used for ceremonies, manufactured by a blacksmith in the period of the „urn fields“, (die Urnenfelderkultur) between 1300 and 800 b.C. It measures about 75 centimetres, decorated with suns, moons and stars. The shape reminds us of a real wizard’s hat as we know it from fairytales and Harry Potter. It had a strap for the chin – and even textiles: with lining inside, as experts found out.
The symbols on this hat were used as a logarithmic table to calculate the lunar solaric calendar. The Berlin Museum Director Wilfried Menghin said about this hat, that „..Who owned the hat and who knew how to decode the symbols, controlled time and was the leader of the cult community“.
It is indeed about the decoding and cult community. Modern wearables are tools, but define themselves less as “solid objects” because they embody the virtual. So we should regard them more involved in actions or processes.
The wearable community is the visualization of the relationship that man has to his tools. In spite of Steve Man’s intention to create wearables that are, as he mentioned it “less off-putting to others”, it is not taken into account that wearables have to have a certain aesthetic value. The designs the Wearable Community works with are mock-ups of the technically possible, but in no way intend to be trend oriented accessories that the end users want them to be.

2. Plug & Play

So we have a false materiality as a starting position, and as a next step in development we might have a situation of surrealism: the negation of the actual function, converting to the non-identity. One could say that this is “surrealistic” and I would like to call it the “Nintendo Effect”. This is based on the idea of modules in the broadest sense of the word. Utilities become temporary und multi functional. The product that is used for “Plug and Play” is only a reference to itself - the mobile phone is the clearest example of this process.
Much of our technology was intended multi-functional in their start. The earliest watches date from about 1500-1520 and were worn around the neck. These were called “musk-ball watches,” after the spherical metal perfume containers that early watchmakers fit the clockworks into.
Multi functionality is the dynamic process of conversion and adaption of fashion and technology. “Plug and Play” carries out the principle. Combining as you wish leads to multiple identities of designs. But *how* it is combined, is often a question of secret codes - only who knows how to decode the symbols, controls and is the leader of the cult community“.
The multi functionality of design objects turns them into modules, and Plug and Play refers to the individual in this context.
The Italian couple Rivetti founded CP-Company. They create waterproof capes that can become tents kites or hammocks, jerkins that can become armchairs. The transformables open the way to a new type of accessory for life in the metropolis. These are not just clothes, they are spatial extensions of the human body, prostheses (which again refers to the Kapp theory about organ projections), that enhance the ability to survive outside the tribe and the herd.
Then, obviously our society needs life support systems, existential equipment for endless voyages.

3. Protective Wear

Jeremy Rifkin describes that information technology „has the potential to release and destabilize civilisation“ [3].
The Camera Performances of Steve Mann demonstrate the other aspect of wearables being a social phenomenon: they are, beyond the available fashion language, a social borderline experience in that they regulate expressiveness and define new conventions. In his work he points out that the right of freedom of information and of expressing oneself in public requires one to be very critical with the so-called „freedom of expression ".
Steve Mann’s statement: “Much of my passion has been fuelled by a desire to restore some balance of privacy in a world where individuals are increasingly affronted by government surveillance and corporate encroachments” [4].
Not to be seen, and refusing to be identified in public places and the protection of the individual are the goals of Vexed Fashion. Their design is based on the principle "protection against unwanted intrusion" and a good example of how fashion trends and social trends interact. Vexed extends the traditional formal and physical design of fashion. They move forward to a world where the interchange of information is one of the driving forces, and fashion becomes concept-oriented.
With view on the recent developments on security (passports with biometric data, surveillance cameras in public space) this topic will further on be a main theme in design.

4. The post material cult of the real self

With a digital reality, the distinction between real and unreal vanishes and it leaves us with products that have multiple or uncertain identities. Interiors in the digital way of life are not merely restricted to the visual. They incorporate relationships of experiences. And this is what I would like to call “The post-material cult of the real self of designs”.
Rooms interact and melt with bodies: the shell becomes the supporting element in managing every day life, nomadism becomes the norm.
The “post-material cult of the real self” is evident in fashion and interior design: everything is temporary or preliminary, no preferences or decision on taste identifies the “ich” or “I”.
Fashion underlines this trend. The designer Chalayan defines „wearable for daily life“ or „a wearable“ as something that allows for the exchange between the immediate environment and the body. Essential in the work of creators like Issey Miyake or Chalayan is the heuristic element in design, to create behavioural patterns and even “design” a spirit, rather than just dealing with the physical world. In the A-poc (a piece of cloth) project, Miyake produces rolls of fabric that hold complete clothing ensembles, including a wallet, a bag and a hat [5].
But the design process in those pieces is not finished yet. This multi-optional collection only finds its final shape when it meets the future wearer. This person has to take over responsibility, which means he or she has to decide what will be cut out.
These pieces of work constantly recreate the foundations of design. They visualize the fundamental changes in our society and offer innovative solutions with aesthetic power – and it is noticeable, that the above mentioned designs are created for the digital society, without having the slightest touch of computer technology in them.
Also the new work places symbolize the transition from an organic, industrial society to a polymorph information system. As a first step, this system has no shape, but just a function.
After the false materiality through the negation of the function we are coming to a certain post materiality, e.g. blue tooth. Data transportation systems have no body, they have a function. Only the additional embodiment will give it an identity, so we deal with a new physical reality and a new physical appearance. And this might include less „hardware“, because it is concentrating on conducting processes. As a result of true innovation, these designs have an inner logic.

Last but not least, it is all about acceptance and that has to do with culture.
Spiritual and bodily openness has changed considerably during the last years [6].We now deal with a new acoustics a new visuality, a different psychological and reduced aesthetical need for keeping one’s distance. Having continual access to communication systems means we are multitasking, even while having a face-to-face conversation. Users develop new forms of social behaviour that, to outsiders, may seem strange or even rude.
In the end, it are social-political conventions that determine use, form and size of tools and environments. An interesting analogue example of size and miniaturization is that watches became bigger when they became more accurate. Not because the improved mechanisms were more difficult to fabricate, but because of the desire of “being seen”. The form is also determined by the function in a social context.

Yes, the globalisation has changed public perceptions – on one hand. But a necessary prerequisite for innovative spaces is that culture and technology become compatible and this is a regional question. Cultural influences determine the logic of action, producing standardized systems will not be enough for getting them to function or for solving problems.

References

[1] Wolfe, T., *From Bauhaus to our house,* Bantam, 1999
[2] Kapp, *Grundlinien einer Philosophie der Technik. Zur Entstehungsgeschichte der Cultur aus neuen Gesichtspunkten*, Braunschweig 1877
[3] Rifkin, J., *The end of work: The Decline of the Global Labor Force and the Dawn of the Post-Market Era.* New York, 1995
[4] Mann, S. "Cyborg seeks Community" in www.wearcam.org/shootingback
[5] Vitra Design Museum *A-poc making,* Weil am Rhein, 2001
[6] Sennett, R., *The Fall of Public Man,* Alfred A. Knopf, Inc., New York, 1976

Being Kasimir Malevich: a reflection on computational creativity

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Abstract

Recently, evolutionary art systems have been suggested to simulate some kind of creativity in computers. Here, a reflection on computational creativity is presented, mentioning classic and historical aspects and showing results of evolutionary art systems. Strong and weak features of these kind of systems are approached.

Introduction

How can computers have anything to do with creativity? The first person to denounce this apparent absurdity was Ada, Lady Lovelace, the friend and collaborator of Charles Babbage [1]. She realized that Babbage's "Analytical Engine" – in essence, a design for a digital computer – could in principle "compose elaborate and scientific pieces of music of any degree of complexity or extent." But she insisted that the creativity involved in any elaborate pieces of music emanating from the Analytical Engine would have to be credited not to the engine, but to the engineer. "The Analytical Engine has no pretensions whatever to originate anything. It can do [only] *whatever we know how to order it* to perform", she said.

The Analytical Engine was never built but Babbage recognized that, in principle, his machine was capable of playing games such as checkers and chess by looking forward to possible alternative outcomes based on current potential moves. Turing [2] countered Lady Lovelace's argument by equating it with a statement that a machine can never take us by surprise. But he noted that machines often act in unexpected ways because the entire current state or initial condition of the machine is generally unknown; therefore, an accurate prediction of all possible behavior of the mechanism is impossible.

But, until the present moment, it is not possible simply to say to a computer to "compose" or "paint". Let us discard the interface problem, and suppose that someone may sit at the computer desk and simply type or select a command like "paint" or "compose". One might say that even a person could ask "what" to paint or compose. How a medium person would answer to a general request for painting or composing? To be short, let us suppose that the required person would be able to create some compositions, trying to discover if he or she was pleasing. Can this human behavior be simulated in a computer?

1. Evolutionary Art Systems

A new generation of computer researchers is discovering that by using simulated evolution techniques it is easy to obtain novelty – often complex novelty – but it is correspondingly difficult to rein in the direction that novelty takes. These type of systems are commonly known as *evolutionary systems*. The loop in an evolutionary system is a rather simple one: *generate, test and repeat.* Basically, a bunch of things is made, tested according to some criteria and the ones that are better are kept.

The process is repeated by generating a new bunch of things – or *population* of any kind of objects - based on the old ones [3]. The loop continues for possibly many generations until the things that are being made are good enough according to the criteria being used. When an evolutionary system is applied to generate objects in the artistic domain, it is called *evolutionary art system*. Since it is difficult in the visual domain for example, to measure the aesthetic success of simulated objects or images automatically, the fitness is provided interactively by a human user based on visual perception [4]. Typically, in this kind of system, the generated frames are simultaneously presented in the computer screen for aesthetical evaluation.

In the musical domain, the temporal nature prevents the compressed, parallel presentation of individuals. First, musical objects cannot be presented in a compressed form without distorting them. The musical analogue to a reduced image would be a sped up musical sample. Even if the correct pitch is preserved, the tempo would be altered, which certainly changes the perception of a piece of music. The second problem is that multiple musical samples cannot be presented concurrently without obscuring the identity of each individual. The eye can focus on one image at a time, but the ear cannot isolate one melodic line from a randomly contrapuntal piece of music [5].

Even more ambitious is to replace in the process the human interaction by automatic critics trained using easy-to-collect examples. Baluja, Pomerleau, and Jochem [6], for instance, working in the visual domain, have trained a neural network to replace the human critic in an interactive image evolution system. Gibson and Byrne [7] suggested a very similar approach to generate very short musical fragments. The network “watches” the choices that a human user makes when selecting two-dimensional images from one generation to reproduce in the next generation, and over time learns to make the same kind of aesthetic evaluations as those made by a human user. When the trained network is put in place of the human critic in the evolutionary loop, interesting images can be evolved automatically.

2. Simulating Creation

But things are not simple. Let it be the famous Malevich painting, The Black Square on White Background [8]. This example was chosen simply because of its technical simplicity; it will not be considered the context and historical moment in which it was created. Kasimir Malevich was the artist who most embodied a new segment of modern art, the Suprematism. Malevich’s geometry had as starting point the straight line, the maximal elementary form that symbolised the human ascension over the chaos of Nature. According to him the square was the suprematist basic element, the seed of all the others suprematist forms. His own movement of Suprematism enabled him to construct images that had no reference at all to reality. Great solid diagonals of color in *Dynamic Suprematism* floated free, their severe sides denied any connection with the real world, where there is no straight lines.

Suppose, for example, that Kasimir Malevich knew about an evolutionary art environment, and decided to try it. How does this kind of system work? Most evolutionary art system tend to resemble each other closely. They all generate new forms or images from scratch (random initial populations). They rely completely upon a human evaluator to set fitnesses for each member of the population – normally based on aesthetic appeal. Population sizes are usually very small (often less than ten individuals), to allow them all to be quickly judged every generation. User interfaces are often similar, with members of the current population shown on the screen in the form of a grid, allowing the user to rank them, or assign fitness scores by clicking on them with a mouse [9].

Let it be an evolutionary art environment such that it generates frames of geometric primitive (line, rectangle, circle, arc) compositions to be evaluated by the user. Suppose that Malevich decided to generate a composition like the Black Square. A possible description for that composition could be: a square frame, with white background, with a black square with size of about 80% of the frame, in the center. Let this composition be called Malevich'. Malevich would have good chances of obtaining a result as presented in figure below, after having selected values (*rectangle, white, 1, black, solid*) for parameters as (*format, background, object number, object color, texture*). In this particular environment, it does not exist the "square primitive", only rectangle. So, the rectangle will have to "evolve" to a square.

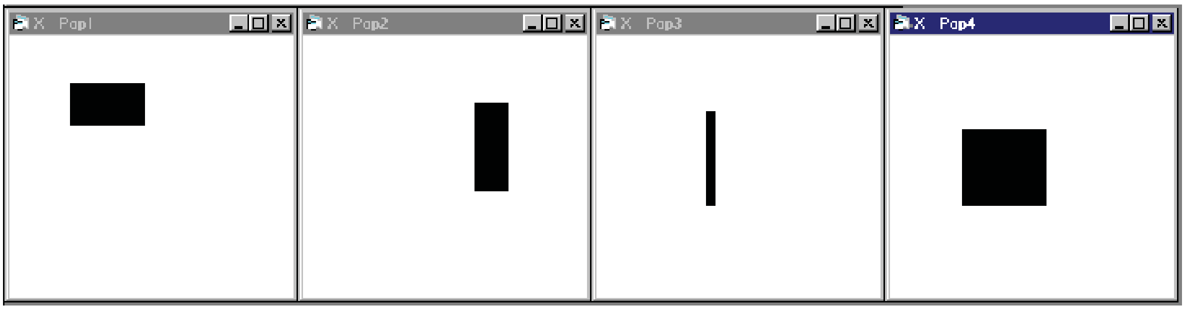

Fig. 1 - Resulting frames from an evolutionary art system, instantiated to generate one black rectangle on a white background.

The set of possibilities resulting from this parameter choice in that evolutionary system contains all the black and solid rectangles on white square frames, and this set certainly contains the Malevich' composition. One could reply that it is possible to simply write a program that attends these constraints. It is really simple, but this is not the intention. Here, the intention is to reward the system whenever it presents a composition closer to Malevich's Black Square, or any other desired. In case of figure 1, the highest note would be given to the right frame. How many interactions would be necessary to obtain Malevich' composition? After fifty interactions, the obtained results are presented in figure 2: the process may be boring.

Fig. 2 - Resulting frames from the same evolutionary art system, after fifty interactions.

It is possible, still maintaining the initial goal, to program an evaluation mechanism in the system, or an automatic critic, that rewards the generated figures by attributing a score to a composition, according to its resemblance with Malevich's Black Square. In this way, it is possible to realize a *simulation*. In one of the simulations, an evaluation of 9.74 (in 10) was obtained in 18 iterations. But to reach the evaluation of 9.99, 1789 iterations were necessary in one simulation, less than 1000 iterations in another; more than 6000 iterations in still another and surprisingly, in another one, the score 9.9 was obtained with 175 iterations.

The evolutionary art system, a population-based search device, was evolving *pictures*. A *chromossome*, described by the selected values (Square, White, 1, Black, Solid) was associated with each picture, as well as others values were associated with the object's dimensions (in this case, only one square object). The initial pictures, randomically generated, might be closer or farther from the objective picture, the Malevich' composition. *Mutation and crossover* operators were applied to the best evaluated pictures, and the results were better or worst. The computational environment did not favour specifically this kind of composition.

Despite of the fact that the evaluation function considered the centralisation of the figure or, in other words, there was a *selective pressure* [10] to centralise the black square object, there was not any specific information in the chromosome specifically addressing the centralisation, or similarity. In other words, the result was reached without the object's chromosome have in itself a basic information as "centralised". The evaluation for the selection was based on the appearance (*the phenotype*) of the object, no information concerning similarity existed in the chromosome (*the genotype*), and the result *emerged,* approaching the objective, simply because of the selective pressure. Even without being part of the genetic code, phenotype characteristics were transmitted to the breed. But, because they are not part of the genetic code, these characteristics can easily disappear.

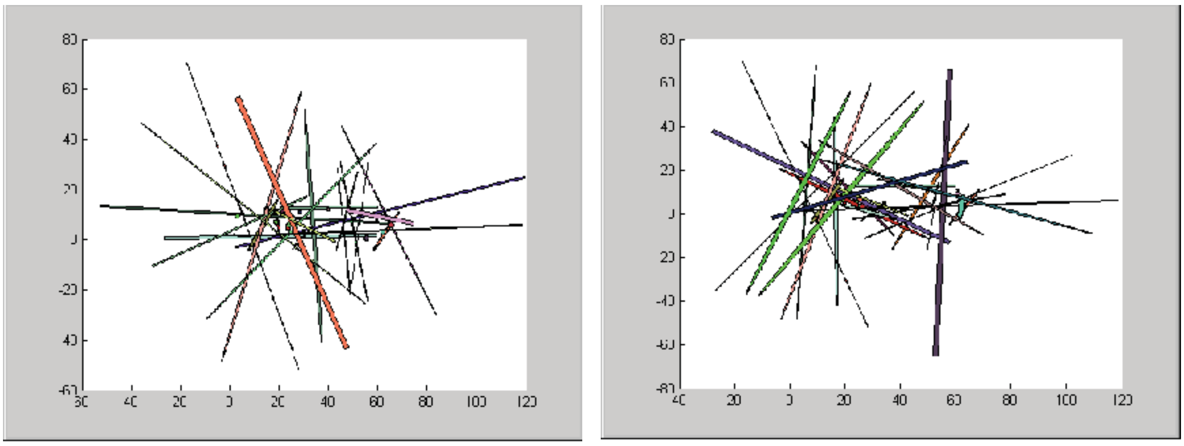

Fig. 3 Frames generated with the same kind of programming rules.

But, if so hard was to obtain the Malevich' composition in that system, the same kind of programming rules immediately generated the pictures in Figure 3. Much more complex compositions were "spontaneously" generated. Probably, Malevich would enjoy to explore this kind of composition, it has some similarity with Malevich's paintings, like the one presented in figure 4. This was the kind of figures for which the system was designed to generate. So, can the computers be creative? The generative potential of a system is not always obvious. The computer can realise tasks that were not explicitly ordered and often fails in realising tasks that were supposed to have been well specified. All the details in the frames of figure 3 were not specified, while a lot of information was supplied for generating Malevich' (the Black Square on White Background) composition.

3. Creativity and Machines

How compelling are the arguments against machine creativity? The claim that computers cannot be creative turns out to be a cluster of related claims. A common version is that they cannot be creative because they merely follow instructions. But sometimes people are *instruct*ed to be creative. Pope Julius II instructed Michaelangelo to be creative when he painted the Sistine Chapel ceiling [11]. So it is possible both to be creative and to be following instructions. The reply to this will probably be that Julius only gave Michaelangelo very general instructions, and left the rest to him, whereas every single thing that a computer does is something that it was told to do. But in fact we do not instruct computers in every action that they perform. This would require us to give them millions of instructions per second. The reply may now be that everything that they do *follows from instructions* that we give them. But what does this mean? If it means that the machine's performance literally follows from its instructions then it is false, for if we wrote all the instructions on a piece of paper, nothing at all would happen. Presumably it means that computers are designed to respond in a predictable way to their instructions. But even this isn't clear. Does it mean that computers are predictable, in the sense that we can predict their output given their input plus an exhaustive account of their innards? Or does it mean that *we* have designed the innards, so that the creativity is really ours? There is a general perception that computers cannot be creative.

Fig. 4 *Suprematist Painting* by Kasimir Malevich, 1915-16. Oil on canvas, 49 x 44 cm (19 1/4 x 17 3/8 in); Wilhelm Hacke Museum, Ludwigshafen

Lady Lovelace said that computers "have no pretensions to *originate* anything". This, too, has taken root in our culture, so that we tend so that we tend to believe that human beings can be described as being machines, to believe that people are machines, but also that machines cannot do something which is characteristically human. There are in fact two intuitions here. If machines cannot be creative, then (a) they cannot be intelligent, and (b) people (who can be creative) cannot be machines. If machines cannot be creative, then they cannot have "minds of their own", in the sense of being able to generate their own ideas, and it is difficult to see how a system that cannot generate its own ideas can be intelligent. This would be the end of Artificial Intelligence researcher's aspirations to develop intelligent machines.

But, if creativity is not a computational process, it might still be possible to *simulate* it computationally [11]. According to Margaret Boden [12], there are three main types of creativity involving different ways of generating the novel ideas. The first, the *combinational creativity*, involves novel (improbable) combinations of familiar ideas. The second and third types are closely linked, and more similar to each other than either to the first. They are *exploratory* and *transformational* creativity. The distinction between an exploration and a transformation is to some extent a matter of a judgement, but the more well defined the space, the clearer this distinction can be. Evolutionary computation is a population-based search engine since it works all the time with a bunch of things, and is certainly a very strong exploration tool. The mutation operator also contributes to exploration. Moreover, because of the crossover, is also combinational and this puts it very close of a transformational tool. So, evolutionary algorithms seems to fit very well to simulate creativity.

Conclusion

Evolutionary art systems supply an environment for creating and exploring novelty, often complex novelty, without requiring human understanding of the specific process involved. Combining evolution and learning can allow a system to "learn" about human aesthetics from the user. Certainly, to teach a system to create visual compositions like Malevich, for example, does not make the system "a Malevich". But, in the same way, to teach a human to create visual compositions like Malevich does not make him "a Malevich". But both of them can surprise us with unexpected results.

References

[1] Boden, M. "Creativity and artificial intelligence", Elsevier Science: Artificial Intelligence 103 pp. 347 – 356, 1998.
[2] Turing, A. M. "Computing Machinery and Intelligence", Mind, Vol. 59, pp. 433 – 460, 1950.
[3] Todd, P. M. & Werner, G. M. "Frankensteinian Methods for Evolutionary Music Composition" em Griffith, N. & Todd, P. M. (eds) *Musical Networks: Parallel Distributed Perception and Performance*, Cambridge: The MIT Press, 1999.
[4] Sims, K. "Interactive Evolution of Equations for Procedural Models", The Visual Computer, 9: 466 – 476, 1993.
[5] Moroni, A., Von Zuben, F.J. & Manzolli, J., "ArTbitration: Human-Machine Interaction in Artistic Domains", Leonardo, 35(2), pp. 185 – 188, 2002b.
[6] Baluja, S., Pomerleau, D. & Jochem, T. "Towards automated artificial evolution for computer generated images", Connection Science, 6(2 – 3), 325 – 354, 1994.
[7] Gibson, P. M. & Byrne, J. A. "NEUROGEN, musical composition using genetic algorithms and cooperating neural networks", London: Proceedings of the IEE Second International Conference on Artificial Neural Networks, pp. 309 – 313, 1991.
[8] Malevich, K. http://www.ibiblio.org/wm/paint/auth/malevich/sup/malevich.black-square.jpg, 1913.
[9] Bentley, P. & Corne, D. (eds.) *Creative Evolutionary Systems*. San Francisco: Morgan Kaufmann, 2002.
[10] Dawkins, R. *The Blind Watchmaker*. London: Penguin Books, 1991.
[11] Dartnall, T. (ed.) *Artificial Intelligence and Creativity: an Interdisciplinary Approach*. Dordrecht: Kluwer, 1994.
[12] Boden, M. "Creativity and artificial intelligence", Elsevier Science: Artificial Intelligence 103 pp. 347 – 356, 1998.

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The generative approach in the Botta's San Carlino

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Abstract

The aim of this paper is to describe the origin of the wooden model of the **San Carlino** (1999) located in Lugano, and realized by the Swiss architect Mario Botta.
To introduce it, we will describe the Baroque style, the importance of the mathematics in the Baroque architecture, and the characteristics of the Borromini's church named *San Carlo alle Quattro Fontane* (1638-1641, Rome). After, we will explain the Botta's wooden model conceived to commemorate Francesco Borromini (1599-1667). It is an example of a new kind of monument. The starting point for our investigation has been to consider the Baroque characteristics of the Borromini's project and the generative approach that Mario Botta has used to conceive and to plan the wooden model of the San Carlino. For example:

- the metaphors,
- the dialog of the context,
- the territory of the memory,
- the fragment to describe an architectural work.

Mario Botta using this approach in his San Carlino has obtained a symbolic and unexpected home coming of Francesco Borromini in his territory.

1. Introduction

The Baroque (1600-1750) was born in Italy, and adopted in Germany, Netherlands, France, and Spain [Schneider, 2001]. The term "Baroque" was probably derived from the Italian word "barocco", which was a word used by the philosophers during the Middle Ages to describe a hindrance in a schematic logic. After, this have been used to describe any contorted process of thought or complex idea. Another possible meaning derives by the Spanish "barrueco", Portuguese form "barroco", used to describe an imperfect or irregular shaped pearl. This word has survived in the jeweller's term "Baroque pearl".
Baroque was also associated with the Catholic art, but during the centuries it progressed and diffused its style into the Protestant countries. In fact, it is a style that expressed power and rigour, "the style of absolutism". Baroque favoured higher volumes, exaggerates decorations, and colossal sculptures [Stella, 1987; Hersey, 1999; Careri, 2003].
The Baroque suggested movement in static works of art, and it influenced important challenges in architecture [Harbison, 2000]. Baroque architecture was based on the mathematics [Hersey, 2000]. In the age of the Baroque, the architects and the patrons thought of the buildings as "studies in practical mathematics" (this is a phrase of the religious Virgilio

Spada (1596-1662), that has realized the plan of the Chapel Spada) [Portoghesi, 1970; Magnuson, 1986; Hersey, 2000].

Guarino Guarini (1624-1683), in his posthumous book entitled *Architettura Civile* (1737), wrote in its preface how "excellent a geometer Father Guarini was, how versed and profound in all part of mathematics, and especially the part that constitutes civil architecture" ("eccellente geometra fosse il Padre Guarini, e quanto versato e profondo in tutte le parti della Matematica e in questa spezialmente dell'Architettura Civile") [Guarini, 1737].

George Hersey, professor of the history of the art, affirms: "I said that in the age of the Baroque the people believed in hierarchies of number and form but some numbers were reliable and others were unreliable. For example Guarino Guarini affirmed: "Some proportions are effable, and can manifest themselves by [rational] numbers, for example the proportion of an inch to a foot, 1:12. But other proportions are ineffable and cannot be expressed in [rational] numbers, but are called irrationals, for example the side of a square with its diagonal, as proved by Euclid Book 12, Proportion 4[1]" [Hersey, 2000; p. 7].

Baroque architecture can be considered as a continuation of High Renaissance architecture, because it used the symmetry, and a kind of simple geometry combined with a greater aesthetic sense of smoothed surfaces.

Baroque architecture also used spirals, helixes and curves (for example, ovals, circles and ellipses) to realize smoothed shapes. Figure 1 shows an examples of Baroque decorations [Sala and Cappellato, 2003].

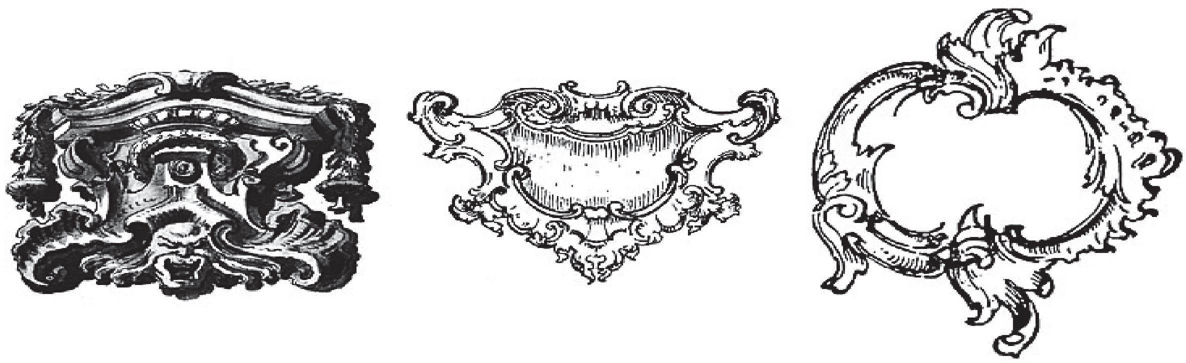

Figure 1 An example of Baroque decorations

One of the most important architectural projects was the rebuilding of the Basilica of San Pietro, which involved the architects of the Roman Baroque: Carlo Maderno (1566-1629), Francesco Borromini (1599-1667), Gian Lorenzo Bernini (1598-1680), Carlo Fontana (1638-1714). The Baroque architecture could be analysed using a fractal point of view. Fractal geometry is a modern discovery of the science, that permits to describe irregular shapes. The most important fractal property is the self-similarity. A fractal object is self – similar if it has undergone a transformation whereby the dimensions of the structure were all modified by the same scaling factor. The new shape may be smaller, larger, translated, and/or rotated, but its shape remains similar [Sala and Cappellato, 2003]. Baroque architecture is self-similar; for example the self-similarity is present in the plans of some churches, as shown in the figure 2, which illustrates the plan of church of Saint Karl (1715-1737, Vienna) where the oval is repeated in three different scales.

[1] The original phrase is: "Così comunemente, ed è manifesto, perché alcune proporzioni sono effabili, e si possono manifestare co' numeri, come la proporzione di un'oncia con un piede, ch'è di uno a dodici ma altre sono ineffabili, né col numero si possono manifestare, e però sono dette irrazionali, come del lato di un quadrato colla diagonale, perché come provo tratt.12 del nostro Euclide, prop.4, non ha alcuna corrispondenza di misura col medesimo".

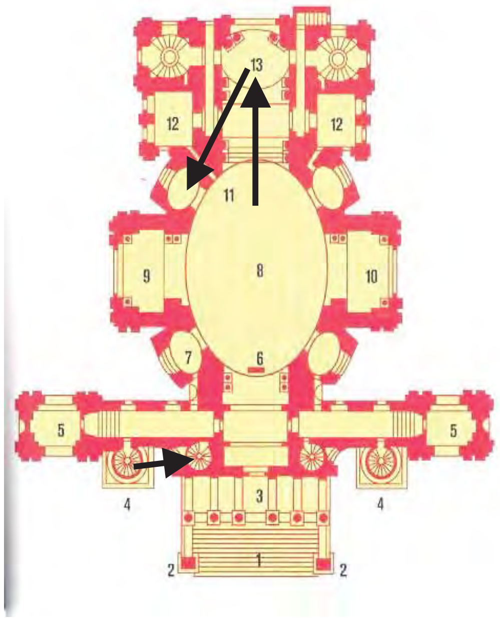

Figure 2 The plan of the church of Saint Karl (Vienna) shows some self-similar shape.

In this paper we will describe an example of Borromini's church and its wooden model realized by the Swiss architect Mario Botta.
The paper is organized as follow: the section 2 describes the characteristics of the Borromini's church San Carlo alle Quattro Fontane. In the section 3 we present the wooden model of this church realized by Mario Botta. The section 4 contains the conclusions and in the section 5 there are our references.

2. The church of San Carlo alle Quattro Fontane (Rome)

The church of San Carlo alle Quattro Fontane (also named San Carlino) was realized in Rome by Francesco Borromini. The project begun in 1638. The main facade, with three bays (shown in figure 3), is located in a narrow road, and the second facade, a little bay at the corner with its own tower, were designed after the interior was completed.
This small Baroque church is a part of a monastery, and it used the gigantic order enclosing a small order [Blunt and Erwee, 2003]. Observing the Borromini's preliminary drawings (shown in figure 4) we can note that the church interior is organized upon two equilateral triangles sharing a common side with two circles inscribed within them. The two circles are combined to form an oval, describing the area of the dome [Hatch, 2002].
In the church of San Carlo alle Quattro Fontane, the longitudinal chapels are defined to form an oval, the oval plan is often met in the Baroque architecture, while the lateral chapels are marked out by the shared corners of the triangle. Borromini used the octagons, the Greek crosses and other shapes for the coffering of the dome of San Carlo alle Quattro Fontane. The figure 5 shows the lattice used to map a detail from Borromini's dome coffers in San Carlo alle Fontane, and figure 6 illustrates the dome interior where the ends of each lozenge and of each rhombus are unequal, the upper half of each octagon is smaller than the lower half, and the top of the upright in each Greek cross is shorter than the bottom of the lower part of the

cross' upright [Hersey, 1999]. Observing figure 5, we can see the presence of two directional compressions, horizontal and vertical at the same time, over a (much shallower) dished plan. Borromini probably achieved the dome interior coffers using a particular technique. These compressions introduces a kind of self-similarity in the dome.

Figure 3 The main facade of San Carlo alle Quattro Fontane (Rome)

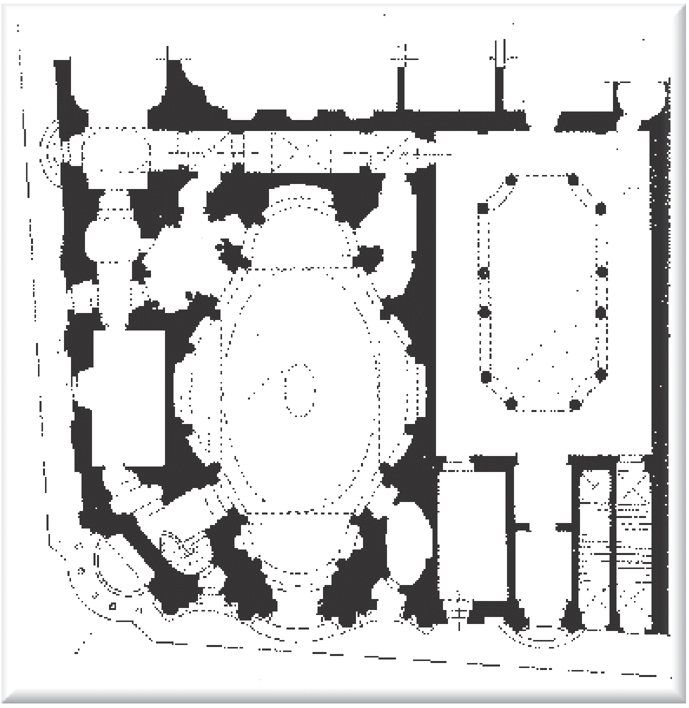

Figure 4 San Carlo alle Quattro Fontane, Rome. Detail of the plan

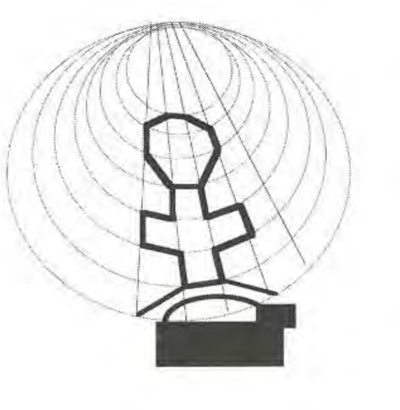

Figure 4 The lattice used to map a detail in the Borromini's dome [Hersey, 1999]

Figure 5 Dome, San Carlo alle Quattro Fontane, Rome. The arrows connect the self-similar shape

George Hersey affirms: “The technique involved using a single-source light to project the shadow of a full-scale, ortholinear grid, made of ropes, onto the curved vault surface. Then the preparatory cartoon with its corresponding grid could be redrawn onto the vault, but obeying the projected co-ordinates that were now properly curved - swollen and contracted – by the vault’s curved surfaces. As the co-ordinates were curved, so then would be the figure drawings constructed from them. I assume that Borromini used the same projection system to map out his coffers at San Carlino. The method is described in a contemporaneous treatise.” [Hersey, 1999, p. 53].

3. The Botta’s San Carlino (Lugano)

To celebrate the 400 years after the birth of the Swiss architect Francesco Borromini, Mario Botta, with the collaboration of Università della Svizzera Italiana, realized on the lake-front of Lugano the reconstruction, in real size, of the famous church San Carlo alle Quattro Fontane built in Rome by Borromini. This wooden model is allocated on a platform situated on the lake of Lugano.
The particularity of this masterpiece (33 meters high and 90 tons weight) is the construction with 35000 of wood boards of cm 4.5 in thickness with cm 1 space between the boards.
This is an audacious invention that proposes itself as architecture and set, as sculpture and installation. This wooden model represents an act of memory, the celebration of the birth of Francesco Borromini, using a reference the church of San Carlo alle Quattro Fontane, the first important work realized by Borromini.
There some differences between the real church and its model, in fact the real is whole, the model is in section. The church is in the urban tissue of Rome and its model is situated on a platform on the lake of Lugano, that is encircled by mountains; the same mountains that Borromini observed in his one’s early youth. The model is seen devoid of its decorations, without its façade, and without its side chapels. In this way, we can describe the Botta’s work as a “building – representation” which permits “to observe” the Roman church and the territory that contains it.
Botta affirms: “The project to reconstruct the San Carlino, was born in Lugano in 1999, to celebrate the 400 years after the birth of Francesco Borromini. The Museo Cantonale of Lugano, the Hertziana of Rome and the Albertina of Vienna agree on the commemoration on Borromini. When the organizers have called me to prepare an exhibition dedicated to Borromini, I have tackled the problem about the different rules of the cities of Lugano, Rome, and Vienna. Our unique opportunity was to consider that we had the history, the territory where Borromini lived his infancy. In this way, the celebrations dedicated to Borromini have been organized using different themes for different localities: Lugano hosted the years of the Borromini’s youth, Rome and Vienna his artistic productions”[Bellini and Minazzi, 1999; Botta and Cappellato, 1999; Papi et al., 2002; Sala and Cappellato, 2003].
Botta read on the Carlo Dossi book entitled: *Note Azzurre* the following phrase: ”Il carattere dominante delle architetture è dato dal contesto che colpisce l’occhio dell’artista (The dominant character of the architectures is furnished by the context that strikes the artist’s eyes”.
Dossi’s consideration is important: it is the context that represents the architecture and it is not the architect’s personality, or his techniques. For example, Dossi affirmed that the architectures of the desert are influenced by the desert.
Mario Botta, using the Dossi’s point of view, decided to realize a reconstruction of a church of Borromini directly on the lake of Lugano. In fact, the geographic configuration of the territory has not been modified in this four centuries.

Botta has chosen to realize the model of the church of San Carlo alle Quattro Fontane, because this is the first Borromini's work that has furnished celebrity to this architect.

Botta has conceived a provocative answer, that does not belong to the symbols but to the imaginary. In fact, he has realized a wooden model, using a cross-section, separated by the urban context that has influenced the real church of San Carlo alle Quattro Fontane. This characteristic suggests some reflections on Dossi's point of view.

The territory of the memory, used by Botta, represents the element of comparison that the architect uses to dialog with the project. The Botta's San Carlino, located on the lake of Lugano, is an disquieting presence because it compares itself with the modern town of Lugano. The "past" is compared with the "present", without prejudices, the melancholic shadow that reveals by the Baroque shapes is filtered by the contemporary language [Botta, 1999].

Botta's San Carlino is an architectural work expressed using a fragment. The interrupted geometry of this wooden model obliges to a subjective interpretation [Botta, 1999].

We have studied the geometry present in the real church and in the wooden model and we have found a kind of fractality. The fractal geometry is present in the church of San Carlo alle Quattro Fontane. A kind of self-similarity has been used by Borromini, and reproduced by Botta, in the shapes for the coffering of the dome. In our interpretation, the dome is like a fractal object, in fact it has undergone a transformation whereby the dimensions of the structure were all modified by the same scaling factor (see figures 5 and 8). The new shape may be smaller, larger, translated, and/or rotated, but its shape remains similar [Sala, 2003]

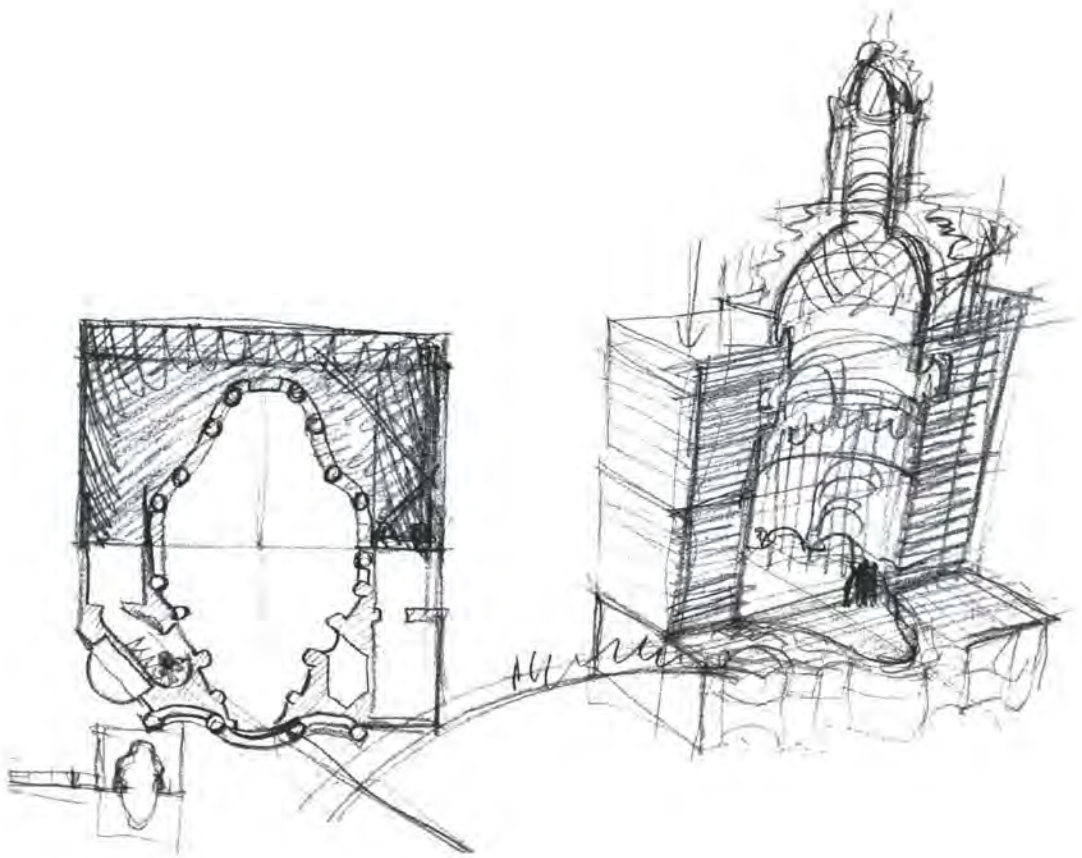

Figure 6 San Carlino (Lugano), some Botta's drawings

Figure 7 San Carlino (Lugano) the cross-section

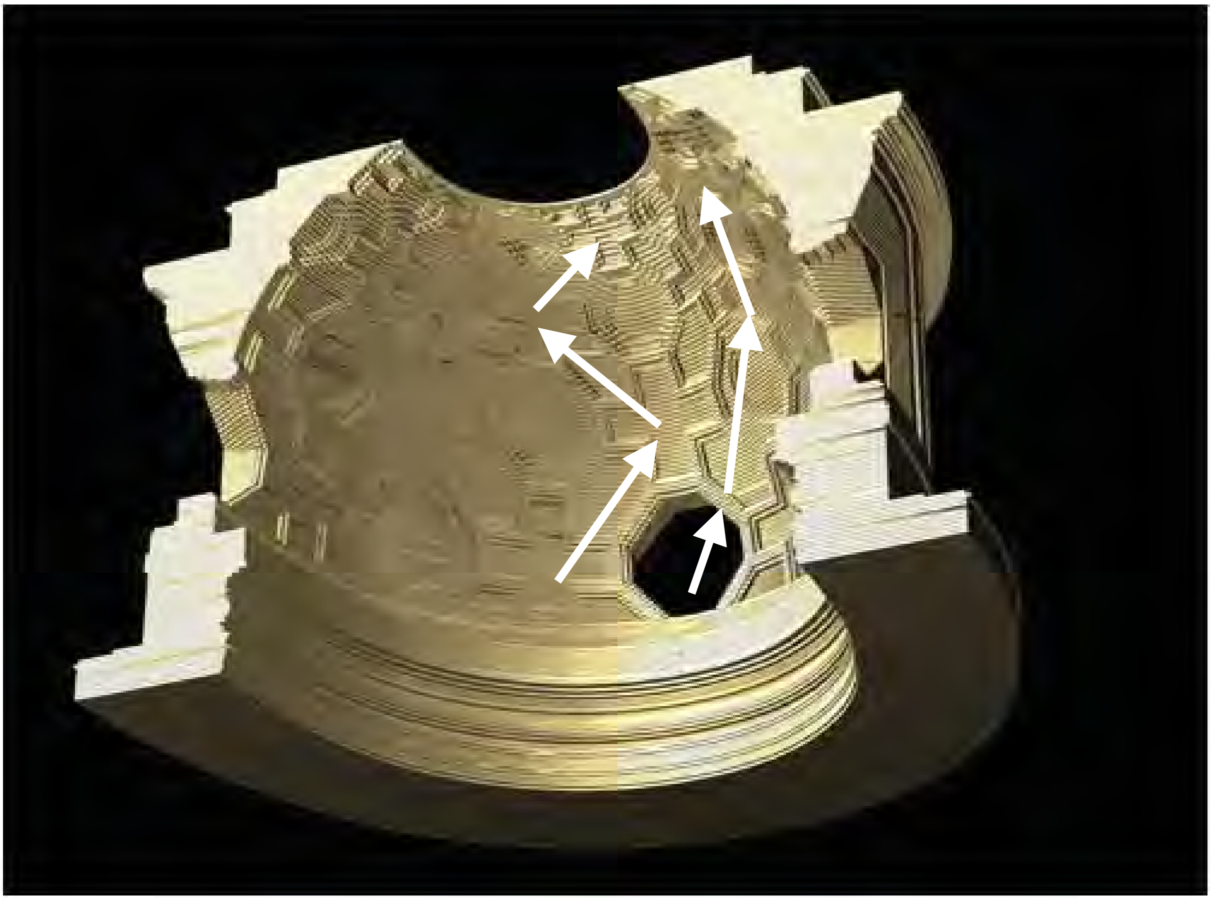

Figure 8 The self-similarity presents in the Botta's wooden model (rendering)

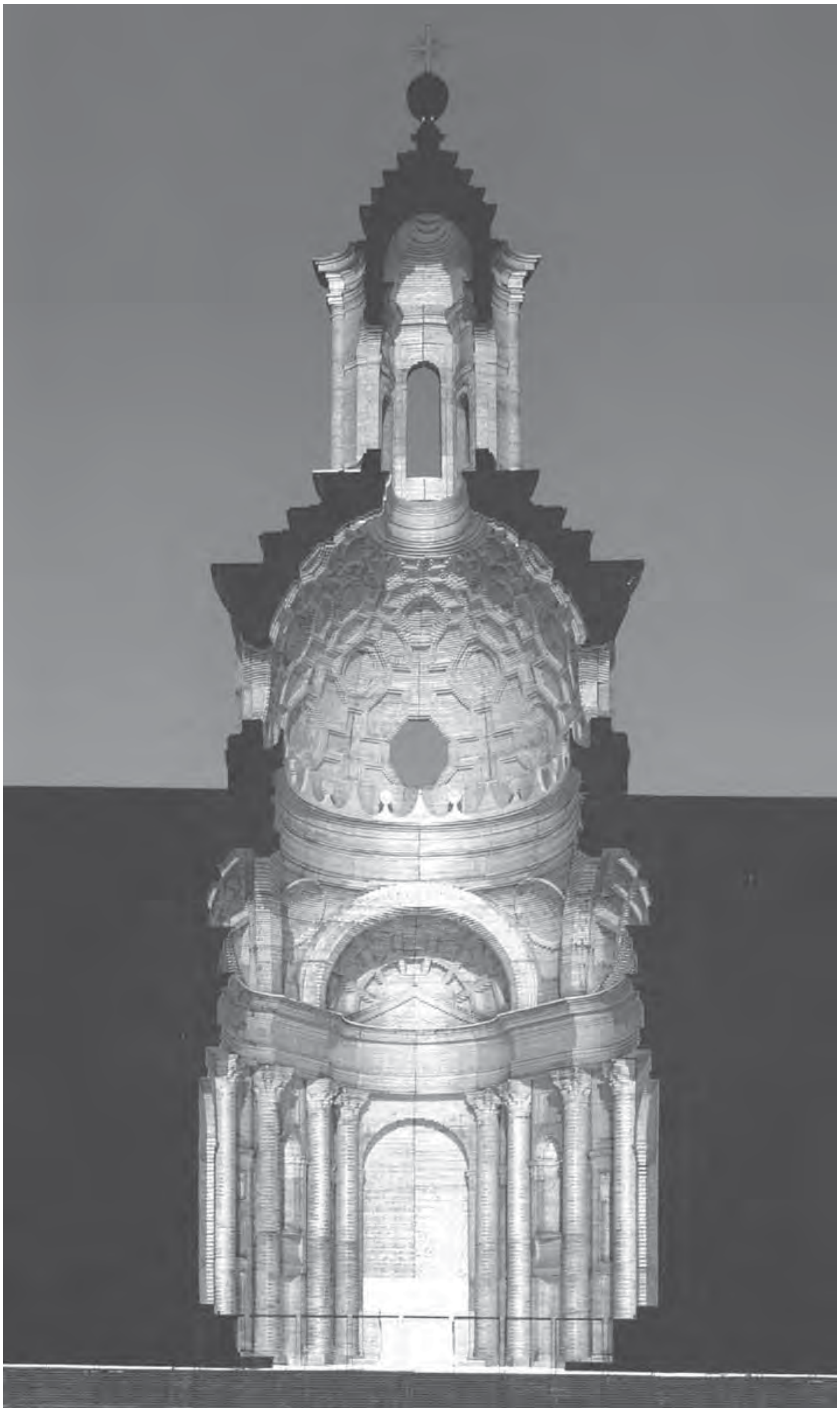

Figure 9 San Carlino (Lugano), frontal view

4. Conclusions

Francesco Borromini was a severe artist and a serious architect, at the same time, he took liberties with the classical system [Harbison, 2000]. Harbison affirms: "He seems to thrive in awkward situations, cramming monumental façades into narrow streets. Like Bernini orchestrating his vast plain, Borromini also aimed at dramatic effects of movement, through compression not expansion" [Harbison, 2000, p. 2]. For example, the Church of San Carlo alle Quattro Fontane is in agreement with the Harbison's considerations.

The Botta's San Carlino performs within an alien urban theatre, that imitates the life. It is the leading actor in the city and, at the same time, the great absentee from the city itself, since its reality is completely Roman [Saurwein, 2001, p.9]. This Botta's project is provocative [Emery, 1999].

Mario Botta, with his wooden model of San Carlino, has realized a modern reading of a Baroque work, and he has given to San Carlino a voice in the context and in the territory where Borromini had his one's early youth.

5. References

Bellini R. and Minazzi F., *Mario Botta per Borromini: il San Carlino sul lago di Lugano,* Edizioni Agorà, Varese, 1999

Blunt A. and Erwee M., *A Guide to Baroque Rome: The Churches*, Pallas Athene Publishers, London, 2003.

Botta M., Appunti sulla rappresentazione lignea del San Carlino a Lugano, Botta M. and Cappellato G. (eds.) *Borromini sul lago*, Skira and Accademia di Architettura di Mendrisio, pp. 13-19, 1999.

Botta M. and Cappellato G. (a cura di) *Borromini sul lago*, Skira and Accademia di Architettura di Mendrisio, 1999.

Careri G., *Baroques*, Princeton Univ Press, 2003.

Emery N., Volontà d'arte, Botta M. and Cappellato G. (a cura di) *Borromini sul lago*, Skira and Accademia di Architettura di Mendrisio, pp. 39-43, 1999.

Guarini G., *Architettura Civile*, 1737 (reprint, Polifilo, Milan, 1968)

Harbison R., *Reflections on Baroque*, Reaktion Book, London, 2000.

Hatch J.C., The Science Behind Francesco Borromini's Divine Geometry, *Nexus: Mathematics and Architecture IV*, Kim Williams Book, Fucecchio, 2002.

Hersey G., *The monumental impulse*, The Mit Press, London, 1999.

Hersey G., *Architecture and Geometry in the Age of the Baroque*, University of Chicago Press, Chicago, 2000.

Magnuson T., *Rome in the Age of Bernini*, Almquist and Wickell, Stockholm, 1986.

Papi F., von Moos S., Bellini R., and Minazzi F., *Per un'architettura vivente*, Centro di Documentazione, Accademia di Mendrisio, 2002.

Portoghesi P., *Roma Barocca: the History of an Architectonic Culture*, The MIT Press, 1970.

Sala N. and Cappellato G. *Viaggio matematico nell'arte e nell'architettura*, Franco Angeli, Milano, 2003.

Saurwein E. (eds), *Notes on the wooden model of the San Carlino in Lugano by Mario Botta*, Gabriele Capelli editore, Mendrisio, 2001.

Schneider Adams L., *Key Monuments of the Baroque*, Westview Press, 2001.

Stella J., *Baroque Ornament and Designs* , Dover Publications, 1987.

The Interpretation of Dreams:

An Explanation of the Electric Sheep Distributed Screen-saver

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Abstract

The name *Electric Sheep* comes from Philip K. Dick's novel *Do Androids Dream of Electric Sheep*. It realizes the collective dream of sleeping computers from all over the Internet. Electric Sheep is a distributed screen-saver that harnesses idle computers into a render farm with the purpose of animating and evolving artificial life-forms. The project is an attention vortex. It illustrates the process by which the longer and closer one studies something, the more detail and structure appears.

1. The Client

When the software is activated, the screen goes black and an animated 'sheep' appears. In parallel, the screen-saver client contacts the server and joins the distributed computation of new sheep, an idea inspired by the SETI@home project [1].

The screen-saver is a window into a visual space shared among all users. Clients render JPEG frames and upload them to the server. When all the frames are ready the server compresses them into an MPEG animation. Each animation is the phenotype of an artificial organism, an "electric sheep". Clients download the MPEG sheep and display them one after another in a continuous, ever-changing sequence.

About once every five minutes a new sheep is born and distributed to all active clients. Each sheep is an animated fractal flame [2]. Example still frames appear in Figure 1. The shape is specified by a string of 120 real numbers—a genetic code of sorts. Some of the codes are chosen at random by the server with heuristics to avoid malformed sheep, somewhat like spontaneous abortion. The rest are derived from the current population according to a genetic algorithm with mutation and cross-over.

Figure 1

2. The Server

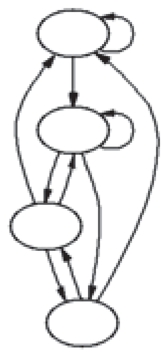
The server has a web interface for people in addition to the one used by clients. It allows users to see and download the currently living sheep as well as monitor the rendering of new ones. Clients can identify themselves with a nickname and URL and see exactly which frames are theirs. The server generates rankings of nicknames and IP addresses by the number of frames contributed. Users can visit each other's web pages and find out who else is in the community.

Normally electric sheep is very reliable and runs for weeks without assistance, but with new versions come new bugs, and at these times the ability to tweak the server live and online is essential to keeping the flock healthy. By entering a password, a user can become an administrator and delete bad frames, entire sheep, or block clients by address. An administrator can also inject a particular genetic code into the system, for example, to resurrect a sheep from the code stored in a previously captured MPEG file.

3. Life, Death, and Interpolation

A sheep's life is finite. I only have enough disk quota to keep about thirty alive on the server. Old sheep are deleted without a trace. Users may vote for a sheep by pressing the up arrow key when that sheep is displayed on their screen [3]. Popular sheep live longer, and are more likely to reproduce. Hence, the users' preferences provide the fitness function for an aesthetic evolutionary algorithm, an idea first realized by Karl Sims [4].

The fractal flame algorithm takes the genetic code and produces a still image, the first frame of the animation. The genetic code contains blending coefficients and 2D affine transformations. The animation of each sheep is produced by rotating all its transforms by 360 degrees. As a result, by the end of the rotation the shape has returned to its original state, and hence each sheep is an animation that loops.



The parameter space of sheep is continuous, and the server generates smooth transitions between sheep by interpolating in the genetic space. The original interpolation method resulted in C^1 discontinuities (angles or jerks in the motion) at the beginning and end of each transition because it was pair-wise linear, and the direction of rotation differed from the direction to the next sheep. Cassidy Curtis suggested the method used to solve this problem: use pair-wise linear interpolation, but make the end-points be rotating sheep instead of fixed.

The set of animations on the client form a graph, as illustrated by the diagram. This kind of diagram is used on the web server to represent the state of the flock. Each arrow represents an animation. The nodes represent key-frames. A sheep animation is an arrow with the same key-frame at its head and its tail, because sheep are loops. The client plays the animations by following the arrows head to tail and branching and to seek out new territory.

4. Measurements and Statistics

Clients typically store about 100 sheep totalling 9 minutes of animation and taking 250 megabytes of disk space. The server uses a free MPEG2 video encoder at a resolution of 640 by 480 pixels and 5 megabits per second.

The high resolution sheep available from the web pages and in the video documentary were born on the sheep server, then the parameters were tweeked to increase quality, and finally they were re-rendered and compressed off-line to avoid MPEG compression artifacts.

In ten days at the end of October 2001, clients from 650 unique IP addresses contributed frames to the server. Multiple users may share an address, and no attempt is made to uniquely identify clients, so the real user count is unknown. At that time about 150 clients were participating in the render farm at any one time. In the first 12 days of March 2003, clients from 4900 unique IP addresses downloaded animations from the two operational sheep servers (the second server supported legacy clients). Currently in November 2003 there are 135 clients simultaneously rendering frames, and 1700 workers within the past week. User growth is currently slow but steady. When the OSX and Windows versions leave beta I expect a surge in clients however.

The user base is limited to those with high-bandwidth, always-on connections to the Internet such as DSL, cable-modem, or university or corporate networks. Because the client uses only the http protocol on port 80 and it supports web proxies (via the underlying curl library), it can generally be used from behind firewalls and NAT boxes.

5. Development

From August 1999 when it was created until October 2001, the Electric Sheep client only ran on Linux. At that time Matt Reda released a Mac OS X client, and the number of clients quickly doubled. Despite many requests, several promises, and one near miss, no working Microsoft Windows version appeared until Nicholas Long delivered a beta version in May 2003.

Linux v2.4 included a substantial upgrade to the core Fractal Flame code including symmetries, and new variational equations contributed by Ronald Hordijk, and the new interpolation technique. The Macintosh client was not updated and its users remained cut off form the server until Mathew (his complete legal name) provided the crucial updates in October 2003.

In October 2002 the domain name was hijacked by a competing "electric sheep" site. Fortunately, after a hacking and legal scuffle, the domain has been returned and the site is back in operation, though the user base suffered a set-back.

Both clients and the server are open source and there is a developer community as well as a user community. The whole system, centered around the electricsheep.org web site, has its own buzz. The users and developers exchange messages by the discussion forum and email, and clients and servers exchange images and animations. There is an evolving ecology of agents, codes, and protocols.

6. The Vortex

Electric sheep investigates the role of experiencers in creating the experience. If nobody ran the client, there would be nothing to see. Eons ago, tiny irregularities in our universe became centers of accretion and eventually grew into stars. A parallel process unfolds in cyberspace. It starts with an idea.

The sheep system exhibits increasing returns on each of its levels. As more clients join, more computational muscle becomes available, and the resolution of the graphics may be increased, either by making the sheep longer, larger, or sharper. The more people who participate, the better the graphics look.

Likewise, as developers focus more of their attention on the source code, the client and server themselves become more efficient, grow new features, and are ported into new habitats. The project gains momentum, and attracts more developers.

And as more users vote for their favorite sheep, the evolutionary algorithm more quickly distills randomness into eye candy.

Perhaps attention acts on information the same way gravity acts on mass: attraction begets attraction and a positive feedback loop is formed.

7. The Future

Electric sheep is open-ended and very much a work in progress. For example, the server is currently a bottleneck because it must compress and delivers large MPEGs to so many clients. But if clients act as servers and become a true peer-to-peer network, the compression and bandwidth load could be distributed much as the computational load already is. This project is currently underway, and I have selected gnutella [5] as the P2P protocol because it has mature open-source implementations. A central server will still be used by clients to find each other and to coordinate basic animation parameters such as resolution and quality. The rendering, compression, evolution, and voting can all be fully distributed.

The architecture is not specific to fractal flames, and the protocol should support multiple alternate renderers. I am seeking collaborators to contribute their own generative animation software.

I believe the free flow of code is an increasingly important social and artistic force. The proliferation of powerful computers with high-bandwidth network connections forms the substrate of an expanding universe. The electric sheep and we their shepherds are colonizing this new frontier.

Acknowledgements

I would like to thank Mike Kuniavsky, Nick Thompson, Katherine Mills, and especially Maribeth Back for their input on this paper. Thanks to Dean Gaudet for hosting the web sites and Carnegie Mellon University School of Computer Science for providing the bandwidth for the heavy lifting. Kudos to everyone who sent me a patch, bug report, or even just one vote.

References

[1] SETI@home searches for a signal from extra-terrestrials in radio-telescope data. It consists of a screen-saver client that is downloaded and installed by users all over the world, and a server that divides-up the data among the clients and collects the results. It puts idle computers to work. SETI@home is the original distributed screen-saver, and its architecture is the inspiration for Electric Sheep's. See http://setiathome.ssl.berkeley.edu.

[2] Fractal flames are the output of a particular Iterated Function System (IFS) fractal rendering algorithm created by the author in 1992. Each image is a histogram of a two-dimensional strange attractor. The flame algorithm contains three innovations: (a) It uses a collection of special functions that are composed with the usual affine matrices. (b) The intensity of each pixel is proportional to the logarithm of the density of the attractor rather than a linear relationship. (c) The color is determined by appending a third coordinate to the chaotic system and looking it up in a palette. Great care is taken to correctly anti-alias the image, both spatially and temporally (with motion blur). Flame is designed to produce images without artifacts, and to reveal as much of the information contained in the attractor as is possible. For more information, see http://flam3.com and the unpublished paper *The Fractal Flame Algorithm*, available there.

[3] Pressing the up or down arrow key transmits a vote for or against the currently displayed sheep. The server's web interface also has voting controls. In Linux, voting by key-press requires a special version of xscreensaver (part of the gnome desktop interface) to work, so it is not widely (if at all) deployed. Voting works correctly in the Mac OSX and Windows versions. The next version of the Linux client will include the modified version of xscreensaver.

[4] *Artificial Evolution for Computer Graphics*, Karl Sims, Computer Graphics (Siggraph proceedings), July 1991, available from http://www.genarts.com/karl/genetic-images.html.

[5] Gnutella was initially developed by Justin Frankel of Nullsoft. AOL (the parent company) pulled the plug in early 2000 and ordered Nullsoft to cease all development. The source code of Gnutella was intended to be eventually released under the GPL (thus the "GNU" in its name), but those plans were crushed by AOL's early intervention. Despite the crackdown, the protocol was reverse-engineered and numerous clients appeared. Today it is by far the most popular file-sharing network.

Generative Layout for A Small Building

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Abstract

Among the classical principles in architecture the so-called of *unity* was popular and widely spread across the world. "*The correspondence of the whole to the several parts, of the parts with regards to each other, and of these again to the whole*", was the beauty's formula of the *form*. Many immutable classical buildings withstand this principle. The idea to endow a building with *flexible spatial* organization appears in 1904. Several decades later, at the end of the 1960's, the design method theories emerge centering their aim on the *design process*. Beauty was not any longer playing the central role on stage. It was time to solve unknown people's needs under socio-economical bases by the aid of geometric and mathematical operations to design. Nowadays *generative design* adds the idea of spatial *transformations* within time in response to the daily economical and technological changes.

It seems to me that putting these architectural trends at once could be a good idea. Beauty, flexibility and transformation could be the major issues in design. I will try to explain here this idea through a real example in architectural design. To begin I will describe the problem's background, thereafter how the building's first image was rendered in perspective. In the second part, a flexible spatial organization is introduced by the so-called *cellular analysis* method in order to satisfy the program requirements, and then the generative principle is applied to both the spatial system and the urban layout to foresee the building's future transformations. Finally, when time comes about the first transformation we will see how it was interpreted.

1.0 The Problem Background

The City Hall of Toluca (México) entrusted me with the design for a small public building in 1992. As donation they accepted a 17m x 34m urban lot, which really is a small piece of land. The mayor of the city asked me to consider the immediate needs but keeping in mind the building's future growth.

Time was crucial to get a preliminary architectural solution. I received the mayor's phone call one day in the morning requesting me to consider some drawings by the next day's morning. The only available data at the moment of the call were the measures of the lot and the visual memory of the plot that I had visited the week before —when all things were just a prospect. But sometimes politicians want, here and there, things to run almost instantaneously.

How could a generative-layout for a building within its site boundaries be proposed? This was the inevitable question related to both the present requirements and the future building growth —which the client asked me to foresee. Based on the fact that the lot proportions formed half of a square I asked to myself, why not develop the project as an entire square but build it as a half? This way the building could reach its final shape when the chance to acquire the neighbor lot became. Nevertheless the essential issue to deal with at this point was: how could I make obvious to others such idea of the square? And the simplest answer I got was: building up a triangle as a half of a square but making it obvious. In other words letting the building speak through them.

1.1 First Perspective Image

Having these questions in mind and no time to waist I started modeling a geometric shape directly in perspective straightaway—by means of the so-called *Modular Perspective* method (the author's) since there is no need of any aid from other geometrical projections. [[1]] The shape I was looking for must observe some restrictions such as leaving free at minimum 25% of the total area. I choose a regular geometric shape but opposed in orientation to those of the neighbor's apartment houses, thus I laid in perspective a triangular volume thoroughly fitting the rectangular shape of the lot; see Figure 1. I was aware at this point, of course, of the inverse design process I had chosen, pursuing first the building's shape appearance and the functionality of its inner spaces afterwards. It is quite reliable to proceed this way if one knows how to make any given spatial organization flexible.

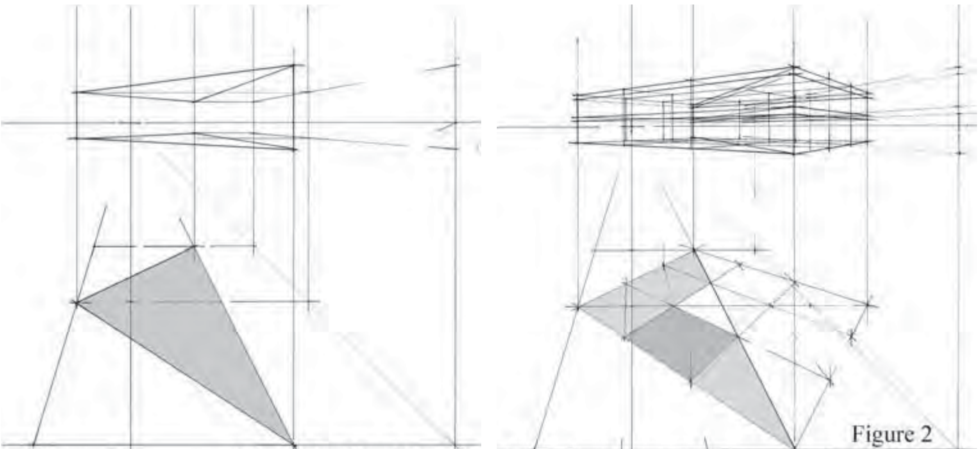
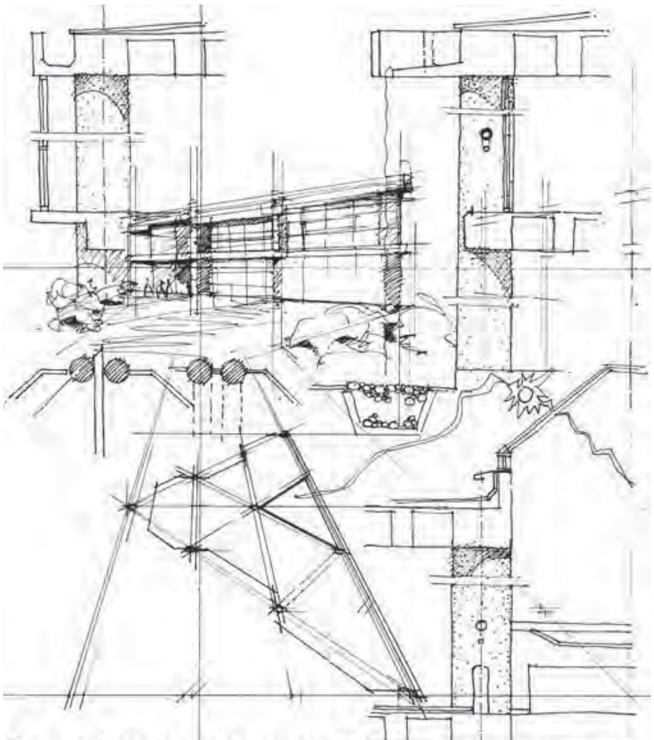


Figure 1 First design image 3 x 3 homogeneous spans arrangement Figure 2

The initial area requested and assigned budget justify the two floors volume. Such calculation was easily determined applying the square-meter cost criteria. Having the triangular shape duplicated on the ground, I started to analyze the best modulation criteria to apply. Putting forth partitions 2 and 4 on one side of the triangular shape some inconvenient came up, being partition 3 the best to satisfy the structural modulation criteria for the plan. Hence the first space lattice was set for the vertical structural elements by means of a 3 x 3 homogeneous spans arrangement; see Figure 2. This array either fitted well a half of a square or in the future could complete it as well. At the core of the layout abided a triangular open space to let the sunlight in. This small space was covered with a transparent roof at the summit of the two stores to warm the building's interior.

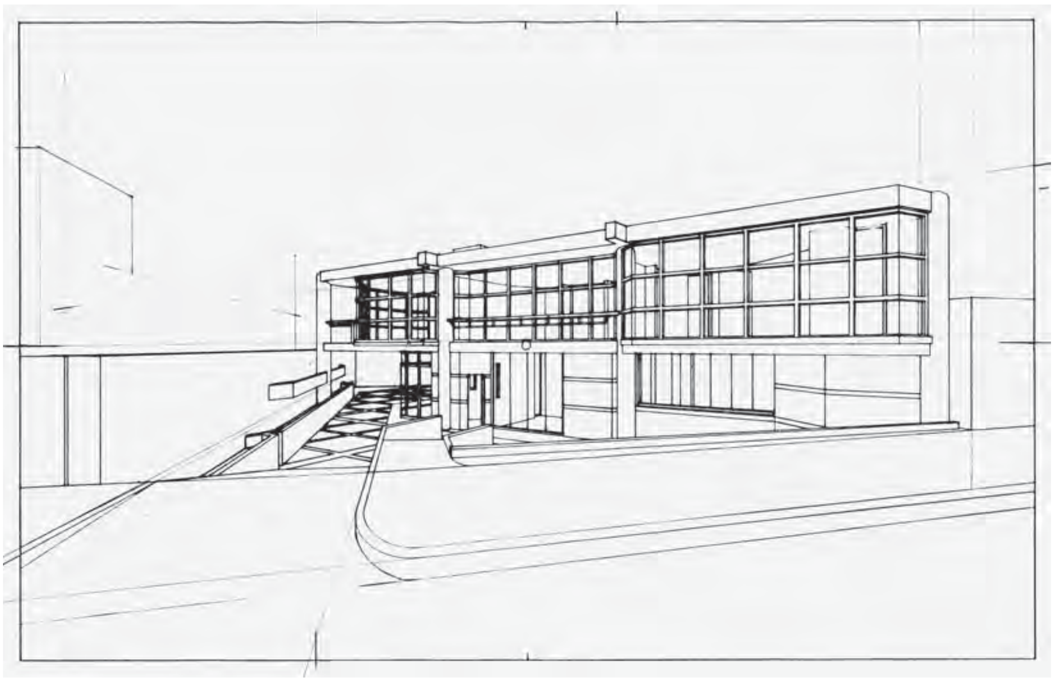
Once the general layout was set the main architectural elements were next to define. To build the structure I chose reinforced concrete instead of steel because the contractors were more familiar with it. Circular columns and flat slab floors conformed the basic building system, thereby the ensemble detail between these elements was important to analyze according to its position in plan, formal variations and proportions. Notice how the triangular geometry of the building within that of the rectangular lot generates five different constructive solutions for columns and floor junction. Sketching one by one within the same formal grammar allows us to easily approximate its solution, as it is show in Figure 3.



Formal grammar approach

Figure 3

Of course this theoretical description was not crossing my mind so orderly at the time I was working. We designers use to work in a much more complex manner until we feel to get something that matches the pursuing solution of the problem. It was rather merging all the above-mentioned aspects during the perspective elaboration for the client. Unfortunately my original drawing was lost but resembles pretty much alike to that of Figure 4.

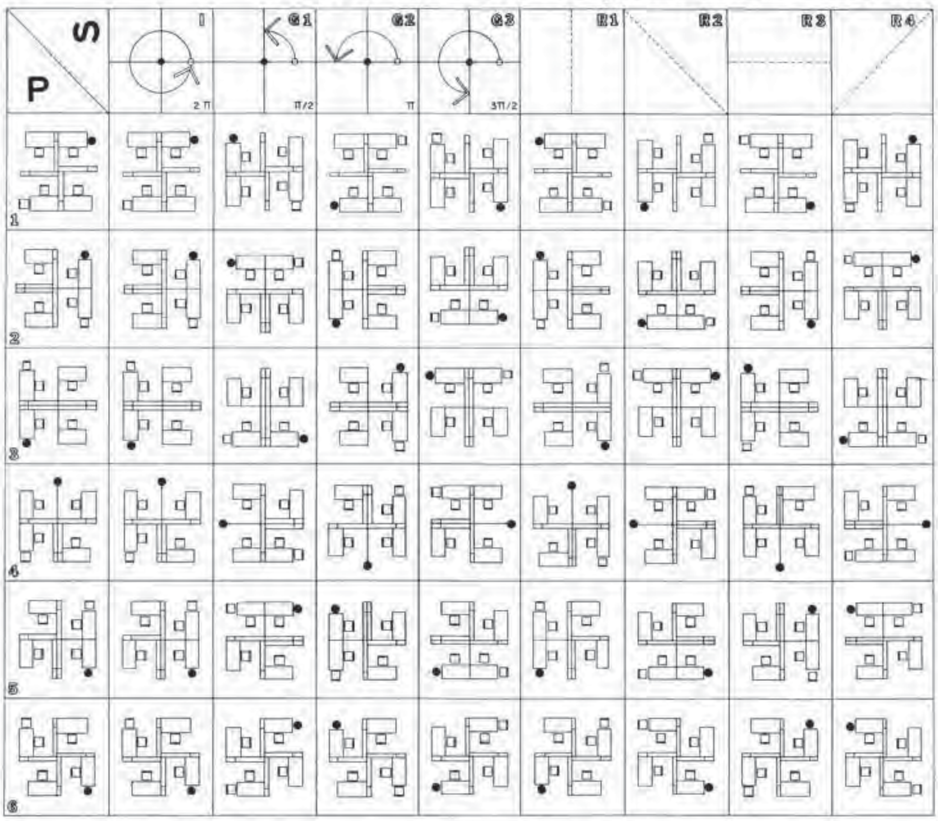


2.0 Cellular Analysis

There is in architecture, as we know, more than one solution for a given program, or shall we say, for a problem. But the question is how to make suitable a “solution” in order to satisfy that program. The features of a program in architecture are basically defined by the users’ needs. Nevertheless the needs change throughout the time due many factors mainly by those of growth and modus operandi. Any way a program must take into account several guidelines, for instance, the available budget, a specific demand about the structural system, special furnishing employed, and so on until all of the client’s requests are compiled. As usual the architect must check out the requirements list with the client in order to fulfill the program. Although in my case this program was plain and simple the *cellular analysis* method was applied to assure the spatial system flexibility.

Cellular analysis is a group of geometrical operations exerted to find out the possible spatial arrangements of a cell within a *spatial system*. The basic geometrical operations for a given spatial array are permutations and symmetries. These operations can be systematically applied through a matrix, as it is exemplified in Figure 5 by the typical office unit-work array. As we see, there are 48 different arrays, which is quite an extensive number to analyze case by case. So the best strategy to follow is to consider first the possible *shape arrays* within the general layout system in order to simplify the matrix application. It is important to be aware that the essential notion in *cellular analysis* is that of “spatial array.”

Figure 5 Permutations & Symmetries' Matrix



2.1 Definitions

Before showing how *cellular analysis* was applied in our example, it is necessary to introduce some definitions in order to clarify what the concept of *spatial-array* means:

Spatial array is the resulting operation of laying *elements* within a spatial cell.
Element is any material thing that can be fixed or movable and belongs to one or more spatial arrays.
Function is a group of human operations that can be attained directly or indirectly by means of an *element*.
Activity is a group of functions that generates one *spatial array*.
Spatial system is a set of *spatial arrays* that conforms a building.

The extension of the concept of *element* goes beyond to all kind of furniture including many other parts of a building, such as windows, doors, walls, columns, glass' integral-facades, any sort of installations, equipments, and so on. Depending on the elements' 'fixed' or 'movable' condition the spatial arrangement flexibility is determined through the geometrical operations aforesaid. There are the following element restrictions within a spatial array:

1 If a fixed element is attached to a movable one this last turns to fixed.
2 If a movable element is next to another movable, both are permutable to each other.
3 Equal elements are not permutable.
4 Similar elements, not attached to a fixed one, can permute.

Other aspects not mentioned here are: the spatial array properties, the elements properties and restrictions, the feasible relations among elements and, the feasible relations between the spatial-array shapes and elements. It would be quite extensive to quote here all the theoretical principles and definitions involved in *cellular analysis*, so I recommend —to those who want to know more about it— to consult my book on the subject. [[2]]

2.2 Application
A building during its lifetime must be adaptable for internal transformations, even for those that radically could change its use. Of course the adaptability idea is not new, it began in 1904 with Perret's free-plan for the apartments building in Rue Franklin 25 (Paris). As in Perret's design the scope of *cellular analysis* is to handle a variety of spatial arrays pursuing the flexible spatial-system behavior. In general terms its procedure is as follows:

The first step is to translate the requirements' program into a *primal graph* in which all the desirable spatial-cell relationships are established. As we can see through Figure 6, all spatial cells, from 1 to 10, conform an interconnected graph in which the dots represent areas or spatial cells and the lines define the kind of connectivity between each of two of them, that is, if they have connectivity or not.

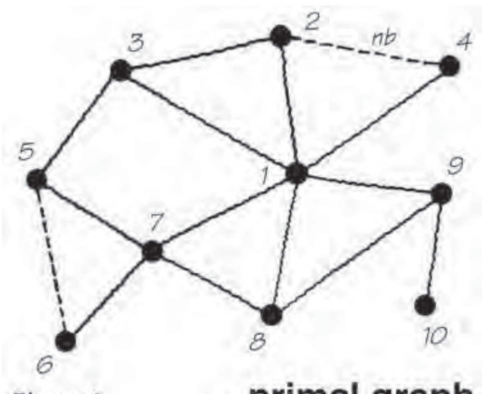


Figure 6

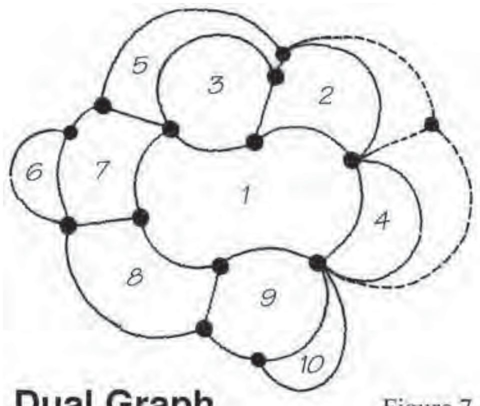


Figure 7

Now the second step is to translate the primal graph into a *dual graph*, in order to conform the areas of the spatial system, as it is shown in Figure 7. The *dual graph* becomes a sort of areas' elastic model since its boundaries have no specific form. Now dots are transforming into areas keeping their connectivity relationship. As it is noticed natural frontiers appeared. This graph is a sort of topological architectural plan much easier to visualize than the primal graph, allowing the designer to modify or add new boundaries.

On the third step the topological dual-graph appropriates the pre-established layout until its forms and dimensions are concealed, as it is shown in Figure 8. When there is no pre-established layout then it must be inferred. [3] This cellular mapping operation is comparable in some way to that of packing items on a box or container pursuing space economy, the only difference being that of the connectivity relationship. It is exactly upon this relationship where complexity in architecture resides. The rest of the design process depends on the architect's abilities to develop all the architectural features of the system; see Figure 9.

Figure 8

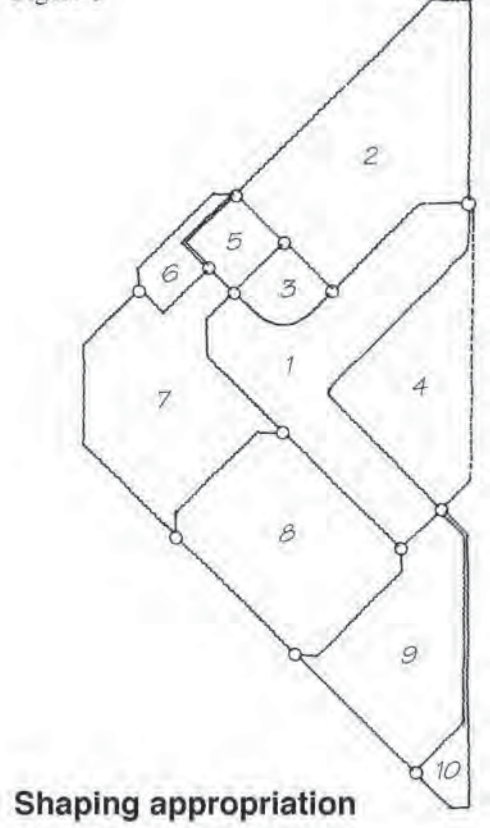
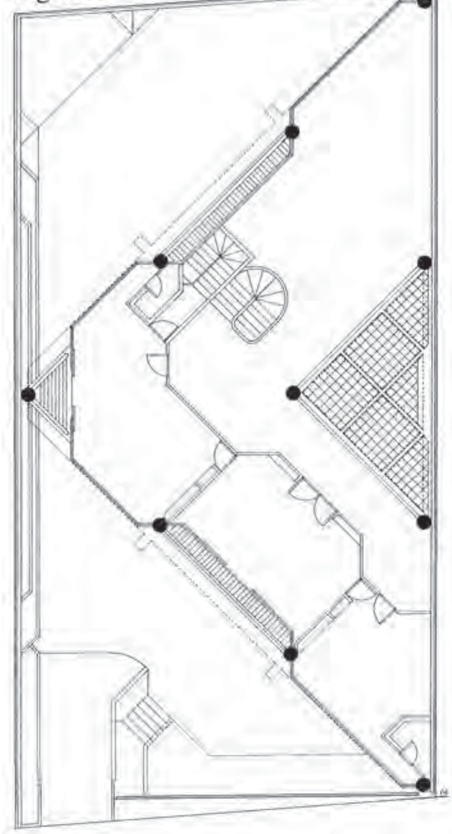


Figure 9



3.0 Generative Layout

The idea of a generative layout involves mainly two concepts: growth —as in the building's capability to increase in size—, and transformation —as in the building's capability of internal spatial arrays variety. In our case, growth was foreseen by increasing the building up to a third floor and then by duplicating it. Transformation was foreseen as the inner quality of the spatial system to be tested throughout the time. These concepts establish the original architectural grammar of the building, which can be used towards new formal interpretations, as Palladio suggested in *I Quattro Libri*, otherwise hybrid architecture will be the result.

"And although some of the designed are not entirely finished, yet may one by what is done comprehend what the whole will be when finished." In this Palladio's statement there is an enclosed *generative-design* idea. Looking closely at the words "*…by what is done…*" they implicitly involve the idea of a preestablished architectural grammar of his works. Of course, this or any other generative concept is not explicitly exposed in *I Quattro Libri*. But as we know, all architectural elements in Palladio's designs correspond to one another mainly through the so-called symmetry and proportion rules. Thus, by observing Palladio's rules someone may be able to accomplish an unfinished building of his as Escamozzi did it for the Villa Rotonda and Teatro Olympico.

The principle of unity was ruling architectural design in Palladio's time under the Vitruvian precepts of *firmitatis* (firmness), *utilitatis* (usefulness) and *venustatis* (beautifulness). [[4]] By building in stone, classical and renaissance architects did not give to much attention about transforming, besides it was not needed because architecture was understood as a whole without any formal or spatial changes to be made. But going back in time, to ancient Egypt, Imhotep transformed the mastaba into a pyramid by reshaping its profile and increasing its height at the same time. [[5]] Egyptian architects design buildings for eternity but they did not realize they were built without a future. The idea of transforming without destroying or superimposing seems to belong to our time. It is a survival idea to avoid building's death by recycling them within the urban areas since architecture cannot move, at least until today.

Thus, buildings and urban plots must be attached to each other under a generative layout capable of supporting transformations. My modest example —in scale— was settled in place as a primary layout capable of transforming according to the urban layout, as an invisible path to follow, to guide or suggest what is next. Figures 10a and 10b show us how the building can grow up along the street —up to four times— within its urban layout by using the right limit of the lot as a reflection axe.

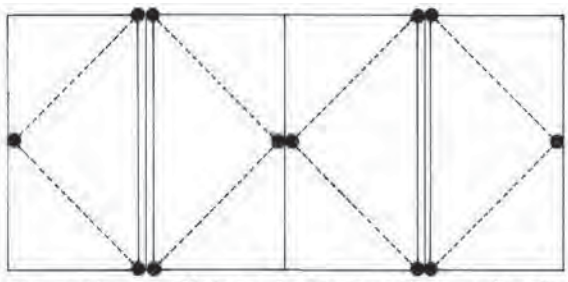


Figure 10a Urban lot growing criteria

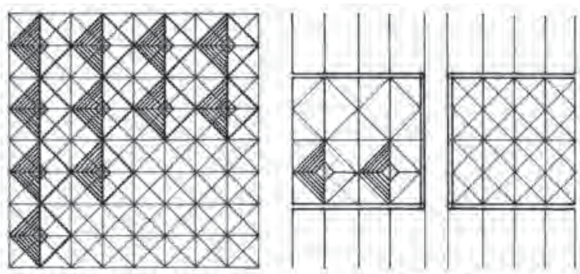


Figure 10b Urban layout

The triangle's assemblage through the open patio will conform a square building, which theoretically would allow increasing the initial area up to three times when the third floor is completed, as it is illustrated in Figure 11.

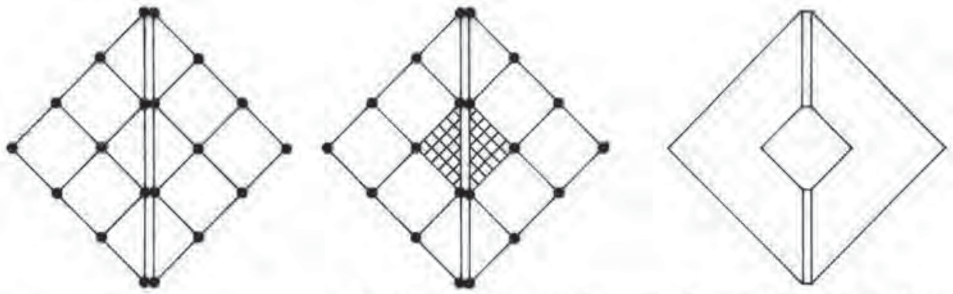


Figure 11 Square' assemblage through the patio

The main shaping variations of the spatial system, based on the 3 x 3 homogeneous structural spans, were explored in Figure 12. Whereas the inner spatial system layout shape is preserved it can be played in forms. That is, the design of the *form* undertakes once the spatial system has been solved. The material form through proportions always withstands beauty.

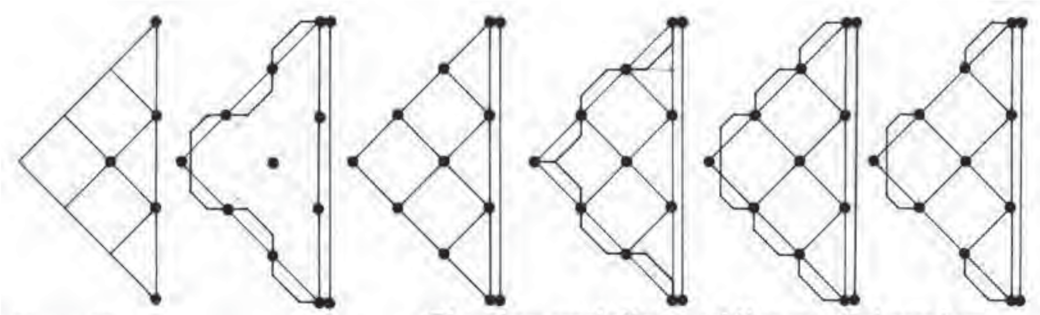


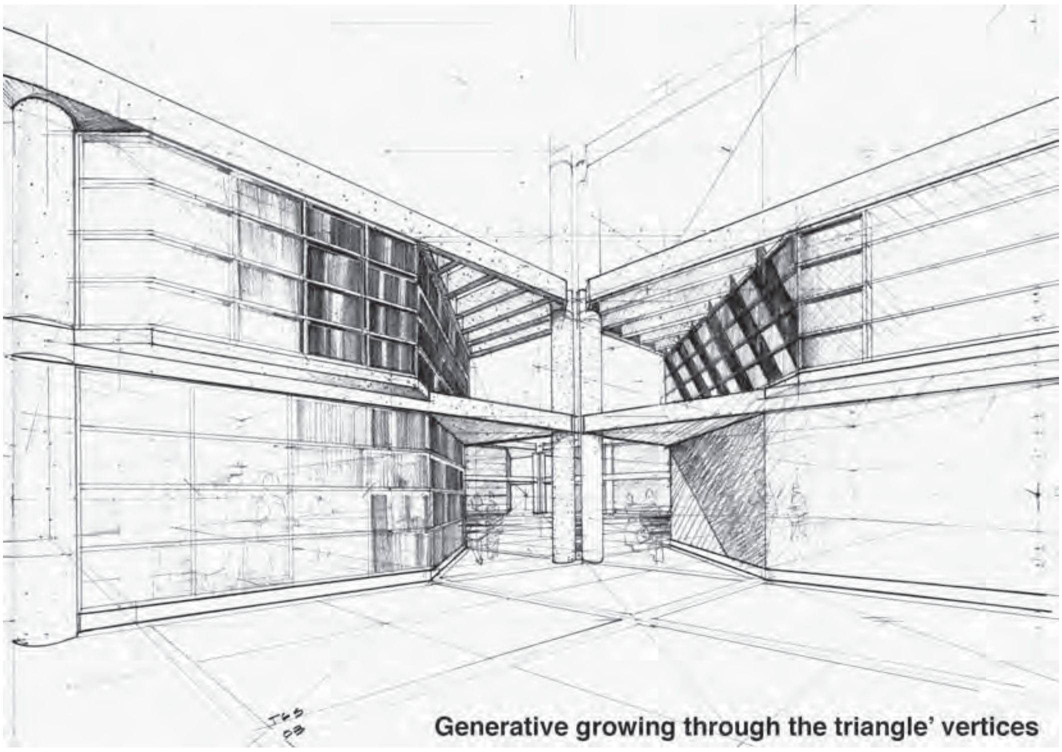
Figure 12 **Shaping variations of the spatial system**

The expected generative code to be interpreted by another designer was the triangular central patio, but as half of a square in order to arrange the whole building around of it. Eight years later, when the City Hall administration acquired the neighbor lot, an architect —that I do not even know— completed the first square but misinterpreted the patio's code. He only was able to read the exterior triangular shape of the building's grammar, fairly enough, but missing the essential; see Figure 13 (Along two occasions I was unable to take a better photograph because there were buses occluding the frontal view). At the present I am certain of the exterior obvious code that impelled the designer's approach but uncertain of its interior supposed signify.

Joining the squares' vertices at the reflection axe creates an interesting spatial variation. An important aspect I had to deal with during the design process was to closely examine all the spatial alternatives I had in mind, as the one illustrated in Figure 14.

The new City Hall administration called upon me this year —on September— requesting my advise of what to do in order to increase the construction area. As they already know a third floor can be added to the building I had designed, but the problem is that the new building floor's level did not match in height with it. When we went to visit the building I discovered the reason the other architect had to misinterpret the patio's code. He built an auditorium taking almost the total area of the lot leaving no room for the patio. Nevertheless this architect wanted to preserve the exterior triangular appearance, for aesthetic reasons, by giving the auditorium's hall this form. It was a pity that of the lack of correspondence in height between the buildings' floors the expected horizontal growth was annulled.

What was my advice to City Hall administration this time? Start over again in a new location considering a broad program of possible scenarios, and if possible to hire a dexterous architect or at least learned in Vitruvio's principles.



Generative growing through the triangle' vertices

[1] Tomás García-Salgado, *Modular Perspective* as a Method for Generative Design (GA 2002): "The *modular perspective* method allows us to work in true three-dimensionality on the perspective plane (*PPl*)." p. 6.1
www.generativeart.com/salgado/salgado2002.htm
[2] Tomás García-Salgado, *Notas Sobre Teoría del Diseño Arquitectónico* [Notes on Architectural Design Theory] (México: UNAM, 1985).
[3] See [2]. p. 45.
[4] Marco Vitruvio Pollione, *De Architectura, Libri X* (Padova: Edizioni Studio Tesi, 1990), p. 28: "Haec autem ita fieri debent, ut habeatur ratio firmitatis, utilitatis, venustatis."
[5] L. Sprague de Camp, *The Ancient Engineers* (New York: Ballantine Books, 1974), p. 23: "Not yet satisfied, Joser and Imhotep enlarged this mastaba twice by adding stone to the sides. Before the second of these enlargements was completed, the king changed his mind again. He decided not only to enlarge the structure still further, but also to make it into a step pyramid, resembling four squares mastabas of decreasing size piled one atop the other. Then Joser change his mind once more. The tomb ended as a step pyramid of six stages, 200 feet high on a base 358 by 411 feet."

On the Art of Designing Science

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Abstract

Science is sometimes described (or better: mistaken) as the venture of seeking *knowledge* or the *objective truth* about things in Nature. Design might not exactly be a science but many of its various sub-disciplines are trying hard to achieve or to maintain scientific status for a number of reasons. One underlying rationale is that natural science represents *truth* in some way, that rigorous science brings us closer to truth and that pursuing design scientifically helps make designed products more valid. It is the purpose of this paper to provide an illustrated inversion of this rationale. Using cellular automata systems, tools of scientific origin with various applications in art and design, as examples, this paper first examines how scientific theories and methods depend on design, whereas design can exist independent of science. It then proceeds to briefly discuss some recent generalisations of cellular automata dynamics that, in contrast to the argument in the first part of this paper, seem to attribute primary explanatory power about the universe to cellular automata. Expressions of science are *designed*, and doing so successfully seems to be an art.

1. Introduction: Science, Nature and Design

To develop our understanding of Nature, scientists observe and analyse our environment to devise theories about it largely by means of reduction, simplification, isolation and generalisation. But there is also no question that the sum of reduced descriptions of natural phenomena is unlikely to produce adequate or complete representations of Nature. Art and design traditionally find numerous *paradigms* and substantial *inspiration* in Nature. Generative art and design, in a somewhat more formal mode of operation, also apply principles, techniques and models of natural phenomena that have arisen from the scientific field. Examples are genetic algorithms, fractals, neural networks, replacement grammars, and – as the proceedings of the GA conferences demonstrate – cellular automata. There are a number of reasons for applying scientific tools to design. They include the wish to model or mimic phenomena we can observe in Nature by formalised means, the wish to make designing more valid by applying scientific rigour, the wish to produce generalised knowledge about form and design to inform work in design or in other fields and the simple wish for tools that produce form and support the automation of production. The general idea is that some connecting relationship exists between *science* and *design*. But what is the nature of this relationship and which of the two fields came first? Design's ambition to be scientific seems to imply its inferiority to science (see Glanville [10]). Simon ([13], pp. 132-133) states that "the natural sciences are concerned with how things are [while] design, on the other hand, is concerned with how things ought to be, with devising artefacts to attain goals". In this sense, design can hardly have originated from science whereas design might well have possessed the devices to spawn science. Accordingly, Glanville observes that design is not a subset of science but that science is rather a subset of design. Adopting this perspective, it can be stated that scientific tools and models are design products. The following sections aim at further substantiating this argument by discussing a variety of design features of cellular automata in place of all scientific models.

2. Choices and Constraints in Cellular Automata Design

Existing in and forming part of time and space, we are in a very difficult position to understand space-time, for the simple reason that we cannot step outside of it to compare a universe with time and space to one without, in order to spot the differences. We have a number of theories and models of space-time, but with space and time being not only essential constituents of our physical universe but probably also of ourselves and our perception, it is difficult to conclusively and scientifically prove or disprove one or the other of them. Most theoretical models of space-time differ only at the astronomical scale and perform practically identical at the scale of human experience. Despite our deficient understanding of space-time, theoretical models (or black boxes) of it are used as bases upon which to formulate other, less fundamental model. Involving concepts of space and time, cellular automata are designed to provide tempo-spatial conditions for cellular “evolution”. These conditions are typically modelled to be uniform within the cellular system following scientists who believe that the laws of Nature are uniform in space and time.

Humans experience time and space as continuous phenomena. Movement through space and aging are not perceived as progress through “granular” environments. We nevertheless find it necessary to measure time and space in relative as well as in absolute terms to facilitate for instance our social interaction and technical processes. We do this by applying scales of units to distances and durations. Science therefore considers light-years or milliseconds and computers execute and count machine cycles, whereas humans experience smooth progression. We do not know the causal relationship between physical change and time. Is physical change a phenomenon for which time provides an independently progressing degree of freedom or is time the result of change in the physical universe? Or is the search for a causal relationship between the two fundamentally misguided? We do not know. Still, when we model physical systems in the form of cellular automata, we typically model time in the form of discrete steps in which the cellular rule sets are executed. There are theories assuming granularity in space-time with definitive smallest possible units of distance and of time. But again, being caught inside our physical Universe, it would be very difficult for us humans or any physical measuring apparatus to sense its grain. In cellular automata, time and space are non-continuous, i.e. segmented into discrete units. This also applies to the logic states of individual automata cells, which are members of the family of so-called finite-state automata. There is a definitive number of states a cell can adopt. This is largely inconsistent with the physical Nature we perceive. Everyone who has observed decaying fruit for example will agree that it would be very difficult to identify a finite number of states in this continuous process. If a decaying object is a finite state system, it will very likely still involve a large number of states, occurring at a very small scale. We also do not know the extent of physical space and it is frequently assumed that our Universe is infinite. This attribute is of course impossible to achieve in a human-designed system, even though it is an essential element of the conceptual forerunner of cellular automata. The tape of the Turing Machine was designed to be infinite. There are different speculations that assume our Universe to be finite, to expand continuously, to alternately expand and contract or to have a so-called manifold topology, meaning that a finite cubic segment of space repeats itself infinitely in all dimensions (a “three-dimensional torus”).

Even though nobody has actually experienced evidence of such a spatial topology in the physical universe yet, this model is frequently used in cellular automata systems to produce infinity-like conditions (i.e. to avoid awkward conditions near the boundaries of a finite grid). Figure 1 shows how a flat two-dimensional automata grid can be transformed into a two-dimensional torus (doughnut) topology. Analogously, higher-dimensional cellular automata systems can be designed to model higher dimensional manifolds' behaviour if the designer wishes to do so.

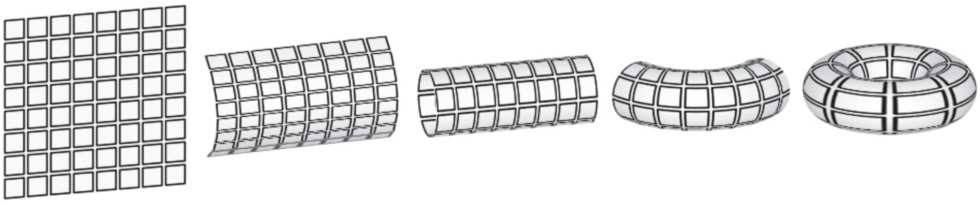

Figure 1: Flat torus to 3D torus ("doughnut") transformation

An automata grid of finite dimension has, in contrast to the physical universe (just as the memory of a von-Neumann computer has in contrast to a Turing Machine) the convenient characteristic of allowing absolute referencing. In programming a Turing-Machine-like system, a great deal of effort is required to enable the program to keep track of "where" it is in relation to given data elements. The programmer of a von-Neumann computer, in contrast, takes the CPU's external view on memory and can refer to memory elements using absolute addresses. So if a cellular automata system were to exceed close-range cellular neighbouring relations, the host system's top-down perspective and absolute referencing possibilities (compare figure 3) would provide convenient implementation shortcuts that have little correspondence with Nature.

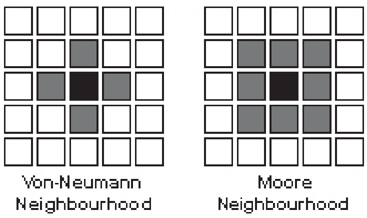

Figure 2: Alternative "neighbourhoods" and cellular automata

In typical cellular automata systems, cells interact (exchange information) with their immediate neighbours only. Usually being arranged in uniform cubic close packing, a configuration that is rather exceptional in Nature, the notion of an immediate neighbour is ambiguous since there are neighbouring cells adjacent to the sides (horizontally, vertically) as well as the vertices (diagonally) of cells. Consequently, there are two typical types of neighbourhoods modelled in cellular automata systems. These are called the "von-Neumann neighbourhood" with four neighbours per cell and the "Moore neighbourhood" with eight neighbours per cell (see figure 2). Neither is inherently correct or wrong. They are designed to suit the requirements of different models, and users are free to choose. Cellular automata systems have been designed that are based on both types of neighbourhoods at the same time, such as a growth structure demonstrated by Schrandt and Ulam (see [9], figure 1). Others have used entirely different models of cellular neighbourhoods.

In cellular tissues in Nature, information exchange between cells can take place in close, middle and long ranges ([6], p. 268 ff.), sometimes requiring rather long stretches of time, sometimes operating extremely quickly, as in electric impulses or crystalline chain reactions. The definition of the cellular neighbourhood is up to the designer of the experiment in which they are implemented. The awkward ambiguity between different types of direct neighbours in cubic tissues can be avoided by designing cellular automata based on hexagonally close-packed structures as shown in figure 8. Cellular automata systems can furthermore be designed to operate using uniform or non-uniform rule sets, uniform or non-uniform cellular geometries, and also to manipulate all these design features dynamically during runtime by various means. These areas haven't yet been the subjects of extensive investigations. While all these design choices discussed above are quite obvious, less obvious and subtler ones exist.

It is often noted that all parallel processes can be simulated in serial. With most contemporary computing machinery built around one or very few sequentially operating processors, this statement is reassuring to those who whish to emulate parallel physical processes on commonplace digital computers. John Conway's Game of Life is a classic example. Using cellular automata, simulated on a single CPU, it has been compared with or used to simulate various types of natural dynamic systems such as population dynamics, adaptation, competition and evolution. From a mathematical viewpoint, it might indeed be possible to re-model a parallel algorithm to perform in serial, producing an equivalent end result. One outcome can be based on more than one causal process. In Generative Design, it is however very often a dynamic system's actual *process* or the *form* it produces that we are interested in, and not some kind of end result. We typically use cellular automata models to serve open-ended processes as opposed to close-ended calculations. Since process, processes and results are perceived and interpreted differently by different observers, we must take notice of a parallel process and a serial process as two different things. Moreover, in being most usually modelled on serially operating CPU's, cellular automata systems show gross shortcomings when they are modelled to represent natural phenomena

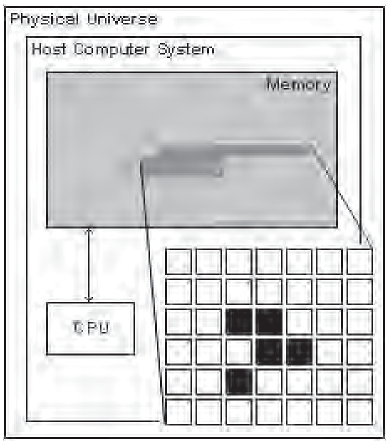

Figure 3: Host CPU operating on CA representation in host memory.

Typical implementations of cellular automata operate ("evolve") by means of an overall sequential loop that sweeps through the entire system to repeatedly dedicate "time slices" of the hosting CPU to each cell (see figure 3). These time slices are discrete, just as the spatial partition of the cellular grid and the total number of possible cell states are. Slices of host CPU time are dedicated to one single cell at each point in time. After one execution loop is completed and all cells' transition rules are carried out, another execution loop starts and so forth. The host loop usually scans through the cellular system using one loop structure or multiple nested loops reflecting the number of spatial dimensions of the system (two loops for a two-dimensional system, three loops for a three-dimensional one). As a result, the cellular execution sequence is performed line- or column-wise from top to bottom, from left to right or similarly.

One of the best-known rule sets is that of John Conway's Game of Life [5]. In this uniform two-dimensional two-state ("alive" and "dead") system, cells refer to their Moore neighbourhood. The rule set states that living cells with less than 2 or more than 3 alive neighbours die and dead cells with exactly three alive neighbours become alive. As is well known, this rather simple system gives rise to very dynamic and complicated processes, including various local attractor patterns, oscillators and so forth. The so-called glider, discovered by John Conway and shown in Figure 4, is probably the best-known example of a stable but mobile self-reproducing pattern within the system. Its replication capability applies to all four possible rotations of any of its four configurations.

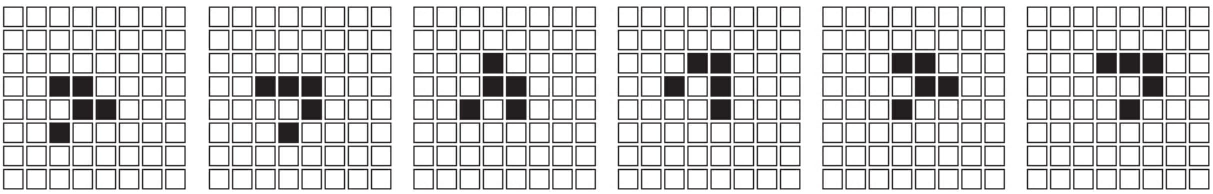

Figure 4: Classic glider replication in John Conway's "Game of Life"

What is typically not discussed in descriptions of cellular automata systems is the necessity of a secondary data array, acting as a backup buffer behind the scenes. During each execution loop, the state resulting from rule set execution is not assigned to the cell directly but to a separate memory array. Only after the completion of a full execution cycle, the content of this secondary array is mirrored to the primary grid of cells before the next execution cycle commences. This secondary array plays an important role in the dynamics, the stability and especially in the symmetry of behaviours observed in cellular automata systems. The difference it makes lies in the way it suppresses state changes to affect neighbouring cells and their states during the same execution cycle – a capability allowing for immense derivative dynamics to unfold if allowed. Carrying out the rules of the Game of Life without implementing this backup buffer could lead to behaviour such as that illustrated in figure 5 below. The Sequence starts out with a classic glider configuration. However, within the four execution loops expected to be required for a displaced copy of the initial glider configuration to re-emerge, the pattern has evolved into a static "still life" of four cells that is also known as a "tub".

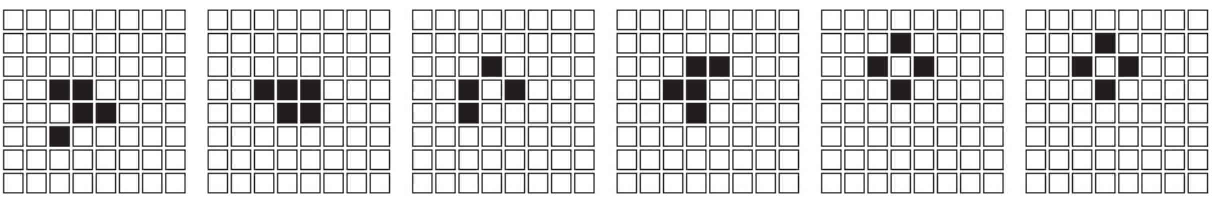

Figure 5: Progression from glider pattern in cellular system without backup buffer

Why does the secondary array exist and what does it imply when compared to the physical universe? One might speculate that the original computers hosting early Artificial Life systems were rather slow machines and that an ongoing and immediate effectiveness of state changes during each execution cycle would have visually revealed the jerky line-by-line scanning of the host system. It would have destroyed the Nature-like beauty of the game. The design decision of introducing a secondary backup array as a kind of Z-buffer might have improved the visual quality with instantaneous overall updates. But the way in which it has been implemented has a significant influence on the system's logic that undermines its resemblance to natural physics. Cellular automata are often associated with autonomous "objects" or "agents" whose collective decentralised action develops emergent properties. Cells in the Game of Life and most other cellular automata do however not comply with this interpretation since, as described here, their performance is not independent of centralised and synchronised control. Elements of physical systems show response to changes in conditions immediately or maybe with some delay, but (at least according to our perception of the physical universe) they do not wait for a universal backup buffer to be written for all types of particles and then for the buffer to be mirrored back into the primary representation of physical reality.

Another reason for the introduction of the backup buffer might have been that without it, processes unfolding in cellular automata systems are largely dependent on the order of cellular execution: of the sequence in which the host system visits individual cells to perform their transitional programs. Different results would be achieved depending on whether horizontal scans are given preference over vertical scans or vice versa, or if cells are executed in a random sequence. In this sense, the progression shown in Figure 5 can only be observed in a system that scans left-to-right lines from the top to the bottom. Other scanning sequences would produce different results than the one shown in figure 5. If desired, increasing the quantity of information in the system can compensate this effect. Figure 6 shows how a six-state system can be designed to produce stable Game-of-Life-like behaviour without backup buffer despite random cellular execution order, by introducing additional transitional cycles.

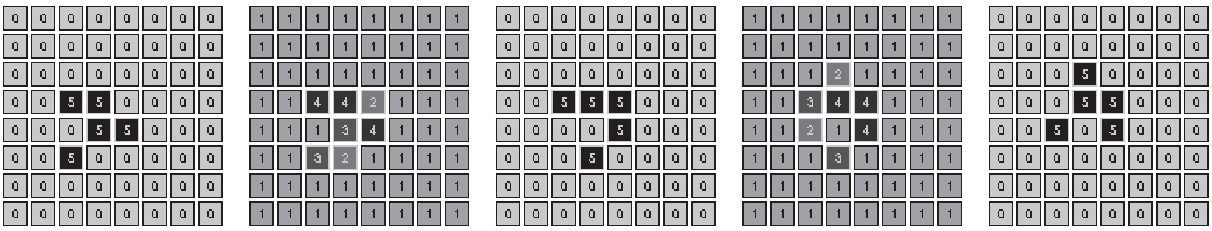

Figure 6: Six-state glider replication in random execution sequence without backup buffer

Synchronicity is a key property of most cellular automata systems. Without it, cellular automata are very difficult to program and control to produce desired results. But with synchronicity being the result and side effect of sequential simulation of parallel processes, the importance of this design feature often goes unnoticed. Where parallel automata are not simulated but in fact implemented in discrete hardware units, ingenious tricks are required to synchronise execution. Frazer, for example, presents a hardware design by Quijano and Rastogi (see Frazer [4], p. 56) in which an array of physical automata is fitted with a light sensor and synchronised by a strobe light. To allow manageable operation, all cells in a system should be executed equally often and no cell should be executed twice before all other cells are executed once (figure 3 fulfils this criterion). This means than within each execution loop, cells can be scanned and executed spatially as shown on top of figure 7. As mentioned above, one disadvantage of this approach is that without a global backup buffer, it can reveal the un-natural-looking scanning behaviour of the system. Alternatively, cells could be executed in a random sequence within every overall loop. A disadvantage is, however, that during multiple execution loops, certain individual cells are likely to be executed twice before others are executed once. The illustration in the middle of figure 7 shows how cells E and F are executed twice while cell D is omitted by the random sequence. In experimenting with morphogenetic automata systems applications [3] that start cellular development from initial zygote cells to proliferate into void space, I found it useful to use the age of cells as a sequencing criterion as illustrated at the bottom of figure 7.

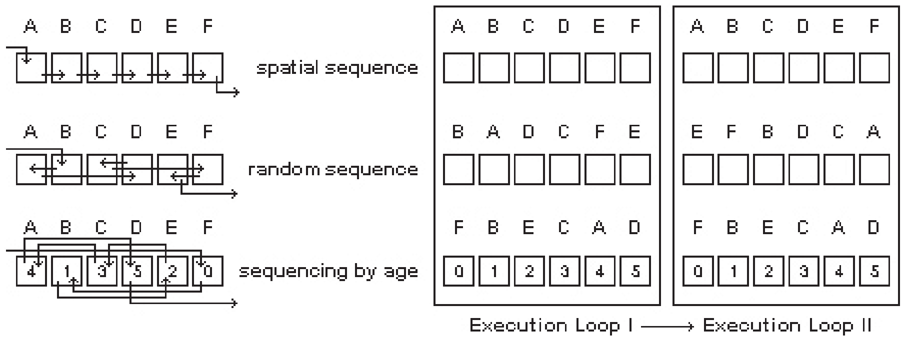

Figure 7: Some alternative strategies in loop sequencing

It seems obvious that the cellular phenomena we observe in Nature manage to produce far richer developments than man-made cellular automata do, without having to pay much attention to the above considerations. Consequently, alternatives to cellular automata have been proposed that are said to model natural processes more realistically in a number of ways [14]. For instance natural cellular systems are richer than many cellular automata systems in that they manage to break symmetry and to express local differentiations. In this sense, the synchronised backup buffer used in the Game of Life and in Schrandt and Ulam's growth system seems to present a strong limitation, since in these systems symmetric initial configurations can only continue to develop symmetrically. Breaking synchronicity makes it easy to break symmetry. Alan Turing [15] was among the first who have examined symmetry-breaking capabilities in morphogenetic processes. His *reaction diffusion* model describes how initially symmetric systems can develop into asymmetric configurations and how initially homogenous systems can express local attributes such as limbs and organs. It describes how small-scale effects such as thermal or Brownian motion or cell-internal asymmetry can give rise to asymmetric pattern differentiation. Biologists have observed a yet simpler strategy for expressing local differences in tissues in the eye disk development of the fruit fly *drosophila melanogaster* (this model is discussed in [6] and a cellular automata model of it was discussed in [2]). The model describes the expression of hexagonal ommatidia with 20 cells of seven types from a hexagonally close-packed two-dimensional array of equal cells. A signalling wave (shown in black in figure 8) sweeps across the eye disk, triggering a state change in which cells behind the wave try to 'lock' surrounding cells to form two rings around themselves, consisting of cells that have not managed to lock such two rings. To mimic this behaviour, a cellular automata system can be programmed in different ways, including one approach in which no propagating signalling wave is required when the sequential scanning direction in a procedurally simulated system is exploited to perform its function.

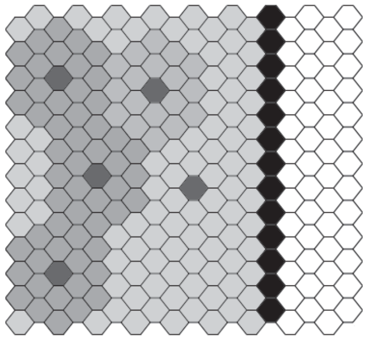

Figure 8: Model of pattern expression in eye disk development during *Drosophila Melanogaster* embryogenesis

Once local attributes such as organs are expressed, further questions arise with respect to system orchestration that can be answered by various alternative design decisions. Figure 9 shows a Game of Life system with an expressed organ consisting of nine cells. The lower-level cellular process (glider progression) determines the state of the higher-level organ – in this case the organ state is 1 when more than two cells “become alive” and 0 when less than three cells are “alive”.

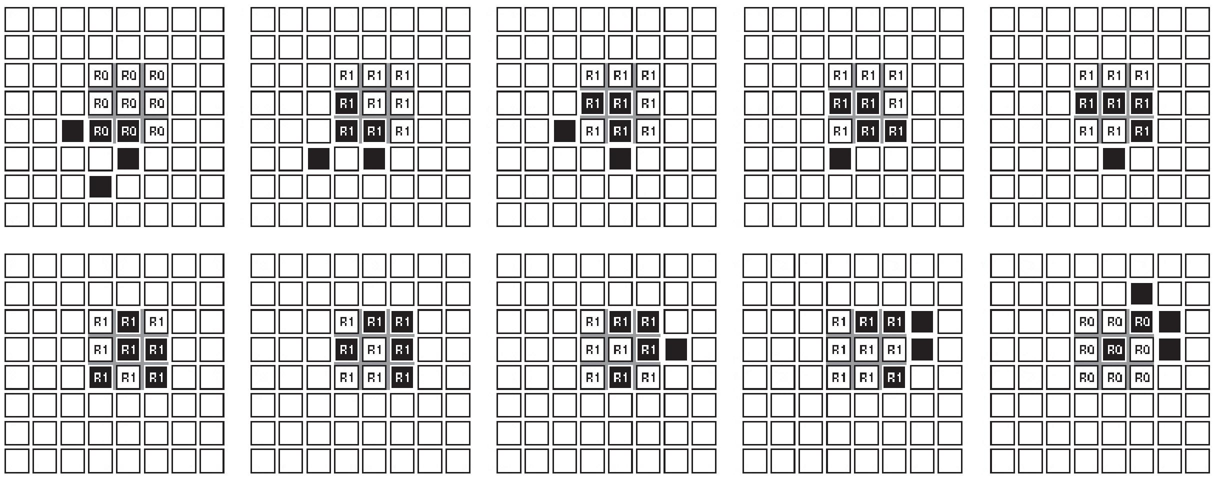

Figure 9: Glider traversing organ

Higher-level cellular automata with features such as organ expression and interaction on higher levels than that of cellular interaction remain comparatively rare (for a recent example see [8]). One reason for this might be that systems of this kind involve some difficult design questions especially with respect to timing and synchronisation matters. How are host time slices to be assigned to elements on the system? Does the action of an organ require dedicated higher-level rules and processing or should it be a mere side effect of low-level cellular activity? The action of discrete elements in von Neumann’s Universal Constructor (construction arm, construction unit, tape unit etc.) are the result of low-level cellular activity only. Alternatively, the illustration in figure 9 was produced with an additional explicit organ rule set that was executed separately at the end of every execution loop. Again, it is questionable to what extent these strategies simulate actual behaviour of hierarchical higher-level processes in natural higher organisms. It seems difficult to grasp the dynamics of hierarchical systems with ever-smaller elements and the temporal causalities their interactions produce. It has been suggested that the common model of a globally synchronous linear time might be an inappropriate starting point for investigation into problems of this kind, and it has even been proposed that it might be fundamentally false. Recently, scientists have suggested that hierarchical organic processes might not only be fractally organised, but that they might be a consequence of a fractal nature of space-time [10][12].

3. Evolution Towards Better Models

The "design quality" of scientific tools such as theories and models depends on how reliable and helpful they are to their users. Cellular automata actually have attributes that strikingly resemble some aspects of natural particle interaction, going beyond the original purposes they were modelled for. This has without doubt strengthened belief in their scientific significance. The fact that there are patterns of cellular automata states that can only exist as initial states and cannot be the result of cellular evolution (so-called garden-of-eden configurations) for example is in some ways redolent of the phenomenon of thermodynamic irreversibility.

Once some observed natural phenomena have been reduced to form a scientific model, it is important that this model in turn be proven effective in making statements or predictions about Nature. For instance, one might attempt to use cellular evolution to predict thermodynamic processes in order to test the usefulness of cellular automata as models. Our observations of physical reality inform science so that science can generalise them to inform our interpretation of other observations we make from physical reality. What is particularly startling about typical cellular automata in this context is that they, being a scientific model, are almost as confusing as Natural phenomena themselves. But as a tool for "chaos science" that is exactly one of the key the points. It demonstrates how complicated natural phenomena with unknown underlying rules and cellular automata evolution with known simple rules can look very similar, as was already stated very early on in cellular automata research (see Schrandt and Ulam, pp. 219 ff. in Burks [1]). Another early point was to show that life and self-reproduction are based on logic processes that can be imitated using appropriately designed simple techniques. However, neither of these points can effectively support the reverse argument, which is to state that therefore everything in Nature is necessarily based on very simple processes. Recently, in the field of cellular automata research, the observation that simple rules can give rise to complicated patterns has been generalised into a *New Kind of Science* [17] concluding that more or less everything in the physical universe is based on simple rules. In the majority of Wolfram's models, "simple rules" refer to binary signals that are exchanged in immediate neighbourhoods of one-dimensional globally synchronised two-state automata with Boolean rule sets. Another vaguely explicit generalisation of observations made in cellular automata published in the same work states that the physical universe can be modelled using cellular automata, that specific instances of cellular automata can be described as computationally universal and that therefore the universe must be computationally universal. The value of these theories and the mechanistic assumptions upon which they are built remain to be proven but it seems that they do not significantly enlighten our understanding of Nature. Nor do they allow the formulation of any statements or predictions about phenomena in Nature. Consequently, the author suggests that the practitioner of his science "just watch and see" the Universe unfold ([17], p. 846).

Regardless oversimplified theories, it must be acknowledged that simple rules giving rise to complicated emergent behaviour do not represent the only type of potentially interesting composite dynamic systems. Simple phenomena can also give rise to simple overall properties and complex phenomena can give rise to complex as well as to simple overall properties. Moreover, systems of all these kinds can occur in arbitrary combinations, configurations and quantities. Hierarchical parallelism in particular seems to bear some key secrets of natural phenomena such as life and space-time. At the same time, it poses a major challenge for dynamic systems modelling and the limitations of procedural digital computation could turn out to be a key obstacle in unlocking these secrets.

In the natural universe, we mostly observe systems with multiple, non-uniform elements. These are neither synchronised, nor fixed in grids. They co-exist at equal scales with similar physical dimensions or nested in different scales of granularity and they seem to have large numbers of states. The relationship between simple rules and large numbers of states seems to be closely related to questions of relative scale. Observations in higher-level systems substantiate this assumption. There are very few general scientific theories to investigate these issues. One theory is Koestler's [11] holon theory which defines a 'holon' as a stable, quasi-autonomous whole or a part of a hierarchical system. Holons exist in parallel at the same and at different levels of scale, and combine to form other holons within a self-organising hierarchy. Genes, cells, organs and organisms are typical examples, all showing relative independence from the structure of which they are part, while still being ultimately controlled by it to some extent. Scientists are only beginning to develop models embracing principles of this kind. The result might be scientifically more useful than cellular automata models, but it will again most likely be man-made, incomplete and a makeshift solution.

4. Conclusion

Even though we use them to represent Nature, scientific models are man-made and incomplete. They are devised for specific purposes and in specific contexts and are the result of ultimately pragmatic design decisions and design constraints. Existing scientific models could have been designed in different ways and many of them will be modified to meet changing requirements in the future. We use cellular automata and other scientific models to drive design for various reasons. Before adopting them too swiftly in order to substantiate other man-made designs 'scientifically', or even to devise new sciences based on them, we need to understand that models of this kind have been the result of design in the first place. The resemblance of some phenomena in cellular automata with natural phenomena can hardly legitimise the general reverse deduction that the universe resembles cellular automata.

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6. References

[1] Burks, Arthur W., ed. (1970): *Essays on Cellular Automata*. University of Illinois Press, Urbana, Chicago and London.

[2] Fischer, Thomas, Fischer, Torben and Ceccato, Cristiano (2002): Distributed Agents for Morphologic and Behavioral Expression in Cellular Design Systems. In: Proctor, George (ed.): *Thresholds. Proceedings of the 2002 Conference of the Association for Computer Aided Design in Architecture*. Department of Architecture, College of Environmental Design, California State Polytechnic University, Pomona, Los Angeles, pp. 113-123.

[3] Fischer, Thomas (2002): Computation-Universal Voxel Automata as Material for Generative Design Education. In: Soddu, Celestino (ed.): *The Proceedings of the 5th Conference and Exhibition on Generative Art 2002*. Generative Design Lab, DiAP, Politechnico di Milano University, Italy, pp. 10.1-10.11.

[4] Frazer, John H. (1995): *An Evolutionary Architecture*. Architectural Association. London.

[5] Gardner, Martin (1970): Mathematical Games. The Fantastic Combinations of John Conway's New Solitaire Game "Life". *Scientific American* 223, October 1970, pp. 120-123.

[6] Gerhart, J. and Kirschner M. (1997). *Cells, Embryos, and Evolution. Toward a Cellular and Developmental Understanding of Phenotypic Variation and Evolutionary Adaptability*. Malden, MA: Blackwell Science.

[7] Glanville, Ranulph (1999): Researching Design and Design Research. In: *Design Issues*. Vol 15, No. 2, Summer 1999, pp. 80-91.

[8] Helvik, Torbjørn and Baas, Nils A. (2002): Higher Order Cellular Automata. Poster presented at the Workshop on *Dynamics of Biological Systems*, Krogerup Højskole, Denmark. URL: http://www.math.ntnu.no/~torbjohe/pub/HOCAposter.pdf [Nov. 2003].

[9] Herr, Christiane M. (2003): Using Cellular Automata to Challenge Cookie-Cutter Architecture. In: Soddu, C. (ed.): *The Proceedings of the 5th Conference on Generative Art 2003*. Generative Design Lab, DiAP, Politechnico di Milano University, Italy, pp. xx-xx

[10] Ho, Mae-Wan (1997): The New Age of the Organism. In: Jencks, Charles (ed.): *Architectural Design Profile No. 129, New Science New Architecture,* pp. 44-51.

[11] Koestler, Artur (1967): *The Ghost in the Machine*. Cambridge University Press, Cambridge, UK.

[12] Nottale, Laurent (1996): Scale Relativity an d Fractal Space-Time: Applications to Quantum Physics, Cosmology and Chaotic Systems. *Chaos, Solitons and Fractals 7*, pp. 877-938.

[13] Simon, Herbert A. (1969): *The Sciences of the Artificial*. MIT Press, Cambridge, Massachusetts.

[14] Stark, Richard W. and Hughes, William H. (2000): Asynchronous, Irregular Automata Nets: The Path not Taken. In: *BioSystems*, No. 55, pp. 107-117.

[15] Turing, Alan M.: (1952): The Chemical Basis of Morphogenesis. In: *Phil. Trans. R. Soc. London B*, 237. pp. 37-72.

[16] Weeks, Jeffrey R. (2002): *The Shape of Space*. Second Edition. Marcel Dekker Inc., New York and Basel.

[17] Wolfram, S. (2002): *A New Kind of Science*. Wolfram Media, Champaign, IL.

USING AGENTS TO ASSIST SPECTATORS TO ORIENT IN INTERACTIVE DRAMATURGY

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ABSTRACT

Non-linear and interactive dramaturgy and story telling can present problems to inexperienced spectators. Younger generations, familiar with computer games, multimedia and Internet are more or less successful in navigation through interactive and non-linear story telling. But people not used to new technology could have problems in orientation as well in reception of content. Even perception could be difficult. We propose a new method for help, as a necessary tool for interactive film and TV applications. The tool is based on agents. In this version an agent is dedicated to specific DVD content, but in the future it could be developed for wide use, as a global agent for non-linear contents. We suggest several solutions, depending on the age, experience and preferences of the users. Users with different levels of skill and experience should have different types of agent.

INTRODUCTION

Present discussions show that DVD authors don't use the potentials of DVD interactivity [3]. Research into Web communication concerning interactive aspects of the Web shows up problems in users' navigation and usage of interactive features [13], [1]. Research in human computer interactions [10] shows that users could have problems using animated agents. Problems could be anxiety and bad task performance. Research in media equation shows that human – media communication has depended on way of media performance and that people equate media as a humans [9]. The DVD video market is faced with several obstacles. The first is that users are familiar with ways of looking at VHS tapes that offer linear dramaturgy and implement two-way linear navigation. DVD video has a strong potential, especially in interactivity, but most users don't know how to use this opportunity. The easiest way to enable them to use it would be to use an agent. But what should the agent look like? Could we build an agent upon different users' preferences? Could our agent cope with different users' age, gender and geographic location? Finally should the agent be animated or static? The literature shows that the use of agents has its advantages and disadvantages [1], [10]. Another big problem is the way of using agents in DVD applications. Most of DVD videos have interactive aspects only in the menu level, not in the content level. There are still very rear interactive films or videos so usage of that kind of interactivity is not even in the development. During the last year we are developing two DVD video projects based on interactive and non-linear dramaturgy structure. The first is Babylon – an interactive film, another is Atlantis - a computer animation – feature - documentary interactive film.

Picture 1 – Adam

Atlantis

Picture 2 Neva and Dolphin

Atlantis is an interactive film directed by X, which contains 3D-computer animation, feature and documentary material. It has 3 different beginnings, more then 25 choices during the film, and 5 different ends. The film is currently in production. 42 minutes of animation have been done by studio Wonderland, and during the summer of 2002 the documentary part of the film will be produced. During the autumn 2002, filming with actors will be carried out. Finally, in the winter complete postproduction for interactive and linear versions will be ready. From the interactive film will be taken 4 linear derivatives for cinema and video distribution. In the DVD version 6 different animated characters will help to spectator in navigation through menus as well as in watching the movie. During watching, the area in the bottom left-hand part of the screen will be devoted to the signal for Interactivity. Choosing of path of interactivity could be done with or without one of 6 interactive agents. From the start of the DVD, Agent number 1 – the Boy will turn on in case the spectator asks for his help. At this moment, the spectator could choose to continue with the Boy or change to Neva, Adam, the Dolphin, the Fish or the Monster - five other agents. Spectators will also be able to choose to continue without agent help. During the film, the agent appears if the spectator chosen the agent's appearance from the start. Otherwise, the agent does not appear, but if the spectator twice in succession presses any button that is illogical or does not make sense, the agent chosen from the start of the DVD (or the Boy if no one agent is chosen) will appear.

Babylon

Babylon is the first feature film based on an interactive manifest [14]. The spectator will be able to see 128 different versions (different in some important aspects) and more than 500 other versions different from the main 128 versions in smaller details (mostly sound). The target viewing media is DVD or some other similar media. But it could be seen in cinema or TV on classical - linear way. That is possible thanks to the fact that film has its linear derivatives. There are 9 linear derivatives, two of them are finished, and we are in process of finalizing the next 3. The others need additional filming that needs to be completed. Every of those 9 linear versions have 3 subversions (with smaller differences like different endings, that makes a total of 27 linear versions.) Any spectator viewing the film could choose from several types of music, which make the film more or less dramatic, increase or diminish the suspense, make the film sad or happy. That kind of interactivity is reflected in "sub-versions". In future, the spectator could choose his own music and implement it into the movie. That is not possible now, but in next year, that will be one of the spectator possibilities. Spectators could choose all the aspects: type of film, even genre, atmosphere, main character, way of developing the story, the beginning and the ending of the film. The target viewing media for such film is interactive film theatre, but it could also be viewed in ordinary cinemas (just linear versions). Two derivatives Babylon - North Cup and Babylon - Keep Walking have been made in accordance with Dogme 95 film rules. The DVD release will have no animated agents, but it will have a voice agent. Regarding the voice agent, the spectator will be able to choose between 3 different voices and 3 languages.

PROBLEMS

Spectators are not familiar with interactive films and video so the main obstacle regarding such projects is to find the way that spectators will use the advantages of interactivity in DVD video. Even when the spectator is an experienced computer user, aspects in interactive story telling are not familiar. The spectator should be aware of the potentials of interactive dramaturgy and how to exploit non-linearity maximally. Several questions arise. How will spectators be informed that places of interactivity occur, without disturbing the flow of story? How will the warning of interactive potentials (hot spot) be presented to them? How long they will be able to react when they are aware that they can? The solution is the introduction of an agent that will help the spectator in navigation, not just through these places, but also through navigation in the whole film.

Human To Media Interaction Aspects

decided to implement animated agents as a solution for improving communicational aspects. In Babylon, we don't implement an animated agent because of the lack of funds necessary for building a model and its animation. We defined different voices and visual appearances so as to have adequate agent for different kinds of users. We divided users into 3 groups on the basis of their experience in working with interactive applications and familiarity with interactive dramaturgy. We defined them in subgroups of masculine - feminine (although there are 4 male and 2 female) users. Besides physical appearance and voice, we chose the agent's gestures and motions – they were animated in different ways in order to distinguish them. We started from the agent no. 1 - the Boy. Searching for the right voice, gestures and motion we find that a minimum of six different agents is necessary for successful implementation. We chose to distinguish two user characteristics, although literature suggests more factors. The main reason is the fact that funds and time didn't allow more characters, so our framework should fulfill the number six. Although we planned from the start to distinguish other characteristic regarding different psychological types of learning, we decided to keep experience as the main factor. In that sense, we divided potential users into 3 groups: beginners, users with some knowledge, and experienced users. For beginners, we targeted Adam and Eva, agents with humanoid faces, smooth motions and human gestures. Their voices are gentle and explanations are broad. For users with some knowledge, we targeted Fish and Dolphin. They are faster in motion and gestures. Their voices are less gentle and tempo of speaking and explaining are faster. For experienced users, we targeted Monster and Boy. We didn't opt for a female character (although the Boy has motions and somewhat feminine gestures) because of the results from Reeves and Nass [9] pp 164. They state that male-voiced computers (we are applying that on DVD) are seen as more knowledgeable about technical subjects then female-voiced, and evaluation from a male -voice is taken more seriously. The Monster was chosen because we wish to add an additional humorous aspect in communication with the experienced user. The reason for that is problems that especially experienced users could have regarding the use of agents, as stated in the introduction. During internal testing, only the agent “Monster” wasn’t evaluated negatively by the experienced users. The Monster has a strong voice, with auto parody elements and violent gestures and motion. The Boy has also elements of self-parody in his gestures and his characteristics could be described as those of a comical TV commentator.

Picture 3 – Monster

Media Aspects

The complexity of interactive dramaturgy makes sense if spectators have benefits. The idea with interactivity in Atlantis and Babylon is to provide a film closer to spectators' tastes and moods. Also, using an agent should be amusing, bringing a sense of adventure and play. An agent shouldn't disturb all the other aspects of the film as a linear form. And that is impossible. The introduction of a toolbar or even a signal that interactive moments are enabled, a so called “hot spot”, brings awareness to the spectator. Also, the time of making the decision reduces spectators’ concentration on structures projected at that time. An even worst solution would be to stop the structure and leave an unlimited amount of time, where the film would be arrested. The solution that we implemented is the spectators' ability to change interactive paths all the time, until the new interactive choice comes. So, even when the time for the interactive place has passed, the spectator can make a hyper jump and go to another interactive path. If the spectator wishes, she or he could turn off many interactive, linear-looking versions offered from the many linear versions, and choose another aspect of the film before its projection.

Navigation Aspects

The first problem in interactive films is that spectators are not familiar with interactive films. Although most spectators are familiar with interactivity in using computers, most spectators are not familiar with DVD abilities. An agent seems a natural choice to assist the orientation of spectators in interactive structures. The use of an agent starts with instructions for using a toolbar and choosing interactive paths. It is not yet clear whether it is better to use animated agents, as in Atlantis, or simple voice agents, as in Babylon. This remains to be tested, but in the final instance, the decision could be left to the spectator, who would be able to choose from several forms of appearance. The final implementation of Atlantis will have incorporated agents in the form of bodiless agent for users who prefer not to use agents. An agent also helps in different problems related to non-linear storytelling, as a reminder for parts that have already passed, as helper in choosing a part where the application doesn't specify what the different possibilities are, and so on. An agent could indicate all the dramaturgical aspects of the chosen interactive path and offer reminders regarding the story, characters and all aspects that could be of interest to spectators. Finally, agents could exchange experiences over the Internet and show spectators the experiences of other users.

CONCLUSIONS

The model hasn't been properly tested yet, as the films are not ready, but on the basis of internal testing, it shows advantages, especially in the start of the DVD, during navigation, and in choosing an interactive path, especially for the inexperienced user. Proficient users didn't remark on the advantages in using an agent. The full testing is schedule for December 2001, but some appreciation has been found after internal testing. DVD needs at least three different types of agents, with different appearances and ways of helping spectators. Spectators should be able to configure the agent at the start of the application, ideally at the installation of the DVD device. The DVD standard committee should create a simple standard, where basic information about users’ preferences would be stored in the DVD. When the new DVD video starts, the video application should have information from the DVD player and make a basic initialization autonomously. In that initialization, the application should configure the user’s preferences regarding the agent's appearance and different information already available from the menu, such as language, subtitles, skipping trailers from the start, immediately starting the film, starting with the biography, starting with commentaries.

Future Investigations

In Atlantis, the agents are used as pre-rendered animation. Using of MPEG 7 support object control and with the ability of better definition of virtual characters, the animation will be rendered in real time. It will allow users to define on their own all the aspects regarding the appearance of the agent, such as his shape, size, texture and place on the screen, his motion, and eventually, the camera's motion. Future applications, especially interactive films, could have use of this, as users would be able to create an agent in accordance with their own wish. Additional investigation is necessary in psychological studies regarding the best possible use of agents

LITERATURE

1. Cassell, Justin, Sullivan Joseph, Prevost, Scott & Elizabeth, Churchill, (Ed) (2000). *Embodied Conversational Agents*, MIT Press, Cambridge, (375-398).
2. *CHI 2001 Conference Proceedings*. (2001). ACM – CHI, New York.
3. *DVD Report*, (2001). **6** (18), (1-2).
4. Heim, Michael (1998). *Virtual Realism*, Oxford University Press, New York.
5. Kender, J.R. & Yeo, B.L. (1998). *Video Scene segmentation via Continuous Video Coherence*, CVPR 1998, CVPR, Santa Barbara.
6. Luger, George F. & Stubbleifield, William A. (1998). *Artificial Intelligence*, Addison-Wesley, Harlow.
7. Moser, Mary Anne (Ed.). (1996) *Immersed in Technology*. *Art and Virtual Environments*, MIT press, Cambridge.
8. Norman, Donald. (1993). *Things that Make Us Smart*, Parceus Books, Reading.
9. Reeves, Byron & Nass, Clifford. (1996). *The Media Equation*, Cambridge University Press, Cambridge.
10. Rickenberg, Raoul & Reeves, Byron, *The CHI 2000 Conference Proceedings*, The Hague 2000, ACM – CHI, New York, (49 -56).
11. Russel, Stuart & Peter, Norving. (1995). *Artifical Intelligence A Modern Approach*, Prentice Hall, Upper Saddle River.
12. Vicer, Dan. (2001). *Hyperactive and Interactive Literature*, Multimedia, Belgrade.
13. Zdravkovic, Vladan (2000). Proceedings IWALT 2000, IEEE, Los Alamitos, (296-298).
14. Zdravkovic, Vladan. (1998). *Interactive Art - Manifest*, AFPC, Zuid-Scarwoude, (5).

THE INFLUENCE OF SCIENCE AND TECHNOLOGY ON ART AND CULTURE AND THE SEGMENTS OF CULTURE DERIVED THEREOF
(Based on the Hannes Bohringer's system)

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Notification for the reviewers: This is an extract from the work that is longer!

Abstract
The system of art and culture in the 20th century is very well represented up by Hannes Bohringer[1]. In this paper we propose extension of the Bohringer's system. We believe those changes are necessary and are result of development of the new technologies in last fifteen years. Bohringer's system should be amended with the "area-circle" of communication about art, the circle of "technological apparatus" and the virtual space of art. The modification of Bohringer's system is shown graphically.

Culture and art, as well as the changes in them, were for a long time directly related to the changes in science and technology. Practically, from the moment that man started painting on a cave walls, art and culture have been an inseparable system. Artists were usually scientists as well. Painters independently discovered new painting materials, new approaches to pictures, including new ways of perception and reception. Musicians discovered instruments. A paradigmatic example of such attitude can be found in the thought and work of Leonardo[2]. Probably the greatest artist of all times, Leonardo d' Vinci[3], is also one of the greatest scientists in human history. With his discoveries in the field of civil engineering, medicine, engineering, mechanics, i.e., in practically all areas of science at the time, he is a prototype of everything that it was considered an artist should be, before and after the Renaissance – the artist-cum-scientist. Libraries above all, but also museums and other cultural institutions such as reading rooms and theaters, are constantly implementing the practical achievements of science and technology. This relationship can be considered inseparable up to the second half of the XIX century, when art suddenly separated from technology, and participation in artistic creation was considered completely separate from all science, and even all knowledge.

During the time of Ancient Egypt[4] and later Rome, libraries attempted to find the most suitable material for writing on, preserving and for the storage of various materials used for writing on, frequently papyrus, clay or stone tablets. It is well known that Alexandrian and Roman libraries had complex mechanisms for the finding and faster transfer of papyrus. The Roman theatres had technologically very complicated mechanisms for moving scenes and achieving scene effects. Roman reading rooms had pulley systems, which changed the position of heavy tablets

[1] Hannes Bohringer, "Begriffsfelder Von der Philosofie zur Kunst", Berlin, 1985.
[2] *Leonardo*, The Museum of Science and Techniques, Serbian Academy of Science and Arts, Center Group, Belgrade, 1997.
[3] According to the study-survey of the "Republic", 1998, and "Times", 1999.
[4] Will Durant, Story of Civilization: Our Oriental Heritage, Fine Communications, USA, 1997.

proclaiming the emperor's decrees and changes in law[5]. The baroque primarily the French Theatre of the XVII century, was theatre that served technology, in the sense that the plays were in the function of the technological inventions of the time. That relationship was severed in the middle of the XIX century, when it was considered that art should not be related in any way to technology. First years of the XX century witnessed several artistic movements that had been connected with technology and on that way with science, as was futurism, constructivism, suprematism and kinetic art. But these movements never have been mainstream. It was only from the seventh decade of the XX century that science and technology re-gained a significant role in art.

On the other hand, culture never has a "break of relations" with science. While art and science were "separate", scientific achievements were applied in different fields of culture with the aim of protecting historical heritage and primarily, that of broadening and improving communication.

Especially important was an increased production of the written word: from books, through lexicons, encyclopaedias, up to daily and monthly newspapers and magazines. This increase of production was caused by the development of the publishing industry. The broadening of communication continued further through radio, and later, television.

It can be said that publishing, radio and television had a decisive role in the "broadening of culture" into "all layers of society", i.e., beyond the "higher classes", who were, until the XX century, the only class of people who were able to follow and participate in cultural life. The creating of cultural property and its wide-spread expansion of this period can be compared only to the period of the reign of the Emperor Augustus in Rome[6].

The condition that had to be fulfilled for such a massive expansion of culture to be possible was the free inter-change of cultural products, as well as the broadening of general education, since these are the necessary conditions for the democratisation of society. Let's bear in mind that in Ancient Rome, in fact, in the whole Roman Empire, each citizen, and even certain categories of slaves, who were incidentally all paid for the work they did, were enabled a free education, and free entry into theatres, libraries, and reading rooms. The talented amongst them were enabled stipends so that they could devote themselves to study and self-enhancement. The stipends were available to slaves as well[7]. It has taken almost 2000 years for culture to reach that level once again. Today free radio and television, and relatively low-cost publications, as well as free libraries and funds promoted art and culture for those less well-off.

Last 80 years of the 20th century[8], political social and cultural systems remain more or less the same. Democratisation of the process of learning about art, involvement in cultural life and creation of artworks is something that distinct the 20th century from the time before[9]. The system of art and culture in the 20th century is very well

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[5] Will Durant, Caesar and Christ: A History of Roman Civilization from Its Beginnings to A.D. 337 (Story of Civilization, Vol 3), Simon & Schuster, USA, 1983.

[6] Will Durant, Caesar and Christ: A History of Roman Civilization from Its Beginnings to A.D. 337 (Story of Civilization, Vol 3), Simon & Schuster, USA, 1983.

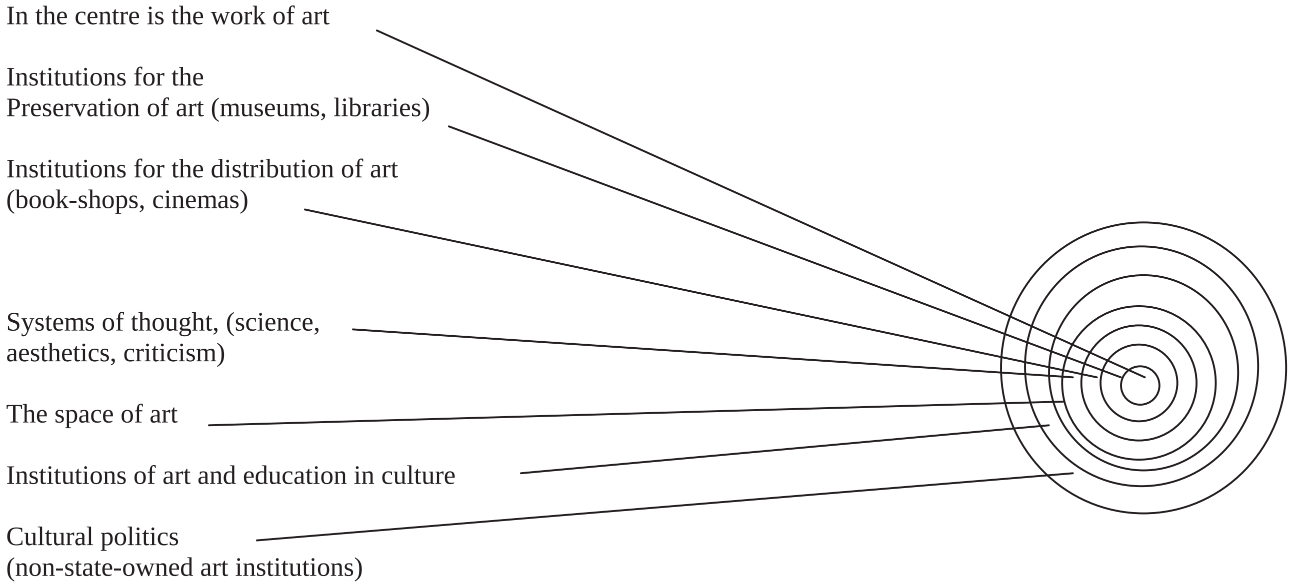
[7] Will Durant, Caesar and Christ: A History of Roman Civilization from Its Beginnings to A.D. 337 (Story of Civilization, Vol 3), Simon & Schuster, USA, 1983.

[8] With exemption of communist systems.

[9] We can pretend that similar process didn't exist before as they were localize in relatively short time period and local space.

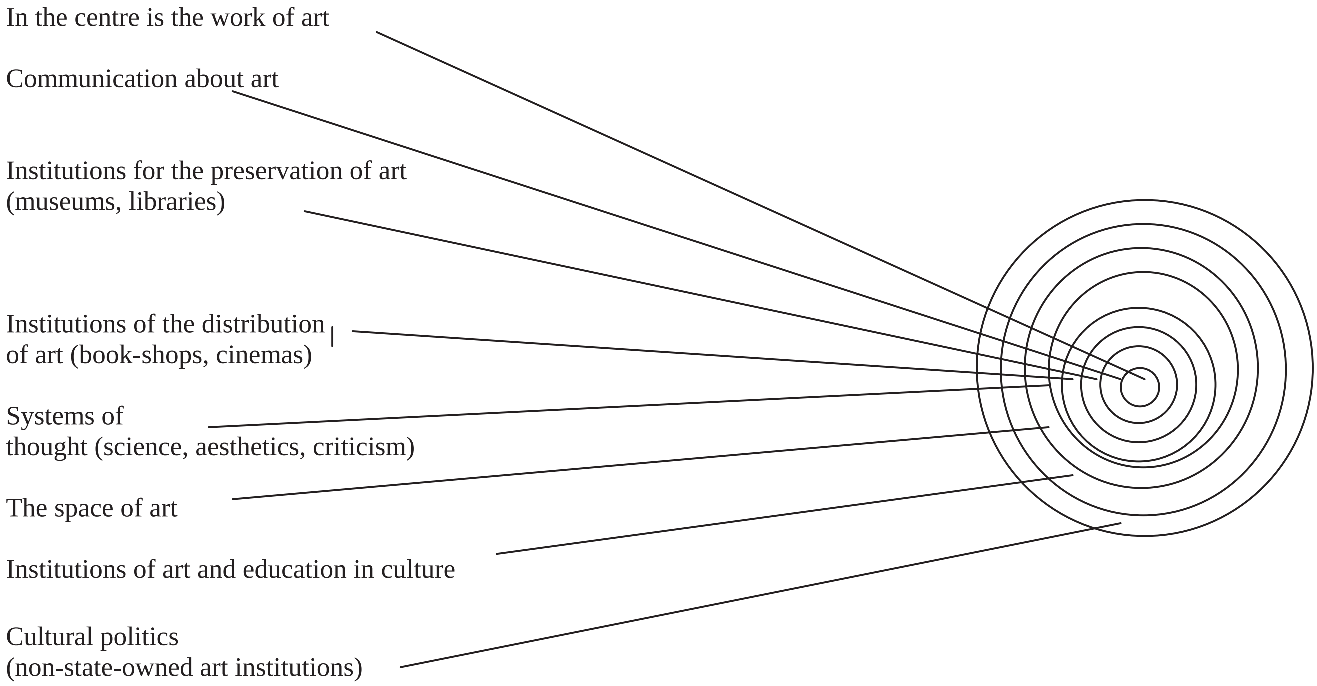
represented up by Hannes Bohringer[10]. Bohringer graphically represented (Graphic 1) the social system of art and culture in the following way:

[10] Hannes Bohringer, "Begriffsfelder Von der Philosofie zur Kunst", Berlin, 1985.



Graphic 1.

Bohringer’s system should be amended with an “area-circle” of communication about art, which would include the following: different aspects of information and communication about art and culture, advertising of art work and cultural institutions, word-of-mouth and communication between recipients of artistic products and services related to culture and art, which constitutes the inter-change of information that does not belong to the system of thought in the Bohringer's system. The area of communication about art encompasses all areas that Bohringer introduced, since information and communication permeate and affects all of the listed fields. The modification of Bohringer's system is shown on Graphic 2.



Graphic 2.

The essential, drastic cultural change[11] in relation to the period of Ancient Roman was brought about with the introduction of computers into culture. 20th century spreads art and culture but essentially did not bring new quality to art or new art form besides film. Last 10 years of 20th century intimate new space of art and culture that will bring dramatic and qualitative changes. Technology – above all, media and computer technology has a dominant role in the expansion of art and culture to diverse categories of users. Thanks to computers, art and culture are now, more than ever, available to a very wide range of users, despite the problems that the use of computers brings. Computers are replacing magazines, books and even television, which was until now considered the fastest transmitter of cultural news and products, as a means of making culture more accessible to the public. The role of television is becoming surpassed, so that television in the future will become just a sub-system of the Internet. Today, and during the next few years, Internet will still be a "subsystem" of television[12], but already today, there are Internet television channels, and practically all the "larger" television stations "air" own programs on the Internet[13].

Use of computers bring the new space - the virtual space to users. It brings the virtual space to world of art, where art works exists in the virtual environment. Computers bring the virtual space to the world of culture, where culture posses new creative and useful tools. Databases and search engines make our life easier. Abilities for new communication and expression as are wide use of metaphor, graphical and spatial tools in art and culture make big difference from the past. Virtual spaces and new tools ask for new technology, something that is so embedded in world of culture and art that new artworks wouldn't exists without it. Technology was always important in the process of creation of art. But before time of video and computers, from the moment when art has been created artwork exists independently from technology. Today exists artworks and some culture fields that are able to evince just through computers. Mentioned artworks and spaces of culture do not exist without computer technology.

In the context of new art related to the use of computers, but also "classical" artistic media that necessitates technological or other apparatus for reception of the work, such as film or holographic pictures, there is a circle of "technological apparatus" which enables the work of art to be available to the artist himself and to the recipient. That apparatus today is represented by computers, virtual reality systems, television, film projectors, laser or light beams, projectors, light-show reflectors, virtual blasters (for "smell-related" installations). Somebody could claim that technology does not have a place in the system that represents a social system. But technology in this system is not just a tool but necessary element - enabler and realizator of art work or cultural space. In relation to Bohringer's scheme, this circle would be placed in between work of art and communication about art, as it is necessary for existence of the world of art.

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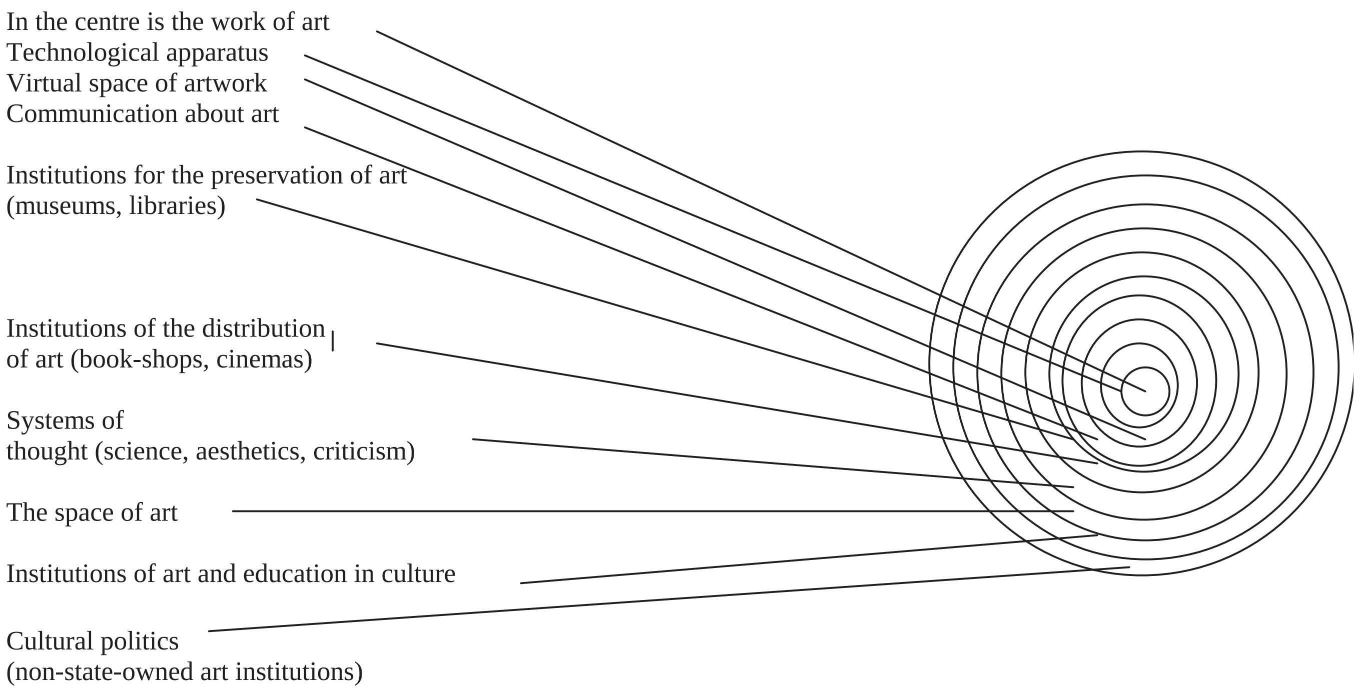
[11] We claimed that art and culture in the 20th century were different from the past, but as is shown in previous paragraphs, in past existed similar environments (during relatively short time period and in narrow geographical area - Imperator August's Rome, Italy during Renascence...)

[12] Practically all providers of cable television in the world offer to their users, together with their TV programs, Internet via television, where viewers navigate through the Internet with the help of their television remote control.

[13] We could claim actually that today television is the subsystem of the Internet. Today television has the bigger influence and importance than Internet, but in the future will be different. As we are able to surf the Internet on television sets, we are also able to look TV programs on Internet. IP television (Television over the Internet) exists today in commercial use and develops fast. But to avoid unnecessary complains we does not discuss this question.

The third circle that does not exist in Bohringer's system is the virtual space of art. In his system, Bohringer defines a "circle" of the space of art, as a physical space where the work of art is placed. With the onset of virtual and multimedia art a "new space" for the existence of works of art is created. We call it the "virtual space of art and culture". For video art, film or early forms of computer multimedia we need technology to expose the work of art. But even if we would destroy technology artworks will exists on media. For new art in virtual environment if we would destroy the technology, artworks will not exist[14]. The virtual space of art comes after circle of technology apparatuses and before the communication about of art. The new system, based on Bohringer's system, is shown on Graphic 3:



Graphic 3.

Literature

Aronowitz, Stanley (ed), *Technoscience and Cyber Culture*, Routlage, London, 1996.
Benthall, Jonathan, *Science and Technology in Art Today*, Thames and Hudson, London, 1972.
Bohringer, Hannes, *Begriffsfelder Von der Philosopie zur Kunst*, Berlin, 1985.
Bolter, Jay David, *Writing Space*, Lawrence Erlbaum associates, Publishers, Hillsdale, USA, 1991.
Conley, Verena Andermatt (ed), *Rethinking Technologies*, University of Minnesota Press, Minneapolis and London, 1993
Durant, Will, *Caesar and Christ: A History of Roman Civilization from Its Beginnings to A.D. 337 (Story of Civilization, Vol 3)*, Simon & Schuster, USA, 1983.

14 We are referring to advanced art works that are not localized in the computer program as a code. Artworks that exist just as a program code will exist without technology as films or video art.

Durant, Will, *Story of Civilization: Our Oriental Heritage*, Fine Communications, USA, 1997.

Featherstone Mike, Lash, Scott (Ed), *Space of Culture*, Sage Publications Ltd., London, 1999.

Godwin, Joscelyn, *Harmonies of Heaven and Earth*, Thames and Hudson, London, 1987.

Moser, Mary Anne (ed), *Immersed in Technology. Art and Virtual Enviroments*, MIT press, Cambidge, 1996.

Norman, Donald, *Things that Make Us Smart*, Parceus Books, Reading, USA, 1993.

Novak, Marcos, *Liquid Architectures in Cyberspace, Cyberspace: First Steps*, MIT Press, Cambridge, USA, 1991.

Penny, Simon (Ed), *Critical Issues in Electronic Media*, State University of New York Press, New York 1995.

Zdravkovi}, Vladan (dir), *Leonardo*, *The Museum of Science and Techniques*, Serbian Academy of Science and Arts and Center Group, Belgrade, 1997.

Zdravkovi}, Vladan, *Ispri~ane pri~e*, A&M, Beograd, 1996.

Zdravkovi}, Vladan, *The Influence of Virtual Reality and Computer Multimedia on Contemporary Art and Culture*, University of Arts, Belgrade, 2001.

Zdravkovi}, Vladan, *Virtuel,* Center Group, Belgrade, 1996.

Zdravkovic, Vladan, *Interactive Art - Manifest*, AFPC, Zuid-Scarwoude, Netherlands, 1998.

Zdravkovic, Vladan, *Interactive Feature Film Babylon*, Computer Graphics 36(2), ACM, New York, 2002.

Zdravkovic, Vladan, *Using Agents to assist spectators to orient in interactive dramaturgy,* Journal Being Virtual - Winter, Sweden, 2001.

Rakovic, Dejan, *On brain's neural networks and brainwaves modeling: Contextual learning and psychotherapeutic implications*, Proc. 2nd Conf., Biomedical Research in 2001, IEEE/EMBS (Vic), Melbourne, Australia 2001

Rakovic, Dejan, Transitional states of consciousness as a biophysical basis of transpersonal transcendental phenomena, Int. J. Appl. Sci. & Computat., Vol.7, No.3, 2000

“Estágio”

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Abstract
The proposal of this study, developed at the Generative Design Lab, Politecnico Milano, is to take contact with a multidisciplinary approach to produce an artistic work. We started with a thought about the problem of the tonality disintegration in the XX Century Music, taking the atonalism in Schoenberg as a theoretical reference. Conscious of the influence that arts and medium can exert one to another, we begun our investigation about sounds, images and words. This research considers experimentation and creation like a way to make art.

1.Introduction

When I did the biographic research about Schoenberg I realized the rapport between him and Kandinsky, father of abstractionism. This opened a way to reflect the possible parallelism between atonalism and abstractionism.

Both, Schoenberg and Kandinsky, coming from the tradition, the first with the tonalism and the second with the figurative art, slowly disintegrated it. [1] It can be observed there were a lot of common points in their productions. It can be seen the similarities in their ideas, spiritualism, attitude and cultural interests but each one made always his own way, each one produced his own work. They didn’t make music translated in paint or paint translated in music.

“Their attitude was more ‘religious’, they believed in ‘another’ world that could be viewed in the art, above of form there are the contents, the intimate essence of chooses above extern aspect, emancipate of dissonance of notes from traditional harmony like of colours”.[2]

The meeting of their bright minds was a great inspiration to our work.

We studied compared trajectory about Schoenberg and Kandinsky to trace a profile of the musical and painting art of the beginning of the XX Century. In this comparison, like Hahl-Koch [3] shows, we could observe that both had more or less at the same time common interests and productions. They had interests for music, painting, theatre and let a lot of letters and writes about their thought.

Since the beginning of XX Century it’s possible to see the parallelism betweem their works, but they had not yet had a meeting. The first meeting between Kandinsky and Schoenberg was in 1911 and until 1914 they had a friendship documented in letters and family encounters. From 1914 to 1921 they had any contact. Both had spiritual artistic affinities.

Kandinsky was 8 years older than Schoenberg, he begun to paint after 30, but his artistic evolution ocurred in the same time with those of Schoenberg. They received public reconnaissance always contemporary, but in parallels ways. This evidence is so surprisingly that one could think that one influenced the other. But this affirmation is wrong because before 1911 one didn't know anything about the other, and from 1914-1921 they didn't have any contact. In table 1 we compare some points of their trajectories, to demonstrate the similarities:

Table 1 –Comparison between Schoenberg and Kandinsky chronology.

Years	**Arnold Schoenberg** (Vienn – 1874/Los Angeles-1951**)**	**Wassily Kandinsky** (Moscow-1866/Neuilly-sur-Seine-1944)
		When he was child studied music (piano and violoncello).
1896		Begin studies of painting
1899	*Verklart Nächt*, op. 4 (theme: pair of lovers)	
1903	*Pelleas und Melisande* *Jugendstil* *Gurrelieder* (1900 and 1911)	Natural language, fable, legend, pair of lovers, folk motives: "*L'Addio*" 1903 "*Il suonatore gusli*" 1907 "*Notte di Luna*" 1907
1906-07	Search of new expressive way: • Reduction of composition duration; • Condensation of expression; • Renunciation of repetizione, until the variations; • Change the harmonic movement from 3 th to 4th; • Enlarge gradually the limit of tonality, surpass the basic tonality, after the tonal island, arrive the atonality. *String Quartet*, op. 10 (1907-8) - crescent atonalism	*"Autum in Bavaria*" (1908) "*Castlel Garden*" 1908 *"Summer landscape"* 1909 "*Church of Murnau*" 1908-09
1906-12	Schoenberg painter: realized the major part of his painting (70 oils, 160 acquarello and drawing)	
1908-9	*Klavierstucke*, op 11 (1909) – higher point of atonalism	Begin his first '*Scenic Composition'*
1910	His first exposition like painter. *Colours*, op. 16, one of 5 pieces for orchestra (anticipation of compositions based on Klangfarbenmelodie)	The first *Acquarello* abstracte. Finish *The Spiritual in the Art* *Improvisation VII* (1910)
1911	Finish *Harmonielehre*	
1911-12		In Berlin – Exposition organized by Kandinsky with 4 painting of Schoenberg.
1912	*Pierrot Lunaire*	First personal exposition
1913	*Gurrelieder* first performance at Vienn	Publication of: *Kandinsky 1903-1913* *Composition VII* (1913) *Poem: "Klange" (Sounds)*
1914		Music compositions to Scenic Composition

1921	Op. 25, *Suite for Piano*, first time to use the dodecafon system; • Principle of non-repeatable notes.	In Russia in the same year his pictoric language shows geometric forms with more rigorous
1922		Professor in Bauhaus New style, reduction of fundamentals form and primary colours. • Use colours with a serial though.
1925	Professor of composition (Akademia der Kunste – Berlin)	
1933	Immigration to New York	Change to Neuilly-sur-Seine

2. Analyse of «Verklart Nächt», op. 4

With the goal to study to create an artistic work we decided to decode Schoenberg. Firstly we broached his atonality like a poetic. To know how a musical system transforms itself we decided to analyse a Schoenberg's composition. We listened to some Schoenberg's compositions [4] and we decided to begin the study of "*Verklärt Nacht*", op. 4 [5], because it:

a)belongs to the first creative period of Schoenberg – a romantic period.

b)has a significant way to deconstruction the tonality, it has points of very clear tonality and points of undefined tonalities;

c)uses a poem (by Richard Dehmel: Transfigured Night) to conception and construction the music, without singing voices. There are two sections: in the first section a woman speaking, in the second a man.

We began to study the logics structures and transforming codes in Schoenberg. Many questions were posed, for example: There are transforming codes in music? Or there is a row of transforming codes? Which are they? How does one define it? Which would be the transforming codes of atonal music? Which would be the transforming codes in Schoenberg's composition?

We made a general analyse that includes motifs, phrases, variations, sequences, harmony. We discovered a Golden Section (comp. 229) where Schoenberg worked with tonality and dialog among instruments.

Besides some questions we arrived to a model of system organization:

First Organization of Analyse

1.Motif
    1.1.Variation
    1.2.Timbro
2.Sequence
3.Tonality
    3.1. Cromaticism

In this way we considered the motifs like a code and its variations like a manner of transforming this code. Then, we begun to study the structures of this analyse, the structures of this system. We saw that was possible remark also 'phrases' in this analyse:

Second Organization of Analyse

1.Phrases
2.Motifs: principal and secondary
3.Acompaniged Melody (with harmony)
4.Golden Section
5.The anacrus like principal motivic element
6.General structure

Finally we found an organization by an arrangement of the elements:

Third Organization of Analyse
Index of elements of analyse
1.Motif/Phrase
2.Melody
3.Variazione (Sequence)
4.Harmony (Principal Tonalities)
5.Accompaniement structure

In this way we organized a Maximum System includes: form, harmony, melody, and a Minimum System that includes basically variations of phrases and motifs. Then, our operative hypothesis was the structure of motifs of «*Verklärt Nacht*».

Table 2 – The Maximum System of the piece

Organization (Maximum System)	
Form	Derived of poem Richard Dehmel 2 distinct parts: the first there is an aspect closed and obscure; the second is opened and clear. There are a Golden Section (comp. 259) characterized a tonal melody in dialog among different instruments.
Melody	Constructed by phrases, and these phrases are constructed by motifs. The motifs are very important to counterpoint, form lines, to development and variations.
Harmony	Centralized in D Major and D minor. Large use of sequences, phrases and motifs also. Modulations and chromatist presents indicate a lot of regions without a specific tonality.

We arrived at a kind of cell of music that we named Minimum System. In this point we observed how maybe Schoenberg thought the development. He worked across the motifs and its variations to organize the plot of the piece.

The concept of *motif* is very important for Schoenberg and it is intrinsically linked to the concept of *variation*. Like he observes:

«A motif appears continuously in a composition: it is repeated. The simple repetition however produce monotony, this even can be avoided across variation»[6]

The study of variations is very reach and demonstrate how Schoenberg though and developed his music. He affirms that:

«The variation means change: but to change each element produces something stranger, incoherent and non logical, destruct the basic form of motif. Consequently, the variation require the change of some factors less important and the conservation of others more important. The preservation of rhythmic elements produces effectively, coherence (even so, the monotony can't be avoided without little changes). The determination of elements more important depends on compositional objectives: through of substantially change it's possible to produce a variety of motifs adaptable to each formal function.» [6]

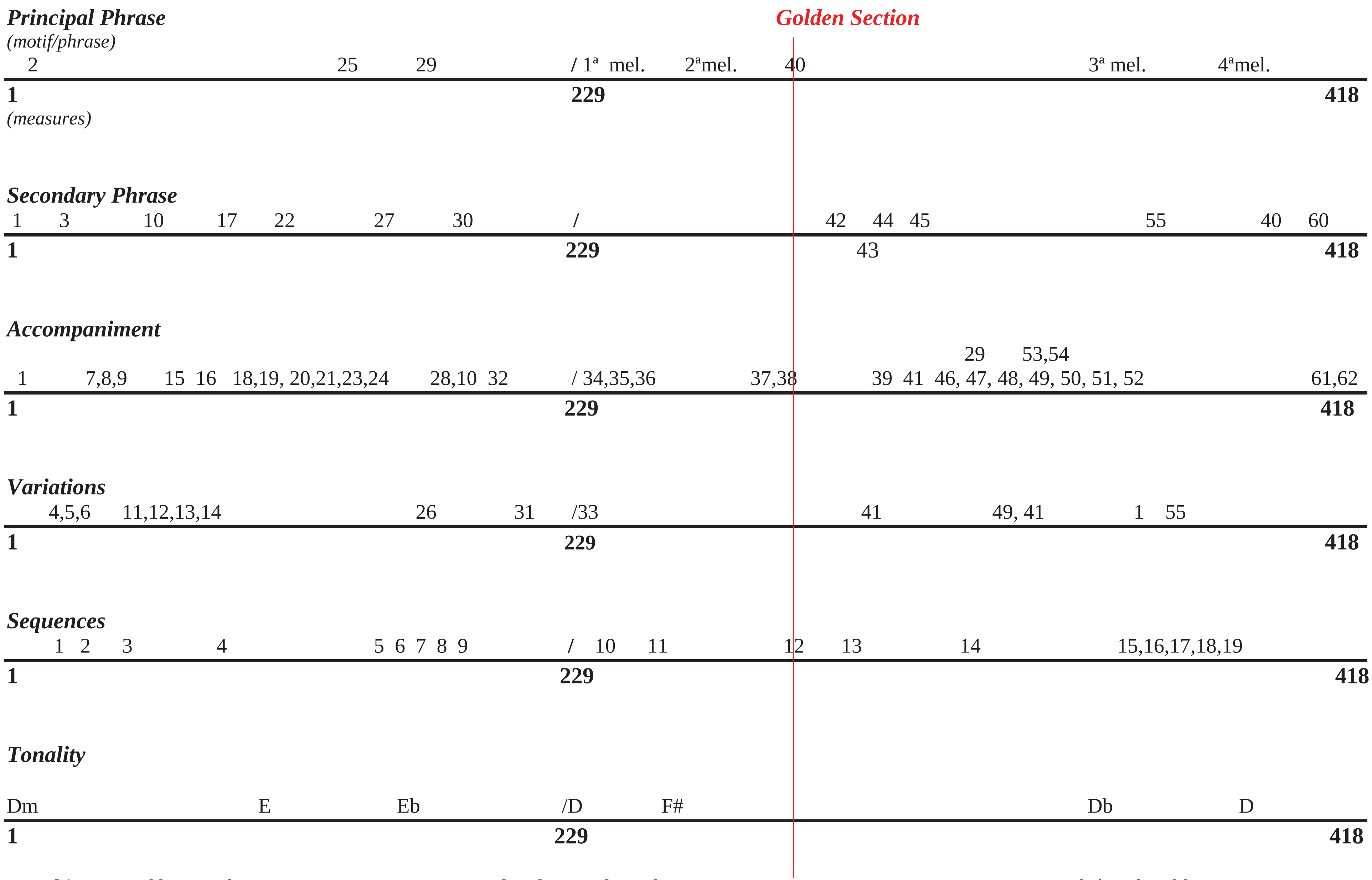
In table 3 there are the variations that occur in Verklart Nacht:

Table 3. The variations of the piece «Verklärt Nacht»

Variations (Minimum System)	
1	Pitch **(**chromatist, diatonicism, Major and Minor tonalities, change of tonality)
2	Sense of phrase/motif
3	Ornamentation
4	Rhythm (polyrhythm, dislocation of the rhythm)
5	Addition of notes, accomplish of space
6	Repetition, Sequences
7	Contrast between sections (counterpoint, bloc of chords, melody with accompaniment)
8	Timbre (pizzicato, string indication, harmonics, dynamic, instrumentation)

We founnd a total of 62 motifs and/or phrases, including some variations in our analyse. These elements were organised, divised, repeated, combined on 4 Principal Phrases, 4 complete melody, 13 Secondary Phrases, 39 Accompaniment Motifs, 14 Variations and 19 Sequences. These elements were organized in different manners and we also found a Golden Section (comp 259). Above in **Image 1** we can see the first and second phrase on the score, and it following the **Graphic 1** presents the general organization of the piece including the tonalities and Golden Section:

Figure 1 – Motif 1 and 2, measures 1-3.



Graphic 1 – *Verklärt Nacht*: Comparaison among Principal and Secondary Phrase, Accompaniment, Variation, Sequence, Tonalità and Golden Section.

3. Method of Creation

When we realize the interactive and multidisciplinary work of arts we must especially to realize an exchange of experiences and to learn with another languag. In this sense the process is very important to the final product because a new system emerges in function of the exchange of elements of different language.

The study related here was an introduction, an depart to make a performance that linked the work of images by Celestino Soddu, of words by Enrica Colabella and of sounds by Daniele Gugelmo.

We used the *"Method of Three Adjectives"* suggested by Professor Enrica Colabella. Therefore we heard and searched 3 adjectives to define this music of Schoenberg (*Verklärt Nacht*). This choice was subjective, arbitrary, but it had an close meaning with who chooses the words. The 3 adjective that I choose to speak about "*Verklart Nächt*" were:

1.strong
2.expressif
3.integral

We made experimentations departing from elements that I met in the analyse of Schoenberg's music. The motif and its variations were viewed like transforming codes and here beginning our work of experimentation and creation. The result is a work presented here (GA 2003) like a performance that shows music, poem and images.

I would like to register that this paper is a kind of introduction to the practical work, a performance that was prepared. It is also a theoretic commentary about the artistic work developed and it can express or express for another medium the relation among painting, music and poem.

«Estágio» in English means *«Training»* and in italian *«Tirocinio»*. These words mean a moment of learning and change of experiences. Learning and experiences among painting, music, and poem guided to Generative Art. Among theses theories and practices a crossing of countries, universities, knowledge and cultures.

4.References

[1]Leoni, A.
http://filosofia.dipafilo.unimi.it/~chora/testi2/liberi4SCHOENBERGKANDINSKY.htm
[2] HAHL-KOCH, J. *Arnold Schoenberg, Wassily Kandinsky, Musica e Pittura*. SE SRL. Milano: 2002, (p. 209)
[3]______________ op. Cit, (pp.243-246).
[4]Schoenberg, A. *Die Gluckliche Hand*
________________*Verklärte Nacht*, op. 4
________________*Le Variazioni per Orchestra*
________________*Erwartung*, op. 17
________________*Pierrot Lunaire*, op. 2
________________*Lied der Waldtaube*
________________*Suite*, op. 29
________________*I Tre pezzi*
[5]_____________A *Verklärt Nacht*, op. 4. Verlag Dreililien Berlin-Lichterfelde. (Richard Birnbach)
[6]___________ *Fundamentos da Composição Musical*. São Paulo. Edusp: 1991, p. 35
[7]___________ Op. Cit, p. 36
[8]Mazzotta ed. *Wassily Kandinsky. Tradizione e astrazione in Russia (1896-1921)*. Milano: 2001.
[9]www.glyphs.com/art/kandinsky
[10]www.artegens.com/tesi/website/tpage.htm

Code, a *password* to *infinite*

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Abstract

This paper tries to investigate around the concept of code, as identity of a theme, and of variations, as results of a *generative* process. The hypothesis is that infinite rises in a borderline between a *visionary* world and an interpreted reality with a strong connected dualism. As in Nature the first gets from a dynamic centre, in endless variations until the border, the second by using diachronic matrixes moves unsteadily toward a static centre for delineating open systems of transforming rules. This is a *creative* route in the site of the Myth of Sisyphus.

1. Aims: To investigate in a creative process, by getting into focus how to define an idea/code for building endless variations.

Preludio

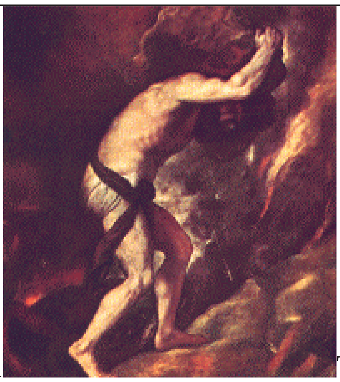

Fig.1 Tiziano, Il mito di Sisifo

The site of the Myth of Sisyphus.
If we image that Sisyphus rises his eyes and looks to his reality *at a distance* as in another contest with a new imaginary borderline, by feeling not only what happened, but also **how** is exactly the frame of his life in a new consciousness of human beings, we can see a freedom root. The endless repetitions become variations of the theme toward infinite. These are like frames of a new complex reality, in which memory can loose its domain and hope can rise.

2. An hypothesis

By learning to discover reality it is a ***visionary*** procedure that defines the dual structure between a discovered reality and a new *idea* of transformation as a *coherent* open system.

2.1 First step: *At a distance*

…. A *spatial* distance….. by discovering a viewpoint.

In "Zibaldone" Leopardi said : "*It exists in human beings an imaginary ability that can conceive things that are not and in a way in which real things are not… man goes wandering in an imaginary world and he figures things that he could not if his vision extended in all, because reality excluded imaginary*." (12-13/07/1820)

Interpretation is an essential condition of a visionary process that starts by choosing a viewpoint.
In Perspectiva Artificialis working from 3d to 2d we can define theoretically all the points of space as points of view, but when we choose a point and an horizon we build an artificial scenario that is starting inside infinite. So we can realize endless representations of the same space in a dynamic approach.
It is also possible, as i.e. in this (Fig. 2) "Ovale della prospettiva della Piazza Granducale" by Bernardino Gaffurri (Firenze 1606), to manage a complex system running from two different viewpoints. This ambiguity is a strong tool to open mind toward a possible interpretation.

Fig 2

3.2 *Reverted* vision

If we work from 2d to 3d using a reverse perspective process, we can design generative codes of transformation with a set of possible 3D results that start from each 2D shape. More in general we can use the multiplicity of results made by the passage from a dimension to the upper dimension. In other words, a two-dimensional image, as a photo or a sketch that represent a possible our imaginary, is really extremely useful when we move from a dimension to a more high one by following our interpretation. This procedure finds again in a substitution group the generative potentiality of describing unexpected configurations of the author' idea/code.
We can define a point of view but only in a coherent system, that works as a supreme invariable. This is a binding condition to recognize the figuration. The dynamical interchanging as interpretative hypothesis is only on choosing a point on the line toward infinite. So we have a limited combination, also if in a big number, of the2d picture. This happens because the relationship structure of the picture is the product of a historical fixed imaginary.
In " The not Euclidean Image" Celestino Soddu wrote about his experimental work in defining 3D interpretative models with a reverse perspective.

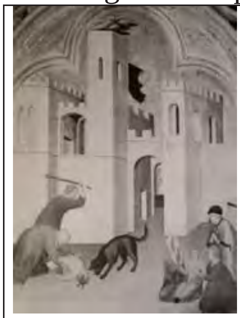

Fig.3

Fig.4

Fig.3 "Il bambino azzannato dal lupo" by Simone Martini, 1328
Fig.4 Two axonometric views of 3D models, as results of 2 different view points of a reverse perspective

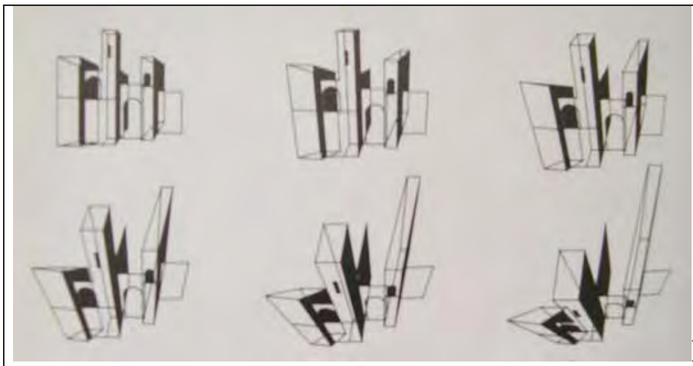

Fig.5

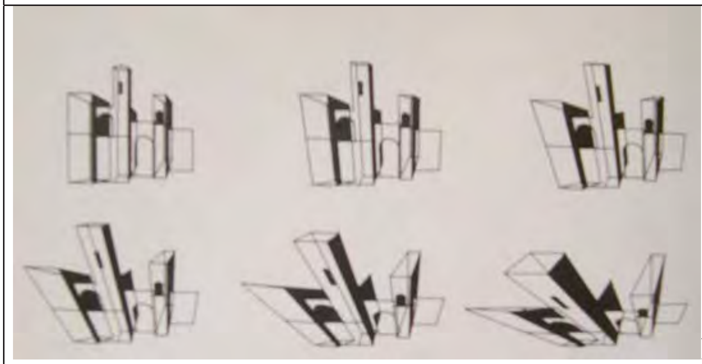

Fig.6

Fig. 5/6 Perspective representations of the identical model by using in sequence a horizontal rotation of 22,5 degree. In this passage, all the possible three-dimensional structures that are generated are able to represent, in their multiplicity, the discovered visions inside the previous two-dimensional one.

3. 3 Anamorphosis and not Euclidean perspective

By analysing Van Gogh, Celestino Soddu defined first algorithms directly connected to natural vision and after he used anamorphosis for representing the totality of the space in a temporal vision.

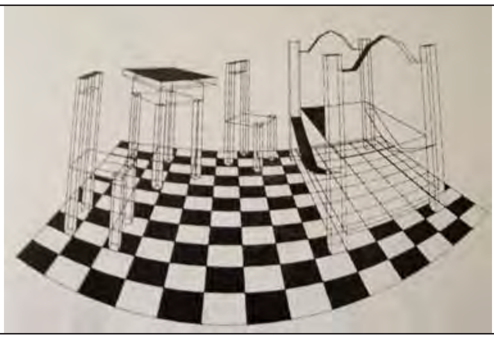

Fig.7 The room of Van Gogh Fig.8 A curved perspective

Total Perspectives with a viewpoint inside the room

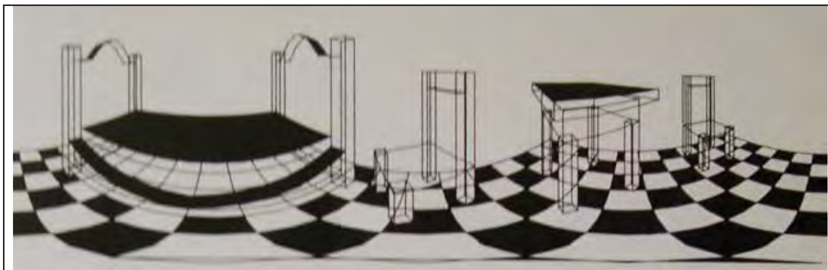
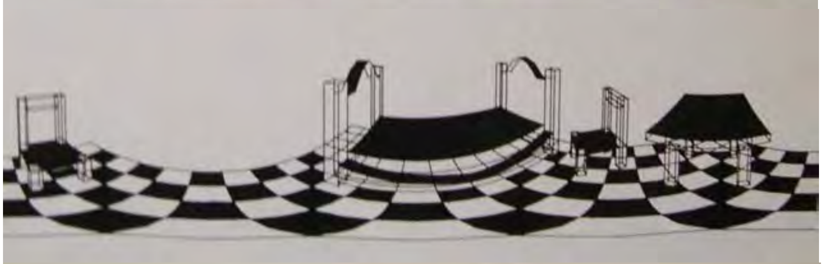
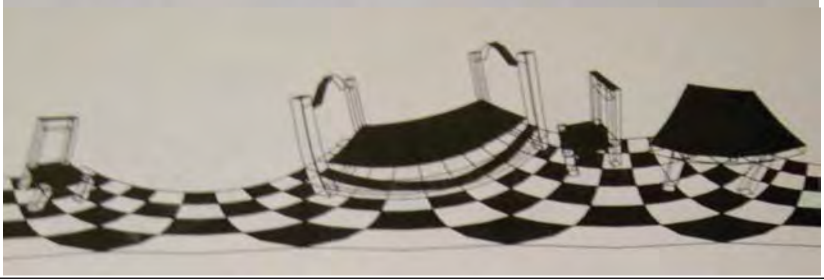
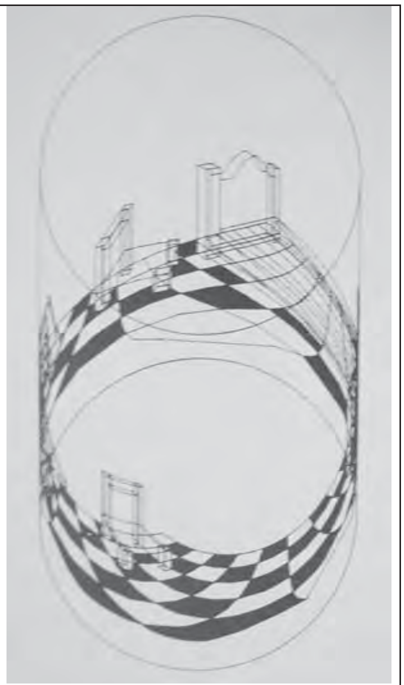

Fig. 9 The viewpoint is closed to the bed
Fig. 10 An oblique vision in a side
Fig. 12 And in the other side
Fig. 12 A total perspective traced on a cylinder in axonometric representation

1.3.2 *Natural infinite*

Leonardo defined philosophy as *"images of mental talk"* by drawing a deep parallelism between Nature and Reason. Luca Pacioli suggested Leonardo to read the V book by Euclide. This was a basic point that he extended with genial intuition, by using proportions also in time, space, sounds, weights, sites etc. By this scientific investigation he discovered "… *varie e strane forme fatte dalla artificiosa Natura*…" (..variant strange shapes made by Artificial Nature..), that he fixed in sketches and used later as codes in his works.

His scripts edited only in 1881 were pressed as a simple first draft on a wax table in only one passage, by using a Roman technique. These were written all in a *reverse* way. It is possible to read them only in front of a mirror, for emerging a similarity between natural process and interpreted reality.

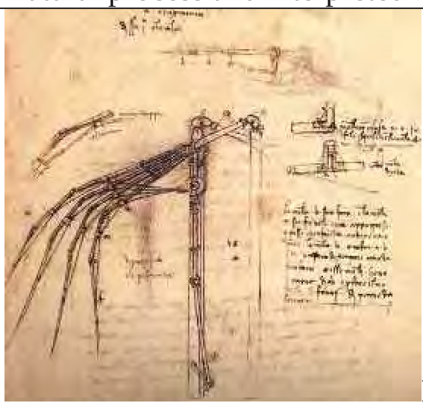

Fig 14 Mechanical wing by Leonardo


Fig 15 Hands drawings by Leonardo

Hand can use a double direction to write vision.
From left site to right, from east to west, the vision of God in human beings as connection between result and matrix. A centripetal vision that works for uniqueness and defined quantity. In this configuration it is also a way from up to down, toward an unchanging centre as permutations of an eternal set.
From right site to left, from west to east, the maternal vision toward human beings as natural infinite in a centrifugal process. Leonardo with his reverse scripts describes this process, by representing the maternal vision.



Fig. 16 The right hand of Madonna litta by Leonardo
Fig. 17 The nearly profile of Madonna
Fig. 18 The right hand and look of baby

1.2.2 Second step: *A temporal distance*

1.2.2 …. A coherent time…..

An allegory

Time, Real and Imaginary
An Allegory
by Coleridge

On the wide level of a ***mountain's head***...
Two lovely children run an endless race,
A ***sister*** and a ***brother***!
This far outstripp'd the other;
Yet ever runs she with ***reverted*** face,
And looks and listens for the boy behind:
For he, alas! Is ***blind***!
O'er rough and smooth ***with even step*** he passed,
And knows not whether he be ***first at last***.

If we define a code, as open strata of diachronic matrixes, we can generate new endless variations.
If we see the generative work by Celestino Soddu about "Medieval Towns Morphogenesis" , we can discover codes and matrices that work to produce endless variations of the same identity.

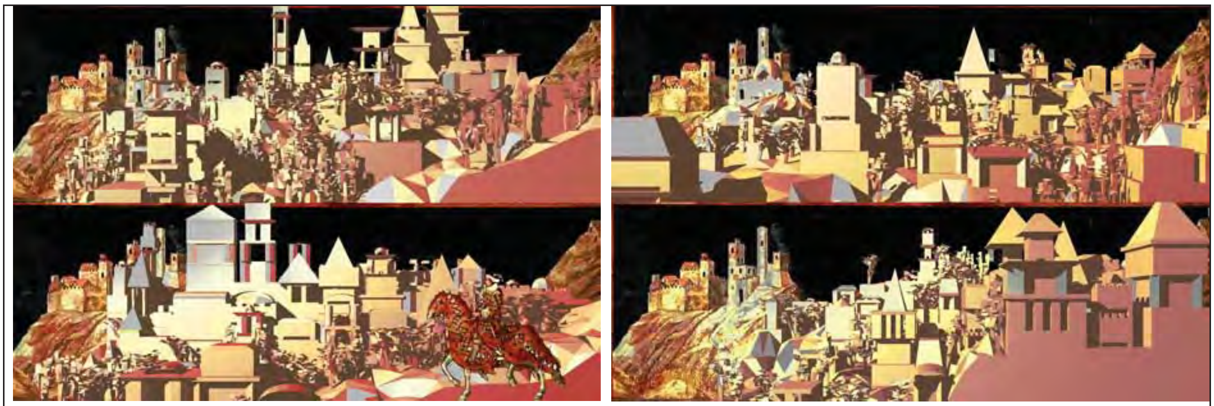

Fig 19/20 Four different Scenarios of Medieval Towns generated from an interpretation of frescos by Giotto and Simone Martini

Also in "Old Chicago", we can discover new generated Scenarios in perfect harmony with ancient environment, such as to seem with the same cultural time code.

Fig. 21/22/23 Different Scenarios of generated sky scrapers in Chicago of the beginning of the last century

1.2.2 *….a reverse time…*

Some days ago people got the news that after seven centuries the tomb of Petrarca will be opened for rebuilding his physiognomy with VR. But it might be for his DNA too

Anonimo, *Francesco Petrarca nel suo studio*, miniatura, XV secolo.

The question is: a Petrarca clone will be a Poet? In a strong temporal distance the same code will rise a great poet in another contest? If yes, the code is the whole, but if we read this fragment:

"If we were not something more than unique human beings, if each one of us could really be done away with once and for all by a single bullet, story telling would lose all purpose. But every man is more than just himself; he also represents the unique, the very special and always significant and remarkable point at which the world's phenomena intersect, ***only once this way and never again****. That is why every man's story is important, eternal, sacred; that is why every man, as long as he lives and fulfills the will of nature, is wondrous, and worthy of every consideration".* Hermann Hesse, Demian (1917)

We can simply deduce that story telling are losing all purpose. So the clone of Petrarca cannot be a poet. But this is not enough.

5. Conclusions

We can only say

1. The visionary world can rise only inside a natural infinite.
2. The cloning is a 2D point (temporal dimension is zero).

In "Zibaldone" Leopardi said:" It is infinite a labor of our imagination… infinite is an idea, a dream not a reality: at least we have not any proof of its existence, not even by analogy."

References

G.Leopardi, Zibaldone, Newton Compton, Roma 1997

H. Hesse, Peter Camenzind, Gertrud, Rosshalde, Demian, Newton Compton, Roma 1992

C.Soddu, "L'immagine non euclidea" (The not euclidean Image), Gangemi, Villa San Giovanni(RC), 1987.

C.Soddu, "L'idea di spazio nelle rappresentazioni d'arte", (the space idea in Art representation), in "Critica d'arte" magazine, n.16, Firenze ,Gennaio/Marzo 1988.

C.Soddu, "Citta' Aleatorie", (Random cities), Masson., Milano 1989

C.Soddu, E.Colabella, "Il progetto ambientale di morfogenesi", (The environmental design of morphogenesis), Progetto Leonardo, Bologna 1992

Index of short papers, posters, artworks and performances

Autobiographical system based on photo trac ing of artefacts

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Abstract

This paper proposes a system which allows anybody to produce an authentic autobiography based on a photographic tracking of his/her interaction with artefacts.

Typologies of artefacts

The typologies of artefacts suitable for the kind of documentation requested are as follow: those that are independent, those that are manual and those that are consistent.
Other typologies results in being too obtrusive for their frequency of engagement and not as easy to represent and recognize for their physical qualities.

Figure 1: From left to right three examples of artefacts that are respectively not independent (the car-wheel is dependent to the car), not manual (the stair are walked with the feet), and not consistent (a candy).

2. System description

Labelling

A digital camera unit is designed to allow the user to immediately label the image with a simple combination of icon-buttons representing the situation in which it was taken.
The system proposes four sets of icons respectively related to the following parameters: *where* the image was taken, *who* else was present, *how* the artefact was engaged and with *what* it did interact.

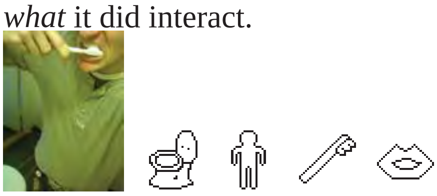

Figure 2: A labelled image representing the user in the toilette, alone, brushing, his mouth.

The user is asked to document all of the artefacts engaged within an action. If the action changes the user is asked to take new images. If a new image has some parameters in common with the previous one the user can skip the typing of those.
Within the four matrixes the icons can be re-customized by the user via a special software editor.

Figure 3: A possible customization of the four matrixes corresponding from left to right to where, who, how and what.

ro sing

The images can be reviewed spatially in a daily chronological sequence. Every image shown in such a sequence is linked to another sequence containing all the other images sharing the same label but captured at different times.
Those other images in this last sequence are linked back to the chronological sequence they individually belong to.

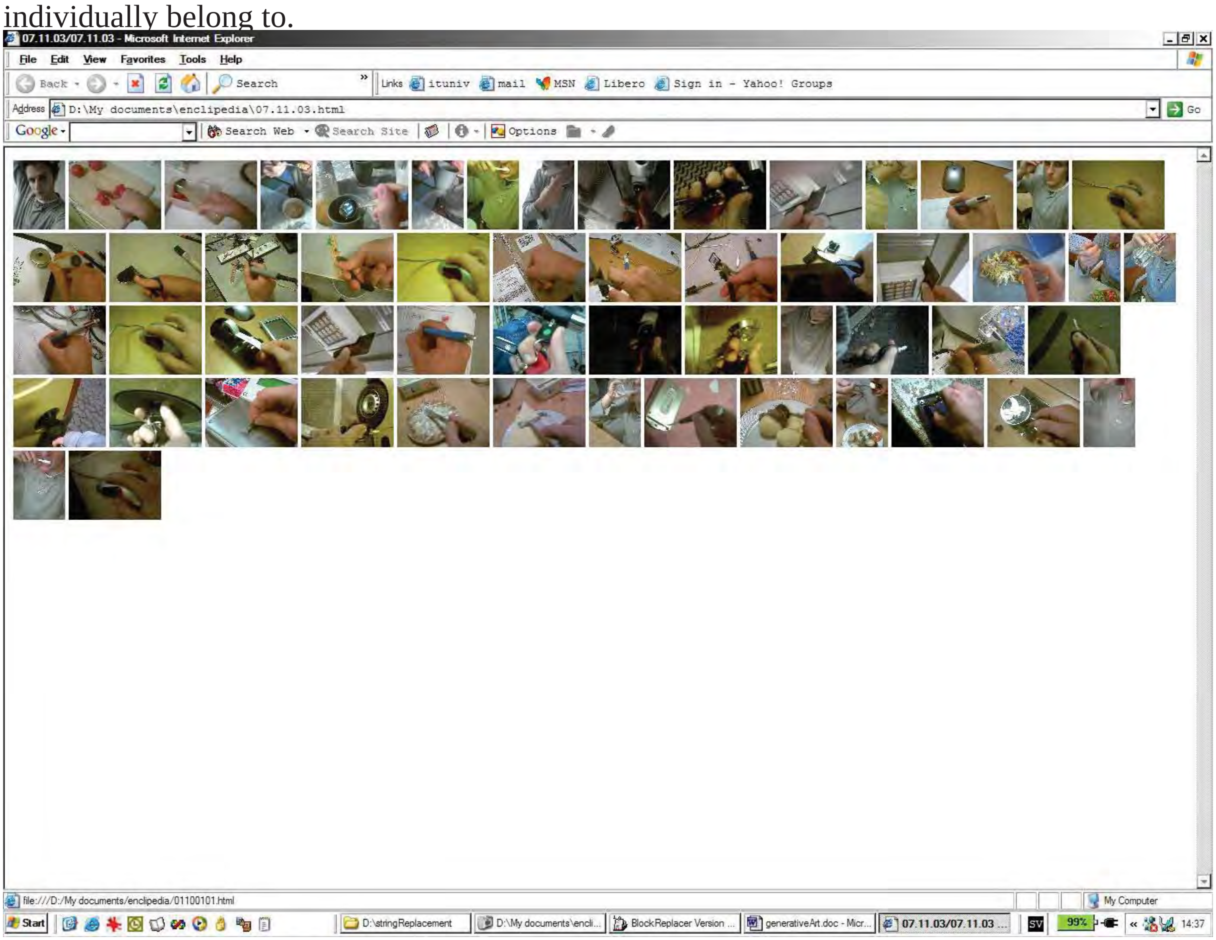

Figure 4: A screenshot sample of the 07/11/03 sequence.

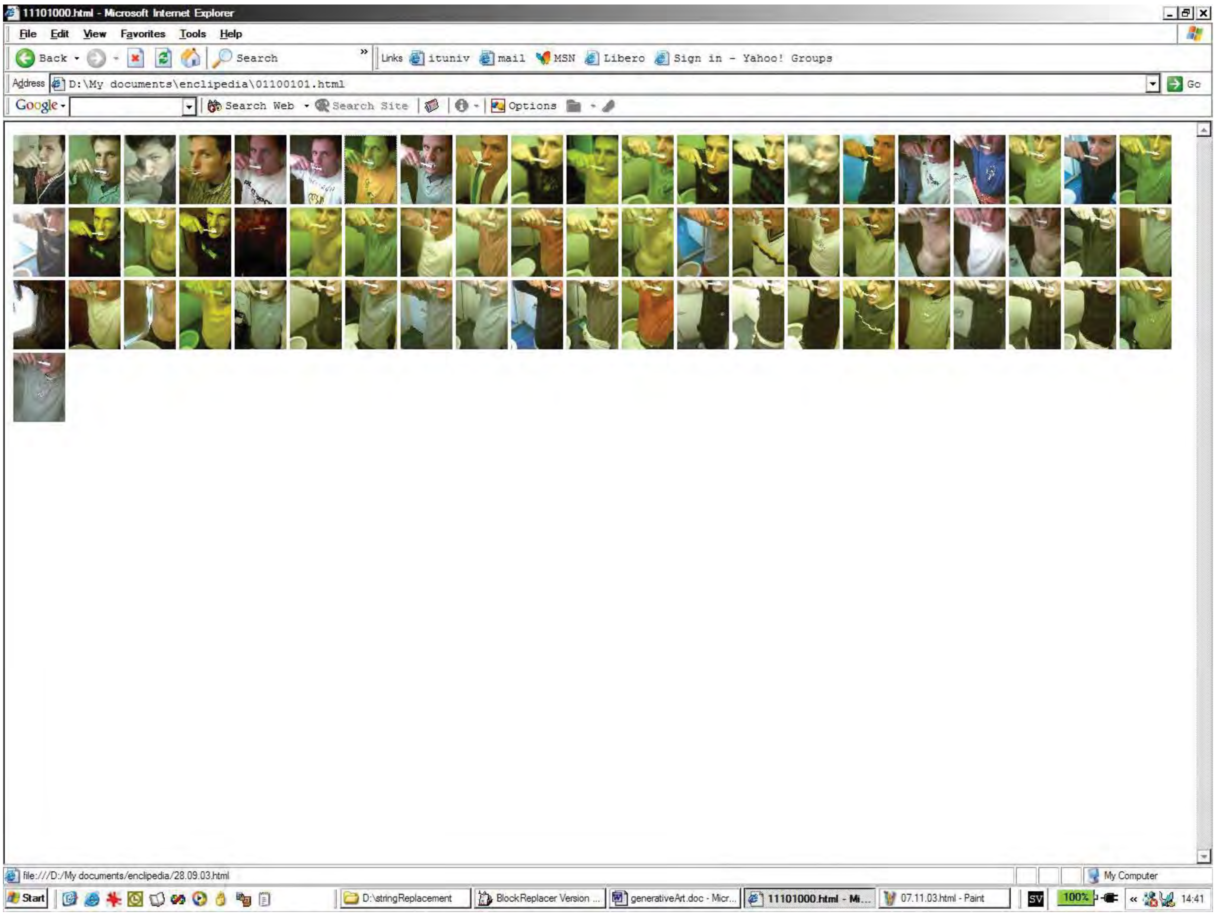

Figure 5: A screenshot sample of a sequence containing all the images with a common label. Such sequence is linked to the previous one with the last two images descending left to right.

An example of this would be the following: a sequence shows the images of a match, a knife, a spoon etc. The user reviewing the sequence is then reminded she was cooking at a friend’s kitchen which has a gas stove. She suddenly associates the gas stove with that of her mother. By clicking on the match the sequence containing all the matches is displayed. Here she finds those she was looking for, she clicks on one and a sequence containing a day she was helping her mother cooking is displayed.

An aesthetic identity

As days pass by the system assumes an increasing aesthetic value, generating a macro image in which the user can at the same time reflect upon his documented life and determine his future activities. This aesthetic, a carefully arranged mosaic of nestled patterns rhythmically repeating themselves, could in the long run become the mask representing him/her in a social context.

A face to face isual communication de ice

An alternative use of the system is to embed a screen visualizing the images on the clothing of the subject. This provides the subject with an augmented “face-to-face” communication device where the images shown correspond to the topic of the discussion the subject is involved in. Two examples of this would be the following: when the subject is thirsty the device displays images of him drinking, and when the subject is telling a friend about his holidays the device displays the associated chronological sequence of images archived.

The demo performance

The presentation will show the result of a three months experiment on myself photographing each of my interactions with mobile/independent/consistent artefacts.
At the time of the conference, during the open public event, I will try to reconstruct my documented history.
This will occur in two rounds. The first time I will story-tell what my memory alone remembers. The second time I will story-tell what my memory remembers with the support of the system engaged. In both times a minimum of two persons will certify that during the demonstration I haven't had any other types of support either on myself, from other persons or in the architecture. The event will be documented and later evaluated to support my studies. Public visitors can interrupt anytime to get further explanations.

The system is updated daily at the following address: http://www.id.gu.se/~alberto/.

Conclusions

In conclusion, such a system is meant to assist an otherwise confused historical reconstruction of the self, characterized by frequent encounters with industrial artefacts that on one side are very seductive entities and on the other are obsolete garbage ready to be recycled for the newer trend. Human history is in the process of becoming those trends and the individuals just its scenography. Therefore a controversial design effort would be to invite the individuals back into the scene. Perhaps further advances in miniaturized technology and biotechnology may allow an autobiographical system free of demands from the users. The design challenge will still be to adapt those future possibilities to an understanding of everyday life, and to understand how this everyday life is already adapted to those possibilities.

Problems in the Perception of Linear Perspecti e

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Abstact

It is well know that the shape and size of objects visually changes if the object's distance from the viewer and the position of the object change, but it needs specific theoretical training in the construction of perspective. For these reasons, drawing three-dimensional objects on the picture plane demands not only knowledge of their external peculiarities, but also skills in matching the shape of objects to the peculiarities of visual perception which allows us to represent objects "truthfully". However, this is one of the hardest tasks in drawing. It needs specific theoretical training in the construction of perspective. A review of textbooks and resource books on drawing published in different countries during the last 30 years reveals that a body of rules for linear perspective has evolved which is stable and interpreted similarly. However, explanations of the practical implementation of one-point perspective are not quite logical. This article covers some of the problems of the perception of perspective, and offers methodical recommendation for implementing linear perspective in training for drawing.

Keywords: *historical treatise, perspective, linear perspective, descriptive geometry, methodical recommendation.*

Introduction

Many centuries ago western artists observed the regularities of visual perception, and by the 15^{th} century, Italian artists had collected important experience in reproducing their observations by means of drawing, painting, or sculpture. These were sufficient to allow the structuring of the experience and knowledge in coherent system. This began the science of explaining and theorizing certain forms of depiction related to the visual perception of the world - "perspective"- meaning the ability to see correctly. It was no accident that Giovanpaolo Lomazzo (1538-1588) once asserted, that he would rather die than disregard the perspective [1].

Following of the "discovery" the area has been examined by scientists, psychologists, architects, and art educators who have theoretically investigated perspective which derived from the creative practice of Renaissance artists and was more precisely named as "linear perspective". Changes occurred as the theories developed and were used and elaborated as practical recommendations for drawing.

Review of textbooks and other resources on drawing published in different countries during last 30 years shows that a body of rules for linear perspective has evolved and is stable where a range of authors maintain general agreement. However, there are some exceptions, e.g., the practical implementations of one-point perspective.

The first part of this investigation was introduced in my article in the International Journal of Art and Design Education, Vol.19.1. (England) [2].

This article deals with the different aspects of studies of linear perspective continuing the discussion about the essence and problems of world perception in perspective.

Linear perspecti e

Linear perspective can be subdivided into three types: one-point, two-point and three-point perspectives.

One-point perspective. Figure 1 illustrates how lines, which are parallel to one another, and recede into the depth of the picture towards the horizon, will all meet at one vanishing point on the horizon line [3].

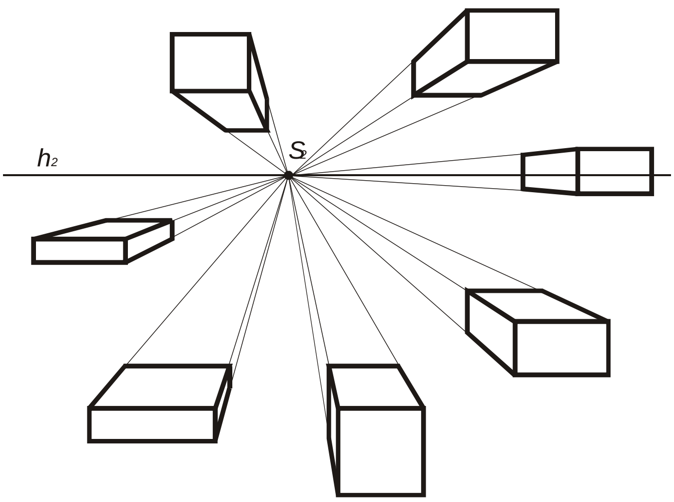

Figure 1.

“Also, we have one-point perspective when both the height and width of an object are parallel to the picture plane” [4]. “In the exercise, …a number of boxes of various sizes and positions are drawn using the same perspective point. Notice that in all cases, the height and the width of the boxes are always parallel to the picture plane” [5].

Analogical definitions can be found also in a range of textbooks [6].

Two-point perspective. Figure 2 illustrates that when two or three sides of a cube are visible and all sides of the cube recede in spatial depth, the lines are directed to two vanishing points [7].

Three-point perspective. Figure 3 shows that when we view an object (e.g. a high building) from either a top view or a bottom view, we are most likely viewing it in three-point perspective. The point, where the vertical lines cross is the position of the third vanishing point.

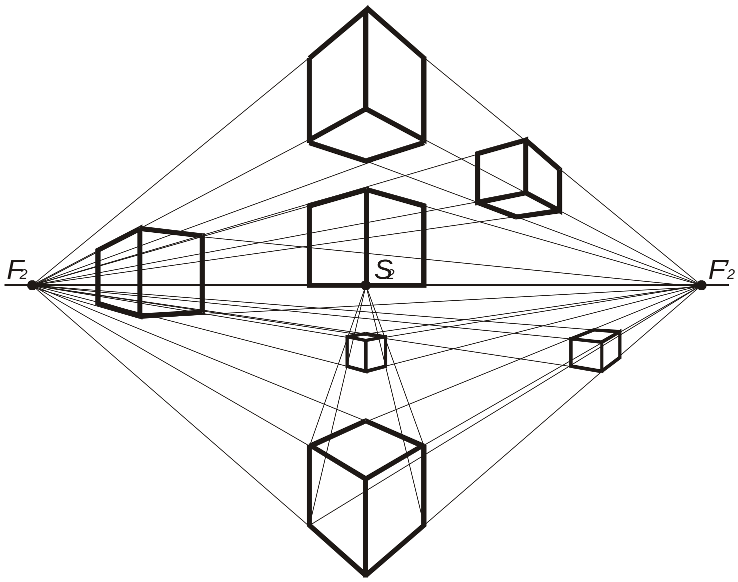

Figure 2.

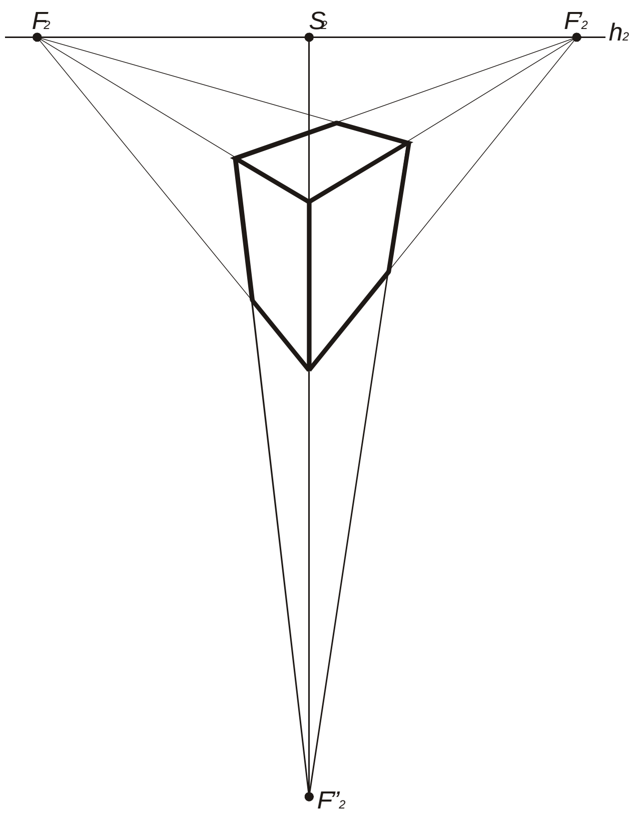

Figure 3.

One point perspecti e

Object construction according to the rules of two-point perspective raises no particular doubts.

We will try to analyze more deeply the peculiarities of object depiction in one-point perspective, where one author give the following specific definition: *"A rectangular-based solid … can be drawn by putting together all the planes created by the perspective rectangles. Thus, the front plane, which is parallel to the picture plane, can be drawn and the sides produced back from the corners to the vanishing point. Think of each side as a rectangular plane going back in space. The rectangular-based solid can also be shown to left or right of the vanishing point, revealing another side"* [8].

In my opinion, the implementation of one-point perspective with the visible side plane has not been interpreted correctly. Let us examine the example of a drawing of a cube in a position where one side of the planes is visible and the horizontal edges of the front side do not have a vanishing point.

Schipanov, writing about one-point perspective construction methods notices: *"For a cube which is positioned at an angle from the central visual ray one extra side plane always will be visible"* and describing the construction of two-point perspective he gives the following definition: *"In two-point perspective the position of cube's lines of receding planes is directed towards two not one vanishing point"* [9]. Attentive reading of both definitions raises the following doubts: if the cube is diverged on to one side of the central visual ray does not that means that the cube already is in a "two-point perspective" position?

Arnheim resolves this by the following explanation: to see the side planes of a physical object a viewer has to look from some side angle. In these conditions all sides, including the front side, have to appear distorted. When the frontal side is seen in the shape of a square this means that the viewer is looking at the object perpendicularly and that none of the side planes or top plane should be visible. By changing the angle of recession side planes become visible, and in this case it is not possible to see the frontal square [10].

Let us consider one more example about one-point perspective construction (Figure 4).

"*Draw two guidelines from the bottom outside corner of each front leg to the V.P.* "(vanishing point). "*This determines the width of the back legs. Now, place two boxes on the table using the same vanishing point"* [11].

Figure 4 shows that in one-point perspective the table's construction is drawn correctly, however, accordingly to Arnheim, the drawing of the two boxes has to be executed in two-point perspective. This can be tested by a small experiment - by placing a large box on the table, as in Figure 5. Then, by means of the visual method of measuring (sliding ones thumb up or down a pencil while maintaining the same distance from one's eye to the pencil) one can define the proportion between the height of the first and second corner of the nearest box's side. In the process of this experiment one can affirm that the left corner is larger than the right. Therefore, drawing a cube, positioned at an angle outside the central visual ray in one-point perspective, when its two or three sides are visible is not logical.

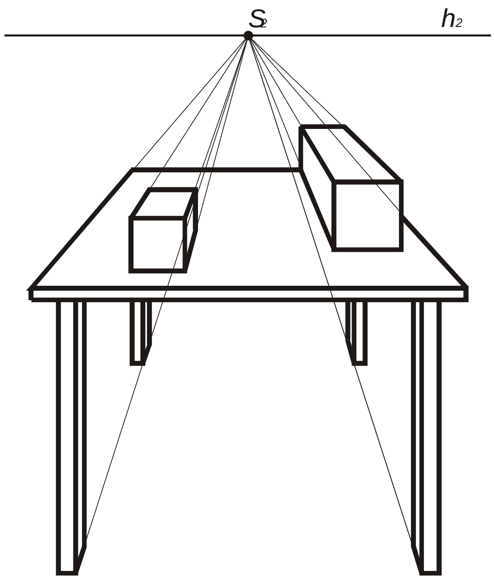

Figure 4.

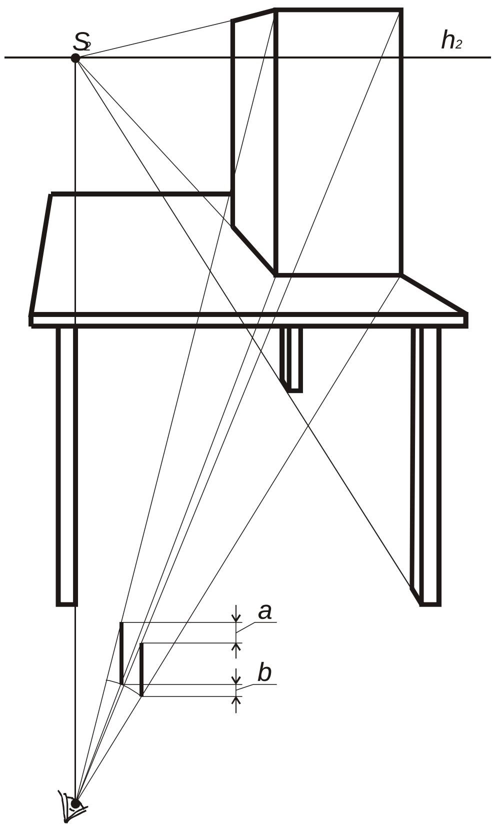

Figure 5.

In "*New essays in psychology of art*", Arnheim suggests that observers usually see parallel lines converging, but in specific conditions, e.g., if an object is looked at from a great distance, parallel lines can actually appear parallel [12].

The correctness of definitions can be easily tested by the following experiment. Fasten a horizontal slip of paper or piece of wall-paper (approximately 5m long and 50cm wide) on a wall. Stand facing the paper but at one end of the paper, at a distance of 3m, estimate the proportions of both ends of the paper using the previously mentioned visual method of measuring. Then step back another 3m and using the same method of measuring you will see that the visible difference has diminished.

Thus, one-point perspective is possible when drawing of three-dimensional object in position where the side planes are not visible, or it can be justified, e.g., in depiction of room [13] or townscape where the objects are positioned at a considerable distance from viewer [14].

But, even the drawing of a room as in Figure 6 is only relatively correct regarding the peculiarities of visual perception. Actually, we perceive the objects placed in the room in ***"****natural perspective****"*** [15] as showing in Figure 7. In the tonal drawing of a room, the artist has tried to represent the objects seen out of the corner of his eye to left and right, in addition to the space in front. The sofa (bottom left) is in reality parallel to the table (bottom right). In certain types of perspective drawing, the back of the sofa and the edge of the table, which are at right angles to the floorboards, would be drawn along the same horizontal line. Here, they are at an angle to each other because that is how you actually see them. Similarly, the central beam across the ceiling is in reality straight and would be drawn so according to conventional perspective, but when you look at it, it appears curved.

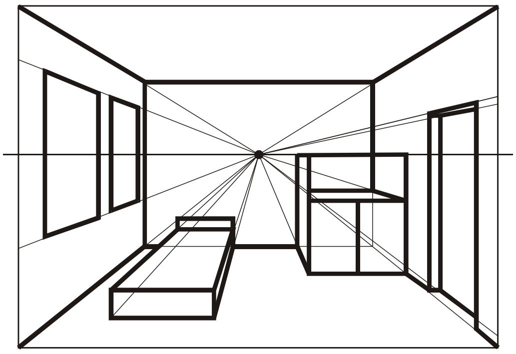

Figure 6.

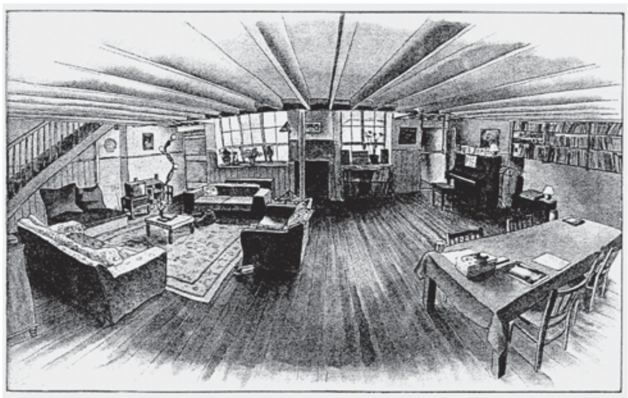

Figure 7.

In addition to this, in many cases one-point perspective may give serious distortions. For instance, in "*Fundamentals of Drawing*" one can read that the cylinder is distorted because the vanishing point is too distant. The distortion happens because the shape has fallen out of a normal viewing plane and to see it you would need either to change the angle of vision or draw it in two-point perspective [16]. An example of this may be seen in Figure 8. The cylinder does not look "wrong", but it is not convincing.

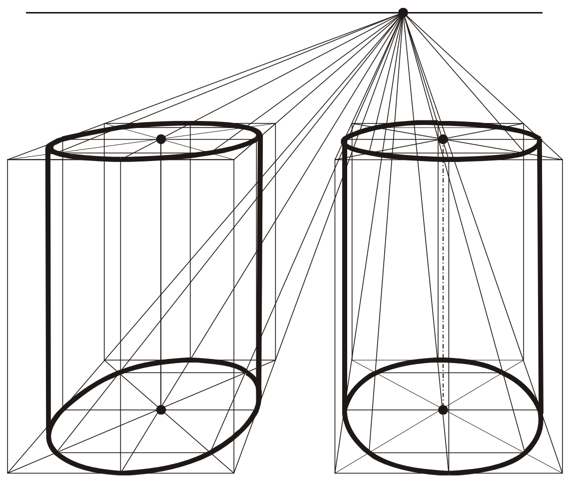

Figure 8.

Pedagogy

How one can explain the inconsistencies of one-point perspective to students? Let us turn to the example of Figure 9 which is a drawing of the same cube in one-point perspective positioned at different distances from the viewer, but at the same distance from the horizon line. This example shows that the outer cube looks like a prism [17].

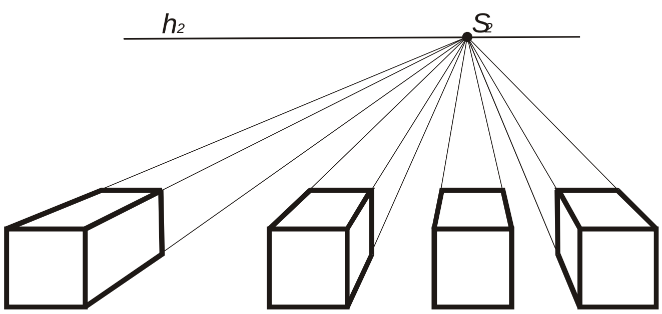

Figure 9.

Actually, it is the outer cube that resembles a prism and this is caused by the imperfection of one-point perspective. Descriptive geometry gives a clear answer to this question. In this drawing the horizon edges of the cube's side plane are drawn longer than the vertical and horizon edges of the frontal side which are depicted in natural size. From the fundamentals of descriptive geometry we know that the segment of a receding straight line always will appear shorter than its actual length. The same example offers an explanation for the distortion of the cylinder (Figure 8).

Having studied from textbooks, which form the students` basis of one-point perspective drawings in the case of a cube, the students also draw the construction of polyhedral shapes with visibility side planes incorrectly. Their conviction can be changed only by acquiring of fundamentals of descriptive geometry.

Defining the linear perspecti e

The general principles of perspective construction are reflected in one of the engravings by A.Direr (1525) picturing the peculiar device for the correct reproduction of perspective in drawing from the nature (Figure 10) created by the author. This engraving depicts the artist painting the picture and viewing the scene by one eye through the specific device with the hole and frame covered with the net of square knots. Frame with the net is positioned in a such length from the hole which allows a full view of the frame and figure without the turn of the head, e.g. without the transference of viewpoint. On the table in front of artist lays the sheet of paper also covered with the regular rectangular grid, which helps the artist to fill in the scene observed through the hole.

Figure 10.

Engraving by Direr illustrates the perspective construction process on the two dimensional translucent picture as it was interpretated by the artists of Renaissance. Contemporary theory of perspective describes this process the same way. This theory suggests the common and fixed viewpoint and translucent plane of picture to view the space behind the picture.

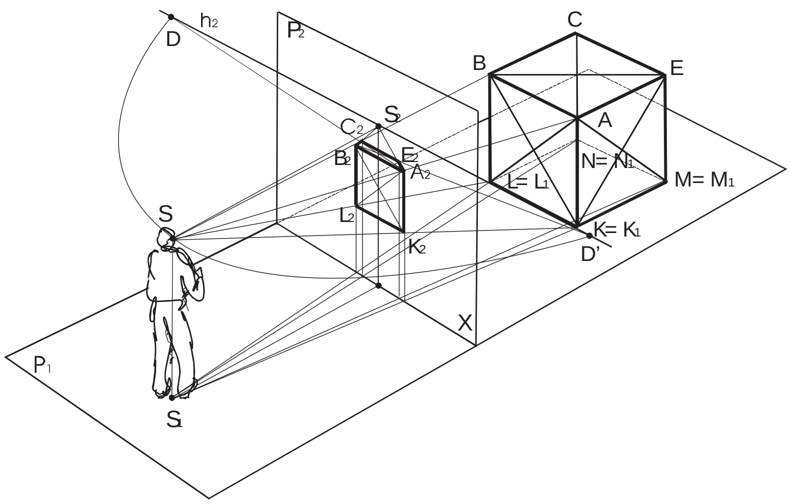

Figure 11.

Figure 11 depicts the popular construction of cube perspective with its observable apexes marked by letters ***ABCEKLM***. Cube is positioned on the ***ground plane*** (**P_1**) frontally towards the ***picture plane*** (**P_2**). Picture plane is perpendicular in regard to the ground plane and the projection of picture plane on the ground plane is the ***ground of picture plane*** (***X***).

Line set at ***90*** degrees from the ***viewpoint of observer*** (***S***) to the picture plane determines the ***central vanishing point*** (**S_2**), but line set at ***90*** degrees toward the ground plane – the ***station point*** (**S_1**). The ***horizon line*** (**h_2**), which intersects the central vanishing point and represents the eyes level is located on the picture plane. Looks of artist to the separate apexes of cube are connected with the straight lines usually called the ***visual rays***. Perspectives of cube's apexes are situated in points where these rays intersect the picture plane. Projection of cube is created by the connection of perspective points of all apexes of cube.

Similarity of perspective depiction to our visual impressions is the main quality of these reproductions, which provides the opportunity of truthful reflection of different objects.

Some regularities of perspective can be deducted from the construction of cube's perspective. Further will follow some well-known information, however, the emphasis on this knowledge is necessary if we want to reach the aim of this article.

Main la s of linear perspecti e

Many textbooks on drawing and perspective interpret these laws differently, though, the meaning of these laws stays the same:

1. ***Perspectives of all lines perpendicular in regard to the picture plane will converge at the central vanishing point on the horizon line***. Figure 11 represents the perspective where the edges ***AE*** and ***BC***, perpendicular in regard to the picture plane really converge at the central vanishing point [18].

2. ***All horizontal straight lines, parallel to the picture plane*** (i.e. ground of picture plane ***X***) ***do not have vanishing points and their perspectives remain parallel and horizontal lines***. In the case of cube – these are edges ***CE, BA*** and ***LK*** [19].

3. ***Straight lines, parallel to the picture plane but not to the ground of picture plane also do not have vanishing point*** (they are located in infinity) ***and their perspectives remain parallel to these lines***. In Figure 11 these are the diagonals of the front edge ***AK*** and ***EL*** [20].

4. ***All the vertical lines parallel to the picture plane do not have vanishing point and their perspective remain verticals*** (edges of cube ***BL***, ***AK*** and ***EM***) [21].

Besides that, we have to mention that second, third and forth laws can be combined in one definition: ***perspectives of all interparallel lines parallel to the picture plane remain the parallel.***

In space horizontal straight lines can be located at any angle to the picture plane: ***all the horizontal parallel straight lines located at acute angle to the picture plane converge at the vanishing point on the horizon line*** (Figure 12) [22]. This law determines the construction of cube projection in position where the observer can see two side planes of cube and in this case the perspective of cube have to be constructed with two vanishing points. However, if these straight lines are set at ***45*** degrees to the picture plane (in Figure 11 these are diagonals ***AC*** and ***BE***), then the vanishing points of these lines will be distant points **D_2** and **D'_2** which will be located in such a distance from the central vanishing point which is equivalent to the distance between the viewer and picture plane.

There are lines which receding away from the viewer either descend or ascend. In descriptive geometry these lines are called the ***general straight lines***. They are not parallel or perpendicular neither to the picture nor to the ground plane (in Figure 11 these are the diagonals ***AM*** and ***KE***). ***General straight lines intersect the picture plane adequately above or below the horizon line***. Figure 12 illustrates the example of parallel general straight lines ascending away from the viewer.

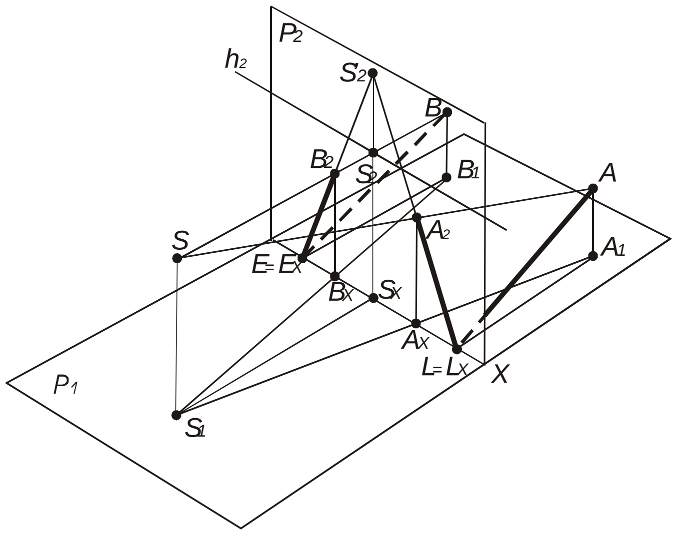

Figure 12.

These laws of perspective construction of straight lines allow to construct every complicated shape in perspective. Though, the deeper analysis of some of these laws asks for the more valid interpretation.

The main problem of perception of perspecti e

Let's have a more detalized analysis of concept of perspective construction for the vertical straight lines, which contradict, with the three-point perspective construction where the parallel vertical straight lines converge in one vanishing point located above or below the horizon line.

In textbooks this method usually is illustrated by examples of many-storeyed building perspective construction. To find the solution for the stated problem let's focus on the axonometric projection of model of many–storeyed building perspective constriction (Figure

13). The picture shows that vertical straight lines will remain vertical does not matter how far we extend them, which rises the doubts and many questions.

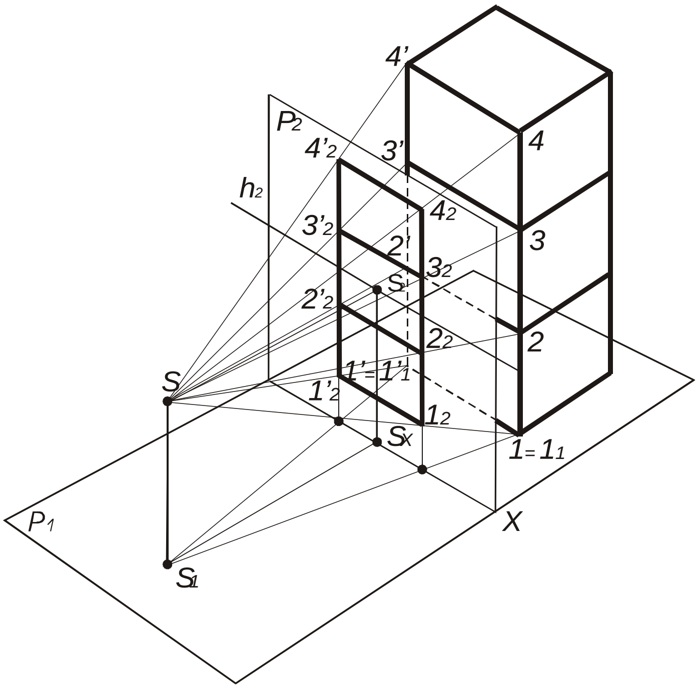

Figure 13.

Many textbooks either ignore the mentioned controversy or give a very superficial explanations about the changes in slope of picture plane without any empirical prove of statements (“*Three-point projection for plans and elevation is more complex than that for one- or two-point perspective. It can involve the incorporation of an inclined picture plane set at the correct angle to the ground plane. Some methods require a special plane of the object as seen from the inclined angle. This is prepared by projection from a tilted elevation*” [23]).

The essence of problem is that neither in case with the description of laws of perspective construction, nor in explanation of three-point perspective not all of the authors emphasize the significance of location of object toward the field (or cone) of vision.

7. The cone of vision

It is well known that if one carefully observes the shape and range of space seen by two eyes, one can reach the less space above than below the horizon. Research proves that the angles made by visual rays intersecting the horizontal line are approximately ***45*** degrees above and ***65*** degrees below. [24] Reach of space by the visual rays to the right and left side is determined by the angle approximately ***140*** degrees (***70*** degrees to the each side).

Picturing the curved line drawn through the four points ***ABCD*** and stationed on two perpendicular axis we can get the rough shape of cone of vision (Figure 14).

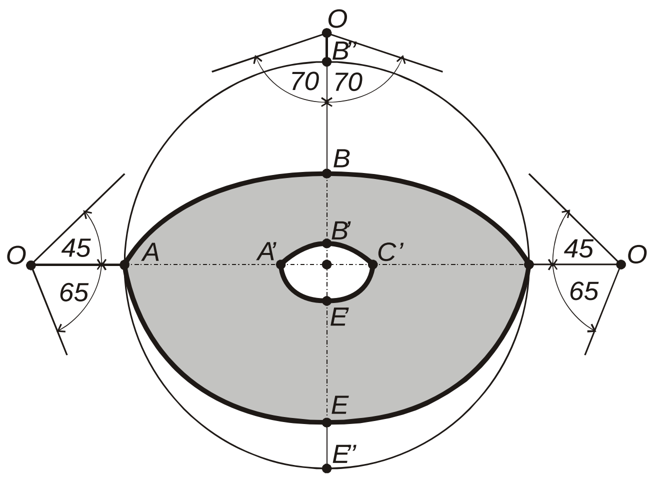

Figure 14.

It is easy to test the fact that we have perfectly clear view of just those objects, which are positioned in a small sector in the centre of cone of vision. Approaching the edge of cone of vision there is a sharp decrease in clearness of visual impression.

The fields of best view ***A'B'C'E'*** can be determined in vertical plane at angle ***28*** degrees but in horizontal plane – at angle ***37*** degrees (Figure 15). This means that to draw the standing person one has to move away from him/her not less than two of his/her heights. Only in these circumstances it is possible to perceive the whole person from one fixed point of view. From the closer distance we will be able to examine the figure of person only part by part. The same is correct also for the drawings of other objects.

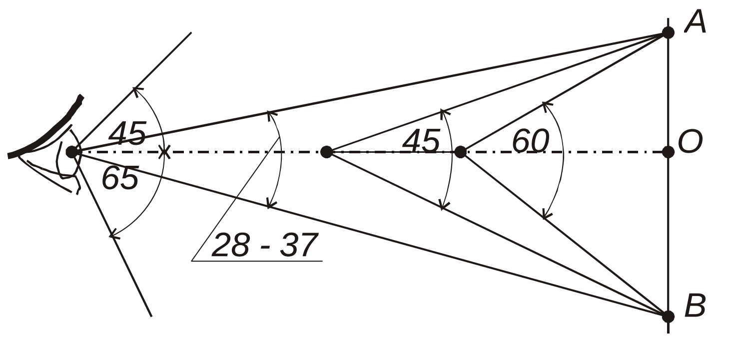

Figure 15.

Perspecti e of ertical straight lines

Figure 13 illustrating the axonometric projection of perspective construction of many–storeyed building proves that all the vertical lines in perspective remain vertical. But if you examine this figure from the position of cone of vision of views, to see the upper storeys the viewer has to rise the head and therefore to change the station point. In this case the main visual ray looses it's perpendicularity in regard to the picture plane.

Let's analyse this example from different aspect. For these purposes we have to spread out the picture in the position where the picture and ground plane will occupy the projective position

(Figure 16). It is clear, that even in this position nothing will change and perspective projections of vertical edges of building congruent with the projection of picture plane will remain parallel.

Now, let's mark the upper limits of cone of vision in picture upwards at angle ***45*** degrees, downwards – ***65*** degrees (Figure 15). Becomes clear that viewer will examine the building part by part. Point ***A*** determines the maximal limits of upper edge of cone of vision. Until the point ***A*** perspectives of vertical edges of buildings really will appear to be the parallel vertical straight lines.

To see the part of building located higher than point ***A*** we need to change the angle of vision, i.e., to rise the head. At the same time the central visual ray also will move above the horizon line. According to the law of perspective construction which states that central visual ray has to be perpendicular to the picture plane, let's move the picture plane accordingly, for example, at the angle of ***45*** degrees in position ***P'2***. In this case regularity about general straight lines (Figure 12) can be used. It states that these lines ascending from viewer in perspective will have the common vanishing point. To make this clear, let's spread out also the Figure 12 to the position where the picture and ground planes will become also the projective planes (Figure 17). Comparison of this Figure with the Figure 16, especially the part of moved plane ***P'2***, reveals the congruence of both pictures.

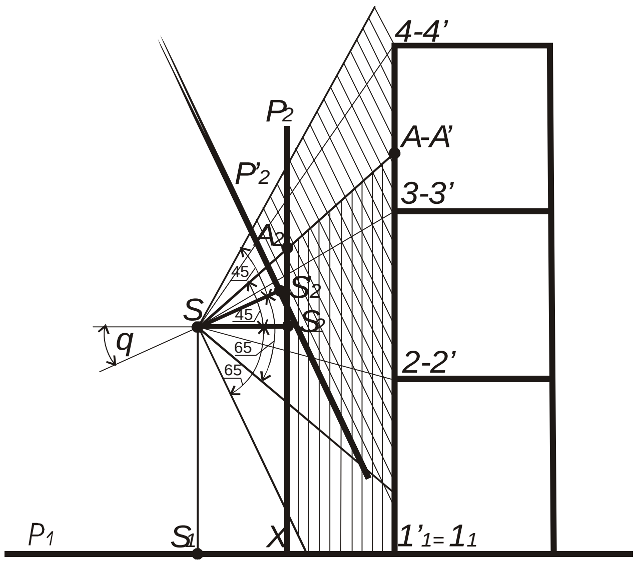

Figure 16.

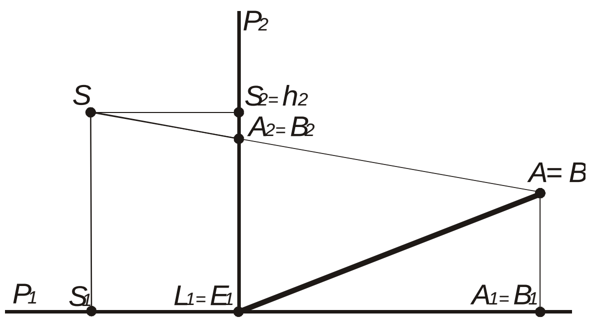

Figure 17.

Therefore the line segments ***A - 4*** and ***A′- 4′***, defining the part of building edges positioned in regard to the new picture plane P'_2 will appear the general straight lines, and their perspectives will have the common vanishing point.

Summary

Thus, one-point perspective is possible drawings of three-dimensional object in position where side planes are not visible. [25]

Law of perspective construction for vertical straight lines will be correct if supplemented with the definition of object position toward the viewer, i.e. ***all the vertical straight lines, perpendicular to the ground plane, in perspective will appear vertical only in cone of vision of viewer, beyond the reach of cone of vision their perspectives will start to converge.***

This conclusion is correct also for all the horizontal straight lines parallel to the picture plane and the prove of this is analogical the one for vertical straight lines. The peculiarity of this prove will be the move of central vision ray and, accordingly, the picture plane either to the right or to the left from the central vanishing point.

These example allow to conclude that there is a need for correction of well-known interpretations of regularities of perspective construction, namely: ***perspectives of all interparallel straight lines which are also parallel to the picture plane will not have the vanishing points only while located in the cone of vision of viewer. Beyond the reach of cone of vision their perspectives will start to converge and after all they will intersect the picture plane in the vanishing point. The location of vanishing point will depend on the position of these straight lines in regard to the ground plane. These lines can be parallel, perpendicular or at sharp angle to the ground plane.***

References

1. Frolov, S.A., Pokrovskaja, M.V. [1985]. *Searching for the Beginning. Stories about Descriptive Geometry* . Moscow: Visshaja Shkola, p. 45.

2. Slahova, A. *Problems in the Perception of Perspective in Drawing* – The international Journal of Art & Design Education. – Printed and bound by The Alden Press, Oxford, JADE 19.1, NSEAD 2000, p.102-109.

3. Volkow, I.P. [1993]. *Art Studio at School.* Teacher`s book. Moscow: Prosveschenie, p. 59.

4. Powell, William F. [1989]. *Perspective.* Walter Foster Publishing, p.9.

5. *Ibid.* p.12.

6. Ozolinsh, M. [1979]. *Perspective and Theory of Shadows*. Riga: Zvaigzne, p.39; Simane, Z. [1998]. *Visual Art. Teachers Book*. Riga: Lielvards, p.26; Johanson, B.V., Klinduhov, N.N., Molovickaja, L.I. [1986]. *School of Fine Art.* 1 part, Issue №1. Moscow: Izobraziteljnoe iskusstvo, p.103; *Full course of Painting and Drawing. Fundamentals of drawing* [1994]. Parramon Ediciones, S.A., p.50; *Drawing* [1975]. Ed. Serov, A.M. Moscow: Prosveschenie, p.110; Bowen, Ron [1995]. *Drawing masterclass. The slade school of fine art.* London: Leopard, p.144; Stanyer, Peter & Rosenberg, Terry [1996]. *Drawing systems.* Arcturus. Printed in Great Britian, p.23; Watson, Ernest W. & Watson, Aidren. *The Watson Drawing Book*. [1962]. Bell Publishing Company, Inc. New York, p. 32; and Metzger, Phil [1991]. *Perspective Without Pain,* Volume 1/Part 1. Benedikt Taschen Verlag Berlin GmbH, p.7.

7. Johanson, B.V., Klinduhov, N.N., Molovickaja, L.I. [1986]. *School of Fine Art.* 1 part, Issue №1. Moscow: Izobraziteljnoe iskusstvo, p.101.

8. Stanyer, Peter & Rosenberg, Terry [1996]. *Drawing systems.* Arcturus. Printed in Great Britian, p.23.

9. Schipanov, A. [1970]. *For Artists – amateurs*. Moscow: Sovetskij hudoznik, p. 9.

10. Arnheim, R. [1974]. *Art and Visual Perception* (transl. from English). Moscow: Progress, p. 269.

11. Powell, William F. [1989], *op. cit*, p.14.

12. Arnheim, R. [1994] *New Essays in Psychology of Art* (transl. from English). Moscow: Prometey, p. 185.

13. Powell, William F. [1989], *op. cit*, p.15.

14. Powell, William F. [1989], *op. cit*, p.13.

15. Smith, Ray [1995]. *An Introduction to Perspective.* In Association with the Royal Academy of Arts.Dorling Kindersley Limited, London, p.13.

16. *Full course of Painting and Drawing. Fundamentals of drawing* [1994]. Parramon Ediciones, S.A., p.48.

17. Nesterenko, O.I. [1994]. *Short Encyclopedia of Design*. Moscow: Molodaja Gvardia, p.43.

18. Ozolins, M. [1998]. *Perspective and Theory of Shadows.* Riga: Zvaigzne, p.38.

19. *Ibid.* p.35.

20. *Ibid.* p.38.

21. *Ibid.* p.38.

22. *Ibid.* p.35.

23. Smith, Ray [1995]. *An Introduction to Perspective*. In Association with the Royal Academy of Arts.Dorling Kindersley Limited, London, p.40.

24. Barishnikov, A. [1955]. *Perspective*. Moskow: Iskusstvo, p.16.

25. Slahova, A. [2000]. *Descriptive Geometry in Drawing. Part.5. Perception of Perspective* – DPU, Daugavpils: Saule, p.1-35.

FORM AND LIFE IN THE ARCHITECTURE OF MIES VAN DER ROHE

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The buildings of Mies van der Rohe (1886-1969) have a quality of extreme emptiness, stronger than that found in other modernist buildings. Mies used to say that the source of his architecture was life and not form.[1] It is possible, therefore, to interpret this emptiness as renouncing all formal excess and centering on the service of life itself. My claim, nevertheless, is that Mies did not manage to serve life because he did not acknowledge the paradox that life contains. The paradox lies in that life as an incessant flux resists imprisonment in form, but it needs form in order to exist. One can say that in Mies's refusal to deal with anything formal he arrived at such a radical purification of life that in the end life itself could not exist any more, or at least not in its human expression. In the first part of this paper I will try to expound this claim and in the second part I will try to demonstrate it in several of Mies's buildings.

a. Mies and the philosophy of life (Lebensphilosophie)

A characterization of the paradoxical nature of life can be found in the writings of the German sociologist George Simmel (1858-1918), who belongs to the school called "philosophy of life".[2] Life, says Simmel, is a homogeneous process that cannot be divided. Form, on the other hand, is what binds several elements together into a unity differentiated from all the things around it. Life is a being that does not limit itself and in fact every limitation brings life to a dead ally, therefore life always strives to transcend any given form, whether organic, spiritual or objective. But life can be realized only through individuals, that is creatures closed in on themselves and totally separate. While the stream of life flows through all individuals, in any one of them it becomes a definite form, distinguished from any other individual. Life is a continuous stream but its bearers are individuals, closed around themselves. Put in another way, life is something embodied in a sharply outlined form, but perpetually striving to transcend its own limits. It takes up a form but breaks it. It is complete but continues to develop. Life's greatest capacity is to transcend itself. Simmel sums this up by saying that life's transcendence is immanent.[3]

The opposition between life and form assumes spatial expression as opposition between outside and inside and temporal expression as opposition between new and old. Life is sometimes said to be the internal side of the living organism, as against form, which characterizes the non-organic world around it. But, as often with paradoxes, we can turn this one around and say that the external is like the stream of life whereas form is what contained inside. In that case life would be understood as contrary to spirit or mind, which creates rigid formal conceptual structures that stop every flow. In fact, the very opposition between inside and outside is understood as part of form, whereas life, as mentioned above, lacks divisions. In any cultural history, says Simmel, exist two contradictory principles: one is systematic, striving to bring a certain form to perfection, and the other progressive, striving to adapt itself to the changing conditions of life. At a certain moment in culture form instead of being a means to life becomes its object. Simmel claimed that we see in order to live, but the artist lives in order to see.[4] This is an example of the temporal opposition, mentioned above, between life and form.

Simmel describes modern ideology as a will to affirm life and to reject form, not as a specific form, the rejection of which would be typical to any change of style, but a rejection of form as form.[5] A good illustration of the temporal version of the opposition, can be found in “The Modern” (1890) by Hermann Bahr, who says that outside “life has changed totally, but the spirit has remained old and rigid…” To let life in “We need do nothing, but eliminate the barrier between interior and exterior…”[6] One can see that the main objective is to cancel the *formal* partition between the internal and the external, in order to allow access to the radically new. While here the use of the words “inside” and “outside” is metaphorical, in modern architectural practice, there were those who wanted literally to abolish the partition between inside and outside. That was also the aim of Mies, who tried to reduce this partition to a transparent skin.

When form is the end there is a tendency toward order, coherence, unity and perfection. When life is the end the tendency is toward functionality.[7] Mies stressed that what concerned him was serving life – that is the functional side of architecture; nevertheless many of his buildings are non-functional and have a quality of coherence and formal perfection. The best example is the Farnsworth House, discussed at the end of this article, in which one cannot live at all. In this building Mies achieved such a radical abolition of the separation between inside and outside that life could not continue to exist there. He did not take into account that the function of architecture is not only to provide shelter from the elements, but also to enable privacy and intimacy. Life itself demands the partition between outside and inside and architecture is supposed to supply this need. Life demands the capacity to shut oneself up in a private domain and architecture should enable one to do so. Life demands the preservation of the memory of the old, which exists “inside”, and architecture is expected to store these memories. Mies’s contemporary, Adolf Loos (1870-1933), acknowledged this fact and thought that the very idea of a transparent house was a mistake. Loos proposed a radical division between the inside, related to memory, psychology and private affairs, which should not be exposed, and the outside face, which is meant to function like a suit that hides the private personality of men.[8]

Mies’s error was that he did not acknowledge that life itself demands form in order to exist. As a modernist his resistance to form as form reveals a purely abstract concept of life. The very contradiction between life and form is nothing but an abstraction constructed by the mind, as such, it belongs more to form than to life. Life itself contains both the concept of life as a formless stream and the form in which this stream is embodied.

As we saw above, Simmel maintained that modernist ideology rejects not only existing form, but form as form. Mies followed the same logic in affirming life as life and not some actual embodiment of life. Put differently, Mies affirmed life as essence, which is actually a contradictory notion, because life as a continuous stream cannot be grasped as a constant essence. In fact, his search was always for essences, what made him design architectural situations in an ever more extreme manner. Hence the feeling that Mies designed his buildings in such a pure manner that real life could not exist in them. In sum, one can say that instead of enabling life his buildings became ideas of a *form of life*.

b. The life of form in some of Mies’s buildings

Let us now turn to a few examples illustrating Mies’s struggle to get rid of formalism; at the same time it will become evident how form acquired its own “life”: Mies’s designs passed through a phase in which the struggle to get rid of form achieved strong formal expressiveness and a second phase in which this expressiveness was overcome, but the buildings became ideas one could not live in. The more Mies struggled to get rid of any formal concerns, the less and less did his designs become able to accommodate life.

Mies's effort to get rid of form is expressed in his search for intrinsic essence and the rejection of any external excessive dressing, but in the end it brings him to eliminate interiority rather than external features. Mies realized Bahr's dream - the "life" outside penetrates inside, but that is exactly what prevents any possibility of life inside.

b.1 The Riehl House – 1907

Mies built his first house as an independent architect in 1907. It was designed for the philosopher Professor Riehl and his wife.[9] The plan seems quite conventional: two floors which contain a series of well-defined rooms, organized more or less symmetrically around a central hall. The facades present a homely appearance, under a huge roof which "protects warmly"[10] and shelters life inside. The internal space is well separated from everything surrounding it. In this phase of his career it seems that Mies let life exist in its traditional forms: the borders between outside and inside and between one room and another are well defined and the connections between the spaces are made by means of conventional doors and windows. The house is plain and barely ornamented, but this simplicity was within the range of contemporary conventions.

The only unusual feature is the arcade in the lower garden façade, which rises directly from the terrace wall. Here the undermining of the conventional distinctions between house and surroundings may be said to begin, the terrace becoming an integral part of the house. Fritz Neumeyer compares this house to the crematorium built by Mies's teacher – Peter Behrens – in the same years.[11] The basis for this comparison between buildings with such diverse functions (the one for life the other for death) is that both treat the site as a terrace and the terrace as a pedestal on which the building is elevated. But while in the Behrens case the material of the building differs from that of the terrace and the building is set back from the terrace wall and is reached by means of monumental steps – thus the building is clearly separated from its surroundings - in the case of Mies the house and the garden become one. We can detect here the first signs of Mies's efforts to annul the formal division between inside and outside, in the name of life, which has no divisions before it is given form. Nevertheless, in this building Mies did not reach the extremes typical of his later years, and life can still actually take place in this house under the roof which "warmly protects" the inhabitants.

b.2 – The Glass Skyscraper - 1921

In 1921 Mies entered a competition for a skyscraper on Friedrichstrasse in Berlin. The plan was triangular consisting of three acute trefoils. The building was to be entirely covered with glass and it makes an impression of something almost immaterial.

It was published in *Fruhlicht* the journal of Expressionist architects, and in light of its expressive form one might mistake it as representing the spirit of Expressionist Architecture.[12] The Expressionists tried to convey through irregular geometries the excitement of life as opposed to the rigidity of "form" as it figures in conventional orthogonal geometry. But their very concern for geometry affirms their formal approach. Mies used mainly rigid orthogonal geometry for his buildings and he did not aim at new forms but rather at essences (of column, wall, roof and floor). However, in this particular skyscraper we can still feel a tendency toward expressive forms, in spite of Mies's efforts to withdraw from any expressionistic ideology.

Though this project reminds one of a crystal, which for the Expressionists was a mystic symbol reflecting infinity,[13] Mies took pains to distance himself from any mysticism in regard to this building. The reasons he gave for choosing the unusual shape were the shape of the site, the need to let light penetrate and the wish to use the reflections in order to avoid the lifeless effect which he thought typical of certain glass buildings.[14] The last reason evidently does not address the functional aspect of life as do the two others but rather its

expression (effect)[15]. In fact, after 1924 Mies changed his terminology: he did not talk so much about technology (the functional aspect) as a goal, but rather about spirit – that is the aim of building is to express spirit.[16] However, this spirit is not related to the mystical spirituality of the Expressionists; it is more like the spirit of life that gives breath to the building.
In the twenties there was a tendency to eliminate representation from painting and sculpture. One of the formal distinctions which the image of life tries to eliminate, is that between representation and its referent. The use of the metaphor of life can suggest an immediate ”presence”, as against the “dead” sign in representation. In Architecture this tendency can be seen in the wish to eliminate the partition separating the internal from the external. Peter Blake says that we can read Mies’ proposal for the glass skyscraper as a statement similar to Kasimir Malevich’s painting “White on White”. As this painting is a sort of empty tablet placed before the world in order to receive new systems of images, so Mies’s building functions as a sort of mirror before the world, reflecting new systems of forms.[17] But unlike Mies’s skyscraper Malevich’s painting remains opaque, which leaves him in the sphere of representation, even though representation of absence. The painting fluctuates between pure materialism – there is no more to it than white canvas, and pure symbolism – the white represents the spirit inside that no external image can express.[18] The transparency in Mies’s building, on the other hand, disallows the possibility of a materialistic reading as well as of a symbolic one. The building would reflect images like a mirror, but a mirror does not represent reality; it reflects it. A mirror depends constantly on the real presence of the image it reflects. The mirror thus enables the reflection of the flux of life instead of the fixation of form. As we saw above such constantly changing reflection was aimed at achieving the effect of life. But what this building could catch was not life itself, but only its reflection, i.e. only an effect. Whereas in Malevich’s painting what is eliminated is the outside and we are left with merely a spiritual inside in which nothing external is reflected, what is lacking when a building becomes a mirror is the inside, because the external continues to be reflected in it. But in this case, the inside only seemingly disappears while in fact it remains sufficiently protected from a penetrating glance, and thus private life can still exist there.

b.3 – The Brick House – 1923-1924

In 1924-1923 Mies designed a theoretical project called the Brick House. The house is made of freestanding brick walls and transparent screens in between, so that it does not consist of definite volumes. The brick walls continue beyond the boundaries of the house, in such a way that the same wall shifts from internal to external. Inside the house the walls do not define rooms, but let spaces interlock. The building is thus not distinct from its surroundings – there is special continuity between inside and outside - nor are the rooms distinct from each other, that is, the room ceases to function as the organizing idea of the house.[19]
As I pointed out in the first part of this article, the very idea of continuity between inside and outside precludes the possibility of the existence of private life which architecture is supposed to enable thus actually undermining the essence of architecture itself. We can see the problems in Mies’s stand when we compare it to that of Adolf Loos. Both held that the aim of architecture was not an aesthetic one. The house, says Loos, does not belong to art but to life.[20] But they differ in their interpretation of the role of the house in life. Loos acknowledged the importance of the division between inside and outside and therefore in his buildings we can find a simple functional exterior combined with an interior rich with objects of sentimental value. Loos accepted the situation described by Bahr of an outside full of changing life while the inside belonged to the old fashioned past, but, contrary to Mies and Bahr, he did not think that this could be changed. The distinction between outside and inside is essential to the house and the duty of the architect is not to obscure but to emphasize it. The

very claim of Loos, that there is a difference between architecture, which belongs to life, and art, which is against life, reflects his desire to make clear distinctions between different realms. Even though these distinctions spring from "form" and not from "life", this "formal" approach is what makes Loos's buildings livable. One can live in them in the full sense of human living, amass belongings, remember, and feel. Although Mies shared with Loos his distaste for an aesthetic approach to architecture, his reasons were different. He did not want to distinguish the realms of life and art, but to "return" to the state "before" every distinction, in which every human activity was aimed at sustaining life. Even though he had an idea of a new living form, not dictated by the outdated "form" of the room, the plan of the Brick House looks more like a painting by Theo van Doesburg than a place one can live in.[21] We can already feel Mies's tendency to touch at extremities in negating architectural form in his buildings, bringing him eventually to negate the central role of architecture in the service of life – the erecting of partitions between spaces.

b.4 – The Barcelona Pavilion - 1929

The Barcelona pavilion, erected in 1929, is perhaps Mies's best-known work. It is a one-story building raised on a pedestal and has no specific function. Eight cross-shaped section steel columns covered with chrome support the flat slab covering the building. The internal space is divided by glass partitions and different sorts of marble and precious travertine. The space in between them flows with no definite "rooms". Some of these partitions continue beyond the boundaries of the covered space. The shining materials and the two pools, which are coved with glass, reflect their surroundings. The exhibits are few: a sculpture of a nude woman by Georg Kolbe and a few pieces of furniture designed by Mies himself.

Mies's buildings do not try to "talk" or to convey messages, but to "live". However, the silence and emptiness in this pavilion are so pure that the theoretician Manfredo Tafuri received the impression of "…a language of empty and isolated signifiers in which things are portrayed as mute events."[22] He goes on to say that in this space there is no possibility of restoring "synthesis". Mies was in fact aiming at synthesis, that is at life, which abolishes any distinctions. But Tafuri does not misrepresent Mies's intention without reason. The search for life as essence – before any formal differentiation – is doomed to failure because the idea of essence of life is contradictory – life is an incessant flux and cannot have a permanent essence. The pavilion was thus tenably read by Tafuri not as a living system outside any language (which is always formal), but as a language emptied of content. The abolition of the clear division between outside and inside and the extreme emptiness do not make one feel the immediate presence of life, but rather leave the impression of empty signs, or death.

b.5 Farnsworth House – 1945-1950

In the Farnsworthe house, built between 1945-1950 in Illinois, the modernist vision of the first half of the twentieth century, of diffusing inside and outside, reaches such pure expression that the *inside has almost totally disappeared*. The internal space is defined only by a transparent "skin" – a glass envelope. The columns supporting the roof and the elevated floor – the "bones" – are external to this envelope (Mies used to talk in terms of "skin and bones" – seemingly a metaphor taken from the realm of life, but actually with a connotation of a dead or at least sick body).[23] In one direction both the floor and the roof continue beyond the enclosure, which blurs the distinction between outside and inside even more. The distinction is farther obscured by an additional platform, connected to the house only by a stair. The stare is made of unconnected steps in such a way that the "outside" flows freely between them. "Internal" space is divided only by one solid bathroom. The building lets the eye penetrate through it into nature on the other side. In other times of the day the glass wall reflects nature in front of it. In either case the inside is reduced to mere isolation from weather and noise. The elimination of the inside came about from Mies's persistent search for the intrinsic,[24] which made him reveal interiority and thus negate its essence. In his resistance to external appearance Mies arrived precisely at the elimination of the internal.

The elimination of interiority makes this house unlivable. When Dr. Edith Farnsworth described the experience of living in her modernist glass box she claimed she felt restless, like a "prowling animal", because she was being observed at all times. The house failed to provide protection from the outside. Its negotiation with the outside world did not provide enough privacy for Dr. Farnsworth to relax.[25] I would suggest that the consequences of this elimination of interiority was that the two principles of human life, as Simmel describes them, cannot dwell in it simultaneously. Life, says Simmel, is "more life" and also "more than life", i.e. life necessarily produces more life and life produces things, which have value beyond life itself. Life can exist only as more life, because the effort to preserve life always implies self-generation. Only as long as self-generation exists does life exist at all. Growing, multiplying, aging and dying are not something added to life, but life itself. One can say that life is a constant movement, which incessantly takes into itself something in order to transform it to life. But, at the same time this process produces something that transcends life – it produces form, which at first is made in the service of life, but later becomes something independent which does not have a direct bond to life. Something permanent is produced which is contrary to life.[26] If *fertility* expresses the first principle – "more life", then *culture* expresses the second one – "more than life". In this house fertility has to exist in exposed and empty spaces. *The purity and transparency of these spaces allows either abstinence, the betrayal of the principle of fertility, or fertility without privacy, the elimination of the cultural state.* One might play with Mies's famous slogan - "less is more", and say that in this house the "more" (of life and than life) has to exist in the "less".

The emptiness in the Farnsworth House is so extreme that one cannot give it any symbolic or representational interpretation, such as was still possible in the case of the Barcelona pavilion. There is no expressive formal pretension as in the glass skyscraper and one cannot compare it to an abstract painting as one could with the Brick House. All the possibilities that still existed in those buildings are reduced to "less" and "less". But one cannot see in this structure a successful "cleaning" up of everything in favor of life. Here life has come to a dead end together with form. As Simmel observed, even though life is perpetually striving to break form it is something embodied in form. Life transcends every formal limitation but nevertheless needs form in order to exist.

REFERENCES

1 Mies often asserted that his aim was life and not form. All citations from Mies are from Fritz Neumeyer, The Artless Word, MIT Press, Cambridge Massachusetts 1991, See for example "We know no forms, only building problems. Form is not the goal but the result of our work… There is no form in and for itself." In "Building", ibid, p. 242; "Life is what Matters." in letters to "Die Form", ibid, p. 252; "… strong impulses for living, and a great urge toward functionality and an undistorted affirmation of life." in a lecture given in 1927, ibid, p. 262.

2 This article is not concerned with the actual influence of Simmel on Mies. Nevertheless W. Gordon Brown mentions Mies possession of Simmel's book on culture in his library. See W. Gordon Brown, "Form as the Object of Experience: George Simmel's Influence on Mies van der Rohe", in Journal of Architectural Education, 43/2 (Winter 1990), pp. 42-46

3 See Georg Simmel, "The Transcendent Character of Life", in Individual and Social Forms, Chicago University Press, Chicago, 1971, pp. 353-374.

4 See, Georg Simmel, " The Conflict of Modern Culture", in The Conflict of Modern Culture and Other Essays, Teachers College Press, Columbia University, New York, 1968, pp. 11-26. See also Rudolf H. Weingartner, Experience and Culture in The Philosophy of George Simmel, Wesleyan University Press, Middletown, Connecticut, 1962, p.55.

5 Simmel, The Conflict, pp. 12-13

6 Hermann Bahr, “The Modern”, in the Appendix to Francesco Dal Co, Figures of Architecture and Thought, Rizzoli, New York, 1990. pp 288-291.
7 Weingartner, Experience, p. 60
8 See Benedetto Gravagnuolo, Adolf Loos, Rizzoli, New York, 1988, p. 51.
9 About the Riehl House see Neumeyer, pp. 36-50, and Elaine S. Hochman, Architects of Fortune, ld &Weidenfe Nicolson, New York, 1989. pp. 32-35.
10 The architect Joseph Maria Olbrich described one of his own buildings in these words. Cited in Dal Co, p 182.
11 Neumeyer, p. 50
12 Ibid, pp.3-4.
13 Wolfgang Pehnt, Expressionist Architecture, Thames and Hudson, London, 1973, pp. 36-4. See also the opening to the first issue of Fruhlicht, The expressionists’ journal: “High the transparent, the clear! High purity! High the crystal! and high and ever higher the flowing, the graceful, the sharp-edged, the sparkling, the flashing, the lightweight – high eternal building!” cited in Neumeyer, p. 3.
14 Mies, “Skyscapers”, in Neumeyer p. 240.
15 Evans argues that Mies’s logic in the Barcelona Pavilion, which I will consider below, is a logic of appearance, so that its aim is effect. Robin Evans, Translations from Drawing to Building and Other Essays, Architectural Association, London, 1997, p. 247.
16 See for example, “…building art is always a spatial execution of spiritual decisions…” in a lecture from 1926, ibid. 252, or “The problem of the new housing is basically a spiritual problem…” in the foreword to the catalogue of the Werkbund exhibition in 1927, Neumeyer p. 258.
17 Peter Blake, Mies van der Rohe, penguin Books, Baltimore, 1966, p. 28.
18 For this fluctuation between materialism and symbolism in modern painting in general see Rosalind Krauss, “Grids”, in The Originality of the Avant-Garde and Other Modernists Myths, MIT Press, Cambridge, Massachusetts, 1991, pp. 9-19. [?]
19 “…I have abandoned the usual concept of enclosed rooms…”, from Mies’s lecture of 1924 in Neumeyer, p. 250; see also p. 179 and p. 247.
20Adolf Loos, “Architecture” in The Architecture of Adolf Loos, An Arts Council exhibition, pp.107-108.
21 For a list of such comparisons between Mies van der Rohe designs and De Stil paintings, see: Juan Pablo Bonta, Architecture and its Interpretation, Lund Humphries, London, 1979. pp.153-161.
22 Manfredo Tafuri, The Sphere and the Labyrinth, MIT Press, Cambridge, Massachusetts, 1990, pp. 111-112.
23 This image appears in his lecture of 1942, see Neumeyer, p. 250.
24 Neumeyer often stress this search for the intrinsic. See especially chapter II, section 1. pp. 30-35.
25 Joseph A. Barry, "Report on the battle between good and bad modern houses", In House Beautiful, May (1953), p.270
26 Simmel, “The Transcendent Character”, pp.368-373.

musicL

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Abstract

musicL is a real-time system for the generation and synthesis of multi-voiced compositions. Employing a set of generative algorithms, musicL disrupts our traditional expectations of what music does.

Description

musicL is a generative system for simultaneously creating music *and* its notation. The generative properties of musicL are determined by L-System equations (a mathematical theory developed to describe the branching and growth of trees). L-Systems are literally instruction sets that, among other things, dictate when to go forward, left, or right, by how many steps, and at what angle (see *Technical Specifications*). Therefore, the rules that govern musicL are a set of spatial directions which manifest sonic and visual characteristics. In other words, each unique L-System simultaneously draws a pattern and triggers sound.

Model/Prototype

In its present form, musicL allows for the arrangement of both pre-defined and random L-System compositions. The interface consists of the Elements, Stage, References, and Toolbar (fig 1).

Each Element is essentially a specific L-System. They are displayed as thumbnails which illustrate their emerging patterns. There are currently 9 pre-defined Elements, as well as one random Element. The random Element is represented by *r* and assembles both its instruction set and its values randomly each time it is used. Consequently, each occurrence of the random Element is theoretically unique.

The spatial coordinates of the Stage are mapped to pitch (top to bottom) and amplitude (left to right). Each Element is dragged on to the Stage to initiate its movement and sound. The Element's vertical range of motion (and thus its pitch range) is limited to 100 pixels above and below it's release point on the Stage. A maximum of ten Elements, in any combination, can exist on the Stage at any given time. Thus, ten occurrences of one Element is allowed, as long as the total number is not exceeded.

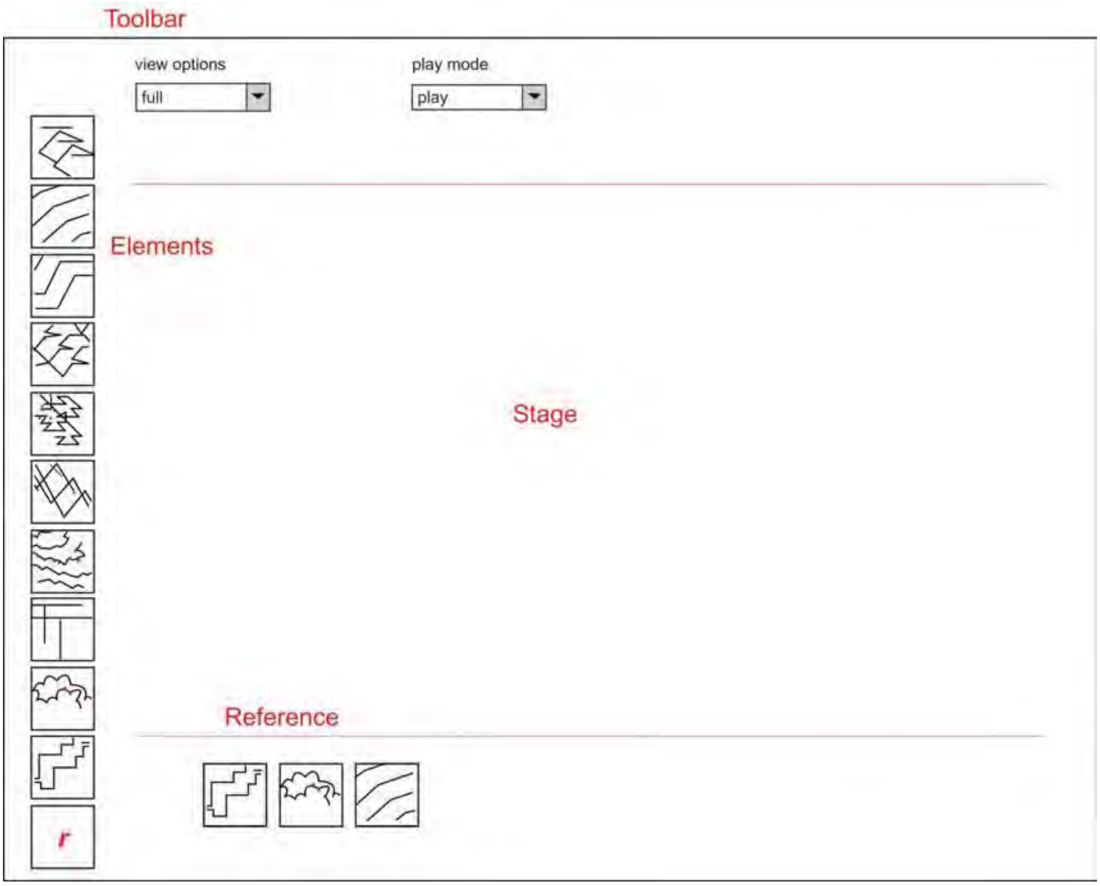

Figure 1: The Interface

The References (displayed in a row) indicate which Elements are currently active on the Stage. As an Element is activated, its thumbnail will appear in the "Reference Row". Additionally, an Element can be inactivated (removed from the Stage) by clicking on its Reference.

Finally, the Toolbar contains musicL's visual options. The patterns which develop on the Stage can be viewed differently, depending on the mode set in the Toolbar (fig 2). The Toolbar also contains a 'pause' button, allowing the user to observe the visual characteristics of musicL in a static form.

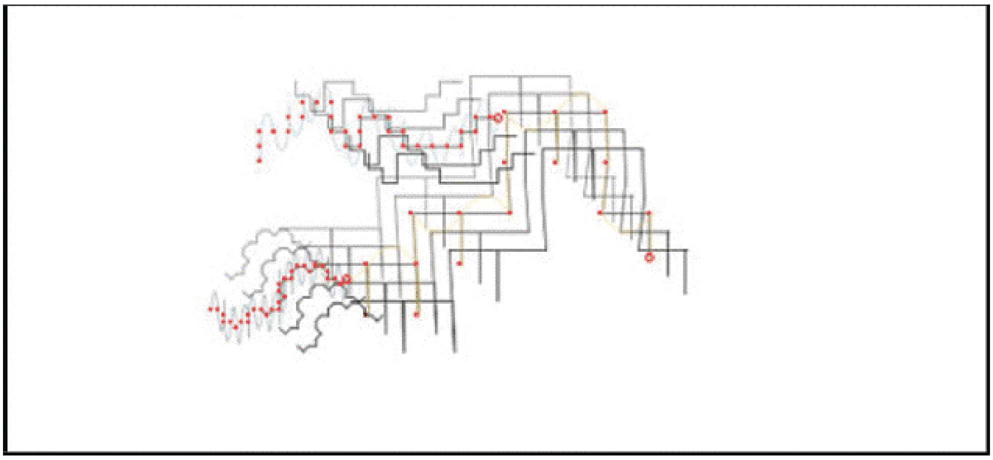

Figure 2a: Demonstrating 'Full' Drawing Mode

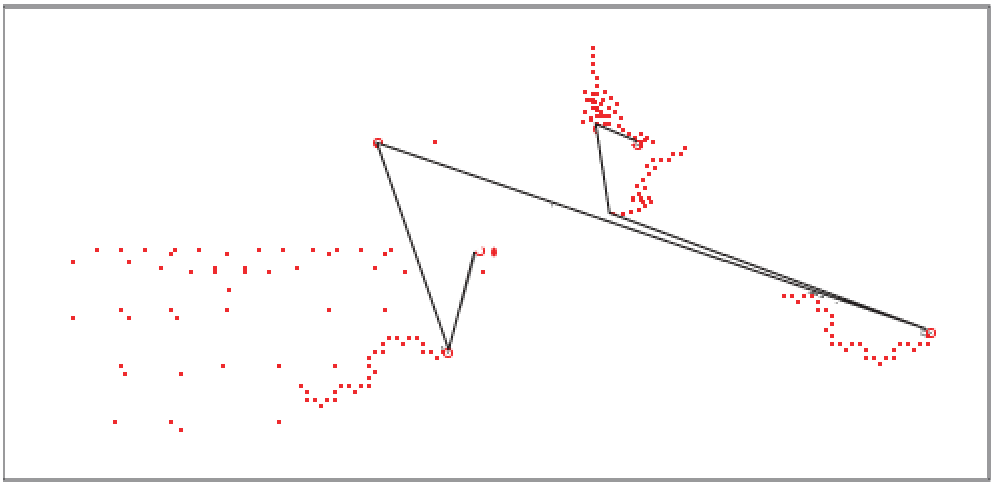

Figure 2b: Demonstrating 'Connect' Drawing Mode

ac ground

enerati e orms

Generative principles, as they apply to music and composition, are understood more clearly if discussed in contrast with classical composition techniques. Classical compositions are written with a pre-defined, specific, and desired outcome. The directions are precise and inflexible. In the end, the classical composition belongs to its composer. However, generative compositions by nature eliminate the idea of single authorship. Relinquishing control over the final product, the generative composer allows unexpected and emergent properties to arise. Brian Eno clarifies the distinction as he states "classical music … specifies an entity in advance and then builds it. Generative music … specifies a set of rules and then lets them [the rules] make the thing."

"...in a sense it means 'putting things together', and I put them together in such a way that they're not fixed in a fixed way but flexibly work together."

-John Cage, on what it means to be a composer.

In the early 50's experimental composers such as John Cage, Earle Brown, Christian Wolff and Morton Feldman, gained notoriety relinquishing control over the execution of their art. Their motivation stemmed from "the immediate desire to deal with what sound is, rather than what the composer may think it is or decides he wants it to be." John Cage tackled this problem by introducing chance and random procedures into his work. Feldman denounced methodology in favor of instinct. Brown's interest in artists such as Calder and Pollock accounts for the spontaneity and open-form mobility found in his music. By providing performers with vague and often incomplete instruction sets, emphasis was, shifted away from the composer, and the individual performer was given more control.

otation

Staff notation, used since at least the 17th century, with its origins dating back to the 9th or 10th century, is a very precise tool for dictation. The New York School's unique methods, however, no longer fit the traditional framework of composition, and often called for new methods of notation. According to Cage, dictation does not have to be built into the notion of a score. "…if there are several parts [of a score] and there's no fixed relationship, then there's nothing built-in. No fixed relation built in."

Morton Feldman was the first to use non-representational graphic notation. He divided the pitch range of each instrument into high, middle, and low, and represented each range as a rectangle on graph paper. The specific pitch and boundaries were left as decisions to be made by the performer. Christian Wolff composed one piece by writing notes vertically down the page, but had the performers read and play the piece from left to right. Cage consulted the *I-Ching* for note placement, while leaving rhythm and detail to the performer. Brown's famous *December 1952*, a musical analogue to Alexander Calder's mobiles, was notated by an abstract series of floating rectangles.

musicL speaks to this tradition of unique forms of musical notation. Here, aspects of notation are separated into two parts:

1) the L-system algorithm, which gives impetus to the music, and

2) the visual/graphical representation of the music, which leaves artifact or record of what has transpired.

Technical Specifications

musicL was created in Java and runs as an applet in a standard web browser. The sounds are synthesized in real-time, using a Java API called JSyn (written by Phil Burke). The properties of musicL are derived from generative algorithms based on L-Systems.

L Systems

An L-System is a mathematical theory that describes plant development. It is represented by a series of symbols representing specific commands. The central concept behind L-Systems is the notion of rewriting. The Algorithmic Beauty of Plants describes rewriting as "a technique for defining complex objects by successively replacing parts of a simple initial object using a set of rewriting rules or productions." All L-Systems consist of an axiom and a rule. The axiom specifies an initial condition and the rule dictates what part is to be rewritten, and by what. The depth indicates the number of times this replacement will take place.

Credits

musicL has been commissioned by to provide the score for upcoming performances with the Esse Aficionado Dance Troupe at the Merce Cunningham Dance Studio in New York City.

musicL was originally presented to the Chair and Faculty of New York University's Interactive Telecommunications Program in May, 2003.

Sensitive Painting

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Abstract

There is a new type of approach of the contemporary art since the beginning of 1990's, based on the digital interaction between the visitor and the artwork. Such experiences are changing the interactive paradigm transporting it on fascinating metaphors rich of potentiality. This research produced a series of new ideas and technologies that could be used for the fruition of cultural heritage and the creation of new environments for communication. As an applicative example we illustrate an interactive installation based on the concept of the *Art of Emergence.* This kind of artworks generate visual and acoustical shapes through the interaction of the visitors and a creative intrinsic ability of the artwork itself.

INTRODUCTION

There is a new type of approach of the contemporary art since the beginning of 1990's, based on the digital interaction between the visitor and the artwork [1,2,3,4,5,6,7]. This type of art is founded on the concept of a navigable artwork or in a continuous generative flow, using scientific metaphors and innovative multimedia technologies. The basic idea is that the artwork is a pyramid with his current status on the vertex, while in the below zone you can find implications, aesthetic suggestions, evocations and esthetic variants of the artwork itself.

The visitor navigates in the pyramid through personal path that sometimes result in situations absolutely original in respect to the original idea of the artist. Such experiences change the interactive paradigm between man and machine, transporting it on fascinating metaphors rich of potentiality. The research of interactive art, consolidated in the creation of artwork-experiments, has produced a series of new ideas and technologies that could be used in order to formulate new approaches and proposals for the fruition of cultural heritage and for the creation of new environments for communication.

This paper refer to a specific experience: the interactive installations of Plancton, a group of artist-scientist, founded in 1994, introducing the idea of the *Art of Emergence* [2]. This kind of artworks generate visual and acoustical shapes through the interaction of the visitors and a creative ability of the artwork to create continuously new shapes.

THE PRINCIPLES OF THE INTERACTIVE ART

We will illustrate some of the main ideas that characterize the interactive artworks and that have general applicability in the approaches of communication of artistic and aesthetic contents. We can resume these characteristics in some essential points: a) immersivity and participation to the artwork; b) naturalness, responsiveness and opening of the interaction mechanism; c) synaesthesia; d) redefinition of the *man-machine* interface paradigm.

The relationship between the observer and the artwork changes completely when you can realize metaphors, in which the observer is part of the artwork. The effect of *embodiment* is a characteristic of the virtual reality: environments in which the visitor is involved, navigating in a three-dimensional context. A greater effect can be obtained when the space of the communication or the artwork physically wraps the visitor. In general, this effect has been rendered with the CAVE systems bases on fully retro-projected rooms. Although strongly involving, such systems are very expensive and difficult to diffuse. A valid alternative is constituted by interactive installations that use natural interaction devices and video-projection (or retro-projection). In such installations, the ideal space of interaction-communication is not the screen, but the physical space where the person interacts. The immersivity is obtained with the ability to create metaphor where the visitor is immersed participating to the game and the distance between real and virtual is ambiguous.

The main ingredients are the responsiveness of the artwork, the naturalness of the interface and the opening of the interaction. The responsiveness of the interaction is determined from the rapidity of the interaction mechanism and by the possibility to influence the content. When the fruition is too much slow, not fluid or when the dimensionality is low (low number of parameters), a frustration is generated in the visitor and the interaction is an obstacle to the concentration.

The naturalness of the interface is one of the more important elements so that the person can feel itself effectively immersed in the installation. With the term naturalness we mean the not intrusive character of the device and the simplicity of the interaction gesture which shouldn't require explanations. The natural interfaces push the visitor to operate with a well known own gesture language. Helmets, mouse, gloves or similar devices have the advantage to divert the attention of the person from the content in order to focus it over the interaction device. Some of the most interesting natural devices are the tracking systems where the visitor uses the own hands or the body in order to interact. Often, such approaches are based on video-cameras and sophisticated programs of real time image analysis.

The opening of the interaction is connected to the dimensionality of the artwork. If the possibility of the visitor consists in a navigation over predefined states, very soon the feeling to explore the content will disappear leaving the place to an emotion similar to leaf through the pages of a book. A different emotion is given when the number of the possible configurations is very large and not expectable a priori. In this case the visitor can renew continuously its desire to find a personal way and therefore of feeling itself creative in the learning of a content created from an other person.

A meaningful aspect is the synchronization of various stimuli like images and sounds. When such synchrony exists, that it goes under the name of synaesthesia, our brain alloys the stimuli exalting the involvement in the perception. A good modality in order to obtain this effect is to tie sound and image to the interaction mechanism, possibly using the real time generation of music and tying the musical reactions to the actions of the visitor. Finally the three-dimensional effects of the sound have a strong effect to dip the visitor in the installation for the spatial localization effects.

For many years the term *man-machine interaction* (MMI) has been used as a paradigm of interaction to pilot computers. Today such term is misleading. The term *machine* has a mechanic connotation and it is little suitable to the idea of the communication that seems a quality connected to living systems. However the real interaction does not happen between the man and the computer but between the man and the software. The MMI paradigm is going to become obsolete in the moment in which program and computers are not more identifiable like a single unit. It is the case of the internet network where the data and the programs do not reside on the computer but they *come from outside*. A possible overcoming of the man-machine paradigm is in the concept of the *man-digital entity* interaction. Such concept can be generalized in the construction of *real-artificial hybrid ecosystem*s. In these contexts digital entities interact in between and with the human visitors evolving in time. This approach includes a provocative reference to the possibility of the *digital life* or an utopian digital intelligence. Although we are still very far from concrete realizations in these directions, the idea of interact with a digital entity with its personality, stimulates a great interest in the visitor.

The described concepts could inspire applications where the visitor interacts with the content of artworks of great masters. The basic idea is that the artwork is an intellectual property of the artist, but the fruition process is a personal right of the person who visits the artwork itself. Such idea can appear banal, but it is necessary in order to claim an important right of the visitor to determine own perceptive path. Such right is obvious in the interaction with the real artwork but it is critical when the interaction is mediated through a multimedia representation of the artwork. In the passage from the real artwork to the represented artwork, often the visitor loses wide part of freedom (and consequently the interest) in the fruition of the content. It is necessary to give back to the visitor the resolution on the detail, the variations of light, the possibility to concentrate itself on a subject, the possibility to dream in front of the artwork and to see the colors to change or to saturate, the shapes to move itself, to imagine and to try the creative process of the artist, to see the color blobs, to feel the sounds of the time. The value of an artwork is embodied also in its dimensionality, that is the potentiality in term of possible variants and interpretations. To realize it in an interactive installation, is not to change the representation of an artwork, but to give back to the visitor the perceptive freedom that he has with the real artwork but that nearly always it is denied in the digital representation.

As a methodological example, in the next paragraph we will refer to a specific installation realized in 2001 from Mauro Annunziato, Isabella Tirelli and Piero Pierucci. The concept at the base of the installation is an attempt to animate a process of dynamics perception of a pictorial artwork. The perception process is guided from our subjectivity, from our history: we see that we want to. The idea is that the visitor, through a cyclical process of interaction, can find a personal way to approach the artwork. In the metaphor, such process has been turned upside down in provocative way: the *Sensitive Painting* has its sensibility and living attitude and it reacts to the actions of the visitor altering the visitor perception.

SENSITIVE PAINTING

Sensitive Painting is an interactive installation where a projector linked to a computer, casts images on a large size picture. The picture has been realized as a patchwork with 8 layers. Each layer has been realized composing infinite fragments of colored, transparent papers, stuck together with water based glue. Each layer portrays the eternal flux between Eros and Thanatos (love and destruction). The Libic Sybil, from Michelangelo Buonarroti on the Cappella Sistina, closes (and opens again) the open question summoned by the painting. The images projected on the painting consist of the internal layers memorized in the computer. The underlying layers of the painting are scarcely visible on the painting itself. Some shots of the scenes were taken and then digitally captured during the artwork realization. Images coming from the creation progress symbolize a sort of genetic memory, composing themselves with the final painting to build the basic material of the artwork.



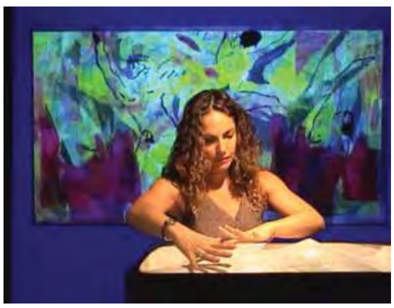


Before the projection, the images are modified in terms of saturation, hue, color inversion and other color contrast models in relation to the people interaction. The perceptive results depends on the composition of the projected image, and the reflection on the physical matter of the real painting. In this way, the painting seems to change dynamically in color and shape.

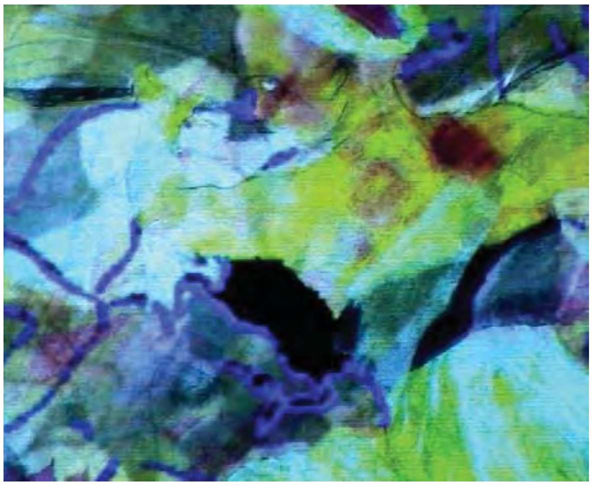


In front of the painting the visitors can interact on a interaction device composed by a table with a *sensitive surface.* The surface has a woman body shape. The sensitive surface represents a sort of *nervous system* of the painting ranging from the eros to the thanatos zones mapped in the surface. The visitor can interact moving their hands on the surface. When the hand of the visitor pass close a *nerve* of the painting, it reacts modifying the perceptive variables. Following the different trajectories on the surface, the visitor explores he whole aesthetic content of the painting. He can modify the color saturation (related to the eros zone), rotate the colors preserving the original relations, navigate in the painting history.





In the thanatos zone, the visitor push the painting to *destroy* the colors towards the gray. This effect is obtained combining the original color of the painting with the complementary color projected by the computer. Still in the thanatos zone, the visitor causes a de-structuration or decomposition of the painting in several shape fragments that begin to move autonomously around the painting. In the eros zone, the visitor push the painting towards the recombination of the fragments to recompose the original shape.



The nervous system of the painting is attached to a music generator. The music flow trough the attractor of chaotic functions. The perceptive variables of the music generation are still connected to the sensitive surface. Depending by the position of the visitor hands and movements, the music seems more passional (eros zone) or more surreal (thanatos zone) or more melodic in the intermediate zone between eros and thanatos. In this zone the eros and thanatos forces are combined producing a sort of dynamic harmony and equilibrium.

The main theme of the installation is perception seen as an active principle and a dynamic process, causing a change in reality based on observer's attitude, culture, action. The perception changes continuously the subject and the subject changes continuously his perception. This sort of continuous self-reflexive cycling of the output in the input is one of the most significant mechanism at the base of the aesthetics and learning process. In this metaphor the painting, animated by its own nature, reacts to the observers, causing a continuous change in perceptive flux, dynamically underlining its aesthetic potential. The meeting between observer and the "sensitive painting" portrays the fusion between the artist's and observer's creative flux. The process of the artwork realization, embodied in the projected images is unceasingly elaborated by the observer's interactions, altering the receptive structures of the painting with their movements.

REFERENCES

1. Annunziato, M.: Emerging Structures in Artificial Societies, in Creative Application Lab CDROM, Siggraph, Los Angeles (CA). 1999. For Artificial Societies see also www.plancton.com.
2. Annunziato, M., Pierucci, P.: Relazioni Emergenti. Experimenting with Art of Emergence, Leonardo, Volume 35, Issue 2 (April 2002).
3. Annunziato, M.: Ed. of Special Iussue of YLEM Newsletters on Artificial Societies, Sept.-Oct. 2001. Articles of C. Sommerer, L. Mignonneau, K. Rinaldo, P. Pierucci, J. Prophet.
4. Annunziato, M., Pierucci, P.: Human-Artificial Ecosystems: searching for a language. In Proc. of Int. Conf. of Generative Art, Milan, Italy, Dec. 2002, www.generativeart.com.
5. Rinaldo, K.: Autopoiesis, In: Int. Conf. Alife VII, Portland (OR), Workshop Artificial life in Art., 2000
6. Sommerer, C., Mignonneau, L.: A-Volve - an evolutionary artificial life environment. In: Artificial Life V . C. Langton and C. Shimohara Eds., MIT, pp. 167-175. 1997.
7. Tosa, N. et al.: Network neuro-baby with robotics hand, symbiosis of human and artifact, elsevir Science B.V, pp. 77-82. 1995.

isual arts e periments artefacts by neural agents in social simulations

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Abstract

In this visual arts study, a simulated population of neural agents is used to produce abstract drawings and animation. The agents develop drawing behaviours through the process of collectively interacting with the marks they leave on a page.

1. eural agents for dra ing

The approach visualises dynamic social structures in a system where the actions of individuals alter an environment, which in turn shapes each individual's internal mappings between perception and action. Individuals are implemented as constrained mobile agents with unsupervised neural nets to map associations from their modelled sensors to motor functions. As the agents move around they leave paths behind them. Visual structures emerge on the page as the agents' sensorimotor mappings adapt in response to one another's marks.

The project is influenced by research into swarm building behaviour [1] and evolution of language [2]. The current work-in-progress continues with questions about how to read the images, whether as aesthetic artefacts, mathematical graphs, simulations, or in a combination of modes.

References

[1] Bonabeau, E., Theraulaz, G., Arpin, E. & Sardet, E. (1995). The building behaviour of lattice swarms. In: Brooks, R. and P. Maes. (Eds.) *Artificial Life IV Proceedings* (pages 307-312). MA: MIT Press

[2] Steels, L. & Kaplan, F. (1999) Collective Learning and Semiotic Dynamics. In: Floreano, D., Nicoud, J-D. & Mondada, F. (Eds.) *Advances in Artificial Life: 5th European conference, ECAL'99 Proceedings.* (pages 679-688). Berlin: Springer

NEvAr – System Overview

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Abstract

In the past few years, a new Artificial Intelligence area has begun to emerge, usually named Creative Reasoning. While some researchers approach the study of creativity from a human perspective, and thus try to model human creativity, we follow a different approach: we consider nature to be creative, and hence try to it in an attempt to create systems that have the potential to be creative. In this paper we make an overview of the evolutionary art tool NEvAr – a system that allows the evolution of populations of images.

1. Introduction

NEvAr (Neuro Evolutionary Art) is an ongoing research project being developed at the Creative Systems Group of the UC-AI Lab (Artificial Intelligence Laboratory - University of Coimbra). This Group focuses its activity on areas such as Music and Image Generation, Design, Creativity and Artificial Intelligence. The ultimate goal of the project is to build an Artificial Artist, a computer application able to generate artworks autonomously. In its current state of development, NEvAr is an Evolutionary Art tool, inspired in the works of K. Sims [1] and R. Dawkins [2]. It allows the evolution of populations of images according to the aesthetic preferences of the user. NEvAr follows an evolutionary paradigm; in other words, it tries to mimic the mechanisms underlying natural selection, namely: survival of the fittest, recombination of their genetic material, and slight random modification (mutation).

2. System Overview

In this section we make a brief overview of NEvAr. A more detailed analysis can be found in [3]. In its simpler mode of operation, NEvAr follows the traditional evolutionary cycle:

1. The program generates a random population of images;
2. The user evaluates the images, assigning a fitness value to them;
3. The program breeds a new population of images trough the recombination and mutation of the genetic code of the images of the current population; images with higher fitness values have higher probabilities of being selected for breeding;
4. Return to point 2.

NEvAr implements a parallel evolutionary algorithm, in the sense that we can have several different and independent evolutionary runs taking place simultaneously. It is also asynchronous, meaning that we can have an experiment that is in population 0 and another one that is in population 100. Additionally, we can transfer individuals between experiments (migration). In figure 1 we present the implemented evolutionary model.

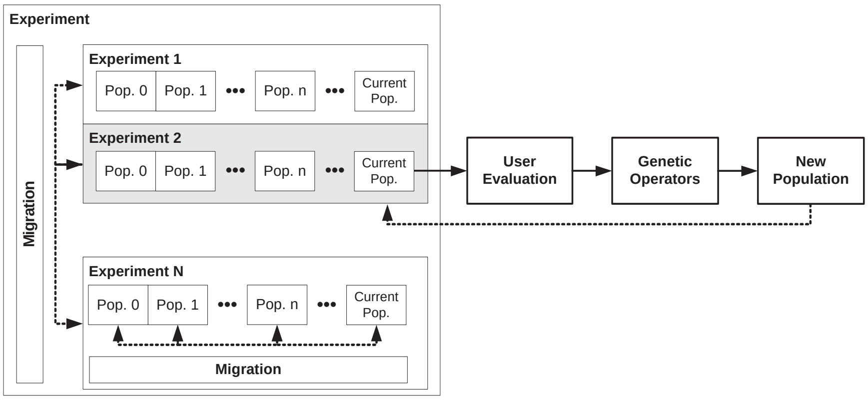

Figure 1. The evolutionary model of NEvAr. The active experiment is depicted in grey.

2.1 Representation

In NEvAr, the characteristics of the individuals (images) are determined by their genetic code. So we have a *phenotype* (the individual) and a *genotype* (the genetic code that, once expressed, results in the individual). The genotypes are trees constructed from a lexicon of functions and terminals. The function set is composed mainly of simple functions such as arithmetic, trigonometric and logic operations. The terminal set is composed of a set of variables *x* and *y* and random constants. The phenotype is generated by evaluating the genotype for each (*x*,*y*) pair belonging to the image. Thus, the images generated by NEvAr can be seen as graphical portrayals of mathematical expressions (see Figure 2).

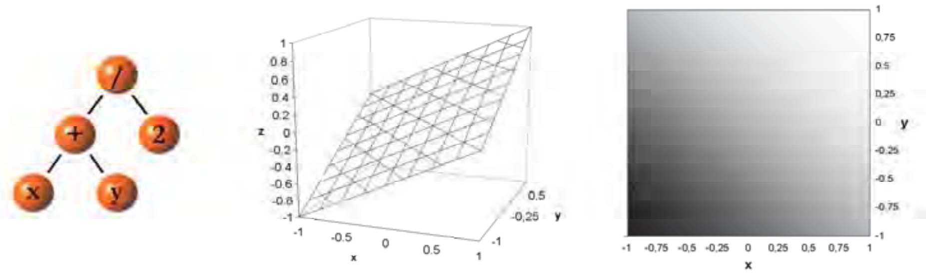

Figure 2. On the left, the expression *f(x)=(x+y)/2* represented in tree format; in the middle, a 3d-graph of the mathematical expression; on the right, an image generated by assigning a greyscale value to each *f(x)* value.

2.2 Genetic Operators

The genetic operations (recombination and mutation) are performed at the genotype level. In Figure 3, we present an example of a recombination operation. In order to produce colour images we resort to a special kind of terminal that returns a different random value depending on the colour channel – Red, Green or Blue – being processed.

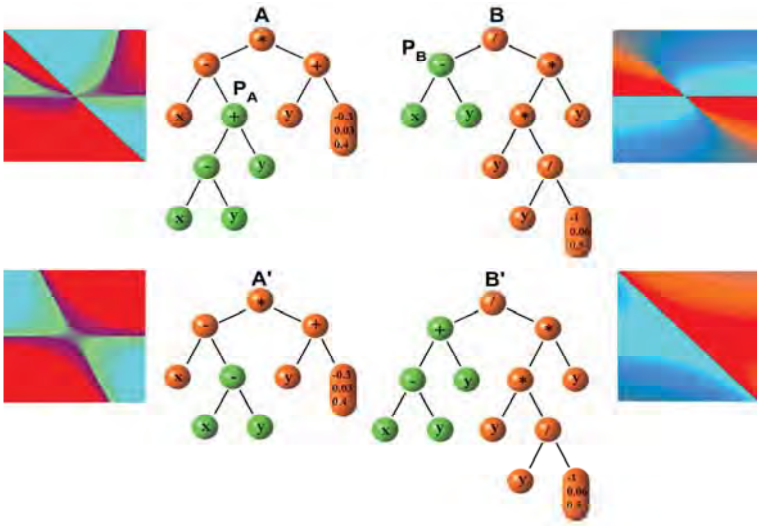

Figure 3. Example of the recombination operation. The code of the individuals A and B is recombined by exchanging the sub-trees implicitly defined by 2 randomly chosen points P_A and P_B, giving rise to the individuals A' and B'.

2.3 Assessment

Working with NEvAr is an iterative process, as the number of populations increases the average quality of the images also tends to increase, giving rise to new, interesting, and aesthetically sound images (at least to the eye of the user conducting the program). Like any other tool, NEvAr requires a learning period. To explore all the potential of a tool, the user must know it in detail and develop or learn an appropriate work methodology. The results, and user satisfaction, depend not only on the tool but also on its mastering. In Figure 3 we present some examples of images generated with NEvAr. Additional images can be found at: http://www.dei.uc.pt/~machado/NEvAr/

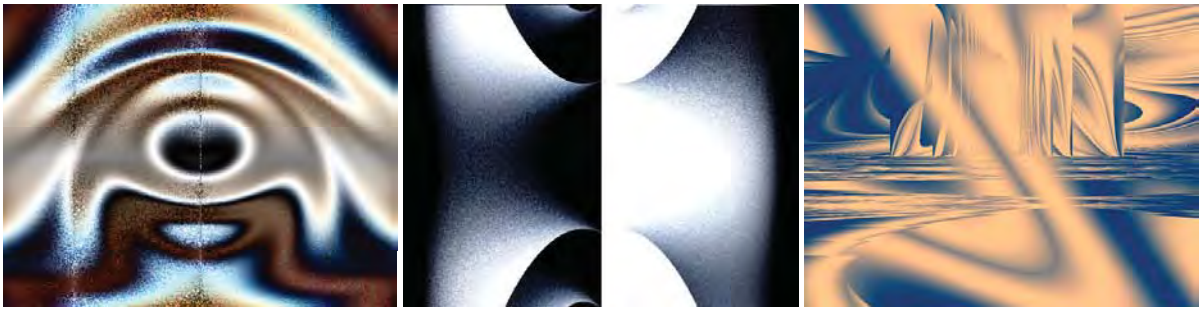

Figure 3. Some examples of images created with NEvAr.

3. Recent Developments

As stated before, the ultimate goal of this project is to build an Artificial Artist. In its current form the automatic fitness assignment procedure [3] only takes into account the lightness information of the images, discarding the hue and saturation information. Therefore, in this mode of execution, we are limited to greyscale images. Figure 4 shows several images generated by NEvAr without any kind of human intervention.

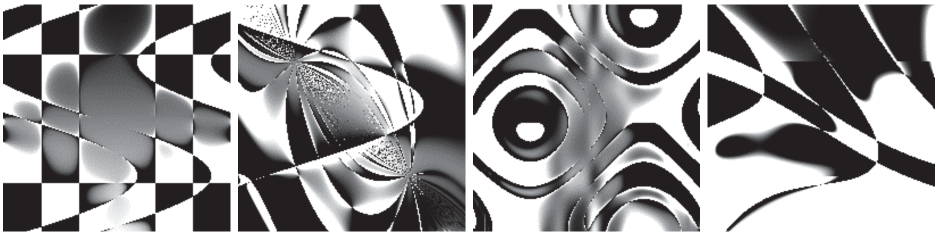

Figure 4. Examples of images evolved by NEvAr without human intervention.

To overcome this limitation we are developing a system that learns to colour greyscale images [4]. We employ Genetic Programming to evolve programs that mimic the colourings of a training set of images. Once such program is found, we can use it to colour the greyscale images generated by NEvAr. One of the advantages of this approach is the ability to use, as training images, artworks of well-known artists, which, assuming that the approach is successful, will enable NEvAr to mimic the colourings of these authors. In [5] we propose a general framework for the development of Artificial Art Critics (AACs), and tested it in the musical domain. Following this framework we are developing an AAC in the domain of visual arts, which will replace the current fitness assignment procedure.

4. Conclusions

We consider NEvAr to be a tool with great potential from an artistic perspective. Through the use of NEvAr, the artist is no longer responsible for the generation of the idea, which results from an evolutionary process and from the interaction of artist and tool. Thus, the use of this tool implies changes to the artistic and creative process. In spite of these changes, the artworks follow the aesthetic and artistic principles of the artist. The use of NEvAr implies losing of control; however, this lack of control isn't necessarily negative. The artist can express her/himself through the use of the tool and review her/himself in the works created.

References

1. Sims, K., *Artificial Evolution for Computer Graphics*. ACM Computer Graphics, 25, 319-328, Addison-Wesley: Boston, MA, 1991.

2. Dawkins, R., *The Blind Watchmaker*, W.W. Norton & Company, Inc., New York, 1987.

3. Machado, P., Cardoso, A., *All the truth about NEvAr*. Applied Intelligence, Special issue on Creative Systems, Bentley, P. Corne, D. (eds), Vol. 16, Nr. 2, pp. 101-119, Kluwer Academic Publishers, 2002.

4. Machado, P., Dias, A., Cardoso, A., *Learning to Colour Greyscale Images*. The Interdisciplinary Journal of Artificial Intelligence and the Simulation of Behaviour – AISB Journal, Geraint Wiggins (Ed.), Vol. 1, Nr. 2, pp. 209-219. London, UK, 2002

5. Machado, P., Romero, J., Manaris, B., Cardoso, A. and Santos, A, *Power to the Critics - A Framework for the Development of Artificial Art Critics*. Proceedings of the IJCAI'2003 Workshop on Creative Systems, Bento, C., Cardoso, A. and Gero, J. (Eds.), pp. 55-64. Acapulco, Mexico. 2003.

'If We Shadows…' and 'A Bouquet for Regina Célia Pinto' - Two works for the Internet.

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michael@somedancersandmusicians.com

Abstract

'If We Shadows' and 'A Bouquet for Regina Célia Pinto' are two small interactive/generative artworks, with sound, for the Internet.

1. 'If We Shadows…' (2001)

http://www.somedancersandmusicians.com/shadowsA.htm
'If We Shadows…' (2001) is a small interactive and generative audiovisual piece for the Internet.
The visuals are derived from DV footage shot during rehearsals/performance of the dance piece 'linked verses', commissioned and funded by Epping Forest Arts and which toured the West Essex of the UK area in Spring of 2003.
Users interact with the visuals by clicking on one of the dancing figures, calling in on each occasion one of three small piano loops.
This happens up to eight times in total during the course of the piece.
The point of entry of each new loop into the whole piece is determined solely by the user – there are literally millions of permutations of the eight lines of the piece with the additional complication that each musical entry is randomly chosen from either all three or, near the start, two, of the loops.
This gives rise to many very distinctive and richly complex phase patterns.
To me the result feels like a small but nonetheless authentic piece of music with a coherent structure and development.
Whether this is true is obviously for the listener/viewer to judge.

The visuals, although they have a utilitarian function in the construction of the piece's sound world, are not simply an interface. They're both a kind of homage to Eadweard Muybridge, film pioneer, and also a little ghost story.

2. 'A Bouquet for Regina Célia Pinto' (2003)

http://www.somedancersandmusicians.com/bouquet/A_Bouquet_for_Regina_Celia_Pinto.html
The artist Regina Célia Pinto was kind enough to send me some beautiful recordings of music from her native Brazil.

I made this small piece as a thank you note.
It operates on principles not dissimilar to ‘If We Shadows…’ except here there is no user interaction - once triggered the piece simply unfolds (but differently, within defined limits, on every occasion).
The sound sources are three fragments played on the African instrument the mbira, or thumb piano.
Once again randomised phasing is employed as a musical structuring device, only this time the randomisation is achieved by embedding a number of copies of the same Shockwave movie within a single page of html.
The movies themselves contain random elements so although each has a limited palette of both sound and image the possibilities for permutation are pretty much endless.
Once again it seems to me that the various statistical possibilities almost invariably yield something that is musically coherent – I like to think of this as a Lutoslawskian rather than a Cagean use of chance although these are works clearly on a much more modest level!
The images are derived from DV footage of an ornamental cherry tree in my garden, taken on a bright day in the late spring.

Offering images to us that are in the limit of the border of the Real and the virtual one
As it defines Manuel Castells this modality of the development he is in the relationship technician of the production and, therefore it can be seen as a social relationship that indicates the modalities of the development of the technological creations, giving forms to the entire kingdom of the social behavior, of course thus including the communication symbolic. Its conclusions can be prosecuted as what they come to produce social a structure new (a society of the net), a new economy (global an informative economy) and a new culture (a culture of the virtual reality). A new society of information.

For this installation they would be used initially a computer, a projector multimedia, two loudspeakers, eyeglasses 3D and one wireless mouse.

In this experiment we will be demonstrating in practical way, interactive imersivo, the qualities and concepts of the illusion and the immersion, according to Oliver Grau.
Although the majority of the peoples considers that the virtual reality is a completely new phenomenon, we find its in the history of the images imersives. The search of imaginary the visual space goes beyond the antiquity. Oliver Grau shows as the art of the virtual one appeared very before the art the illusion and the immersion. It describes metamorphoses of the concepts of the art and the image, the interactive art, the project of the relations, the agents, the telepresence and the evolution of the image. Grau not only considers a history of the spaces of the illusion, but also of a theoretical structure for an analysis of the fenomenology, its functions and its strategies for the future. (Oliver Grau - December 2002).

The interaction in cyberespace allows to circulate in space shaped for computational, composed way of three-dimensional environments that can contain some scenes, activated in one determined moment, where current objects are reconfigured in function of events and behaviors determined for the reader and the real time is determined by the machine in almost the concurrence of the emission and reception of the information.

Thus we will be able to perceive that the artistic productions certify that the creation and the communication are in tunning with a proper mentality of the digital age, point with respect to new forms of relation between the human beings and machines from the technologycal devices and of the numerical language.

2.1 Indentation

Installation project .

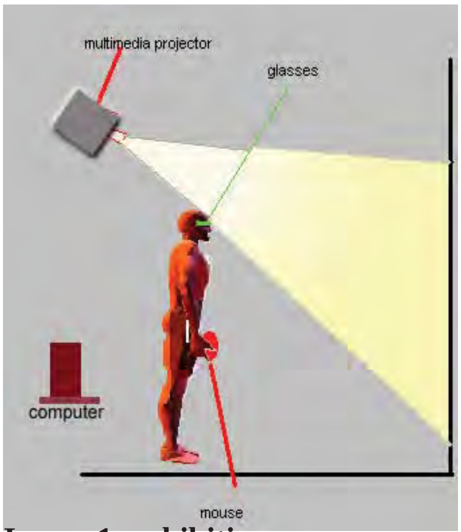
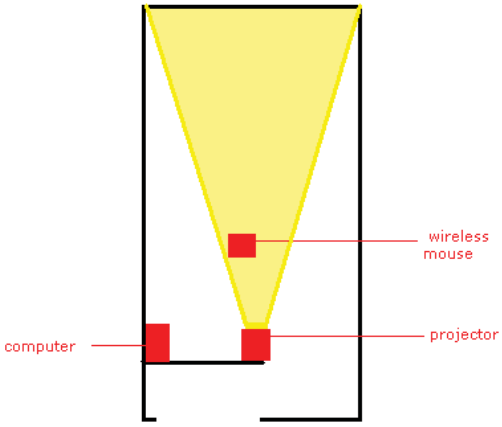


Image 1: exhibition



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2.2 Tables and Figures

Image 1: Interactive space

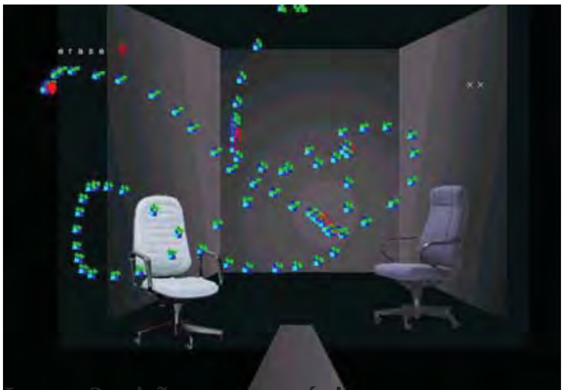

Image 2: visão estereoscópica

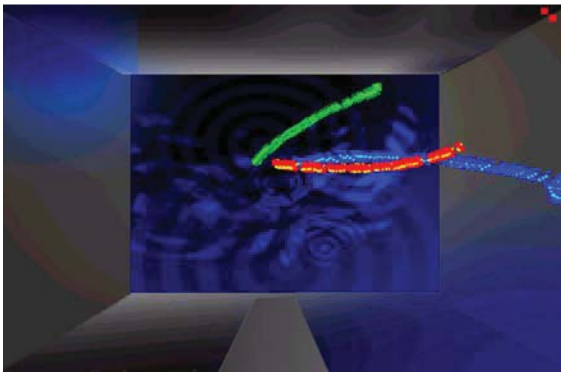

Image 3: imersive space

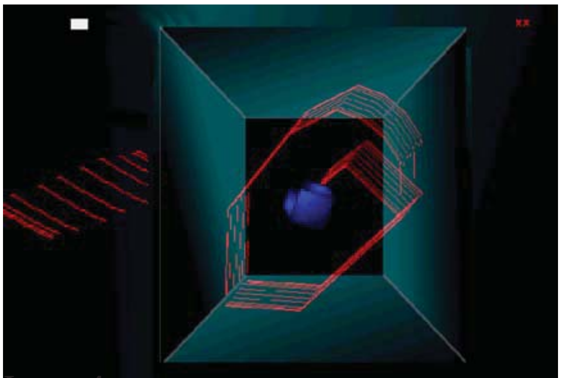

Image 4:

2.3 Quoting references

[1] AARSETH, Espen J. (1997) *Cybertext: Perspectives on Ergodic Literature*. Baltimore, EUA, The Johns Hopkins University Press.

[2] BEIGUELMAN, Giselle

2001.2002-. desvirtual.com Disponível em: http://www.desvirtual.com.

2002

a- *Ceci n'est pás um nike Disponível em http://www.desvirtual.com/nike*

b- *Revista trópico* : Disponível em http://www.uol.com.br/revista trópico acessado em 10 de março de 2003

c- *Liquid Texts*, Leonardo Eletronic Almanac, volume 10, number 8, agosto de 2002. Disponível em: http://www.desvirtual.com/thebook

d- 2003 "*Notes on the Loss of Inscription*", in: P0es1s , Berlim, literaturWERKstatt, no prelo

[3] OLIVER,Grau (2002) *Virtual Art*- MIT PRESS- Cambridge- Massachusetts

SELF PRESENTING GENERATIVE PROGRAM - performance

Bogdan Soban

The idea to develop a generative program that can present itself was born approximately one year ago (October 2002) after several presentations of generative concept in public. Usually I used PowerPoint with static text and images to present the basic theoretical starting-points and later I ran some programs creating real time images. “If the presented material speaks about generative method why couldn’t be generative itself” I posed a question often. Using this approach the whole presentation could be entirely generative. I was conscious of existing a certain level of risk that the program could generate not good enough images to be representative. But this is the main characteristic of generative method and I decided to develop this program believing in good results.

I reconstructed one of my recent programs introducing the concept of underlying text on movies. On the main part of the screen the image is real time generated and in the bottom there are two lines if explaining text. In the beginning of the program is possible to set English or Slovene language version. Text lines are string constants according to typical image created on the screen. Repeating the program means to present new images of the defined type with the same description in the bottom text. The program is time controlled and depending of defined duration of the whole presentation the duration of elementary presentations is shared. The program allows placing time regulation depending on processor speed to obtain approximate time of presentation.

The program is divided in four parts. The first part is dedicated to symbolic imagination of the generative art birth. From the technical point of view generative approach as the useful method last to some ten years ago. From the philosophical view the generative process is old as the cosmos is. Starting form this fact it seems to be logic to place its birth in the period of “big bang”. The nature is primary and the method is only to be the copy of natural processes.

In the second part the program generate some examples of images from geometry to virtual landscapes explaining in brief what the main characteristic of generative art are: unpredictability, coincidence, creativity, time depending process, not repeatable results, etc.

The third part is dedicated to generated images based on geometrical concept. Those were my first experiments on the area of generative approach about twenty years ago. There are points, lines and plains as the basic elements to create a graphic composition. It is the typical pragmatic algorithm where the final result as the motif is predictable, only the version is always different.

In the last and the largest part of the program are presented different algorithms based on mathematical formulas. The images appear in the sequence of the development of my concept in the recent time: from the 16-colcors shapes to shot-colored landscapes and virtual spaces. There are presented different screen elaborations too.

The program is modular designed with the possibility to add new algorithms and new image types in the future. To be executable in different PC platforms I used Visual Basic programming language with as less as possible library call routines. Till now I have no problems to run it on different MS Windows versions or platforms.

Digital Reflections of Palladian Spaces

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Description

This interactive art project (figure 1) investigates in experiential ways the generative power of Palladian architecture taking "La Rotonda" as the starting point of the digital journey. The purpose of the project is to expose the visitor to spaces generated through abstract rules starting from a known familiar pattern.

The interactive character of the digital space allows the visitor to experience La Rotonda both as pure geometrical abstraction starting from the plan, and section drawings, and as anthropomorphic digital architecture allowing human orientation in the virtual space based on behaviours acquired through interaction with real architecture. The visitor's actions generate new patterns of possible Palladian architecture representing the digital reflections of the real Palladian spaces.

The movie explores interactions between the inner and outer spaces of the Palladian digitally generated forms of architecture. The investigation is meant to emphasize the idea of a new space conception related to the specifics of architectural space in an artificial changeable environment, developing along the historical line described by Siegfried Giedion. The new forms of digital architecture are explored from the perspective of their relation with thought, perception, and multiple dimensions of human existence in the information age.

The proposed interactive art project provides a basis for qualitative analysis synthesizing principles for virtual architecture design as a basis for the creation of spatialized information spaces. New directions of design and development for Internet portals are investigated based on the transfer of architectural composition and structures to the organization of the digital medium.

This interactive art project has been developed as a platform for qualitative analysis and research in the area of Internet portals and hybrid immersive environments for architectural research and design. These projects are funded through a University of Lethbridge Research Fund Grant, through a University of Lethbridge Teaching Development Grant, and through Alberta WestGrid Collaborative Visualization Program.

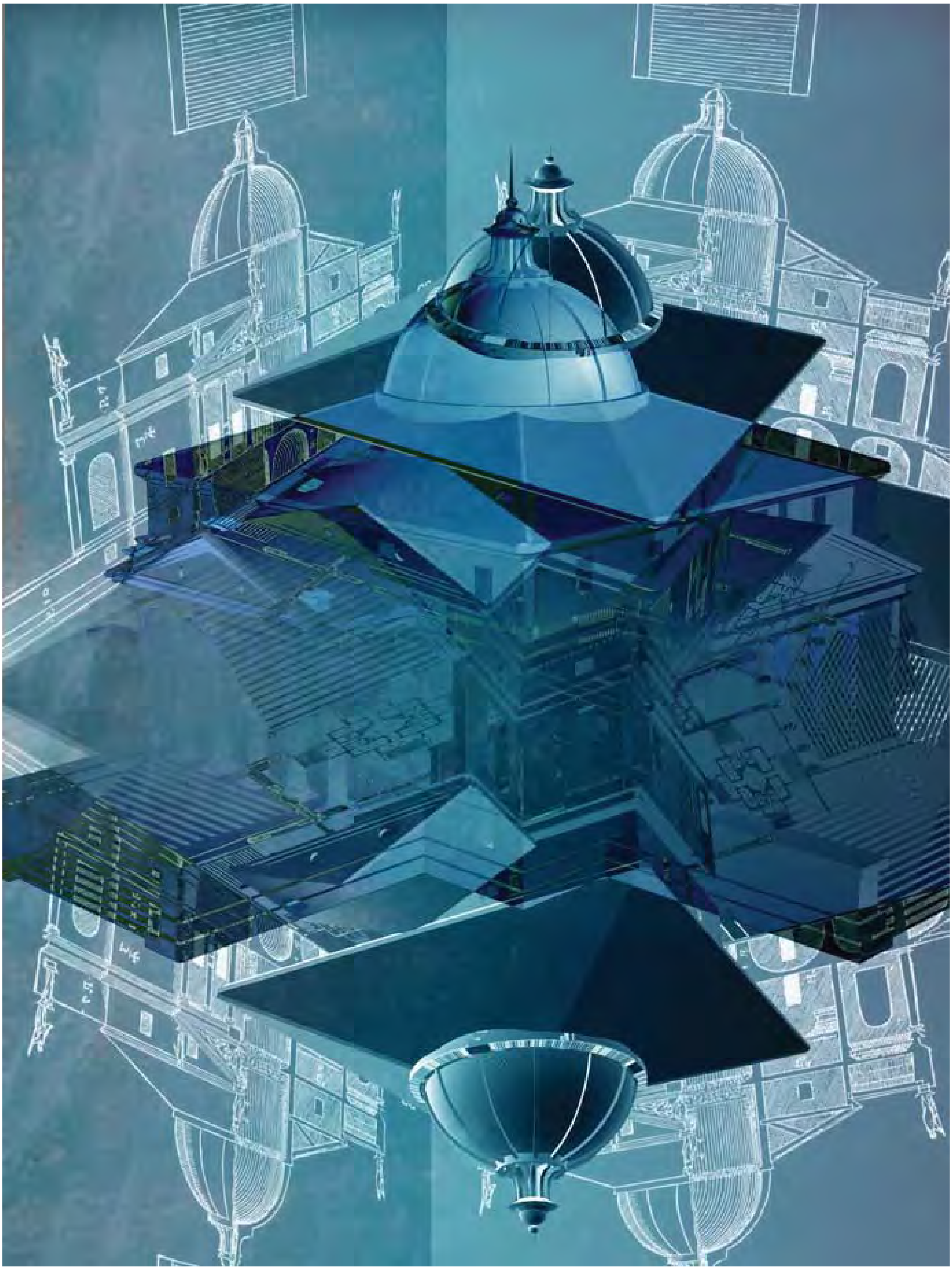

Figure 1. Digital Reflections of Palladian Spaces - Interactive art. Screen shot. Project developed by Daniela Sirbu, University of Lethbridge.

Imaginary Palladian Spaces

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Department of New Media, University of Lethbridge, Alberta, Canada
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Description

This movie (figure 1) explores in experiential ways the idea of a fourth space conception [1] rooted in the specifics of the digital medium. Changed relationships between the interior and the exterior of the virtual architecture and their coexistence in simultaneous shots are investigated in order to experiment with differences and similarities in the perception of represented and real spaces.

Figure 1. Imaginary Palladian Spaces - Movie. Screen shot. Project developed by Daniela Sirbu, University of Lethbridge.

This movie investigates the interplay between the evolving character of the digital architecture and the development of new patterns of human behaviour in interaction with the changeable virtual environment. It explores a digital architectural space in development taking as a starting point Palladio's villa "La Rotonda." The architectural space is first exposed as pure geometry, then it is investigated as a growing abstract construction evolving from a nucleus pattern provided by "La Rotonda," then it is explored through interactions between emerging inner and outer spaces, available for exploration on multiple planes.

Starting from architecture as abstract form, the movie attempts to link the beauty of pure geometry with human thought, perception, and the multiple dimensions of human existence. The movie begins with abstract representations of architecture, and then develops towards an exploration of evocative values of an active and changing digital architectural environment. The movie investigates the poetics of the evolving architectural forms and how these are related to the original starting pattern.

The movie development is characterized by the coexistence of a number of parallel universes. An accumulation of details is used as an operational device throughout the movie to provide references toward the coexisting different universes. The development in time of the visual composition is operated through manipulation of visual perception shifts from one meaningful element to another. Throughout the movie, shots staging emphasize the exposition of different artificial worlds. The viewer is floating between emerging universes that can never be seen concretized. Transitions in the movie are a very effective device, an counterexample of pictorial continuity in the sense it is performed in classical Hollywood style.

Ac no ledgements

This movie, together with the interactive art project proposed for GA2003, has been developed as an experimentation platform for research in the area of Internet portals and hybrid immersive environments for architectural research and design. These projects are funded through a University of Lethbridge Research Grant, through a University of Lethbridge Teaching Development Grant, and through Alberta WestGrid Collaborative Visualization Program.

Preservation of Urban Historical Region with Generative Design

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Abstract:

With the booming development in the recent decade, especially the last five years the urbanization process has caused the immoderate expansion of the cities. And the areas around the big cities, especially metropolises have been encroached. Due to the lack of proper and efficient urban planning management and corresponding planning code, some cities are in a state of irrationality. Accordingly, the preservation of urban historical region has been a tough problem for the governors to face. In addition, the officials in charge of the urban planning and land development also feel great pressure of the rapid development of the city and the increasing environmental issues. Sometimes they have not enough energy to go through all the planning projects in details and even have no idea of what it would be when the projects are carried out several years later. Besides all these reasons above, lack of systemic and consummate institution to inspect and evaluate the whole process of the projects is also a big concern for the officials.

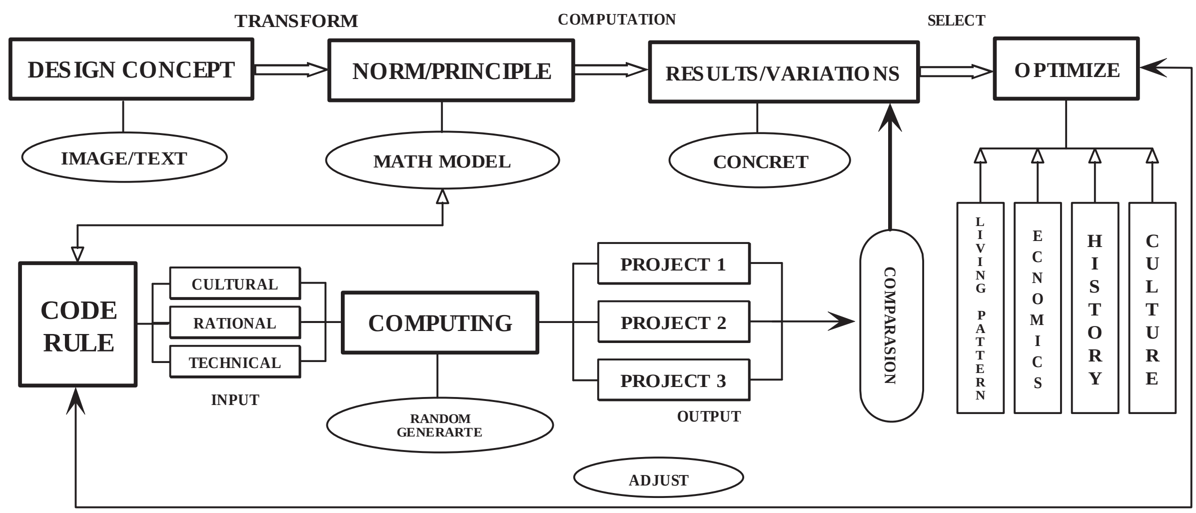
On the other hand, the architects and urban planers design or plan a project more imaginarily than rationally, because of the tight working time and lack of proper design and analysis tools in China. Therefore, sometimes even they do not know the indexes of the projects designed by them until they finish these projects. Furthermore they have no sense of the indexes given by the developer or the relevant managers of the urban planning. In addition, there are not any objective procedures to help them to obtain accurate data or information to base the design on and to evaluate what should be preserved in a historical area.

Consequently, that is the aim of this joint research to establish an evaluation system via computer and internet, and based on this system, design a systematic program to help both the officials and designers, planners to manage, design, plan and protect the urban historical region more efficiently and effectively. This program is an open system allowing for different conditions of different areas, different city, different culture and different economic situation of different site.

This program contains these main elements below:

1. Evaluation system.
2. Generative design of Urban Historical Region Preservation.
3. Revaluation system.
4. Tested by designers and relevant officials.
5. Optimizing the Generative design of Urban Historical Region Preservation.

In this research, Shanghai is chosen as a typical sample because of her representative character and unique charm. To some extent, the particular location and urban history have made this city a focus of the world. Before the Opium War in 1840, the city had become an important harbor city in china, because she is located near the outlet of the mother river of China—the Changjiang River and the wealthy inland such as Jiangsu Province and Zhejiang Province. After that, with the establishing of the settlement of the western countries, Shanghai experienced a different urban process from other cities of China. There are two prime periods in the development of this city: the first time is during the First World War, which laid the foundation of the city as a famous international metropolis; the second period is in 1990's, especially after the Reform and Opening of Shanghai in 1990, which gave Shanghai an opportunity to become a modern international metropolis and also an opening window of China to the world. But through all over 160 years, the same feature of the city expansion and renovation has remained that Shanghai acts as a tie between China and western countries. In regard of the city and the architecture, the meeting and integrating of the local and the western culture are the main characteristic. Due to this important role， Shanghai is one of the keys to research the modern history of China. The development and renovation of Shanghai have also witness the development of Chinese cities. In addition, the residential texture of Shanghai reveals a typical character of the blend of the traditional Chinese housing and rowing house of west countries, which is very different from other cities of China. But with the reform and open to the out world, especially during the recent decade, Shanghai has undergone a booming in city renovation. Many traditional residential areas have been replaced by high-rises. The former identity is missing and the contradiction is how to preserve the identity and traditional city memory as well as accommodate more people in the city.



1. The procedure of this research

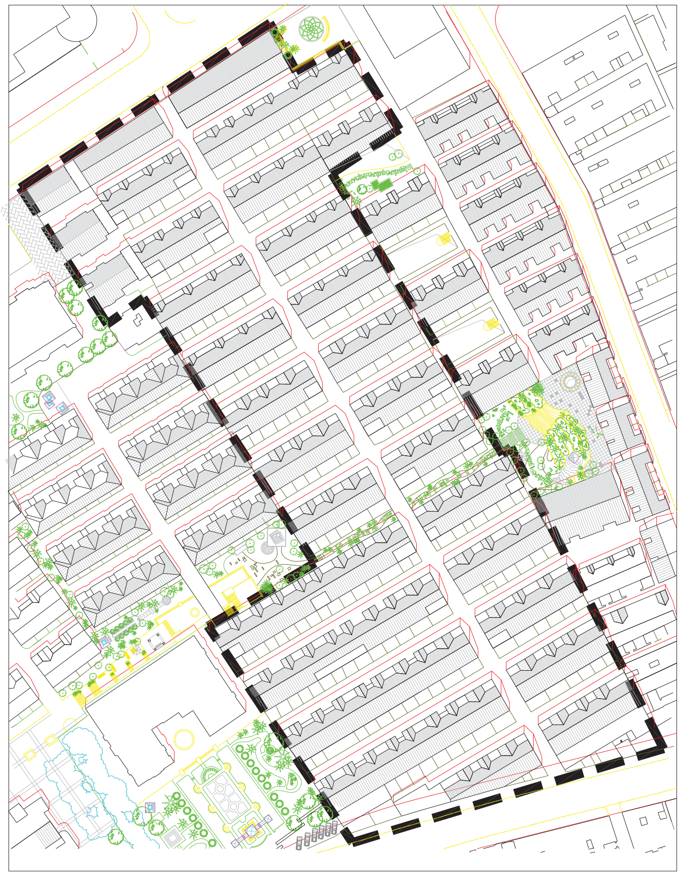
At the beginning, a practical project is chosen; the character and structure will be summarized and generalized by computer and internet with the convenient interface about this site including exchanging ideas between the designers and local residents. Through generalizing and programming, a program system will be generated and this system will reapply to the project to confirm the validity of the system and be adjusted. And the generative buildings and architectures are mostly shaped by the physical and then cultural environment. Consequently we reshape it by its inner rules such as function and construction and the relationship of the different space. Therefore we can get the architectures meeting our needs with generative program. Another project is also a good example to examine and evaluate the validity of the program. The process of the research is as figure 1.

The site, Jingan Villa， chosen for the GA research is a preservation area in the center of Shanghai, which is of “New Lilong” style with West Nanjing Road in the north, Weihai Road in the south, north Maoming road in the east, Shanxi Road in the west. The planning structure of Jingan villa is composed of a main lane and branch lanes similar to the backbone of fish, the typical texture of Lilong.

The object of this research is to set up a general process and effective system to offer architects, urban planners and urban managers some useful ideas and indispensable references with the help of GA methods and ideas.

1. Establishment of evaluation system with computer and internet

By the support of computer and internet, a survey is carried out to know the most valuable merits and elements of the given area, including both physical and spiritual aspects.

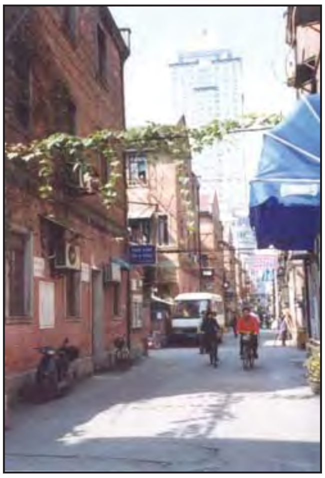


2. The site

The results will be the resources of the program to reproduce the characteristic of the unique site of particular culture. They are also the raw material of the generative design of the preservation. This origin is derived from the theory of Kevin Lynch about the city image, the memory of the city.

FACTOR	ITEM	THE IMPORTANCE OF EACH ITEM				
		1	2	3	4	5
PHYSICAL	LOCATION				×	
	AREA			×		
	SUNSHINE					×
	GREEN AREA					×
	COURT YARD					×
	MATERIAL					
	TRANSPORTATION				×	
CULTURAL / FORM	PLAN			×		
	SCALE					×
	COLOR		×			
	DECORATION			×		
	HUMAN RELATIONSHIP					×
	COMMUNICATION				×	

"Jingan villa", the "New Lilong", (figure 2) is the largest New Lilong in shanghai which was built up in 1928. Its structure is composed of a main lane and 24 branch lanes (figure 3, 4). There are 183 units, 34300 M^2 floor space in the site of 23500 M^2. The units have 6 different plans, 3 along the street (totally 20 units), and 3 inside the site (totally 163 units). The distance between each row of housing is 8.25M and the wall is 9.6M high, with a ratio of 1:0.85. Comparatively Jingan villa has a better and more comfortable convenient living



3. The main lane

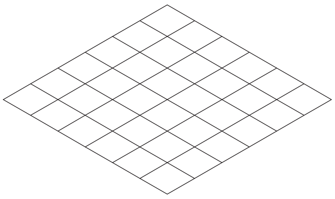
4. The branch lane

condition than the "Old Lilong", with proper court yard sunshine, ventilation, sanitation facilities.

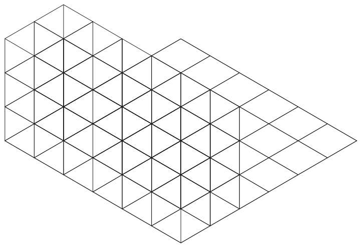
The survey is made up of two parts: physical and cultural. The sample table is just as above.

2. Generative design of urban historical region preservation:

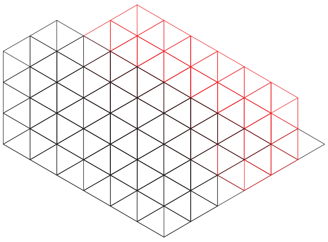
Firstly, this program allows mainly for technological variations as a rational process, that



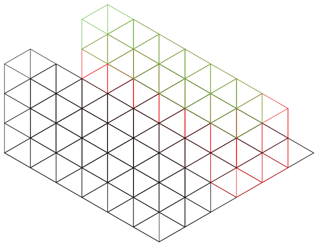
Given site



Add building 1

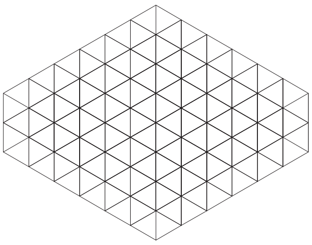


Add building 2

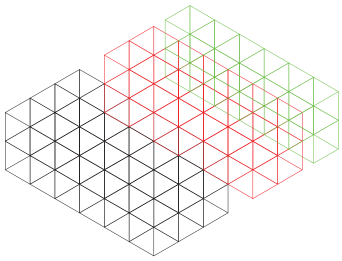


Alternative project

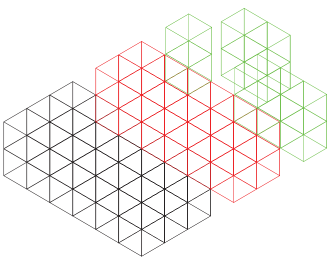
5. Generate building with the method of addition



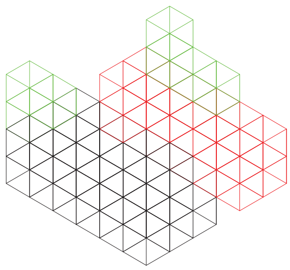
Given site with
the floor space needed



Road generated by cutting



The remaining space is separated



The separated space is
added to original building

6. Generate building with the method of subtraction

considers the index variations as the starting point. Then, in the second step, the cultural variations will be input according to different situations. In the third step, the program will be set up; the preservations are filtered and generated by the designers.

There are two kinds of methods to generate design in a given site of this project, one is to add, and the other is to subtract (Figure 5, 6). There are also two steps to accomplish the generative process, one is on rational factors, and the other is on cultural factors.

In a given site, the pivotal indexes are the total floor space, plot ratio, building density, boundary lines of roads, building ling, building interval, insolation standard, greening rate, height, etc.

The math formula is as follows:

(1) $R_a = F/A$ (R_a: plot ratio; F: total floor space; A: site area)

(2) $I = D/H$ (I: insolation standard; D: building interval; H: total height of the tallest building)

(3) $R_g = G/A$ (R_g: greening rate; G: green area; A: site area)

(4) $H = M*h$ (H: total height of the tallest building; M: stories; h: storey height)

(5) $F = F_1 + F_2 + F_3 + \ldots\ldots F_n$ (F_1: total floor space of building 1; F_n: total floor space of building n)

In the first step, the generation follows the method of subtraction, because this is more suitable to decide the structure of the site. The road structure will restrict the arrangement and the shape of the building.

In the second step, the cultural factors are added into the generation to filter the results of the first generation. For example, different materials will define the height and the inner structure of the building. The space scale (help to form the typical space character of this site) will shape the space distance of the buildings (Figure 7). But the generations also need to be filtered by designers, for there are several factors can not transfer into rational forms (Figure 8). In addition, the program system should be adjusted by other projects.

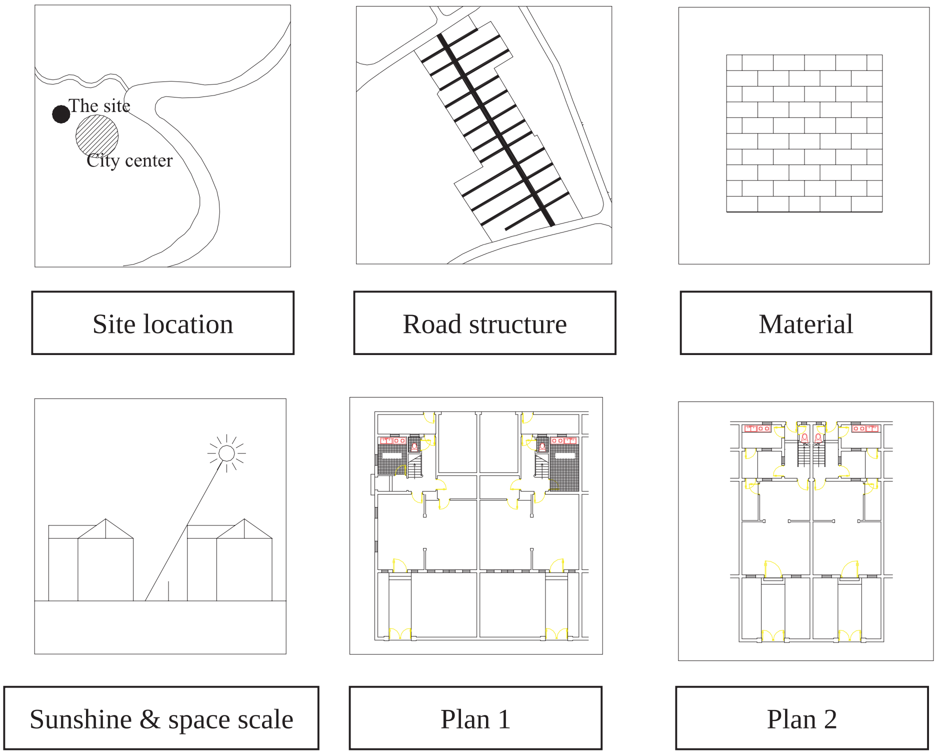
3. Revaluation system:

In this stage, the generative preservation plans will be revaluated. Some model samples will be applied to check the coincidence of each other, so that the generative design program will be adjusted according the offset. Also it is necessary that these three procedures will be processed many times to ensure the effectiveness of this program.

Therefore, another project (a urban design in Shaoxing, Zhejang province, China) is selected to testify the validity of the program and find the shortage of the GA program, actually there are some problems caused not by GA itself or that is the program that we can not solved by GA, because that is affected by other irrational factors such as people’s preference, decorations.

Through this step, the factors are divided into two parts: correlated and uncorrelated. Correlated parameters are the factors that have great influence on the results and the uncorrelated parameters are the ones that have little or no influence on the final generative designs. For instance, the court yard, both in the generative and the revaluation process, the court yard can’t be shaped as what we think of. And as to the different story plan, the outline and the balcony are also random; otherwise it adds the possibilities to the alternatives of GA.

In addition, when the road subtraction is added to the building block, the division of the subtraction scale should be adjusted according to different building scale and the position placed should also be regulated. The first grid chosen for the site is too big and should be rectified according to different room space.



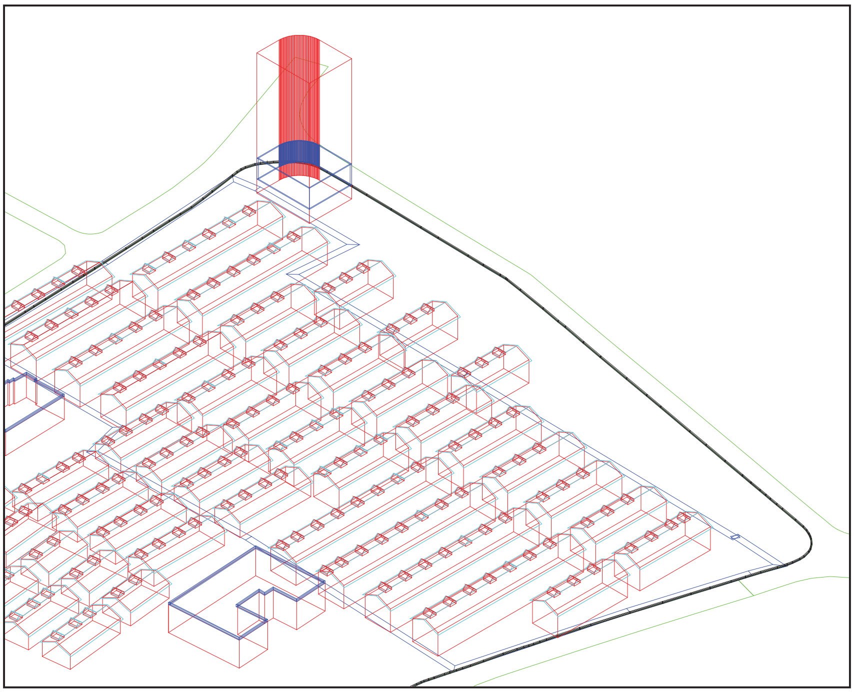
7. Add cultural factors to generative

4. Tested by designers and relevant officials:

Testing is of great importance for the generative program before its' practical application in different field. Different users have different version of the program accordingly; furthermore the opening of the system will help them customize their own system meeting their respective requests.

As to designers, the research also gives them some reference and inspiration. The testing is indispensable, which is carried out by urban designers, architecture designers major in urban preservation and urban planners. And the results are effective. To urban designers, this research is very helpful especially in transportation structure and form generation; to architecture designers, the outline and the form; to urban planners, different configurations of different indexes. The random generative designs will inspire the designers and give them more alternatives and more rational thinking.

Testing carried out by urban managers and officials firstly gives them a general idea about the research. Finally, the research works as an intermediary to bridge the concrete indexes and pictorial image. At the mean time, the historical elements will be also blent into the generative process. This research will also help their decision-making and decide proper development intensity.



8. The generative design (project1)

5. Optimizing generative design of urban historical region preservation:

In the end, the program will be optimized based on the feedback from different users, but that does not mean the process of adjusting is over, actually it is just a beginning which is a circulation without end. Due to the changing design condition, custom and living pattern, the program system should be also adjusted according to the changes. In addition, different sites have different cultural and preservation concerns, and corresponding historical elements should be added into different program system.

6. Reference book

[1] Celestino Soddu . GENERATIVE ARTS, proceedings of GA’2002, Milan December 2002

[2] William • J • Mitchell .《City of Bits ： space，place and ihfobahn》. Massachusetts：The MIT Press，1995

[3] Gerhard Schmitt .《Information Architecture》. Basel：Birkhauser，1999

[4] Luigi prestinenza Puglisi .《Hyper architecture》. Basel：Birkhauser，1999

[5] Luca Galofaro .《Digital Eisenman》. Basel：Birkhauser，1999

[6] Drewp .Third generation .《The changing meaning of Architecture》. London：Pall Mall Press，1972

7. Reference website

[01] GA: http://www.generativeart.com/

[02] GA: http://www.celestinosoddu.com/

[03] GA: http://www.artegens.com/

[04] GA: http://www.fractal.com.cn/

[05] Architecture Schools: Harvard University, http//www.gsd.Harvard.edu

[06] Architecture Schools: MIT, http//alberti.mit.edu/ap/ap.html

[07] Architecture Schools: ETH Zurich, http//www.arch.ethz.ch

[08] Architecture Schools: Illinois Institute of Technology, http//www. iit.edu

[09] Architecture Schools: BBS of Tsing Hua University, bbs.tsinghua.edu.cn：23

[10] Digital Books: 《City of Bits》，William Mitchell，1995：http//www-mitpress.edu/City_of_Bits/

[11] Virtual Museum: Virtual Palladio Museum, http//www.andrea.gsd.Harvard.edu/palladio/museum.htm

[12] Virtual Museum: Virtual chair Museum, http//caad.arch.ethz.ch/teaching/nds/schreg

[13] Virtual Museum: The World Virtual University, http//www.ccon.org/theU/index.html

Comple   Acti e System

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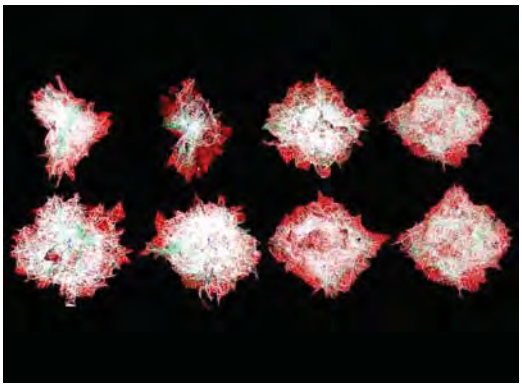
Abstract

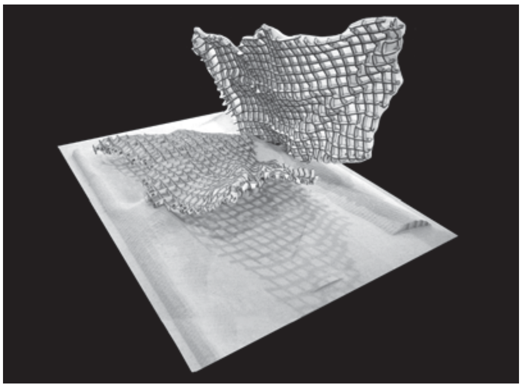
A design of a Complex Active System is being developed which adapts in response to external and internal conditions. The composite system reacts dynamically to different loads and ground configurations, moving from a surface to create an enclosure space, simply by changing pressure and tension. This removes the need for moving-part mechanisms for active control. An experimental method has been employed to predict the material behaviours. The result has been used to identify appropriate architectural applications for the composite system.

Introduction

This paper reports on progress with the research on a Complex Active System which is being developed as thesis for a Master of Architecture within the Emergent Technologies and Design programme at the AA Graduate School.

The aim of my research is to perform an idea as process; the process leads to a generative design.
The line of investigation followed an experimentation approach, evolving from the effects exerted jointly by the information age and increasingly sophisticated materials processing capabilities.
Combined investigations influenced the original idea of form finding as a generative tool to design and produce the form. In particular, an evolutionary computational growth of surfaces in a mathematically defined environment that simulates biological growth on one hand, and the formation process through pneumatic membranes and fibrous systems in biological structures on the other.



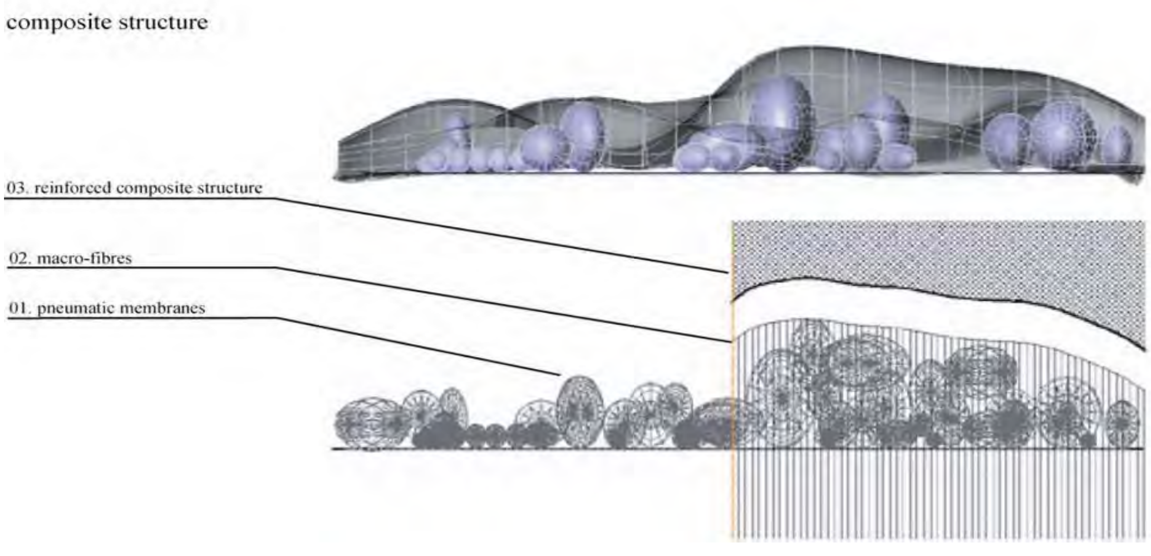


01. Genr8 _ evolutionary form generation   02. Materialized out coming form generated

I have been fascinated by such natural complex systems: fibre-supported soft-pneumatic structure.
Examples in nature, i.e. radiolarian shells or crustaceous organisms, combine the use of pneumatic membrane, primitive life generator, with an abiotic building element to partially harden the body, crossing the boundary between animate and inanimate.
Many multi-cellular organisms rely almost entirely on internal hydrostatic pressures to oppose the elaborate and varying tensions in their membranes.
Natural composite structure: this is the chosen model for the design, the strategy of organisation to be pursued through an evolutionary process.
Besides, a research on material properties and construction methods for yachts with fibre composite hulls and three dimensional weaving of racing sail manufacturing technology supported the design development.

Structural Hypothesis

By emphasis on generating complex surfaces through modelling rather than through mathematical formulation, the aim is to have an immediate material consequence that is architectural and structural. Therefore I direct the scope of my research for developing a complex active system with non-linear behaviours.
The structural hypothesis is a layered pneumatic membrane in a fibre matrix, a composite where the fibres are orientated in layers to give responsive properties to the pneu, and the potential to control changes to the overall form. With a biological approach, there is no solution of continuity between structure and material; the ‘composite’ could be as much a structure as a material.
The system is then constituted of a soft-core of pneumatic membranes, a number of flexible envelopes all tension surfaces, and macro-fibres, constraining tension membranes, that can turn into hard-body as a reinforced composite, where the fibres carry mechanical loads and a matrix transmits loads to the fibres.
The latter, while adding structural properties to the system, varies its responsive performances by introducing a time-scale factor.



03. Structural System

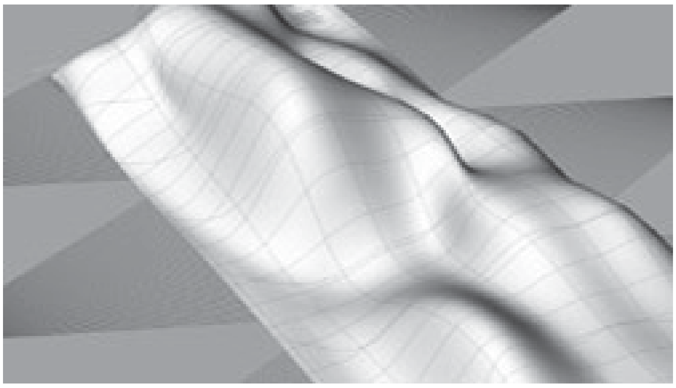
On one hand a soft body, reversible, locally dynamic, able to change in space and time; on the other a hard body, irreversible in its form, locally static, influenced by time towards a steady configuration.

Adaptability and responsiveness within the system are generated by changes in volume of the pneus achieved by pressure alteration and/or restriction or freedom given by the macro-fibre's tension and distribution.

Pneus absolve a fundamental role. As in biology, they can be used in the formation process, or be part of the active system.

The out coming object when pneus are involved in the formation process is characterized by an unknown form, with a steady configuration obtained by hardening the soft-body, adapted to certain load conditions, self-organized to the best configuration by exchanging pressure.

04. Hard- body



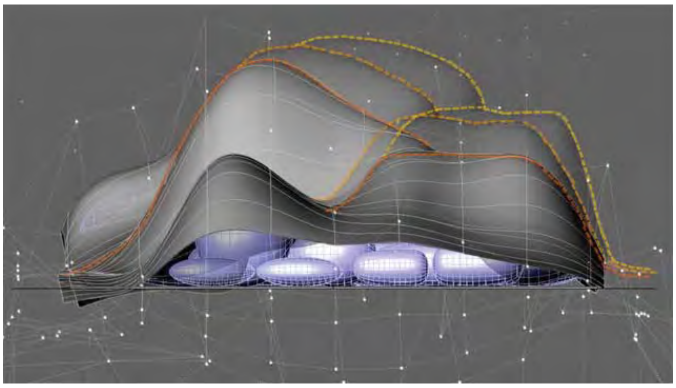
05. Complex surface through formation process

The complex active system becomes a generative tool for industrial manufacturing process of highly complex surfaces across architectural scales, from landscape to design.

Once the pneumatic membranes keep their ability of change volume, exchange pressure and 'breath', the system performs dynamically, with global movement controlled at local scale.

Unpredictable behaviours are confined within a range of stable configurations, adapting to different load conditions generating topography changes, being responsive to external/internal lighting and thermal conditions.

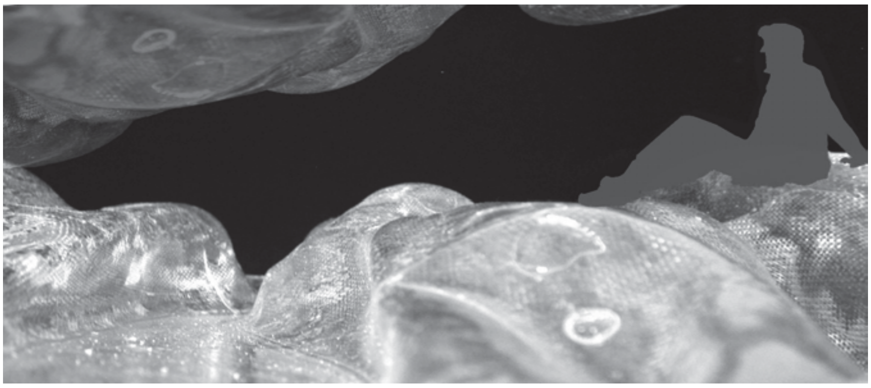
06. Soft-body



07. Complex Active System

Applied Research

The experimented bottom up approach generates animate forms.
Complex objects with articulated shapes can easily be obtained and controlled by a self-sufficient construction process; architectural bodies easy to locate and move, adaptable to sites not suitable for conventional construction, with low impact on the surrounding environment.
Potential applications in architecture are defined by the characteristics of the system itself and its materials.
Among a transportable field, in particular our focus is on shelter structures that can be applied for emergency situations such is the case of earthquake, flood, and storm disasters.



08. Semi Active Building

The suggested structure tends to define design solutions alternative to tents or conventional temporary shelters, a rapidly deployable structure.
Evaluating its ability of being adaptable to different ground conditions by changing its curvature from an initial flat configuration to an enclosed space; being dynamic so to expand and modify both its span and its enclosure space according to the users needs; being economical and easy to transport, it becomes a convenient solution for a wide range of situations which do not need to be contextualized a priori.

09. Rapidly Deployable Structure

The Technologic   ody Using by Artistic Support in the Route of Post Human

The art and Scientific fiction as a reference for changes that happens at the Human body

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Abstract

This paper summarizes the thesis: "The Technologic Body Using by Artic Support in the Route of Post-Human (The Art and Scientific fiction, as a Reference for Changes that Happens at the Human body)", who intend to show that, the human body, as an art object, can be found at Scientific Fiction story, as Isaac Asimov's book "The Bicentennial Man" and contemporaneous artists work, as Stelarc. The uses of the body to support the creation enforce the relationship of the men with the technology and the environment, allowing questions concerning the future of the human body.

Introduction

The purpose of this study, *Technological body used as artistic support in the route of post-human*, is to show that the use of body as a creation support led us to the relation between man, machines and environment, what made possible to question the future of this body. In this sense, the dialog between man and his environment is the more embracing meaning of the notion of communication and it refers to the complexity of exchanges between man, machines and his environment.

In order to research the changes operated in the body, science fiction and contemporary art were used. Thus, the opposition between the science fiction history "Bicentennial Man" by Isaac Asimov and Sterlac's contemporary art, has the goal to find the counterpoint between these two approaches. An important distinction must be considered: in one hand Sterlac's view comes from human to machine, by the use of prosthesis to compensate the obsolescence of human body, in the other hand Asimov's view goes to the opposite side, it comes from machine to human. However, Andrews's robot, a robotic creation, trends to prostheses and extensions, as he becomes human.

McLuhan

The idea of this research emerged after our contact with Marshall McLuhan theories, in *"Understanding Media: The Extensions of Man"*. These theories show the means of communication's effects originated from Electroelectronic Revolution and the artist's capacity to understand the perceptive changes, which came from technological effects over individuals. Thus, McLuhan believes that the artist can solve disequilibrium problems made by the emergence of a new mean. "The artist can correct the relations between feelings before new technology's impact put the conscious procedures to sleep." [1]. McLuhan quotes Wydhan Lewis: "The artist is always concerned on writing the history of future, because he is the only person who is conscious of present nature" [2]. The author emphasizes the artist's function:

> Every new technology creates an environment that is considered corrupt and degraded. However, the new one transforms its predecessor in a form of art (...) any extension of skin, hand or foot – affects the whole psychological and social complex (...). The serious artist is the only person who is able to face, unpunished, the technology, because he is a specialist on perceptive changes [3]

Besides this, McLuhan shows that means of communication are not isolated, but they are tune as complementary ones. In this sense, the author uses the definition of hybrid means to exemplify those that embrace two or more means:

> The hybrid or the meetings of two media constitute a moment of truth and revelation from which the new form rises. It happens because the parallel between two means keep us inside forms that wake us up from our narcissistic narcosis. This is a moment of freedom and liberation from torpor and trance that was imposed to our feelings [4]

McLuhan's definition of hybrid helped us to understand the body today. Exactly, because the meeting of human and mechanic is building this moment of revelation with the goal to understand the new man who comes from this hybridization. Thus, it is not so far from the double of man, the clone. One can ask: is the traditional body becoming an artistic support or are the contemporary art and science fiction tending toward to the questioning of this body?

Not only McLuhan concepts were fundamental to the first part of this research but other concerns led this study, like the curiosity in understanding the dialog between man, machines and environment. Thus, our intention is to show how inside the evolution route of mankind, the technologies have had and keep on having a decisive role in questions about individual and environment changes.

Dialog bet een man technology and en iroment

The artist who are concerned about the relation man/machines, show the perceptive changes that came from this relation and stress the mankind evolution process. Thus, Sterlac's concerns echoes Terrence Deacon, cognitivist dinamicist and Dr. Professor at Harvard, who researches mind evolution and argues a evolutionist theory; Arthur C. Clarke, scientist and fiction writer; Edgar Morin, philosopher director of National Center of Scientific Research, Professor *honoris causa* of Consenza University in Italy.

Deacon emphasizes that humanization is the evolution point on which the instruments become the principal source of selection, in the body and brain. The brains became bigger at the same time the man started painting and making instruments. In Deacon's view, the man humanizes himself because the use of instruments and not the opposite argued by so many theorists. According to him, the kind of instrument was fundamental in the course of humanization, provided that it is determinant. Deacon shows that, when changes operated by technology are deep, they need to be followed by a genetic transformation and concludes that because of it the human brain has changed too.

In the same direction, Clarke shows that the success of more simple instruments originate the total tendency of human evolution and lead it to civilizations. The professor emphasizes that the old tendency in believing on the fact that the man invented the instruments is mistaken in his view the instruments invented the man.

According to this approach we can ask: wouldn't the process between man and machine be responsible for evolution?

In the same direction, Morin says:

> In the point where we could see *Homo sapiens* disconnect himself from nature by a majestic jump and produce with his beautiful intelligence, the technique, the language, the society, the culture, we can see otherwise, the nature, the society, the intelligence, the technique, the language and the culture co-produce the *Homo sapiens* in the route of a process that has last some millions of years. [5]

It's important to remember that the suspicion has always being around human inventions, producing on beings' imagination an impression of destructive ghost arrive, feed by the fear of loosing their places in the world stressed by the possibility of being controlled by machines.

The fear of unknown can be seen since Prometeus, Old Greek, on histories of science fiction that, along time, showed the man involved on the construction of a being, as Fausto by Goethe, Frankenstein by Mary Shelley and so many others. In all these histories the destruction of the creator by the creature has always happened.

However, on Asimov's histories, there is a pacific relationship between man and machine what provides another view about this relation. Asimov is the Three Laws of Robotics' creator which was responsible for the new directions on robots histories. They are:

1. A robot can’t hurt an human being or, by omission, allow that the human suffer any evil.
2. A robot must obey the orders given by human beings, except in the case of these orders be opposite to the First Law.
3. A robot must protect his own existence, since this protection doesn’t conflict the First and Second Law.

In order to emphasize the fear of man *vis-à-vis* the new discoveries we quote Antoine de Saint-Exupéry, in his book: ‘Wind, Sand and stars” (Terre des Hommes)

> The use of an intelligent instrument doesn’t make you a dry technician. It has seemed to me that people who are horrified a lot with our technical progress mislead the goals with the mean. (...) No doubt, the airplane is a machine- what a analytical instrument! This instrument allowed us to discover the true physiognomy of the Earth (...) If sometimes we think that the machine dominate man, maybe that’s because we haven’t got yet enough perspective to judge the effects of transformations that are as fast as the ones we are suffering. What is a hundred years of machine history compared with two hundred thousands years of man history? We haven’t finished to lodge ourselves in this mine and electrical centers’ landscape. We haven’t felt ourselves as residents of this new house that we haven’t built yet. Everything has changed so quickly around us: human relations, conditions of work, costumes (...) Every progress has expelled us to a farther place from acquired habits; in truth we are emigrant that haven’t found our country” [7]

In this sense, the discussions about new technologies have two approaches: the critical and defensive ones. Every invention has a positive and a negative side. It depends on the way it is utilized. Thus, if men were seen as a result of their discoveries, a negative view about their instruments, about their machines, can show a contradictory and blind position. Because of it, histories of science fiction help to understand the body and its relation with technology and McLuhan thought about technological discoveries and their interference in individuals’ social and physiological complex is pertinent.

In this direction, Asimov argues that technologies must be faced in a positive approach, consciously according to the period. According to him, modern man needs to define himself because his perception is divided into the necessity to face the risks of changes originated form new artifacts, and to regress from these new know ledges. We can say that the way new technologies are used is the obligation of modern man, provided modernity is to understand and transform the present moment.

One of the important focuses of this research is that the future characteristic can be found both in the science fiction and in the contemporary art once they allow a set of questions related to the man-of-tomorrow.

Stelarc and the icentennial Man

According to Stelarc, the actual human body is limited, obsolete, and then it needs to be remodeled. In conformity to the artist, the biological body hasn't succeeded in accompanying the advances of technology, consequently Stelarc affirms that:

> Man produced an environment composed by data that are completely strange to their subjective experience. We have constructed a world of powerful, quick and precise machines, where its efficiency is beyond our body competence. We have computers able to win a champion of chess. Computers are able to overcome a chess champion. Our body is captured in a world that isn't adjusted to the biology. For this reason, I consider that, body has become obsolete. It doesn't mean that I'm 'against' the body. The point is: Will we accept the limits of evolution concerning death and birth? We can change the body genetically saying, but we can also add technological components. The idea of cyborg is already a reality, if we consider the medical meaning. [8]

In contraposition, the book 'The Bicentennial Man' by Asimov, he approaches Andrews' wish to turn itself into a human being. Andrews is a machine that suffers the technological effects on its own body, hence, turning itself similar to a human configuration. The Andrew's mechanic seeks for the human, internalizing the desire of being a human, in such a way that, it abdicates the immortality in order to become itself mortal.

Stelarc questions the environment trough the use of the body and makes use of the new technologies to talk about the obsolete body. Is it possible to think the human body doesn't suffer mutation as a consequence of the technological advantages speed? How can we support the thesis that the body interacts with environment and technology? Is it possible to accept Stelarc's affirmation about how human body is obsolete?

Stelarc's concernments of being mechanic and Andrew's humanization perfectly show the actual moment of human evolution. The hybrid being who is rising from the body's mutation is explained by Donna Haraway (Professor of History of Consciousness at University of California) who wrote the 'A Cyborg Manifest' argues that the cyborg is a fusion of animal and machine. The author emphasizes that:

> (…) Being a cyborg has nothing to do with the freedom of self-construction, it has to do with webs (…) technology is not impartial. We are inside the things we do, as well as, these things are inside us. We live in a world of connections – who is done and undone (…) we are talking about completely different ways of subjectivity. We are talking seriously about mutant worlds that have never existed before on this planet. This is not only about ideas. It is about a new flesh (…) the truth is that we are building our own selves, the same way we build an integrate circuit or politic systems (…) in order to survive we have to be aware to the speed of techno culture complex realities. [9]

Conclusion

The present moment has got a complexity that has never been found before in the history of humankind, it opens a route to the infinity of questions related to mutations consequences produced by new technologies. What will this new man be like? How can we define the elaboration of the body, as an artistic support that seeks a new man?

One thing is evident; however, man and machine have always been in a constant process of interaction. Therefore, the questions raised both in science fiction and contemporary art indicate a futuristic view of a long interactive process.

Emphasizing the doubts about the post-human being we quote Saint-Exupéry [10] who shows how tools help human being to know himself: 'By facing an obstacle, man learns how to know himself; however to overcome it, he needs the tools'.
Proceeding on his reflections, Saint Exupéry finishes his book 'Wind, Sand and stars' (Terre des Hommes) mentioning the following maxims 'Only the Spirit, blowing on the clay, can creates the Man'. We can raise the hypothesis that only the Spirit, blowing on new technologies can recreate the Man. According to these thoughts, is it possible for the actual machines to enable another view around human being and his environment? Wouldn't exist the possibility for this new man to re-establish feelings more human? Wouldn't be possible for the pos-human man to be more human than the human being?

Going on these inquires about future: The contemporary artists have probably been doing a link between the tradition of the body and this new body that is arising, between what is present in the collective perception and what is covered, between what is considered out and what is entire. What will the configuration of the body be like, as an artistic support that seeks for the post-human's route? Will there be a continuation in the relation between man/machine and environment or we need a Creator's leap?

For all the interactions that have occurred between man and machine, we need the computer's emergency lead us to think post-human as a result of an accelerated construction. Would it be a fact or a heresy to consider by analogy, the numerical origin in India (where '1' symbolizes masculine and '0' feminine) and the computers logic (that creates from the combinations of '1' and '0', be creating the idea of Adam and Eve? Would it be possible to intuit that humankind is living in a new paradise? Would the post-human represent the expulsion or permanency in the 'paradise'?

References

[1] McLuhan, 1964: 86
[2] Lewis *apud* McLuhan, 1964:85
[3] McLuhan 1964:12, 18, 34

[4] McLuhan1964:75

[5] Morin 1973:53

[6] Asimov 1975:7
[7] Exupéry.1979:37, 38
[8] Stelarc. 2002:5

[9] Haraway *apud* Silva, 2000:25

[10] Saint-Exupéry 1979:2

I LIO RAPHY

ABBAGNANO, Nicola.(2000) *Dicionário de filosofia*. São Paulo: Martins Fontes.

ASIMOV, Isaac.(2001) *O homem bicentenário*. Porto Alegre: L&PM.

MACLUHAN, Marshall.(1964) *Os Meios de comunicação como extensões do homem.* São Paulo: Cultrix.

MORIN, Edgar. (1973) *O paradigma perdido:* A natureza humana. Portugal: Europa-America.

SAINT-EXUPÉRY. Antoine de. (1979) *Terra dos homens.* Rio de Janeiro: José Olympio.

SANTAELLA, Lucia. (2000*) A teoria geral dos signos*. São Paulo: Ed. Pioneira.

SILVA, Tomaz Tadeu da. (2000) *Antropologia do ciborgue: as vertigens do pós-humano.*

Belo Horizonte: Autêntica.

STELARC. (2002) site: Stelarc.va.com.au/

THE DESI IMPLICATIO S O TIME ASED I TERACTI E MEDIA

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A STRACT

Time is central to architectural design, but has not been fully investigated through computational media. The works of Heidegger [1], Bergson[2], Virilio[3] and Deleuze[4] suggest that the study of the elusive concept of time has more to contribute to an understanding of the human condition than space. One can argue that contemporary society is being governed increasingly by temporal structures, as the space of the town square is replaced by time-based broadcasting and digital communications. We present three digital media projects that start with the problematic of time, and examine the implications for architectural design of working with media where time is a primary consideration. In turn, the projects address “real-time” interaction, “evolution” over time, and time-space perturbation.

Keywords. evolution; phenomenology of space and time; time-based architecture

Smooth simultaneity

In his discussion of new (digital) media, Lev Manovich (1996) notes similarities in Walter Benjamin [5] and Paul Virilio’s[6] approach to “the intervention of technology into human nature.” (Manovich, 1996)[7] He points out that both Benjamin and Virilio equate our perception of the natural with spatial distance between the observer and the observed. Technology (film for Benjamin and telecommunications for Virilio) reduces this distance. The fact that anything can be transmitted anywhere at the “speed of light” makes the notion of distance redundant. This condition assumes the collapse of the spatial dimension altogether. Distance and the inevitability of time delay that once provided the opportunity for assimilation and reflection supposedly cease to exist. With instant communication comes instant reaction time, a feedback loop that ultimately can only be handled by computers. Whereas the collapse of distance is, for Benjamin, marked by the development of film and its ability to represent different spaces at the same time, Virilio transfers the collapse of space to telecommunications. The richness of our perceptual field is diminished, removing what Benjamin calls “aura”. The “collapse” of distance implies a condition which conflates the observer with the observed, the human with the machine, the subject with the object, transforming previously discrete dualities into a blur.

Time fractured

Perhaps this fusion and collapse in space and time accounts for one aspect of our experience with new media. On the other hand our media-saturated experiential field sometimes presents the character of a fracturing, a kaleidoscopic confusion of media and images (Tschumi, 1994). The troubling of distance through film and telecommunications can also be seen as aggravating the gap, instilling a separator in the observer-observed continuum, fragmenting our experience, or perhaps giving expression to the already fragmentary nature of human experience.

Arguably, spatial and temporal discontinuities are best appropriated when space and time are processed in relation to each other. For example, film can use time to render spaces disjoint. Instead of the broad sweeping panorama (smooth), filmmakers *cut* from one scene to another. Instead of conveying a scene as one continuous time sequence they introduce an element of temporal disruption by switching from one spatial location to another. We note Alexander Sokurov's "The Russian Ark", filmed as one continuous 90 minute take, and spanning several centuries, where the "cut" is achieved at the threshold, the doorway, the passage, or the gaze that lingers (on a painting), and from which we awake to a new time frame. Of course cuts can be used to convey a sense of the smooth. Perhaps in a film and MTV-enculturated world cuts are everywhere. Whatever the "impression," be it of smooth or distressed, the effect takes place at the cut, the conflation, and this is time-abetted. In any case, it is a temporal plus spatial control that gives new media its power to explore discontinuity.

Temporal D En ironments

What kind of spatial exploration results from digital tools that celebrate and exploit the time aspect? How does the designer gain access to the unmaking of smooth space, the fabrication of distressed geometries? How does the designer play with fractured and disturbed unities? Time-based media provide an opportunity to play with the smooth and the rough, the continuous and the fragmented, and thereby explore discontinuities within our experiential field.

Real-time three-dimensional technologies have only recently become part of the designer's tool box. Digital tools that are now commonplace suggest functions and processes that typically become extensions of traditional design practice. An architect might use 3D modelling software at various stages during the design process. The ability to mould and shape surface and volume is provided as an extension to traditional physical model making. The promise for photo-realistic visualisation comes as a well-received technological "improvement" on drawings and perspectives. The smooth ideal draws on metaphors of creation and process that pertain to temporal-continuity (Lynn, 2003) whereas the distressed exploits intervention, disruption, event-based discontinuities, the non-linear and the non-local (Novak, 1996).

THE E OLUTIO O ORM

The first project is a generative system for "real-time" 3-D modelling using a procedural programming language (C++) with access to OpenGL 3D graphics primitives. Generative models can be used to simulate 3D architectural spaces to successive levels of detail, thereby contributing to an understanding of design as a process of evolutionary refinement. The project raises questions of evolution and continuity through algorithmic events.

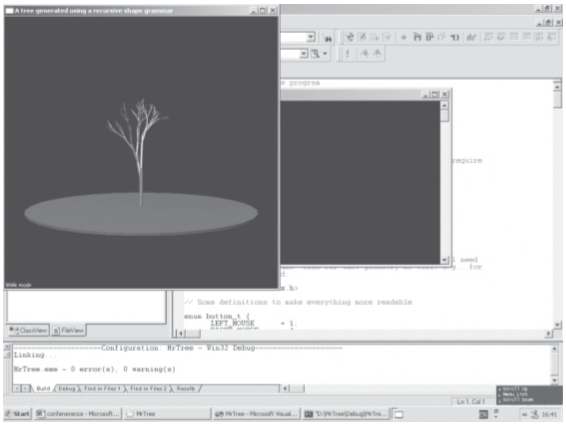


Figure 1.1 A basic tree by L-grammar

This project develops a generative method to explore time-based 3D modelling for abstract spaces. The algorithm starts with a simple “key” parameter from which a “self-generative” complex form develops. The system is based on a “growing tree code” via an L-grammar [8]. Almost all elements in the structure are generated to the next stage by following the “growing tree code” process. The recursive algorithm selects its branches in this derivational structure according to “the law of possibility.” Some elements grow faster than others, and some atrophy. The derivation of the elements is governed by one constant key parameter.

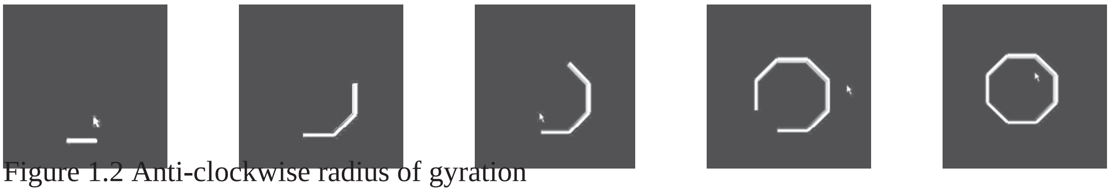


Figure 1.2 Anti-clockwise radius of gyration

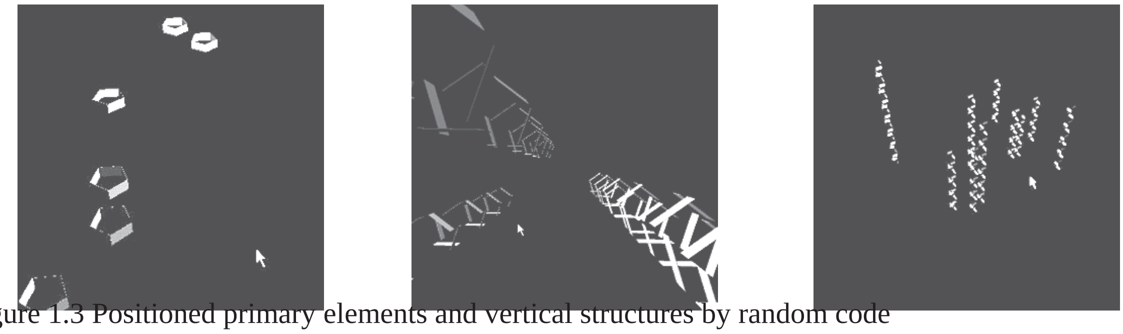
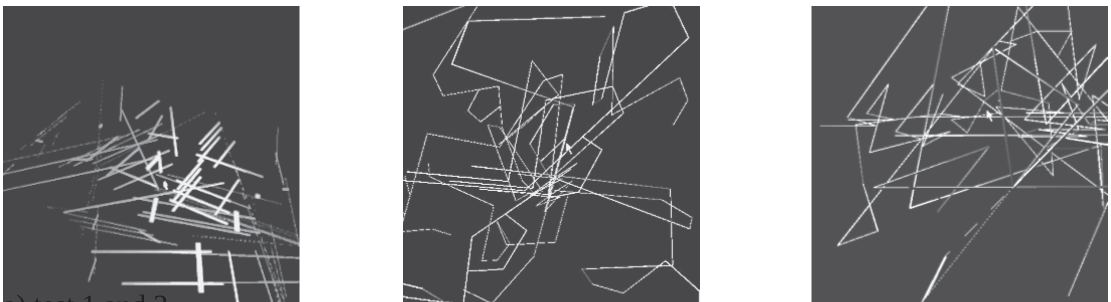


Figure 1.3 Positioned primary elements and vertical structures by random code

In the examples shown here, a single element, which we call a “virtual brick,” is to be located in a certain position and forms the basis of an assembly. This assembly is then transformed into a complex spatial structure. This is a flexible, multi-cloning assembly which can be of any scale and extent. Colour, scale and the position of elements are all determined by the initial selection of the key parameter. Forms of great diversity can be generated. Figures 2-4 to 6 show the derivation of forms using different key parameter values.



a) test 1 and 2.

b) test 3 and 4

Figure 1.4 Linear form Structure: test 1, 2, 3, 4

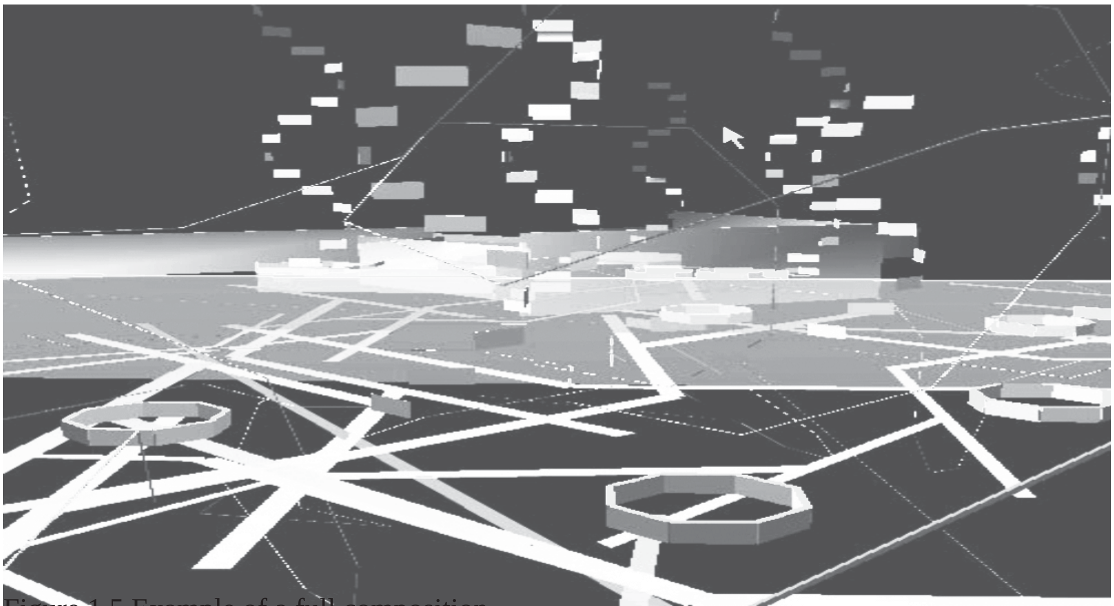


Figure 1.5 Example of a full composition

As we see, a single block of computer code and variation of a single key parameter results in large differences in the composition. The compositional possibilities can be explored repeatedly over a short period of time. The project raises the issue of evolutionary derivation as a smooth or disjointed algorithmic process. Though the algorithmic process is smooth, successive runs of the program show discontinuities. Further discontinuity is introduced by the intervention of human agency, and multi-user agency in an immersive environment. These are the subjects of further research.

PERTUR I THE CO TI UUM

In our second project, we developed an event-based system using a set of programmable objects which are an extension to MAX/MSP [9] graphic programming environment-Jitter [10]. Jitter is a collection of 130 or so standard objects which deal with time-based graphic content. Subsets of these objects are dedicated to video processing, data manipulation, and 3D Open-GL programming and rendering. The Max/MSP/Jitter user community is mainly composed of artists, musicians and programmers who develop applications for audio and video processing, interactive installations and audio-visual performance.

Max/MSP presents the user with a graphic interface in which boxes with inputs and outputs are connected (following the metaphor of circuit design). Each set of boxes (patches) can contain any number of nested boxes (sub-patches) and communicate with them at various rates. Its design is primarily for time-based applications and therefore follows a strategy of rapid prototyping which to some extent by-passes compilation and de-bugging, hence exposing the error, the accident, the interference, and makes them available for exploitation. The (application) design process that is implied in Max/MSP/Jitter tends to be attractive to non-programmers and to some extent forces a visualisation of decision-making processes and erratic connectivity. The clusters of boxes and connecting lines effectively represent a kind of multi-dimensional flow diagram that underlies the computational process. One of the central aspects of Jitter is the fact that all data structures are represented as configurable matrixes of specified data types, dimensions and sizes. A great part of Jitter's possibilities in the realm of processing and mapping relies precisely on this fundamental entity. The values of a pixel array on a screen of 400 by 400 would take the form of a 4 dimensional (RGBA) integer, 400 by 400 matrix. Figure 3 shows an by connecting/disconnecting, re-configuring in a time-dependent way, and experimenting while examining the visual or kinaesthetic result.

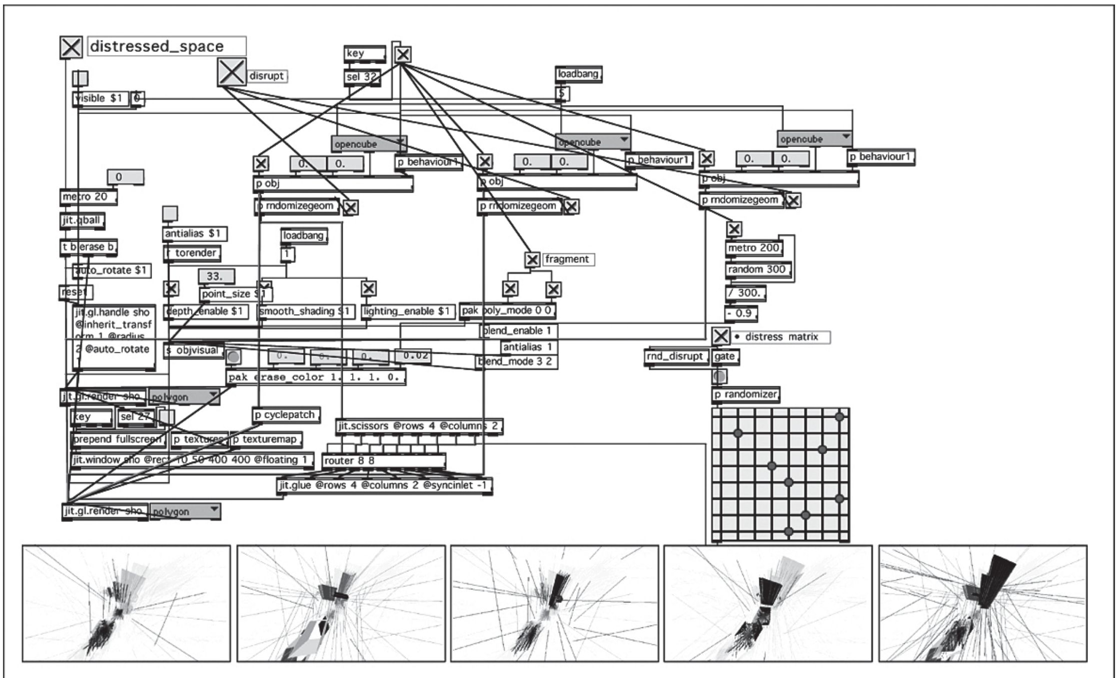


Figure 2.1 Example of environment with which the designer interacts

E E T A D ARRATI E SPACE

The time-based medium of Macromedia Director's Shockwave 3D [11] exposes a series of 3D primitives, user behaviours, 3D animation strategies and a real-time physics simulation engine (Havok). Shockwave 3D has been used by designers of computer games that, due to Shockwave's standard specifications and increased computational power of the average PC, can distribute and play their environments on-line.

We indicate something of the potential of this time-based environment in our third project that explores the character of the home as described in Bachelard's (1964) *Poetics of Space*, the home as a cellar, a garret and a hut. The phenomenon of space is closely linked to intimacy and memory in Bachelard's writing. Certain parts of the house, such as the attic, serve as "repositories" of memories. The house also provides a person's protypical spatial experience, a reference point from which all other spatial experiences derive and with which they are compared. The house is also understood episodically, in relation to sequences of events (getting out of bed, bathing, dining, opening windows, etc). From this perspective, our being-in-the-world is structured narratively. The house serves as a space for Bachelard's narrative, and a house is itself a narrative space.

To instantiate Bachelard's spatial narrative as a 3D computer model available for game-like navigation and interaction introduces some startling incongruities. As users of this new space we sense a familiarity with it, though we are perhaps struck by the mismatch between the medium and our bodily awareness. Our physical presence is perhaps reduced and moved into hardware and software. Our sense of recognition is suspended and the spatial phenomenon reduced to concepts of digital interaction.

The Shockwave 3D environment works with concepts of the model, movement, interaction and frames. It is possible to "jump" from one frame to another, in the manner of movement from one frame, sequence, or episode in a film. It is also possible to overlay frames, as in the case of film overlays. We have extended the frame metaphor to a consideration of a room in the Architecture building [12], data projecting a window as presented in the Shockwave 3D "attic" space onto a window in the room (Figure 1.1). The actual window is covered by a screen and an open window is projected (Figure 1.2 & 1.3).

Different interactions are available, such as opening the virtual window or closing it, or opening a blind — simple prototypical micro-event that we may have performed many times before, and that frame our experience and structure our space for the moment.

Of course the familiar event is rendered strange in this encounter as we see familiar objects projected. As we encounter something foreign, we draw on the strength of the metaphoric relations between image and space in order to make sense of our environment. The interaction of the user of this space and the computer-mediated space draws on the power of metaphorical association. The project highlights issues of familiarity, interaction, augmentation, the virtual, narrative and metaphor. We expect that a phenomenological understanding of such interventions helps develop understandings of digitally mediated space.

The familiar, homely event of opening a window is rendered strange, and consequently gives us a new understanding of the spaces we inhabit. The next challenge is to test this interaction with subjects to see what narratives of augmentation (metaphors) emerge. The task will then be to examine multi-user interaction in the same space, to see how such experiences are negotiated collectively, and through digitally-mediated communications.

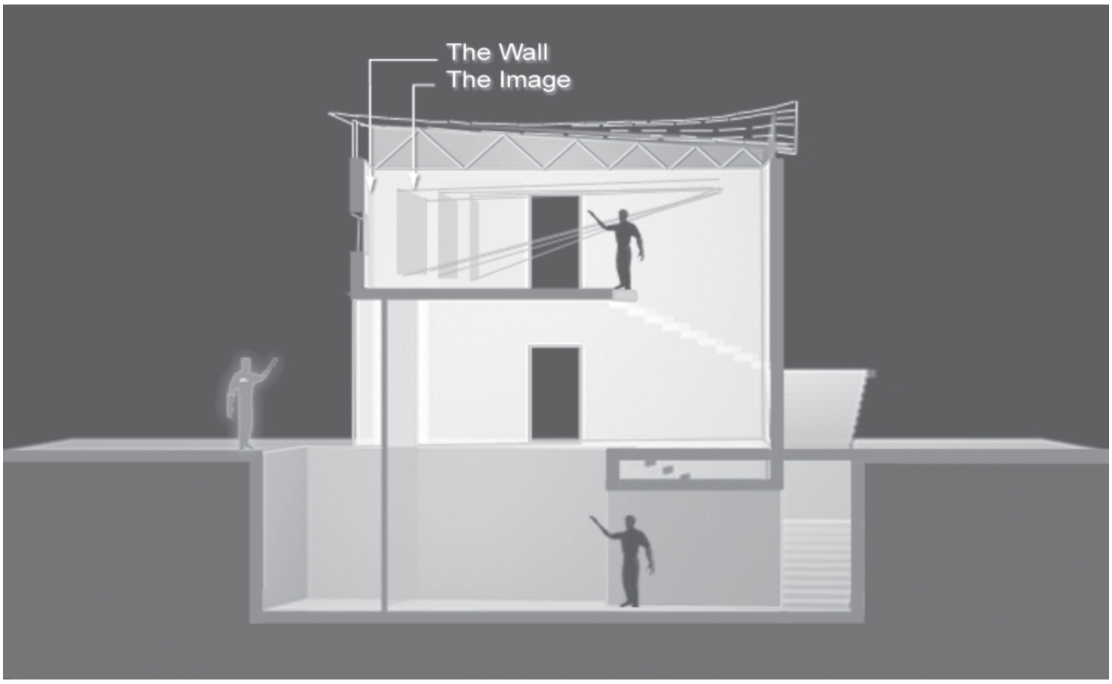


Figure3.1. Picture of house section showing projection.

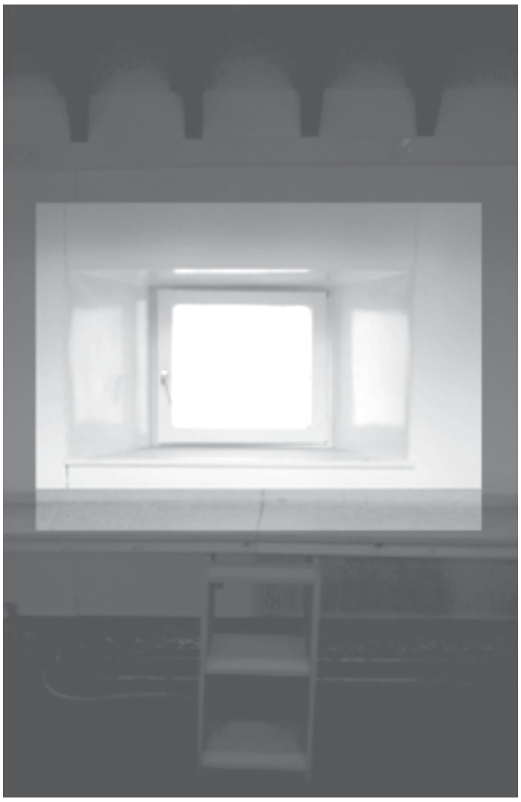


Figure3.2 & 3.3. Pictures of architecture window projected as closed window first, and open in the other one.

CO CLUSIO

The conclusion of our study is that time considerations can perturb the impetus towards smooth, seamless interaction and step-wise derivation, contrary to developments which seem to aim for techno-human environments that are integrated, seamless and smooth. It also questions the recurrent digitally-inspired theme of an architecture based on organic and smooth forms.

The practical application of the outcomes of these explorations is a means of exploring and generating designs and patterns, in a way that is algorithmic, interactive and time-based, utilising computer animation and multi-user control. The challenges include further developing languages for designing in new ways, and new languages of interaction design. What are the best ways of interacting with such capabilities? The interface is unlikely to be smooth and seamless.

One of the most interesting ways for design practitioners to appropriate these capabilities is to experiment with tools that are designed primarily for other than architects and spatial designers. These include computer tools for animators, artists, choreographers, film makers, and composers. There is also benefit in collaborating with such practitioners, who bring different conceptions of space, time and computer capability to bear on the design process. This paper represents such a collaboration, in our case between architectural designers and practitioners of the time-based media of musical composition.

RE ERE CES

ibliography

Bachelard, Gaston.1964. *The Poetics of Space,* trans. Etienne Gilson. Boston: Beacon Press. First published in French in 1958.
Benjamin, W. 1992, Illuminations. Trans. H. Zohn. London, Fontana Press
Coyne, R.D. (2002). The cult of the not-yet. In *Designing for a Digital World*. Ed Neil Leach. London: Wiley-Academic, 45-48.
Deleuze, G. 1992, Cinema 1 : The Movement-Image. Trans. H. Tomlinson and B. Habberjam. London, Athlone.
Heidegger, Martin. 1962. *Being and Time*, trans. J. Macquarrie and E. Robinson. London:SCM Press. First published as *Zein und Zeit* in 1927.
Lynn, G.: 2003, http://www.glform.com/
Manovich, L.: 1996, Film/Telecommunication – Benjamin/Virilio. http://www.manovich.net/text/Benjamin-Virilio.html (May 2003)
Novak, M.: 1996, Transmitting Architecture: The Transphysical City http://www.ctheory.net/text_file.asp?pick=76 (May 2003)
Schneider, C.W. &Walde, R.E. (1992), *L-system computer simulations of branching divergence in some dorsiventral members of the tribe Polysiphonieae* (Rhodom elaceae, Rhodophyta). Eur.J.Psychology.,29:pp165-170.
Tschumi, B.: 1994, *Architecture and disjunction*. Cambridge, Mass., London, MIT Press
Virilio, P.: 1991, *Lost Dimension*. New York, Semiotext(e)
COSMO3D REFERENCE MANUAL\Program Files\Silicon Graphics\Optimizer\doc\developer\cosmo3dIndex.html
Karl S CHU; Modal Space. On the http://synworld.t0.or.at/level2/soft_structures/allgemein/modal_space.htm

End note

[1] Heidegger, Martin. 1962. *Being and Time*, trans. J. Macquarrie and E. Robinson. London:SCM Press. First published as *Zein und Zeit* in 1927.

[2] Mullarkey, J. 1999.Ed. The New Bergson. Manchester and New York: Manchester University Press
[3] Virilio, P.: 1991, Lost Dimension. New York, Semiotext(e)
[4] Deleuze, G. 1992, Cinema 1: The Movement-Image. Trans. H. Tomlinson and B. Habberjam. London, Athlone
[5] Benjamin, W. 1992, Illuminations. Trans. H.Zohn. London, Fontana Press
[6] Virilio, P.: 1991, Lost Dimension. New York, Semiotext(e)
[7] Manovich, L.: 1996, Film/Telecommunication – Benjamin/Virilio. http://www.manovich.net/text/Benjamin-Virilio.html (May 2003)

[8] L-System, Lindenmayer System, is a string-rewriting techniques developed by Astrid Lindenmayer in1968, which can be used the model the morphology of a variety of [rganisms(Schneider,1992),
[9] 1990-2003 Cycling 74/ IRCAM
[10] 2003 Cycling 74
[11] Macromedia Director MX, Macromdia,Inc. 1984-2002. http://www.macromedia.com//
[12] Architecture Building, (Minto House), *School of Arts, Culture and Environment*, University of Edinburgh

MetaMi
A Symbiosis of amiliar Content ith enerati e orm

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Abstract

MetaMix (2003) is a cross between a musical composition, a digital audio player, an interactive environment, a software tool, and a work of conceptual art. An algorithmic DJ of sorts, the program remixes a user-selected audio track in real time, using a simple generative process based on an infinite integer sequence. *MetaMix* demonstrates that within the context of an interactive environment, generative processes can form a symbiotic relationship with familiar, pre-existing source material. The familiarity of the source material enables users to more easily follow the generative process, while the transformation of that material by the process encourages users to experience the source from a new perspective.

O er ie

MetaMix [1] is software art for Windows and Mac OS X. A simple generative process remixes an audio track, using an infinite integer sequence to reorder and layer chunks of the original audio. The graphical interface enables users to select an audio track from their own music collection to remix, to view information about the generative process, and to configure several parameters of that process.

The Integer Se uences

MetaMix superimposes new structures onto existing audio tracks via infinite integer sequences. The program includes twelve such sequences, chosen from Sloane's exhaustive collection, *The On-Line Encylopedia of Integer Sequences* [2]. Most of the sequences are self-similar, and several of them may be interpreted to describe properties of binary or ternary representations of numbers.

For example, one sequence used by *MetaMix* is the Ones Counting Sequence, sometimes also referred to as the Thue-Morse Sequence; *MetaMix* designates it Exponential Slow because its progress through the natural numbers slows down exponentially as the sequence progresses. It begins:

$$0, 1, 1, 2, 1, 2, 2, 3, 1, 2, 2, 3, 2, 3, 3, 4, 1, 2, 2, 3, 2, 3, 3, 4, 2, 3, 3, 4, 3, 4, 4, 5\ldots \quad (1)$$

and can be computed by the following recursive formula:

$$f(n)=\begin{cases}0, \text{ if } n=0\\ f\left(\dfrac{n}{2}\right), \text{ if } n \text{ is even}\\ f\left(\dfrac{n-1}{2}\right)+1, \text{ if } n \text{ is odd}\end{cases} \qquad (2)$$

The sequence describes the number of ones in the binary representation of *n*. It is also self-similar; taking every alternate element in the sequence yields the original sequence. (See Sequence A000120 in [2] for a more thorough discussion.)

The Remi Algorithm

To remix the audio track based on an integer sequence, the software first marks the audio track at equal-length time intervals and labels those markers with the natural numbers. Each time it obtains the next number in the integer sequence, it begins audio playback at the correspondingly-numbered marker.

When a new number from the integer sequence triggers audio playback at a marker, one or more previous layers of audio playback may continue uninterrupted. This layering renders the discrete generative process in a smoother, more fluid manner. To further this effect, *MetaMix* also gradually fades each playback layer in and out over the course of its lifespan, creating gradual crossfades between old and new playback layers.

Here is a simplified version of the algorithm:

Step 0. Set *LENGTH* to the length of the audio track.
Set *INTERVAL* to the amount of time between successive events.
Set *LAYERS* to the maximum number of simultaneous playback layers.
n = 0
currentTime = current system time
Step 1. While stopping condition is false, do Steps 1-7
Step 2. *playbackTime* = *INTERVAL* • | *f* (*n*) |
Step 3. If *playbackTime* > *LENGTH*, then set stopping condition to true.
Else continue:
Step 4. Start a new playback layer beginning at time *playbackTime*.
Step 5. If more than *LAYERS* playback layers are active, stop the layer which has been active for the longest amount of time.
Step 6. *n* = *n* + 1
currentTime = *currentTime* + *INTERVAL*
Step 7. Wait until current system time equals *currentTime*

In practice, this algorithm almost never terminates. Most of the sequences used by *MetaMix* move through the natural numbers at an exponentially slowing rate. In many cases, it would take longer than the age of the universe for the software to reach the end of even a five-minute audio track.

User Interaction

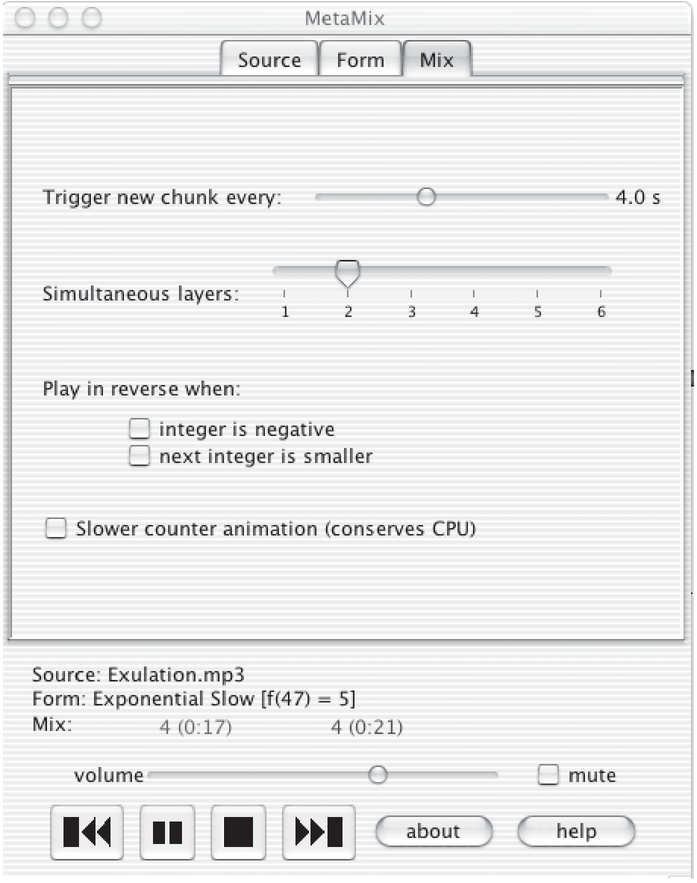

Figure 1: The Mix tab of the *MetaMix* GUI.

MetaMix's GUI enables users to manipulate parameters of the algorithm and helps them to follow the generative process. The *MetaMix* GUI is not meant to be continuously manipulated; users are instead encouraged to interact with it during an initial period of experimentation and to then let the program run without further intervention, so that the large-scale musical structures it produces have ample time to unfold.

Users control basic parameters of the generative process by selecting the audio track, the integer sequence, and the *INTERVAL* and *LAYERS* parameters of the algorithm. They can also set the software to start from any point within the audio track and can determine conditions under which the algorithm triggers backwards playback. *MetaMix* also provides standard tape-transport controls, including fast-forward and rewind buttons which skip exponentially through the integer sequence. User interaction causes immediate, real-time changes in audio output.

To help clarify the generative process, the software includes short descriptions of each of the integer sequences which explain their derivation and structure; users browse these descriptions while selecting a sequence. It also displays information tracking the current state of the process. The current values of n and $f(n)$ are always displayed, along with a scrolling counter which shows the $f(n)$ value and position (in minutes and seconds) of each active playback layer. As playback layers fade in and out, their respective counters do as well.

Discussion

I created *MetaMix* to be heard for long periods of time and to allow users to easily move along a continuum between active and passive listening. I wanted users to grasp some aspect of the generative process regardless of their level of engagement.

To accomplish this goal, I chose an extremely simple and straightforward generative process which is easy to aurally and visually follow. The repetitive, often self-similar integer sequences inject some structural redundancy into the experience; even if a user were to miss hearing a portion of the music, he or she would still be able to follow the large-scale form. In fact, since the music is virtually infinite, every user does “miss” a large portion of the piece.

I also chose to use the process to operate on a pre-existing, familiar audio track which listeners choose themselves. They quickly and easily recognize each chunk of sound output, and they can usually even identify its original location within the source material. As the integer sequence weaves through the natural numbers, listeners quickly grasp the corresponding manner in which *MetaMix* weaves through the original audio track. Because listeners recognize the content, they can focus more on the new, unfamiliar structure. And the very familiarity of that content makes the environment less intimidating and more inviting; it is something concrete which listeners can hold on to in an unfamiliar world.

The use of familiar content also helps render the process in an interesting way. The subtle and unexpected interactions of the audio track’s original structure with *MetaMix*’s generative process create a more interesting musical environment than the process could alone produce, full of prolonged expectations, fascinating juxtapositions, and unexpected coincidences.

My design approach was influenced less by recent interactive works than by some older compositions which predate digital technology. For example, Alvin Lucier’s *I Am Sitting In A Room* [3] generates its material by playing and re-recording a spoken voice recording again and again until the voice eventually gives way to “the natural resonant frequencies of the room.” Like *MetaMix*, this work is an interactive environment in which a predefined process operates on user-selected source material. The algorithm is fixed, but the score allows the performer to select the content (the spoken-voice recording) and some parameters of the algorithm (such as the room to be used and the number of iterations).

Ultimately, *MetaMix* thrives on the symbiotic relationship between familiar, pre-existing audio content and unfamiliar, generative form. The content helps listeners grasp the form, while the form encourages them to approach the content from a new perspective. At its best, it can lead people to discover new things about music they love.

References

[1] J. Freeman, *MetaMix* (2002), available as a free download at http://www.jasonfreeman.net.

[2] N. J. A. Sloane, editor (2003). *The On-Line Encyclopedia of Integer Sequences*, published electronically at http://www.research.att.com/~njas/sequences/.

[3] A. Lucier, *I Am Sitting In A Room* (1970), reprinted in *Sound By Artists* (1990), ed. D. Lander and M. Lexier, Toronto: Art Metropole and Walter Phillips Gallery.

The Phylosophical and Pragmatical Meanings of ARS CERAMICA; General Aspects and a Point-like Example: the Visitor Center/*Salutatorium*/ Installed in the Plant TERRAPLAST

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Terraplast, Bistri]a,
ROMANIA**

§.1. *De philosophia*

When somebody/or even myself/ ask me the question: '**What is Philosophy?**" we ascertain that we understand without difficulty the question, and, even we "feel" a the set of answers, but we are in a real difficulty to express immediately this set of enounces in a satisfactory reasonable manner.

Philosophy is a dominant feature of the **MAN**/*Homo*/[1] operationally defined by the articled (inter-active) questions/*Questionis*/ and*** by their (idem) answers tried/advocated/ argumented logically:

- a. what[2] is **MAN**/*HOMO*/? =>

a satisfactory[3] definition[4]/description[5] of **HIS** essential, real/perceivable, *de facto* maximally complex existence: material, spiritual (reason, feeling, intuition, willingness, awareness/consciousness/ – *Homo conscius*), individual & communitarean/ **MAN** & **MANKIND**/, *per se*/in itself/, **MAN** & **MANKIND** *versus* extra-

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**. Engineer, General manager of the TERRAPLAST S.R.L., Bistri]a, ROMANIA.

MAN/**MANKIND** (*Physis/Natura*/[6], trans MAN[7]; the insulation, the contacts);

- b. what[2] is **HIS** origin? => the *genesis* in **space** (*topos<situs*) and time (*cronos<tempus*);
- c. what[2] is **HIS** evolution? => in **Space** (*topos<situs*) & in **Time** (*cronos<tempus*: structural *metamorphosis*).
- d. what[2] is **HIS** goal/place[8]/ in the **Universe**? => **HIS** (relative) complexity – simplicity – uniquenes[9]:

d.1. with regard to **HIS** own judgement: personal *ego*, *ego*-s of another *antropos*[10,11],

d.2. with regard to another frames of references which can/could be conceived or imagined[12,7] angels, devils, spirits; transhuman (real/hypothetical) entities, godesses, GOD[11],

d.3. His possible[12,13] place/role/ in the design of trans *HOMO*/*AlienS* from the **All**/ in the "**Strategy** and[14] of **The Tactics Big Anonimous**[14]/**GOD**/ – **Universal Spirit, Creator Maker, Nature, The** mysterious omnipotent **Person/Entity/ which is in all the thinks** (in past, present, future) and, concomitently, **is over all the thinks**[11,14].

§.2. *Philosophia perenis*

The slogan/enounce[14]/ '**All the men**/unique persons[9,15,16]/ make (sometimes[17] in their terrestrial life[16] – consciously/half consciously/ - **Philosophy** ' – is considered an evidence; thus I postulate: it is an evidence – assumed axiom of this discours/alocution/ –, statement which define *in verbum*[14,]**** **MAN**/*HOMO*/ as *HOMO PHILOSOPHANS*.

In consequentia all the relevant antropic activities has reach to their philosohies[16]: philosophy of Science, of work, of Politics, of Love, of Creed, … of Technique … et al.

§.3 Axiological perspective

The manner in which is viewed/lectured/ considered the Philosophy – *modus vivendi* of *Homo Philosophans* – in very different[16]:

- a. for the same person of reference, P [18,19], during his terrestrial life[16],
- b. for qualified/not qualified[20] philosophers: scholars, profesionists, schools/currents/, positions[19,21] in motion – included in the vast **History of Philosophy**.

We postulate the axiological perspective[19] => *Homo* make permanently[22] elections/options/, some of them achieved in judgements[19]/: is a conscious (vivid, spiritualized) being[22] which, on the basis of some defined/guessed, intuited **Values**, operate (in *mente cum anima*) valuation. We define and express *in verbum* this axial structure of MAN by . *Homo Aestimans atque Ierarhicus/Axiologicus*/.

Homo achieve his destiny not in *Physis*[23], not in *Bionatura*[23] but in *AXIOS*![11,23,24].

§.4. *AXIOS*

The realm *Axios* is complex[25]

A. **Auto-thelical Values**: **Cardinal**[26] **Values**[27] by each of them can be reached the **Sublime**, i.e. the humanized climax/[14,28] which is not perfection[28] but “brilliant”, marvelous.

– a. The **Truth** => the work/living within **Truth** is **Science** = the axiological hypostasis is named *Homo Sapiens Scientifer*.

– b. The **Moral/Goodness**/ => the work/living/ within **Goodness** is **Moral/Ethics**/ = the axiological hypostasis is named *Homo Cogitans/Eticus*.

– c. The **Beauty** => the work/living/ within **Beauty** is **Art** = the axiological. hypostasis is named *Homo Aesteticus*.

– d. The **Love**[29,] (of himself: Narcis; of another person: man women[AB] child[31] friend) => the work/living/ within **Love** is **Loveness** = the axiological hypostasis is named *Homo Amans*.

– e. The **Meditation** => the work/living/ within Meditation is **Philosophy** = the axiological hypostasis is named *Homo Philosophans* (systematically; accidentally: philosophers, respectively philosophants, dexterous clever speculators,

***.Questions & answers organically **unified** in a spiritual activity: the *modus vivendi* of *Homo Philosophans* (philosophers, philosophants).

****. A poor human expression/attempt to express *in verbum*.

I. By us; we suppose also by you!

meditative persons; *Homo* is considered the *centrum/Axis*[32] *Mundi*/ – i.e all the problems are relativisated with regard this point of view; even (conventionally: *ex definitio* antropical) *GOD, Natura*, trans/infra *Homo* are considered (in *analysis*, *synthesis*; *actio*, *praxis*) from this basis.

– f. The **creed**/*Creddo*/ => the work/living/ within Creed/*Creddo*/ is **Religion** = the axiological hypostasis is named *Homo Religiosus (Pius*[33] *Fides*[34]): *TEO*/**GOD**/**Spiritualized Nature**/ is really the *Centrum/Axis*[35] *Mundi*, i.e. all the problems (conceived by men/*Homo*/ are, absolutely, in the being of **GOD**)[35]; but men /*Homo*/ cannot[36] depass their own condition (no man[37] are/could be **God**; *Homo* is protected/endowed by **God**, revealed by **God**); thus, compulsory, the men/*Homo*/ conceive/consider (in analysis, synthesis; actio, praxis) the **Godness**/Divine hypostasis/ only in their limited antropical frame of reference: as believers (fervent, moderate; atheistical, deistical)[33,34].

B. **Mean-values**: are in Important[38]: **directional values**, they actually make possible the achievement[39] in real existence of men of the **auto-thelical values**/valuations.

- a. the **economic** =>the work/living/ within Economic/economical value/ is **Economy**/*Ekonomia*/ = the axiological hypostasis is named *Homo Economicus*[40,41,42,43];
- b. the **politic** => the work/living/ within Politics/political value[44]/ is *Politika* = the axiological hypostasis is named *Homo Politicus*[40,45];
- c. the **labour** => the work/living/ within Labour/laboural value/is **Ergonomy** = the axiological hypostasis is named *Homo Laborans*[46];
- d. the Action => the work/living/ within **action** /actional value[46]/ is = the axiological hypostasis is named *Homo Agens*; in a strong sense *Homo Militans*[47,48];
- e. the **technique** => the work/living/ within Technique/technical value/ is **Technique**/*Téchnika*/ = the axiological hypostasis is named *Homo Tehnicus; the Technika* is the set-summ/[49] system, *compositum*/ of techniques (with their specificities/tehno-logies/: methods, procedures, with their *Logos*/think/ (modal logie[50]: *Tehno-logia*; the polimorphical work in *Tehnika* generate/are expressed/ by the peculiar axiological hypostatis named = *Homo faber*[51], *Homo artefactor* /*artifex*/, /*machinarium*/;
- f. et al. => the work/living within them are speaking Euphoria, calculation, organization, mobility, commerce, defence & agression et al = the axiological hypostases are named *Homo Locvens*[52]*,Homo Ludens*[52], … /*Ridens*/Felix/, *Homo matematicus*[53], *Homo ciberneticus*[53], *Homo viator*[53]*/mobilis*[54]*/,* Homo *mercator*[53], *Homo militarius*[53], etc.[55].

C. Crossing-Values => are realistic value-ations operated in the "flow of lifes"/*flumen vitae*/ circumstantial *casus*; the practicants, and the theorists conceive *in abstracto*, proceed *in concretto*, various mixtures/*axio-mixtum compositum*/ of various adequate complexity; these *mixtums* are often rough[56] expressions of the **real** sophisticated **organigram** of some factual situations – the auto-theical values $\vec{V}$[57] and the mean-values, $\vec{V}$[57], are, intrinsically, not completely separated[58] but organically coupled (influences, sinergias; systemic connections): it exists in all the major antropical activities (ruled/dominated) by auto-thelical values, $\vec{V}$,some not pure influence, of mean-value, $\vec{v}$ **,**/mean-values aspects/: economical, political, technical, laboural/ergonomical/ et al.

==

Exemple. The technical & techno-logia-l aspects in:

a. science = *organons/instrumentums*/ et al., various, material apparatus, operational/matriceal/ calculus, et al.

b. arts = technical quality (concertos, pictures, architecture, drawing, *retorica*, *ars poetica*, et al.)

c. moral = moral exercises, *normas, dogmas*, canons/ordeals/, *exercitio espiritual*[59], et al.

d. love = *ars amandi*[60], sex training, family guides, et al.

e. *meditatio* = silogistical rules, *homo significans* (*locvens*: *in verbum*; *in scriptum*), *homo problematicus* (science of interogations, argumentation, presentation, et al., rethoric, didactic, et al.

f. creed = *modus*-es to realize the communion believer /priest/ God (*religare*, *comunicare*; devotional practices, dogmatics et al.).

==

Mixed values/valuation/ *axio mixtum compositum* of various adequate complexity[61]: men need these "amalgamation" to face/cope with the intricate reality[62]; these mixages[61] are often only roughtly[56] expressions of the real sophisticated **organigram** of some factual situation.

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Example

Homo Cogitans/Philosophans & *Religiosus*/ *Homo Sapiens Scientifer* *Homo tehnicus-tehnologicus* . economicus /laborans, agens, *militans*[62]/ *politicus*[63] *(militans, militarius,*[64,65] …); et al.

==

The **values** – the basic, the mixed, – defined, postulated, are used in **valuations of various human activities**.

§.5. Culture – Civilisation

Man/*Homo*/ is[66] organically => **Creator** – producer – consumer of **axio goods** products/items/*fructum*/ of **Culture** & **Civilization** = this axiological mixtured hypostasis is named *Homo creator, Homo productor, Homo consumans*.

They are *in usum* several definition of **Culture** & **Civilisation**[67]: more or less equivalent; often used with some ambiguous meanings (confused; in accordance/in oppositions, et al.).

The axiological-definition =>

a) **Culture**, C, => the set and dynamics (individual < social) of **auto-thelical Values**, $\overset{\rho}{\forall}$, in pure sense < in crossing sense < in mixed sense[68],

b) **Civilisation**, C, => the set and dynamics (individual < social) al mean – values, $\overset{\rho}{V}$; in pure sense[68] < in crossing sense[68] < in mixture sense[68].

The axio-couples[67] (*C*, **C**; C & **C**, *C* **C**) define the interactive, vivid, sociality of *Homo*[69] => Men/*Homo*-s/ are living in society, "axio-environment" in which they are integrated as creators, producers, consumers in **matrix of Culture**, C , **alveolus of Civilization**, C .

==

Example 1. The **Lombardean** matrix, C – in early Middle[70] ages, later in more recent epochs – & Lombardean alveolus, C , – in early Middle ages, later – has also many relevant technical-technological aspects.

Example 2. The **Carpato-Danubean-Pontean Space/C.D.P.S.**/ from many centuries – in fact (essentially, dominantly)[71] Teritoriul Românesc (largerly dominant Romanian & multicultural, ethnical, cultual, linguistic).

§.6. *Enuntiare Philosophiae*

The philosophical meditations – in which are conceived[72] some aspects[73] of the **Reality** analyzed by thinkers – are expressed in various forms[II]: oraly[74], in written[75], by symbols (letters, numbers, images, sounds, gestures[76], plastic forms[77,78], et al. logically organized in enounces and asertions[79,80,81].

§.7. The messages of *Ars ceramica*

The production of ceramical objects – **ceramics** – were made by men from the beginnings of humanity and are made until nowadays: earth[83] was at hand of the skilfull *homo faber*, *artefactors*[84], and the members of this axiological hypostasis are often used it intensively, in diversity[85].

The *vox philosophiae* were called (told, transmitted) also by the forms, the uses, the colors, the magnitudes, the positions, etc. of some objects made by **earth/ceramic materials/** products of which were prepared by men from very early ages: the vessels were symbols, the decorations were bearers charged with messages[III,87,88,89,90,91,92,93].

§.8. *Praxis*

We have conceived a peculiar philosophical message transmitted mainly with the reproductions of some reputed old***** ceramic-al products[95] by which is expressed a homage of the human labour[96] which is concretised in a monument which will be[97] placed in the projected **visitor center**/*salutatorium*/ of the **Terraplast plant** – *fabrica****** in Bistri]a, Romania* – in whose functional structure the production of ceramics[98] is in *focus*. This central monumental objects[99] express to the visitors[100], specifically interested in the activity of this *fabrica*, the program of this technical-units, its social message, and, much more, **the dignity of the endeavour of Man which meditate on HIS position in the World** – frame in which *Homo* achieve various works[96] and live experiences[101].

The organigram of this "**philosophical ceramic monumentum**" i.e. the set of meanings and representative material components (images, symbols)*******, ******,********* is =>

I. Evocation of the **Present**[95,102] and the **near Future**[96,103]/The pragmatical zero hierarchy/**********:

a. corporal typical pipes[S], fittings, et al. produced in the factory: in ceramics[104,]***********,

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II. *Vox Philosophiae Chonus.*

III. The case of **Carpathean-Danubean-Pontean Space**/C.P.D.S./ is exceptionally relevant.

b. a miniature of the used furnace/*cuptor*/[S]: the old "motor"[105],

c. a vertical wall[S]: which represents a monumental stove with all the faces richly decorated with ceramical plates (various, expressive *cahlen/kahlen*/; in a neo-barock/"plataresque"/ design)[105,106,]*********,

d. a miniature of the used furnace/*cuptor*/: the new one[107]; this design show, concretely, the **technical progress**[108,109]

e. typical pipes, fittings, et al. (idem).

II. Evocation of the **Permanence**[110]/the First/Basic/ Hierarchy of *ontos*/the existence/**********: the **Pillars of Spirituality**, i.e. the symbolized **Forces***********:

A. The **Thought**: represented by

a. the well known statue from neolithical age named the Thinker of Hamangia[111,S],

b. items from archeo-culture Gumelni]a developed in the low Danube/*Dun\rea de Jos*/ areals,

c. archaic items.

B. The Creed/*Creddo*/: represented by

a. archaic ceramical representations[S/P] of *prominent vestigiums* from the shrines, altars, funeral monuments, tombs, icons[112,113], objects (sacred, ritualic), from the old cultures – pagans and early Christians – which were developed in the **C.P.D.S.**

a.1. items from pre-history

a.2. items from ancient history,

b. archaic religious symbols[114,115]: **carpathean-danubean–ponteans**

b.1. items from pre-history

b.2. items from ancient history.

C. The **Fertility – **the **Feeling**, the **Affection**, the **Maternity**: – represented by

a. the image of the thick woman, associated with the well known **Thinker of Hamangia**,

b. the image of Fortuna,

c. archaic items.

*****. The most of them.

******. A prospectus concerning the statute of this *fabrica* – (the history: the private workshop from the 1880 years the state-al institution, the socialist-ical//^*ntreprindere socialist\ de stat*/; the actual private institution will be delivered at the occasion of the **Generative Art Conference**.

D. The emblem of the plant **Terraplast** from Bistri]a: the coat of arms made with a prestigious material – bright metal ceramised[116]; the visitors/observers which remake the trade mark can/must think also on the intensive work achieved permanently in the prestigious *fabrica*: a not anonymous "point" in the Universe.

III. Evocation of the **Past**/the second/memorial/ Hierarchy**********/;

A. The consumed physical & historical time – the *Tempus praeteritus* – axial position[117] of the **Man**/*Homo*/ in this **World**/Cosmos/: represented by some ancient images, signs of **Time**:

a. physical time/*cronos*/: old gnomons et al. used in **C.P.D.S.**,

b. axiological time: *tempus*: old reputed ruins of shrines, thermal, fortifications, *basilica, amfiteatrum*, *stadium, via, pons*, et al. from **C.P.D.S.**

B. The passed persons: reputed***********, anonymous persons, groups represented by images[118,P] recorded in some *vestigium* of the old cultures developed in **C.P.D.S.**

IV. Evocation of the **human values**[112]/the third hierarchy**********/: represented by archaic images *in ceramica*, which was/can be considered expressive symbols for human virtues – the courage, the scientific reason, the technical hability, the justice, the devotion, the maternity, the familyality.

V. Evocation of **Tools**[119,120,121]/the fourth hierarchy[121]/********** => represented by suggestive archaic *images in ceramica*.

VI. Evocation of the archaic ceramic products/the fifth hierarchy/**********:

a. pre-historical items[122]: the images[P] compose a beautiful impressive belt which surround the lower part of the central monument,

b. ancient historical items[123,124]: the images[P] compose a beautiful impressive belt which surround the lowest part of the central monumentum*************.

§.9. *Salutatio cum fortuna*

The **visitor** are invited to meditate on the *curriculum* of some arts, techniques, human achievements, from the **past** and to rethink the **present**[125] and to imagine some scenarios for the **future**[126]. This monumental stylised giant[127], decorated "shell",

*******. An “exercise book” with the images composing this monument – central item of the **visitor center**/*salutatorium*/ will be exposed at the occasion of the **Generative Art Conference**.

placed in the *atrium* of the *fabrica*, in the middle of *centrum salutatoris*/*salutatorium*/ **visitor center**************, is thus conceived as a “philosophical vase[128] & horn[129].

This modern *Ars ceramica* – venerable and vivid human profession which is “located” in a prestigious position in the “realm” of *ARS*/arts and *TÉCHNIKA*/techniques, technologies – express, in a *sui generis* manner*** – i.e. by some hieratic/permanent************** reproductions of some existed items, endowed which symbolical meanings/virtues – the *Philosophia Perenis*.

********. From the top to the bottom of this spaceal complex material & symbolic artefact.

*********. The formation of young skilful handicrafts which can produce poporal-like/**folk**/ items – traditional ceramics et al. – is a permanent command for the leaders of this *fabrica*.

**********. In this *cosmo-graphia*: acomplished with elements and structures of *ars ceramica*.

***********. Spaceal/quasi plane representation: S/P.

************. Some ancient images[P] are considered by the experts as the official images of some historical persons (emperors, kings, priests, et al.); but these names will not be mentioned *expressis verbis*.

*************. Placed on a appropriate pedestal in the middle of centrum salutatoris: the monument can be clearly regarded and studied by the visitors.

**************. Old but not obsolete.

Final notes and some short subsidiary comments

1. For men which are aware *ab initio* with concern their meditation; for men which became aware during/*al fine* of their meditation.
2. Why? For what purposes?
3. More or less.
4. *In verbum*.
5. Comprehensive description.
6. Biocells, protozoars, animals.
7. Angels, devils, spirits, ghosts, et al. such live/”live”/ entities.
8. Role in *Theatrum Mundi*.
9. With **no copy**/”**brother**” in the **Universe**: in the **observable/Known** *more humanum* part of **The Big All**/*Kosmos*/ which is a “**Realm**”/**World**/ in extension *in Tempus*, i.e. in quantitative (*quantum*=space-al) & qualitative (*qualitas*= progressive knowledge/*antropic gnosis*/.
10. Faces of His personality.
11. Philosophical antropology.
12. Fictitious.
13. Logically a correct interrogation.

14. *Homo logicus: locvens*.
15. With their unrepeatable own personality, destiny/*Fatum curriculum vitae*) with biotic brothers, loved friends, accepted sympathetic persons members of the complex system **Mankind**/*Societas Terra*/*Terrapolis*/.
16. Has their own Philosophy.
17. The essential ones.
18. “Orto” person: pointly determined *in concreto/in abstracto*.
19. Judgements of value: axiological judgements.
20. By his systematic studies, academic documents et al.
21. Philosophical points of view, *Weltanschaung*.
22. When is *HOMO > Animalus*.
23. *Mundus rerum < Mundus Naturalis < Mundus Axiologicus*.
24. Sometimes some men are reduced in a quasi/in an extremely low position: as **objects** (physical thinks: re-ification), as **animals** (instinctual beings: animalisation).
25. Imago of MAN: distilled “substance” of the human *onthos*; *Homo Humanus* is MAN which all his axiological hypostasis.
26. In the Latin language the name *cardo* means a small but essential part/piece/ of a door (mechanical system: device) which make possible/facilitate/ the openings & closures of the door/gate/ a simple system with specific qualities (in-put, out-put; exit, entrance, inner side, out side); in Romanian language this piece/item/ is named *]â]ân/balama*/ and are used in many cases (the monumental gates of some rural homes et al.); the name cardinal is used in *Theologia*: the cardinal virtues of the moral orthodox theology are The Wisdom/~*n]elepciunea*/, The Right/Justice/*Dreptatea*/, The Courage/*Curajul; Responsabilitatea*/, The Moderation (temperate attitude)/*Cump\tarea*/; the word is often used metaphorically in the coloquial language and in literature (the time is escaped from its “joints”, the nervous man is getting out from his “joints”); the word is used in technique: joints, cardical spaceal geographical main dirrections North, South, East, West.
27. They are major: “abstract”/ideal/-tors.
28. A noble, elevated, *more humanum position*: which produce satisfaction enjoy partially, happiness.
29. Really very diversified; which is more than sympathy, sex attraction.
30. Amour: omnia vincet.
31. Family the cell of antropic normal/harmonious/ existence.
32. Scope: purpose, *focus*, hub of the universe.
33. *In status nascendi* religious: natural born, without conflicts (with no/minor doubts, hesitations, confusions.
34. Which arrive to his *creddo* after many interrogations, doubts, contorsions, experiences: ateist/sceptical phases, confusions, conversions, apostasias, dramatic struggles in his soul (excruciating feelings, breaks; revolts, despairs, et al.).
35. *Sensus*.

35\. *In vivum Dei*.

36. Objectively: by his nature.
37. Homo a marvelous being: unique, strange, contradictory, in miseries (“divine”-ised persons – heros, rulers, tyrans … by some enthusiastic partizans/maniacal excited fans; proud rulers which are, crazily/madly persuaded that they are/were “elected” no less than “instruments of G**od**”, human/exceptional mortals

achievers of the **Devine Will/Design** and they act effectively, in some circumstances as "*instrumentum Dei*" in sublimes religious extasies, visions, prophecies, et al..

38. Also essential: *sine qua non* necessary to define the **real antropical condition**.
39. They are important: "real"-isators.
40. *Co-modus vivendi* of persons which (inexorably; specifically [1]) belong to a community/society/.
41. In harmony, with some real conflicts, tensions[42] acute differences, …, which are moderated/politicalized.
42. In crisis there are strong/*extremum*: contradictions, antagonist contradictions, *casus belli*, bellum/*conflagratio*, riots, revolutions.
43. *Antropos: zoon ekonomikon*.
44. *Ex definitio* non identic with *politikia* (intrigues, hypocrisies, lies, felonies, crimes, et al.; terrors, which also, animate some *real politik*).
45. *Antropos: zoon politikon*.
46. Animals – biotical systems – made mechanical work, but not *stricto sensu* conscious labour activities.
47. Military: *manu militari*.
48. Another social militants.
49. *Summa*, product of ensembles.
50. Not in all cases apodictical, optimal, mathematical; in many case empirical, circumstantial; in some cases also are involved esthetical "arguments" (improvements; *sectio aurea*, *symmetria*, variational principle, et al.), economical "arguments" (prices, conjunctures; failures, et al.).
51. *Animalus faber* can be considered in some limit cases i.e. in *latto sensu*: unconscious/instinctual achievements of some damms, beehivesnests, Tanteaters made by "clever" "laboural animals".
52. Universal features of *Homo*.
53. Specialized *modus* of *Sapiens Scientifer*, *Cogitans*, *tehnicus-tehnologicus politicus, economicus*, *et al.*.
54. *Terrestris, navigans, volans*.
55. The exagerations/dominances/hegemonies are, sometimes real axiological phaenomena: scientism, moral/political/ fundamentalism, estetism, technocratia, politico-cratia, buro-cratia, militarism, economism, politicianism, "totalitar"-isms, et al..
56. Didactical, aproximative.
57. Vivid species/"forms of crystalisation"/ of the human spirituality/Humane-ness/.
58. As is convenient to consider them often: methodologically, didactically, academically.
59. Saint Anton, San Juan de la Cruz, Santa Terezia de Avilla, etc. etc., *gurus*, *eremites*/hermits/, et al.
60. Various; with many aspects: identities, equivalences, subtle differences variants et al.
61. Multiform: *quasi ad infinitum* composite axio-hipostasis.
62. *In concretto*; for some representation *in abstracto* of many interesting (unavoidable, perceiving et al.) situations.
63. The dossier "presented" by *Homo aestimans* (*criticus*; judge; incriminate; *advocat*/attorney/defender/prosecutor), to the *Aeropagus* **of Values**/ *Jus axiologicus*/: chemical war[64], biological war, climatological war, extrem in formational bomb,. A/H/N/ bombs, Space science – technique – policy, oil competition[65], transport (*Homo terrestris – navigans – volans*; *informaticus*: *significans* et al.), informational science – technique – policy, spy, manipulations, controls, globalization, propaganda.
64. Chemical war = in fronts, in K.Z./Gulag, in propaganda.
65. Savage "oil wars": Suez, Irak, Golf, et al.

66. By its very nature: in the moments when it is not in failure (in animality, satanized).
67. “Bi-cephalic” Axio-structure.
68. Thus Technique too has some aspects of Culture (genitorial, productive; aditional), composed with those principal which, statutorly, are civilisational ones (generator, producer).
69. *Zoon Politikon/Spiritus Civicus*.
70. In the time of the invasions of barbareans (German peoples: the the lombards/longobardi/*Die Lombardean* et al.), later (under the reigns of ducs/*duce*/: the Sforza dynasty; under the administration of Austrian Empire et al.).
71. Ethnographically, linguistically, culturally et al.
72. Systematically: meta-physics, religion, doctrines, conceptions, *Weltanschaung*; partially (logical, methodological, epistemological, ontological, gnoseological approaches; essays; reflexions on metaphysics, religion, moral, Art/arts, Science/sciences, Technology/techniques, technologies, justice, politics, economy, history, culture, civilization, praxis, et al.
73. Faces, sides.
74. *Eloqui declarare*.
75. *In verbum scriptum*: with the symbols named letters of some alphabets.
76. Ritualic monuments, et al.
77. Sculptures.
78. Inadequately chosen materials: wood, earth (ceramics, stones) metals (cooper, bronze, iron, glass, special materials (plastics; mixtures, et al.) with their physical-chemical properties (colours, elasticity, rezistence, rigidity, flexibility, et al.).
79. Explained, declared explicitly implicitly.
80. With some “hidden” keys: the initiatic texts.
81. In all the case the analysis/exegesis are necessary: *interpretatio, hermeneutica*.
82. Creation; industrial productions.
83. Special ones: good for procession (by hand, with the help of the whell et al. *instrumentum*) (caolin; clay stones, et al.).
84. The results of the studies made by etno-noms (etnologs, etnographs) historio-noms (archeologs, historiographs, historiologs) in many *situs*-es of the *Terra* where in different periods of *tempus* were conceived, achieved, used ceramic objects[III] are extremely eloquent.
85. Pottery, plates (written, et al.) bells, constructive structures, et al.
86. “Spokesmen” heard and understood by many communitareans.
87. In some case positive information were print on the surfaces of vesels: *Decebal per Scorilo*, the name Petre, paint on the Capidava-ean *oal* (sec.X p.Ich.).
88. In Antiquity the **Sculpture**, the **Picture**[89,90,91], the **Mozaic**[92,93], the **Ceramics** were organically connected with **Architecture**[94]. The ceramics is very important to all the persons of Antiquity: this *ars* is distinguished by the richness of forms and the generous variety of decorative motifs: Ex. In faraonic Egypt: urns, vessels, Ex. In imperial China: has generated the production of porcelain/china/, Ex. In Greece: the marvelous painted vessels (amphoras, Tanagra, et al.), Ex. In Roman Empire: *terra sigilata*, Ex. In Mesopotamia: the resistant ceramical books written plates with cuneiforms et al, Ex. In pre-columbian Americas: many structures.

89. The picture has developed in parallel with the sculpture but he creation of the eminent *magister* – which has worked in fragile materials quasi totally has disappeared and we have some information of them only in some ancient description (literary, historical)[90].
90. In Greece: Polignot, in the V[th] century before I.Ch. is the author of *Stoa poikilé*/the variegated gate/colored portal/*portico*/ in Athens, decorated with *fresco*-s with thems taken from mythology and the history of Athens.
91. The most celebrated works in Roman Antiquity preserved until nowadays are the *fresco*-s from some *aedificium* in Pompei and Herculanum town covered by the lava of the volcano Vezuve in the catastrophic eruption from 79 A.D.; the thematics are rich (representations of flowers, birds, mythological subjects).
92. The mosaic: is specific to roman art/*Ars romana*/ in some material structures are reproduced figures of men, animals, geometrical and floral drawings.
93. In **S.C.D.P.** are preserved the *pavimentul*/*pavimentum*/ from Tomis, floor of a warehouse in the harbor of Tomis/nowadays Constan]a/.
94. In some cases were *ancilae Arhitecturae*.
95. From the *patrimonium ceramicum* of the matrix of culture & alveolus of civilization from **Carpathean-Danubean-Pontean Space**.
96. *Homo laborans, homo artifex, homo faber*.
97. A giant shell, a vessel, a horn: full with fruits, spices, …, meanings, …
98. Stoves, pipelines, pots, devices, parts of motors et al.
99. A system of symbols, representations, material bearers.
100. Passengers *in situ*, contemplators of the images of this complex arte fact.
101. Major, important, secondary, minor …: for peculiar persons, community, Mankind.
102. Living in **Reality**.
103. The reasonably predictable future.
104. The basis of this empty cylindrical structures/columns/ are achieved, the superior part is “open”; this design suggest the progress, yearning for improved qualities.
105. Used many years before; used in some case, also nowadays.
105. Used in traditional art: in Romanian, German/Saxon/, Hungarian, et al. settlements (villages, towns).
106. Not poporal art: more recent, original models.
107. Complex, sophisticated, automatized, efficient.
108. Accomodation to the <<**New Age**>>: technical progress/technical “*agiornamento*”/ in the electrical-electronical era.
109. Accepted, known, desired, introduced, learned, used, developed.
110. Meditation: in the process of work, in the instants of detachment of *homo ludens*, of *homo philosophans*.
111. Small, magic sculpture found near the village Hamangia, in Dobroudja on the shore of Danube; dated: Neolitical era.
112. Statues, effigies, lamps, et al.: of gods, godesses, believers in adoration etc.
113. Images of Aphrodite/ /, Zeus, Mithras, Tracean Knight, et al.
114. Gnostical gemma/gemmae *abraxeae*/[115] (abrasax:) *crux gammata, lucerna*, et al. runs, pictographical letters.
115. Considered by believers as apotrepaic substances with the sign of abrasax/abraxas/( ): criptographical denomination used by some gnostics (of Basilides) to name the Supreme Divinity/The God

in their poli-teistical religion) which has the exceptional numerological property endowed, for the believers, with magic powers: the some of the numbers which represent the Greek letters is 365: the total number of days in a solar year.

116. The symbol of the authority of the owner of home/*fabrica*/, the host of the **visitor center**/*salutatorium*/.
117. Worthly activities.
118. Coins, effigies, statues, et al.
119. Pottery (items, workshops, nominated places, etc.), et al.
120. *Illo tempore* in stones, woods, metals.
121. A positive perception specific to *Homo Agens* (*Ingenius*, *Tehnicus*, *Laborans*…).
122. From archaeo-cultures: Cucuteni, Boian, V\dastra, Gumelni]a, Hamangia, Co]ofeni, Bratei, Witemberg, Ferigele, Dridu, et al.
123. Tracean, dacean, getean, roman, greek, daco-roman, carpean (free dacs), sarmatean, celtean, scythean, illyrean.
124. Some images evoke the barbarean/migratory/ populations: huns, slaves, avars, goths, et al.
125. An ideatical trajectory in curl/ring/.
126. Scientific, plausible visions, dreams, fictitious evasions, premonitions, inspirations.
127. In comparison with real normal vessels, shells, horns.
128. With ceramic flowers, species, …, with meanings.
129. Of abundance, emitter of harmonies, receptacle of meanings.
130. Neo-barock, "plataresque".

BIBLIOGRAPHY******************************

1. « " » Academia Român\ - Istoria României, vo.I-VI, Bucure[ti, 1996-2002.
2. « " » Dic]ionar de istorie veche a României (coordonator D.M. Pippidi, Editura {tiin]ific\ [i Enciclopedic\, Bucure[ti, 1976.
3. Constantin C. GIURESCU, Istoria Românilor, vol.I-IV, Editura Funda]iilor Regale, Bucure[ti, 1942.
4. Horst KLUSCH, Siebenbürgischen Kahlen/Cahle transilv\nene, Sibiu, 2001.
5. Ion SIMIONESCU, }ara Noastr\, Editura Funda]iilor Regale, Bucure[ti, 1938.
6. Liviu SOFONEA, The Areopagus of Values, XIXth International Congress of Philosophy, Brighton, 1987.
7. Liviu Alexandru SOFONEA, The *Museum*-isation of some relevant technical *artaefactae* in the european town Sibiu/Hermannstadt/ and in the Transilvanean *Jude]ul*/County/ Sibiu

at the beginning of the XXIth century *A.D.*, {tiin]a Modern\ [i Energia Universitatea Tehnic\, Cluj-Napoca, 2002.

8. Liviu SOFONEA, Florentin OLTEANU, Cogitatum pentru }ara F\g\ra[ului, Rosturi [i Rostiri, nr.1, F\g\ra[, 2001.
9. Liviu SOFONEA, Elena HELEREA, Homo Tehnicus-Tehnologicus eminens in limit situation; case of Romania in the period cca.1 december 1989 – 1 February 1990; XXIXth International Congress on History of Science, Liège, 1997; Proceeding 2001.
10. Liviu SOFONEA, Emanoil VICIU, Realizarea unui visitor center/centrum salutatoris/ ^n fabrica Terraplast din Bistri]a, România; in the volume Hermeneutica Historiae et Philosophieae Scientiae et Technicae, liber V, Bra[ov; in print 2004***************.

***************. Extremely short.

****************. For orientation.

*****************. Proceeding of the annual session of the **Comitetul de Istorie [i Filosofie a {tiin]ei [i Tehnicii al Academiei Române**, filiala Bra[ov, iulie 2003.

Pervasiveness of Visual Systems in Learning

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Abstract

Everything in nature is affected by multiple factors, which in turn are further affected by other factors. Linearity of any system, whether natural or artificial is only an isolated aspect of that system.

In an educational environment, to avoid linearity and repetition and for effective learning to take place, an educator encourages multiple investigations in any given subject.

The importance of comparison and contrast can best be translated in the digital interface, if a structure is built in the system that encourages the user to do just that. Many people will argue that the search engines and the world wide web encourages comparison.

However that is a comparison of information, in which the user moves from one window into another.

The experiment proposed in this paper is about multiple levels of information access in the same window, thereby involving an active participation of space, time and movement – which hopefully may lead to visual thinking and a new level of creativity.

1. DEFINING THE PROBLEM

Through further exploration of the structure and interface of the digital visual technology, the author hopes to evolve diverse models of graphical and data structures. This in turn leads to a deeper understanding of graphics and graphic information processing.

It is hoped that this study will help in understanding the significance of digital visual technology and its inherent cognitive implications.

1.1 Defining the terminology

For the purpose of clarity, the key words *visual system* and *learning* are defined in order to focus on the key elements.

1.2 Visual System

Jacques Bertin in his excellent analysis [fig.1] on the *Semiology of Graphics* defined Visual System as a form of visual perception which has at its disposal, "three sensory variables which do not involve time: the variation of marks and the two dimensions of the plane. The sign-systems intended for the eye are, above all, spatial and atemporal." [1]

The atemporal attribute of visual system, according to Bertin applies only to the two dimensional visual media as he further goes on to state that, "the intervention of real movement…although perceptible by vision, would make us pass from the graphic system (atemporal) into film, whose laws are very different."[2]

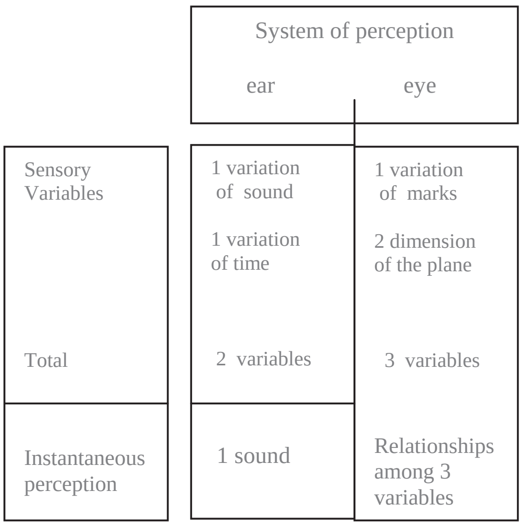


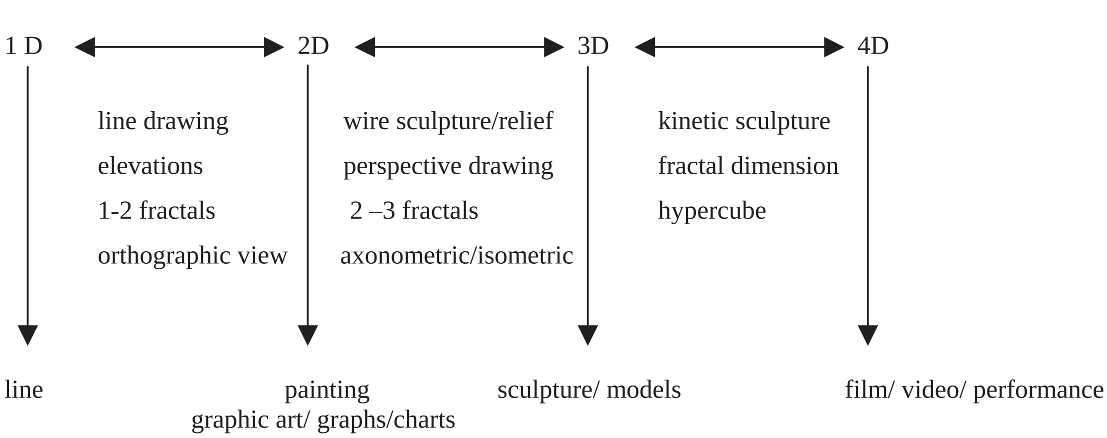
Fig. 1 Bertin's chart on the: Perceptual properties of linear and spatial systems.

Movement whether temporal or metaphorical has played an important role in the history of visual arts. With its presence in digital media it has now become an integral part of the digital visual technology. Therefore in order to define visual system in the digital context, Bertin's system of perception is slightly altered, by including the third and fourth dimension of space within the two dimensional plane. This gives the digital visual technology a temporal attribute as well as an inherent disappearance of the so called congenital fixity of the image.

1.2.1 Structural Basis of Visual System

Visual system in the theoretical context is a space that can be visualized through a point, a line, a plane, a physical form or a temporal moment. The dynamics of visual system allows innumerable intermediary stages as shown below in fig. 2.

Fig. 2: Visual Learning



1.3 'Learning' Defined

Arnheim (1989) defined perception as a cognitive/learning activity and stressed the interdependence of perception and thinking. He believed cognitive activity to encompass; "all mental operations involved in the receiving, storing, and processing of information: sensory perception, memory, thinking and learning.

Screenshots of graphic software applications [fig.3] commonly used in technology enabled classrooms show the use of almost identical interface design.

Example include:

1. Software that generate music, e.g., 'Sound-Edit 16',
2. Software for basic graphic design layout such as, Photoshop, Illustrator and QuarkXpress.
3. Software that generate animation: Flash, Director.
4. Software for three-dimensional model making: Form Z, Maya, AutoCad etc.

The above mentioned, software, due to their common interface, encourage the eye to scan predominantly in a two dimensional space. This may affect the development of visual perception, thinking and learning habits of the user.

According to Dake (2000) a continuous use of web or computers in general may affect the ‘eyescan patterns’ [3] of the individual. A recent neuropsychological study (Zangmeister, Sherman, and Stark [4], 1995) of professional art viewers and artists vs. non-professionals, showed that professionals relied on many more global movements of the eye to determine structure. Professionals also had a significant greater ratio between global and local (small and detailed) eye scans than did non-artists. Yarbus (1967) demonstrated that although eyescans patterns are highly individual, they are also greatly altered by verbal instructions given to a subject. Since individuals are not conscious of the patterns of the eyescans, this finding may have great implications for the manner in which instructions are given.[5]

A study in 1995 by Heilman et al. discovered that the global – local dichotomy, may be related to the manner in which the right and left hemispheres respond to spatial frequencies. Their data showed that the right hemisphere tends to direct attention towards visual extrapersonal space (far from the body). This makes right hemisphere processing more concerned with global matters of fuzzy, low spatial frequency. The left hemisphere by contrast directs attention to visual information that takes place close to the body (peripersonal space with detailed and sharp, high spatial frequency [6]. (Humphreys and Bruce 1989) The integration and synchronization of the functions of the two hemispheres has been related to the phenomenon of creative visual thinking [7]. (Elliot, 1986)

2. PROPOSED EXPERIMENT

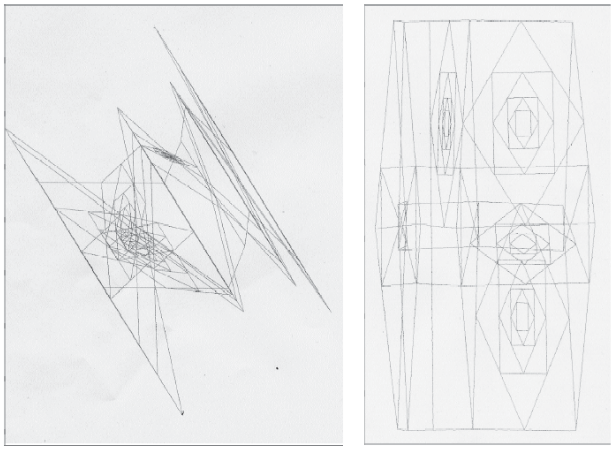
"After comprehending the outside of the object, the child likes also to investigate its inside; after a perception of the whole, to see it separated into its parts; if he obtained a glimpse of the first, if he has attained the second, he would like from the parts again to create the whole"
Frederick Froebel, 1896

2.1 Rationale

The development of a multi-dimensional interface permits the user to investigate multiple information. The generation and study of the interface will be based on, ‘shape grammar applications.’

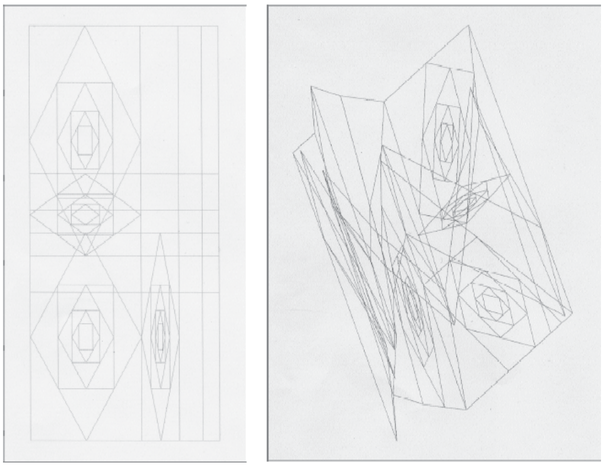
(Economou, 2000) Shape grammar applications have been developed for analytic and design purposes. Typically in analytic applications, a set of designs is selected, abstracted versions of these designs are extracted to bring forward some aspects of the composition that are of interest to the designer of the shape grammar, spatial relations between parts are selected, shape rules are defined in terms of these spatial relations, an initial shape is selected to start the computation, and shape rules are applied successively to an evolving shape starting with the initial shape. Designs generated by the grammar typically include the original set of designs that was chosen for analysis, and many other hypothetical designs that share the same spatial and functional characteristics with those of the

Fig.4



Proposed Experiment.
Details of the multiplanar structure. (MathCad, AutoCad)

Fig.5



original set. Typically in design applications, a set of spatial relations is selected, shape rules are defined in terms of these spatial relations, an initial shape is selected, and shape rules are applied successively to an evolving shape starting with the initial shape. Spatial relations between shapes may be taken from a predefined set of spatial relations that are of interest to the designer of the grammar, or can be constructed from scratch as instances of generalized types of spatial relations between shapes. These generalized versions may include all possible relations that can be constructed between any two shapes and shapes may be any finite arrangements of points, lines, planes and solids, including the empty shape. [8]

2.2 Experiment

In the proposed experiment [fig. 4-6] the interaction of the user with the structure is the key element of the concept. The interaction takes place at three levels.

Physical interaction
Intellectual interaction
Cognitive interaction

2.2.1 Physical Interaction

Physical interaction between the user and the computer, has the potential to promote intellectual and cognitive development if the computer has an interface designed to address these areas of learning.

Unfortunately current computer interfaces disregard intellectual and cognitive implications and focus more on concrete physical interaction. Many scholars are beginning to question the viability of the digital medium in the current age.

According to Gilbert Ryle; “We should begin by dismissing a model which in one form or another dominates many speculations about perception. The beloved but spurious question, ‘How can a person get beyond his sensations and apprehension of external realities?’ is often posed as if the situation were like this: There is immured in a windowless cell a prisoner, who has lived there in solitary confinement since birth. All that comes to him from the outside world is flickers of light thrown upon his cell-walls and tappings heard through the stones; yet from these observed flashes and tappings he becomes, or seems to become, apprised of unobserved football-matches, flower-gardens

Fig. 6

and eclipses of the sun. How then does he learn the ciphers in which his signals are arranged, or even find out that there are such things as ciphers? How can he interpret the messages which he somehow deciphers, given that the vocabularies of those messages are vocabularies of football and astronomy and not those of flickers and tappings?

This model is of course the familiar picture of the mind as a ghost in a machine, about the general defects of which nothing more need be said. But certain particular defects do need to be noticed. The use of this sort of model involves the explicit or implicit assumption that, much as the prisoner can see flicker and hear tappings, but cannot, unfortunately see or hear football matches, so we can observe our visual and other sensations, but cannot unfortunately observe robins. [9]

It isn't possible for any visual system, except nature, to give a full sensation of natural objects or sensations. However it is possible for a visual system to train the eye to capture such a spectacle, and to use that training in a manner that helps deduce multiple interpretations.

2.2.2 Intellectual Interaction

Technology and more specifically computers and desktop publishers have an interface, that allows the user to compute, draw, read, write and evaluate data and images in pretty much the same manner. The idea behind this practice is to allow for maximum familiarity and usage. Commenting on this trend, Ivins notes; "Thus the more closely we can confine our data for reasoning about things to data that come to us through one and the same sense channel the more apt we are to be correct in our reasoning, even though it be much more restricted in its scope. One of the most interesting things in our modern scientific practice has been the invention and perfection of methods by which the scientist can acquire much of their basic data through one and the same sensuous channel of awareness. I understand that in physics, for example the scientists are the happiest when they can get their data with the aid of some dial or some device which can be read by vision. Thus heat, weight, lengths, and many other things that in ordinary life are apprehended through senses other than vision have become for science matter of visual awareness of the positions of mechanical pointers." [10]

Does this not imply that if we can devise a consistent means of translating all aspects of our world into the language of one sense only, we shall then have a distortion that is scientific because consistent and coherent? Blake thought that this had actually occurred in the eighteenth century when he sought liberation 'from single vision and Newton's sleep.' For the dominance of one sense is the formula for hypnosis. And a culture can be locked in the sleep of any one sense. The sleeper awakes when challenged in any other sense.

The experiment hopes to break the monotony and regularity of the computer interface, in the hope of awaking the user to think beyond the rigidity of existing digital visual technology.

2.2.3 Cognitive Interaction

Cognition, generally is believed to mean the accumulation of knowledge. Accumulation of information by books, or through the electronic media seems to be the sole criteria for defining knowledge. Under this criteria the current digital systems seem to be adequately equipped to impart knowledge.
According to Brett: “The idea that knowledge is essentially book learning seems to be a very modern view, probably derived from the mediaeval distinctions between clerk and layman, with additional emphasis provided by the literary character of the rather fantastic humanism of the sixteenth century. The original and natural idea of knowledge is that of ‘cunning’ or the possession of wits. Odysseus is the original type of thinker, a man of many ideas who could overcome the Cyclops and achieve a significant triumph of mind over matter. Knowledge is thus a capacity for overcoming the difficulties of life and achieving success in this world.[11]

The proposed experiment in its hope of breaking conformity and linearity of the system hopes to explore knowledge as a self assessed phenomenon.

The main purpose of the proposed experiment is to bring in some sort of change in the existing mode of perception of the computer user. By modifying the navigation, the interface, the entire concept of data display and analysis through a revised interface, it is hoped that the user will awake from her/his slumber and be more creative and analytical.

CONCLUSION

By studying visual systems and their immense effect on learning, it is imperative to question the role of existing digital visual technology in learning. As we move into the 21st century, the developed world moves from visualization of information to a visualization of environment [12]. We already think in images, we need to redefine the role and properties of visual images, keeping in mind the role of Brain compatible visual art education. The purpose of this paper was a brief overview of the pervasiveness of visual systems in learning. An experiment was proposed to explore digital visual technology, in order to study learning in a less monotonous environment.
Moholy- Nagy in *The New Vision*, believes; “Art is the senses’ grindstone, sharpening the eyes, the mind and the feelings. Art has an educational and formative ideological function, since not only the conscious but also the subconscious mind absorbs the social atmosphere which can be translated into art. The artist interprets ideas and concepts through his own media. Despite the indirectness of his statement, his work expresses allegiance to the few or many, to arrogance or humility, to the fixed or the visionary. In this sense, he must take sides, must proclaim his stand and no true artist can escape this task. Otherwise his work would be no more than an exercise in skill. What art contains is not basically different from the content of our other utterances but art attains its effect mainly by subconscious organization of its own means. If that were not so, all problems could be solved successfully through intellectual or verbal discourse alone.” [13]

References:

1. Bertin, Jacques Semiology of Graphics p.2
2. Bertin, Jacques Semiology of Graphics p.6
3. Dake, D. M 'Brain Compatible Visual Education Part 2: Some Promising Art/Science Connections Translations: From Theory and Practice A Reference Publication of the National Art Education Association Summer 2000 Vol. 9, No. 3
4. Zangmeister, W. H., Sherman, K. & Stark, L. (1995) 'Evidence for a Global Scanpath Strategy in Viewing Abstract Compared with Realistic Images. Neuropsychologia Vol.33, No.8, p.1009-1025
5. Yarbus, A.L. (1967) Eye Movement and Vision NY, Plenum Press.
6. Humphreys, G.W. & Bruce, V. (1989) Seeing Static Forms in Visual Cognition: Computational, Experimental and Neuropsychological Perspectives Hillsdale, NJ, Lawrence Erlbaum Association Pub., p.9-21
7. Elliot, P. (1986) 'Right (or left) Brain Cognition, Wrong Metaphor or Creative Behavior. It is Prefrontal Lobe Volition that Makes the Human Difference in Release of Creative Potential., Journal of Creative Behavior, Vol.20, No.3, p.203-214
8. Economou, A. Shape Grammars in Architectural Design Studio Georgia Institute of Technology 2000 ACSA TECHNOLOGY CONFERENCE 75
9. Ryle, The Concept of Mind p.223-4
10. Ivins, William. Print and Visual Communication p. 54
11. Brett, G. S. Psychology ancient and Modern p.36-7
12. Dake, D. M 'Brain Compatible Visual Education Part 2: Some Promising Art/Science Connections Translations: From Theory and Practice A Reference Publication of the National Art Education Association Summer 2000 Vol. 9, No. 3
13. Moholy-Nagy The New Vision Wittenborn, (Schultz, Inc. New York 1947) p.45

Notes:

The Kindergarten method, or Children's garden method, was invented by Frederick Froebel, a German educator at the beginning of the nineteenth century. The method was based on a system of categories or realms of geometrical forms and a series of geometrical gifts. The system of categories was employed by the teachers to suggest possibilities in the children's play. Froebel identified three categories of form; forms of knowledge (or science), forms of beauty (or art), and forms of life (or nature). Forms of knowledge introduced abstract logical elements and relations found in numbers, ratios, proportion, equivalence, the Pythagorean theorem and so on. Forms of beauty introduced abstract spatial relations exemplified by symmetrical arrangements of blocks, patterns, ornaments, rotational or reflective symmetries and so on. Forms of life introduced relations observed in objects of the real world, such as in arrangements of blocks representing tables, chairs, houses and so on. An emphasis on organization of thought, selection in observation and awareness of the underlying principles involved were the direct lessons that the children were learning through this structured play within the kindergarten..
Source: Athanassios Economou COUNTING, COLORING AND COMPUTING:
LESSONS FROM THE KINDERGARTEN (2000) College of Architecture, Georgia Institute of Technology, USA

The Instant office in the ageing society Accessible and sustainable or spheres for politropic space systems ob ects and de ices related to the needs of ageing people in Europe

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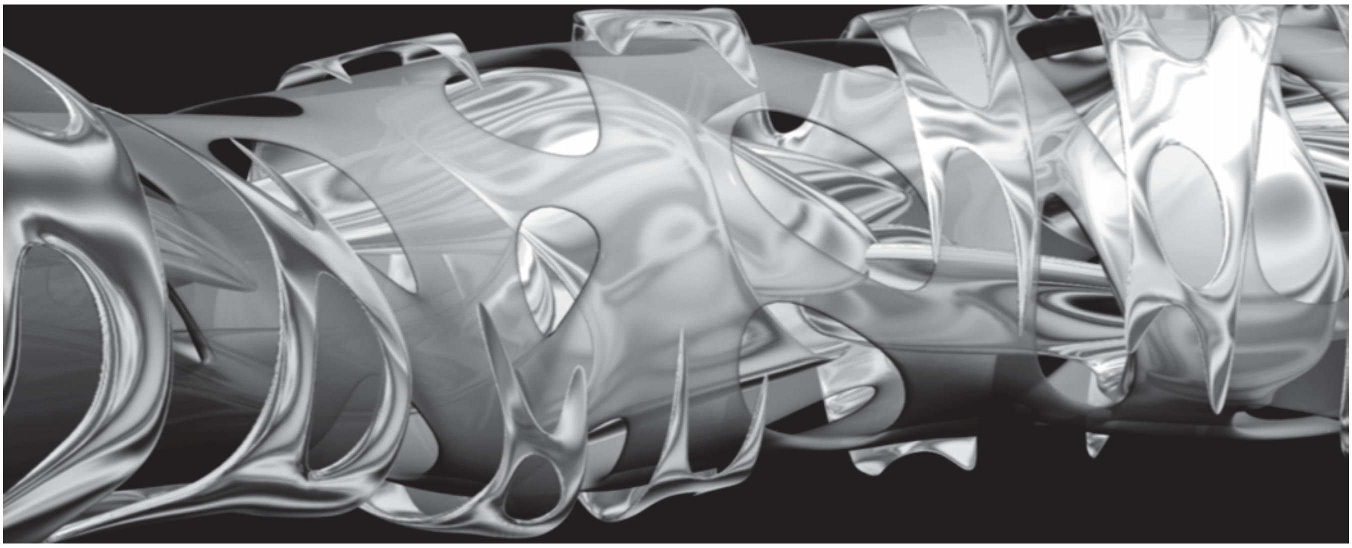
Abstract

Focusing the research activity on the defining of design solutions capable of assuring the most effective individualization of workspaces, with regard to the issues related to global mobility, physical and cognitive accessibility, and particularly to the phenomenon of mature age employment, the project is aimed to introduce new comfort tenor in the everyday life practices involved in the incipient work-spreading process. The investigation of a specific work landscape, related to the instances of temporariness, mobility and ubiquity of non-residential work conditions, highlights a great variety of practices and attitudes, space and device organization, comfort and communication systems, and identifies different conditions in which the incipient transformations are particularly relevant in their relation with architecture, bringing new instances to the permanent structure and to institutes of associated life (office buildings, open spaces, airports, railway stations, malls...). Addressed to fulfil the needs of workers subjected to the fragmentation of bijection between workplace and activity, and complying with the requirements of new work organization, it introduces an articulated system witch merges intimately in the urban tissue, allowing the sprawled workers the highest conditions of wellness, information and communication exchange, and technical equipment.

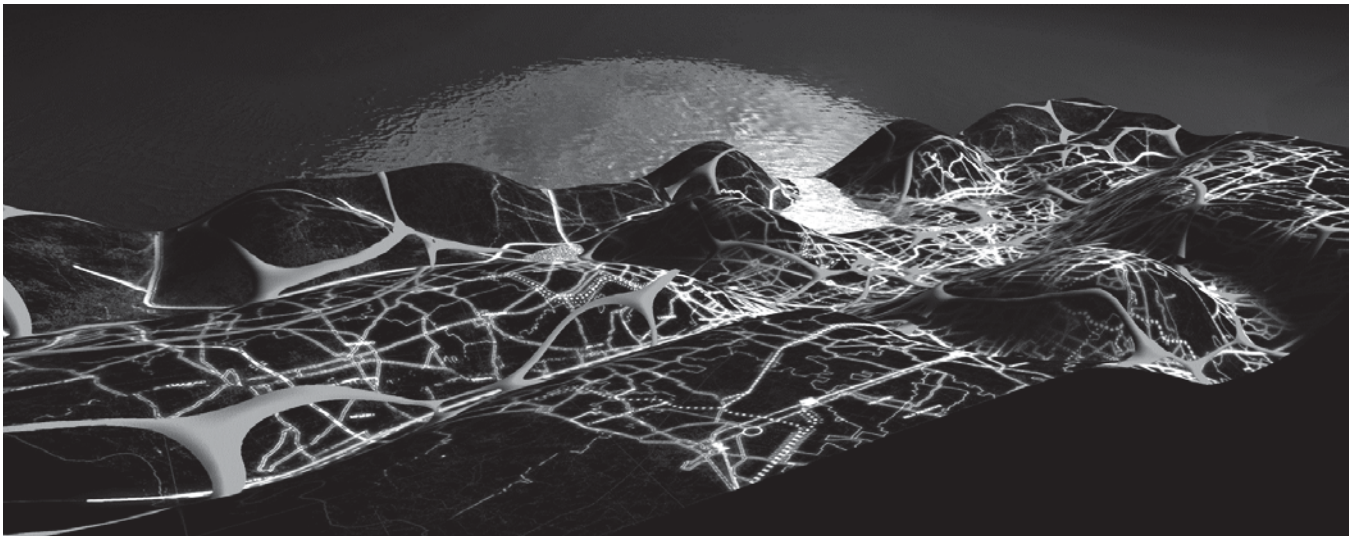


Intro

The design program considers intervention at different scales and in different environments: from the constitution of network in new brownfield sites (the main city centres are undergoing a radical metamorphose caused by decreasing needs of office space) to individual architectural objects (open structures, or integrated building with installation, hvc and cabling), to stand alone interior elements (partitions, flooring, ceiling, furnishing and lighting systems) and product (workstations, display and storage systems, complements), integrating the most promising application of ICT both in the building construction and management, and in the users physical and informational interface, facing the problems of re-using of existing objects, spaces, buildings and city complexes in a harsh evaluation of its environmental and economical sustainability.

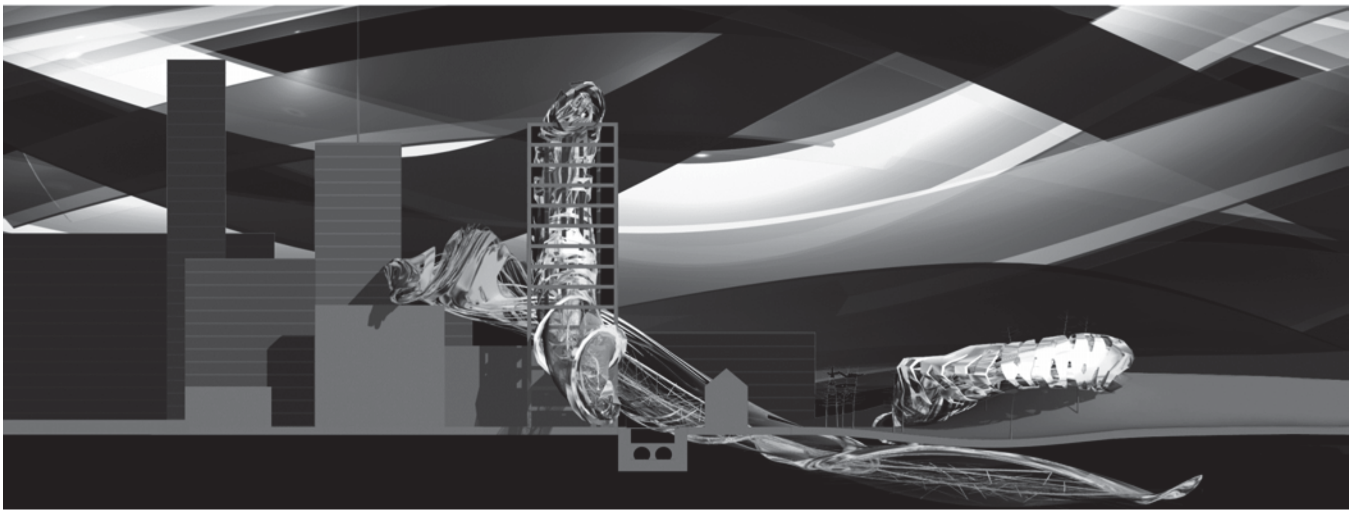
Hurban Pathscape

Fostering the dynamic and non-homogenous evolution of activities, the system is conceived to reflect the characteristics of the new organizational structures based on responsibilities sharing and objective defining: knowledge brokering management; unstable and self defining setting; articulated architecture (core unit, project/task related integrations, external components); co-creative, integrated and multi-modular work process; share of responsibilities in the project development; continuous shift of roles and relations; agility, nimbleness and swiftness in adaptation to different physical and cultural contexts. The barriers, which once separated the active part of life from the non productive fractions on the different levels of duration (age, week and day) and locations (productive spaces and leisure and rest environments) becomes permeable and sets new questions for the reorganization of physical spaces and temporal rhythms. The decline of stiff bond, that ties the work market to permanent and continuative relation between individual and company, opens new options in the work market to prospects for the redefinition of the socio-economic role of the knowledge workers, activating the possibility in making always and everywhere available and applicable the complete wealth of individual knowledge, competence, accumulated experience and wisdom. Following the dissipative model, it activates new work practices, attributes decisive values in the evaluation of diversity in different states and behaviours, and considers loss and gain of resources in both energy and information as the primary issue.



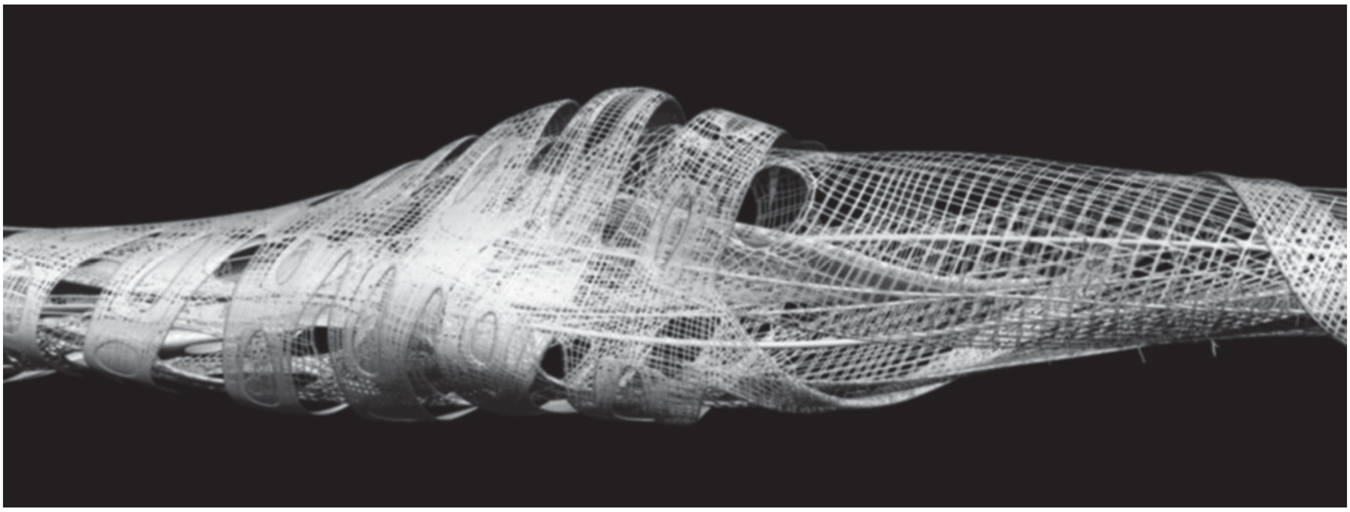
Spatial Scenario

The project reveals itself in the improvement of the permeable quality of systems that might reorganize spatial and movement rhythms through the graft of rhizomatic multi-crossed networks that allow performance in both intensive and discontinuous activities with instantaneous or unlimited duration, bearing different work styles, supporting, both in individual and team work, the speedy and the easiness of textual, visual and audible information transfer (e.g. improved by the growing integration of wireless and interactive systems) and the agility of their accessibility with increasingly smaller, lighter and performing devices determine in the relentless increase of flows and commuting of information, people and places.



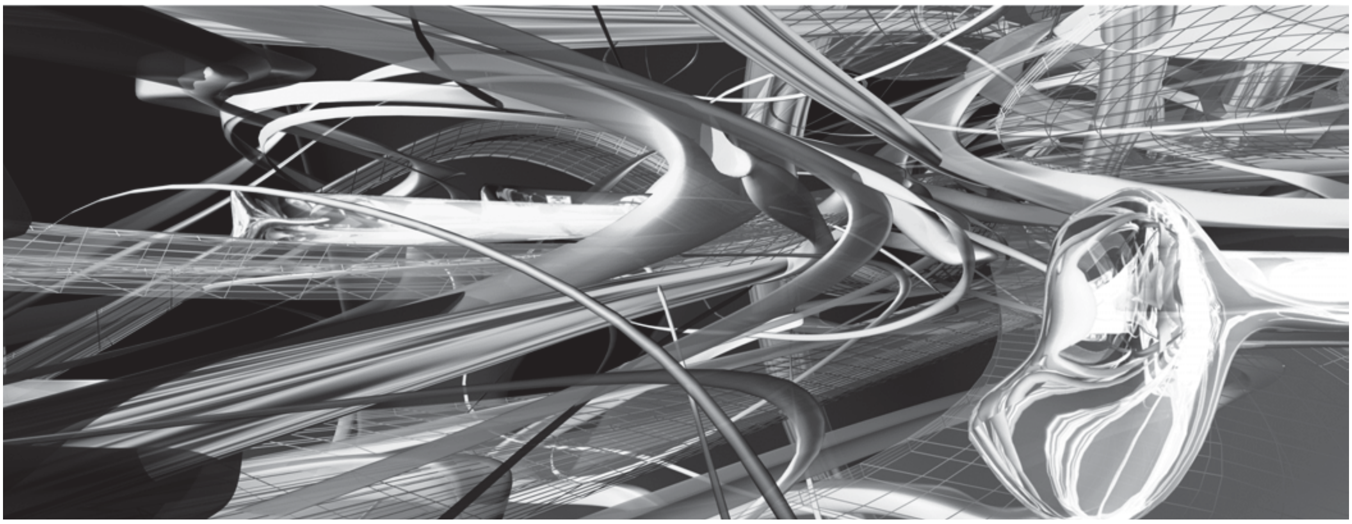
Di ersity Interaction and Communication

Through a program that stimulates the strengthening of diversity, in terms of places, individuals and groups, the project takes in consideration the likeliest range of users in the near future were the swiftness of changes will deeply affects cultural and social behaviours of individuals and groups, generating crucial situations for the personal capability in expressing identity in critical thinking, consciousness and sensitiveness, facing non linear, idiosyncratic, cross- and inter-cultural self comprehension. Also related to the recent decline in welfare administration, the trend of the work market sees the decline in permanent work positions, that ties the individual to permanent and continuative relation with the company, which implies a notable widening of the work life duration and opens new options in the work market to prospects for the redefinition of the socio-economic role of elderly people. The urgency to cope with the heavy effects of the trend in demography in European Countries, focusing the specific conditions of ageing society, sets the research goal of contributing in finding solutions that allow them to conduct a consistent part of activities and duties that in the recent past were to them inaccessible, as consequence of the performances reduction.



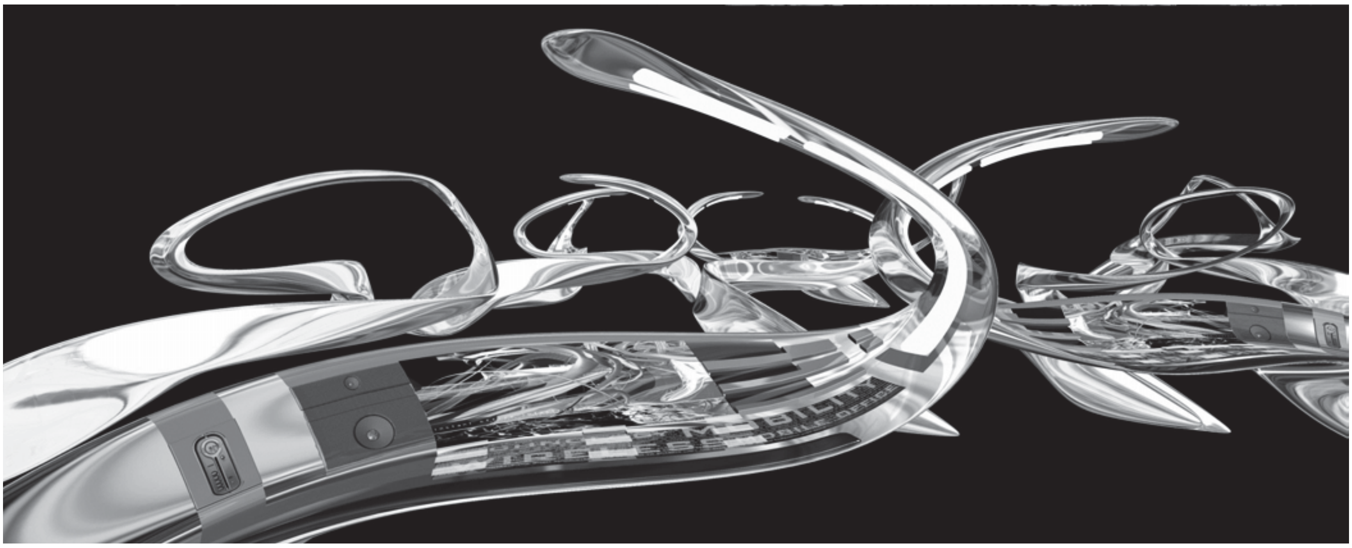
En ironmental Morphing and social Cohesion

In order to remove or contribute to get over the barriers caused by the decline of individual physic, psychical and sensorial conditions (impaired mobility and dexterity, reduced sensorial capacity, difficulty in learning new paradigms), social relations (isolation from family, friends and colleagues; deficiency in human interaction, exclusion), personal security and self-sufficiency (need of sheltered habitat), the project formulates an open program for environments, fittings and furnishings adaptable to the specific anthropometric, biomechanic, cognitive, organizational and operatives of the individuals using advanced devices based on personalized setting profiles, which facilitate the movements, the use of special personal aids and the adaptation to individual needs. Generating a pro-adaptive environment, that stimulates a productive friction between persons, objects and information networks in a variable balance between interpersonal interaction and communication routes and individual concentration conditions, the system follows the fallout of new needs, depending from the non-linear relation between real and virtual realms of activities, exploring a series of themes, including domesticity, rituals of daily life, personal and data security, prostethics.



Information Space Immersion s Emersion

The system can be seen as a big metadisplay device, were concealed technology gives information, as intelligible as possible, by different media, involving different senses (light, sound/noise, termo-igrometric comfort, tactile comfort, smell control…). The materials and technology choices will be related to the study of the multisensorial values (visuals and haptics) of objects and surfaces, considering a frame that includes the whole life-cycle of the object in connection with the environment sustainability aspects (low energy production, management and recycling; low pollution; intelligent regulation systems; recyclable materials, re-use). Intuitive and context related tools do not require accuracy or complex motion and are placed in a limited field of reach, light. Implementable working places, with variable dimensions and adequate interfaces constitute consequently instable structure: architecture and information melted together stimulate latent behaviours, avoid punctual over-loading and communication barriers, value contingency and allow slower or delayed environmental reaction times.



References

CLAC, *Inclusive Design and Intelligent Technology for Accessible Workplaces*, SMAU Exibition Catalogue, Cantù, 2003, ISBN 88-7569-000-6 ;

Manfredo Manfredini, *Instant Office Infostructure*, Pavia, 2003, ISBN 88-86719-39-6;

www.arch-i-lab.polimi.it;

www.idia2002.com;

www.humantec.it.

Interest from creative activity to creativity

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Abstract

The development of students' creative activity depends on the level of interest in creativity. The higher the level of interest, the more creative a person is.

Interest in creativity develops gradually and passes some levels from cognitive interest to the interest to be engaged in creative activity and, then, to creative interest. These levels are interrelated and constitute dynamics of the development of creativity of a person.

In the article distinctive features of all levels of the development of interest have been considered and ways of dynamics of the development of a creative person have been described.

Introduction

Interest as a psychological phenomenon have been viewed and analysed frequently and different viewpoints exist in its interpretations. Analysing the phenomenon of interest, captivating and interesting seems its pedagogical direction in the field of cognitive interest. Cognitive interest can be analysed as a manifestation of interest when frequent cognitive activity, cognition occurs. A specific manifestation of cognitive interest is observed in its realization in the environment of creative activity. This is because cognitive interest can be either markedly creative or not.

Basing on the analysis of pedagogical practice, we conclude that interest at different levels can be developed within creative activity. That is why the aim of the research had been set: to clarify the stages of the development of interest.

1. The interpretation of interest as a phenomenon in pedagogues and psychologists' inferences and the interpretation of its essence

Interest plays a great role in the development of every individual. Basing on interest or complete denying of a problem, we can change very many processes by finding the golden mean. The classics of pedagogy investigated interest, as well as outstanding modern pedagogues and psychologists of the 20th century such as B.Ananjev, A.Antciferov, V.Asejev, J.Atkinson, J.Babansky, A.Bodalyev, H.Eisenk, D.Elkonyn, N.Fetherson, M.Jaroshevsky, A.Lyeontjev, K.Madsen, J.Nuttin, E.Peterson, S.Rubinshtein, G.Schukina, B.Veiner, D.Vinter, J.Alen, J.Nerne, A.Špona, I.Žogla [1], and others.

A human being finds interest in the surrounding world. Personal interest, which is as multi-faceted as the surrounding world, is significant for every individual. Within the context of the development of personality, interest gathers round all the psychical processes- perception, memory, thinking, sensations, imagination, which, in a particular direction, activate the development of a personality in general. It is based on the interrelation of several factors.

Many scientists who are conducting investigations into the problems of interest focus their attention on the matters of professional interests. Not enough investigations have been conducted into the formation of interests within creative activity in the pedagogical process.

Interest- a **phenomenon** that is usually investigated in isolation from external factors, beyond activity, which is the only way interest can develop, if at all. The complexity of a phenomenon is rooted in the bias towards its nature and essence.

The term **interest** can be viewed according to the meaning. It can manifest itself as interest in something.

The explanations of several authors are expounded in Table 1.

Table 1. *The explanation of the term* ***interest*** *in the interpretations of many scientists*

Interest	Active attitude towards activities, objects and occurrences that is conditioned by **need, experience and imagination**. Interest can be active, purposeful and also passive.(I.Beļickis, D.Blūma, T.Koķe, D.Markus, V.Skujiņa, A.Šalme) [2].
Interest	A brightly expressed attitude towards reality, one of character traits of a personality (V.G.Kriskjo) [3].
Interests	**Needs, inclinations, passions,** objectively or subjectively significant that provide for the physical existence, mental development and/or status in the society, etc.; also goodness, favourableness. (I.Beļickis, D.Blūma, T.Koķe, D.Markus, V.Skujiņa, A.Šalme) [4].
Interest	**A feeling of value**– it can be aroused by ojects and/or it can testify to the formation of the first stage of a new necessity. If we gain satisfaction from some activity, emotions offer the object to be responsible for this favourable effect in a particular sense. (ed. G.Breslav) [5].
Interest	**Tendency** and **the progress** of a personality that advances thanks to condenced reflexion on a particular object. We understand reflexion as complex and diordered education– the progress of thought, thoughts– care, thoughts– participation, thoughts– a corpus including a specific emotional nuance. **Manifestation**– to be interested in or to get interested in (S.Rubinshtein) [6].

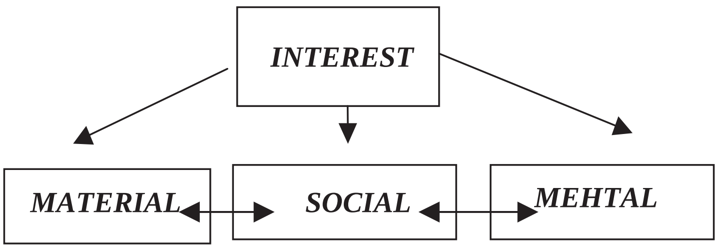
Interest	That is **a sense of inner joy**, in other words, **aspiration** that we experience observing a captivating thing or reflecting on pleasant past events, or, finally, looking forward to something pleasant (J.A.Students) [7].
Interese	A form of manifestation of the necessity of cognition that provides for comprehension of the aims of diversity, as well as promotes orientation, acquaintance with new facts, more fully and extensive reflexion of reality (A.Petrovsky ed.) [8].
Interest	The motive or the motivation of mood that promotes the development of creative activity. The emotional and free moments of interest appear specifically as intellectual emotions and efforts to overcome intellectual difficulties (V.Zinchenko ed.) [9].
Interest	One of **conditions** of the progress of behaviour, thoughts and will (A.Špona). A specific **attitude** of a personality towards an object that is conditioned by the importance of this object in life and **emotional** attractiveness [10].

The above table illustrates different views on the explanation of interest. These views are both similar andcontradictory. We shall dwell upon different types of interest in order to grasp the essence of cognition.

Interest has been distinguished in more detail in G.Breslav ed. [11]:

- **the material** that provide for the physical existence of a human being;
- **the social** that provide for the place of a person in the society;
- **the mental** that provide for the mental growth a person and its realization in creative activity, also including cognition.

Drawing 1 reveals the division of interest.



Picture 1. *Division of interest*

Summarizing the content of the above picture, we can ascertain that the mental interest, the social interest and the material interest provide for the mental growth a person, the awareness of art cultural and aesthetical values, reflecting multi-faceted manifestations of cognition.

Examining the explanation of interest within the context of creative process and creative activity, basing on the pedagogical practice provided in the study programme “The teacher of visual art” at the Daugavpils University, we acknowledge that the most significant in the interpretation of the essence of interest in the above Table 1 is **the emotional attitude**, **the desire** to work creatively, **aspiration** to acquire different modes of fulfilling creative assignments. Basing on this assertion, we offer a definition of interest: **Interest is a positive emotional attitude towards active creative process encouraging desire to acquire abilities and perfect skills in creative activity.**

2. The essence of creative activity

Nowadays in Latvia in education much attention has been given to the main value- a human being as a creative person who encourages the progress of the development of the society. A creative personality is objective and unique wealth of the society. Definite delimited frontiers do not exist in the process of the development of a creative person. It continues all life long. In pedagogy investigations into creative activity are particularly significant.

The problem of a creative personality has been viewed in Russian and Byelorussian psychology and pedagogy, as well as Western psychology and pedagogy. In Russia and Byelorussia many scientists enormously contributed to the understanding of this problem. Among them are V.Druzhinin, V.Teplov, S.Rubinshtein, D.Bogoyavlensky, N. Vishnyakova, V.Kriskjo and other scientists. In Western psychology- E.Fromm, A.Maslou, K.Rodger, E.Landau, Mark A.Ronco, R.Mey, D.Fontana and others.
In Latvia this problem is significant in pedagogy. Many scientists have given great attention to this problem. Among them are V.Hibnere, J.A.Students, V.Reņģe, P.Tjurina.

In different sources of literature the word “creativity” has got the same meaning as the notion “creative activity”. The word “creativity” in the Latin language means to beget, to form, to create. Creativity must be present in all modes of activity. Creativity is a possibility to grasp the meaning of things from a new angle by dint of fancy and imagination, the ability to find something new and to create something new [12].

Creativity is at the core of personal and community growth. Evolution itself is a creative process - it's as if creativity is woven into fabric of the universe. And yet creativity isn't taught at school [13]. Creative people may look deceptively ordinary or outright strange. They might be robust and productive or scarred and depressed after a lifetime of rejection. Creativity also connects us with deeper things. Creativity, foibles and all, connects us with each other and is the growing point of our world.

According to a psychologist Vygotsky, creative activity progresses if a personality enjoys full freedom to express thoughts and feelings [14]. Creativity is a difficult learning outcome to assess with a traditional scoring rubric. However, a creative assignment can generally be scored on three main things: originality, fluency and flexibility [15].

***Creative activity in art*–** it is the creation of something that did not exist before and it also could not exist without its creator, that is, creative activity in art, which is a particularly creative mode of activity by its content [16]. Creative activity is not only a way to the cognition of the inner world of a human being and creativity, but also a result of comprehension and a manifestation of this inner world [17]. It is inconceivable that Leonardo de Vinci’s masterpieces or Beethoven’s symphonies would have been created without themselves.

By a creative process it is understood the creation of a new product by the means of a new product, growing, on the one hand, from uniqueness of a person, but, on the other hand, conditioned by the material itself, happenings, people and circumstances of life. The most significant in creative activity is the novelty, as K.Rodger acknowledged in his investigation [18].

Many scientists have proved that **activity** is a general form of activity that represents the greatest unit of activity subordinated to a particular motive [19]. Success of any activity of a human being depends on three components: knowledge, skills and motivation.

M.Klarin adds that creative environment is significant for successful development of creative activity:

- to eliminate inner contradictions;
- to give attention to the work of subconsciousness;
- to abstain from value judgment;
- to display a possibility of the use of analogy;
- to create the environment of inner freedom and understanding;
- to help to see sense of the direction of creative activity [20].

Because creativity is partly motivational, educators can go quite a bit with it simply by manipulating incentives and rewards. They do, however, need to ensure that they do not undermine the intrinsic motivation of students. This is one reason the diverse expressions of creative expression are so important. Children can be creative in many different ways, if they are allowed to follow their interests [21].

Much has been done to improve the theory of creativity in resent years. New methods of testing have appeared [22], but, irrespective of considerable amount of investigations, the theory has not improved particularly. Testing and analysing not a person, but the product of creative activity (drawings, music, etc.), a creative personality gets out of sight.

A creative personality is a particular type of a human being. Evidently it is closely connected the ideas of holism. According to A.Maslou [23], everything that helps a personality to develop encourages creativity. The essence of a personality changes and reaches a more advanced level of the perfection of creative activity.

Lecturing on a particular course study of visual art, we encourage the development of creative process that constitutes **interest** of a personality and interest, in its turn, promotes the self-actualization in creative activity.

Creative activity is a process that develops creative abilities and is characteristic of a pupil's inner readiness to create artistic works [24].

Two types of artistic works exist:

Type 1- artistic works that are created according to a particular plan (mainly academic artistic works);

Type 2- works that are created as if out the artist's will. At the same time these works are also the expression of the artist's nature. The artist might be unaware of this, revelation or inspiration can spring up [25].

Inspiration- a result of intensive work in a creative process is a peculiar transition of mental work from one quality to a new quality. Knowledge, abilities and skills- all the components of creating of a new image- intensively accumulating quantitatively, transforms into another, more advanced stage of creative activity at a definite moment. In this case it has been said that an artist, a scientist or a poet has got inspiration. It can be characterized as the most advanced form of creative work on the rise, the most complicated level of the expression of imagination [26].

The artist's ability to create a creative product can be considered as the artist's personal ability and talent, which appears to be one of the main conditions of creative activity. Creativity specifically distinguishes an artist from a highly qualified craftsman [27]. Talent miht be applied to a psycho-psysiological phenomenon and considered as something "given" to a human being. Creative work, however, becomes apparent in activity [28].

Scientists started to seek common characteristics of all kinds of creative process as a result of attempts to develop a general theory of creative process and creative activity. It has been acknowledged more often that a process that constitutes the base of all kinds of creative work is the same: a combination of elements with the purpose to gain a new quality and, afterwards, search for revelation and selection of "significant" combinations. The difference is reduced to the difference in an idea. Now we shall elaborate on the analysis of some conceptions in this direction.

A widespread theory of a threefold process of creative work exists in psychology. That is expounded in Vorobjev's work [29]:

1. A preparatory stage when the aim has been set, possible variants of the solution to a problem have been considered;
2. A correction stage of the realization of new images and notions; An approbation stage of a new object (phenomenon) and its realization in real life.

Many scientists distinguishes (L.Kryzhanovskaya[30], E.Landau [31]) four stages of creative process: preparation, maturation, illumination and verification.

D.Fontana proposes a similar conception [32]:

- ***Preparation***, which is primarily concerned with the recognition that a particular problem is worthy of study, or a particular theme is suitable for a book or a picture or a piece of music.
- ***Incubation***, during which the problem or the theme is mulled over, often at an unconscious level.
- ***Inspiration***, when the possible solution to the problem or a flood of ideas for the book, etc., come abruptly into the conscious mind.
- ***Verification***, when the solution is put to the test or the ideas are tried out on paper or on canvas.

Creative process have been substantiated in N. Vishnyakova's work [33], where she depicts modelling and describes a creative process comprising five levels: a creative act, a creative informative field; a creative strategic process; creative technologies and a creative result. Such modelling is more complete and reveals more precisely the essence of a creative process.

However, the formation of creative activity also comprises several stages. These stages are closely connected with a creative process.

Basing on E. Kisin's, V.Procecky's, N.Gnatko's and other scientists' investigations, V.Druzhinin examined the models of creative activity the most broadly [34].

According to the research of a pedagogical process conducted lecturing on different courses of study of visual art at the Daugavpils University, we propose the following model of the development of a creative process. We base on two models developed by E. Kisin and V. Procecky [35].

This is very a complex process, depending on different variables and experience. As it was mentioned above, experience builds and grows gradually and creative activities develop through the peculiar stages of levels [36].

The ***first stage*** usually comprises the reproductive creative activities when a student tries to understand and reproduce something resembling the object, i.e. ***imitate*** or even ***copy*** the object, but satisfying results encourage him to commence the systematic work.

The ***second stage*** **–** interpretative creative activities can be characterized by the ***creative imitation***. This stage focuses on the aspiration of a student towards new artistic methods and techniques, which, in their turn, develop the perseverance and urge towards the unaided quest.

The ***third stage – imitation of creativity*****.** This stage suggests the disposition of a person to apply all the knowledge and acquired artistic skills in a new situation. This is the situation of creation of new images, which are created due to abilities of anticipation, and which are quite different form the previous experience of a person.

The ***fourth stage*** is called the ***transformation*** and the characteristic feature of this stage is the search for the recognition of discovered solution from the audience and from the artist. At this stage the student learns not only representation but also transformation of the world.

The given model is used as grounds for designing a study programme of training teachers of visual art.

3. The definition of creative interest and its substantiation

According to the information obtained from the materials of pedagogical practice, the development of the process of creative activity from one level to another (more advanced) coincides with growing interest. It constituted the base for further investigations into appropriate criteria according to which the dynamics of interest is to be determined.

The pedagogical experiment revealed that interest of the students who have not been majoring in art undergoes the same levels of development as creative activity does. This is because different technical methods in art have been used.

The bigger the interest, the more sophisticated the level of creative activity is. The abilities obtained at the next level encourage interest in the new, that is, different techniques and methods. The levels are mutually interrelated and supplement each other successively. As interest grows gradually, creative activity activates and creative activity, in its turn, encourages interest. It allows of four levels of interest:

1. primeval interest;
2. cognitive interest;
3. creative cognitive interest
4. creative interest.

Each level of interest corresponds with a particular level of creative activity.

- the first level- **the primeval interest**- the activation of cognitive processes all that is creative;
- the second level- **the cognitive interest**- the motion of cognitive process, motivation towards a particular activity;
- the third level- **the creative cognitive interest**- the formation of one's own initiative with the purpose to reach creative aims more proficiently;
- the fourth level- **the creative interest**- emotional satisfaction derived from independent permanent creative tasks.

Table 2 reveals a close correspondence between the levels of creative interest and the levels of creative activity.

Table 2. *Parallels between creative activity and creative interest*

Level of interest	Peculiarities of interest	Level of creative activity	Characteristics of each stage of creative activity
Primeval interest	Activation of cognitive processes all that is creative	*The first stage*	This stage usually comprises the reproductive creative activities when a student tries to understand and reproduce something resembling the object, i.e. ***imitate*** or even ***copy*** the object, but satisfying results encourage him to commence the systematic work.
Cognitive interest	Motion of cognitive process, motivation towards a particular activity	*The second stage*	This stage – interpretative creative activities can be characterized by the ***creative imitation***. This stage focuses on the aspiration of student towards the new artistic methods and techniques, which, in their turn, develop the perseverance and urge towards the unaided quest.
Creative cognitive interest	Formation of one's own initiative with the purpose to reach creative aims more proficiently	*The third stage*	This stage **–** ***imitation of creativity***. This stage suggests the disposition of person to apply all the knowledge and acquired artistic skills in the new situation. This is the situation of creation of new images, which are created due to abilities of anticipation, and which are quite different form the previous experience of person.
Creative interest	Emotional satisfaction derived from independent and permanent creative activity	*The fourth stage*	This stage is called the ***transformation*** and the characteristic feature of this stage is the search for the recognition of the discovered solution from the audience and from the artist. At this stage the student learns not only the representation but also the transformation of the world.

Conclusion

Interest generates as a result of the process of creative activity interest and develops accordingly to particular levels that correspond with the levels of creative activity.

Creative activity proceeds in four levels: imitation; creative imitation; imitation of creativity; transformation. Each level of interest corresponds with a particular level of creative activity. Interest proceeds from primeval interest to cognitive interest, which perfects itself in the process of creative activity and results in the next stage- creative cognitive interest. The most sophisticated level- creative interest.

The research allows of the following definition of creative interest:

***Creative interest* – is positive emotional satisfaction derived from independent and permanent creative activity in the context of art.**

References:

1. Kopelevica A., Zukovs L. (2000). *Didactic*. Riga: RaKa - p. 203.-205; Petersons E. (1931). *General Didactic*. Riga: Publishing House of A.Gulbja – p.1.-38; Spona A. (2001). *Theory and methodology of upbringing*. Riga: RaKa – p 79.-81; Zogla I. (2001). *Theoretical foundation of didactic*. Riga: RaKa – p. 220-228.

2. *Glossary of Pedagogical terms* (2000). Belickis I., Bluma D., Koke T., Markus D., Skujina V., Salme A. - Riga: Zvaigzne ABC – p. 71.

3. Krisko V. (1999). *Psychology and pedagogy in schemes and tables.* Minsk. Harvest - p. 182-183.

4. *Glossary of Pedagogical terms* (2000). Belickis I., Bluma D., Koke T., Markus D., Skujina V., Salme A. - Riga: Zvaigzne ABC – p. 71.

5. *Glossary of Psychology* (1999). Editor G.Brelov - Riga: Macibu gramata – p. 61.-62.

6. Rubinstein, S.P. (1998). *Basics of general psychology*. Series, design. Publishing House “Peter Com” - p.235.

7. Students J. (1998). *General pedagogy*. Part II. Riga: RaKa - p.151.

8. *Glossary of Psychology* (1990). General Editor Petrovsky A., Editor Jarosevsky M. - Moskow.

9. *Glossary of Psychology*. 2nd ed. (1990). Editor Zincenko V. - Mosow: Pedagogy–Press.

10. Spona A. (2001). *Theory and methodology of upbringing.* Riga: RaKa – p 79.-81.

11. *Glossary of Psychology* (1999). Editor G.Brelov - Riga: Macibu gramata – p. 61.-62.

12. Landau E. (2002). *Endowments demands courage* (transl. from German). Moskow: Akademija - p. 16; Hibnere V. (1998). *Art activity of children*. Riga: RaKa - p.10.

13. Milne J. *The Van Gogh Creativity Test*. www.tlc.ac.nz/vangogh_creative.htm.

14. Rogers Carl R. (1994). *On becoming a person. A therapist's view of psychotherapy* (transl. from English). Moscow: Progress, Univers - p.421.

15. *Problem Solving and Creativity.* www.mse.byu.edu/ipt/ipt301/jordan/creativityquiz.html.

16. Tiurin P. (2001). *Introduction in psychology of design creativity.* Riga: JUMI - p. 16.

17. Vishniakova N. (1995). *Creative Psychology. Psychology of creative learning.* Minsk - p. 113.

18. Rogers Carl R. (1994). *On becoming a person. A therapist's view of psychotherapy* (transl. from English). Moscow: Progress, Univers - p.413.

19. *Glossary of Psychology* (1999). Editor G.Brelov - Riga: Macibu gramata – p. 61.-62; Krisko V. [1999]. *Psychology and pedagogy in schemes and tables.* Minsk. Harvest - p. 182-183.

20. Klarin M. (1995). Innovations in world pedagogics. Riga: Eksperiment - p.37.

21. Runco Mark A. (1993). *Creativity as an educational object for disadvantaged students.* www.gifted.uconn.edu/ronco/html.

22. Druginin, V.N. (1999). *Psychology of general abilities.* Series, design. Publishing House "Peter Com" - p.54 - 82.

23. Maslou A. (1999). New boundaries of a human nature. Москоw: Smisl .

24. Alijevs R. (1998). School of development of creative ability. Riga: RaKa - p. 6-13; Students J. (1998). *General pedagogy*. Part II. Riga: RaKa - p.244.

25. Renge V. (1999). *Psychology. Psychology theory of person.* Riga: Zvaigzne ABC - p.73.

26. Vorobjovs A. (2000). *General psychology*. Riga: Izglitibas soli - p.115.

27. Bogoiavlenskaia D. *Psychology of creative ability*. Moskow: Akademia - p. 199-201.

28. Mey R. (1995). *Courage to create. A sketch of psychology of creativity.* (transl. from English). Livov: Iniciativa - p.37.

29. Vorobjovs A. (2000). *General psychology*. Riga: Izglitibas soli - p.114.

30. Krizanovkaia L. (1996). *Psychology of thinking.* Moskow: Akademia - p.21.

31. Landau E. (2002). *Endowments demands courage* (transl. from German). Moskow: Akademija - p. 25.

32. Fontana, David (1988). *Psychology for Teachers*. Second edition. Printed in Hong Kong, p.115.

33. Vishniakova N. (1995). *Creative Psychology. Psychology of creative learning*. Minsk - p. 156-159.

34. Druginin, V.N. (1999). *Psychology of general abilities*. Series, design. Publishing House : Peter Com, p.211-242.

35. *Ibid*. p.235.

36. Čačka M., Šļahova A., Volonte I. (2003). *Development of Creative Activities in Visual Art*. International Conference: "Teaching and Learning in Higher Education: New Trends and Innovations" – April 12-18, 2003, Aveiro, Portugal – CD–ICHED-Aveiro/main/Comm/p82pdf – p.1-12.

Strategy of Sustainable Education in Art Pedagogy

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Abstract

Sustainable education is a dominating value in the process of development of a person. Art training is playing an essential role in this process. Three major factors can be identified in the process of art training: environment, society and economics. These factors are summits of one triangle. Each factor follows another and they supplement each other as well. This article analyses major factors in the process of art training in the context of a sustainable education and analyses their influence on a development of a person.

Introduction

Each nation can gain for itself as much as it can contribute to a common heritage and the development of our common culture with its resources and wisdom.

The Importance and Essence of Sustainable Education

The education of a person in our contemporary world is a never ending process of growth. The notion "*sustainable education*" implies the understanding of a human-centered ethics, as it is indicated in UNESCO document published in 1997. It describes the relationships among people and the place they live. The ethics of future is understood as the ethics of the Universe which is oriented towards ensuring the security of person in the world.

Sustainable development is a difficult concept to define; it is also continually evolving, which makes it twice as difficult to define. One of the original descriptions of a sustainable development is cited in the document written by the **Brundtland Commission**: "*Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (World Commission on Environment and Development , 1987, p.43) [1].

On year 2000 the international UNESCO project was designed towards fostering national research on developing strategies for reorienting education towards a more sustainable goal [2].

Daugavpils University has also been invited to participate in this project which was intended as the demonstrative research. The results of the research will be reported in 2003 during a seminar in Grahommstoun (DAR). The problems off this research were discussed during a conference.

"*Sustainable Development. Culture. Education*" which took place in Daugavpils University in May, 2003. As a result the "*Journal of Teacher Education and Training"* was issued [3].

To be an educator in the society where everyone is given an opportunity to study and where adults can obtain the education during all their lifetime , and in the society that gives everyone a chance to act freely, is a precondition towards an open and democratic society. The realization of this condition is determined by the influence of the international environment, the initiatives of international organizations in Latvia, as well as by comprehension of the necessity of life-long education [4].

The aim of art education is determined by the requirements of the State Syllabus of Art Education, that is aimed to foster a development of a creative, as well as emotionally and intellectually educated personality for whom art is one of the ways to understand oneself and a world. The State Syllabus can help to determine the aims and the tasks of art education in higher educational establishments in the context of the sustainable education.

The key concepts of pedagogy are education, teaching, knowledge, skills to find new meanings. It is very important to acquire new knowledge and skills to meet all new requirements of our time. Education can not be viewed narrowly within the framework of an educational institution.

All the society is involved in the educational processes - students, teachers, university professors, parents, the representatives of all social groups in order to survive, to meet the requirements of our time, to develop, to grow personally and professionally.

It brings forwards the task to our educators to provide a person a chance to continue education all his or her lifetime. The main emphasis is on self expression as well as to acquiring communicative skills.

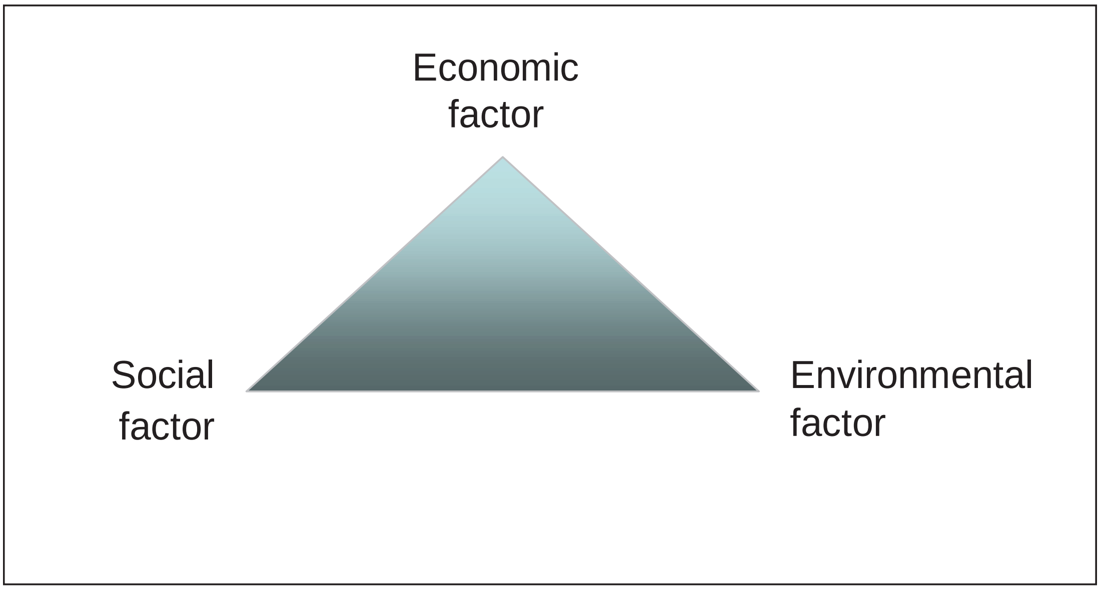
Sustainable development has three components:

- Environment;
- Society;
- Economy [5].

In the dictionary of pedagogical notions sustainable education is defined as education which is characterized by the stability in a long time span. Such an education can be ensured by the clearly defined strategic guidelines.

Thus, to ensure a sustainable art education it is essential to define the strategic tasks. Strategy is described as detailed plan of action for the long term goals. The highest art of management that includes understanding of regularities of management and the use of the results of the research for preparing, planning and implementing socially significant processes [6].

Varies interpretations of the meaning of a sustainable education in different sources help us to define three main factors of the sustainable art educational strategy. These factors form a triangle, on the top of which is the environmental factor, the second is social , and the third is economic factor (1st drawing).



Drawing N 1.

All three factors are interdependent and supplement each other Sustainable development is a difficult concept to define; it is also continually evolving, which makes it twice as difficult to define. One of the original descriptions of sustainable development is credited to the Bbrundtland Commission: "*Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (World Commission on Environment and Development, 1987, p. 43 [7].

Comprehending Identity in the Conte t of Sustainable Education

Life is not possible without a presence of a person; it is appearing and developing constantly. The person has a self - reflective ability or self image. Self – image becomes a basis upon which knowledge and the views about ones appearance and inner world is formed. Such knowledge and notions about oneself is called “ self-image”.

A. Vorobjov has written that “Self-image” includes in itself notions about ones body, ones physical and moral characteristics, but on the other hand, ones image in comparison with others [8].

American scientist V. Dzeimss has divided “self image” as:

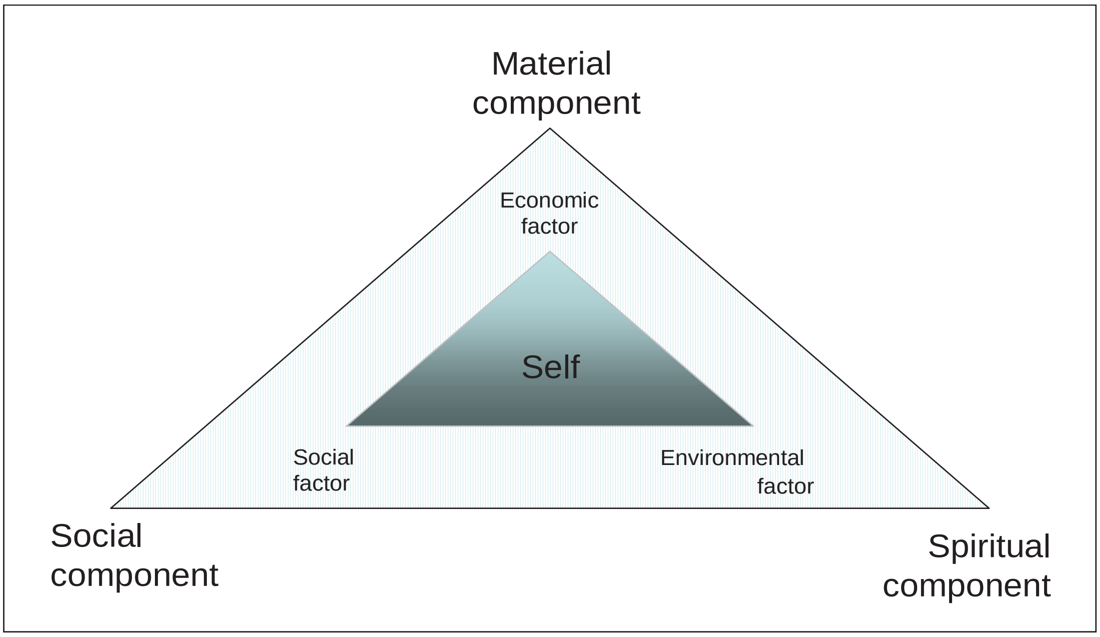
- Empirical “me”,
- And self- acquiring me”

Self acquiring “Me” is involving in the process of self enquiry, but the empirical “Me” is oriented towards results [9].

According to V. Dzeimss, empirical “Me” consists of three components:

- Material “Me” (body, clothes, property);
- Social “Me” (the evaluation of oneself by others);
- Spiritual “Me” (psychical characteristics of a person).

All these components correspond to the triangle of a sustainable education (2nd drawing).



Drawing N 2.

We can conclude that the existence of a person can be viewed as the endless cyclical movement. While being a member of a society a person needs to think of his or her spirituality. Spirituality stimulates ones material stability, which influences the development of a society in return.

American psychologist H. Kuli has introduced the notion " Me - idea" "Me" idea is an integrative notion that is formed in the process of interaction with other people. It has three parts:

1) notions about oneself as viewed by others;
2) notions about the evaluations about oneself by others;
3) self evaluation.

"Self" notion is also presented in theories of E. Erikson. He presents three aspects of "Self" identity:

- "self" – the notion includes past, present, and future;
- "self" – is a resemblance of oneself and ones stance towards tendencies harmful to ones' personality;
- "self" - a notion of oneself which underlines a holistic vision of oneself, ones difference from others [10].

E. Ericson concluded that "self" is a result of reconciliation of all contradictions , the threat between the past and future – it represents the essence of a sustainable education.
This "self" is placed in the middle of the triangle which joins all three factors of a sustainable education.

The ey features of a sustainable education

Now we can view "self" concept in the context of art pedagogy. A significant condition in the process of the development of a person according to V.Hibnere is acquiring students with local, ethnical and art handcraft. Afterwards students must learn about the national art, traditions of national culture, and different kinds of arts.

"This understanding of art fosters not only the development of a person but also gives a person creative potential for strengthening ones cultural identity. It is based on being aware of ones own Self. [11].

Persons' understanding of ones Self can be seen in ones attitude towards the world. The attitude of the person can differ from nation to nation, it can differ in various regions. The scientist from the Netherlands Kesta van Hamelinks develops his own notion of a culture. He wrote: "Each society is forced to adopt to an environment, therefore he or she establishes various relationships. These relationships form a system which can be represented as a triangle. It represents:

- Symbiotic part (language, science, art);

- Social (relationships);
- Instrumental (technical, tools) part [12].

This all play a significant role in development of a person. This helps to involve a person in the socialization process - to educate him or her, by choosing a profession, for a creative work within ones profession and developing ones potential.

Our research indicates that “self” image is a relatively stable system consisting of notions about oneself on the base of which one can develop relationships with others and oneself. These are the social, material and spiritual values of ones nation which form a cultural phenomenon and become is a determining factor.

Conclusions

Sustainable development has three components: environment, society, and economy. These factors depend from each other as well as supplement each other.
Empirical “self” consists of three components of “self”: material, social and a spiritual “self”.

The existence of a person can be viewed as a cyclical process. One needs to think about ones ongoing spiritual development. Spiritual development stimulates ones material stability that determines social development in return.
Self image is a carnal that unites three key factors of a sustainable education.

References

1. Rosalyn McKeown. *Waste Management Research and Education Institution* - www.esdtoolkit.org/
2. Salīte I. (2002). *Teacher’s views on the aim of education for sustainable development* - Skolotajs, N5 - p.4-10.
3. *Journal of Teacher Education and Training*. (2002). Volume 1.Publishing house “Saule” of Daugavpils University; *Journal of Teacher Education and Training*. (2003). Volume 2.Publishing house “Saule” of Daugavpils University.
4. Koke T. (2002). *Pedagogical bases of long-term training.* - Skolotajs, N2, p.4-8.; Liegeniece D. (2002). *Introduction in training of adults.* Riga: RaKa, p.5.
5. Rosalyn McKeown. *Waste Management Research and Education Institution* - www.esdtoolkit.org/.
6. *Glossary of Pedagogical terms* (2000). - Editor Blinkena A. Riga: Zvaigzne ABC, p. 66.
7. Rosalyn McKeown. *Waste Management Research and Education Institution* - www.esdtoolkit.org/
8. Vorobjovs A (1996). *Foundation of Psihology*. Riga: Macibu apgads, p.270.

9. *Ibid.* p.271.
10. *Ibid.* p.272.
11. Hibnere V. (1998). *Art activity of children*. Riga: RaKa p.125.
12. Zitane L. (1997). *History of Culture*. Riga: RaKa, p.14.

Random Digital Clouds – A Generative Art Approach

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1. Random Digital Clouds – Computer Generated Drawings

1.1 Analogue and Digital Lines

Lines drawn by humans with their hands are - in a certain way - alive. Mind moves hand and the feeling of the drawn lines, their visual impression, the sound of the movement of the pencil on the paper, are returned. The „smoother“ the used media are, the more potential for freedom is in this interplay of perception, thinking and action. Digitally generated lines are „hard“ - in a double sense: Their algorithmic definitions have to be very strict, the only freedom is in the design of these algorithms and usually ends when the output starts. As well this output of digitally generated drawings doesn't permit much tolerance. The device follows exactly the digital model within the scope of its physical possibilities.

1.2 Intentions

Not important what kind of (drawing-) technique is going to be used, being digital or analogue or both, techniques are always just media to express certain concepts. It is of lower importance in what this concept consists and what fundaments it may have. The intention of putting something into a different content can lead towards art and this intention is commonly before the process of creating (or generating) art starts.

1.3 Starting Point – A Random Discovery

The approach of *Digital Clouds* has had no artistic intention in advance and from this point of view it is discussable whether it can be categorized as being (generative) art or not. It is based on a random discovery that then was carried on further: A small experiment on evolutionary algorithms tried to evolve a surface based on nine randomly distributed points towards a plane. Some of the surfaces of the intermediary stages between the random starting point and the desired goal have been exported as vector graphics. Mistakes in the export process led to effects, which somehow have been disturbing the digital aesthetic of the images: lines missed where they should be, other lines appeared where they shouldn't, background lines came to the foreground, and so on. The results seemed to have some characteristics of handmade drawings. Due to these effects the formerly senseless line-bulks started to make sense. The more time one was looking at them, the more meaning could be found - similar to the discovery of figures in clouds slowly passing by.

2. Experiments and Results

2.1 First Experiment - Structure

Starting from this random discovery a simple script was written, which used the same workflow than the experiment described above. This script (a macro file for the CAD-Software IDEAS) places three splines in a fixed construction space. Each one of the splines is defined by three randomly distributed points. Then the splines are connected with a surface. There is a high probability that the resulting surface are self intersecting because of the random distribution of the points. (See Fig.1)

Then the scripts sets the isoline density of the surface to an average value, the display method is changed from wireframe to shaded hardware, the surface object is exported as a *.cgm file and deleted. Then the *.cgm files are opened in Adobe Illustrator and in a batch process the stroke weight is set to 0.5 points and the stroke color is set to black. A sequence of 123 files have been generated by this script in the first experiment.

Figure 2 shows the first 15 figures of this sequence.

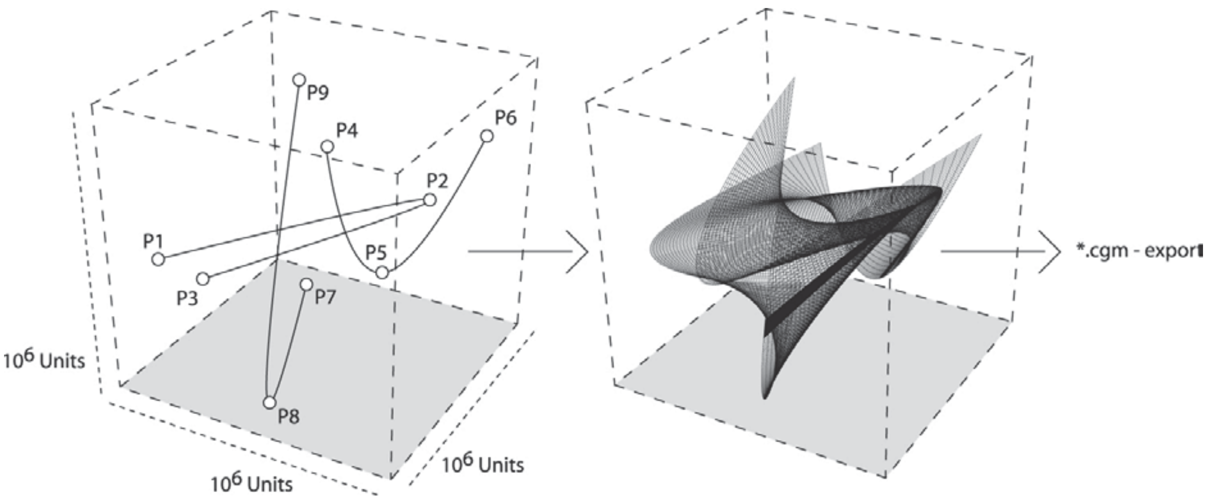

Fig 1 – Basic Script Structure

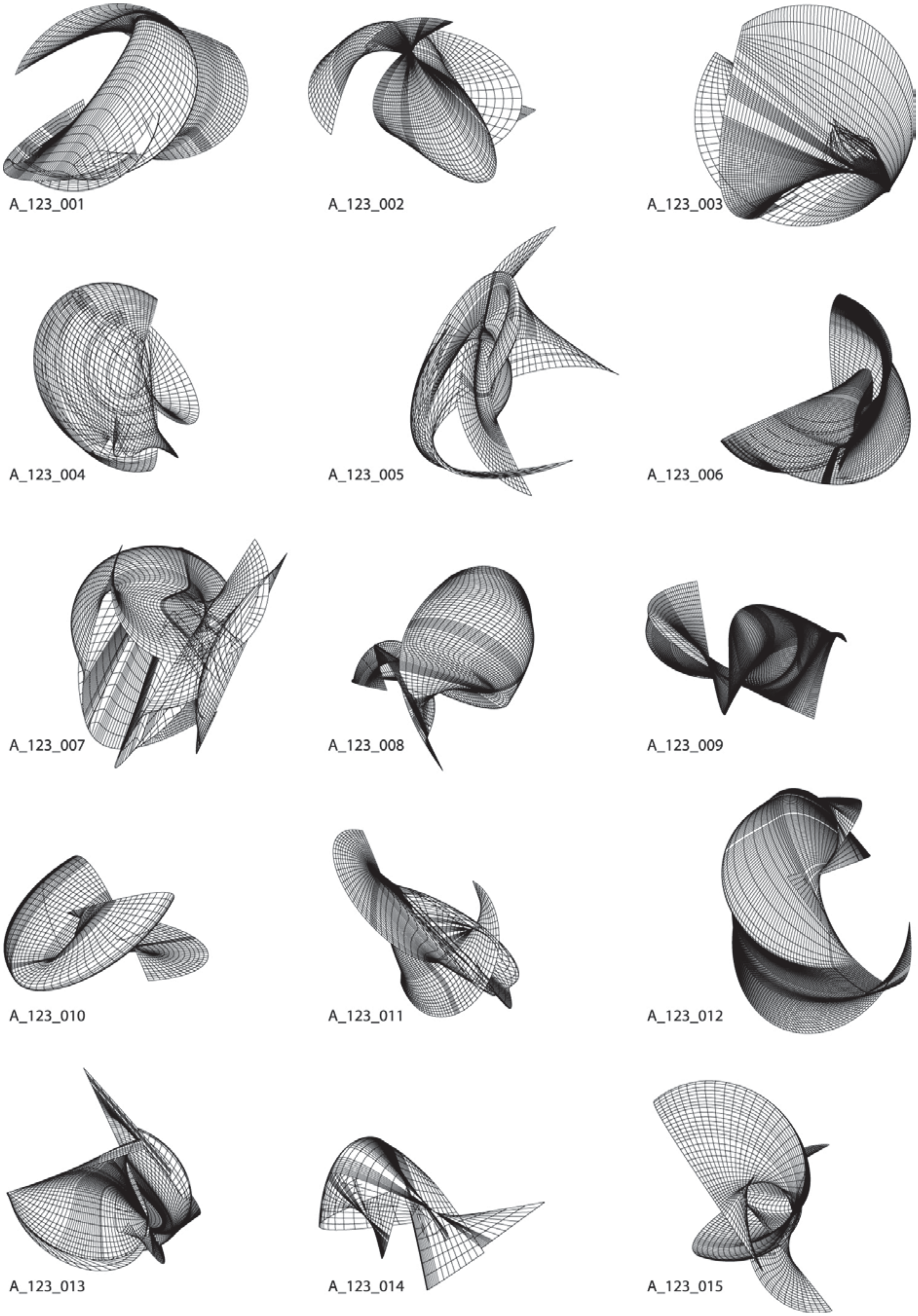

Fig 2 – First 15 of a Sequence of 123 Generated Events

2.1 First and Further Experiments - Results

The experiment showed the expected results. Among the 123 generated events there have been some which seemed to be more interesting than their neighbors. A few of them even had the potential to cause associations of something concrete. But the density of results of this kind of quality was quite low, about 5 from 100 events, which figured out as an average value later. Also some other parameters could be identified that are restricting this approach of generating drawings:

a) The mistakes in the process of vector file generation, which at least is the base for this approach, could only be achieved with one single and unfortunately six years old computer. Consequently the computing time to generate the images was very long (About two days per 1000 events).

b) To increase or to lower the number of splines and/or points per spline doesn't improve the results, in contrary: In the first case the resulting structures have been too dense and the computing time again slowed down tremendously. And in the second case the resulting structures became so boring, that they didn't resemble anything.

c) The line structures attained their best effect only within the range of a certain size and a certain stroke weight. The bigger the structures have been scaled, the more distance to them has been maintained to discover something, but with increasing distance the single lines started to disappear and the whole thing lost its character. And in a very small scale the lines partially melted to black dots.

The insights gained by the first experiments set the basic framework for the generative approach. After that it only remained to solve the problem of how to deal with the generated raw material and to chose and adequate form for presentation.

2.2 Abundance of Images

The digital construction space is defined as a regular cube with edges divided into one billion units each. This means that theoretically 10 to the power of 54 different surface objects could have been generated. Actually 15.000 have been generated as raw material for this project. Printed out of 80g paper, this still makes a pile of paper of about 1.50 m. For not getting lost in this enormous amount of different images, very strict rules for the further work on the raw material have been defined. The only allowed operations have been: Rotating, scaling and collecting various images in one file. High-resolution inkjet plots in different sizes from (40cm to 40cm until 70cm to 100cm) have been used as output media. This way of presenting the project was chosen to strengthen the analogue touch in the digital nature of the line structures.

2.3 Interpretations

The interpretation of the material started to fall into place while dealing with the generated material. When starting to organize the material, concrete and abstract categories came into existence automatically: fishes, dwarfs, fantasy creatures, bird heads and bodies have been drawing their borderline from erotic, ridiculous, warlike or quarrelsome shapes.

From the delight of searching and discovering without purpose about 90 graphical works resulted. Each of these works has one of such categories as main point of emphasis. The following Figures are showing 1:1 details from the original prints.

The whole project will be shown at the end of January 2004 in an exhibition in Erlangen (Southern-Germany) and be published in a catalogue.

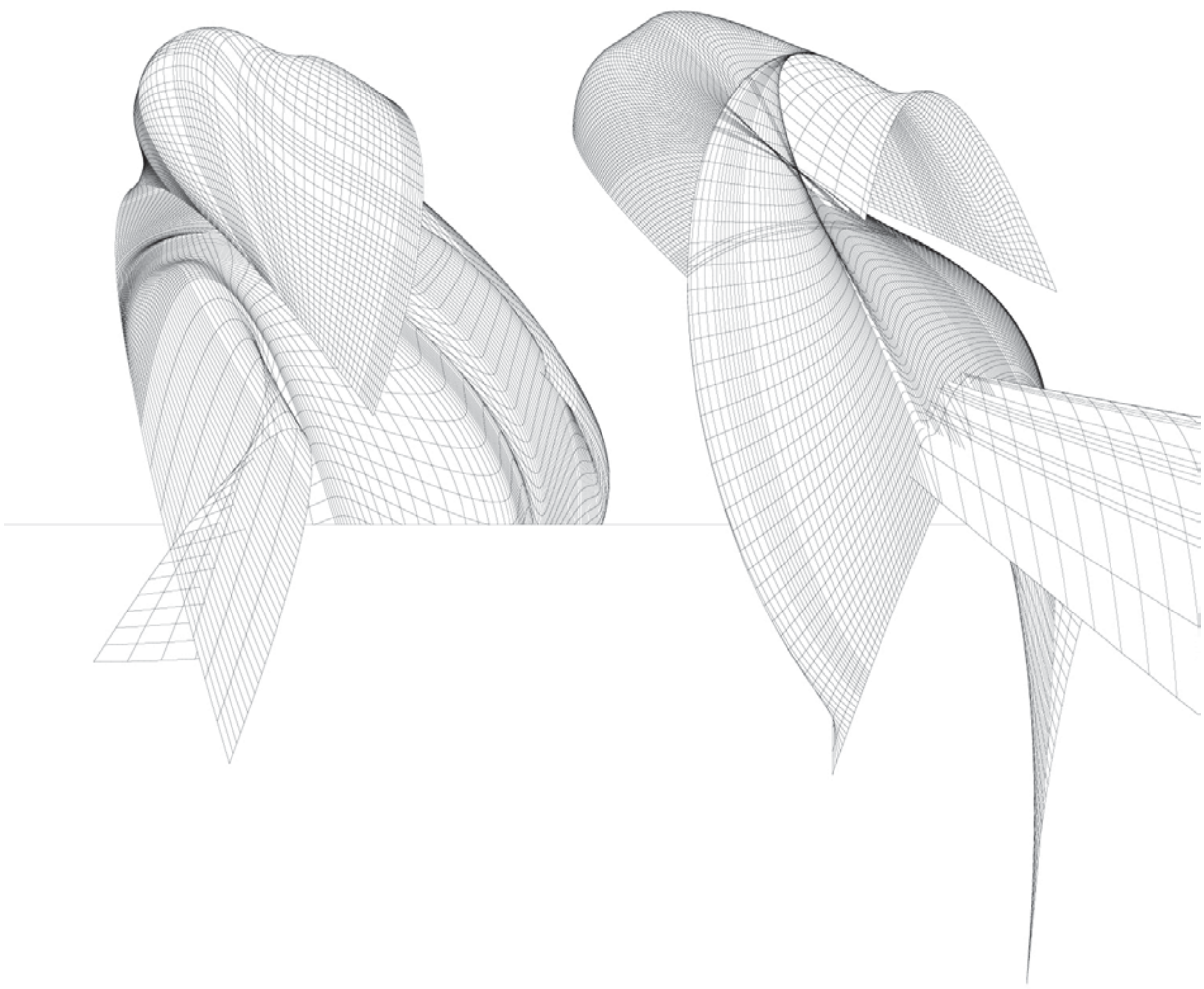

Fig 3 – 1:1 Detail of : 4birds_03 – size: 70cm x 50 cm

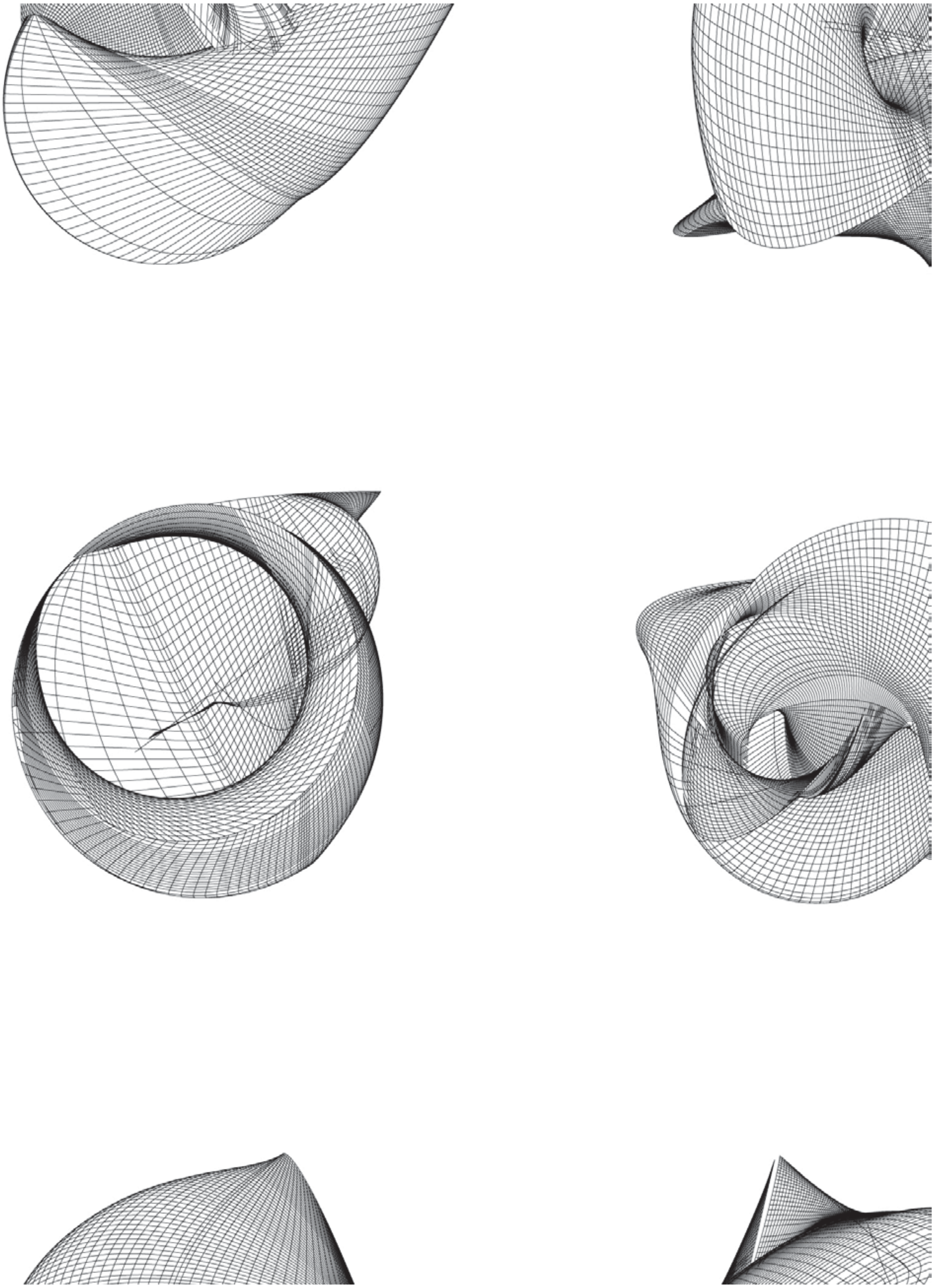

Fig 4 – 1:1 Detail of : shells – size: 100cm x 70 cm

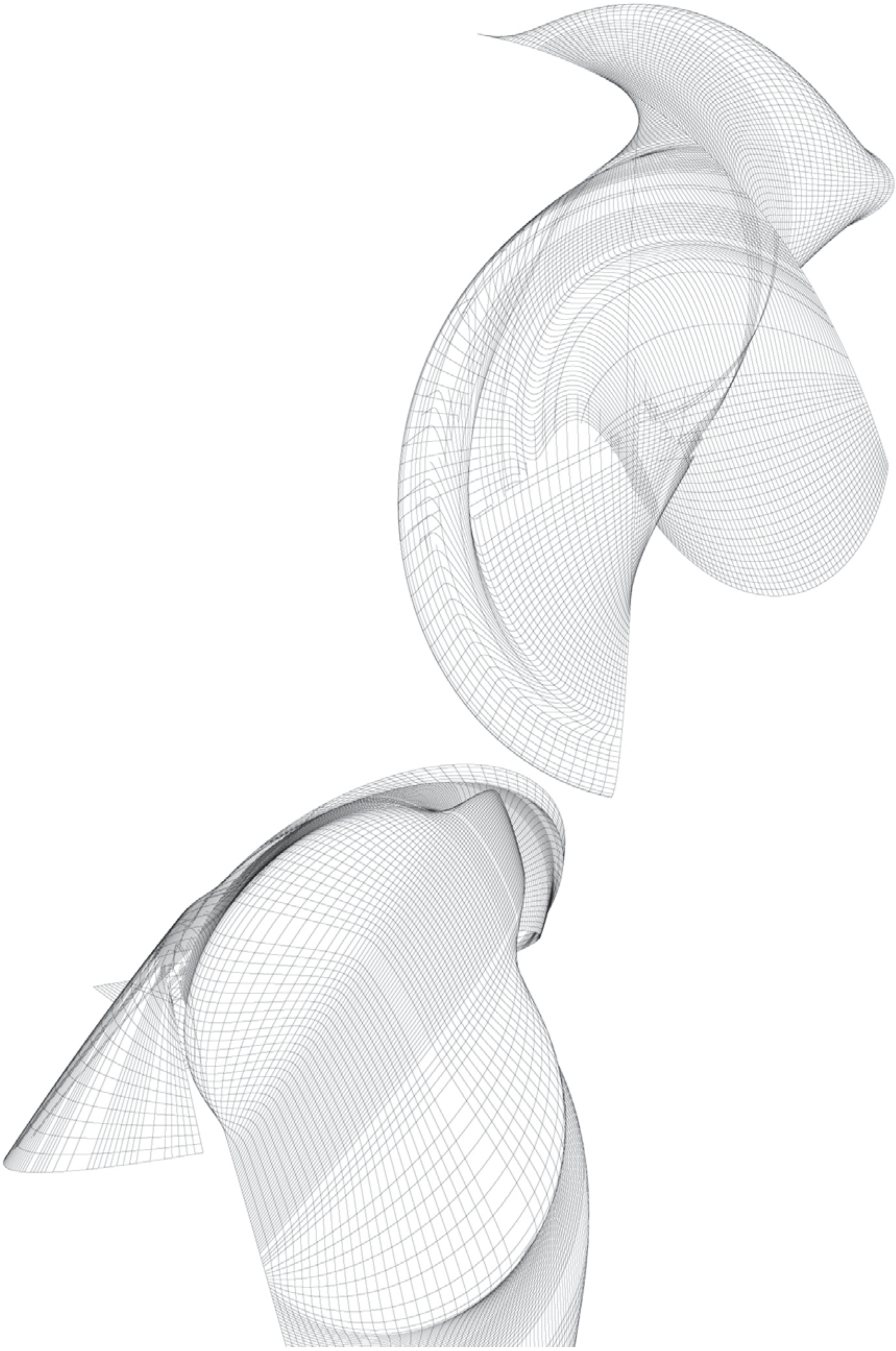

Fig 5 – 1:1 Detail of : akt_03 – size: 40cm x 40 cm

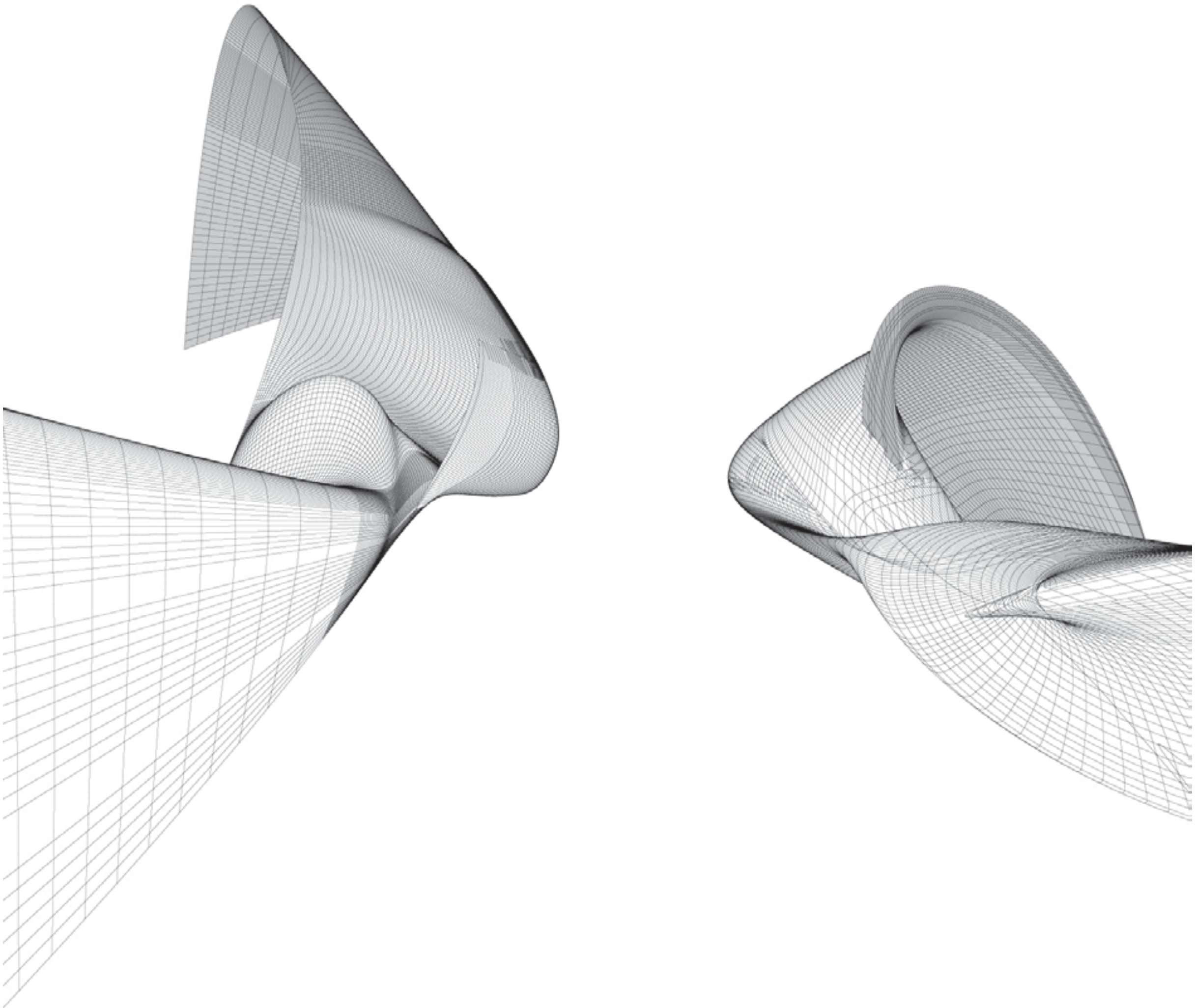

Fig 6 – 1:1 Detail of : imps – size: 50cm x 40 cm

3. References

The main source of inspiration for this project was the line art of Hans Dehlinger. More:

http://www.uni-kassel.de/~dehlwww/

Breeding new designs
The use of morphing algorithms in design computation

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Abstract

This paper proposes new ways of using morphing algorithms in design computation. The use of morphing algorithms in design processes is not really new however the intention they are used today. If the method so far was exclusively used in the fields of optimization and engineering design, it has the potential to gain new meanings as a generative form-giving tool.

Morphing is the transformation of a form by the effect of forces. These forces can be naturally arising or freely invented forces. Morphing based optimization procedures usually use naturally arising forces such as air resistance.

The approach described with this paper examines the form manipulation on the basis of invented forces, represented by the geometries of goal forms. The use of goal forms allows the intuitive manipulation of product-designs without sophisticated mathematical knowledge and therefore may attract attention to a large group of designers.

Introduction

Discussing the use of morphing algorithms, probably everyone remembers Michael Jackson's music video "Black and White" directed by John Landis in 1991. Different faces are transformed continuously into others. Nowadays these effects are everyday business in the fields of visual media.

While the mentioned music video only transforms two-dimensional picture sequences, morphing became a standard operation in 3D Animation today. The geometry of a character in position A is transferred into a geometry of the same character in position B. The computer calculates the intermediate positions and creates a smooth movement. In animation morphing is the continuous transformation of a given starting geometry into a given goal geometry. Morphing designates the way between two conditions and thereby describes no end of intermediate conditions.

However computer applications permit not only the change into given goal forms, but allow transformations on the basis of physical rules and regularities today. The animation of clothes or water is a well-known example. The appearance of fabric or water corresponds to naturally arising forces like gravity or wind. The necessary models and algorithms were invented by engineering sciences [1]. The best known example is done research on the construction of bridges. The simulation of naturally arising forces determines the construction of airplanes and ships as well. The shape of an airplane depends on the airflow, it depends on the interaction of internal and external forces [2].

While the effect of these forces had to be examined with the help of complex and time-consuming models in the past, nowadays they can be computed on the base of procedures like Computational Fluid Dynamics and Finite Elements Method. The output of these models is the result of a morphologic evaluation focusing on optimization. However to compute constructions like bridges or airplanes, the functional requirements need to be defined by mathematical expressions. The need of sophisticated mathematical knowledge may be one reason why this method was exclusively used in the fields of optimization and engineering design so far (Figure 01).

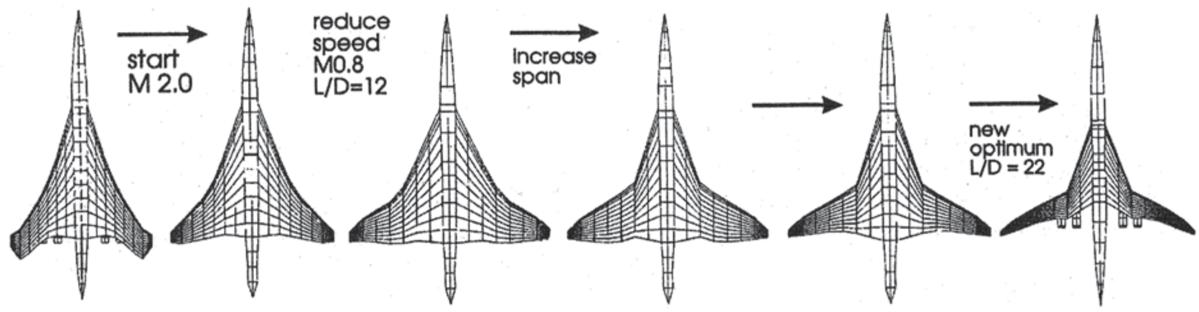


Figure 01: A supersonic aircraft is optimized for the subsonic region, A. van de Velden [3]

If we try to give a general definition at this point, morphing is the transformation of a form by the effect of forces. These forces can be naturally arising or freely invented forces. Morphing based optimization procedures usually use naturally arising while morphing based animation uses both, naturally arising and freely invented forces.

The use of morphing algorithms as a generative tools

As described above, the use of morphing algorithms to optimize various constructions seems to be a common method in the fields of design. But what is going to happen if one shifts the origin intention to gain variety of forms instead of reducing variety to an optimum? What is going to happen if one excludes the optimization for the time and uses morphing algorithms in the way they are used for animations?

The form of a design A is going to be transformed into the form of a design B. Thereby the computer calculates the intermediate geometries and creates a film sequence, which can be stopped at any point. If one stops this sequence before reaching the end, if the dynamic process of the transformation is frozen before reaching the goal form, one receives a design C showing characteristics of design A and design B.

Regarding the biology one can describe this procedure as a generative process: form C is the result of interbreeding shape A with shape B. But C is just one out of infinitely many solutions. Similarities between this process and breeding animals or plants are obvious: Breeding is the goal-directed evolution within one species and creates variations of already existing species. The advantage of this analogy is in fact that one neither need to know how the characteristics of an individual are represented, nor how they pass on. When humans began to domesticate animals and to cultivate plants, they could only observe the results of interbreeding procedures. Only many years later the first theories of genetics arose.

Nevertheless it is briefly to be dealt with the black box of morphing algorithms: Mesh morphing, meaning the continuous transformation of a three-dimensional starting geometry into a three-dimensional goal geometry, is described as a two-stage process. It is differentiated between preprocessing and interpolation. During the first step, the correspondence between the geometries needs to be determined. Therefore they get divided into corresponding surfaces and transferred into the same virtual space. The intermediate geometries get computed during the interpolation. This sounds simple at first, but if one is looking at today's applications most implemented morphing or blending procedures do not obtain acceptable results in all cases (Figure 02). A good morph should be received as a natural and smooth change, the corresponding elements of the starting and target object should turn into each other (nose to nose, ear to ear etc.) and if possible no artifacts or recognizable errors should occur.

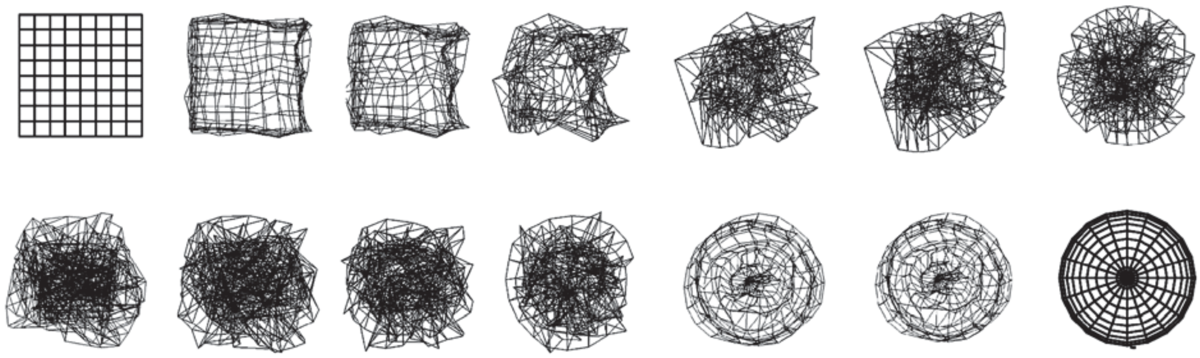


Figure 02: Continuous transformation between a cube and a spere (Maya)

According to the two main processes, preprocessing and interpolation, there can be defined two central problems of mesh morphing. The correspondence problem, which point of the starting-geometry corresponds to which point of the target-geometry, and the vertex path problem (interpolation problem), on which way does the point reach its destination.

The actual solutions to solve the correspondence problem can be divided into two groups: The first relies on dismantling the geometries into corresponding and parametrizised surfaces by the user. It allows control of the correspondence information, however it is connected with substantial work and can only badly be supported by the computer. The second solution suggests an automated dismantling and parametrizing of the geometries. But this gives little control to the user and succeeded so far only for certain model classes. Intensive research at the GRIS (Institute for Graphic Interactive Systems) of the technical University Darmstadt is accomplished to improve this second solution. The goal of the research is to expand the automated correspondence identification to a large class of geometries and to improve the users control [4].

The second large challenge is the interpolation. The frequently used naive-linear interpolation may cause intersections and deformations of the geometries. These problems can be avoided by interpolating lengths and angles instead of points [5] or by introducing an additional skeleton [6].

Although the central problems of mesh morphing are solved, yet, a practically working system is not available [7].

Breeding coffee- and teapots

If one remains with the metaphor breeding, the first step is to select a species. In this case coffee- and teapots were selected. Above all this has practical reasons. Only rotated geometries were selected, since their two-dimensional description contains all information necessary to transfer them into the three-dimensional space. There is no difference whether the coffee- and teapots are morphed in two or three-dimensional space. Thus the problem of missing algorithms to morph three-dimensional geometries can be by-passed.

After this, suitable breeding-pots need to be selected in a second step. The Internet offers a huge stock of images that can be used as gene pool. With the help of the search engine Google the Internet is scanned for images referring to the search words "coffee-pot" and "teapot" in order to meet a preselection. This preselection is reduced to thirty images due to further criteria such as symmetry of the body, distinction or quality of the picture. In a third step the selected images need to be converted into vector geometries (outlines). Thereby potential interference factors (background, unequal resolution etc.) can be avoided (Figure 03).

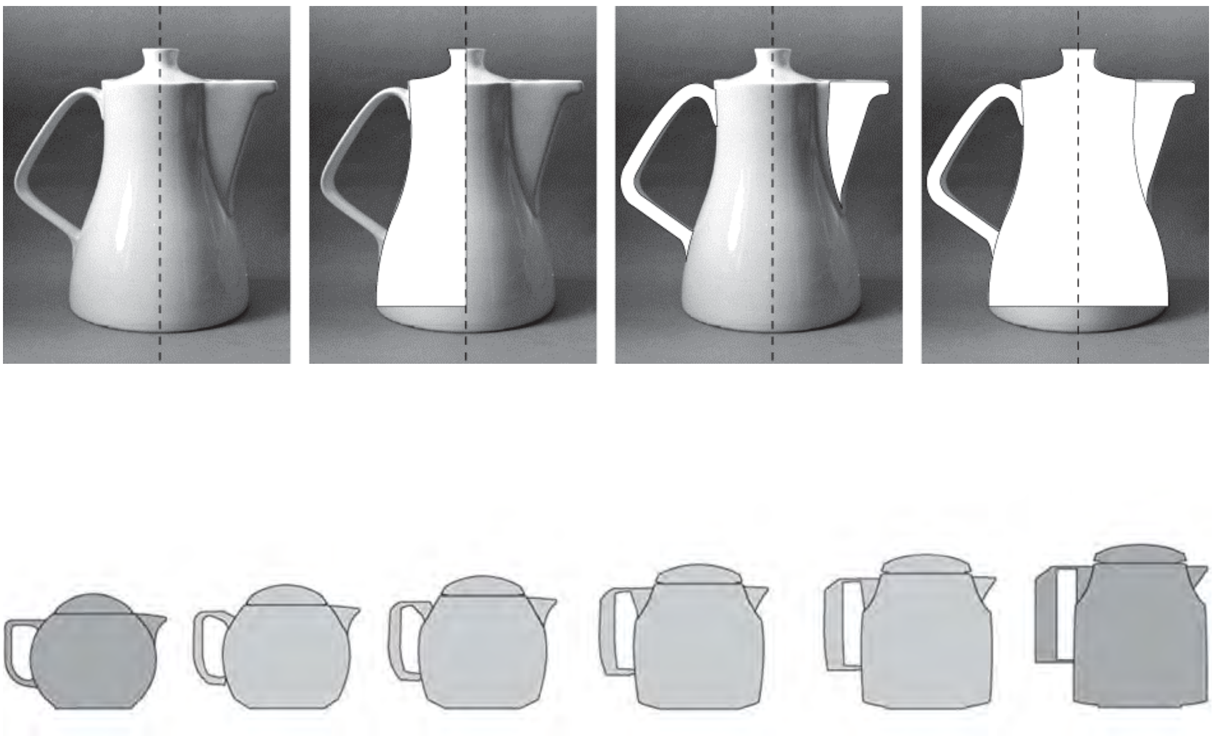


Figure 03 / 04: Transformation into vector geometries / Morhing of complete pots

In the first series of experiments each of the 30 input-geometries is morphed with the 29 remaining. With every morphing process 20 intermediate geometries are computed. Thus altogether 8,700 new geometries or descendants result (Figure 05). In order to create a second and third generation these new geometries become input-geometries themselves in the next series. That means, a selection of the descendants (first / second generation) becomes parents of the second / third generation.

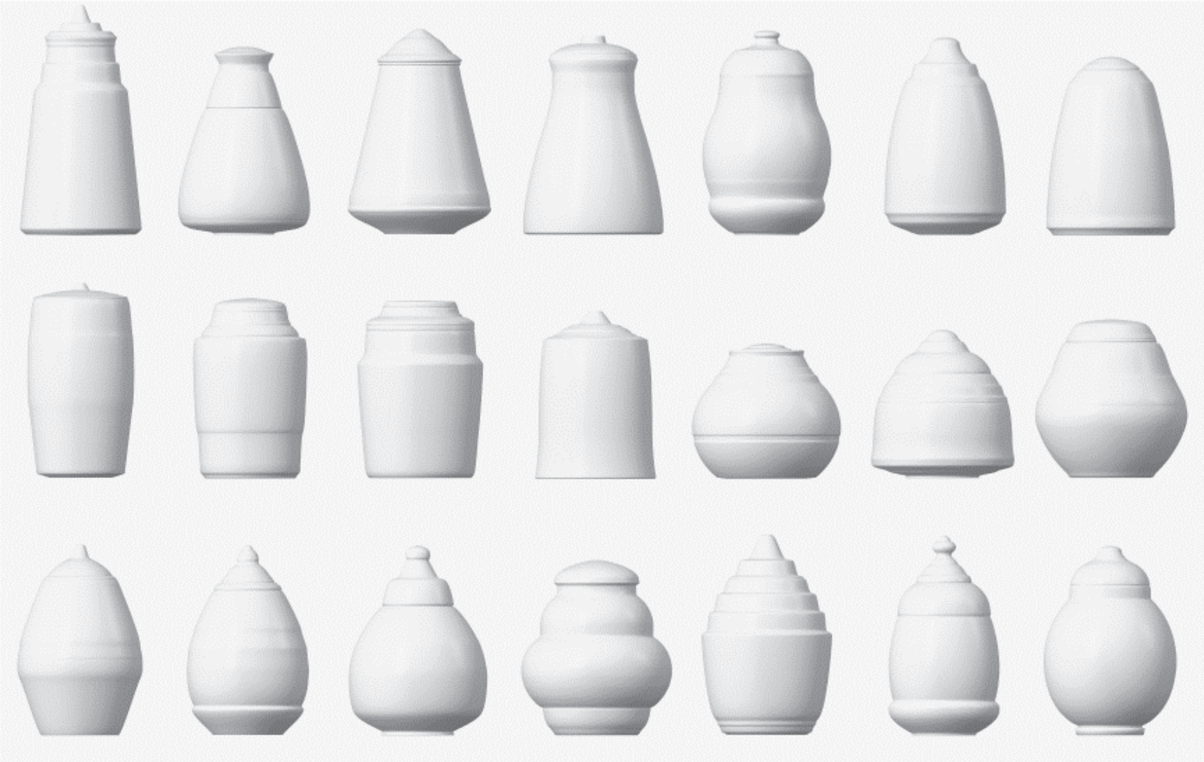


Figure 05: Selected examples, first series of experiments

Briefly regarded, all resulting bodies appear as suitable new coffeepots. In its appearance some of them are quite close to the original objects, while others do surprise. The following can be held: The more strongly the topologies of the input-geometries deviate from each other, the more frequently surprising results arise. And the more closely the topologies correspond with each other, the easier the results can be predicted. Facts that do not surprise particularly, if one consider the basic principles of morphing algorithms. Nevertheless surprising observation can be made. Some resulting shapes are quite close to well-known coffee or teapots, although these have not been part of the morphing process.

The results of the first two series of experiments refer to a special problem: Because every input-geometry is limited on its body outline, most results can hardly be identified as coffee or teapots. Typical characteristics are missing. The results rather suggest associations to vases or urns. For this reason a selection of complete pots (including handle and spout) is morphed in the next series (Figure 04). This series examines the validity of the principle and thus the validity of the two preceding series of experiments.

The solution space of morphing operations

The morphing operation requires at least two input-geometries. They mark the starting point and end of a linear transformation process. Thus in this case the solution space can be described as a straight line, limited by two input geometries. All descendants of this morphing process, as well as all descendants of the subsequent generations, are positioned on the same straight line. In morphing processes this straight line is usually described as time axis. The starting geometry always obtains the value 0 and the goal form always the value 1.

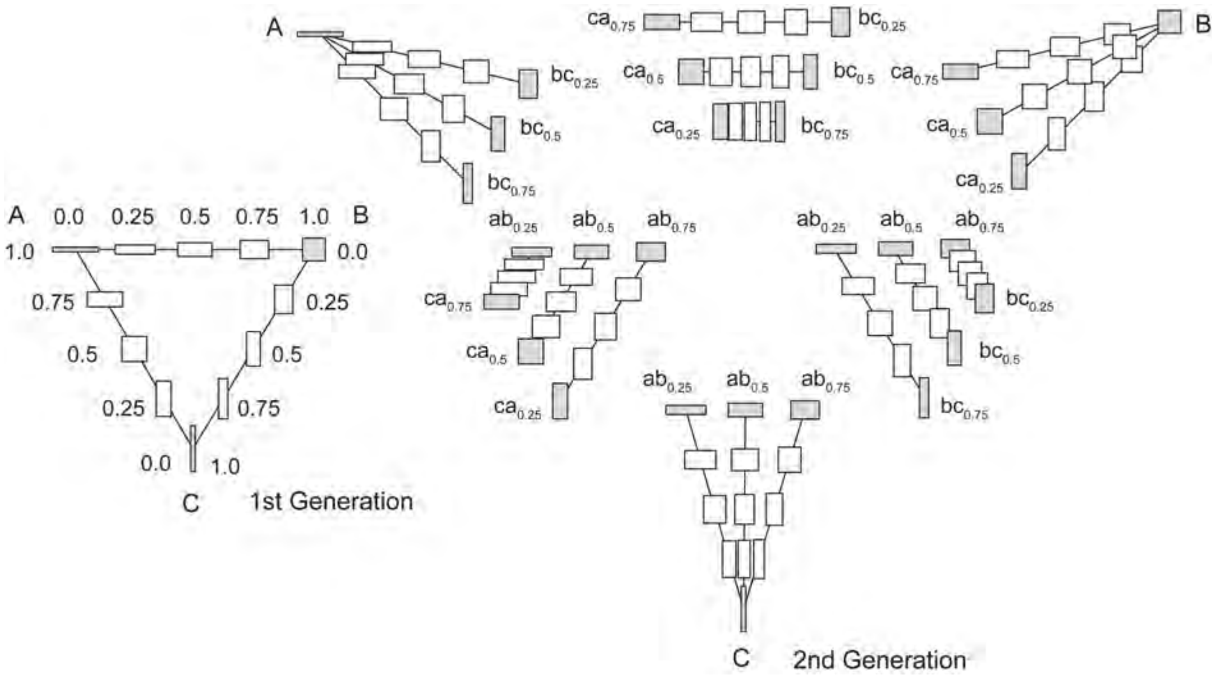


Figure 06: Solution space of morphing operations based on three input-geometries

According to the number of intermediate stages this time axis is then partitioned equally. If a morphing operation creates two intermediate geometries, the axle is divided into three parts. The first intermediate geometry is described by position 1/3 and second by position 2/3. According to this 10 intermediate geometries are described by the positions 1/11, 2/11, 3/11,4/11 etc.

The solution space of morphing operations based on three input-geometries can be described as a triangular area. Straight lines between the three geometries define the two dimensional area. In order to check the validity of this model the second and third generation were examined. Within the triangular solution space morphing operations can be described with the help of straight lines. These lines are running crosswise and intersect at certain points but every intersection describes only one geometry. In order by-pass peculiarities or inaccuracies, caused by the morphing algorithm, only basic geometries were used in this experiment (Figure 06).

According to the preceding examples the solution space, limited by four geometries, can be described as a three dimensional area. And like before, at every intersection only one geometry is described.

Morphing processes can be controlled with the algorithm and the input-geometries. If one takes the algorithm as given and unchangeable only the geometries remain as variable parameters of the process. They become variable parameters of the solution space and each corresponds to one dimension. Therefore the model of the solution space depends on the number of dimensions. According to this, the solution space of the first series of experiments contains 29 dimensions. One out of 30 input geometries becomes the starting-geometry, which can be manipulated with the help of the 29 remaining geometries (parameters). The solution space of morphing operations can be described as *n*-dimensional space, whereby *n* is corresponding to the number of variable parameters.

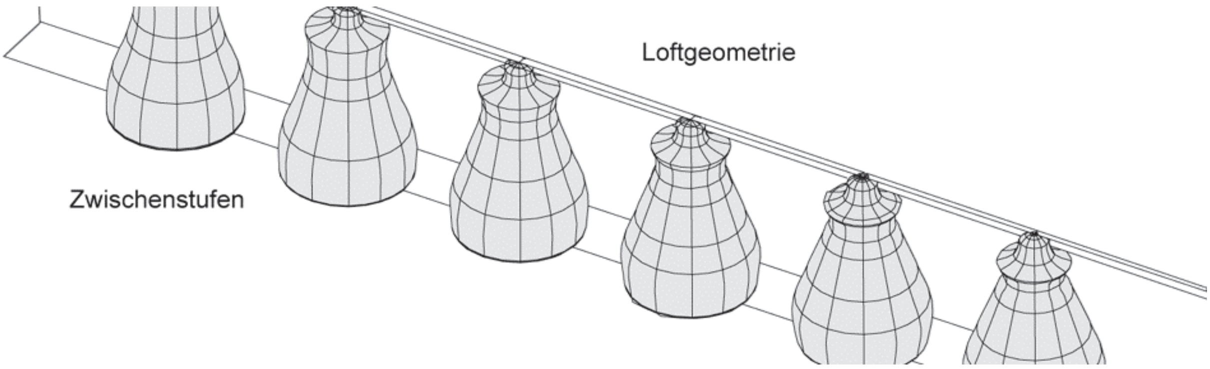
Evaluation of the solution space

The construction of a solution space does not only include increasing variety but also reducing variety. A solution space can be extended or limited by:

1) Adding and excluding input-geometries.

2) Restrictions of the morphing operation (e.g. permitted number of intermediate geometries or the restriction on a defined range of the transformation axle (time axis)).

3) The use of computer-aided procedures to evaluate resulting geometries according to defined criteria. Geometries that do not fullfill the requirements can either be excluded or modified. All criteria used for automated evaluation must be computable (volume, price, weight, technical negotiability).



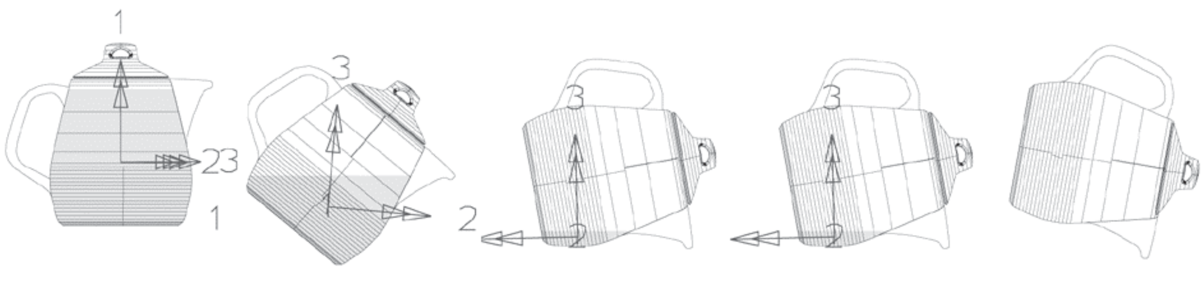


Figure 07 / 08: Simulated morpging operation (I-DEAS) / Automated evaluation procedure

To compute defined criteria, the morphing process needs to be transferred into computer-aided-design applications. Because the chosen application I-DEAS does not offer morphing operations, they have to be simulated by using the loft operation. The loft operation creates a three-dimensional solid on the basis of two cross sections (outlines of coffee-pots). The two cross sections are transferred into one another by a constant transformation similar to the morphing operation. New cross sections can be extracted and rotated from this solid (Figure 07). The solids, created in this procedure, can be used for computer-aided evaluation. Defined criteria can be misalignment of weight when pouring out, distance between the centre of gravity and handle necessary angle for emptying the pot (Figure 08) or size of the surface in proportion to volume.

Figure 09: Physical models of morphed nature forms

But even if all used geometries of coffee- and teapots are based on physically existing cans, the additional evaluation of physical models (scale 1:1) can be very helpfull. Physical models supply information, which cannot be computed. Surely one can try to evaluate proportions on the basis of computer representations, but with high probability the evaluation of physical models will come to different results. Experiences, gained thereby, can be formalized again and then be implemented into an automated system.

Increasing variety

In the preceding series of experiments the different geometries were always morphed with geometries of the same species, coffee- and teapots with coffee- and teapots. The solution space convinces by the large portion of suitable solutions (without consideration of aesthetic preferences). But at the same time these solutions offer only little surprises or innovations. The borders, determined by the preselection of geometries of only one species, seem to be quite close.

The following two series of experiments shift these borders and expand the solution space by supplementing by new geometries of different species. This is a big advantage of breeding designs on the computer. One is not limited to interbreed within one species, like breeders normally are. Using morphing algorithms one can interbreed every species with every different one.

The first series is using the outlines of the preselected pots, like before and additionally new outlines of glasses, posts and table legs. In the next series the outlines of coffee- and teapots are excluded. Instead of using already designed input-geometries this experiment is based on grown nature forms like leafs, blooms and branches. They are reduced to their outline and rotated along their center axle (Figure 9 / 10).

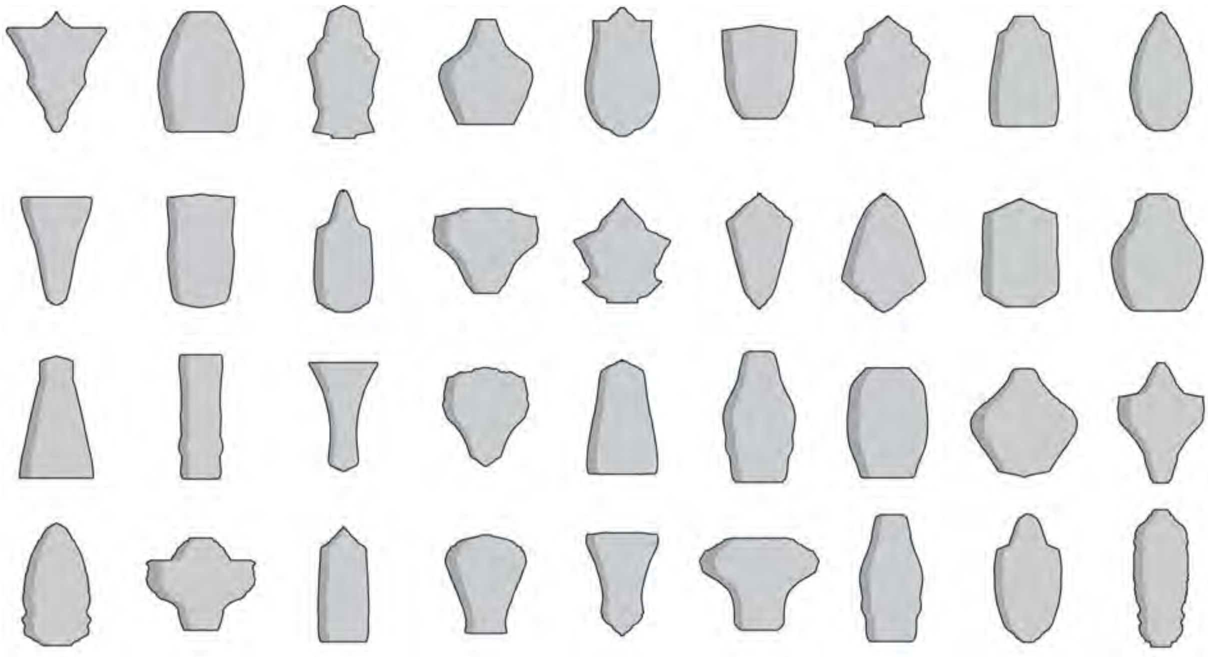


Figure 10: Selected examples, series of experiments using nature forms

The results can be summarized quite briefly. The less the input-geometries are predetermined by meanings, the more freely the results can be interpreted. In particular the morphs of nature forms offer space for free associations like vase, candle stand, streetlights or wine glasses (Figure 10). This space is only limited by the dominance of the rotation-symmetry. Thus morphing algorithms can also be used as initial-tools during early stages of the design process.

References

[1-2] Böhm, Florian: Evolutionäres Entwerfen? - Florian Böhm im Gespräch mit Sabine Kraft und Schirin Taraz-Beinholt. In: ARCH +, Zeitschrift für Architektur und Städtebau,

Ausgabe 159/60, ARCH + Verlag GmbH, Aachen 05/2002, S. 128-133

[3] ARCH +, Zeitschrift für Architektur und Städtebau, Ausgabe 159/60, ARCH + Verlag GmbH, Aachen 05/2002, S. 128 –133

[4] Alexa, Marc: Morphing von Polyedermodellen, GRIS / GDV Jahresbericht 1999, Technische Universität Darmstadt 1999

[5] Sederberg, T.W.: 2-D shape blending: an intrinsic solution to the vertex path problem Computer Graphics 27, 1993, S. 15-18

[6] Shapira, M.; Rappoport, A.; Shape blending using the starskeleton representation. IEEE CG&A, 1993, S. 44-51

YO SHI UD
irtual Puppetry ith Spiraling Interaction

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Abstract

"YONG-SHIN-GUD" is a virtual interactive puppet performance driven by sound input, such as storytelling and musical instruments. Inspired by the Korean Shaman ritual, "Gud", this live puppetry consists of 3 components: the virtual world, the real space of the performance room, and a sound activated puppet, "Virtual Shaman," who mediates between the virtual and the real. This project explores the most intimate and spiraling connections inherent in human-computer interaction, based upon the yin/yang theory and the Shaman ritual. The artist's flute playing and the audience's storytelling motivate the puppet's mouth and movements on screen with real time. The virtual puppet constantly speaks and sings back to the puppeteer, like continuous echoes and mirror reflections.

Interactive technology is an ongoing expression of human desire that has been continuously manifested from the days of primitive rituals to contemporary cyberspace. Revealing its hidden essence, historical presence and spiritual value would be the next paradigm of computer interactive art practice.

ody

rom Linear to Spiral

This live puppetry produces a true form of interactive cycles based on an understanding of the yin/yang process. Yin and Yang continuously exchange their position side-by-side without hierarchy, like the puppet and the puppeteer do in my puppetry. Each component penetrates into the other side through a membrane and is transformed into its opponent in cycles. My puppetry applies this concept to ongoing real-time lip-sync process, as the real puppeteer becomes the virtual puppet and the virtual puppet becomes the real puppeteer in cycles.
For this process, Yong-Shin-Gud requires that the performer keep watching her puppet's continuous response on screen. The puppet's response gradually motivates her musical emotional state and story telling imagination. Her instrumental performance and storytelling is inspired by the dynamic inner dialogue between the puppet and herself. For this reason, the puppeteer should face her puppet on the screen while the audience is located between the puppeteer and her puppet. The audience is not only physically, but also spiritually, placed between this spiraling dialogue of the puppet and the puppeteer.

All symbols of becoming are spirals. It is the passage from one mode of being into another which represents cosmic rhythms of interaction and eternal becoming [2]. This can be seen in lunar structure, the phases of the moon and wave, and the movement in cycles shown at the yin/yang ritual. The following steps indicate the procedure of the spiraling ascension of binary relationships:

Spiraling sequence of binary relationships

1. Inter-coexistence: There are no other relationships other than coexistence in space and time [1].

2. Inter-action: There is a physical relationship rather than a logical one.

3. Inter-dependence: By increased interactions, interdependence is also increased and helps create harmony and cooperation.

4.Inter-penetration: Developed interdependence. This is the most active and creative relationship, because it already contains another potential for new change and harmony.

In this sequence, the interactive process gradually rises up to its highest level of inter-penetration. Each binary opposition penetrates through a membrane into the other side and is transformed into its opponent, like the virtual puppet and the real puppeteer do in my puppetry. This is the ultimate stage of shamanic ritual and yin/yang, which evokes our primitive vital function of transformation. Linear flow is entwined by the magnetic force of metamorphosis and finally spirals up to the sky. Such a magical phenomenon is accomplished by the presence of a mediator, the so-called "Shaman." In Yong-Shin-Gud, the virtual sound-activated puppet is Shaman who mediates between the spiritual world and the mundane, and the virtual and the real. He evokes our repressed functions of the body and helps us to realize our forgotten selves. That's why, when people talk with the virtual puppet, they often come up with freely improvised and imaginative storytelling that would not be revealed in their ordinary life.

rom Physical to Spiritual

Interactive technology has primarily been utilized as a physical *control* device, following the tradition of Cartesian ideology, in which there is complete separation of mind from body with explicit hierarchy. It hasn't sufficiently explored its gigantic potential as a true *interactive* medium. From the beginning, this tendency to focus on the physical side of interactive technology has ignored the mental and spiritual attributes of interaction. However, no event can occur without a physical and a mental dimension [3]. Every experience is molded and completed by both the physical and the mental interactive components. Without our mental transformative perceptions, our interactive experience can't come true. Both the physical and the mental dimensions always come together to fully shape our complete experience of interaction. The physical motive initiates this action, then our mental process fills up the rest of the experience. Maintaining a balance between these two elements is important, but unfortunately, such balance is often neglected in today's digital interactive art practice. Yong-Shin-Gud, however, demonstrates a different perspective in which the body is also a strong spiritual entity which has been continuously transformed into our binary reflections, seen as objects, images and puppets. The puppetry starts with a simple physical motivational element with which to interact, and then the whole interactive process becomes more and more powerful by the puppeteer's increasing spiritual engagement with the puppet. This is the magical part of the puppetry, which goes back and forth between the physical motivation and our spiritual activation.

Figure 1. Virtual Shaman: Sound activated puppet

rom Scenario to Impro isation

"Once upon a time, long time ago…"

This is the opening sentence given to audiences when they interact with the Virtual Shaman before and after the artist's musical performance. It is the secret interface to open the door of spiritual communication and improvisation. Virtual Shaman is designed for the public, not only for the trained artist and the technician. It is a creative application of a simple technology which works perfectly in every environment. What the audience gets from this puppetry is not only the theory, but also the true interactive experience they can play with.

Everyone who enjoys puppetry can come to the microphone and be a storyteller, a puppeteer, and eventually his/her puppet. The dynamic dialogue between the puppet and the storyteller/puppeteer brings forth the energy of free imagination and improvisation in the storytelling. As in the Shaman ritual, such a spiraling interaction ultimately will erase the line between all the binary pairs, such as artist/audience, reality/virtuality, mundane/spirit and puppet/puppeteer. Yong-Shin-Gud, as a contemporary Shaman ritual, frees all those who are oppressed in our predominantly structure-oriented society.

References

[1] Bak, Jae–Joo. The Theory and Process of I Ching. Chong-Gae Sa, Seong-Nam, Korea, 1999, pp.300-301.

[2] Eliade, Mircea. Symbolism, the Sacred and the Arts. The crossroad Publishing Company, New York, 1988, pp.4.

[3] Kim, Sang-il. Hanism as Korean mind: interpretation of Han Philosophy (John B. Cobb, Jr., "Process view on Yin and Yang"). Eastern Academy of Human Sciences, California,

1984, pp.45-47.

Research on the Object on GD Application in Furnature-Designing Area

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Abstract:

As the progress of the science and technology, the places of people's producing and living tend more and more to be indoors, which makes people contact the furniture more and more frequently. Furniture are playing an important role in people's daily life.

Generative Design offers a new way for designing. Through this way, we can easily resolve those problems of large quantity or complicate process, what's more, we may draw out absolutely new results that cannot be find by the old common ways. We transplant this method into furniture-designing area to give the furniture creation a new angle of vision.

In this article we propedeuticly approached the GD application in furniture-designing area, taking the Ming-dynasty style chair for example.

Backgroud: As the progress of the science and technology, the places of people's producing and living tend more and more to be indoors, which makes people contact the furniture more and more frequently. Furniture are playing an important role in people's daily life. Excellent furniture design become one of the important ways to prove the living level of their daily life. A perfect furniture design will meet not only the needs of using function and comfortableness, but also the needs of transporting aesthetic pleasure and cultural experience. therefore, the designers are faced with a significant task: how to inherit the merits of traditional furnitures and reconstract them to make them fit the modern style life .

GA design method gives a new angle of vision to furniture creation .

Progress to know about GD:

To transplant GA into furniture-designing area, we must know what is GA ,what is its specialty and advantage.

First, what's GD. GD , for short , is the way that the computer generates numerous defferent results by re-organize the genes according to certain rules.

Second, the effect and value of GD. GD has advantage on solving such problems like: quantity problem, complicate problem, creating problem and so on.

Third, the mode of generating .

It commonly includes gene's recombination, imitation and growth.

Research on GD application in furniture -designing area(taking ming dynasty -style chair for example)

Ming dynasty -style furtifure is a most typical style in chinese traditional furniture history, which reached a very high level in techinics and arts.

Fisrt, study the character of ming dynasty-style chair, including its shape, element,construction and material, then draw out the genes. We take the elements and construction studying as our first step.

Mming dynasty-style chair has varieties in concrete shapes, including handrail-chair,collor-chair, meigui-chair and so on.Concerning the construction, it is composed with support part,seating part,leaning-back part,handrail part and other affiliated parts.Its joint is mortice.Concerning the materials, they are always made up with hardwood such as pterocarpous wood,huali wood ,huangyang wood etc;sometimes fabrics can be seen ,mainly in bakcboard or seating part,to make it more comfortable. Then we first pick out construction as our studing emphasis.

handrail-chair collor-chair meigui-chair

Supporting part includes legs,treading board and joint stick;seating part is comparably simple, sometimes changing in materials;leaning-back part includes head and backboard; handrial part includes arm,goose-neck and assistant stick.

For this step,the genes drawing is limited to prototype drawing, that is, to draw out the existing parts of ming dynasty-style chair and categorize them. In the contimuing work, we will draw out the essence ,that's to say, we will induce the conceptional genes of every parts.

Second, try it out through the way of gene’s combination, imitation or growth according to certain rules.

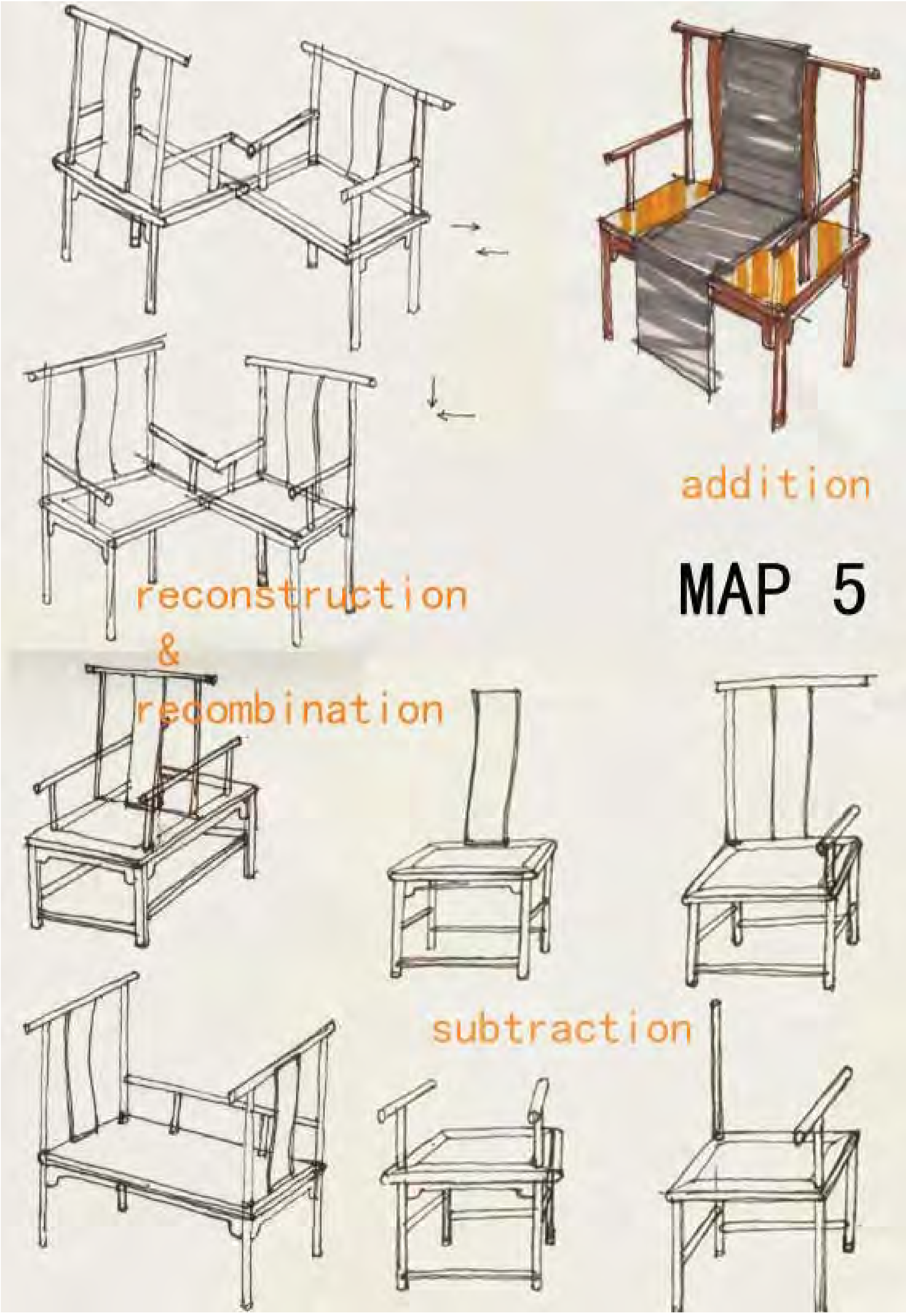
Through studing, we got the follwing stimulation factors for changing.

1. shape generating. A: retian the main outline while changing concrete pattern such as pattern place or pattern form. (MAP 1~MAP2) B: retain the patterns while changing the outline inchuding size and proportion.(MAP 3~MAP 4)

MAP 1 MAP 2 MAP 3 MAP 4

2. congstruction generating. A: change the constitution such as addition, subtraction, reconstruction or recombination.(MAP 5) B: change the joint ways such as transplanting or recreating.(MAP 6)

3. meterial generating. A: replace meterial .(MAP 7) B: compound meterial.


addition
MAP 5
reconstruction
&
recombination
subtraction

MAP 6

MAP 7

We began with the genes' recombination.,choosing 3d max as our software support. In future, we will congtinue the research about genes' imitation and growth..

fisrstly, we want to combine the prototype genes at random. Now we simply devide the whole chair into three parts: leaning-back,seating-part & handrial part. Some kinds of these three parts will be recombined at random according to the programme 1 that we have written. The results are very clear.

secondly, basing on above step, we generate a chair by controlling certain parameters, then change some comonds such as <taper><bend><stretch>in the "modifier" of 3DMAX at limited random. So we we get lots of boeyond-imaging shapes ,and then we repeat the first step recombine them at random. The course is shown in programme 2. Here follows some results.(MAP 8~MAP 9)

Long-term research plan:

GD is a monstrous project,were a very large researching space can be found .After having a full research on ming dynasty -style chair, we will enlarge our research area to common chair or even to other furnitures. Through changing the area, we may find more stimulative factors.

Reference:

1. www.generativeart.com
2. www.generativedesign.com
3. www.celestinosoddu.com
4. 《collection of "lecong"-cup furniture design match》
   Sunliang, Ganlong, Pengliang
   chinese forest-industry publishing house
   2002.11

MAP 8

MAP 9

Spiro and free jazz programming

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Abstract

Spiro is software that generates abstract organic forms which can be reused in the design process or simply viewed as artwork in themselves. Spiro was generated by a programming method more akin to fine art process than computing science. This has been given the light-hearted name, free jazz programming.

Free jazz programming and software art

Most IT related courses today teach scientific methods of software engineering. Generally most software is produced to satisfy a specific need. The software is designed right from the start and programmers will work concretely towards that end, creating code which solves the problem in the most efficient way possible. However, this method is also being taught to art and design students as a way of realising their ideas in the digital and/or interactive realm. This is in many ways anathema to fine art practise - engineering can be, at best, an awkward bedfellow or, at worst, an inhibitor of artists' work.

Artists need to see IT as a medium in itself, like a sculptor sees wood. As Henry Moore worked with stone and marble to bring out figures which he perceived to be extant or latent within the material, so Spiro works with the existing "natural contours" of IT and, in particular, Macromedia Director with its unique object-oriented programming language, Lingo.

This process can be easily described in a metaphor – that of free jazz – the best symbolic approximation we know. For the process and its free jazz equivalents, see Fig 1 below.

About Spiro itself

The free jazz programming method here started with an algorithm, or code riff , that animates a shape along a circular path. While improvising on the riff, I developed a program which produces patterns similar to those that could be drawn with the child's toy 'Spirograph' and yet not at present physically possible in the real world. No interesting or pleasing bugs occurred during the process. But the final interface for the software allows the user, again, to play with settings and number input, creating their own Spiro designs.

The art powerfully evokes organic forms such as jellyfish and primitive organisms, expressing the mathematical order woven into the fabric of the universe. It also recalls the work of John Whitney, Sr. and other early digital art pioneers.

Software art practise	**Free jazz equivalent**
We start with a block of code; an existing algorithm.	A free jazz musician starts with a musical piece or riff.
We explore the code, we play and experiment with it, building in possibilities as they occur.	The musician improvises on the riff, exploring melody and rhythm.
A bug occurs. It may produce interesting and unexpected results. We use the bug and work it back into the system.	The musician makes a mistake – a slip of the finger, an off-beat note. It may sound interesting. The musician plays the mistake into the piece.
The program takes shape. We accommodate the needs of users in a sensory interface, whether tactile, aural or visual, allowing to create their own works with the software.	The musician collaborates with other musicians on a performance.

Fig 1: Free jazz programming and its equivalents in musical jazz.

BUILDING [IN] FRAGMENTS
A Case Study on Karm El-Zeitoun

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Abstract

Classifying structures embodied in physical space and social practices have become a sub-level of understanding whereby questions like "what does it mean to build this wall in such a way and not differently? Whom does it address? And how is it functional through shaping and reflecting social practices?" Utilizing and manipulating urban and architectural semiology becomes a tool of discourse whereby meaning and form start to constitute and mutually define each other. The interest lies, however, in the mechanisms of differentiation and othering that operate as indicators of class structures and are perpetuated through the production of meanings at the social and cultural levels. The attempt of this research is to highlight and bring to the surface such mechanisms through Karm El-Zeitoun, which is the site of investigation. Karm El-Zeitoun is produced through internal social practices that are produced by the other as their other. The challenge of Karm El-Zeitoun is the fact that mechanisms of "differentiation" and "othering" function at a very specific and integral level internal to it; whereby they become visible through its production. Consequently, classifying structures become operative at the level of the city as much as they become operative at the level of Karm El-Zeitoun as an entity by itself. In this paper, I will be dealing with the notion of fragmentation through **social/physical structures** in Karm El-Zeitoun and their inter-relational dependence as one cohesive and unified network whereby the notion of dismemberment starts to entail more than dismantling objects but rather transcends that to become a **tool of discourse**. The aim of this research is to methodologically deal with the complexities of such contexts as Karm El-Zeitoun and see how we, as architects from without, can intervene within such site- specific complexities.

Introduction

Architecture has the power to talk, defy, embrace, segregate and alienate. Physical space, through projecting meanings embodied and produced by social practices and structures, which dialectically produce it, creates a lexicon of relations and conditions that become political tools of power. Physical space becomes a tool of negotiation among social classes where desired positions within class structures are transposed into desired positions within physical space. The mechanisms, operative through fragmentation at the architectural and urban/social levels, produce complex networks for our intervention as architects. Issues of differentiation, classification and alienation are integral to the course of this research through, what I will have the liberty to call an urban phenomenon, Karm El-Zeitoun. The question remains: How can we build [IN] fragments?

Fragments Defined

My interest in Karm El-Zeitoun lies in the complexities of relations, physical and social, it offers. The attempt is to fragment the place into a set of relationships and understandings, like rules to be reinterpreted later on in design interventions through juxtaposition, transformation and transcription. "If space is a product, our knowledge of it must be expected to reproduce and expound the process of production. The 'object' of interest must be expected to shift from *things in space* to the actual *production of space*."[1]

Fragment 1

Overview

Karm El-Zeitoun[2] was given to the Armenian fugitives from the Turkish genocide in the 1920's as a planned olive grove, with urban considerations (see Figure 1). It sits on the very steep hill of *Achrafieh*, on the eastern edge of municipal Beirut. It is bordered from the east, which is its lowest edge, by the river of Beirut, from the north by *Ararat Street*, which leads up to Sassine square and which is considered a main axis in *Achrafieh*, from the west and the south by *Cheikh El-Ghabi Street* and *Patriarch Douaihy Street* respectively, which separate Karm El-Zeitoun from what the locals denote as the "classy sector" where the rich and exclusive live. It happened that I experienced the place before seeing its plan, and so, as you can imagine, it came as a shock to see that a place so complex, multifarious and intricate would have a spatial organization that resembles that of an American suburbia; so organized and structured. The plan of Karm El-Zeitoun is that of a grid sliced by two main axes from which minor parallel alleys emanate till they reach the steep edges where they transform into stairs that lead down to the lower levels. Looked at today, and because of its overpopulation and mechanisms of construction, Karm El-Zeitoun seems like a place on the tip of explosion. It appears that the planning scheme which was supposed to play an urban organizing role was bluntly overwritten, denied and transcended; however, the matter of fact is that the grid reappears again; it forms defining edges whereby the overwriting and transgression starts to operate inside the limits of the block where organizing structures fail to exist as part of the planning scheme. Architecture, inside the limits of the block, falls into a game of disfiguration; it is no longer conceived and dealt with as a totality but as elements to be manipulated, cut, pasted, replicated, connected and disconnected. Though it might seem to the first-time observer (me, as architect[3]) that Karm

Figure 1. Plan of Karm El-Zeitoun (scale-less)

[1] Lefebvre, Henri, *The Production of Space*, Blackwell Publishers Inc., UK (1998), p. 36-37

[2] Karm El-Zeitoun is the Arabic translation of "Olive Grove" because that is what it was before the Armenians moved into it. Today only two olive trees remain.

[3] It resembles architectural horror, chaos and anarchy to us architects because we tend to be disillusioned by the fact that we can retain control over our products; we design them to the very detail hoping to be able to fixate it as a design in space and time, eliminating the ultimate fact that once the design is realized we no longer exist. It is theirs, the users. So as it changes and transforms, we suffer the agonizing feeling of the deconstruction of our object of desire, our control and our ego.

El-Zeitoun is a site of architectural horror, of chaos and anarchy, it embodies a very intricate social system and a physical aspect underlined by the logic of need through which the issue of fortification starts to manifest itself.

Fragment 2

From the Margin to the Center to the Margin

Karm El-Zeitoun, when it was given to the Armenians as a refuge was conceived of as a field at the edge of the city of Beirut; at the margin. As marginalized as its inhabitants, Karm El-Zeitoun embraced its own community and provided a site for the permanence and proliferation of a cultural and social heritage. During the Lebanese civil war, Beirut was divided in two, by the Green Line: East Beirut and West Beirut. Each side started to expand from the center to the periphery, to accommodate refugees, thus moving away from the critical central zone. Consequently, areas that once were at the edge of Beirut became central to their own portion of the separated city. After the war, when Beirut was unified once again, areas like Karm El-Zeitoun found themselves in the heart of the city surrounded by populated and well-established areas from all sides. However, this integration did not last long, for a new kind of marginalization began to formulate. The post-war period witnessed the emergence of new class structures with the return of rich Lebanese migrants and the nouveau-riche; a fact that created new boundaries in the social fabric of the city. These boundaries manifested themselves physically in the space of the city thus emphasizing class differences through the appropriation and production of a localized web of sites in different parts of Beirut led by the star-site, the Beirut Central District. Consequently, Karm El-Zeitoun was again located within an edge condition; an edge condition that is not defined by physical boundaries which can be easily transgressed, but by a complex network of social, cultural, economical and political boundaries that are so tightly structured that they become very difficult to transcend. [To rent a house in Karm El-Zeitoun it costs an average of about $150/month while in places like Cap sur Ville, an apartment's rent is about $2000, excluding maintenance and service expenses].

Fragment 3

Aesthetics of Conformity

A very significant phenomenon that would capture the imagination of any observer in Karm El-Zeitoun is the attempt to aesthetisize the river front of this "ugly and chaotic" area. Ever since the renovation and unconditional intervention of Solidere in the BCD (Beirut Central District), it has become the reference of what is to be considered "beautiful" in the city; spick and span, polished, well-organized, and so on. It was a *dream* come true for a lot of people in Lebanon, whether they were in power or not, but since such a drastic and gentrifying project was not possible to implement in all parts of the city, new techniques were devised. Instead of "cleaning up the mess" it was

Figure 2. 9:05 Round the Clock

more feasible to "shove the dust under the carpet." In Karm El-Zeitoun for example, the Lebanese government commissioned a French organization "Help Lebanon", in the summer of 2002, to paint the river front of Karm El-Zeitoun with nice colorful murals of up-scaled clock towers (see Figure 2), trees, clouds and a blue sky frozen in time all year long. The project entails dressing up Karm El-Zeitoun in colorful garments hiding the inadequacies that the place projects on the rest of the city thus disillusioning the foreign full-of-dollars investment-hunting eye. The government, consequently, found that the best way to deal with "problems" like Karm El-Zeitoun is to drop a curtain on it and pretend it does not exist. The extent by which the front of Karm El-Zeitoun is conceived as a façade to the city is extremely visible by the marks and edges of paint, detaching the façade from the rest of Karm El-Zeitoun like a screen.

Fragment 4

Stacking / Layering: A New Condition

The Armenians exploited their newly granted land and began to construct their dwellings there within the limitations of the planning scheme. During the Lebanese civil war, different groups from different parts of Lebanon came to Karm El-Zeitoun, partly as a refuge and partly to exploit the employment opportunities which were lacking in their cities or villages and which the capital was able to provide. The main advantage they saw in Karm El-Zeitoun was the fact that housing there was cheap. Both parties, the Armenians and the newcomers, took advantage of each other; the Armenians made money by renting their rooms or houses, and the newcomers were happy to find accommodation at such low prices. So, the number of inhabitants increased drastically and the existent houses were no longer sufficient; new solutions had to be devised and implemented. The fact that Karm El-Zeitoun is physically bounded from four sides made a horizontal extension impossible to attain; therefore, the expansion had to happen vertically. One on top of the other, people started to build their dwellings from other dwellings, where the roof of one became the porch of another, windows became doors and doors became walls. Karm El-Zeitoun is involved in a constant additive process taking full advantage of its physical givens; nevertheless, retaining the stepped quality of the hill thus providing sunlight and air circulation to the insides of the place (see Figure 3).

Figure 3. The Current Condition of Karm El-Zeitoun

Fragment 5

Street / Stair Redefined

One of the most significant features of Karm El-Zeitoun is the combination of a street / stair network resulting from the overlapping of a grid and a steep topography; whereby the parallel character of the streets transforms itself into crooked stairs to accommodate for the extreme change in levels with very defined edges. The gridded street network provides a sort of an edge that defines the building blocks adjoining it; whereas, the stairs are defined by the blocks that surround them. Sometimes the stairs penetrate the houses, go over them, above and in between; their landings become porches and their steps become spaces for socializing, playing cards, drying laundry, cooking smelly food like frying fish or barbequing, sunbathing on a good day, and so on. The stairs gain new meanings and start to function differently; they no longer are mere access ways but spaces with an acquired social baggage of meanings. The streets, similarly, become impregnated social spaces but that function slightly differently. The main difference between the social context of the street and the stair is the fact that since the street lies on a relatively horizontal plane, it provides a better setting than the stair for commercial arteries to emerge, and, consequently, the form of social relationships that materializes is more intermixed, variable and juxtaposed rather than domesticated, private and limited as is the case with the stairs.

Fragment 6

Ethnic / Religious Composition

The first residents of Karm El-Zeitoun were Christian Orthodox Armenians. Later, other Lebanese Christians moved in, in addition to a group of Muslim Shiites from South Lebanon. The new community formed groups of different religious and ethnic backgrounds organized in clusters in Karm El-Zeitoun defining new boundaries of social interaction and power structures. In the last five years or so, however, new residents moved in, constituted of foreign labor forces i.e. Sri Lankan and Ethiopian domestic workers (mainly females), in addition to Syrian and Egyptian laborers (mainly males) who live communally in shared apartments to minimize their living expenses and to sustain a homey environment in a foreign aggressive context. Their presence has ever since instigated friction among the residents whereby coalitions started to form according to different criteria of "othering" depending on what is at stake. Fights and harassments happen constantly in Karm El-Zeitoun between Muslims and Christians, locals and immigrant workers, and so on creating a milieu of aggression and tension among the inhabitants.

Fragment 7

The Armenian Orthodox Church: "Othering" by Self-definition

Despite the juxtaposing and overlaying that becomes a physical characteristic of Karm El-Zeitoun, one object stands out giving way to a new understanding of the social / spatial dialectics already present. The Armenian Orthodox Church presents itself as an object in space so well defined that it emphasizes the notions of juxtaposition and layering differentiating the rest of Karm El-Zeitoun from itself. The church is the only religious institution in Karm El-Zeitoun, despite the multitude of ethnicities and religious backgrounds present, that functions as an icon and signifier of a power structure that is asserted through its presence. It is so well taken care of, newly painted and clean, independent of the surrounding fabric whereby an empty space is created around it. Aside from its religious connotations, the church becomes a tool for manipulating the power structure in Karm El-Zeitoun; it identifies a group of people, the Armenians, and presents them with the right of territoriality and dominance. The function of the church as an object of power becomes more and more crucial with every newcomer to Karm El-Zeitoun; it immediately puts everyone, non-Armenian Orthodox, in opposition as the "other" to itself, claiming the Armenian body as the "identity" of the place, a localized physical object.

Fragment 8

Fixed vs. Mobile Tools of Power: Chair vs. Wall

In an attempt to understand the physicality of Karm El-Zeitoun as a potential tool of power, two forms of physical elements start to manifest themselves: the ***mobile*** and the ***stationary***. The chair (see Figure 4) is present in Karm El-Zeitoun extensively in the public space, creating a pattern of physical objects which are mobile, mutable and extendable. The chair becomes a tool of power, a social practice, projecting gazes, monitoring social practices, extending the boundaries of the private space into the "public" space. The chair also plays a socializing role whereby shopkeepers sit awaiting potential customers. It becomes a trigger of conversations, chats and debates with other shopkeepers and/ or passers-by. The chair plays a major role in animating the place, defining territoriality and, consequently, privatizing the street. The chair becomes a tool of power; of surveillance and control, but, at the same time, it provides a defence system that endows Karm El-Zeitoun with security and a sense of protection. Fixed tools of power, on the other hand, are mainly the consequence of Karm El-Zeitoun's spatial organization and topography. The place provides visibility patterns that induce positions of privilege, disadvantage or parity. One is either above, under or at the same level as another. But each position takes different forms of course and that is mainly because of the richness and complexity of spatial relationships the place provides. The significance here lies in the fact that the gaze is not intentional and conscious but is actually influenced, manipulated and operated by its spatial context. In Karm El-Zeitoun, instead of forcing the gaze into the guts of houses and private sectors, one forces oneself out. Again while I was conducting my fieldwork there, I had to employ an effort not to look inside houses where people were having their lunch, chatting, watching TV, etc. in their pyjamas, linen and slippers, sometimes half naked. As Beatriz Colomina put it, "architecture, therefore, is not simply a platform that accommodates the viewing subject. It is a viewing mechanism that produces the subject. It precedes and frames its occupant".[4] My discomfort in Karm El-Zeitoun, however, was not the consequence of its spatial organization and the relationships it creates, but mainly because of the social practices associated with my breeding and social education where the public and the private are very well defined and where it becomes taboo to peep into other people's private spaces. The reason why I relate that to social practices is the fact that while I was feeling extremely discomforted, and a bit ashamed, for having to

Figure 4. Privatizing the Public

[4] Colomina, B., "The Split Wall: Domestic Voyeurism" in *Sexuality and Space*, Princeton Architectural Press, NY (1992), pg 83

gaze into the insides of houses, the inhabitants, though they clearly were able to spot me, were indifferent to my presence; in other words, they were used to it; it was an inherent practice in their social life and existence.

Fragment 9

The Roof: A Space of Deviance

The additive process of construction that characterizes Karm El-Zeitoun has led to a very intricate interconnected roof system which diminishes in-between spaces if not completely eliminates them. It creates a platform of juxtaposed planes, stairs, thresholds, gaps, intrusions and extrusions that form a continuous fabric projecting, transcribing and transforming ground 0. The roof becomes an indicator of transforming typologies and changing relations creating new conditions in space. It becomes an apparatus for transgressing boundaries whereby acts of deviance begin to manifest themselves. Mireille, a student, moved into Karm El-Zeitoun with two of her friends because of its proximity to their university and its very low renting rates. They have to work at night and come back at one in the morning if not later. They are perceived and surveyed by their neighbours every time they leave their apartment and every time they come back. For girls to live alone and to go out and come back at such late hours and whenever their wanted is a situation foreign to the inhabitants of Karm El-Zeitoun; it is a state of deviance. However, this deviance manifests itself through physical space by the appropriation of the rooftops as spaces of resistance to overpower and manipulate a social pressure that does not accept an "other" lifestyle. Mireille and her friends, being aware of the intricate network the rooftops provide, exploit it to exit and access Karm El-Zeitoun at "inappropriate" times; they go up to the roof of their building and move their way out by transgressing interconnected roofs till they reach the main street where they go down the stairs of an adjacent building onto the street, and consequently, to their chosen destination in the city. Another event, that actually has transformed the rooftops of Karm El-Zeitoun into a legend, is the story of Garo. Garo was an outlaw who lived in Karm El-Zeitoun and who was chased by the police for seven years. During those seven years, he never left Karm El-Zeitoun but used it as his hideout. Through local social support and a rooftop network that functioned continually as a means of escape, he was able to defer the police from capturing him several times. Consequently, the rooftops of Karm El-Zeitoun, interconnected and continuous, cease to be spaces of excess, where water containers, antennas and old useless objects are stored or disposed of, and become spaces with social significance affecting directly the lives of the inhabitants. They become hideouts, means of escape and transgression, projecting the non-possibilities of the streets and alleys of Karm El-Zeitoun to another level creating a new layer of a social / physical interdependence.

Finally, as a conclusion, the main question remains: how feasible is our process of design, which entails the production of meaning through representation, within a context like Karm El-Zeitoun where meaning is produced and reproduced through lived space? Can these fragments act as an interface between a site and an architectural or urban intervention, and in what ways? For people who deal with the physical, with objects, it is important to be able to inject oneself into a process that would allow for a shift from dealing with a context as *objects in space* to an actual *production of space*. This fact would allow for architecture, as a discipline, to transgress the boundary of mere formalism and attain the complexity of a social/spatial dialectics; thus becoming more of a ***social art*** rather than a set of mere fashionable attempts.

Acknowledgements

I would like to express my utmost gratitude and appreciation to the people who taught me how to learn, my advisors Chairperson Prof. Howayda Al-Harithy, Prof. Rana Haddad and Prof. Marwan Ghandour.

References

[1] Colomina, B., "The Split Wall: Domestic Voyeurism" in *Sexuality and Space*, Princeton Architectural Press, NY (1992)

[2] Lefebvre, H., *The Production of Space*, Blackwell Publishers Inc., UK (1998)

The Interpretation of Dreams:
An Explanation of the Electric Sheep Distributed Screen-saver

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Abstract

The name *Electric Sheep* comes from Philip K. Dick's novel *Do Androids Dream of Electric Sheep*. It realizes the collective dream of sleeping computers from all over the Internet. Electric Sheep is a distributed screen-saver that harnesses idle computers into a render farm with the purpose of animating and evolving artificial life-forms. The project is an attention vortex. It illustrates the process by which the longer and closer one studies something, the more detail and structure appears.

1. The Client

When the software is activated, the screen goes black and an animated 'sheep' appears. In parallel, the screen-saver client contacts the server and joins the distributed computation of new sheep, an idea inspired by the SETI@home project [1].

The screen-saver is a window into a visual space shared among all users. Clients render JPEG frames and upload them to the server. When all the frames are ready the server compresses them into an MPEG animation. Each animation is the phenotype of an artificial organism, an "electric sheep". Clients download the MPEG sheep and display them one after another in a continuous, ever-changing sequence.

About once every five minutes a new sheep is born and distributed to all active clients. Each sheep is an animated fractal flame [2]. Example still frames appear in Figure 1. The shape is specified by a string of 120 real numbers—a genetic code of sorts. Some of the codes are chosen at random by the server with heuristics to avoid malformed sheep, somewhat like spontaneous abortion. The rest are derived from the current population according to a genetic algorithm with mutation and cross-over.

Figure 1

2. The Server

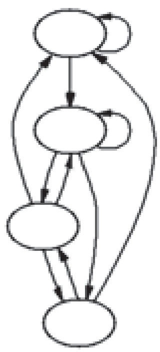
The server has a web interface for people in addition to the one used by clients. It allows users to see and download the currently living sheep as well as monitor the rendering of new ones. Clients can identify themselves with a nickname and URL and see exactly which frames are theirs. The server generates rankings of nicknames and IP addresses by the number of frames contributed. Users can visit each other's web pages and find out who else is in the community.

Normally electric sheep is very reliable and runs for weeks without assistance, but with new versions come new bugs, and at these times the ability to tweak the server live and online is essential to keeping the flock healthy. By entering a password, a user can become an administrator and delete bad frames, entire sheep, or block clients by address. An administrator can also inject a particular genetic code into the system, for example, to resurrect a sheep from the code stored in a previously captured MPEG file.

3. Life, Death, and Interpolation

A sheep's life is finite. I only have enough disk quota to keep about thirty alive on the server. Old sheep are deleted without a trace. Users may vote for a sheep by pressing the up arrow key when that sheep is displayed on their screen [3]. Popular sheep live longer, and are more likely to reproduce. Hence, the users' preferences provide the fitness function for an aesthetic evolutionary algorithm, an idea first realized by Karl Sims [4].

The fractal flame algorithm takes the genetic code and produces a still image, the first frame of the animation. The genetic code contains blending coefficients and 2D affine transformations. The animation of each sheep is produced by rotating all its transforms by 360 degrees. As a result, by the end of the rotation the shape has returned to its original state, and hence each sheep is an animation that loops.



The parameter space of sheep is continuous, and the server generates smooth transitions between sheep by interpolating in the genetic space. The original interpolation method resulted in C^1 discontinuities (angles or jerks in the motion) at the beginning and end of each transition because it was pair-wise linear, and the direction of rotation differed from the direction to the next sheep. Cassidy Curtis suggested the method used to solve this problem: use pair-wise linear interpolation, but make the end-points be rotating sheep instead of fixed.

The set of animations on the client form a graph, as illustrated by the diagram. This kind of diagram is used on the web server to represent the state of the flock. Each arrow represents an animation. The nodes represent key-frames. A sheep animation is an arrow with the same key-frame at its head and its tail, because sheep are loops. The client plays the animations by following the arrows head to tail and branching and to seek out new territory.

4. Measurements and Statistics

Clients typically store about 100 sheep totalling 9 minutes of animation and taking 250 megabytes of disk space. The server uses a free MPEG2 video encoder at a resolution of 640 by 480 pixels and 5 megabits per second.

The high resolution sheep available from the web pages and in the video documentary were born on the sheep server, then the parameters were tweeked to increase quality, and finally they were re-rendered and compressed off-line to avoid MPEG compression artifacts.

In ten days at the end of October 2001, clients from 650 unique IP addresses contributed frames to the server. Multiple users may share an address, and no attempt is made to uniquely identify clients, so the real user count is unknown. At that time about 150 clients were participating in the render farm at any one time. In the first 12 days of March 2003, clients from 4900 unique IP addresses downloaded animations from the two operational sheep servers (the second server supported legacy clients). Currently in November 2003 there are 135 clients simultaneously rendering frames, and 1700 workers within the past week. User growth is currently slow but steady. When the OSX and Windows versions leave beta I expect a surge in clients however.

The user base is limited to those with high-bandwidth, always-on connections to the Internet such as DSL, cable-modem, or university or corporate networks. Because the client uses only the http protocol on port 80 and it supports web proxies (via the underlying curl library), it can generally be used from behind firewalls and NAT boxes.

5. Development

From August 1999 when it was created until October 2001, the Electric Sheep client only ran on Linux. At that time Matt Reda released a Mac OS X client, and the number of clients quickly doubled. Despite many requests, several promises, and one near miss, no working Microsoft Windows version appeared until Nicholas Long delivered a beta version in May 2003.

Linux v2.4 included a substantial upgrade to the core Fractal Flame code including symmetries, and new variational equations contributed by Ronald Hordijk, and the new interpolation technique. The Macintosh client was not updated and its users remained cut off form the server until Mathew (his complete legal name) provided the crucial updates in October 2003.

In October 2002 the domain name was hijacked by a competing "electric sheep" site. Fortunately, after a hacking and legal scuffle, the domain has been returned and the site is back in operation, though the user base suffered a set-back.

Both clients and the server are open source and there is a developer community as well as a user community. The whole system, centered around the electricsheep.org web site, has its own buzz. The users and developers exchange messages by the discussion forum and email, and clients and servers exchange images and animations. There is an evolving ecology of agents, codes, and protocols.

6. The Vortex

Electric sheep investigates the role of experiencers in creating the experience. If nobody ran the client, there would be nothing to see. Eons ago, tiny irregularities in our universe became centers of accretion and eventually grew into stars. A parallel process unfolds in cyberspace. It starts with an idea.

The sheep system exhibits increasing returns on each of its levels. As more clients join, more computational muscle becomes available, and the resolution of the graphics may be increased, either by making the sheep longer, larger, or sharper. The more people who participate, the better the graphics look.

Likewise, as developers focus more of their attention on the source code, the client and server themselves become more efficient, grow new features, and are ported into new habitats. The project gains momentum, and attracts more developers.

And as more users vote for their favorite sheep, the evolutionary algorithm more quickly distills randomness into eye candy.

Perhaps attention acts on information the same way gravity acts on mass: attraction begets attraction and a positive feedback loop is formed.

7. The Future

Electric sheep is open-ended and very much a work in progress. For example, the server is currently a bottleneck because it must compress and delivers large MPEGs to so many clients. But if clients act as servers and become a true peer-to-peer network, the compression and bandwidth load could be distributed much as the computational load already is. This project is currently underway, and I have selected gnutella [5] as the P2P protocol because it has mature open-source implementations. A central server will still be used by clients to find each other and to coordinate basic animation parameters such as resolution and quality. The rendering, compression, evolution, and voting can all be fully distributed.

The architecture is not specific to fractal flames, and the protocol should support multiple alternate renderers. I am seeking collaborators to contribute their own generative animation software.

I believe the free flow of code is an increasingly important social and artistic force. The proliferation of powerful computers with high-bandwidth network connections forms the substrate of an expanding universe. The electric sheep and we their shepherds are colonizing this new frontier.

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References

[1] SETI@home searches for a signal from extra-terrestrials in radio-telescope data. It consists of a screen-saver client that is downloaded and installed by users all over the world, and a server that divides-up the data among the clients and collects the results. It puts idle computers to work. SETI@home is the original distributed screen-saver, and its architecture is the inspiration for Electric Sheep's. See http://setiathome.ssl.berkeley.edu.

[2] Fractal flames are the output of a particular Iterated Function System (IFS) fractal rendering algorithm created by the author in 1992. Each image is a histogram of a two-dimensional strange attractor. The flame algorithm contains three innovations: (a) It uses a collection of special functions that are composed with the usual affine matrices. (b) The intensity of each pixel is proportional to the logarithm of the density of the attractor rather than a linear relationship. (c) The color is determined by appending a third coordinate to the chaotic system and looking it up in a palette. Great care is taken to correctly anti-alias the image, both spatially and temporally (with motion blur). Flame is designed to produce images without artifacts, and to reveal as much of the information contained in the attractor as is possible. For more information, see http://flam3.com and the unpublished paper *The Fractal Flame Algorithm*, available there.

[3] Pressing the up or down arrow key transmits a vote for or against the currently displayed sheep. The server's web interface also has voting controls. In Linux, voting by key-press requires a special version of xscreensaver (part of the gnome desktop interface) to work, so it is not widely (if at all) deployed. Voting works correctly in the Mac OSX and Windows versions. The next version of the Linux client will include the modified version of xscreensaver.

[4] *Artificial Evolution for Computer Graphics*, Karl Sims, Computer Graphics (Siggraph proceedings), July 1991, available from http://www.genarts.com/karl/genetic-images.html.

[5] Gnutella was initially developed by Justin Frankel of Nullsoft. AOL (the parent company) pulled the plug in early 2000 and ordered Nullsoft to cease all development. The source code of Gnutella was intended to be eventually released under the GPL (thus the "GNU" in its name), but those plans were crushed by AOL's early intervention. Despite the crackdown, the protocol was reverse-engineered and numerous clients appeared. Today it is by far the most popular file-sharing network.

The Many Voices of St. Caterina of Pedemonte: An Experiment in Non-Linear Digital Narrative

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Abstract

The Many Voices of Saint Caterina of Pedemonte is a digital narrative published on CD-ROM, which attempts to answer questions regarding the nature of interactive participation, and its role in unveiling non–linear storytelling and meta-commentary. The story is comprised of a multitude of voices that compete and compliment each other to form a cacophonous narrative. This project aspires to illustrate the many voices, which shape our perceptions of past events and people. In this case, the authors focus on mystic saints who use starvation as a way to illustrate their devotion.

Keywords

Interactive, electronic literature, medieval, saint.

1. Introduction

1.1 Mapping the Mystical and Interactivity

The Many Voices of Saint Caterina of Pedemonte is an interactive CD-ROM, created with Macromedia Director, that attempts to fully integrate the user into mystical studies by focusing on the problematics of authorship that are inherent in many mystical texts, and electronic and web-based literature. *Saint Caterina of Pedemont*e is created to explore the possibilities of scholarly discourse in a fully interactive digital narrative. Our main objective is not to simply provide theoretical musings with attached hyperlinks, but to immerse the reader in a unique experience – arriving at a theoretical conversation through words, sound, images, and an interactive interface to tell a large part of Saint Caterina's story. Ultimately, this project is an attempt to illustrate the many voices, which shape our perceptions of past events and people using an interactive interface that endeavors to answer questions regarding the nature of interactive participation itself, and its role in unveiling non–linear storytelling.

Many differing perspectives, both modern and medieval, have formed the countless ways mystics are received on the Internet, by the scholarly community and popular culture. Originally, we had decided to use a real, and extremely popular, female saint in place of Saint Caterina, mainly Saint Catherine of Siena. After almost completing the entire written project with the "real" saint in mind, we realized that the richness of her life was being diluted by our cursory account of her existence. Even including many different voices, illustrating different facets of her life, we felt as if we were doing the saint an injustice by being just another voice that tries to subsume and retell her experiences instead of letting her story speak for itself. Saint Catherine of Siena is intellectualized in so many different circles that it became hard to distinguish our retelling of her story from the many that came before us. So, in light of these factors, we created Saint Caterina, who is a conglomeration of women that we came across in our research. We have used elements of many medieval saints as a basis for Caterina; their experiences give her shape and form. Caterina is neither entirely real, nor is she simply a figment of our imagination. Ultimately, she is meant to be a fictional saint that, we feel, still remains true to the many women who have shaped her existence.

2. Competing Voices

Saint Caterina is comprised of various sections, dubbed 'voices,' that compete and compliment each other, together forming the user's view of her life.

2.1 The Church's Voice

The first voice the viewer encounters is that of the Catholic Church. Modeled after a hagiographic retelling of a saint's life, this section illustrates the miracles and church-related happenings in the life of Caterina. Hagiography becomes a powerful tool used by the Church to not only record the lives of saints, but also becomes the first voice that constructs our idea of saints' holiness and piety. Iconographic images of Saint Caterina, which serve as visual hagiographies, further demonstrate the Church's voice. As words scroll on Saint Caterina's body, they are nearly impossible to read because of the distortion that occurs when the words pass through the image of Saint Caterina. One must listen to the narrative, much like listening to a sermon, instead of attempting to read the passage.

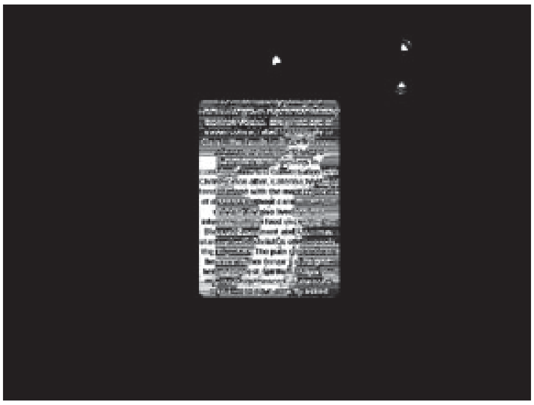

Figure 1: Words passing through Caterina

The words blend and redefine the iconographic image of Saint Caterina, as the Church rewrites her history.

2.2 The Academic Voice

The second voice that the viewer encounters is the Academic voice. Whether scholars will admit this or not, we refashion whatever we study with modern verbiage and theoretical constructions. One such text that posits a very modern answer to a medieval quandary is *Holy Anorexia*, by Rudolph Bell [1], who compares fasting saints to the modern anorexic. Caroline Walker Bynum also examines the relationship between food and medieval women, but does not automatically assume that the women she studies had eating disorders. As Bynum notes [3], her approach

> clearly assumes that the practices and symbols of any culture are so embedded in that culture as to be inseparable from it. […] the notion of anorexia nervosa […] should not be wrenched from its modern context and applied to the fourteenth and fifteenth centuries. (299)

Bynum discourages scholarly approaches to mystic studies that rely on the application of modern terminology and culture to the medieval, as it cannot be separated from the culture from which it came. In *Saint Caterina*, we play with this notion by giving a separate 'voice' to scholars. It is this rescripting of the medieval voice by modern audiences, which Bynum argues against that becomes important in the reconstitution of the identity of the mystic.

Figure 2: Peeling off the Church's voice

In this section, the viewer is presented with another canonical image of a saint and must manipulate the picture by lifting it with the mouse button to view a shadowy photograph of an anorexic woman. As the user lifts up the first image, symptoms of anorexia nervosa are displayed on the screen. This play between painted and photographic representations further emphasizes the blending of past technologies with more modern applications. It is only when the viewer is manipulating the image that one can hear the academic voice speak. Intoned in much the same way a scholarly paper would be delivered, there is no written text for the use to scan, only the voice calling on modern theory as it applies to the mystical saint.

2.3 The Autobiographical Voice

The third voice that is illustrated in *Saint Caterina* is the autobiographical voice. Many mystics used an amanuensis to produce a retelling of their life. In some extreme cases, mystics were forced to write down their stories as penance to ensure their canonization after their deaths. For these mystics and saints, autobiography becomes both a way to speak on their own terms but also a chance for the church to attempt to speak for them. Kate Greenspan [4] claims that a better term for medieval saints' autobiographies is "autohagiography" (218). Even in autobiography, true authorship becomes questionable because of the threat of the Church and because many saints used amanuenses to write their stories for them.

This section of *Saint Caterina* is divided up into two parts, as we attempt to describe the process of writing as penance and begin to introduce the voice that appears within the saint's body. Writing can be both a freeing tool and a punishment. The lack of vocal sound in both parts of this section illustrate the tie that is present between the church's dictation of an autobiography and the saint's true voice. In the first part of the autobiographical voice, the viewer encounters a disorganized array of images. As she attempts to read the autobiography by scrolling down, the words become distorted and unreadable until the viewer takes the cursor (appearing with the word "lick") and licks the spiders from the screen, just as the first sentence of the autobiography stated: "They make me lick the spiders from the walls." (Licking spiders was an actual punishment for one of the saints that we researched for this project.) Using "lick" where the user once would have "clicked" also brings the interface into the foreground of the user's experience. The viewer takes part in the autobiographical experience as well as retains an insight to the difficult nature of the autobiographical voice.

Figure 3: "Licking" over the spiders revealing the text

The second part of the autobiographical voice, examines the mystic's body in relation to her position in society and within the church. The viewer sees an image of flesh-like links forming a wall that cannot be passed.

Figure 4: A bodily prison

No matter where the viewer points the cursor, the prison remains, illustrating how St. Caterina's body, and other mystics' bodies as well, becomes a prison. There is no interruption in viewing the text, in what we see as one of the most personal narratives in the piece. In examining other mystic saints' stories and literature written for and about anchorites, a common theme represented in each is the ways in which their bodies became prisons. The imagery of a fleshy prison is also very prevalent in saints' autobiographies because it is the body that separates the human from the divine. The body also becomes the only autonomous voice that the mystic saint possesses because the church has the ability to appropriate all other means of expression.

2.4 The Mystic Voice

The mystic voice explores the concepts of *l'ecriture feminine* that Kristeva [6] and Irigaray [7] introduce in their respective texts, "Stabat Mater" and *Speculum of the Other Woman*. In this section, we attempt to forfeit words altogether and illustrate the corporeal nature of Saint Caterina's visions. Visions for most of the mystic saints were not passive experiences, but were gut-wrenching times of both pain and joy combined. The body becomes a powerful metaphor to resist the church's doctrines for Caterina. The body is the one place the church cannot sanction worship. Surprisingly, we found a simple prayer for Saint Catherine of Siena called "Prayer of Saint Catherine of Siena to the Precious Blood of Jesus," [8] which illustrates remarkably the powerful and visceral nature of the mystic's vision. Four blocks with images of blood and the body are placed horizontally on the screen. Depending on which image the viewer clicks on, the prayer can be said in many different orders. Worship, especially with the mystic voice, becomes a prayer - a direct communication with Christ through speech.

Figure 5: Four panels of prayer

The last voice, which is unnamed, is perhaps the most visceral of all that have come before. A beating human heart appears on the page. A simple story is related to the viewer about Caterina exchanging her heart for Christ's, a trope that appears throughout mystical literature. The image of the heart takes Caterina back to her own body, and also brings the viewer and Caterina to a common point in the narrative. It seems the simplest and most direct image to portray the corporealness of the person Caterina. The human heart becomes an image of the sacred heart, illustrating how a simple body-part becomes immortalized by society. Then, a narrative is read about the reappropriation of Caterina's heart back into the church, literally explaining how the mystic's voice and body are subsumed by the many different voices that describe her story. Caterina's heart, which is the part of the body that fought so diligently against the church's dictations, becomes part of a church once again. As a relic, Caterina's heart serves both as a reminder that her bodily voice lives on, and also of the circular nature of the voice itself.

Figure 6: The heart of Caterina as a relic

At both the beginning and end of the project, the user is presented with the image of the sacred heart with spokes, which lead to each of the different voices, surrounding it. Representative of the human heart, and the appropriation of the body as an icon, a smaller version of the heart floats through every voice in *Saint Caterina*.

Figure 7: Menu featuring a heart with spokes illustrating the various voices.

If the user clicks on the heart, she is taken back to the 'menu' page and can view the voices in whatever order she wishes. The story, then, becomes broken apart and interwoven with the user's manipulations. This menu function gives the user ultimate control over the narrative.

2.5 The Authorial Voice

Finally, the Authorial voice is our attempt to bring in our voice as one of the many that construct saints such as Caterina. We have included, voice by voice, a narrative that explains in some sense the reasoning behind the images and text. Not only does the authorial voice bring to the foreground once again that Saint Caterina is both a creation and conglomeration of voices and attitudes, it also reminds us that, as authors, we are not the final voice, as it is the viewer who always gets the final word and interpretation of Saint Caterina's life.

3. Interactivity and non-linear narrative

Utilizing interactivity to illustrate the different voices within the project seems like a natural choice given the tremendous possibilities that a digital interface can provide. As we have illustrated in the previous section, every voice has intrinsic characteristics that are manifested through the direct participation of the viewer. Using the authoring software of Macromedia Director, we attempt to answer questions regarding the nature of interactive participation itself, and its role in unveiling storytelling and narration. Lev Manovich [9], when considering the myth of interactivity suggests:

> when we use the concept of 'interactive media' exclusively in relation to computer-based media, there is the danger that we will interpret 'interaction' literally, equating it with physical interaction between a user and a media object (pressing a button, choosing a link, moving the body), at the expense of psychological interaction. The psychological processes of filling-in, hypothesis formation, recall, and identification, which are required for us to comprehend any text or image at all, are mistakenly identified with an objectively existing structure of interactive links. (57)

The reader or user always ‘fills in’ pieces of images, texts and stories based on their own experiences. “We all see differently,” Trinh Min Ha [10] notes; “How can it be otherwise when images no longer illustrate words and words no longer explain images?” (56). As different voices seek to give life to Caterina, so do competing theoretical and ideological structures provide new layers to any person or text that is studied. Interactivity is not then, a simple ‘point-and-click’ interface; interactivity is an emotional and metaphorical process of interaction, which are frequently undermined in favor of more literal translations.

Reflecting upon these considerations, *Saint Caterina* is particularly concerned with the appropriateness of the interaction in relation to the content of the narrative. In other words, we are interested in exploring interactive participation that not only reveals the various media (text, images, sound, etc.) but also works as meta-commentary, reinforcing the significance of the user’s experience as a whole. The combination of text, images, and sound is fully integrated as a unity by the intentional or unintentional interactive mechanism, which not only activates the different components, but also more importantly, creates a relationship between these components. “An interface is not simply the means whereby a person and a computer represent themselves to one another” posits Brenda Laurel [7], “rather it is a shared context for action in which both are agents (4). In this shared context, the interaction draws mental and literal links, and also activates resonance and reminiscence that hold together separate parts of the narrative. It is this personal series of links that users build themselves that is the true interactive experience.

Especially relevant to a discussion of the medieval and interactivity is Jay David Bolter and Richard Grusin’s [2] theory of “remediation.” Informing our methodological strategy, the notion of “remediation” explores how new media “refashion[s] older media and the ways in which older media refashion themselves to answer the challenges of new media” (15). In *Saint Caterina*, “remediation” is not only applied to different media elements within the design, but also as a strategy of questioning arbitrary or unidirectional point of views expressed by the single voices. The particular and the discretional inform the whole through participatory intervention that activates correspondences encoded in the design. As every single voice of the story possesses its own identity and spatial position that is altered in relation to the others voices, similarly, different media components in a single screen possess a specific identity and discretional value that assumes different connotation when they are "remediated" through the interactive process. Single positions are “refashioned” by the idea of complexity implied in multi–perspective, interchangeable viewpoints expressed by the constitutive collage–like, multimedia structure of the project. In other words, "remediation" represents a way of challenging formulations of control, authority and transmission of knowledge.

4. In conclusion

The Many Voices of Saint Caterina of Pedemonte is meant to experiment with the possibilities of non-linear narrative mediated by an interactive graphical interface, which ultimately encourages theoretical meta-commentary within the narrative itself. Through the usage of many differing interfaces with numerous voices, the retellings of Saint Caterina’s life are countless. By interacting with the story on multiple levels, the user must actively become a part, and construct pieces, of the narrative; thus, Caterina’s story is constantly changing. It is our sincere hope that *Saint Caterina* is able to bridge the divide between theory and artistic practice, medieval and modern, and most of all staticity and interactivity.

References

1. Bell, Rudolph. Holy Anorexia. U. of Chicago Press, Chicago, 1985

2. Bolter, Jay David, and Grusin, Richard. Remediation. MIT Press, Cambridge, 1999

3. Bynum, Caroline Walker. Holy Feast, Holy Fast: The Religious Significance of Food to Medieval Women. Univ. California Press, Los Angeles, 1987

4. Greenspan, Kate. “Autohagiography and Medieval Women’s Spiritual Autobiography” in Gender and Text in the Later Middle Ages, ed. Jane Chance. Univ. Florida Press, Tampa, Florida, 1996

5. Irigary, Luce, Speculum of the Other Woman. Tr. Gillian Gill. Cornell University Press, Ithaca, 1985

6. Julie Kristeva, Stabat Mater in The Kristeva Reader, ed. Toril Moi. Columbia Univerity Press, New York 1982

7. Laurel, Brenda. Computers as Theatre. Addison Wesley, New York, 1993

8. http://www.catholicforum.com/saints/pray0346.htm Access: January 21, 2003

9. Manovitch, Lev. The Language of New Media. MIT Press, Cambridge, 2001

10. Minh-Ha, Trinh. When the Moon Wakes Red: Representation, Gender, and Cultural Politics. Routledge, New York 1991

Creati e Artistic Acti ity of Music Teachers to e in the Conte t of the alues Orientating Education

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Abstract

In this article the author dwells upon the changes, phenomena and the related mechanisms taking place in the society, education and music education.
It is necessary to emphasize that in the centre of modern humane pedagogics there is the person as the main value and, in this connection, the pedagogical science propounds the pedagogical values which present the source for the development or for the perfection of the person. Music is also one of these sources of perfection. Therefore the problem of teachers-to-be traditional pedagogical activities has become topical today. The question arises if the model of these activities can improve the professional skills in the pedagogical process today and if this model can contribute to the quality of the teaching and educational process.
The author presents the structural model of music teachers-to-be professional pedagogical activities which appeared as the result of her long-term research. This model is connected with the specific character of music lessons. If the lesson in exact sciences is considered to be the object conducted by the teacher, then, in terms of music education, the lesson is regarded as an artistic phenomenon. In this connection and, on the basis of the results of the accomplished pedagogical experiment, it was necessary to modify the structure of music teachers-to-be professional pedagogical activities in Latvia. It was also necessary to include in the model these creative artistic activities which facilitate the revelation of a student's personality and present the variety of forms of individual development as well as the possibilities of education and the variety of choices in the pedagogical process. With the help of this innovative artistic model of the lesson it is possible to develop learners' creative abilities, to change, enrich and develop the environment, to create new socially important materials, the orientation in the system of spiritual values. With the help of this model it is also possible to prevent the traits of disorientation or these of destructive orientation in the society, due to the cognition of music reproduction, its perception, comprehension, aesthetic and emotional experience, etc., in musical activities.
In this connection, in the course of the research there were elaborated and defined the criteria for and types of creative artistic activities of music teachers-to-be. The basic criterion is the ability to plan these activities creatively and to foresee the goal. The definite subjective and objective factors, phenomena, mechanisms, which influence the quality of these activities, were considered. The conceptual creative artistic model of music teachers-to-be was elaborated.
This world can be regarded as 'artificial' rather than 'natural'. 'Artificial' in this case means 'managed by the man'. A lesson is not a natural phenomenon either, but designed by a music teacher. The lesson is often placed on the same footing as a theatre performance; though, to what degree this comparison might be correct is occasionally argued by teachers. But this is not a good thing to do, as we speak only about the resemblance, the model relations.
A music lesson includes the main components of the educational process in their interrelation: the goal, the content, the methods, the aids, the organization and the results.

The structure of a music lesson is, primarily, a conceptual model, which, however, has a very definite, practical task – this is a modelling instrument for the educational way of thinking of a music teacher.
Speaking about music as a social phenomenon, we often come across the following statement: the language of music is the language of image, emphasizing the unique character of the latter. Thus music appears as part of culture in the world outlook.
It is worth mentioning that only the survey of the individual course of life – social in terms of its content and form – makes it possible to characterize the subject of music as being social, as 'sociality' is not an abstract outward quality, but a real determining factor, influencing an individual.

Introduction

Ongoing social changes in the society and the problems of education activate the necessity to alter the model of education. Experience shows that the former traditional orientation of education to the past experience inevitably leads the development of the society to crises. But it is essential that educational strategies are purposefully aimed at the future.
Educational strategies in Latvia are to be directed to values orientating education, in which the productive model is based on creativity and humanitarian paradigm. Such model envisages the development of every personality's creative individuality, who, in his/her turn, develops new society.
A music teacher as a subject of pedagogical process is one of the main characters, who participate in reorganization of educational system.
Therefore at present the attention is paid to the mechanisms of work, which are connected with the development of every school, the source of which is to be found in music teachers' creative work in frames of their innovative activity. New elements are being introduced, new approaches to the content of education, educational technology, assimilation of the world experience are being implemented; they are aimed at realization of a personality's nature in creative work.
Having studied the most important existing approaches related to the music teachers' work and values orientating education we can assume, that there is a demand for actualization of the music teachers' creative artistic work. Thus the *aim* of the research is as follows: characterizing creative artistic activity of music teachers-to-be to study its significance in context of learners' values orientating education.
The *tasks* of the research:

1. To investigate influential factors of values orientating education, and their interaction in development of a learner's personality, and to draw up a theoretical model of the essence of values and their interconnections;
2. To formulate a theoretical justification of the concept of creative artistic activities of music teachers-to-be, and to reproduce the characteristic of the image of this work in a model;
3. To investigate the approaches of creative artistic activity of actual music teachers-to-be, and its level in comparison with the development of their professional competence during the studies.

The *methods* of the research:
Theoretical method: analysis of philosophical, art, musical, pedagogical, psychological and methodological literature, comparison of the resent tendencies in education, vocational training of teachers and music teachers.

Empiric methods: observation, documentation (reports, characteristics, diaries, etc.); *pedagogic experiment* concerning the comparison of approaches to creative artistic work of music teachers and determination of the level of this work during their studies.

Pedagogical and Philosophical Aspects of alues Orientating Education

Latvian educators and philosophers (I.A.Students, I., P.Dale, Z.Maurina, and others), as well as famous European philosophers such as M.Scheler, M.Miller, etc. and Russian philosophers (V.Tugarinov, O.Drobnickis, etc.) have turned their attention to this issue [1]. Majority of the above-mentioned authors (P.Dale, Z.Maurina, M.Scheler, V.Tugarinov, and others) admit that a person's values orientation and development of personality are in constant interaction, therefore it is important to prevent the features of disorientation or destructive orientation, because positively orientated people live in harmony with themselves and other people, thus looking for better opportunities for development of society in future [ibid.].
For instance, in Great Britain K.Swanwick in his work "A Basis for Music Education" has proposed four categories of aims for music education, including also *musical values*, considering that every person should be aware of importance of music, in which individual musical expression is possible [2].
E.Husserl (Germany) observes the significance of musical aesthetical values in music understanding and knowledge [3]. But R.Miller and P.Gang write that a person as a participant of creative process acquires his/her own subjective point of view that conforms with his/her experience. Thus the diversity of subjective opinions is developed, and in the learning process this diversity acquires its value [4]. R.Miller adds that it facilitates deepening, reconstruction and transformation of our identity and knowledge. In interpersonal interaction knowledge becomes a process of creation, in which individuals are connected with the world in active and delicate way. Thus the findings of these authors are directed to *intellectual* vales in education [ibid.].
It should be noted that in all European countries the totality of values – the system of values, which is to be implemented in educational process, has been defined.
In Latvia the system of basic educational values – ideas is expressed by the system of basic principles determined in the Educational conception. This system is to be implemented by every music teacher regarding every learner. I. states, that the main mission of the teacher is to create the *educational situation* that corresponds to the paradigm (world outlook) that is being established in the Latvian schools. It is the paradigm of humanitarian education and its basic feature is the atmosphere of objective values that is transformed into a lesson [5].
In connection with this an interesting idea is expressed by German philosopher G.Kerschensteiner. He describes the model of a lesson in relation to the *artistic humanitarian* model that is based on the following basic principle: positive, productive interpersonal relations that are based on the holistic theory of knowledge – a trend (pedagogical views that emphasize the unity of physical and intellectual, and pedagogical situation of a lesson. According to these views an individual is inseparable and acts as an entirety) [6].
We have to acknowledge that this model includes *transformation of humanitarian values* (G.Kerschensteiner's term) in learners' *awareness* and *behaviour* that occur with the help of *artistic means*. This model is closer to the specific character of a music lesson (Author's addition).
On the basis of the assumption that ***music*** is a type of art, and as any art it inquires human nature and universal features connected with it, we can state that music as a *social phenomenon* has multifunctional character, which influences person's self-development,

formation of taste, enriches his/her intellectual world, at the same time teaching to notice different phenomena in nature, everyday life, peoples' relations and choice of values.
Therefore, speaking about ***music*** as a ***discipline*** we should emphasize that establishment and development of learning process and creation of pedagogical situations are representations of a music teacher's deliberate creative activity. All of these find their expression in a definite teacher's activity, which is aimed at a definite ***values orientating education***. Thus, a music teacher has definite functions of activity. Taking into consideration everything said above, we think that a music teacher's functions are based and dependent on his/her ***system of values***. *A subjective system of values of an educator is the potential* expressed in his/her functions.
Here the question arises: how is the music teacher's activity evaluated nowadays? It is usually evaluated in a definite educational situation. But one has to take into account that this definiteness means also that the educator's activity is determined by his/her *system of values* (totality of interrelated elements – an entirety arranged in accordance with definite rules), which is carried out in a definite values orientating educational situation, for example, in learning process [7].
Hereby the music teacher should be aware of the significance of the learning process functions (instructive function, educational function, and developing function) in learners' development. It is apparent that all the functions are equally important. Special attention should be paid to educational function, for it determines the topicality of our theme. It means that this function (as emphasized by Dz.Albrehta) in the learning process helps learners to motivate the development of their world outlook, moral and aesthetical views, confidence, ideals, relations, attitudes, system of needs, socially acceptable behaviour and aspects of activity [8]. Thus the main *values orientations* within the situation of *values education* are formed and developed in the result of mutual communication, influence and interaction of the music teacher and the learners.
For example, the values education pedagogy states that it is: ***education*** that consists of *knowledge, abilities, readiness skills*, but ***the values orientation***, in its turn, is *the system of persuasions, attitudes and priorities* used by a person him/herself [9]. This system is based on a person's attitude towards values, and it is foundation of his/her viewpoints and actions. That is why it is necessary to take into account which development of structural model of a music lesson is chosen by the teacher.
For example, nowadays special attention to specific significance of development of values orientated lesson is paid by I.Belickis. The scholar emphasizes that the importance of *values orientated* lesson is *reasonable analytical depth* that depends on the level and type of education. The feature of such lesson is *dynamics* – rapid *intellectual* and *physical* alteration:

$$\boxed{\text{teacher}} \longleftrightarrow \boxed{\text{contents of studies}} \longleftrightarrow \boxed{\text{learners}}$$

It finds its expression in two systems of values: learners – teachers. There the interaction of two systems takes place, in which communication, cooperation, correlation and reciprocal influence have particular importance. In the result of the above-mentioned factors it is possible to facilitate the development of the learners' intellectual and musical needs, as well as to create conditions for the learners to acquire intellectual values [10]. The authors: Zh.Piazhe, V.Vigotsky and J.Students deal with the questions concerning the role of parents and teachers in the development of the rising generation's values. They consider that it is necessary to help the rising generation to think about values that are important for them.
In the further study of this question the authors emphasize that the determinant of a child's development is the character of adults involvement in a child's life activity, which promotes also the development of his/her values. But the Latvian scholar I.Belickis justifies the idea that in the development of a learner's values an important role is played by his/her

corresponding social status – a definite position among others. A child observes his/her "I" opportunities in comparison with "I" of other children. Thus the system, in which the learner's status is closely connected with peripeteias of relationships and development of values, is established. According to L.Zukovs [ibid.], establishing his/her values orientation the teacher influences also the development of the learners' values orientation. The greater connection between values and dispositions of both parties, the greater the teachers influence on the learners is [11].

Having analyzed the above-mentioned features of interconnection we can draw a conclusion that for every music teacher it is essential to study and understand the significance of values.

It appears that in the science of philosophy and pedagogy the explanation of the concept of the essence of value has been discussed rather widely. I.Students notes that the concept "value" in aesthetical aspect is the measure of all *the good* itself, for nothing is a value itself; it may become one only in comparison with the good. Writing about the value the author refers to is as *the highest intellectual value* [12]. But V.Zelmenis , K.Swanwick, V.Tugarinov and others investigate the development of values in connection with a person's ***needs***. They have come to the conclusion that the value is a material or ideal object in a person's viewpoint, which can satisfy his/her needs [13] (V.Zelmenis, V.Tugarinov). Educators A.Spona and V.Zelmenis, philosophers M.Kule and R.Kulis, L.Arhangelsky and others consider that the **values** not simply record and observe ongoing events, but also express **the attitude** to them. This attitude appears in evaluation: valuable or valueless, important or unimportant. A.Spona declares that **attitude** is an integrated feature of a personality, which characterizes the human nature, and it finds its expression in the aims, ideals, values, norms and principles of a personality's life. Thus developing the attitude to impersonal reality, at the same time also development of *intellectual values* takes place [14]. M.Scheler, R.Miller and A.N.Johnson, in their turn, emphasize that the actual task of philosophy is to facilitate discovery and revision of *objective value*, in the result of which a person has *to enrich his/her intellectual* world. V.Tugarinov, M.Kule, R.Kulis think that *values* exist in hierarchical order: higher and lower [15]. Therefore the music teacher's objective of educational process is the following: through the contents of education and instruction, and his/her own activity to encourage the learners to distinguish their values, *to admit individual processes, to cultivate control functions in their personal* life.

A.N.Johnson considers that every educator, who tries to help his/her learners to search for important commitments in their life, is a mental educator. This is the mission of the values orientating education.

Evaluating variable approaches to explanation of the essence of value and its interconnections we have come to our own theoretical assumption, in the result of which we have established the explanation of value and its interrelation in connection with the development of intellectual values (see Figure 1.1.). We believe that this model can serve as a checkpoint in collaboration of teachers and learners.

Having evaluated this figure we can *conclude* that it is a *systemic totality of elements of values, on the top of which there are the highest – intellectual values, such as intelligence, holiness, piety, love, deference, harmony; artistic values connected with the sphere of aesthetics, categories of ethics (good, fair, ect.), intellectual sphere: education, art, religion – people's relations, all of which functioning together are based on friendly, favourable interaction.*

VALUE is the significance of some idea, process, thing or another phenomenon for a definite person, part of society, nation, humanity. It is a very complicated phenomenon that interweaves and **arranges our life, beginning with the biological one** and ending with **the highest levels of culture and intellect.**

ESSENCE OF VALUE is connected with the totality of things, phenomena, **spheres of human activity, positive features:**

- sense of humour,
- emotionality,
- **positive attitude,**
- motivation,
- empathy,
- goodness,
- delicacy, etc., which determine usefulness, significance, possibilities of usage, **efficiency** and is connected with:

INTELLECTUAL SPHERE:

education (knowledge, mind, book, etc.);
science (discoveries, mind, creative abilities, cognition, reasoning, memory);
art;
religion (belief, certainty of opinions, humanism, grace, God's love, love to people, holiness, life, deference, esteem, mind, feelings, harmony, order);
aesthetic categories
holy, sacred experience,
the beautiful or the gentle,
right, genuine.

CULTURE:

- general;
- individual,
  musical,
- intellectual;
- culture of conduct and action;
- communication;
- speech;
- work;
- professional.

The values of culture as a totality of mental values form the basis of a person's spiritual comfort.

MORALS (ETHICS):

Morality (goodness, lenience, piety, beauty of work, action, conduct, order, politeness);
basic concepts of ethics
- good – evil;
- fair – unfair;
- honesty – dishonesty;
- genuine – false;
- sublime – sordid.

SPHERE OF ART AND AESTHETICS

(values of deep feelings, artistic vales of composition)**:**
- **aesthetic perception** (entirety);
- **aesthetic feelings** (beauty, fairness, absurdity);
- **aesthetic judgement** (moral and aestheic, beautiful, good, fair, etc.)
- **aesthetic evaluation** (sacred, genuine, beauty or fairness);
- **aesthetic taste** (emotional attitude and opinion on beauty)
- **musical aesthetics**, which reflects life phenomena in "musical images".

PEOPLE'S INTERRELATIONS,

which are based on communication and beauty, and they contain social norms and culture.
There exist:
- **positive** (favourable) **attitude** to work, people, environment, action;
- **neutral** (indifferent);
- **negative** (deprecatory).

The primary is the first type of attitude.

Figure 1. Essence of value and interconnections of intellectual values

Interpretation of the creati e artistic acti ity of the music teacher

Investigating this question we will at first turn to the activity. For example, philosopher M.Kagan deals with *action* as a form of a person's attitude to environment, emphasizing, that every action has a definite structure, i.e., totality of specific acts of activity and definite sequence, according to which these activities occur, for every activity has its grounds, goal, means, result and process. This activity is acknowledged [16].

But philosopher, who is famous in Europe, Aristotle, elaborating his morality doctrine, anticipated the connection between quantity and quality and the great significance of quantity in a person's sphere of activity. It should be noted, that more than 2000 years after Aristotle this rule was clearly and knowingly defined by Hegel. Hegel thinks that quality depends on quantity [17].

Comparing these two characteristics of activity we can establish a fact that activity is a structural and systemic aggregate, in which quantitative activities may acquire new quality.

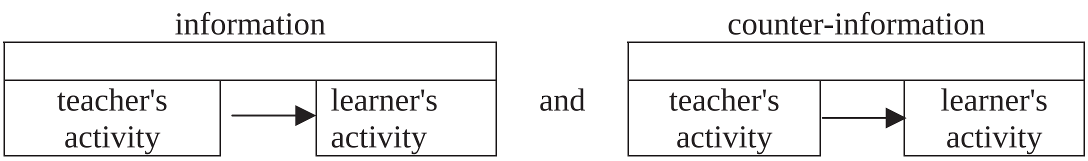
The development of this idea is closely connected with the paradigm of creative education, and that is why many scholars in Latvia (L.Zukov, I.Belickis) and in the whole world (V.Slastenin, V.Proseckis, J.Ponamoryov and others) rather often write about it generally – as about the character of creative activity of educator's profession, precisely pointing at the significance of the principle of creative activity, but not indicating its artistic sphere [18]. That is why we were interested in a more thorough research of this issue. In the result of numerous investigations, we had to come to the conclusion that attention is not paid to the music teacher's creative artistic activity.

It was not accidentally that already in the 17th century classical pedagogy, the founder of the science of didactics Yan Amos Comensky, observing pedagogic activity, came to a very important conclusion: *didactics* is the art to teach well. To teach well to do everything, to get others learn quickly, with pleasure and properly [19].

It means that the music teacher is the one who controls not only his/her own activity, but also activities of others (learners). And here it is necessary to study what the direction of his/her activity is. For instance, the world-famous representatives of didactics A.Disterveg, J.Bruner (USA), V.Klafki and others recommend directing pedagogical activity towards the principle of creativity. J.Bruner in humanitarian pedagogics takes as a basis the skill to solve problems and to transfer knowledge to a new situation. But V.Klafki holds the idea that acquisition of material in educational process has to be creative and heuristic, i.e., practice orientated, applicable in real life [20].

Thus we can conclude that the scholars discuss the direction of creative development of contents of education and cognition in order to create a possibility to evaluate the *result of education* taking into account creative abilities, level of intelligence.

Continuing investigation of this question V.Zelmenis (Latvia) pays special attention to the development of educational process. He notes that the development of educational process has its didactic functions that include teacher and learner' activities. It can be illustrated in the following way:



This model of activity can be referred to *problematic learning type* that is based on *the creative exploratory activity*. Here the teacher does not present complete information, but offers necessary consultations, at the same time evaluating learners' preliminary knowledge and quality of their exploratory activity. The teacher tries to give necessary explanations asking leading (heuristic, Socratic) questions thus facilitating learners' thinking. This type of education is intellectually effective, but it takes more time; good resource basis, sufficient preparedness of learners and teachers' methodological proficiency is essential. It is aimed at *creative process*, development of a personality's creative potential [21].

Also in Latvia one of the principles of education is the principle of *creative activity*, which means that *education* develops and activates and individual's creative personality [22].

Y.Yakovleva asserts that *creative process* itself is the expression of a personal individuality in the light of personal emotional conditions and feelings. But investigating the development of a creative personality's potential the author proposes the main principle, which is as follows: *principle of transformation of cognitive content into emotional one,* and *creative activity (creativity)* as the realization of a human being's personal individuality [23]. But for a personality to realize him/herself both in this and cognitive activity, according to the theories elaborated by outstanding European scientists (H.Gardner, S.Arieti, E.Torren, Y.Ponamaroyov, K.Stanislavsky, and others) direction of creativity is necessary, as well as mutually connected features of personality such as:

- intellectual structure in which function the following mechanisms: intuition, cognition, analysis;
- creativity;
- character;
- physical processes: thinking, memory, imagination;
- attitude;
- abilities;
- morality;
- level of culture and education;
- emotionality, etc.

K.Stanislavsky adds that creativity is formed by the totality of activities of thoughts and feelings. V.Proseckis and other scholars express the idea that *activity* includes elements of *imitation* and *creativity*. V.Proseckis states that imitation is reproduction (reflection), but *creativity* – invention. The author admits that imitation and creativity are interrelated and are included in each other [24].

Thereby V.Proseckis views the development of an individual's activity in accordance with the following scheme:

imitation copying	—	creative imitation	—	creative work of imitation	—	fair authentic creative work

The scholar emphasizes that the problem of correlation of imitation and creative work is especially apparent in activity of young teachers. Their creative activity has a character of imitation. In this context it is a phase of creative individuality's development, which in perspective, when free of imitation, leads to fair and authentic creative work [24].

We think that the proposed line of the development of an individual's activity is very close and specific to professional activity of music teachers-to-be, which is aimed at development of activity.

Psychologist A.Vorobyov (Latvia) emphasizes that in any process of creative activity it is possible to notice three phases:

- a phase of preparation, when the goals are set, possible ways of problem solution are considered;
- a phase of correction of implementation of new images and opinions and their carrying out in a real object, phenomenon, etc.

- a phase of *approbation* and implementation of a new object (phenomenon).

Thus *creative work*, according to A.Vorobyov, Z.Freud and other scientists, is a person's activity that produces new material and *spiritual values*. Creative work is ability (that appears in the result of a person's activity) to create from the material 'offered' by reality (on the basis of study of interrelations existing in the objective world) the new reality that satisfies the needs of extensive society. Creative work is determined by the character of creative activity (creative work of an inventor, scientific and artistic creative work, etc.) [25].

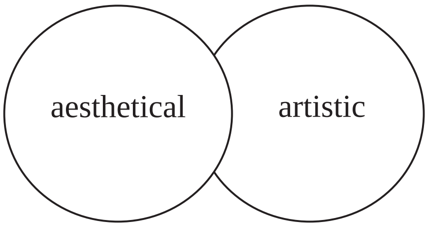
As noted by scientists of pedagogics A.Disterveg, A.Lihtvar, R.Shteiner, satisfaction of society's needs is closely connected with *artistic value*. A.Lihtvar proposed to introduce artistic value into all the subjects. Emotional experience was brought to the fore [26].

Thus, returning to the artistic value we should turn to the interpretation of understanding of the concept of artistic value proposed by O.Divnenko.

The scholar asserts that the artistic value is the measure of *aesthetical values* of the product of art (musical composition), the indicator of its level of beauty. The *source* of artistic value is the genuineness of features of its aesthetical singularity, which is genuinely reflected in the musical composition (product) [27].

To continue our research we have to pay attention to an important philosopher M.Kagan's statement concerning *creative artistic activity*. The main idea of his findings is that this activity includes two parallel activities which are dialectically closely connected with each other:

- *aesthetical activity* – first of all it is practical creation of aesthetical values, and, secondly, it is introduction of objects with aesthetic character. The author relates this expression of activity with
- *artistic activity*. The scholar does not separate these two activities, because he holds that they intersect each other. He illustrates it by two circles:



The author *concludes* that in each definite situation one of these activities may more or less manifest itself. Wherewith, we can state that this interrelation (correlation) of *artistic* and *aesthetical* activities is flexible [28].

Thus, summarizing various approaches, theoretical conceptions and ideas about the artistic value and creative artistic activity established by the above-mentioned scholars, we can make a *conclusion*, that the question has been investigated in general, but there is no direct research concerning activity of a music teacher.

In connection with this, in the process of her research the author interprets theoretical conception of this activity, which is essential for music pedagogy and psychology [29]. **Thus, in the profession of music teacher creative artistic activities are connected with the fact that they figuratively reflect the reality, in which artistic and figurative discovery of life is united with creation according to so-called laws of beauty… It is a sphere, type or variety of creative activity, characteristic feature of which is aesthetic cognitive attitude towards the reality. Music teacher is the artist being like the whole world with its inner rules and uniqueness, with a certain reaction and impulses, using in his/her work elements of art typical for music, which correspond to criteria of the art of music, artistic image, shape, artistic figurative thinking, stylistic means, quality, at the same time developing artistic skills of both teachers and learners.**

As a possible realization of this activity the author has elaborated and proposes the model of the characteristics of the image of creative artistic activity of music teachers-to-be. This model reflects the transfer from a didactic situation to a school situation (see Figure 2), and it can be applied by experienced music teachers as well.

To compare the approaches to creative artistic activity of music teachers-to-be in the study year 1993/1994 a pedagogical experiment was done, in which the students of Daugavpils University, Music Faculty were involved during their teaching practice. The participants of the experiment were 35 third-year-students of the specialities "Music Teacher" and "Primary School Teacher". The research was based on the method of system worked out by outstanding director and educator K.Stanislavsky. The method is connected not only with creativity of an actor-teacher, but also with control over the unconscious, logic of intellectual and physical activities, means of pedagogical influence, development of different abilities and skills (artistic, theatrical, pedagogical, etc.). We have to admit that the author's system optimally develops intuition, memory, initiative, reaction, thinking, creative imagination and attention. For example, in connection with the development of actor's and teacher's initiative, imagination, attention and creative exploratory activity, the author distinguishes four types of people. From these four we will take a closer look at two of them: a teacher with initiative, well-developed imagination – he/she constantly looks for new methods; a teacher having no initiative – he/she needs help in work, etc. These two types were taken as a basis for our research (see Table 1).

The method chosen for the research was *the observation method*. The main tasks were defined as follows:

- to elaborate a nonstandard lesson structure;
- to search for new methods, using additional sources of information, music materials (songs, games, music materials for listening, sports breaks, etc.);
- demonstrating (presenting) a new song to use all the necessary musical expressive means, as well as accompaniment on the piano, which could incite children's interest, develop imagination and activate their attention.

The determinative indicator of this activity is ***ability to design artistic activity and to anticipate the goal***.

We were interested in the following indicators of a student's activity: ability to set the goal without any assistance; skill to be flexible in one's work; skill to evaluate and solve problems; expression of artistic cognitive cooperation of teacher and learner; essential professional knowledge and skills.

Having analyzed and summarized data of the research we came to the conclusion that the second type of teachers is the prevailing one. These teachers in most cases work without initiative, ask for support, they are unsure in their actions, but at the same time they are determined and love children. We concluded that for students it is necessary:

- to get acquainted with general psychological statements that influence the level of development of creative activity, for instance, self-suggestion, body positioning, tension relief, which is very important for a student's presentation of a song (conducting, playing the piano), for the transfer of image from teacher to learners, public depends on the work of a teacher's verbal and non-verbal means of expression;

to direct their skills towards creative activity integrating all necessary professional pedagogical expertise (knowledge and performance techniques of general and special subjects).

We have established that one of topical problems is skill to combine emotional, expressive, clear performance of a song with accompaniment on the piano, observing both vocal technique (diction, nuances, and articulation) and technique of playing the piano.

Table 1. Comparison of students' approaches to artistic activity

Type of teacher – learner	Characteristics of the type of music-teacher-to-be and criteria	**Year 3, 1993, specialities: "Music Teacher", "Primary School Teacher". In total: 35 respondents:** 27 girls, 8 young men		**Year 4, 1994, specialities: "Music Teacher", "Primary School Teacher". In total: 35 respondents:** 27 girls, 8 young men	
		Number of learners	In the beginning of practice	Number of learners	In the end of practice
I	**They fascinate children with their initiative,** have well-developed imagination, and intuition, originally model a lesson, constantly search for new methods of work. They are able to design and anticipate the goal. Creative cognitive cooperation.	**6**	**18.18**	**9**	**27.27**
II	**Without initiative**, they need support, but at the same time they are determined, children like them.	**9**	**27.27**	**13**	**39.40**
III	**Irregular work**, children's interests are not balanced; they are performers of instructions, directions, there is no creative search in their work.	**11**	**33.33**	**8**	**24.24**
IV	**No feel, skill to see** and imagine, formal approach, inefficient, unskilled, uneducated.	**7**	**21.21**	**3**	**9.09**

As students and methodologists say:
N. …"Comparing with the accompaniment on the piano, during presentation of a song I cannot achieve sufficiently artistic, emotional performance. I feel uncertain, unconvincing. I think that vocal performance is too subdued, because I cannot balance joint performance of our ensemble ".
The methodologist of the subject expresses the idea that during performance a young teacher has to be more emotional, artistic, creative, freer, and she has to be able to control her voice and body more flexibly.
We deduced that this result is connected with the above-mentioned factors, as well as with a student's individual abilities, typological structure of personality, disposition or indisposition to work actively, to realize oneself, inexperience, and reflection in approaches to creative artistic activities.
The above-mentioned skills are the most characteristic skills of the music teacher's varied professional activities, as then students are able to direct methodology of people's aesthetical feelings development, because these skills form the basis for pedagogical influence, ability to properly organize learners' aesthetical, artistic instruction and education.
But in the years 2002 and 2003 on the basis of the research of records (teachers' characteristics, diaries) and comparison of the approaches to creative artistic activity used by the 3rd and 4th year students of the speciality "Music Teacher", we have acquired the description of interpretation of this activity. To illustrate it we offer several fragments of what was said by the teachers – methodologists.

J. …"Responsible, hardworking. Has great creative potential, which is especially revealed when performing rhythmical exercises, in sports breaks, which take place in a music lesson".
I. … "Professionally purposeful, well-designed, organized and conducted music lesson, favourable, friendly atmosphere in the classroom, the student has good posture, good elocution. The teacher is well-read, competent, creative, artistic, has good imagination and intuition. To achieve the aim of the lesson she applies various efficient methods. Brilliant, emotional performance of the song".
J. …"The student is friendly, emotional, very polite, kindhearted, respects children. Children love the teacher. She is artistic, has great erudition, elocution and *initiative*. Her classes are interesting and exciting; she uses various visual and technical aids, musical instruments. She always achieves the goals set for the lesson. Free, creative artistic cognitive cooperation with learners."
Carrying out the research it is possible to conclude that the level of expertise of creative artistic activity of music teachers-to-be is average – 63, 60%, but over the years we can notice dynamics of the development of skills. But there is also a negative factor to be mentioned: this direction of activity is not studied in connection with a definite values orientation in education. Therefore this issue needs further research and it is necessary to improve the creative artistic activity of music teachers-to-be.
Summarizing the content of the research we can draw the following *conclusions*:

1. Values orientating education and development of learner's personality are influenced by the following factors: environment created for educational situation and conditions, which are based on transformation of human and intellectual values; direction of teachers and learners' education, content of studies and activities; their mutual influence and interaction, etc.
2. Productive educational model that is based on creativity, aesthetically artistic approach. It is considered that it is an innovation that directs towards crucially new approaches.
3. Concept of creativity is closely connected with the concepts of self-development, self-actualization.
4. Development of creative personality's potential is connected with the principle of transformation of cognitive content into emotional one.
5. Creative artistic activity of music teacher-to-be is related to artistic, imaginative and aesthetically cognitive attitude to the reflection of the reality.
6. Having investigated the actual principles and level of creative artistic activity of music teachers-to-be during their studies, we conclude:
    1) in most cases they work without initiative, search for support, they are uncertain, but at the same time determined, children like them, they have no explicit artistic imagination, etc.;
    2) that creative artistic activity is average – 60, 63%
    3) that direction of this activity is not realized in connection with the values orientating education. That is why further research of this problem is necessary, it is essential to work in order to improve activity of music teachers-to-be, as direction of activity nowadays is mediated, reflexive, modeling.
7. It is essential to develop teachers and learners' skills in choice of values:
    - to look for alternatives if there is choice;
    - to anticipate consequences before making choice;
    - to make choice without assistance, independently from others;
    - to be aware of one's choice doing something and to be ready to confirm one's choice in public, etc.

References

1. Students J.A. (1933). *Vispariga paidagogija: Zinatne un maksla sevis un citu audzinasana*. Riga: Fr.Blaumana apgadiba.- p.70 – 76.
   Belickis I. (2000). *Vertiborienteta macibu stunda* // Ieskats vertibizglitiba. Riga: Raka.- p.19 – 29.
   Dale P. (1928). *Ievads filozofija. 1.dala*. Riga: A.Gulbis.- p.16 – 20.
   Maurina Z. (1973). *Dzives jegu meklejot: Esejas un aforismi*.- Riga.- p.30 – 38.
   Scheler M. (1921). *Der Formalismus in der Ethiko and die materielle Wertethik*.- 2.Aufl. Haile.- p.298.
   Miller I.P. (1996). *The Holistic Curriculum* (2nd ed.). Toronto: Ontario Institute for Studies in Education Press.- p.50 – 54.
   Tugarinov V.P.O. (1960). *O tsennostyah zhizni i kultury*. Moskva,- p.150.
   Drobnickiy O.G. (1970). *Tsennost'// Filosofskaya entsiklopediya*. Moskva, t.5,- p.30.
2. Swanwick K.A. (1979). *A Basis for Music Education*. London: Routledge,- p.10.
3. Husserl E. (1939). *Erfahrung und Urteil: Untersuchungen zur Genealogie der Logik.* Prag,- p.116.
4. Miller I.P. (1996). *The Holistic Curriculum* (2nd ed.). Toronto: Ontario Institute for Studies in Education Press.- p.10 – 13.
   Gang P.C. (1989). *Rethinking Education*, Dagaz Press, Oakland, California, USA,- p.100 – 105
5. Belickis I. (2000). *Vertiborienteta macibu stunda* // Ieskats vertibizglitiba. Riga: Raka.- p.19 – 29.
6. Kerschensteiner G. (1926). *Theorie der Bildung*.- p.60 – 64.
7. Belickis I. (2000). *Vertiborienteta macibu stunda* // Ieskats vertibizglitiba. Riga: Raka.- p.40 – 45.
8. Albrehta Dz. (2001). *Didaktika / Talmaciba pedagogija*. Riga: Raka.- p.166.
9. Smite A. (1997). *Paligs pedagogam. Pieredze. Teorija. Prakse*. Riga: Raka.- p.123 - 124.
10. Belickis I. (2000). *Vertiborienteta macibu stunda* // Ieskats vertibizglitiba. Riga: Raka.- p.120 – 127.
11. Zukovs L. (1997). *Ievads pedagogija (Pamatkurss). Pieredze. Teorija. Prakse*. Riga: Raka.- p.102 – 106.
12. Students J.A. (1933). *Vispariga paidagogija: Zinatne un maksla sevis un citu audzinasana*. Riga: Fr.Blaumana apgadiba.- p.30 – 32.
13. Zelmenis V. (2000). *Iss pedagogijas kurss*. Riga: Zvaigzne.- p.65.
    Tugarinov V.P.O. (1960). *O tsennostyah zhizni i kultury*. Moskva,- p.15 – 17.
14. Spona A. (1996). *Audzinasanas teorija un metodika*. Macibu lidzeklis LU Ped. un psih. kat. Riga,- p.27 – 30.
    Zelmenis V. (2000). *Iss pedagogijas kurss*. Riga: Zvaigzne.- p.110 – 115.
15. Scheler M. (1921). *Der Formalismus in der Ethiko and die materielle Wertethik*.- 2.Aufl. Haile.- p.298.
    Tugarinov V.P.O. (1960). *O tsennostyah zhizni i kultury*. Moskva,- p.150.
    Kule M., Kulis R. (1996). *Filozofija*. Eksperimantala macibu gramata. Atlavusi lietot Latvijas Izglitibas uz zinatnes ministrija. Riga: Apgads Burtnieks.- p.159.
    Johnson – Laird (1988). *Freedom and Constraint in Creativity // The Nature of Creativity* (Sternberg R.I. (ed.)). Cambridge: Cambridge University Press.- p.202–219.
16. Kagan M.S. (1974). Chelocheskaya deyatelnost'. (Opyt sistemnogo analiza). Moskva.- p.115-125.
17. Hegelis G. (1981). *Filosofijas zinatnu enciklopedija // Pagatnes domataju darbi*. Riga:

Zvaigzne.- p.8 – 15.
18. Zukovs L. (1997). *Ievads pedagogija (Pamatkurss). Pieredze. Teorija. Prakse*. Riga: Raka.- p.25 – 27.
Belickis I. (2000). *Vertiborienteta macibu stunda* // Ieskats vertibizglitiba. Riga: Raka.- p.120 – 124.
Slastenin V.A., Podimova L.S. (1997). *Pedagogika: innovatsionnaya deyatelnost'*. Moskva: Magistr.- p.73 – 74.
Ponamoryov Y.A. (1976). *Psihologiya tvorchestva*. Moskva: Pedagogika,- p.99–106.
19. Komenskis J. (1992). *Liela didaktika*. Riga: Zvaigzne.- p.50.
20. Albrehta Dz. (2001). *Didaktika / Talmaciba pedagogija*. Riga: Raka.- p.166.
21. Zelmenis V. (2000). *Pedagogijas pamati*. Riga: Raka.- p.87-88.
22. Smite A. (1997). *Paligs pedagogam. Pieredze. Teorija. Prakse*. Riga: Raka.- p.144.
23. Yakovleva E.L. (1997). *Psihologiya razvitiya tvorcheskogo potentsiala lichnosti*. Moskva: Moskovskiy psihologicheskiy institut, Izdatelstvo "Flinta".- p.194-195.
Gardner H. (1973). *The Arts and Human Development*. New York: Wiley.- p.28 – 31.
Arieti S. (1976). *Creativity: the Magic Synthesis*. N.Y.: Basic Books.- p.70 – 75.
Ponamoryov Y.A. (1976). *Psihologiya tvorchestva*. Moskva: Pedagogika,- p.99–106.
Slastenin V.A., Podimova L.S. (1997). *Pedagogika: innovatsionnaya deyatelnost'*. Moskva: Magistr.- p.10 – 12, 20 – 21.
Stanislavsky K.S. *Rabota akt'ora nad soboi // Sobraniye sochineniy*: t. 3-c.- p.256 – 262.
24. Slastenin V.A., Podimova L.S. (1997). *Pedagogika: innovatsionnaya deyatelnost'*. Moskva: Pedagogika.- p.256.
25. Vorobjovs A. (2002). *Vispariga psihologija*. Riga.- p.212 – 213.
26. Albrehta Dz. (2001). *Didaktika / Talmaciba pedagogija*. Riga: Raka.- p.166.
27. Divnenko O.V. (1995). *Estetika*. Moskva: Izdatelskiy tsentr "Az".- p.52 – 54.
28. Kagan M.S. (1974). Chelocheskaya deyatelnost'. (Opyt sistemnogo analiza). Moskva.- p.80 – 85.
29. Erliha S. (1999). *Pedagogiaka prakse ka toposo muzikas skolotaju profesionalas kompetences veidosanas lidzeklis*. // Dissertation. Academic pedagogy (music pedagogy sub-branch). Riga.- p.91 – 95.
Erliha S. (2002). *The IMAGE and Mission of Future Music Teacher in a Democratic Society. Person. Color. Nature*.- Abstract of he III International Conference.- Daugavpils.- p.79.

A New Approach to Interior Environments of Transportation Centers

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Abstract

Intermodal transportation centers, although in existence for several years in selected European cities, are relatively new in the United States. Supported by Federal law, their major purpose is to serve as transit links between train, bus, and airline systems thereby facilitating the improved movement of passengers from one system to another. To effectively realize this, the centers must be able also to meet the diverse needs of the traveling public while in transit. This requires that the centers not only provide essential services, but amenities for passengers as well depending on the specific needs of a center.

Where possible, intermodal transportation centers are designed in such a manner as to take advantage of existing structures. Therefore, the design study is to develop a prototype center based on the study of existing transportation centers—railway stations, bus terminals, and airports. Their design characteristics, functions, facilities, as well as special requirements are explored and identified in order to define the functional standards for a prototype center.

To achieve the appropriate design for the prototype, the design experiment is conducted by applying the functional standards to an existing transportation center which can be developed into an intermodal transportation center. The Main Street Station in downtown Richmond, Virginia, is selected as the project location. The design concept not only addresses the effective use of public transportation systems for the Richmond Metropolitan Area, but, as appropriate, also includes in the project existing facilities located at Main Street Station.

1. Introduction

Public transportation used to be separately described only in terms of a specific mode of service--train, bus, or air. Potentially, although each mode may provide efficient services, it may not, however, meet the complete traveling needs of all of today's passengers. These needs are being replaced by utilizing a different approach in transporting passengers, namely to provide them with convenient interconnections by using different transportation systems to get them to where they are going. In other words, getting from point A to D is no longer so simple. Passengers may need to transfer from A to B and then to C before arriving at D.

The development of the intermodal concept typically pays much attention to utilizing existing infrastructures, for instance, old railway stations or bus terminals which are normally located in central cities. Thus the use of a centrally located station or terminal supports the view that an intermodal transportation center not only forms an integral part of the urban scene, but has the potential for also becoming a tourist center. This trend has already begun in several cities in both Europe and North America where existing railway stations have been converted to intermodal transportation centers.

An intermodal transportation center can be a new form of structure, a distinctive building, and a group of buildings at a single location which are intended to introduce new methods and patterns in handling a large number of people. Efficiency requires that the center is designed and constructed to incorporate the latest technologies and innovations. Many centers built in the late 20th century, for example, have very strong characteristics for combining technology in building structures and systems with architectural and interior design shapes and forms.

2. Design Application

2.1 Project Summary

The application of design criteria established during the research phase develops a new language for designing transportation centers. The design outcome emphasizes a conceptual process of development. In pursuing the design idea, the study is conducted by applying the research outcome to an existing transportation center, which has a high feasibility of future development. The Main Street Station, a historic railway station in downtown Richmond, Virginia, is selected, and serves as the project's location. The compatibility of the development plan prepared by the city of Richmond with the intermodal concept will transform the current railway station into a new transportation hub for the Central Virginia area. The new intermodal center will serve the Richmond Metropolitan Area with a building complex integrating the services of a railway station, a bus terminal, an access to Richmond International Airport, and a shopping district.

2.2 Location

The station is located at 1520 East Main Street, Richmond, Virginia. It fronts the north side of Main Street between 15th and 17th Streets, and the back is bordered by Broad Street. It has been accepted as the focal point of the surrounding neighborhood since first opening in 1901. Passenger train service was terminated in 1971, and the station closed for some time. In 1985, it was opened as an adaptively reused regional specialty shopping center, but closed again in 1988.

2.3 Building characteristics

The station building includes a four-story head house joining an elevated train shed located behind the house. The second level is flanked by rail tracks on both sides. Both parts of the building are considered significant historic landmarks. The head house was listed in the Virginia Landmarks Register in the National Register of Historic Places in 1970 and the train shed in 1976.

The façade of the head house is divided into four stories by the distinguished treatment of the fenestration. The steep hipped roof consumes one third of the height of the structure. The southwest corner of the building rises into a six-story clock. The huge gable-roof train shed is located at the rear of the head house. The structure is supported by cast iron.

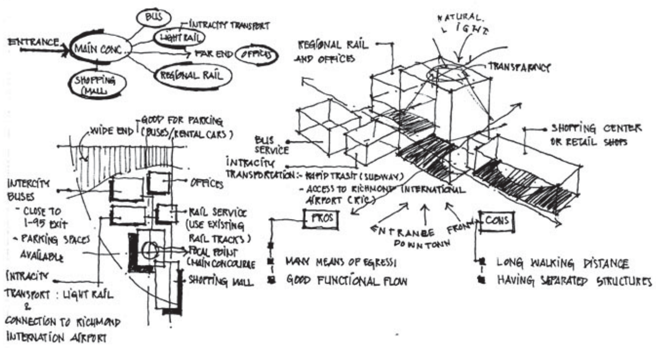
Originally, when serving passengers, the ground floor of the head house contained a central waiting room with a ticket office on the left, and a main staircase on the right. The second floor was a large open space connected to the train shed. Currently, the train shed is enclosed, and the interior space has been rearranged into government offices. The main entrance has been moved to the rear of the building facing Broad Street, and the head house entrance on Main Street is closed.

2.4 Design Process

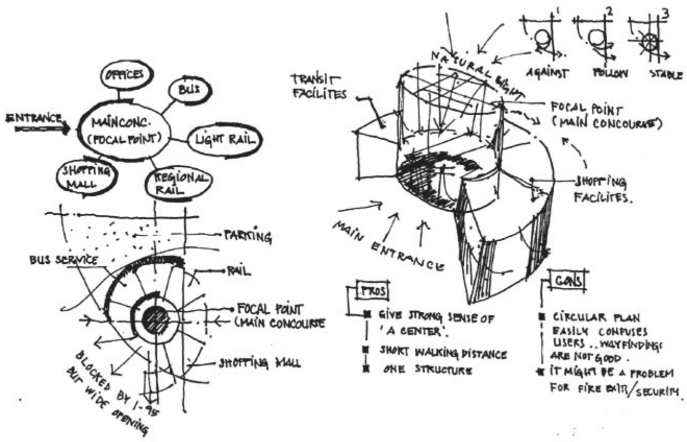
Design Approaches

Three approaches are explored and developed. The hypothesis of each approach is the response to the interrelationships of site configuration, axes identified by traffic patterns, and interior functions. The analysis of the functions shows that the design and construction of primary facilities and area requirements of most transportation centers can be approached in similar manners. Each encompasses four interrelated area, core are, transition area, peripheral area, and an area for administration. Four areas are placed on and plays with site and traffic patterns as follows:

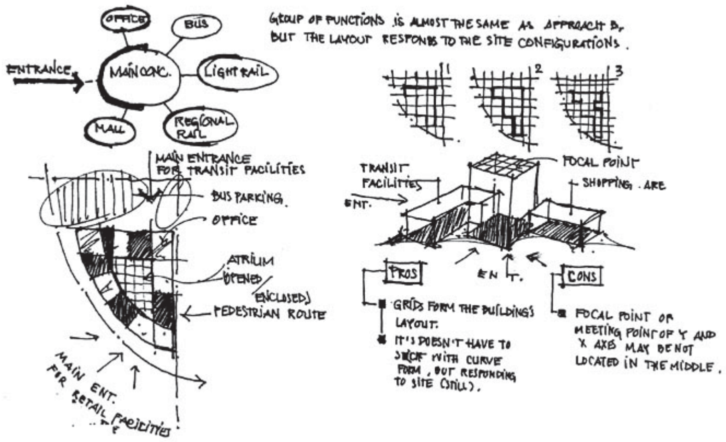
Development of Approach A



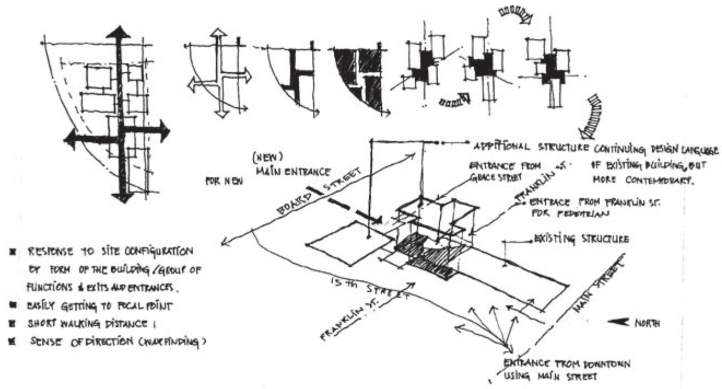
Development of Approach B



Development of Approach C



Integration of Three Approaches



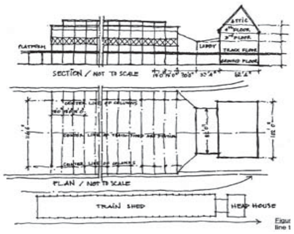
Design Concept

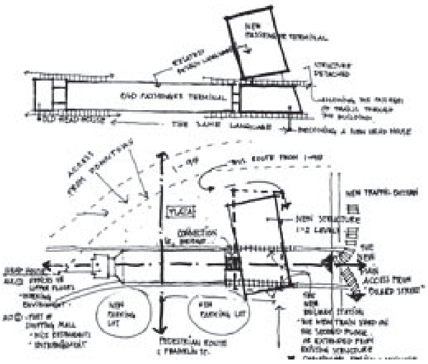
The concept addresses the blending *of **what is new** in design and technology with **what is important** in historic characters*. In response to the expansion of transportation technology, future information, and human factors, the design will illustrate an effective use of public transportation space for the Richmond community.

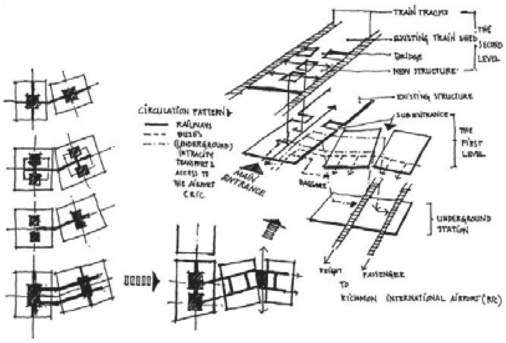
"the same language but different accent"

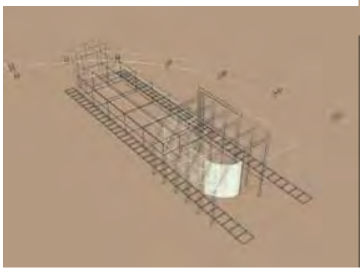
The transformation and manipulation of the design elements from OLD to NEW play important roles. “Connection” is a condition I encountered earlier with what exists. It is meant to express a suggestion of dynamic, movement, and transport of “the same language of deign in different accent”. Rhythm and repetition of existing elements are considered the grammar. Some old idioms are sometimes borrowed for reminding the past while some slang is always discovered.

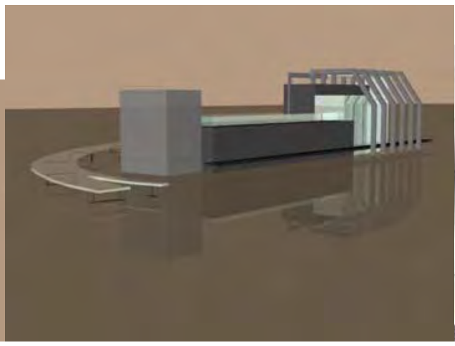
Design Development

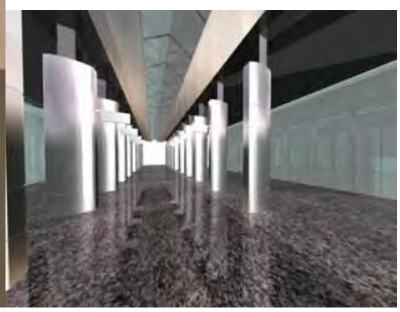












Selected References

[1] Blow, C.J. (1996). Airport Terminals: Butterworth Architecture Library of Planning and design. Oxford: Butterworth-Heinemann.

[2] Blumenfeld, Y. (1999). Scanning the Future: 20 Eminent Thinkers on the World of Tomorrow. New York: Thames & Hudson.

[3] Edwards, B. (1998). The Modern Airport Terminal: New approaches to airport architecture. London & New York: E & FN Spon.

[4] Edwards, B. (1997). The Modern Airport Terminal: New approaches to railway architecture. London & New York: E & FN Spon.

[5] Latham, T.K. (1979). Main Street Station. Unpublished manuscript, Virginia Commonwealth University.

[6] Lyon, E. (1991, November). Richmond's grand dame celebrates her 90th birthday. Chesapeake and Ohio Historical Magazine, 2-22.

[7] Riewoldt, O. (1997). Intelligent Spaces: Architecture for the Information Age. London: Laurence King Publishing.

EXPLORING DEPTH, PERSPECTIVE AND SPATIAL STUDIES WITH THE APPLICATION OF CAD AND VRML TO DEVELOP BACKGROUND AND SET DESIGN IN ANIMATION.

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Abstract

Background design is basically the designing of a location or environment in which the characters will interact with. The main purpose of set and background design is to let the viewers understand the timeline and the place where the story is taking place, and to enhance the mood in every scene or shot and also to inspire the artist how to visualize the story and to set the proper layout. It is essential that a good composition and cinematography can be established by having a proper background or set design. Besides that, most backgrounds play the role of guiding the target audience's eyes to the main focus of the composition. However, some backgrounds lack the features to establish a proper scene or are irrelevant for use. Despite having a good layout, there are still certain rules and regulations regarding the virtual world and the real one in terms of science and space that will play an important role as the projection of a fantasy one.

This research studies the necessary techniques and procedures of studying depth and space to produce a proper way of creating set and background for animation. This includes studies of application in Computer Aided Design (CAD) and Virtual Reality Application (VRML) and other related topics. The findings of the research are a guide to enhance scenes in animation.

What is Background Design?

It can be defined as designing of location or environment and the timeline in which the characters will act. The characteristics of background design are also to create and establish the mood, atmosphere, time, place etc.

- Composition
- Perspective
- Style/Design
- Atmosphere/Mood

The Importance of Background Design

- To let the viewer understand where and when the story happen.
- To enhance mood in every scene or shot.
- To inspire the artist how to visualize the story

How to create a good background design?

- Identifying where and when the story happens.
- Do some visualization or sketches as a whole setting.
- Break-in some important parts of the setting to be visualize in detail.
- Double-check the proportion and perspective in every scene.
- Study some color styling based on the mood and time of the story.
- Color background must not distract the focal point of any scene; unless it is the only subject matter of the given shot.

Viewpoints

In exploring spatial studies, we are able to see or envision from a variety of viewpoints. These alternative points of view give us flexibility in representing our visual thoughts and perceptions. Each type differs, however, in its capability to facilitate the development of ideas.

In the industry today, background artists tend to explore more into the usage of 3D because it is believed that 3D backgrounds will enable more function and thus give more accurate calculations. By implementing 3D background, the designer can explore the space in the scene such as zooming in and out, rotating upwards, downward or even sideways. Even the lighting in the scene will be more accurate because all light sources such as the diffuse lighting, the ambient lighting or even the reflected light, will all be calculated by the computer.

Computer-Aided Design (CAD)

"The use of CAD as a drafting tool versus its employment as a modeling aid can be synthesized in two buzzword: 2-D and 3-D." (Bertol, 1997)
Despite its name, CAD (Computer-Aided Design) is least used for the activity of design. A more appropriate definition, for which CAD already provides initials, would be computer-aided drafting. While the efficiency of electronic drafting versus traditional drafting is unquestioned, architects are hesitant to design straight from the keyboard. Often design capabilities are misinterpreted as 2-D efficiency or rendering capacity. The reality is that, in the majority of practices, while drafting is highly automated, the hand sketch is still the primary medium in the exploration of design alternatives.

Being able to build a three-dimensional, CAD generated model is already a good start for design exploration. But visualization by itself does not investigate design strategies or alternatives.

"Wireframe drawing is where CAD began; creating fine line structures in flickering green on black screens." (Porter, 1997). It remains the underlying function of most CAD programmes that offer the option of assembling an initial drawing in two dimensions or in three dimensions. Once the orthographic co-ordinates of a design are fixed in 2D plans, elevations and sections, they can be exported to 3D programmes where, using a carefully planned layering system, the machine plots the relevant position of end points for their integration into a virtual three dimensional space. The resultant white or multicoloured wireframe perspective provides a valuable first glimpse of a skeletal structure defined in abstract form. Often used as a check on initials ideas previously sketched on a drawing board, many students and practitioners will have the machine assemble them with the hidden line routines omitted so that all the underlying levels of information are simultaneously in view, the resultant image providing a stance which many designers find to be the ideal interface between the physical aspects of a design and the abstract ideas that underpin it.

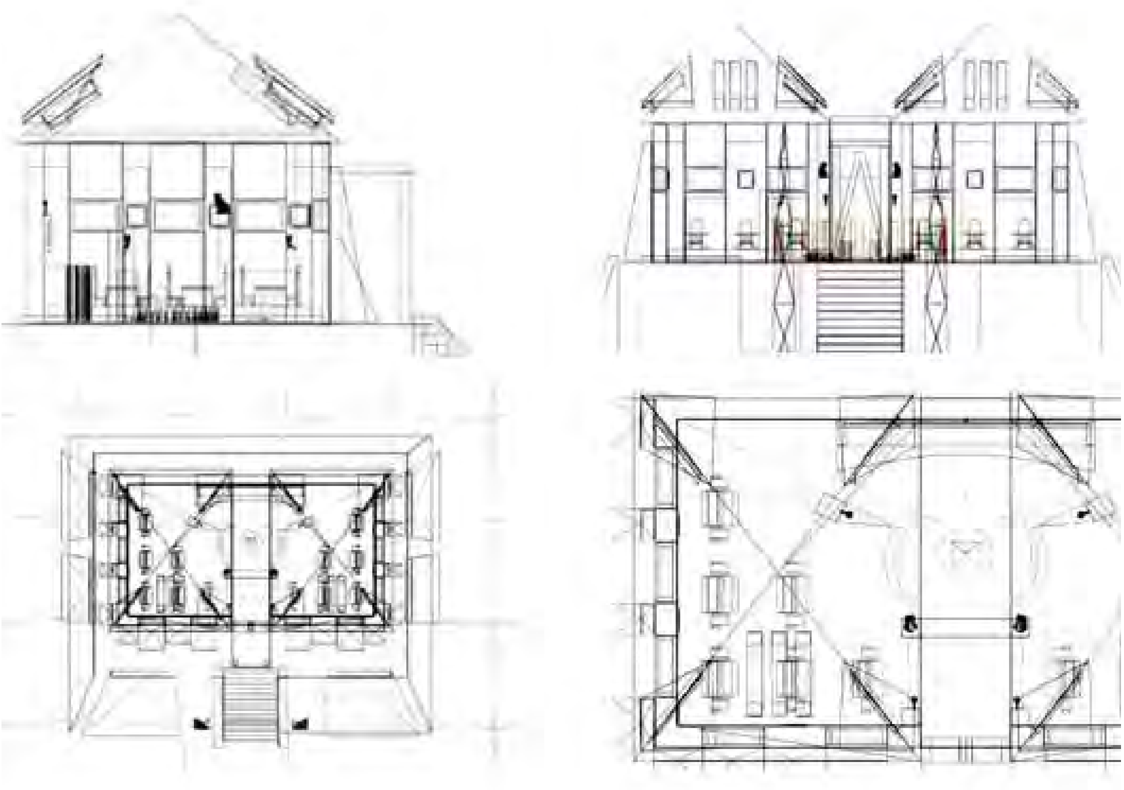

Fig. 1.0 Spatial Studies for a Computer Generated Café Design.

In addition to this ability to this ability to examine a project using a see through, x-ray vision, there is the attendant ability to command a myriad of possible and, indeed, impossible vantage points from which to generate the views. This provision allows the mind's eye to preview and rehearse the nature of a spatial complex in flux – a perceptual liberation that echoes the montage approach extolled by Koolhaas and Holl. Yet another aspect of this perceptual freedom is the dynamic provided by the three-point perspective view so quickly generated on a screen - a dynamic which has come to supplant the conventional rigidity of those one- and two-point versions laboriously produced on the drawing board.


Fig.1.2. Wireframe Render of Interior Perspective Shot
Fig. 1.3. Scanline Render of Interior Perspective Shot

A resolved design can be taken to even greater heights of resolution: photographic source material can be scanned in and, for a photo-montaged animation, even fully-rendered building proposals patched into scanned photographs of the site. Also, the incidence of light in a rendered image becomes far more realistic via a technique called ‘ray tracing’. Relying on sophisticated programming, extensive memory and fast computing times, ray tracing is a process in which all the lines of light visible from the viewer’s position are calculated and valued, including light rays passing between objects within a given scene.

In applying all the spatial variables intrinsic to moving pictures, the computer-generation of design concepts represents the first step in a new and exciting adventure into visualization. The challenge of creating a virtual image of a concept in the same virtual space as that occupied by its conceiver now confronts the media. To do so, we have to make a creative leap through television screen and into the world of imagination that lies beyond. Previously the domain of trainee astronauts and video game designers, it is a world that returns us to the full-scale design overtures used by the ancients but this time reconstructed electronically in the pace of our minds.

Digital Space with Virtual Reality (VR)

“The term virtual Universe denotes the database defining a static three-dimensional model and the other components needed to simulate and generate the interactions which take place in a virtual environment.” (Bertol, 1997)

Designing in a Virtual Environment

From the many definitions of virtual reality (VR), there is one that is concordant to the logical tread of this narration: Virtual reality is a computer-generated world involving one or more human senses and generated in real-time by the participant's actions. The real-time responsiveness of the computer to the participant's action distinguishes VR from other kinds of computer-generated simulations. The participant in a VR environment is perceiver and creator at the same time, in a world where the object of perception is created by actions.

Immersive Virtual Reality

"There are two means of access to the world of virtual reality: non-immersive and immersive." (Porter, 1997)
Giuliano Zampi and Conway Lloyd Morgan have outlined several distinctions between non-immersive and immersive virtual reality technologies and other active three-dimensional CAD models. By contrasts to planned flythroughs and walkthroughs, in true virtual reality the user is autonomous, that is, free from predetermined paths and in complete control of every movement. In non-immersive VR, the user is looking into a screen, where as the immmersive user is actually engaged in the virtual realm. Indeed, the immersive user is part of it, rather than a spectator, even one able to move across and into the screen in all directions. There is a further distinction between the two: the creation of the virtual world requires a powerful computer 'engine' that not only connects the virtual; space with the user but is capable of representing to him or her a realistic perspective and polychrome environment which, in real time, response quickly, accurately and convincingly to every movement made. The quality of the playback relies on the programming skills and computer memory, aspects of which are still in the process of development.

In the current state of immersive VR technology the hardware worn is normally a headset and data glove, or three-dimensional mouse. The headset, or Head Mounted Display, familiar in fantasy games, is the main part of this operational system. The headset houses two LCD screens: one for each eye. The addition of earphones to the headset means that the wearer can both participate visually in three-dimensional and 360-degree experience as well as stereophonically hear virtual sounds. Data gloves embody tactile feedback sensors which, when touching virtual objects or surfaces, transmit equivalent sensation of resistance and plasticity; pointing or clenching the gloved hand conveys commands to the computer so that movement and the manipulation of virtual objects and spaces is possible.
More lightweight displays and tracking systems are now being developed, small goggles and even contact lenses are coming to replace bulky headsets. Full body suits are available, often used by computer animators to record exactly complete body positions. There is also research which aims to perfect choice command recognition and an 'eye-tracking' technology in which playback is projected directly on the retina. In responding to head and eye movements, a newly generated perspective stitched together in real time,

is received by the eyes thirty times per second. There are also developments, especially in the computer game industry, in which smells and even tastes can be simulated, but this technology is still in its fancy. Using slimmed-down data gloves, the sense of touch is being increasingly fine-tuned to the point of simulating the sensation of stirring thick substances. However, a crucial aspect of immersion is that the virtual traveler, as in the real world, can see and communicate with others who, similarly garbed, occupy and share the same virtual kingdom.

Albeit confined to a screen, the ability of high-end CAD programmes to provide walkthough and flythroughs allows our mind’s eye to take predetermined journeys through and around the dimensions of a design flux. This ability is the important distinction that separates CAD from all former, traditional modes of 2D representation. What was a single, static and fixed viewpoints in space has become animated – a serial visual experience in which the spatial features of a design concept can, on demand, be viewed as a continuum from all possible vantage points. In non-immersive and immersive constructs of virtual space it is apparent that the primary cue of motion parallax together with all secondary cues to depth are imported and present. However, by replicating all the faculties of human perception in a complete and three-dimensional illusion of real time space, immersive VR systems place the act of designing in a radically new context. It is one in which the drawing board or the monitor screen is replaced by the ability directly to confront and fashion an architecture at full scale and complete with all its spatial variables. Furthermore, within this context the architect together with the client can wander around a design proposal in a new kind of partnership. If VR brings an unexpected setting in which architect and client can co-exist, it also brings the notion of a new rapprochement between them, plus the direct involvement of the client, and with this, the promise of a greater diversity in the outcome.

Virtual Reality Aided Design (VRAD)

Could it be said as a next step to the new evolution in technology as the world of CAD has now been developed to VRAD? (Bertol, 1997), elaborates that, *“Virtual reality can be defined as the component of communication which takes place in a computer-generated synthetic space and that embeds humans (actors) as an integral part of the system.”* The tangible components of a VR system are the set of hardware and software providing the actors with a three-dimensional, or even more-dimensional, input/output space, in which, at each instant, the actor can interact in real-time with other autonomous objects. Under these premises, VRAD can be defined as computer-aided design using the methods of virtual reality.
Thus, a virtual reality aided system has to be configurable for each actor, to be separable into a public and private sphere, and able to react in a sophisticated way, as well as to offer access to external information and, ultimately, to be navigable. (Bertol, 1997), also stated that the main design goal of a VRAD system should be the possibility for the actor to experience the space.

Interactive Walk-Through

"A great deal of development and research has been undertaken during the last few years to establish virtual reality techniques in architecture. Most of these systems are simply viewing programmes, also known as walk-through system." (Bertol, 1997). With many different degrees of complexity and detail the immersive walk-through is probably still the main application of VR. The architectural artifact is visually simulated in computer models according to the level of detail allowed by the computer system used and the complexity of the architectural model.

Higher or Denser?

A Debate Aided by GD on the Historic Urban Texture Conservation of a Typical Commercial Region in Shanghai

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Abstracts:

The foreign concession period from 1840s to 1930s is the birth of modern Shanghai. And its influence is so widely and deeply that the colonial character has become an important part of the city's identity until now. As a witness of this period and the main city-growing-axis, Nanjing Road (Garden Road) is an epitome of the city, which was always the backbone of Shanghai, just following the Bund on the east and leading the city's development to the west.
With the varied political, commercial and traditional reasons, the urban texture on the both sides of the road has its own special identity, which is an important grown footprint of this region, as well as an invaluable evidence of the foreign concession history in Shanghai. So, the conservation of its urban texture should be very carefully considered before taking any irretrievable action.
As a pity, three roads have been erased to transform the special crushed street blocks into a normal one with proper proportion and dimension for a designed skyscraper. Then a part of such a characteristic urban texture is being erased! The intention of such a brutal action is just the result of the inadequate consideration on the region's context and the shortsighted economic pursuit of the floor area quantity in an instinctive way to go higher without any rational analysis!
As an architect the author believes the quality is the life of quantity. In this case, concerning the urban regulations and the existing commercial pedestrian environment, good quality means a continuous shopping interface and a human scale, all which would be decided by Density rather than Height. So, between the two options to increase floor areas he prefers being denser.
Then with a VB program "HOD" coded according to the GD concept, the author planned four experiments in four circumstances, for each one to generate 100 samples according to a different set of construction volume parameters. Based on the several typical samples out of the 400 samples a visual analysis and comparison were conducted.
Finally, the author proved that being denser was more sensible on this region, which could have enough floor area as the market demand, altogether with the benefits of the urban texture conservation, longer continuous commercial interface, acceptable sunshine around, better city image and scale no matter on the street or from the sky.

I. The Introduction of the Site

A. The Location

The site is located at the north side of Nanjing Rd, which is the top commercial pedestrian region in Shanghai, even in China since 1840s, when the city began its modern life [1]. In figure 1, we could see the location of the city Shanghai in China, and the location of the road in the city, the both drawn in dark black. In figure 2, the site is red-masked. The area of the site is about 50,000 square meters.

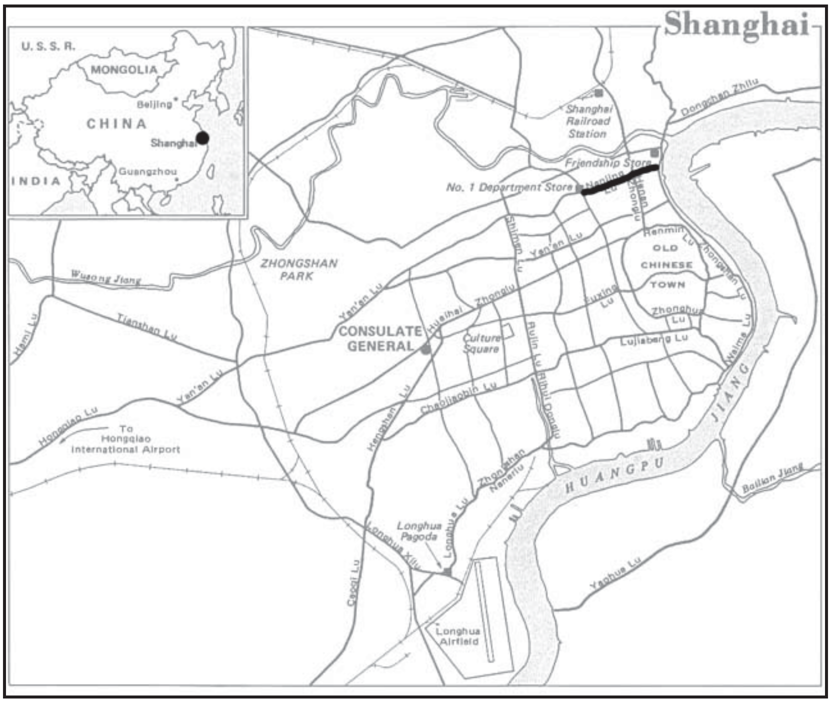


Figure 1

Figure 2

B. The Growth of the Region

1. The Forces Composing the Urban Texture in the Region

a) The Political Force

The process of a strategy called “Construction beyond boundaries” [2] wove the city since its colonial period. In the figure 3, the above zone in yellow is the British concession, the below in blue is the French zone, both setting out from the Bund. The colonists just got the permission to settle their homes along the Bund from the Tsing Dynasty after the 1840s war. To expand their region, the British built new houses along Nanjing Rd. from the east to the west as their living and commercial axis. At the same time, they "offset" this main axis to the both sides in a very short distance offering cheap houses to the local people without the local government's permission. Initially the local government didn't notice such small construction process. With full filled residents living in this region supported by the urban facilities offered by the colonists, the British got the tacit permission to expand their concession to the north and south, which is called "Construction beyond boundaries".

As a part of colonial history, the growth of the city is the result of the expanding forces of the foreign countries, during which the streets' patterns of the Tsing Dynasty were broken into pieces and reconstructed by the strong western politicians.

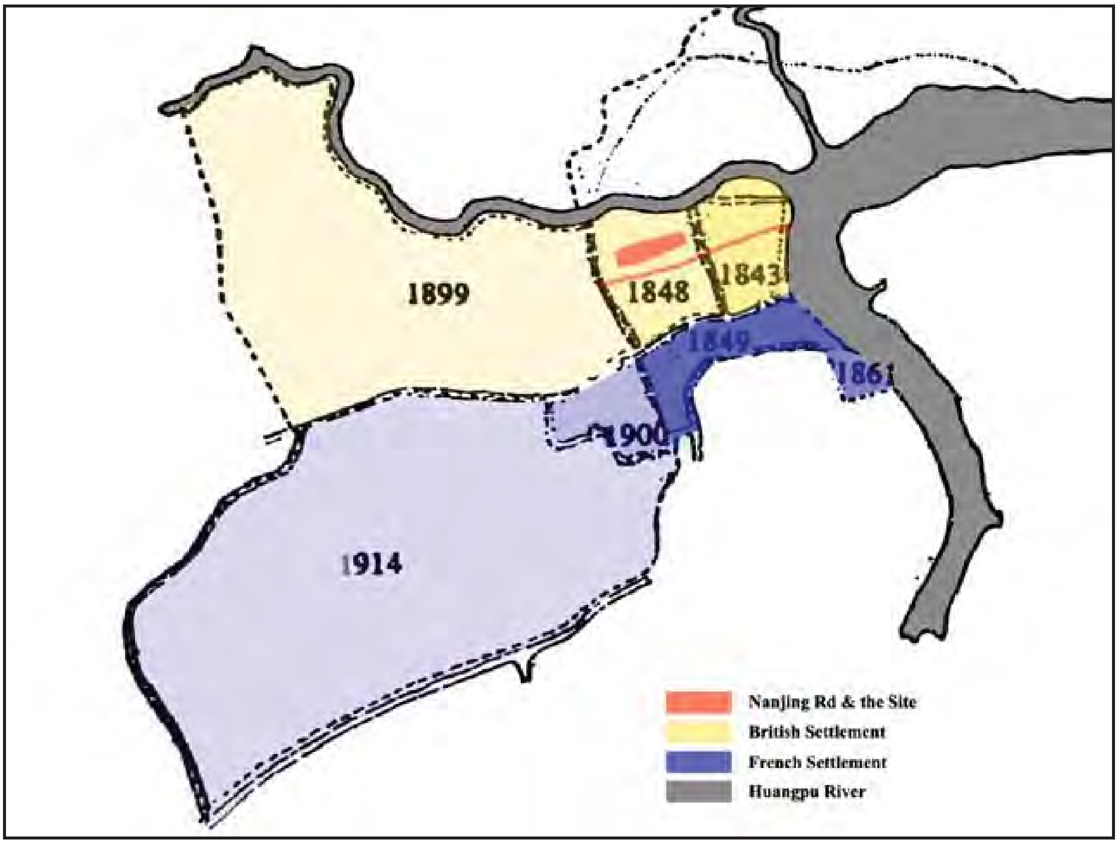
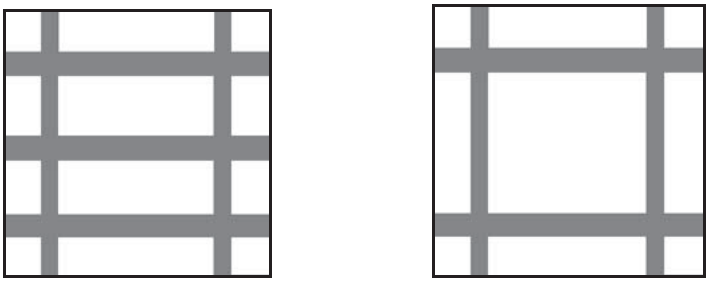


Figure 3

b) The Commercial Force

The main developing axis Nanjing Rd. got its unique commercial position in Shanghai naturally. The value of the interface between buildings and streets became an obvious aspect for the developers to consider. With the born proportion of the crushed street blocks as the results of the "Construct beyond boundaries" the developers could pursue the maximum continuous commercial interface in a given region as showed in figure 4. And actually the north and south interface of the street blocks in this region became the top commercial streets of the city even the country at that time. The land price was known as "One inch square one inch gold bar".



Crushed Street Blocks **Normal Street Blocks**

Figure 4

c) The Traditional Force

The concept of Feng Shui, which means the location of anything would bring the owner different fortune has a deep influence on all the construction of Chinese people. It is why the buildings always face north or south never the east nor west. The developing of the city Shanghai was also guided by it as a mixture of the western planning and the local tradition.

2. The Special Urban Texture of the Region

The combination of the above forces wove the special urban texture on this region around Nanjing Rd as we could see in figure 5. The street blocks on the both sides of Nanjing Rd. are crushed, while the blocks away from it are stepping into the normal proportion, which is something like the tree’s growth rings from the dense to the loose. All these urban textures recorded the growth of the city since the colonial period, which is regarded as the birth of modern Shanghai.

As the conservation result the old multi-story commercial buildings are still standing there acting as the volume of the top commercial pedestrian region, while the new skyscrapers stand behind them. The processing urban revolution hasn’t destroyed these old buildings because of the good shopping atmosphere they providing which the skyscrapers can’t. Looking at the figure 6 we could find the situation of this region. The pressure from the high buildings is there. From the eagle views the region is like a valley with old low buildings in dense surrounded by new high buildings in loose.

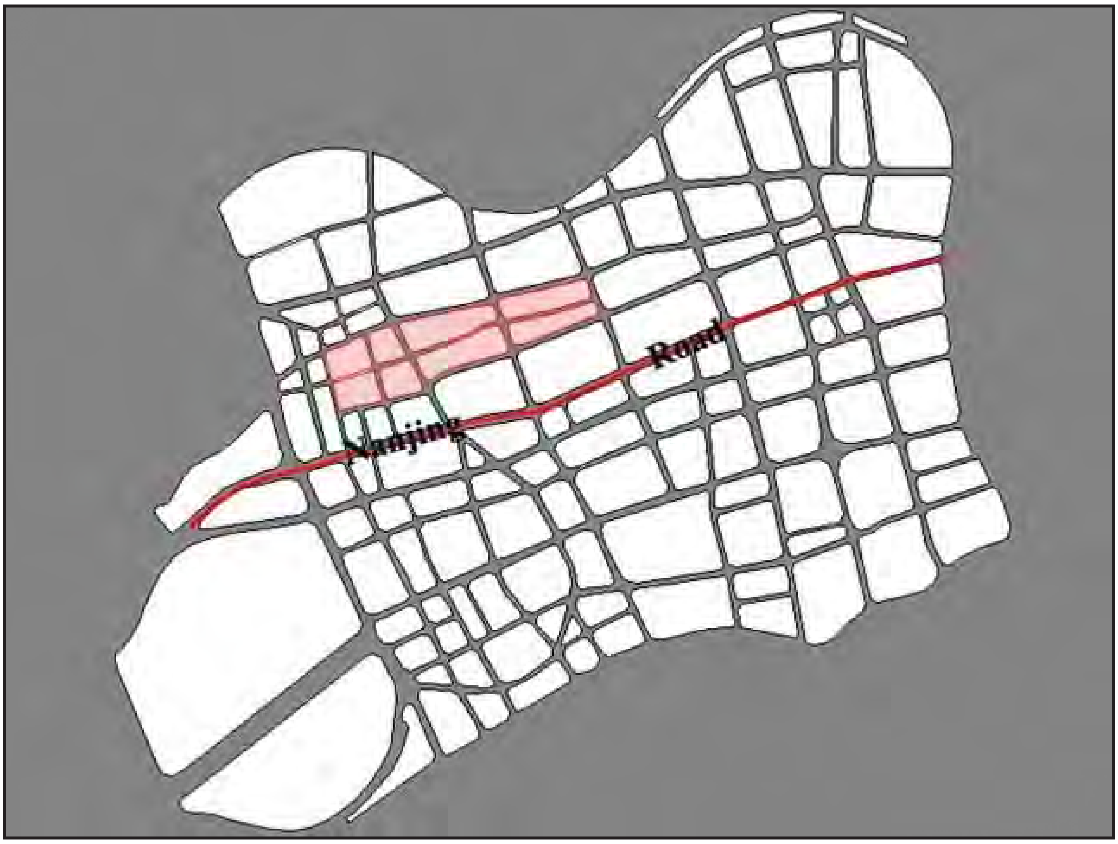


Figure 5

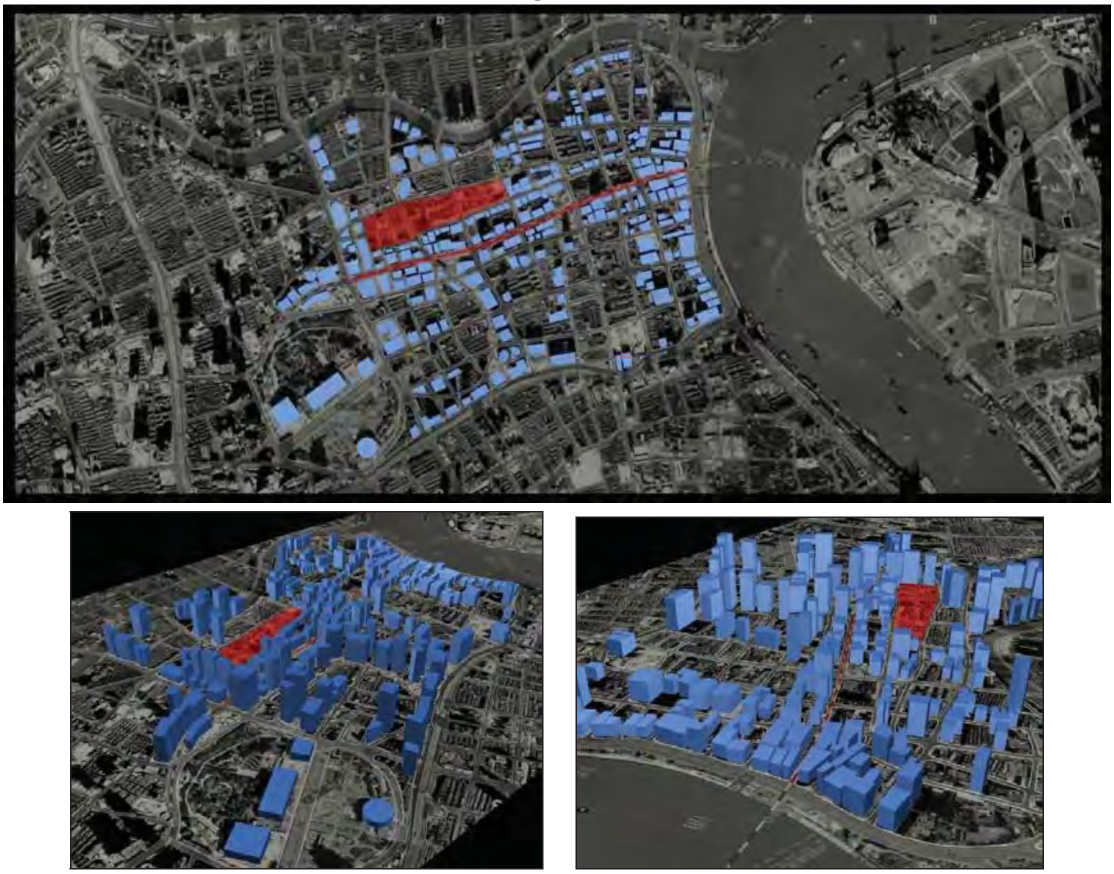


Figure 6

II. The Crossroad in Front of Urban Planners

A. The Demands from the Booming Economy

The city of Shanghai is having an urban revolution based on a booming economy, which could be drawn from the huge urban construction amount. The investment on the urban construction in Shanghai from 1990 to 2000 is 310 billion RMB (equal to 38 billion USD). The total exchange amount of the real estate of the city in 2001 was beyond the whole Europe. And the increase is about 33% every year [3]. From all these figures we could imagine why we called Shanghai a world site nowadays. The developing model here is very simple, just destroying all the existing to build a brand new one. Such strategy is based on the demand from a tight construction schedule, which equals to the profit to the investors. So we didn't have time to consider more on the way we are taking. Everything is just from our instinctive response. What we know best is, "We want good floor area as many as possible on a given site in a short time as soon as possible, all which could repay us the most."

B. The Way We are Taking

With the thinking above, the investors helped by the designers found the easiest and the seemly infinite way to get floor area is to combine the crushed street blocks into bigger one with proper dimensions to build high buildings on it. Such process is under going now in our site. In figure 7 we could see three streets have been erased. Then the six crushed blocks have been combined to adapt the dimension of a new skyscraper. As a result, a part of the urban texture as an evidence of the city's growing history has been erased.

Figure 7

C. Urban Complexity Beyond Two Options in Front of Planners

It seems inevitable to destroy the old urban texture to full fill the economic demand to build skyscrapers. But this decision is just based on one condition that the floor area demand could only be full filled by the skyscrapers which could always offer more floor areas than the multi-story buildings. So in front of us there are two options in urban development as shown in figure 8, to be higher or to be denser. As we know, on a given site building higher would definitely get more floor areas than building lower. But the real urban situation is much more complex. Another aspect "Density" would count a lot. For the reasons of fire protection and sunshine hours, the high buildings have to stand in a low density, while the multi-story-buildings could stand shoulder to shoulder in a very high density. Then with a different density, it would be very difficult to tell immediately which model, “higher but looser” or “lower but denser”, provide more floor areas.   This is why we always provide 3 main figures as Total Floor Area, Density and Height Limit, when we give a development plan to a region. With these figures the further designers always have a very big design space, in which he could choose to go higher or denser both having the same construction volume. Here on this pedestrian site, it is obvious that the denser model could provide a better shopping atmosphere, much longer commercial interface, and better view from the bund than the higher model on the condition that the total floor areas the denser model could offer here could full fill the real market demand. If we could prove that, it will be a strong beat on the popular building-higher-model in Shanghai, and a good path to save the historic urban textures under the huge revolutionary pressure from the economy demand or just an excuse of a lazybones.

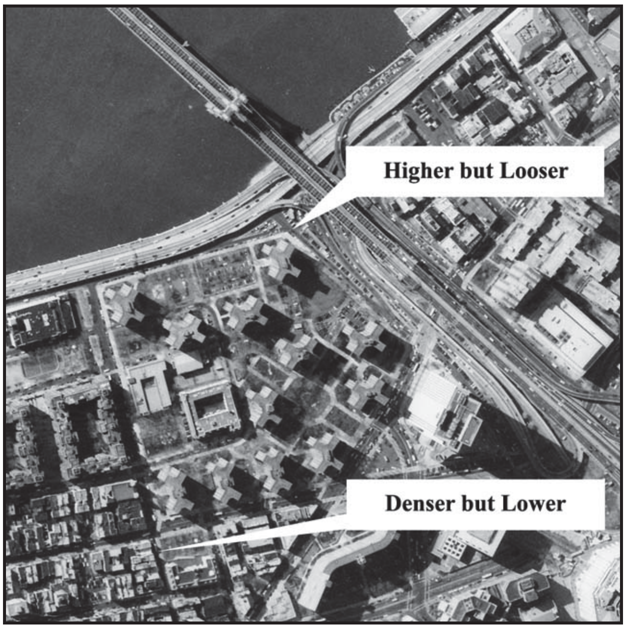


Figure 8

D. The Author’s Defense

The period of foreign concessions is at least one of the most important parts in the history of Shanghai, especially in the fields of the city’s construction development and the city’s culture. As a main growing axis, Nanjing road and the region on the both sides are the best clues to understand the city. Then the special urban texture in this region is a lively evidence. So the author believes that there should be no reason to erase such an important footprint of the city. To keep it and to full fill the demands from the booming floor area usage, the author tries to establish that to be denser but lower will be better than to be higher. To debate on that, he takes the following analysis, and tries to defense with iron evidence.

III. The Author’s Analysis Aided by GD Concept

A. The Usage of GD Concept

The concept of GD (Generative Design) is introduced to this analysis. The philosophy in front of us is revolutionary. The traditional design process is always abstracted as a loop of generating one solution following a careful evaluation. The quality of the solution in a limited schedule is decided by the amount of the loops. More loops would lead to better consideration on more aspects, which is always the foundation of a better solution. We always regarded that the two parts, generation and evaluation are the domain of human intelligence. But the GD concept frees the human brain out of the generation part instead of rapid computer generated solutions based on some rules, which we used unconsciously in design process in the past. Then the human brains can focus totally on the evaluation part. Actually the speed of one loop in the design process is greatly accelerated by the aide from the computer. Then with more loops we can raise the design quality. At the same time, the design process is becoming a selecting process. Maybe in the future, everybody could enjoy the design process with all the special complex rules and calculation done by a program [4].

With such a new concept, we could try to generate building boxes on a site according to any given parameters such as Total Floor Area, Height Limit and Density with the layout rules we used to apply on the site. Then the computer could generate hundreds and thousands of different solutions or we called them samples [5]. Let’s generate 100 samples for each set of parameters. From the view of statistics, more samples will lead to more accuracy [6]. One designer would give 1-5 different solutions to a site according to a set of parameters normally. Then 100-sample is enough to hold all the possibilities of street space forms on a building-box level (The “building-box level” is the premise of the following analysis, which means every building is presented as a box of the same volume). After we adjust the parameters as we planned in the following, we could get 4 sets of 100-sample which could present all the possibilities and features of the street space forms on a building-box level of the site in the planned 4 circumstances. Finally, we could do the visual analysis based on the features and representative models among these four 100-samples.

In the following we could discover that GD method offers us a path to the rational analysis on the space regulatory parameters in a decision-making stage while the most work could be done on the building-box level.

B. The Factors Considered in the Experiments

As we mentioned above, the real site situation is very complex. A pure form without the consideration on the other factors means nothing. From figure 9, it is clear that the buildings in the site have to conduct the relationship with the conservation buildings on the Bund to the east, the atmosphere when people shopping inside on the streets, the extent of the sunshine disturbance on the surrounding buildings, and the height’s up and down from an eagle view.

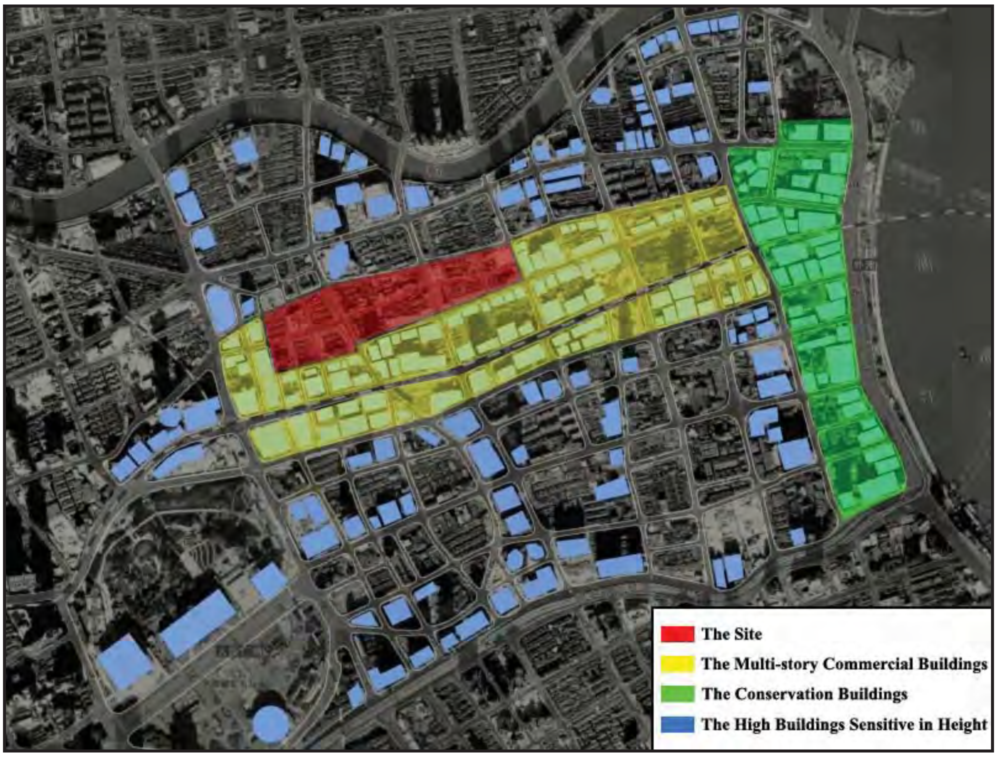


Figure 9

1. The Visual Disturbance on the Conservation Buildings

The government documents need the Bund to be visually protected. That is to say people should not see anything disharmony on the skyline of the Bund, when he stands on the other side of the river. In other words there is a height limit (for our site it is 24 stories) [7], near the bund being lower while away from it being higher. This could be controlled in the program to set different height limit. And the result could be examined by a 3D perspective view on the generated box models.

2. The Visual Harmony while Shopping along the Streets

The commercial atmosphere is usually effected by the proportion of the street width and the façade height, altogether by the scale and continuity of the street space. There are a lot of books to introduce the special figures, which are the results of experiments and observations. Not to be too dogmatism, we just adopt some rules not the exact figures. Usually continuous interface and WH proportion between 1:1 to 1:3 will be welcomed by the commercial pedestrian streets. Anyway, we have the 3D models. With the VR tech we could feel the atmosphere directly.

3. The Sunshine Disturbance on the Surrounding Buildings

The sunshine hour is a very important figure in Shanghai real estate market. And the disturbance on the other buildings always limits the design space in a great extent, especially in such a developed region with a very complex situation. So in this stage we just use a basic distance formula to keep the building density in the site.

4. The Heights' Up And Down of the Region from an Eagle View

As far as the eagle view from the towers in Shanghai is concerned, we used the VR again to simulate the perspective views from several important towers such as Jin Mao Tower. It may be an exciting aspect for the governors to consider.

C. The Four Experiments Designed for the Rational Comparison

The 4 planned experiments (see Table 1) are based on the government planning regulations and the construction experiences with the premise [7] that in this site, the high buildings would have 18-24 stories; multi-story buildings would have 5-7 stories; for the high ones, “Density” has to be below 70% and “Floor Area Rate” has to be below 8; for the low ones “Density” has to be below 70% and “Floor Area Rate” has to be below 4.5.

Then the author generated 100 samples for each experiment (A-D) with the program HOD.

The operation steps are introduced in the following.

Step 1. Run HOD which is programmed in VB6 using the ActiveX interface of ACAD 2004 [8-10].

Step 2. Open the DWG file of the site containing the red lines and surrounding building boxes with the thickness representing the heights.

Step 3. Pick the red lines of the design region in a window selection.

Step 4. Setup the parameters such as Story Range (low & high), Density, Floor Area Rate and the others as shown in the figure 10.

Step 5. Click the button “Generate”. (“100 loops” was set in the program, so it will generate 100 different samples of the whole site with building boxes according to the above parameters in several seconds. All the results are placed in ACAD Model Space in another layer. Then we could check it conveniently.)

Step 6. Browse the samples and pick out 5 typical samples from each experiment to visually analyze in 3DMAX through several fixed cameras.

The figures 11.1-11.4 for A-D are a part of the eagle views rendered in 3DMAX. And figures 12.1-12.4 for A-D are the street views from the human views.

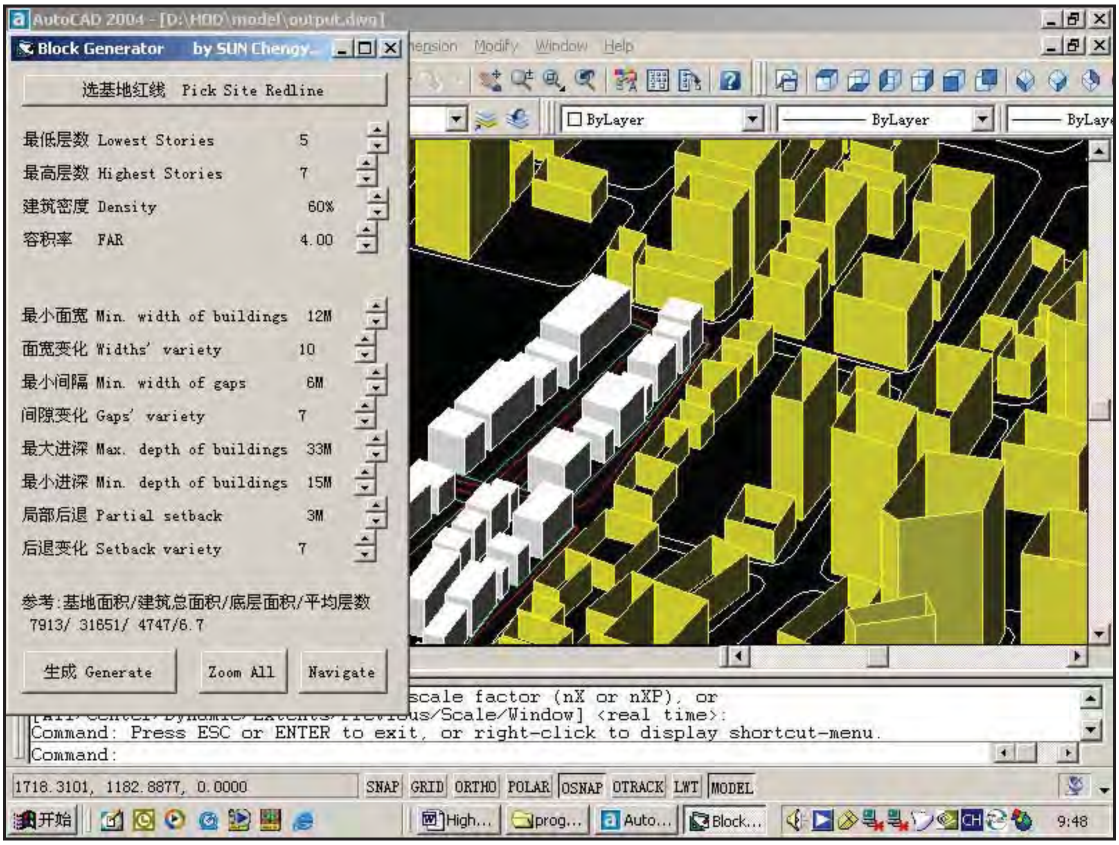


Figure 10

Experiment	A	B	C	D
FAR	4.0	4.5	4.5	8.0
Density	60%	70%	19%	38%
Stories	5-7	5-7	18-24	18-24
Notes	Keep the existing urban texture		Have to erase five streets	

Table 1

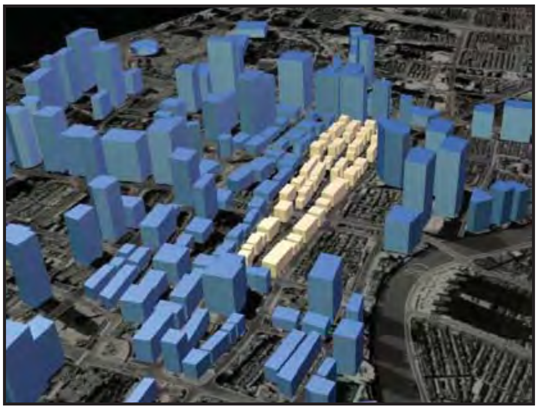


Figure 11.1

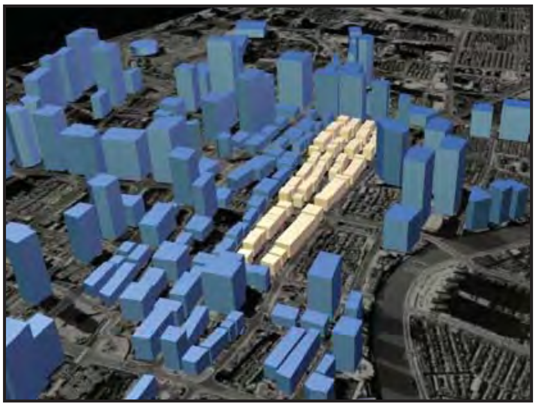


Figure 11.2

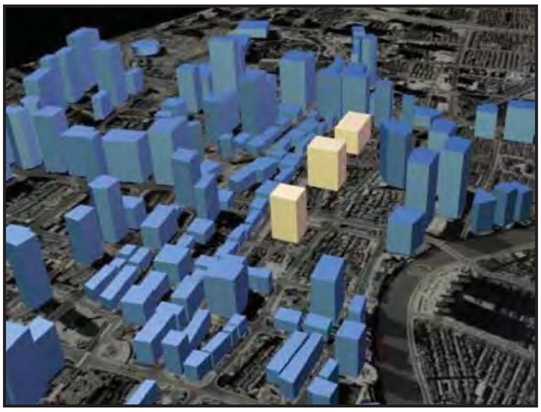


Figure 11.3

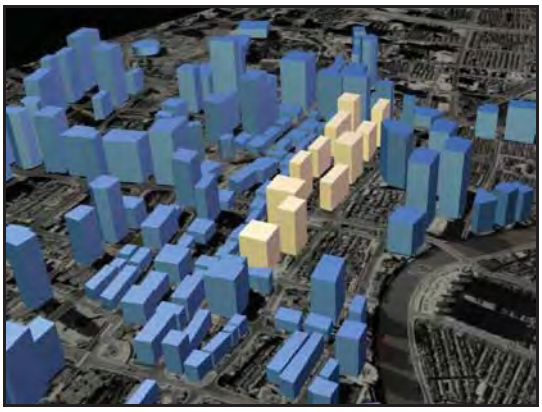


Figure 11.4

Figure 12.1

Figure 12.2

Figure 12.3

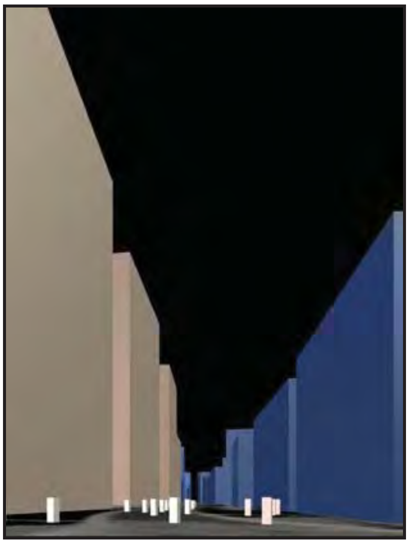


Figure 12.4

IV. Conclusion

Based on the analysis of the generated samples the author found that:

First, it is impossible for the planners to keep both the skyscrapers and the existing special urban texture on one site. They have to choose one direction.

Second, the floor area limit of multi-story building is 225,000 square meters as in sample B (figure 11.2 and 12.2). At the same time the density is 70%, which could full fill the real market demand of 180,000 square meters [3].

Third, according to the conservation height limit and the FAR limit, the density of high buildings can't beyond 38% as in the extreme sample D (in figure 11.4 and 12.4), which would lead to a shopping malls model not a pedestrian model.

Fourth, concerning the continuity as well as the atmosphere of the commercial interface and the relationships to the opposite buildings on Nanjing Rd. and the people walking on the pedestrian streets, the visual effect of the sample A and B (in figure 12.1 and 12.2) are much better than in sample C and D (in figure 12.3 and 12.4).

In summary, going denser is more suitable on this site, which could not only full fill the real market demand, but also offer the benefits of the urban texture conservation, better commercial atmosphere and human scale, or we say that it keeps the quality of this top pedestrian shopping region in Shanghai. At the same time, the author found that the proper parameters for this site is FAR= 4.0, Density=60%, Height=5-7 according to the samples, which could offer a good visual effect and 20,000 square meters.

Wish this conclusion could contribute to the urban construction on this site in future.

References

[1] Wang, Shaozhou, 1989, *The Shanghai Urban Architectures*, Jiangsu Science Publishing.

[2] Wu, Jiang, 1997, *The Shanghai Architecture History in One Hundred Years*, Tongji

Publishing.
[3] Shanghai Economic Committee, 2003, *The Real Estate Survey*, Shanghai.
[4] William J. Mitchell, 1995, *City of Bits*, MIT Press.
[5] Goldberg, D. E., 1989, *Genetic algorithms in search, optimization and machine learning*, Addison Wesley Publishing.
[6] Feller, W., 1971, *An introduction to probability theory and its applications*, New York: John Wiley & Sons inc.
[7] Shanghai Urban Planning Committee, 2002, *The Regulations of Shanghai Urban Planning*, Shanghai.
[8] Holland, J. H., 1962, *Outline for a logical theory of adaptive systems*, Journal of the Association for Computing Machinery.
[9] Howard, Lee M., 1995, *The GA-P: A genetic algorithm and genetic programming hybrid*, IEEE Expert.
[10] Michalewicz, Z., 1996, *Genetic algorithm + data structures= evolution programs*, New York.

GANERATIVE DESIGN OF CHINESE PAGODAS

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Abstract: After the research of “The generate method of Multi-storey Chinese Pagodas”(GA2002 Page26.1), we go on to find the usage of GA in the design of Chinese pagodas. For Chinese pagodas are traditional buildings, not all of modern designer can design it with traditional way. We try to find a modern way for modern designer to design traditional Chinese pagodas with GA in this paper.

Keywords: generative, pagoda, design, Chinese, pagoda

Buddhism

This religion took shape in about 500BC in ancient Indian, and was soon widely propagated in the world, especially around the Eastern-Asia. During the first century AD it got into the territory of the Han Dynasty, then in the following several centuries it had been widely spread around the Eastern-Asia, including the Korea Peninsula and Japanese islands. With time going on, it had been one of the most important parts of the Eastern-Asia culture.

Buddhism is a religion of image, that is to say, it is preached through images. Thus innumerable images of Buddha as well as Buddhism pagodas had been built up, which monks and laymen can pay their homage to. Through the whole Eastern-Asia area and during the history with Buddhism in this area, Buddhism pagodas had been constantly erected under Buddhists’ religious zeal. Thus Buddhism pagoda gradually became one of the most important architecture types in this area, and the constructing technology of this kind of building gradually became mature.

Buddhism pagodas

As time going on, Buddhism pagoda evolved more senses beyond religious symbol, its tall, graceful and striking appearance usually made itself a mark of a city, or an important part of a scenic spot.

As a cultural symbol of Eastern-Asia, Buddhism pagodas are still popular today. Many famous Buddhism pagodas in the history had been repaired, renovated or even rebuilt; and new ones are still constantly built up because Buddhism is still well received in these areas. Furthermore the elegant, striking appearance of multistory pagoda is still admired and enjoyed by people there. This pretty appearance can be used in the new multistory building and new scenic spot too.

Pagoda today

So pagoda still has its market in Eastern-Asia. The problem is how does nowadays architects design this kind of building, with traditional appearance or with characteristics.

We know that ancient Eastern-Asian had evolved their traditional architecture system, this system included a whole set of ideas: designing, manufacturing, constructing and so on. These ideas are mature and definitely different with nowadays. And they are a little complex, so obscures to nowadays architects. This paper wants to establish a mathematical model to simulate this kind of building. The references in the model can be achieved from these numerous relics. Then we can make a communicable computer program to help architects to design nowadays pagodas.

What is the experiment?

As we talked above, the aim is to establish a generative project for nowadays Eastern-Asia Buddhism pagodas designing. Thus the final appearance of the building must have the traditional disposition. So this experiment is an exploration to probe the realities of historic research. Furthermore this experiment puts forward an idea of how to abstract historic spirit and then bestow them on nowadays creations.

1. Typical Model of Buddhism Pagodas' Shape

As we had discussed in the previous paper, in Eastern-Asia people had evolved four main types of Buddhism pagoda, and the multistory ones 楼阁塔） and close-eaves ones 密檐塔）occupy a great part of these. Even more these two kinds are better received in nowadays new-pagoda designing. So this paper will concentrate on these two types.

And as we had talked about in the previous paper, every traditional Eastern-Asia pagoda has four parts: underground palace, platform, body and steeple. We know that the body is the main part of the appearance, so this paper will focus on the shape of the body. The other three parts will be discussed in future research.

Because this paper pays close attention to the body shape of the pagoda, regardless the religious themes and other details, we will just focus on the rough shape of the body, and only on the geometric figure.

Then looking into all traditional multistory pagodas楼阁塔) and close-eave pagodas密檐塔)we can find out that though in details they are definitely different from each other but from geometric angles they are typically the same. They are all central symmetry platforms, and are constituted with several such kinds of platforms. The geometric model can be a series of similar platforms, which are pilled up on each other with size diminished while height increased. Another feature is that the planes of these platforms are all regular polygons while the number of edges is even number, in Chinese philosophy this kind of number resembles YIN阴)the earth, low, muddy and things like these. While the layers must be odd number, which resembles YANG阳)the heaven, high, clear and things like these.

2. Steps of Generative Designing

From above analyzing, we can easily establish a typical model of pagoda. Then we should consider how to undergoing a nowadays pagoda designing. From our experiences, it can be separated into three main steps:

Firstly, we decide the scale and type.

Secondly, we decide the rough outline.

Thirdly, we decided the details.

As we had discussed before, this paper will just focus on the first two steps. Lets deepen the study now.

The first step: deciding the scale and type

When we begin a design, firstly we should make sure the location, then deciding the scale and type. We used to describe the scale with two references: H (the height of the pagoda), R1, R2 (the radiuses of the circumscribed circle at the bottom of the lowest platform (R1) and that at the top of the top platform (R2)). We describe the type with two references. One is S (the shape reference of the pagoda. For example, we can define S=1 standing for multistory pagoda, S=2 standing for close-eave pagoda.) The other reference of type is N (refers to the number of the stories, as we had discussed before it should be an odd number).

When we input the certain numerical values of these references, then we can acquire a rough shape of a pagoda: it will be a frustum of a cone. We can judge the rough shape according the nearby environment.

Then we go deep into the second step.

The second step: deciding the rough outline of the body.

As we had discussed above, the body is not a simple cone, it is constituted with a series of piling-up similar frustums of platform whose flat form is regular polygon. Thus we should go into details of the outline of the body. We looked back into all traditional multistory pagodas楼阁塔）and close-eave pagodas密檐塔）easily　 we can find out that the outline can be simply sorted into two rough kinds: One is nearly a line, the other a kind of parabola. Thus we simply decide two main types of the outline:

$H_i=f(R_i)=a*Ri+b$--------------------------------------when the outline is nearly a line.

$H_i=f(R_i^2)=a'*Ri^2+b'$--------------------------------when the outline is nearly a parabola.

H_i: the height of the outline of the No. i story

R_i: the radiuses of the circumscribed circle of the outline of the No. i story

a, b, a’, b’: constants decided by the designer. The shape of the outline has relationship with these constants. But we can bestow historic characteristics into the shape through give certain scopes of these constants, and the scopes are decided on the basis of analyzing all the traditional pagodas.

When we input the certain numerical values of these references, then we can acquire a rough shape of a pagoda: it will be a series of piling-up similar frustums of platform whose flat form is regular polygon. We can judge the rough shape according the nearby environment.

Then we go deep into the third step. This will be discussed in future research.

3.Data Base

To make the project be generative and with ground, we must analyze all pagodas built during ancient in the Eastern-Asia area first. To make it more useful, we suggest that analyses should be undergoing after sorting all historic pagodas, and undergoing according to the classifications. The standards for classifying can be eras, districts, types and so on. Eras can be classified according to the Chinese historic periods. Districts can be sorted according to the different local architectural styles. Types refer to multistory pagoda type and close-eave pagoda type; maybe in future we can spread our research to the other types.

Through the above analyses we can acquire a series of references or scopes of constants, these have relationship with the era, local architectural style and type as well, they come from history and go into future. Thus we can establish a database of the Eastern-Asia pagodas, this will be the base of the generative project. Then architects can design pagodas with the help of this generative project. With the database the final shape of the pagoda outline will have some traditional characteristics even the designer has poor knowledge about the traditional architecture. He can create a pagoda with pure Tang Dynastic feature; even the features were only popular in a small area, as if he is an architect with profound traditional architectural accomplishments. Or he can create some compromise pagodas.

4.How to Use?

Then we should set up the project with the help of programmer. They can design an easygoing program on the base of the mathematical model and the database we had discussed above.

For architects, they just input some mathematical values then the program will generate a three-dimension model, which is readily for designers to judge. So it is very easy to communicate with the program.

An Automatic eneration System of Hip Roof uilding and Case Study

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Abstract

This research is our first trial in the field of generative design.

When we do research on the form of building roof, we find the ridge roof is quiet familiar to us not only in China but also other countries. We often meet some architecture design projects that need us to design buildings with the form of ridge roof in consideration of context, function and so on.

Hence we begin to focus on an Automatic Generation System of Hip Roof Building and aim to explore the practicability of using generative design methodology in the field of Architecture and Urban Planning Design.

In this paper, we state the process of automatic generating Three-D models of hip roof building. On the basis of case study, we point out the peculiarity and limitations that exist in the Automatic Generation System of Hip Roof Building at current study stage. At the same time, we make an outlook about the development of this system.

Introduction

With the development of computer technology, we have changed our life and culture concept imperceptibly. Nowadays, in the field of Architecture and Urban Planning Design, there are many new design methodology and concept which closely relate to the computer technology have been coming into being, such as dynamic architecture, evolutionary architecture, hypersurface architecture, cyberspace, generative design and so on. Many people, such as Marcos Novak, feel that we are in the centre of a global, architectural renaissance: that we are in an exhilarating climate where the most advanced and challenging architecture being designed around the world could not have been conceived without the use of computer. It is hard to deny such a proposition when looking at the changes in our surrounding. [1]

Nowadays computer technology used in architecture is restricted to drafting, or building up Three-D model after we have designed the architecture. As Frank Gehry once said that computers cannot create the curves of a design, and are only a tool to help us draw the curves as they are in our mind. [2] This is a good explaining what the role of computer is at present.

This approach to the computer as an extension of previous design techniques severely limits its potential. [3]

There's no doubt that computer technology has changed us enormously. So it's time for us to do some fresh attempt in the field of Architecture and Urban Planning Design, and we want to use generative design method as our first trial. At first, we felt quite puzzle about what kind of research we could do. We thought that Architecture and Urban Planning design were practical science, and decided to put this research on the basis of practicability. We considered that every building or urban planning located in different area, and had different function to satisfy people; but the lack of specific function is totally in keeping with the liquid variability of algorithmic space. [4] Therefore, the morph of building that generated by computer will be quite pseudo. Then we determined to focus on house roof. We find that not only in ancient China but also other foreign nations, there exist many buildings that have ridge roof characteristic. (figure 1) Nowadays, we also design ridge roof buildings in considering of context or function and so on. Hence we chose to do research on an Automatic Generation System of Hip Roof Building, and we found it's quite useful to generate this kind of roof by generative design method according to its mathematical regulation.

Figure 1: left: the Forbidden City in China right: traditional residence in foreign country

We decide to use this system at the initial stage of our Architecture and Urban Planning design, for we don't think much about the function of the architecture at this stage, and thus we can make full use of the randomness of computer program to automatic generate much more possibility of one project in a short period of time. This Automatic Generation System of Hip Roof Building is premised on the outline of the architecture's plane, and it can automatic generate Three-D model of architecture or architecture cluster by using some kind of algorism and programming language such as VC++ and so on. We also set up parameters to control the result of the system. At the first stage of our research, we think that the ridge roof of modern architecture is quite concise in construction than that in ancient China, so we simplify the hip roof, and consider that it is composed of four planar. Furthermore, we make some constraint on the original plane of the building, such as the monomer architecture should be orthogonal and its location in the master plan should also be orthogonal.

Method

Description of the system

We mainly use Visual C++6.0 to edit this Automatic Generation System of Hip Roof Building. Additionally the system comes down to AutoLISP, MAXScipt language what are the script language of Autocad and 3DMAX. Simultaneously, the OpenGL that provides standard program interface is also necessary.

The structure of this Automatic Generation System of Hip Roof Building is composed of category and syntagm. The category class is shown in figure 2.

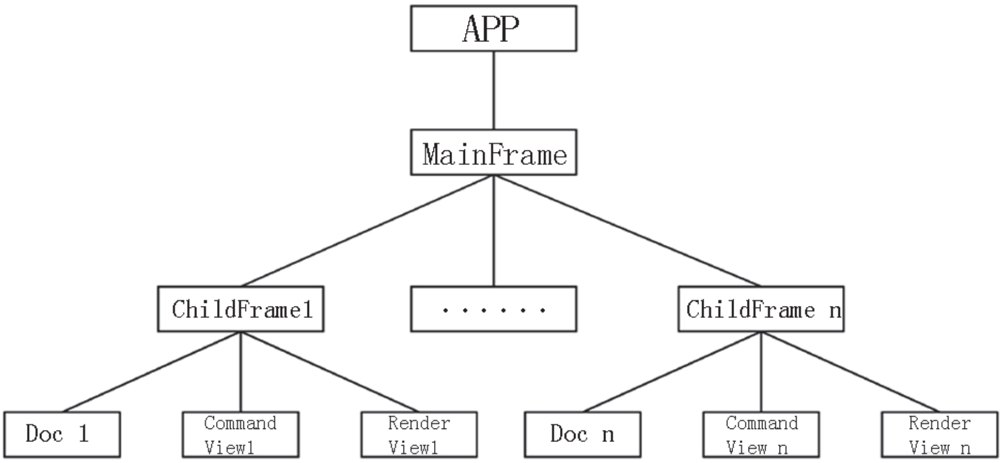


Figure 2: category class of the Automatic Generation System of Hip Roof Building

enerati e process

We take one single building as an example.

2.2.1 Read primitive DXF document

We'll import primary file what serves as the source of automatic generative Three-D architecture model to the Automatic Generation System of Hip Roof Building in this step.

First of all, we need to set up the primitive file. We shall extract the outline of the building which we want to generate it's hip roof from the master plan that we have drawn in AutoCAD2000, and save it as the format of DXF document. In respect that it's our first step in the research and it's quite reasonable to bring down the difficulty degree for the second step, we determine that the single building's outline should be orthogonal and it's position in the master plan should also be orthogonal because of the specialty that most of the hip roof building's plane are orthogonal. If the position of the architecture cluster is not in orthogonal, we can deal with the buildings placed in the same angle as one group, and rotate them to the orthogonal position, then save them as the format of DXF.

We use the AutoCAD script language AutoLISP to read DXF file into the Automatic Generation System of Hip Roof Building. The outline of the building's plane will be shown in the view window as figure 3.

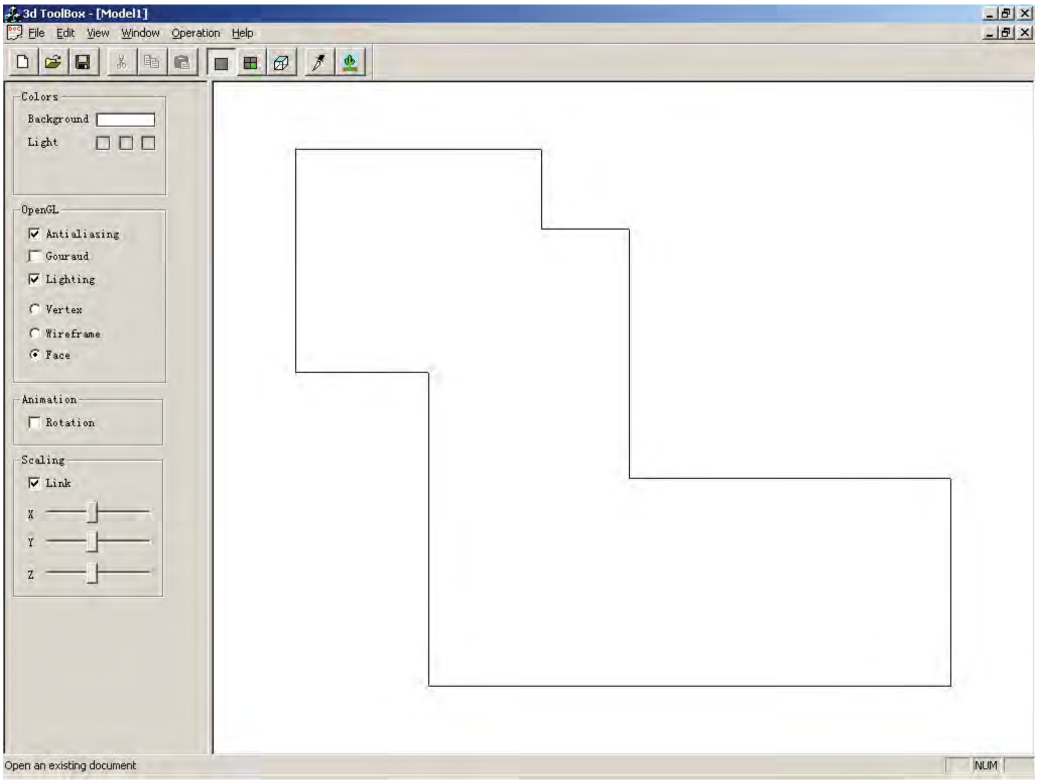


Figure 3: operation interface and the presentment of original DXF document in the view window

2.2.2 Subdivide two-dimensional plane

This operation procedure will divide the building's plane into several rectangles for the purpose of the next step. We subdivide two-dimensional plane by means of upright (shift vertical line from left to right) and lateral (shift horizontal line from below to above) division according to our algorism.

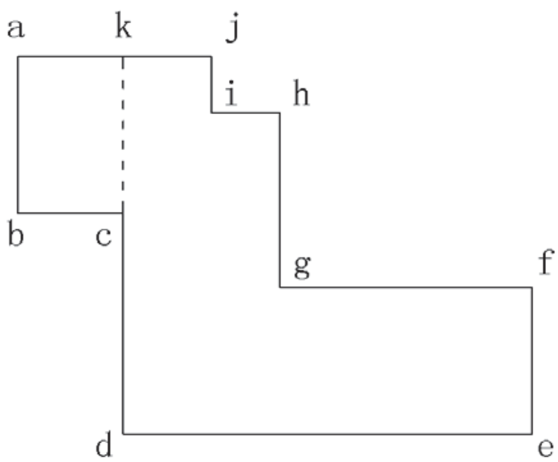


Figure 4: schematic of two-dimensional subdivision

For example, in the case of subdivision polygon abcdefghij shown in figure 4, we first shift vertical line from left to right. When the line meet the first end point c, according to the algorism, the system will carry out "adding edge" operation, and add an edge names ck. Thus the abck forms a rectangle. The system will exclude the rectangle abck in the next subdivision step, and it'll carry out "subtract edge" operation at the same time. The edge ab, bc, ak will be subtracted. The same method will be carried out on the polygon cdefghijk until it is subdivided into several rectangles.

In this step, we establish an upright division rate in consideration of the hobby of the user. The total of upright division and lateral division rate is 1. If the parameter is over 0.5, the upright division rate will larger than the lateral division rate. In addition, experiments passing by many times, we discovered that the accuracy of the document in AutoCAD2000 was larger than that in VC++. Therefore it appeared sometimes that when the document of DXF read into the system, the polygon shown in the view window was not close, and thus the subdivision would make some mistake. Therefore, we established in addition another parameter named "accuracy (number after decimal point)" shown in figure 5 for the purpose of avoiding false phenomenon caused by accuracy problem.

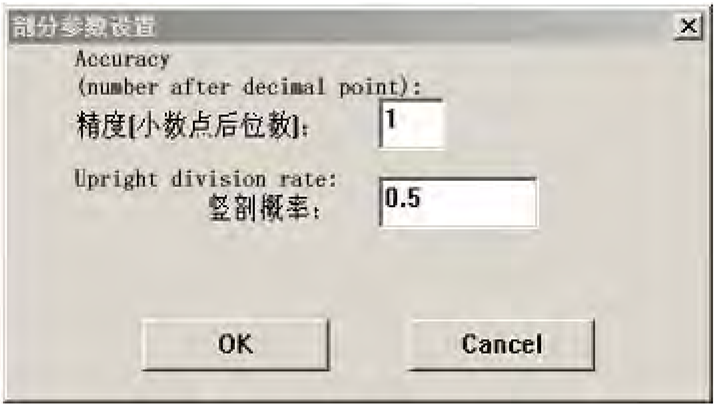


Figure 5: accuracy and upright division rate parameters set up list

The results of the two-dimensional subdivision are shown in figure 6.

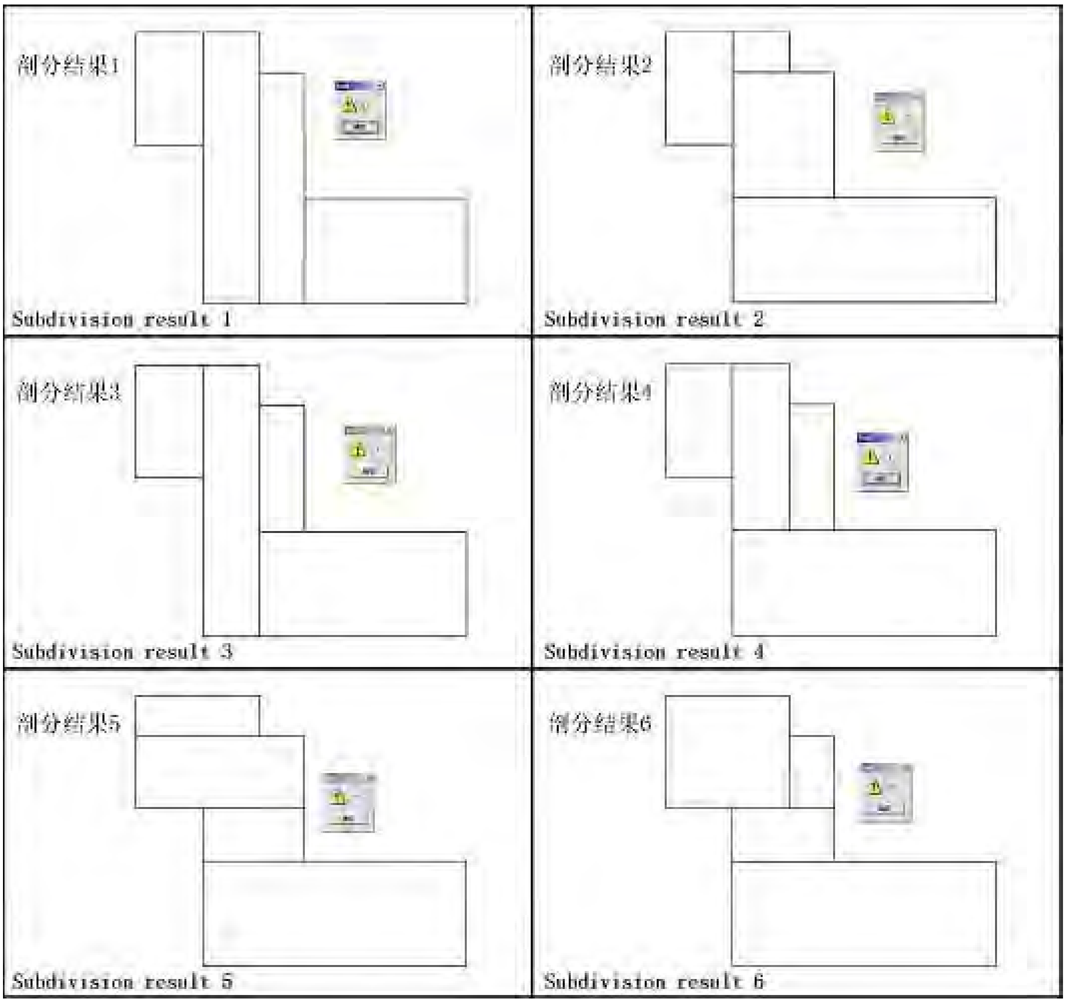


Figure 6: the results of two-dimensional subdivision

2.2.3 Three-dimensional generation

We plan to use this system at the beginning of our Architecture and Urban Planning design and hope to offer designers with inspiration. As we all known, designers often have no accurate request for the image and function of the building at this stage, therefore we give our system much randomness. And we'll find the results of the generation are quite different from each other.

On the basis of step two, in this step the system will first automatic generate Three-D model of the building with random according to the two parameters "layer number" and "story height (meter) " established by us, and then generate hip roof on the block that have the same height.

We have set up several parameters such as "height scope of the roof (meter)", "scope of the roof angel (degree) ", "probability of center ridge roof " and "probability of simple sloping" (figure 7) to general control the roof generated by the system.

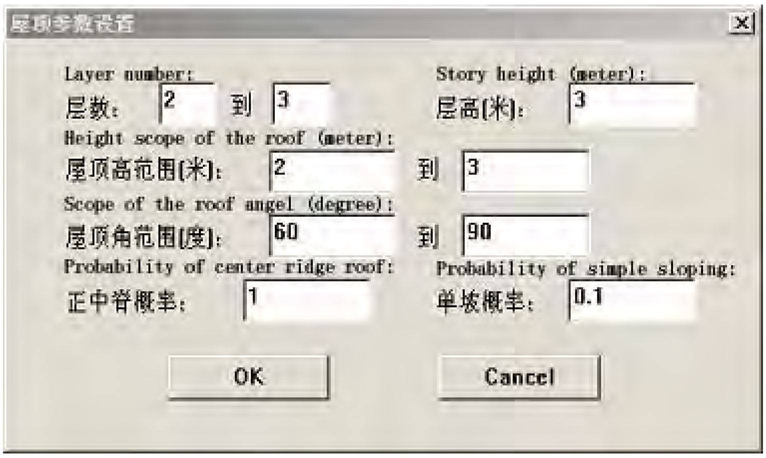


Figure 7: roof parameters set up list

When the roof angle α equals 90 degree, the system will automatic generate ridge roof with two slope; when roof angle α and roof height h at a certain setting, the four oblique ridges will cross at one point, and the center ridge will inexistent; and when the probability of center ridge is 0, and the probability of simple sloping is 1, the system will automatic generate simple sloping roof building. We look these kinds of roof building as particular cases of hip roof building. (figure 8)

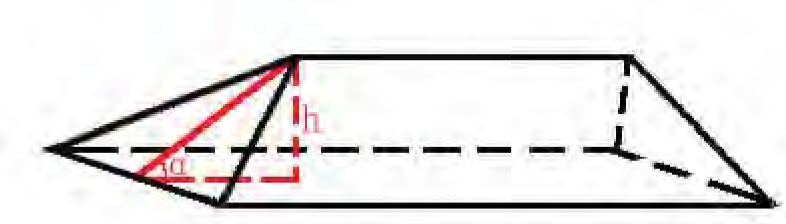
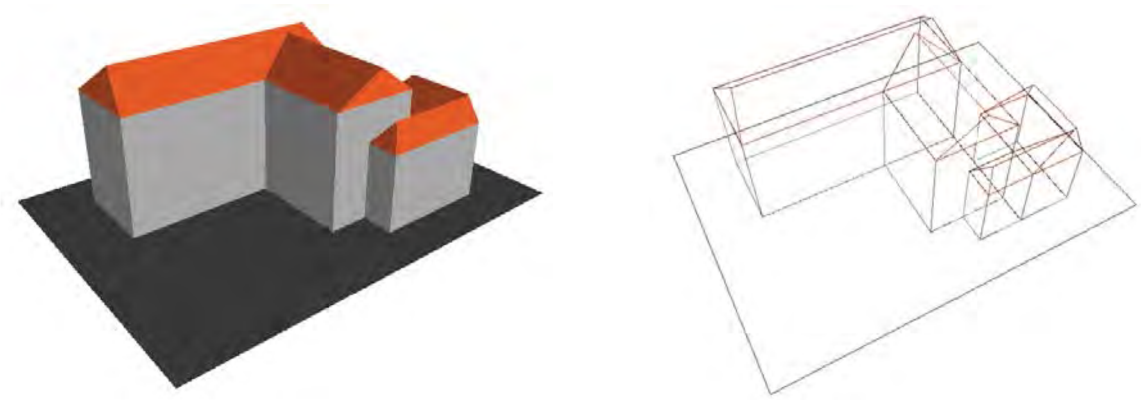


Figure 8: roof parameters sketch map

We choose result 2 and result 6 shown in figure 6 as example to generate Three-D models. Because the system can generate lots of models quite different from each other according to the parameters we have set, we select only six results for each time we set up the parameters. The results are shown in figure 9.

Figure 9: we select two samples from the results of two-dimensional subdivision and these are four groups of Three-D models automatic generated by the system with different parameters set up, while the six results in one group share the same parameters set up

There're several display mode for the Three-D model, such as vertex, wire frame and face. (figure 10) In addition, we can adjust the background colour and the colour of the light. Rest operation contain animation, 360 degree rotation and scaling adjustment in axis x, y, z.



Three-D solid model display **Wire frame model display**

Figure 10: Three-D model display mode

2.2.4 Save automatic generation result

The above three step has finished the procedure of automatic generate Three-D model of hip roof building. Because it'll cost much manpower to edit more operations function in this system, we decide to use software 3DMAX that has strong function in operating Three-D models. Subsequently, we make use of MAXScript, the script language of 3DMAX as interface and save the format of Three-D model generated by the system as MS document. We found it's feasible to run the MS document in software 3DMAX5.0. (figure 11, figure 12, figure 13)

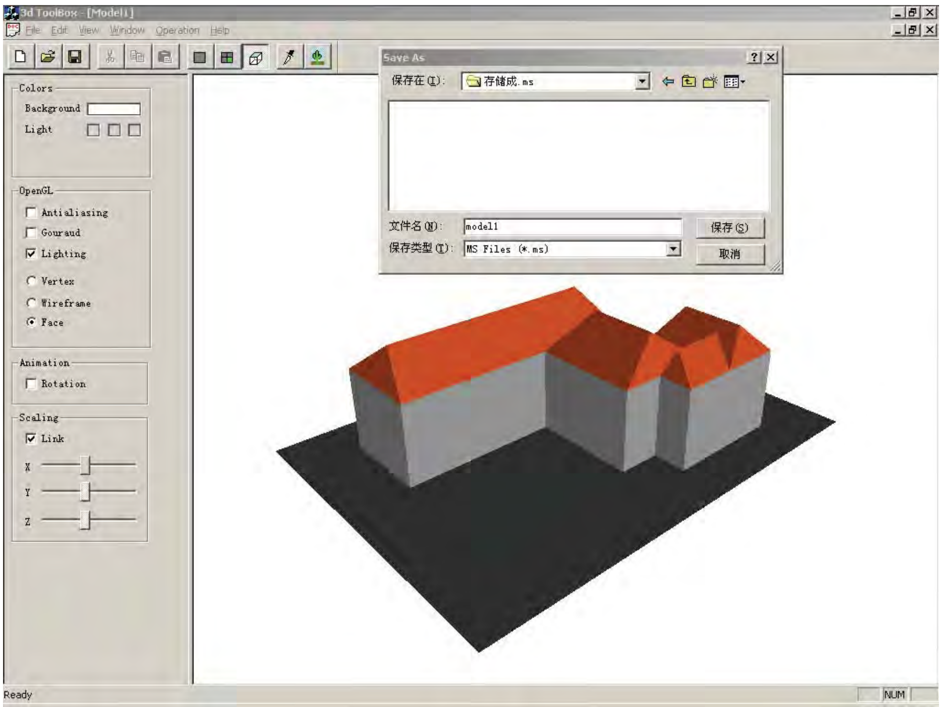


Figure 11: save Three-D model generated by the system as the format of *.ms document

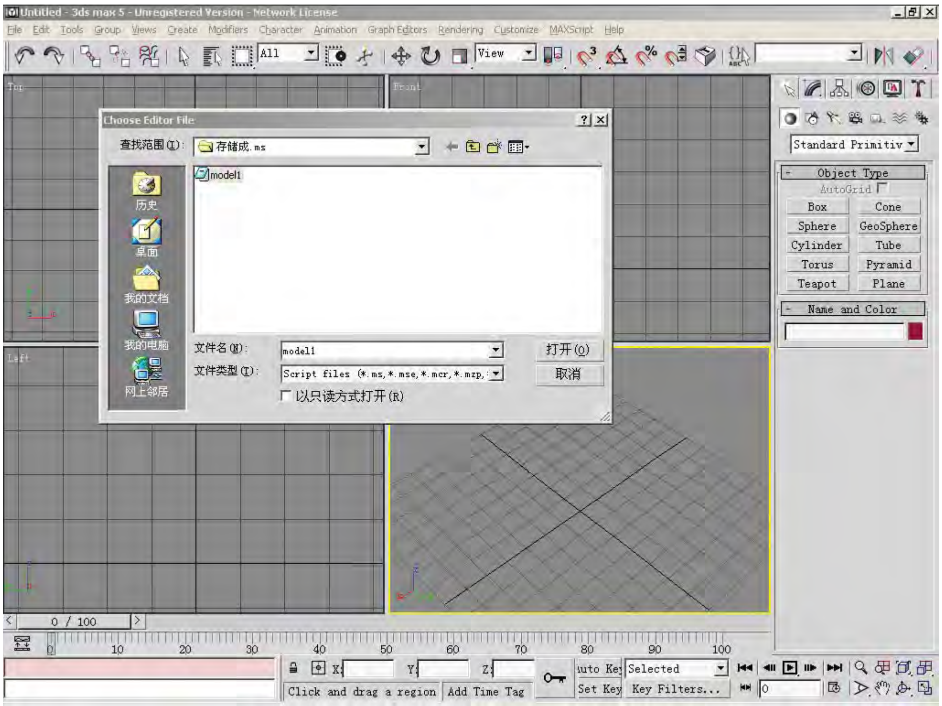


Figure 12: we utilize MAXScript as the interface to run *.ms document in 3DMAX5.0

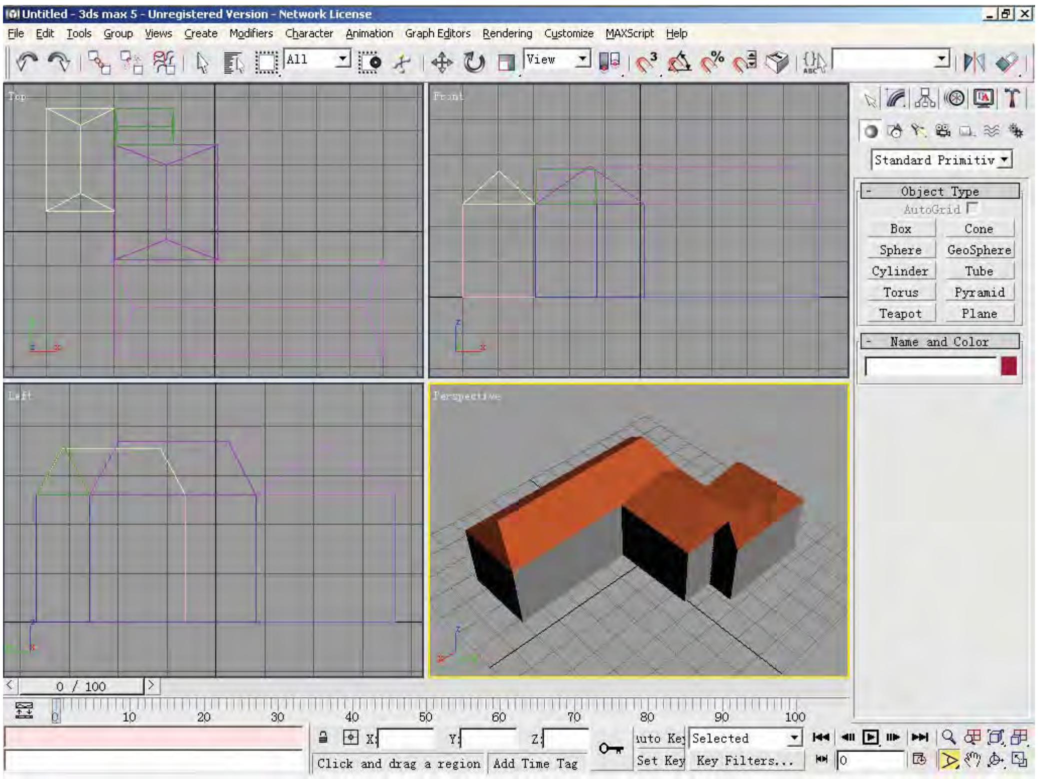


Figure 13: the display of Three-D model automatic generated by the system in 3DMAX5.0

Application

At the initial stage of our research, we choose architecture design project which master plan conception is quite fit for the requisition of the Automatic Generation System of Hip Roof Building. This architecture design project is a business occupation technical college that locates in Zhejiang province. We are request to design the campus building with ridge roof in accordance with the context in this region. After we have sketched out the planning of the campus, we extract the outline of the main building such as teaching building and so on, and make use of this Automatic Generation System of Hip Roof Building. It's quite exhilarant that the system generates lots of Three-D models in a short period of time along with the parameters we change each time. From so many results, we get intuitive impression about the campus, and we are enlightened on the spatial morph of the campus or the roof style of the building. Here we select two results that generated by the system shown in figure 14

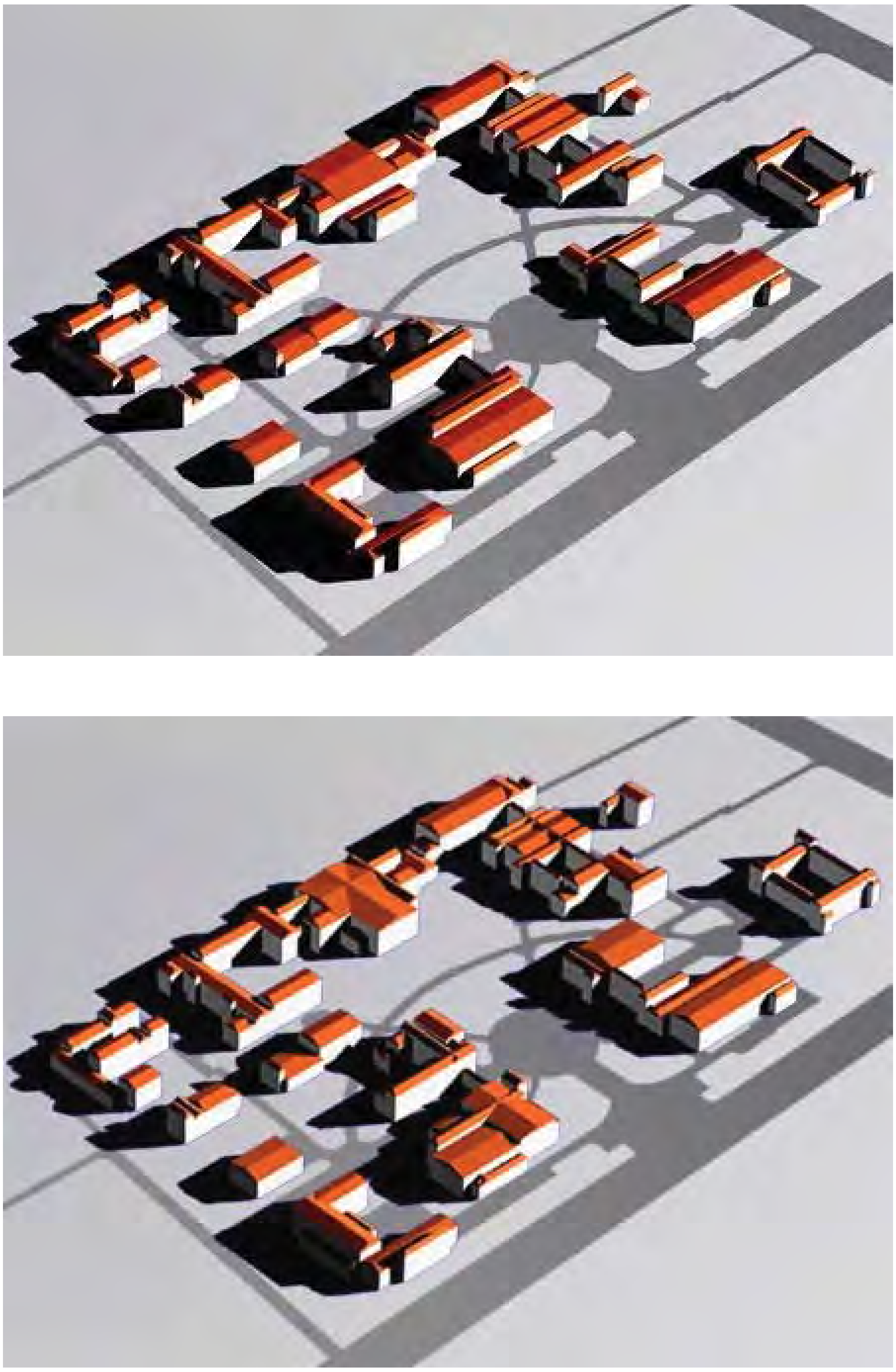


Figure 14: we select two Three-D architecture models generated by the system from lots of results, and interlard them with the software 3DMAX5.0 and Photoshop7.0

Peculiarity limitations and outloo

After a series of architecture design projects practice, we find the biggest advantage of this Automatic Generation System of Hip Roof Building is rapid, and it can automatic generate lots of possibilities for the same architecture design project. It's absolutely impossible for us to design so many possibilities in such short period of time. Moreover, we'll inspire and get great benefit from the models that generated by the system. There exists greater randomness not only in two-dimensional subdivision but also in Three-D model generation. As a result, we position the usage of this system on the very beginning of Architecture and Urban Planning design, so that designers can get inspiration from the system.

The research of this Automatic Generation System of Hip Roof Building is only at the first stage, and the limitation is also quite obvious. First of all, there exists limitation in the primitive building plane. The system can only handle building which plane and location in master plan is orthogonal. Therefore the system can't handle if the building plane doesn't match this term. When the position of the building plane isn't orthogonal, we should first rotate it to the orthogonal position. However after the Three-D model has been generated by the system, we have to rotate it to the original position when we continue operation in 3DMAX. Thus it increases our workload. In addition, the system can't handle building plane that is subdivided by us beforehand because of the primitive term that the plane should be outline of the building we have given to the system. Secondly, there exists some unreasonable phenomenon about the Three-D model generated by the system because of the randomness. In this system, we adopt to select two-dimensional subdivision results artificially, and then let the system automatic generate Three-D model. We haven't given the system opportunity to select and exclude some unreasonable phenomenon by itself. In addition, the generation result is unpredictable, and people can't precisely control the form of the Three-D model automatic generated by the system. Therefore currently in accordance with the firstly fixed position, this system can only used at the beginning of Architecture and Urban Planning design.

We believe that part of the limitation we have stated above will be improved along with our going further into the research. For example, we can edit other algorithm through which the system can judge building plane which position in the master plan is not orthogonal. Hence we needn't rotate building plane artificially. This improvement can raise efficiency largely. As to the building plane which is subdivided beforehand, we can also realize its' automatic generation Three-D model with the improvement of the system.

The much larger development prospect of this Automatic Generation System of Hip Roof Building is the form of roof. Currently, the hip roof model generated by the system is quite simplified. However, there're many special roof form not only in China but also other foreign countries. (figure 15) Even similar ridge roof, it's quite different from each other because of the weather, custom and so on. Usually, we can find some parameters that represent the characteristic of the roof form. As long as we summarize these kinds of parameters, write them into the system through programming language, the system can automatically generate lots of Three-D building models which roof have the characteristic of local style.

Figure 15:above: traditional housing complex in Suzhou, Jiangsu province, China
Below: traditional residential area in European country

Conclusion

The Automatic Generation System of Hip Roof Building is our first research in the field of generative design. Many experiments we have carried out prove that it's quite useful to make attempt with some programming language that are quite different from the drafting software we usually use in the field of Architecture and Urban Planning Design. We'll also find the new methodology can expand our design realm and stir up our creative consciousness.

As we all known, Architecture and Urban Planning design are creation work, and no matter when they can't get away from mankind. Therefore our architects should have gimlet eye to sense the pulse of the times. Trace back to several years before, architects have to apply paper, pen to draw the building design diagram, and no person can anticipate that we drafting with computer software now. The fast improvement of computer technique has aroused fierce affection in our profession. Therefore, it's inadequate for us architects to use some software only. We should carry out much more deep thinking, such as what kind of fresh dynamic can computer technology give us in the field of Architecture and Urban Planning Design? We need to communicate with other experts who are learned in computer technology and continue to learn new computer technology at the same time. We should also study new methodology on making use of computer technology in the field of Architecture and Urban Planning Design and proceed with innovation in our design field. We believe that we'll get much more harvest along with our further study in generative design.

References

[1] Maggie Toy: Editorial, Architectural Design Profile No 136, Architects In Cyberspace Ⅱ, P.7

[2] 刘育东，《数码建筑》，大连理工大学出版社，2002.7，P.068

[3] John Frazer And Manit Pastogi: The New Canvas, Architectural Design Profile No 136, Architects In Cyberspace Ⅱ, P.9

[4] Marcos Novak, Next Babylon, Soft Babylon (trans) Architecture is an Algorithm to Play in, Architectural Design Profile No 136, Architects In Cyberspace Ⅱ, P.23

THE REPETITION AND COMBINATION OF UNIT SPACE

FROM TIANJIN UNIVERSITY

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[Summary]: The repetition and combination of the unit space are a kind of organization way of the building space. This essay centers on the repetition phenomena, the combination mode, out of the mode and the argumentations of significances of unit space, combining with a great deal of outstanding instances explained . The essay aims at offering the designer one method of how to organize the space. What is the most important thing is that brings the designer the inspiration of the architectural design.

[Keyword]: the unit space repetition and combination, the combination mode, out of the mode, the organization and arrangement of procedure, significance

Ⅰ The repetition phenomenon of the unit space

- **The repetition phenomenon in the nature:**

The most basic order is taken shape from" repetition" in the nature. We can regard the " repetition" as one of the most original and basal organization means and these phenomena can be seen everywhere at anytime. Such as: Time, during the repetition of the ticktack, day by day, year in and year out; The winter alternates with summer every year; The home of the honeybee was replied and made up by a lot of many pieces of units, etc. Thus, we should study for nature and utilize" repetition" to create a colorful world in good order.

- **The repetition phenomenon in the building**

"The building can be called as organization art too". “Repetition” has become one kind of organization means of the building here. The repetition phenomena can be nearly found in all buildings. Concretely embodied in: The repetition of the element, the material, the symbol, the window or the hole, the plane and the inside space or the overall arrangement.

- **The repetition phenomenon of the unit space:**

Among the many “repetition” appeared in the building above, the repetition of the inside space and overall arrangement is one kind of tissue art on higher level. We define it as “the repetition of the unit space”. The unit space is succinct and same or similar, but after the repetition, the building will be present differently with complex, changeable and abundant form.

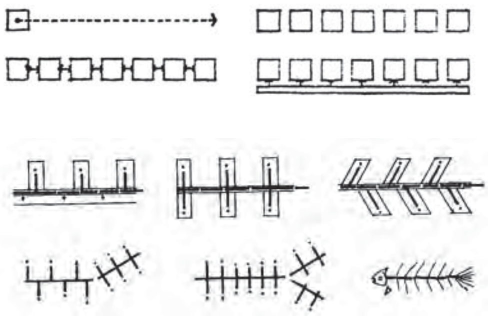
Ⅱ The mode of the unit space combination and out of the mode

1、The mode of the unit space combination

(1) The combination of unit-space on water level

a. The line type:

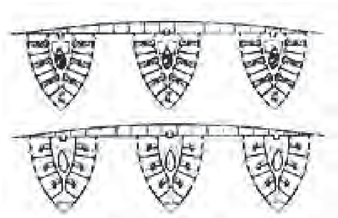
The Unit space joins one by one or is linked by another line space (picture 2 - 1). This mode is suited to the building that has a lot of branches. The characteristic is outstandingly expressed by its convenient traffic and freely development.



2 —1 the structure of line type

- **Instance analysis:**

The student Dormitory of Paris University, France *(picture 2 - 2)*



2-2 the appearance and plane

The dormitory space is composed of three units and a piece of curve space. The modeling is rich in rhythms. The effective combination of the unit space has solved the main problems of the tense of the land, the noise and pollution as a result of being very close to Paris line .It Becomes a building with two orientations, double skin textures and double meanings.

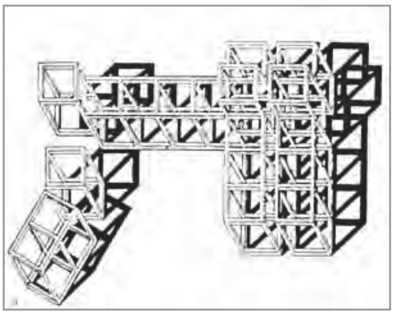
b. The network type

2 —3 the mode of network type

The building's framework is strictly based on the clear network line, that's, choosing the inside and outside space should depend on the network unit, which is the generating foundation and rule. It emphasizes the coherence of design process and the unity of space size, the form or the function. The advantages of this mode are obviously embodied in the strong structure system and adaptable space. It's used relatively more in the fields of the building and even urban planning. (picture 2 - 3)

- **Instance analysis:**

Gunma Prefecural Museum of Modern Art, Japan designher:Arata Isozaki *(picture 2 - 4)*



2 —4 the structure of network

This Museum is Isozaki's early representative works. It is located in the park corner where the grass looks like a carpet, the relief is smooth and the environment is rather empty and quiet. The cube unit is the basic key element that makes up the unit body with the method of the network. The basic network is square one, meanwhile, joined another network which is deflected by 22.5 degrees, making the unit full of interests.

c. The interlaced type

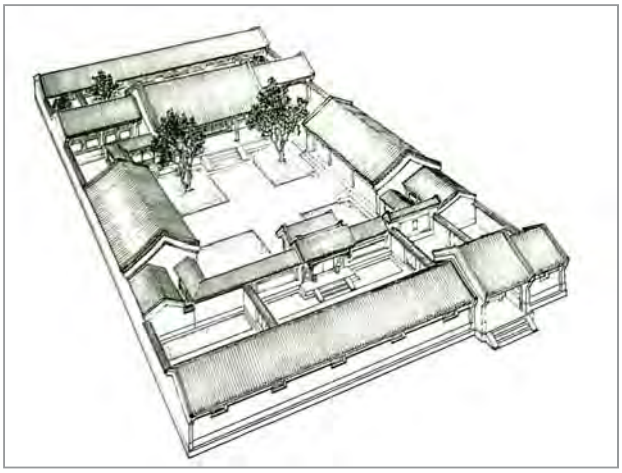
According to certain law, the inside function space is interweaved with outside space such as yard and garden with natural characteristics, showing an alternate change. This type takes advantage of two opposing principles, the former masculine and positive, the latter feminine and negative, to emphasize the relation between space and space. At the whole overall arrangements of space, natural space and functional space appears alternatively, not only forming space rhythm but also melting the building with nature, avoiding the great influence caused by the single and closed buildings.

- **Instance analysis:**

a). The traditional Chinese architectural complex *(picture 2 – 5,6,7)*

2 —5 the inside and outside are interlaced.

Li YueSe had once said: " In fact, the modern architecture is influenced by the idea of China more than general supposition, in view of China personality, increasing and repeating unit to solve yardstick and scale people required. " After the analysis of the special structure of Chinese traditional buildings and we are surprised to find it is the most great application of unit space repetition and the minimum unit space is adopted "jian" as unit, namely a house, and then enclosed a traditional Chinese courtyard house round the space of a center (the courtyard) by such several units. Thus the association of the interlaced space is formed. This kind of association mode is applied in the Chinese architectural complex and the tissue of the city. And Chinese traditional building is all basically influenced by this idea from start to finish.



2 —6 the traditional Chinese courtyard space

2 —7 the void and solid are interlaced

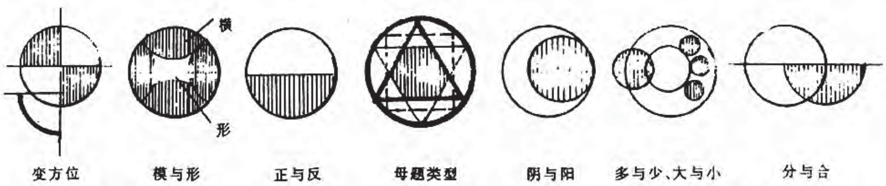
b). Gandhi museum, India Designer: Charles Correa *(picture 2 – 8,9)*

2 —8 seeing from water yard

2 —9 the general layout

Gandhi museum is the extension of the former residence. The unit space of this building is a square space that carrying the pyramid tiled roof. In the square network, function space, water yard and courtyard interweave together. It is exactly the interlaced relation between the close space and open-air space that formed the theme of this building ——seeing the subtle change during simple repetition.

c. The self-similar type



2-10 the type of self-similar

This type is adopted the method of changing the size, the orientation and the quantity of the unit space. It is shown as the duplicating of a kind of" self- similar quality" as a whole. This kind of type possesses the unity on the whole while the flexibility on the part. *(picture 2 - 10)*

- **Instance analysis:**

Municipal funeral Home, Spain designer: BAAS Jordi Badia,Josep Val *(picture 2 - 11)*

This is a commemorative place. Its entry space is composed of several self-similar units. The changes of the angle and size of the unit have stressed the entry space.

2-11 Municipal Funeral Home

e. The scattered type

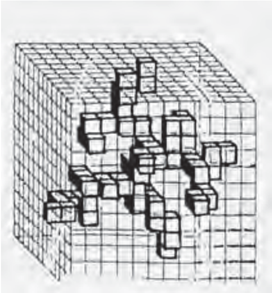
The units are scattered all over the vast space without any solid connection. But through the common information or a certain idea expressed by the units, they will get in touch on the level of spirit and form an invisible network of connections that can make them become an organic whole. This kind of association way has extremely high artistry that makes the repetition receive the distillation on spirit.

(2) The combination of unit-space on vertical level

The units are combined through the vertical folding of the natural space and functional space, which will solve the contradictions of the limited land and the aspiration of mankind closing to nature. It becomes one of the tactics adopted frequently in contemporary skyscraper. *(picture 2 - 12)*

2-12

(3) The combination of unit-space on multidimensional level



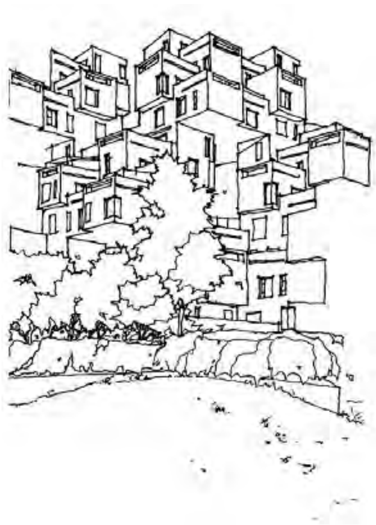
2-13 multidimensional combination

The repetition of the unit body was connected in the multidimensional space, namely combining units around it. The way of the combination is just like the means of honeycomb's forming, the characteristic of which is bionic. At the same time the standardization of the structure helps to construct. *(picture 2 - 13)*

- **Instance analysis:**

Habitat 67 , Canada designer: Moshe Safdie *(picture 2 - 14)*

It regards the standard house of 5m×4m as the unit, and the units are piled up similar to honeybee's building their nest. The ones that interlocked and suspend are offering a large amount of roof gardens and platforms。The construction method adopts the prefabricates，which will save time and energy。It is the one that has highly symbolics on behalf of the complexity and variety that "the unit repetition " can create.



2 —14 Habitat 67

2. Out of the mode

The above several kinds of " modes" are the summary of the combined method of the unit space and it is in a formal set of categorized way. We can't equate the existing achievement in research with the final research purpose. Our research purpose is: Ingeniously organizing the repetition of unit space and so making it radiate the splendors of art. So we should not be overcautious the mode above. The correct method is to regard the mode as the foundation and then probe into the combination means in deeper level, namely in the level of organization and arrangement of the procedure, to push the organization to the heights of art and emotion and make unchangeable become changeable.

Ⅲ The significances of the unit space repetition and combination

The unit space repetition and combination is the needs of the function to a certain extent, however, it is even the needs of vision, aesthetic, spirit, etc. Under the specific historical condition, it is still a kind of needs of system and tradition. The aim of studying the significances of this subject is to find the value of the unit repetition.

1. The significance in function :

1. **Adaptability:** "Unit space" and “its repetition” possess the virtues of multipurpose and multifunction, almost corresponding with any building type. So, this means of space organization is often applied to the building of inhabitancy, culture and education, factory, hospital and hotel, which belong to the multi-cell.

2. Order quality: The function space is the unit space and relatively put independently. Meanwhile, the traffic space is often a corridor regarded as a tie of the connection. The whole is in perfect order.

2. The significance in aesthetics:

The unit repetition can create various kinds of beautiful forms characterized as repetition---- the beauty of rhythm.

(1) The beauty of successive rhythm

To keep invariable distance and relation between the unit space, and it will show the successive rhythm.

- **Instance:** ***The Model of River Museum, Belgium*** *(picture 3 - 1)*

(2) The beauty of gradual change rhythm

The unit space in succession changes in direction according to certain order, such as becoming wide or narrow, dense or rare, which forms the beauty of gradual change rhythm.

- **Instance:** ***The Photo Museum, Japan*** *(picture 3 - 2)*

(3) The beauty of undulating rhythm

The quantity of the unit is increased sometimes or reduced sometimes according to certain law, just liking waves rising and falling.

- **Instance:** ***The Hotel, designer: Zaha M.Hadid*** *(picture 3- 3)*

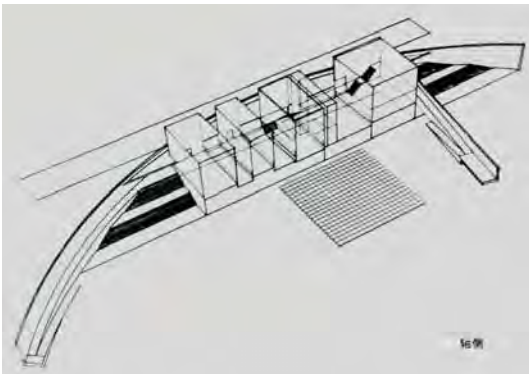
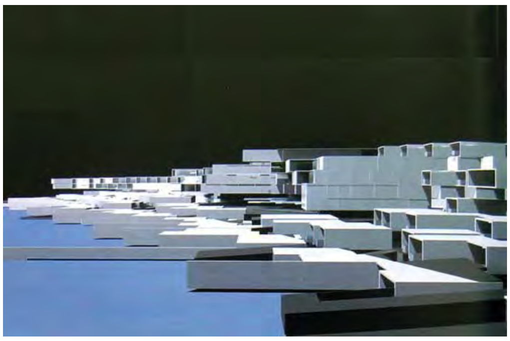
(4) The beauty of interlaced rhythm

When natural unit space and functional unit space appears alternatively according to certain law, the two opposing principles of negative and positive form the interlaced rhythm.

- **Instance:** ***A office*** *(picture 3 - 4)*

3-1 the River Museum *3-2 the Photo Museum*

3-3 the Hotel *3-4 the Office*


3. The significance in space-time

This kind of space organization injects the factor of time into the three-dimensional design, which means the change of the location causes the change of time sequence, having the significance in space-time. People walking in the sport of the space can experience the transition between space and time.

A great characteristic of the Chinese culture is paying attention to " time"。In the book of YiJing, it emphasizes that " change " is the essence of" time". The traditional Chinese building combination is a result under this kind of culture.

- **Instance analysis:**

The combination of the traditional Chinese courtyard house *(picture 3 - 5)*

3 —5 bird’s eye view of Imperial Palace

Li YueSe once had a section of commentaries aimed at Beijing's Imperial Palace:”…… The Chinese idea is very far-reaching and extremely complicated, because in a composition, there are hundreds of buildings, the palace is nothing but a part of bigger organism such as residential district of city wall by itself. Though there is so strong axis, the independent center or climax doesn’t exist. So during the design, a kind of sudden change against the climax has no position……” This passage shows: The Chinese building obtains the artistic experience not through the emphasis of grandness of the individual, but the organic combination created by the unit space repetition. This kind of artistic experience exactly comes from the meaning of " space-time ". The course of advancing is the course of change between space and time, meanwhile, it is a sequence of experience which can bring a emotion resonance.

The architects of today have already paid close attention to use the repetition of the unit space and are probing its design meanings coming from the phenomena such as 'sport', 'the scenery in succession', 'drama', etc.

4. The significance in sprit

In the modern architectural design, a lot of famous public buildings have adopted the unit repetition to organize the internal and external space and achieved the main purpose of creating the spirit space.

(1) The unit space is so pure, strong and original and people always prostrate themselves this kind of space from the ancient to now. For example, Egypt expresses the original worship by the repetitions of the pyramid unit.

(2) The order of combination is so well arranged that agrees with the rule of development of the nature. It is a human spiritual ideal to gain the coordination of people, architecture and nature.

(3) The organization and arrangement of the procedure can cause the sympathetic response on spirit.

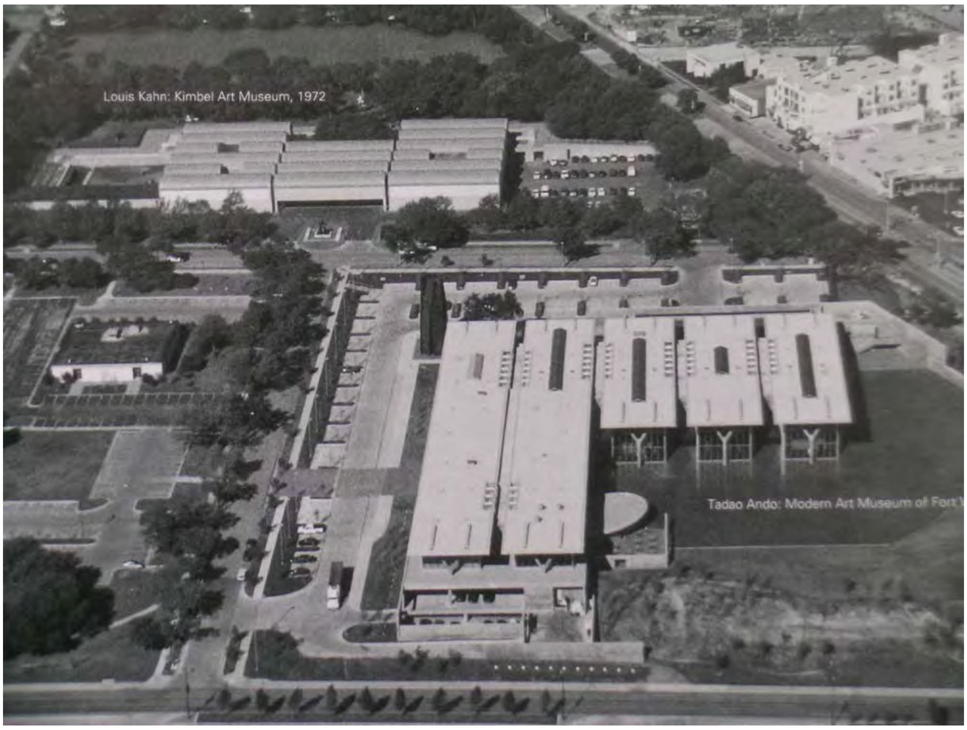
- **Instance analysis:**

  a) Modern Art Museum of Fort Worth, Fort Worth, Texas USA *(picture 3 – 6,7,8)*

  Designer: Ando, 1999-2002

3 —6 the model of design

The site is located in a corner of a municipal park on the outskirts of Fort Worth, Texas, adjacent to the Kimbell Art Museum designed by Louis Kahn. The building consists of five "box" wings arrange parallel to one another, a "box" being the base unit. Each "box" has a double-membrane structure of concrete and glass, and is given either one of two lengths, short or long, according to the program. Here, Ando created spiritual worlds for us, with unit spaces so strong and deep that will penetrate to the people who contact them. This Art Museum will be a outstanding works of spiritual space that the unit space repetition and combination creates.



3－6 the relation between Kimbell Art Museum and ***Modern Art*** *Museum*

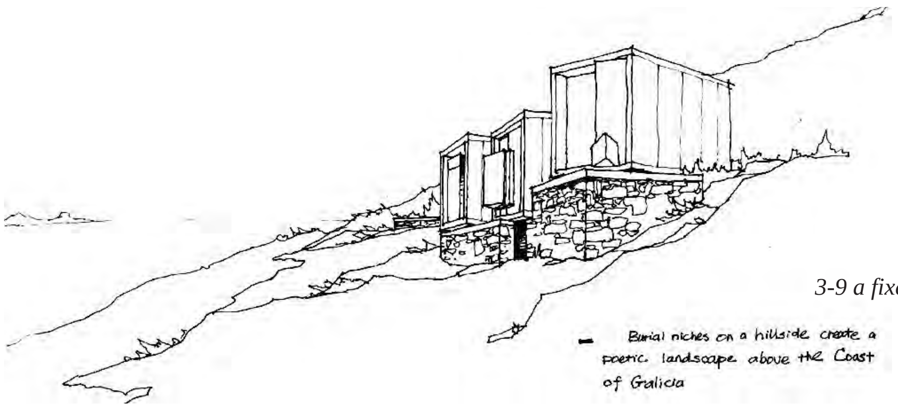
3－7

b) Finisterre Cemetery, La Coruna,Spain *(picture 3 – 8,9,10)*

Designer: Cesar Portela

On Galicia's westernmost peninsula, a number of cube-like structures built of local granite seem carelessly strewn across the landscape. Each of these mausoleums opens towards sea, liking pairs of eyes staring at the distant place, which owns grief and expresses the endless cherish to relative passed. This is an inner world being full of poesy.

3-8 missing



3-9 a fixed gaze

3-9 Finisterre Cemetery

5 The significance in generation

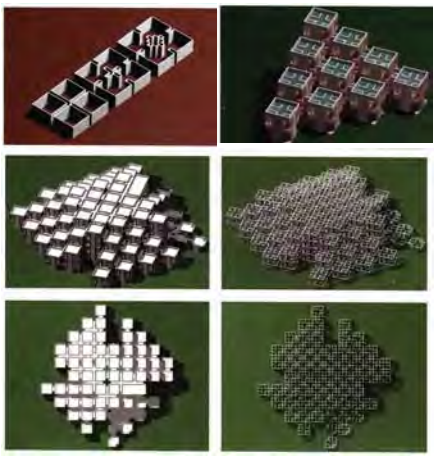
The theory of architectural generation, belonging to the methodology, indicates that the design is an abstract design procedure and the starting point is study the relation between the architecture and then draws up a set of generation way of reasoning. Concretely speaking, the relation of generation includes combination, separation, intersection, condensation, dispersion, etc, which makes the course of design reasonable and logical. The combination of unit space is often influenced by this theory

- **Instance analysis:**

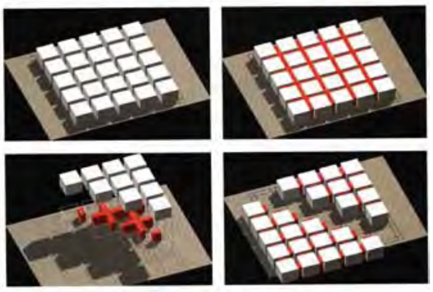
Head Office Central Beheer, Netherlands designer :Herman Hertzberger *(picture 3 - 10,11,12)*

3—10

He has designed two sets of networks, the main one and auxiliary one. With all kinds of intersection and dispersion of units based on networks, several kinds of operation and combination means are designed and then he building is generated. In such cases, the procedure of design is reversible. It means the combination can return to the original unit. This office is the typical delegation of the theory of generation.



3 —11 the generation law



3 —12 the white delegates the main network, while red delegates auxiliary one.

6 The significance in ecology

(1) The unit body symbolizes cells characterized as the qualities of expansibility and renewability.

(2) The combination of the unit combines the environment closely setting up the relation of intergrowth with nature.

(3) As a result of adoption of structural standardization and constructional mechanization, it saves time and energy.

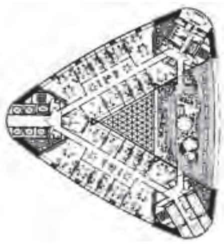
- **Instance analysis:**

Commerzbank Headquarters, Frankfurt, Germany, 1997

Designer: Foster Assosiates *(picture 3 – 13,14)*

The plane consists of three pieces of unit space that joined end to end, taking the form of ring trigonometry. Among them, two units are official space; the third is the garden space. These two types of space are interlaced and mixed by vertical making most official area able to see two gardens that one is regarded as the background of the sky and another as the background of the city. Owing to such ingenious combination with nature, it deserves to be called the highest ecological

3 —13 Commerzbank Headquarters



3 —14 the standard plan

skyscraper of the world.

7 The significance in history

The unit space and its repetition can often arouse people certain complex of reminiscence.

(1) The succinct unit space is so pure, original, sculpture and eternal that has the significance in history.

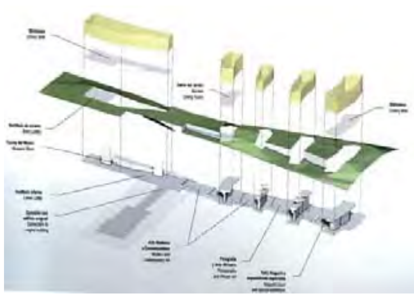
(2) The proper arrangement and organization of procedure makes the space and time changed or misplaced continuously, which let visitors have artistic experience of coming into the history.

- **Instance analysis:**

Nelson Atkins Museum of Art Expansion, USA (competition, first prize), 1999-,

Designer: Stephen Holl *(picture 3 – 15,16)*

3-15,16 the model and structural analysis



The style of old museum is classical designed at 1933. The expansion of the Nelson Atkins Museum will occur through five new units or lenses forming new spaces and new angles of vision. Though the addition has so many new elements to be in contrast with the old, we can also find the addition will merge and organically connect the new spaces with the existing 1933 classical "temple to art", the reason of harmony is that the qualities of sculpture, pure and unbounded that the unit repetition possesses, arouse people certain complex of reminiscence.

8 The significance in urban

If the unit repetition occurs within the range of the city or larger area, it will have special urban meanings that will help the city to realize an integrated comprehensive environment of an idea, event and culture.

- **Instance analysis:**

"The Green Box" in Rotterdam, Netherlands *(picture 3 - 17)*

3-17 the Green Box

" The green box" is regarded as a unit within the range of Rotterdam. What the meaning of them is intend to offer a concrete cultural platform to people. Different from general unit repetition, it is an urban project. All of them will connect closely for the same information they have passed on. Because of their existence, the whole city will have more cohesiveness.

9 The significance in temperament and interest

Flexibility and random displayed in the combination process of the unit will bring the infinite temperament and interest to space.

- **Instance analysis:**

a) The boxes among the mountain,Japan *(picture 3 -18)*

These boxes, made of wood grill, are put in jungle at will and the pathways meander through them. People will enjoy the happy and easy in the winding route and space that created by of the unit repetition.

3-18

3-19 interlaced figures

b) Interlaced figures, Colombia *(picture 3 -19)*

Designer: Peter Eisenman

The several curved and tenuous boxes, different in size and shape, are unfolded and unlaced together just looking like fingers of hands. The interest of the unit repetition and combination is full of imagination.

Ⅳ **Summary**

The article has explained the phenomenon of the unit space repetition, sum up several kinds of modes of the unit, creatively proposed the key out of the mode namely the organization and arrangement of the procedure and probed into the significances in many aspects combining a host of latest instances. Hope to reach this result: Base on the space considered as the content of architecture noumenon, comprehensively understand the organization mean of the unit space repetition and combination, and finally we can gain abundant source of inspiration for design.

The list of references

a. *Architectural Record Nol. 07/2002; 03/2003*

d. Architektur+Wettbewerbe/Architecture+competitions/cemeteries-crematouriums Nol.AW192

e. GA Document Nol.74

f. Charles Correa with an essay by Kenneth Frampton Printed in Singapore

1. 李允鉌著 华夏意匠 中国建筑工业出版社 1978。

2. 刘亚芬译 建筑体验 中国建筑工业出版社 1990。

3. （美）托伯特·哈姆林 邹德侬译 建筑形式美的原则 中国建筑工业出版社 1982。

4. 刘永德著 建筑空间的形态·结构·涵义·组合 天津科学技术出版社 1998。

5. 张楠著 当代建筑创作手法解析：多元＋聚合 中国建筑工业出版社 2003。

6. 丁沃沃著 欧洲现代建筑解析 江苏科学技术出版社 1999。

7. 李雄飞著 建筑设计信息图集 天津大学出版社 1995。

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