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GENERATIVE ART 2005

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8th Generative Art conference

edited by
Celestino Soddu

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In the 1st cover a visionary variation of “Citta’ Ideale”, generated using the codes of harmony of Renaissance, 2005.
In the 2nd cover a visionary variation of “Citta’ Ideale” using generated coffee machines, 2003.
Generative projects by Celestino Soddu

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Proceedings

Edited by Celestino Soddu
Generative Design Lab
Politecnico di Milano University, Italy

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GENCITIES AND VISIONARY WORLDS

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Abstract

When we look at clouds transforming themselves with the help of the wind we interpret them following our subjectivity mixed with own cultural references. Exactly the same that we use for recognizing and facing the events surrounding us.These are transforming logics, an anamorphic approach that builds our subjective system of codes.

This interpretative system, unique because it fits our subjectivity, mirrors our creativity and imprinting as artists and designers. Generative artworks spring from this subjective morphogenetical engine. Forms are only subsequent steps.

Investigating on these transformation logics and the subsequent anamorfic approach we can construct our generative engine reaching a strong identity and recognizability of our artworks.

One of the most interesting fields for investigating these logics is the generative engines coming from moving from different dimensions, from 2D to 3D and back, using different perspective approaches.

In this process each physical city, looking for its own Ideal City in the multiplicity of its visionary variations, will be not clonable but unique, unrepeatable and unpredictable as mirror of nature and harmony.

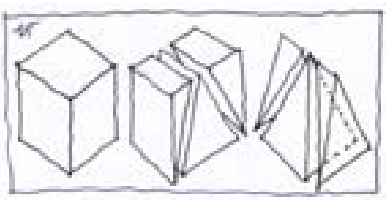
1. Forms, identity, recognizability and morphogenesis

We recognize a form if we identify it as similar or, however comparable to those already experienced. We recognize only a form through the memory of other forms. But they are not singly remembered forms, neither sequence of different events. The memory is structured ina system built activating a logic that reflects our subjectivity that links and associates different forms by identifying particular aspects of them. We can affirm that each of us builds and identifies a proper morphogenetic code in associating different forms together. This code is direct expression of our way of seeing, of our cultural references, of our identity.

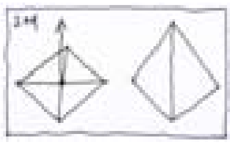
There are a lot of different ways of experiencing and of recognizing the physical world. Some people identify and build the code through the logical-geometric reconstruction of the process of realizing the forms, other people approach it by recognizing, structuring and following the subjective satisfaction of particular needs, using practical, aesthetical or symbolic requests. Everyone identifies and progressively sharpens during lifetime a series of his own codes as structure of species that fits his own subjectivity and that progressively creates and identifies to follow the increasing of his own experience and culture. Everyone, therefore, has a unique approach in recognizing and appreciating the events surrounding him. Besides, each person identifies, following his personal way, what appears as normal (inside the species) and what as exceptional. Every system of subjective codification allows people, however, to share identifications with other people and to find the possibility that each form simultaneously belongs todifferent species. Looking at a stool, we could affirm, for instance, that the object belongs to the "chairs" species, with the exception to have not the back, or that it belongs to the "tables" species, with the particularity to have a reduced dimension, or to the "staircases" species with the exception to have only a step...

If we consider the field of creativeness in a design process, the investigation on species is very useful for explaining the logical structure of creation. This investigation expressly identifies different creative ways bringing to the conceptual acting an idea, able to structure and specify the identity of the personal creative approach.

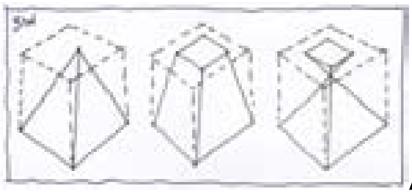
For instance, let's take a pyramid: a physically existing pyramid like the Pyramid of Cheope. Each people have a memory of this form and is able to associates it to other forms. If we call these forms as "pyramids" all people could agree, because a individualized geometry with the name of pyramid is a common concept that exists for all people. Instead, if we want to go ahead, each of us could also associate the pyramid of Cheope to other events whose logical structure belongs to the species that each of us built for recognizing the pyramids. These logics can conceptually be very different, and they allow us to produce groups in which it is possible to overlap similar events. Some examples. A first logical approach could be defined by considering the pyramid as a solid cube from which a whole series of pieces has been removed through plain cuts.



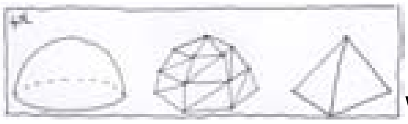
This vision for subtraction of the three-dimensional solid is the characteristic vision of the sculptor. Michelangelo affirmed that the statue already exists in the stone; it is only necessary to remove what is superfluous. If this logic is adopted for building a species of forms, any form that can be identified as what remain of a cube after cutting away some pieces, it belongs to the same species of the pyramids.



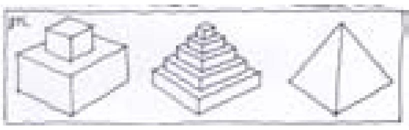
A second logic could be constructed starting from a plain matrix that produces spatial events. A square with two diagonals, when the center and intersection of the two diagonals is "lifted" and moved in the space produces pyramids of which that of Cheope is only one among endless possibilities.



A third possible logic still could be born from the cube. If the superior face is magnified or reduced smaller, this transformation produces a whole series of solids where the pyramid is the moment in which the superior face is reduced to zero, while the trunks of pyramid and the hourglasses are the moment when the dimension of the superior face is positive or negative.



We can identify a fourth possible logic considering the pyramid as a solid generated by the following facets of a half-sphere. If we progressively divide the half-sphere in triangles we produce a whole series of solid that, departing from one almost-half-sphere with a large number of triangles we reach the square based pyramid as next to last step before the tetrahedron.



A fifth logic, that we could call zigurrat, considers the pyramid as an overlap of squared based prisms. The range can start overlapping two prisms and can go ahead increasing the number or prisms when each one becomes more and more thin.

But we could continue imagining the pyramid as one individual of a species in which each event is inside the progressive transformation from the cone to the triangular based pyramid or to the triangle itself, imagining this last event as a pyramid with the base constructed with two or only one side.

Which is our subjective logic for declaring that an event is a pyramid? If we find us in front of the pyramid of Cheope anybody have no doubts because this pyramid is a common point of reference. But if we are looking at an event whose form is not so axiomatic, because it contains, for instance, also some curved surfaces or it has not peak, and so on, who will identify it as pyramid, even if particular and on the boundaries of this species? Perhaps only who conceives the pyramid as an event inside the progressive transformation of a half-sphere, or of a cone. Other people will associate the form to other morphogenetic species.

Every form, when losing its geometric axiomatic aspect, that is the result of an incontrovertibly association to an only one geometric species, becomes an anamorphic shape. Form enters into a process of changing meaning, changing character, changing "species" according to the subjective approach of the observer. In other terms it is possible to associate each complex form to different species of events using different logics and association codes. These differences define the subjective recognizability, the matrix of reference based on personal cultural background. We define these approaches to forms as anamorphic interpretations, as the results of subjective anamorphic logics.

These approaches normally happen when we are fascinated by the contemplation of the clouds, interpreting their forms in multiple ways; or when we find human expressions in the form of some rocks or in the plot of a carpet.

The anamorphic logical approach is different from anamorphosis because it doesn't happen through an artifice, where the author stratifies meanings. It happens when we look at complex forms, also natural forms, using our memory and our subjective codes of recognition. The anamorphic logical approach is a creative speculation on possible different readings of the existing form and of the possible variations of the same image, meaning, and structure. Each of us implements this approach with the awareness not of the ambiguity but of the stratification of possible affiliations to different species, to different functions, to different aesthetical, symbolic and functional structures. In this sense, the anamorphic logical approach can be considered one of the basic tools of creativeness, of design imprinting and of style. Following this subjective logic, each artist make recognizable his artworks. This approach is able to interpret forms as an essential part of idea identity.

Defining Generative Art Idiscovered the anamorphic logical approach as one of the possible motors able to produce endless possible events through the activation of codes, as morphogenetical logics. I also discovered the not-eludeble strength of species. So, now, generative artists need to realize their creative identity in an endless generated artworks. Each artwork, also unexpected, becomes recognizable not only as single results but as belonging to a species, to the artist's identity and style. If not Generative Art will be confused with Random Art. Nothing is so far and different as Generative Art and Random Art.

2. The passage from a dimension to another.

The field of reference is the relationship between the three-dimensional form and its two-dimensional image performing manifold variations. But we could consider also the image and its possible forms, in its manifold interpretative variations. The "generative" reciprocity between form and image of the form where every form "produces" a plurality of images and where each image "produces" a plurality of forms, in an endless spiral, is one of the principal fields of construction of Generative Art as art that rises from expressing ideas as morphogenetic logic.

First of all, a difference of dimension can exist between form and its image. Often this difference exists by considering form as a three-dimension event and its image as a two-dimension representation. But this is only one of the possibilities. We can get a 3D representation from an event having a lot of dimensions or we can increase the dimensions of the representation in comparison to the dimensions of the event. When we, for instance, try to represent the image of a jewel pending from the neck of a noblewoman in a seventeenth-century portrait by building a three-dimensional object that interprets the image of the painting. In this case only one of the possible two-dimensional representations of the constructed 3D event will fit the original image.

If we want that the result of this moving through different dimensions can be considered totally acceptable, it would be necessary that each point of the form corresponds to one point of the image and that the structure of the form-system will have the same topological logic then the image-system. This obviously is not possible in the passage from a dimension to another. The "perspectiva artificialis" of Piero della Francesca is only one of the possible two-dimensional representations of three-dimensional events. With this approach a lot of information are lost. The inverse run, from the perspective representation to the three-dimensional event is, in fact, only a reasonable hypothesis. This passage could be considered as acceptable only if we built this three-dimensional event on the base of a lot of further knowledges that we don't find in the image, as the point of view used in the representation. If we don't know previously it, we could identify it only through a subjective interpretation. Therefore every interpretation "produces" different forms.

More. We can reconstruct only what we see and not what is behind or what is inside our represented events. As Florenskji said, the perspective image represents only the skin of the three-dimensional event approaching the three-dimensional event to the two-dimensional representation. But, also with this consideration, the bending of the skin won't be ever sufficiently represented in the plain sheet of the sketch. The relationship between bending of the skin and plain sheet can be compared to the relationship among Euclidean geometry and not-Euclidean geometries.

Not only. We have to operate a further interpretation choosing among possible different techniques of perspective representation that we suppose could have been used for producing the two-dimensional images. These techniques are manifold and we could synthesize them in three types, each of which links the form to its image in different way:

1. Perspective - 1*1.

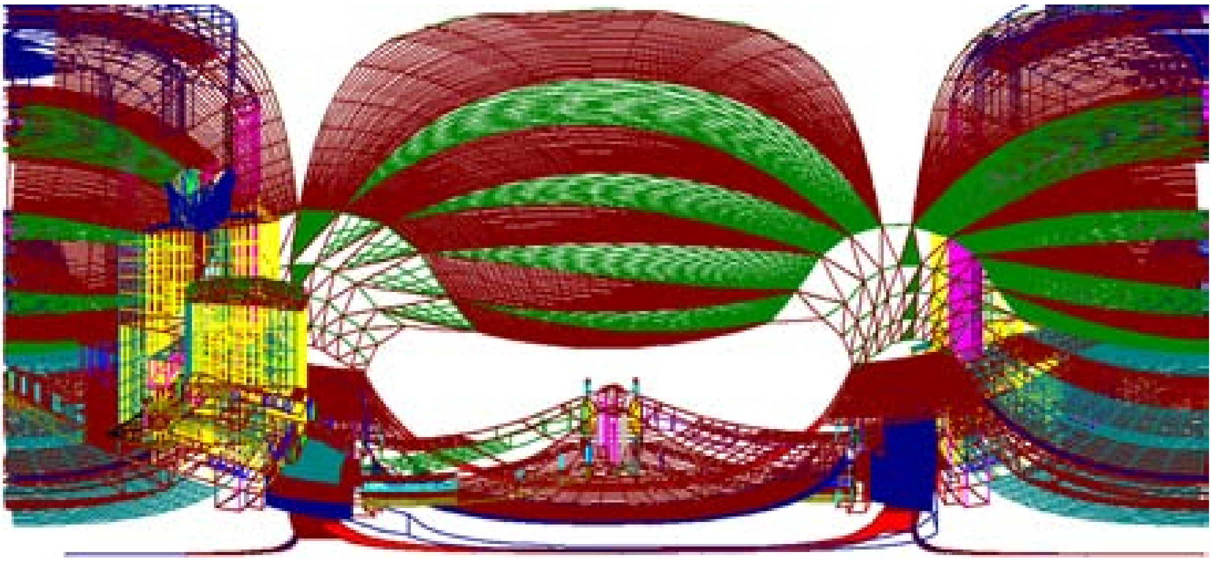
Perspective with only one point of view and only one direction of the look. The observer and the represented event are faced.

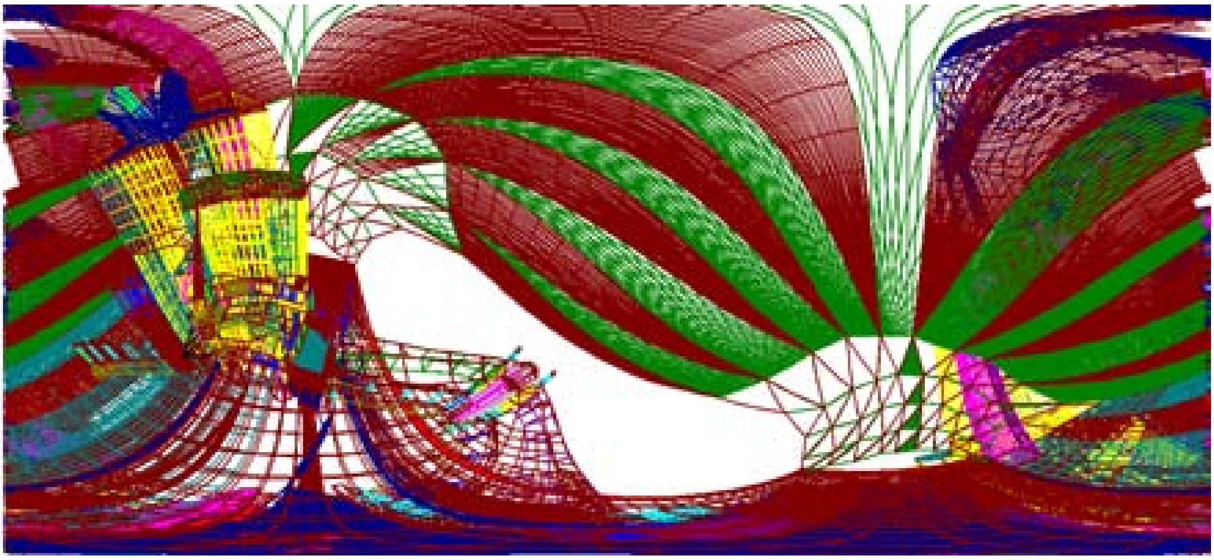
This is the "perspectiva artificialis" by Piero della Francesca: only a point of view, therefore only one eye and not two, and only one direction is considered. This direction becomes also the point of a central escape in the geometric construction of the image.

Piero della Francesca, “Flagellazione”, the “perspectiva artificialis”.

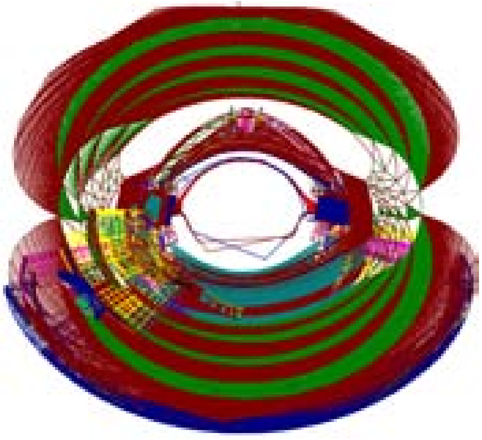
2. Perspective - 1*N.

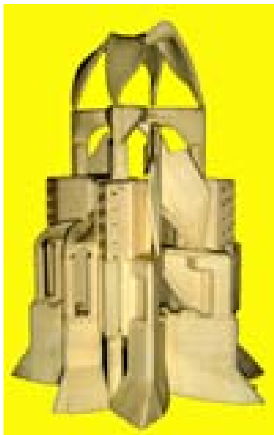
Cylindrical and spherical total perspective: these perspective technique considers only a point of view but manifold directions of the look, up to cover 360 degrees in horizontal (cylindrical perspective) or also in vertical (spherical perspective). The observer is the center of the system.





Generated Castle by C.Soddu represented in Total not_Euclidean perspective in two different views, the first one with horizontal sight and the second one inclined, using the software designed by the author





The Castle of previous images represented with an anamorphic perspective using Argenia software designed by the author. This image can be full understood if a mirror cylinder interface is used, following the 15th century approach. Generated Castle realized with rapid prototyping using 3D STL model directly generated by Argenia.

This curved perspectives follow the naturality of our vision. In fact, if we are inside a space, for instance a rectangular room with the parallel walls and with the plain ceiling, and we look toward a side we will see all the parallel sides of the constructed image converge toward a point (the fire). Then, if we turn our eyes and we look at the opposite wall, we realize that the same lines converge toward another point, opposite to the first one. Quickly turning our look from one side to the other, we could realize that these parallel lines converge in two points of the image that we are building in our mind. A bundle of parallel straight lines converge in two points only inside a non-Euclidean geometry system. The amazing aspect is that if we pass from a perspective built inside a Euclidean geometric system to a perspective built inside a non-Euclidean geometry, as spherical geometry, the mathematical representation of the transformation, the algorithm representing the passage from 3D into 2D becomes, mathematically, very beautiful and useful being possible to represent all through the measure of the angle. I have experimented these non-Euclidean total perspectives twenty years ago. These experimentations and the algorithms that I wrote for building and representing the "total perspective" are at base of my generative software. They configure a generative engine able to generate endless possible results starting from a single image. (C.Soddu, "L'immagine non Euclidea" non-Euclidean image, 1987, Gangemi Publisher)

3. Perspective - N*1.

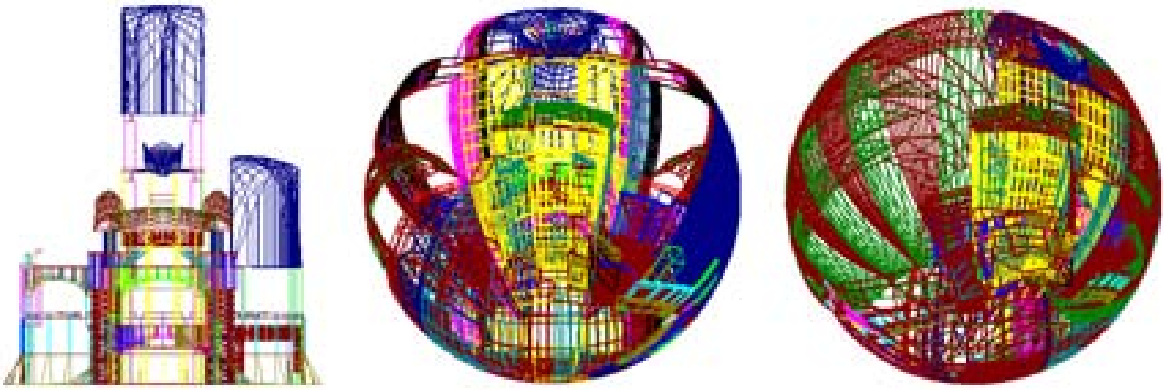
Reverse perspective by Florenskji. This approach considers a multiplicity of points of view, the two eyes and their various possible motions, and only one target of looking.

The represented event is the center of the system.

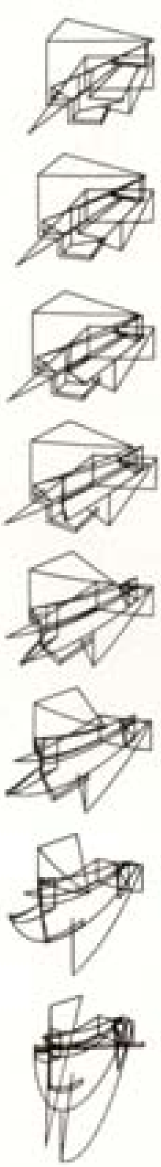
Russian icon with Christ represented in “reverse” perspective.

This perspective intends to contain in one two-dimensional image the multiplicity of different visions. The practice construction of this perspective approach can be realized through an interesting conceptual overturn that I have experimented in my software. If the target of the look is unique and the points of view are different we can capsize the total perspective. This has only one point of view and different targets, setting the point of view in the target and the directions of looking in a lot of "eyes".

The realized images could be assimilated to a representation of the skin of the object, seen by the inside. The reverse perspective has been identified and explained by Florenskji looking at the Russian icons. Being sacred representations the fundamental choice is setting the represented event as the center of manifold looks. In these two-dimensional images the representation of the face of Christ head is, according to my hypothesis, represented as seen by the inside of its same head. Since, as Florenskji affirms, we represent only the "skin" of the physical event we can capsize the face. Its projection on a sheet will result similar to the representation in reverse perspective of the Russian icons. In other terms I like to affirm that the reverse perspective is the overthrow of the spherical total perspective and not the overthrow of the" perspectiva artificialis" of Piero.



Generated castle by C.Soddu, represented in elevation and in two different "reverse" perspective, using the software designed by the author following the Florenskji approach.



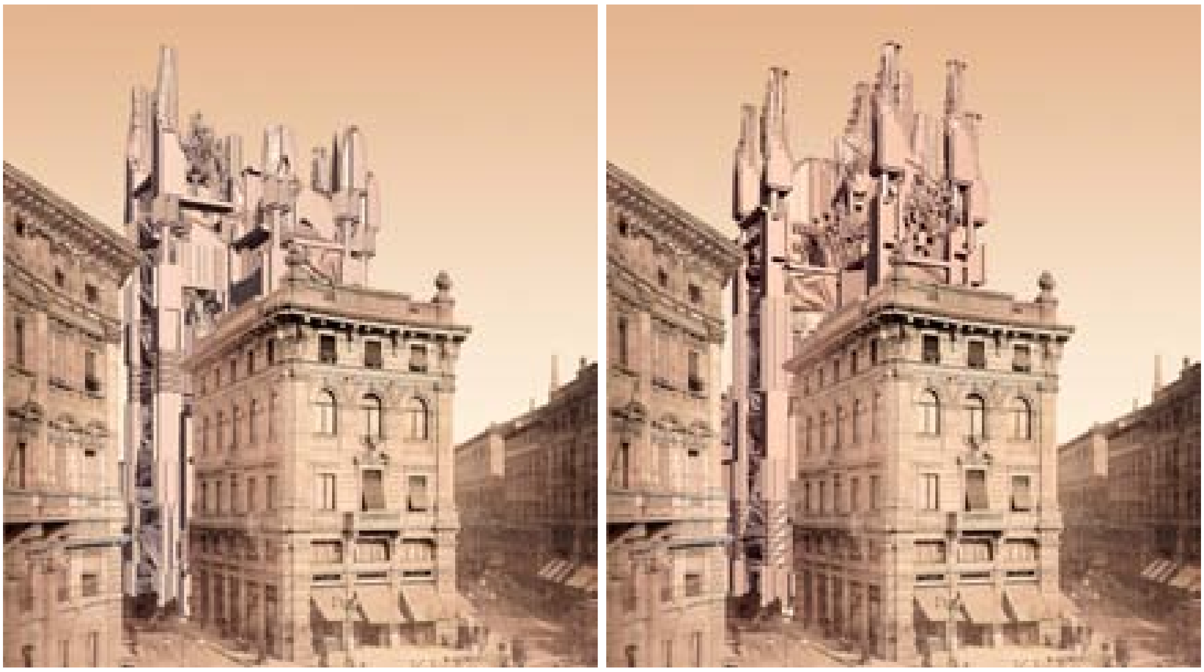
3D reconstruction of "Un mio istante del 4.4.1928, ore 10 e 2 minuti" by Balla. The reconstruction was defined moving from Euclidean geometry into non-Euclidean perspective. The reconstructed 3D model fits the Balla's image only in the first image and transforms itself in the subsequent dynamical rotation. (C.Soddu, "L'immagine non Euclidea", Non-Euclidean image, Gangemi Publisher, Rome, 1987).

The passage from a dimension to another introduces fields of variation owed to different factors inherent in the dimensional transformation and in the type of used representation. And particularly we discovered them from the three-dimensional to the two-dimensional events through different perspective logics, but above all from the reconstruction of the object 3D using different perspective-visual logics. These fields of variations belong to our subjective interpretation of an image or better, to our interpretative reconstruction of the parameters that could be used for the production of this image, the reconstruction of the parts that are hidden following the volume of which the skin is represented.

The hypothesis in reading an image is a defining process able to build through the Florenskji reverse perspective unpredictable forms. For instance a cube could be reconstructed as a pentagonal prism. This happens because, with the inverted perspective, the two opposite faces of a cube are represented as "in sight" together with the face in front of the observer. The reverse perspective of a cube is able to show three faces in sequence because you can see the cube both from left and from right. This happens everyday when we look at a very small cube and we approach it to our eyes. An eye sees the right face and the other the face on the left. The resultant image is the synthesis of the two sights. The mental image reconstructs a cube representing three consecutive faces. If we look at this representation with a canonical Euclidean perspective approach we need to suppose something different from a cube. The space "behind" appears too much ample and the re-constructive interpretation of the three-dimensional form can bring us to imagine more than a hidden face, for instance two, and therefore to generate an acceptable reconstruction of a prism with five or more consecutive sides. The cube, through these following passages of dimension (3D - 2D - 3D) is turned into a pentagonal prism.

These transformations are born from our interpretations: It is a "natural" construction of generative motors that mirrors our creative identity, our cultural references.

The idea of an architect doesn't base on forms but on transformations. This is a transforming approach able to see the existing world as a dynamic world, and able to generate visionary scenarios and their endless variations. The generative engines are the structure of the designer's idea. They work on morphogenetic codes fitting the oneness of the approach; they are the anamorphic logics that allow the designer to generate endless visionary worlds by mirroring, in their multiplicity, the design idea.

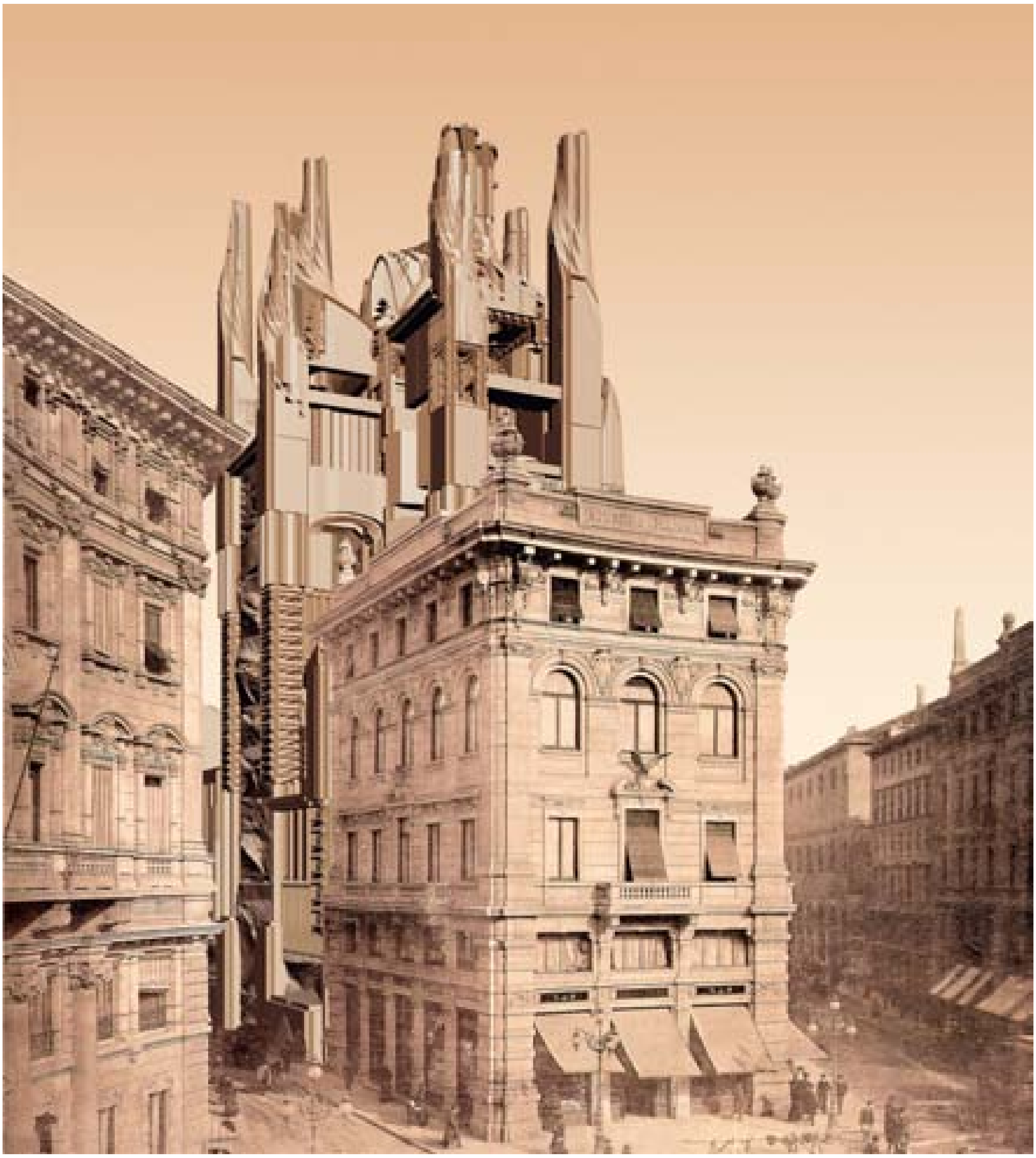


Two variations of "Cordusio" project by C.Soddu. All these 3D models are fully working in the field of functional and structure system and are completely generated by Argenìa.

3. Construction of generative morphogenetical processes: subjectivity and variations.

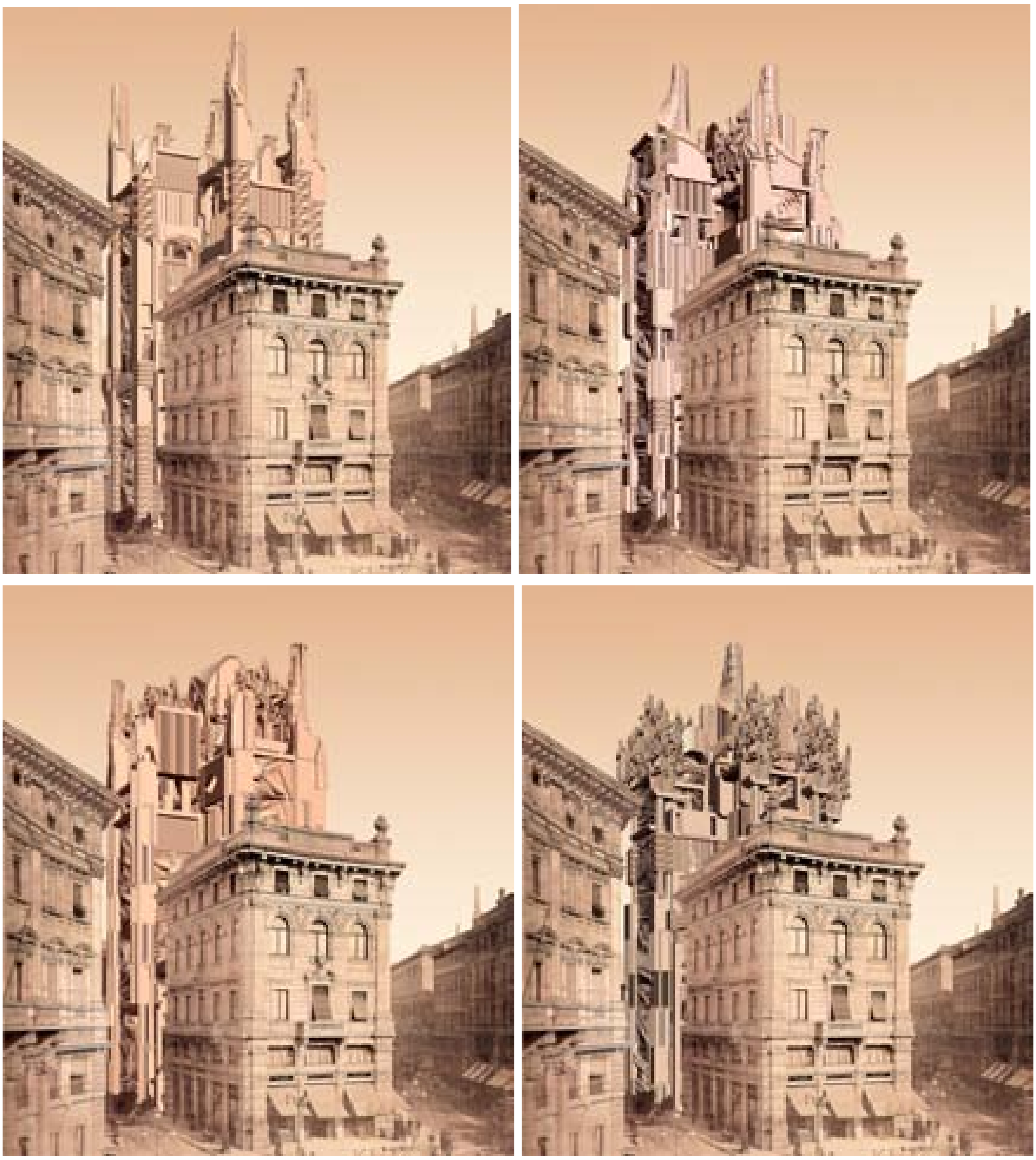
The identity of an artwork exists if people can recognize it as belonging to a species. So, if we like to build the identity of our artworks we need to identify its species and to realize it designing an artificial Dna. This approach is Generative Art: building a series of logics of transformation able to generate endless possible results recognizable through the morphogenetical paths used for their creation and through the reference to possible anamorphical logics belonging to our creative and cultural identities.

The results, in terms of quality and extended appreciation, are the best where the anamorphic logics produce answers pertinent to different subjectivities, therefore where the generated complex system don't give only the possibility to be understood as axiomatic structure of a shape or of a function but its complexity performs the availability to subjective and unpredictable uses. This usability is realized and appreciated when the suggestions, the logics of use and the aesthetical appreciation of each user is related to the complexity of the designed system and to the potential anamorphic interpretations that this complexity makes possible.



“Cordusio” project by C.Soddu. the aim of this architectural projec was to fit the Futuristic cultural reference of Milan buiding an architecture able to fit the Milan identity as represented by the Cordusio square in the beginning of last century. This because the twenties of ‘900 were really important in construicting the “idea” of Milan in a visionary futuristic expression. 2005.

Not only. Identity has to belong to a species without denying, rather strengthening the identity as individual, as unicum. It brings to consider that the design of morphogenetical paths rather than of shapes doesn't remove anything from the final results identity but strengthens then, especially thanks of the parallel presence of "variations". As happens for music, from Bach to Mozart to jazz.

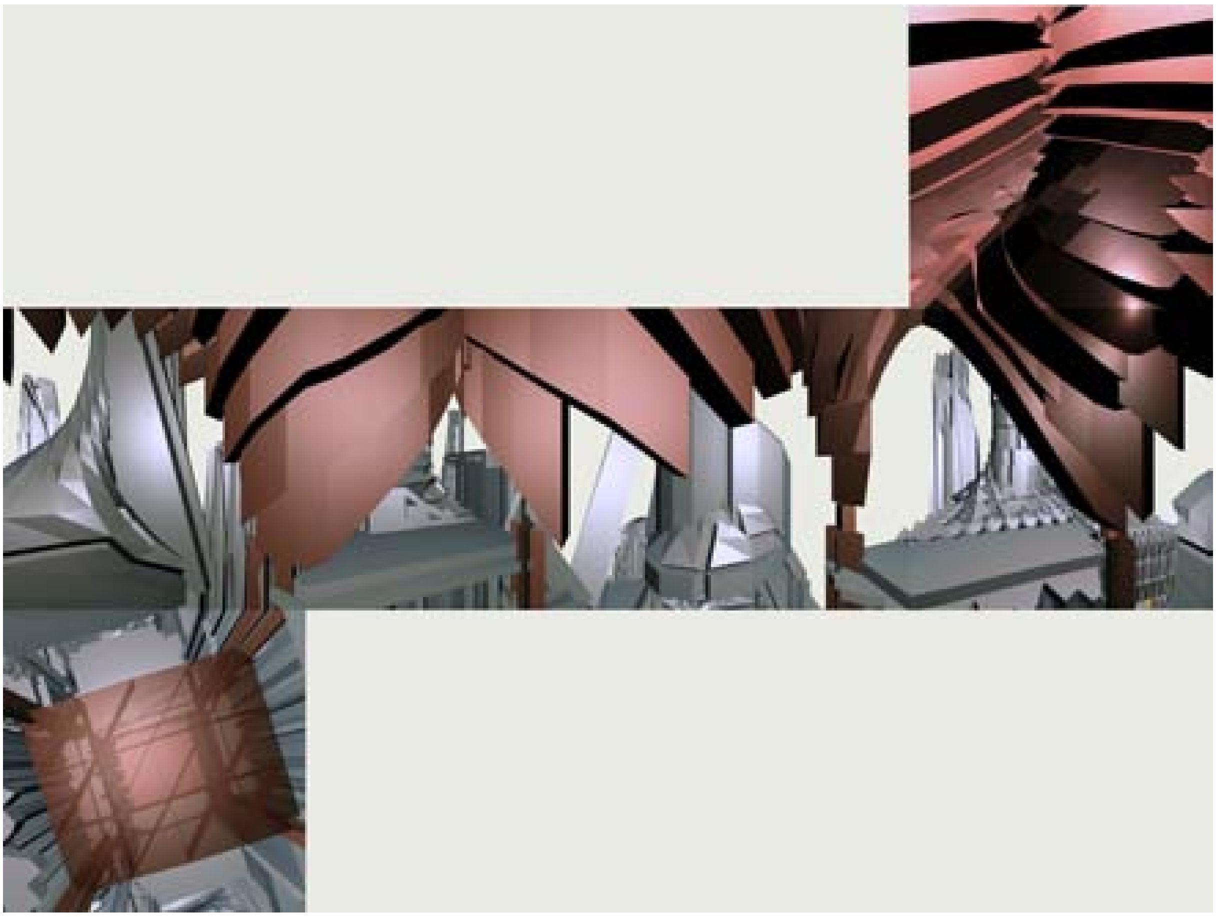


Four more visionary variations of "Cordusio" project for Milan, realized by the author usig "Argenìa", his generative software. Milan, 2005

Variations are built consolidating different forms in different moments, but these results are reciprocally congruent because they belong to the common morphogenetical paths that, from the detail to the whole, are at the base of an idea. These "endless" variations could seem aesthetically less strong and functionally, less recognizable than only one result chosen because considered the best at the end of the optimisation of the form/function relationship. This approach is misleading. The affiliation to a species, with the possibility of mirroring each result in the infinity of the parallel variations, creates two congruent layers of recognizability and identity that are strengthened one each other: the identity of the species and that one of individuals.

This approach finds a quality also in the uniqueness conjugated with the recognizability. For instance the oneness of a painting of Van Gogh is also appreciated through the possibility to recognize it because painted by Van Gogh, and for belonging to a species with unique characters and unrepeatability. This happens in the appreciation of Nature where the multiplicity of variations mirrors the multiplicity and oneness of every people.

This process of appreciation happens not only on the aesthetical layer but also in the aspects more directly related to functionality. The use of objects becomes "intuitive" really because linked to subjective runs of appreciation and recognizability. As, for instance, sometimes happens in the structure of software interface. For using a function, manifold "logical" runs are designed mirroring different and subjective possible approaches.



360 degree view from the top of “Cordusio”, 3rd variation. The view is represented with an interface shaped as a cube skin. C. Soddu 2005.

4. Generation versus Cloning.

In a production process of individuals belonging to a species, the copy doesn't exist and, we could say, it is not possible because it is an error. For the simple reason that we can only add quantity with the copies, but quality of a copy is static and not dynamical. Art is another thing. We are able, in fact, to copy an object, to reproduce it until the least details, but we are not able, with the same tools and with the same philosophy to copy a species. This because the anamorphic logic that has been activated during the design of species is, for its own nature, different from the anamorphic logics of whom analyses an object, or also a series of objects belonging to the same species. The subjective and interpretative component is so strong and involves the passage from a conceptual system to a plurality of physical events that is not possible to "reconstruct it". It is possible only to "redesign it". A "generative" design is not reproducible departing from the results. It is possible to produce only "clones" of single variations. The only certainty that we can acquire is the feasibility of the generative project, because someone has already realized it. We cannot copy it. We can recreate it only ex-novo using our personal subjectivities and interpretative ability. But it will be another project, however.

5. The generative city and the visionary worlds

The future of the ideas and their realizations is a city living of unique events, unrepeatable and anamorphic events able to answer in pertinent and recognizable way to a plurality of citizens with their unique identity. But also a city that progressively discovers its own identity approaching to the Ideal City that is in the mind of people who lives and designs it. As each Ideal city and the visionary worlds representing this idea, also every physical city could be, surprisingly, unpredictable, not homologable neither clonable and therefore, finally, in harmony with Nature.

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Past images of the future

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Abstract.

The majority of the techniques known until today make it possible to create images which solidify one moment (painted, photographed, filmed, etc.) or which is held at the present (interactive installations, performances, 3d in real time). The creation of artificial worlds, having their own clock of time makes it possible to explore the future finally, with various stratagems. The use of the methods of evolutionary creation is used to travel in the virtual time of worlds of artificial beings. Moreover, when these worlds are connected to the real world (by images, photographs or video camera in real time), one can plan to visualize our future, seen by the evolutionary creatures of another world.

What the images coming from painting, of photography and the cinema, to quote only the most known techniques, have in common? They all are of the images which are fixed on supports, and which have the characteristic to describe last moments. Painting solidified a still life or a landscape, the photographer captured an image of an animal in action, from one strong moment of sport, the scenario writer assembled a film with catches of sights turned in the previous months. All these moments are passed (within the meaning of our time, such as we live it as human). We will keep ourselves of course statement which they are techniques of the past (not to confuse...). But, they produce images of past (more or less near). Even a photograph taken on a numerical camera that one can visualize almost instantaneously, shows one last moment of a few seconds.

1 From past to present

Of course, many scenario writers of films of science fiction propose to us, which are supposed to be held in 100 years, thousand years, etc. Some is the date on which the action of film proceeds, we look at images which are fixed on a film: they are thus recorded images, in the previous months for the diffusion of film, even if the subject is futuristic: their contents are future, but their form, their structure even passed. However, of many artists already tried to play with time. Among the most famous examples, it is significant to quote the movement cubist, and certain famous fabrics of Picasso, where one sees on the same painting several sights of the same character, at various moments of its action. In another style, Marcel Duchamp endeavours to represent on only one painting of the figures moving, like his "nu descendant l'escalier" (see figure 1). The current most extremely in this direction relates to the Italian futurism, which tests many techniques to represent time in photographs, paintings and other works of art.

Figure 1 : Nu descendant un escalier. Marcel Duchamp

But it will be necessary to await new ways of creation and mainly the arrival of the computer to generate images in real time, through interactive performances or works to see appearing works of the present. Of course the painter whom one looks at carrying out his work is also "in real time", just as the artists who use it video in a direct way. It is with the advent of the 3d real time, and the virtual ballades in the medium of fictitious worlds that the production of images at the present takes really its rise: it is the era of the interactivity in all its splendour, where the witness can interact on the work of the artist, to walk there, but even if required to modify of them certain aspects, etc.

2 Artificial life and its clocks

And then the first works related to the artificial life made their appearance. Generally using evolutionary techniques to make evolve/move creatures in their environments, these works have the characteristic to put to us in front of new worlds, populated by strange creatures, which have some kind of life. Among the strong currents having explored the first this type of technique, it should be quoted the artists that us (like Mitchel Whitelaw [16] says it well) the “breeders of art” will name, or “breeders of images” (or of sounds, etc). Among the famous artists of this current, it is necessary for us to quote names like William Latham [1], Karl Sims [2], Steven Rooke [3], Penousal Machado, Jeffrey Ventrella, Driessens and Verstappen [7], etc (see figure 2). These artists use the genetics to make evolve/move worlds of images and creations. They are the precursors of the artists who straightforwardly will create worlds of artificial life, letting evolve/move their works with the wire of time, the time of a performance, an exposure, or even uninterrupted by using Internet network. We could study many characteristics on the creation of such worlds and creatures, but one of it was often neglected: the aspect of time. Indeed, dice the moment when these creatures are generated, it is held a certain time, which is measurable in general by a clock in the computer. In theory, this clock is supposed to follow that of our time, which one will name "human time", but does anything of it does not oblige there. The clock of the computer has this characteristic, which it can be even modified by us or a data-processing program who has any capacity to advance time, to move back it, slow down it or accelerate it.

We can with ease travel in the time of our computers, simply by changing the date of the system or by accelerating the rate of the clock: the future of the virtual worlds that we create is thus (enough) easily visible! The creations based on the artificial life thus have this characteristic to be images, which can belong to their own future, and it is undoubtedly the first time that that occurs in the history of Art...

Figure 2: Genetically advanced self-portrait in the space of Mandelbrot. © Ventrella. 2005

3 To play with time

It is not quite difficult to understand that while advancing the clock of a computer, one can go "to see" an image of the future (if one considers the time measured by the computer as the principal scale of measurement of time for beings which exist only in the computer). For example, an image which would consist in plotting a curve of a F(t) function where t represents the life time of the image (for example: f(x) = 2*x), can be seen with its starting point, in real time at the time present, but also, suddenly and suddenly in its future, simply while advancing artificially t, measurement of the internal time of the computer. Not really very revolutionary, certainly. But, this becomes already definitely more interesting when one uses the techniques of evolutionary programming. If it is supposed that one makes evolve/move an artistic work on the basis of genetic algorithm, one in the same way can, outward journey to see what will occur for the future generations from these worlds, and to go to explore the evolutions of these worlds in thousand years or more. Of course, it is necessary for that to have a certain computing power: but nothing stops a technician who can, if it wants of it, simply use network computers for example, calculate twice more quickly an evolution of virtual world (with 2 computers) or 20 times or why a million times, with a coupled use with Internet network ! This concept is not easily conceivable for our human brain, but after all, it is not more astonishing than the concepts of curve of the space time [17] which controls us: also we decided to explore evolutionary creations of the future, this in order to seek to open new tracks to discover how to produce images of the future.

4 Evolutionary creations

Most of the time, the artists or the scientists who create virtual worlds, pass most of their time to explore and study these worlds, with our own clock of time, and also our own knowledge of the world. We endeavour here to make the reverse exactly! Indeed, since we create virtual beings, which have a certain degree of intelligence (at least of behavioral action) and a certain way of behaving in their virtual world, it appears interesting to see our quite real world, since the virtual world, which we created. We will take again here the world of the "beings paintings", described by the author in particular on the last Siggraph (see figure 3). They are beings whose body is composed of virtual pigments and whose principal occupation is to organize itself in a 3D space to generate images. They are thus able to be driven, and to colour multiple ways, according to various parameters, according to evolutionary methods. In preceding work, especially "we were to like their primary education goal", because the artist could then visually choose parts of the world of the "beings paintings" which it likes and inspire it. But here, we propose to study the reactions of these beings in front of series of images that we propose to them: photographs, drawings, paintings of large Masters and even of the real image time in video with the use of Webcam, quite simply. The method of creation will be found extremely moved: we do not look at to only any more "being them paintings" to organize itself to create images. We will try to see how virtual beings can react to our world, how they can create, by looking at us.

Figure 3: Vision on the world of the “beings paintings". © Alain Lioret

5 Attention, these images look at us!

The choice "to see" the world since that of the virtual beings that we create is far from being pain-killer. Indeed, it will be necessary in this case to try to include/understand how these beings there can perceive our world. And a priori, they are well far from perceiving it as one can think it. They do not have for example any notion of the objects of our environment: they do not know what is a chair, a body, a face nor even a flower. When one presents an image or a video to them, they "see" just a juxtaposition of pixels, an arrangement of colors, whose they will be able to analyze the composition. Indeed, these beings are data-processing creatures. They cannot know a priori what an image with our direction represents: on the other hand, they can try "to include/understand" an image with the tools they have. It is there that the concept becomes interesting: the only tools, which one can allot to this type of beings are generative tools, functioning on the basis of parameter. It can be a question of software of creation of fractals, cellular machines, L-systems, data-processing languages (3d for example), of tools for generation of images by genetic algorithms, networks of neurons, filters of images, etc. Thanks to this type of tools, the "beings paintings" can try "to include/understand" the images that one proposes to them by analyzing them, and while trying to reproduce them more or less perfectly. This stage, they finally do not seem more advanced than owe us the great mysteries of the universe. But, they can try to analyze our images by using genetic algorithms to produce data-processing generations of images, whose aptitude can be measured by a resemblance to what they "see". (see figure 4).

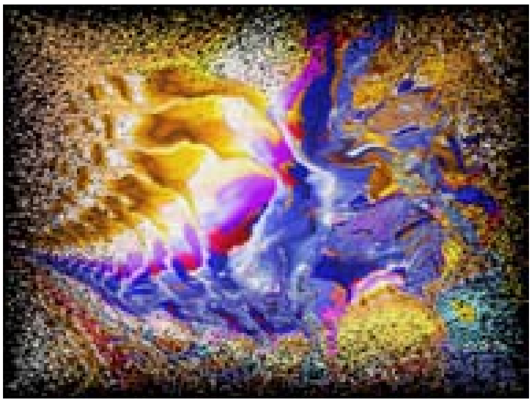

Figure 4: an image analyzed with fractals and 2D filters by the beings paintings. © Alain Lioret

6 Genetic analysis of images

Our "beings paintings" can thus use all the software, which they want to try to analyze our world. Dice which they are tools being able to be launched automatically. This principle is very open besides, and one can provide them a list of tools which they can use. Here is a small example:

Ultra Fractal

XenoDream

Mcell

Visions of Chaos

Filtres Gimp

Apophysis [6]

PovRay

Kandid (voir figure 5)

MEL sous Maya

Mathematica [5]

As one can see it, this small list example is very open, and non exhaustive of course. In fact, dice that a software able to produce image has an integrated language, which makes it possible to describe a process of creation of image, it can be used in the total diagram of analysis of image of the virtual beings. One in the only ways for these beings of trying "to include/understand" our world is to compare their creations with our images, pixels by pixels (they do not have a priori a sense of organization in lines, circles, etc, but they can "learn" that if one educates them in this direction). It should be noted that this method takes as a starting point the work of Jeffrey Ventrella, which used this kind of technique to create self-portraits in space fractal of Mandelbrot. The aptitude of the virtual beings to include/understand our world can thus be simply measured by adding the errors on each pixel with an image that one presents to them. Fitness = Σ1, N e(xy)

Where e(xy) represents the difference in color of the pixel of coordinates xy between the real image and the image generated by the "beings paintings".

Figure 5: use of the Kandid tool to analyze the human images by the virtual beings.

7 Images, films and works in real time

The general outline of creation of these beings is simple: one or more images of our world are presented to them (photography, video, painting, etc). They then will try to produce populations of judicious generative images to resemble the model suggested: in that, they are comparable with our artists who will try to reproduce a landscape or a still life on a fabric: but their tools are very different. With genetic algorithms which measure the differences in image, they try to reproduce their model as well as possible. This stage, it is significant to distinguish two types of very different tools. The tools which generate an image solidified in time (like a raytracing in PovRay language) and the tools which generate an evolutionary image according to rules' (cellular L-systems or especially automatas). The first category of tools is often useful to implement to manage to produce more realistic images, but hardly allows to play with the internal clocks of the creatures. The second category on the other hand is much more interesting, since by providing rules of construction of the images, which are closely related to the process of generation in time, it makes it possible to make evolve/move the images according to their "age", of their birth to their future. It that one can plan to study "our future", is seen here by the beings of a virtual world. Let us take a simple example, (drawn from Mcell, software of cellular automatas [8]). Let us suppose that a "being painting" produces image 6. This image is the resultant of a process of a cellular automata visualized at one moment

T, starting from complex rules. These rules can thus make it possible to generate the future of this image, simply continuously the generation of the cellular automata.

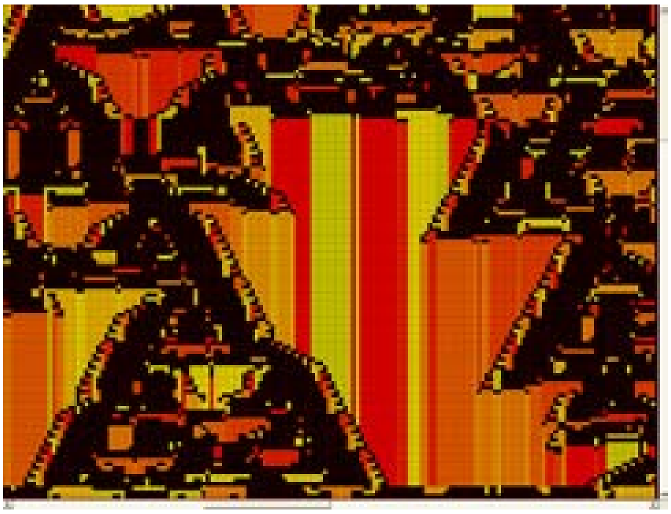

Figure 6: a creation at the moment T by a cellular automata.

This very general process of creation will enable us to also create fixed images of course, but also some works in real time, perpetual genetic evolution, and even of quite simply astonishing films, bus to generate by virtual beings having their own design of the world. We thus carried out the film "Galateia 2005" with this methodology, while presenting at a group of "beings paintings" of the series of fixed images, which were used here as storyboard for the creation of film. The realization of the images is very complex here, and includes/understands several layers of images, realized with very diverse tools (population of the drawn software tools randomly). The movements themselves of pixels from one key image to another were analyzed according to same process's by the virtual beings which translated and analyzed movements of pixels produced by a parallel video capture. Moreover, each time that a cellular automata was implemented in the design of a key image, the preceding and following images (last and future) was calculated. Galateia thus integrates images of the future. This experimental film is a good example of evolutionary creation.

8 The first experiments of creations of images of the future

It will be included/understood well that the evolutionary techniques of research of creation of images are interesting in more than one way. However, our attention is held definitely here by the possibility of exploring the future, our future even, and this for the first time in the history of art. Thus, the use of WebCam in real time can make it possible the "beings paintings" to collect our world on line, to analyze it with their way, with their tools and to deduce their evolutionary rules from them. These rules make it possible to generate images close to what one can show them, and to deduce from it their past and especially their future! And it is indeed our future, seen by virtual artists, but of our future nevertheless.

9 About the beings paintings

The "beings paintings" themselves can be created multiple ways. We mainly used the simulator of Artificial Life Framsticks [9] to generate the beings paintings, but we also made tests with other environments, in particular Breve. As we explained in preceding work [11,12,13], our beings paintings have only one objective in the Life: to organize itself to produce images. Previously, the produced images were chosen by the user. With this new work, the images carried out try to resemble the models that one proposes to them. The visual analogies can be done at various levels, color or with a simplification black and white. One can even use certain filters (for example detection of contours) to facilitate the work of "imitation" [10]. Each being painting belonging to the population of the creative beings thus will analyze us with his way, with the generation of populations of solutions, which will utilize various tools 2d or 3d, free or commercial, according to those which are available. It is thus simulated genetics on double level, which is implemented, with evolutionary populations of creatures painters which generate solutions of combinations of process of creation of images.

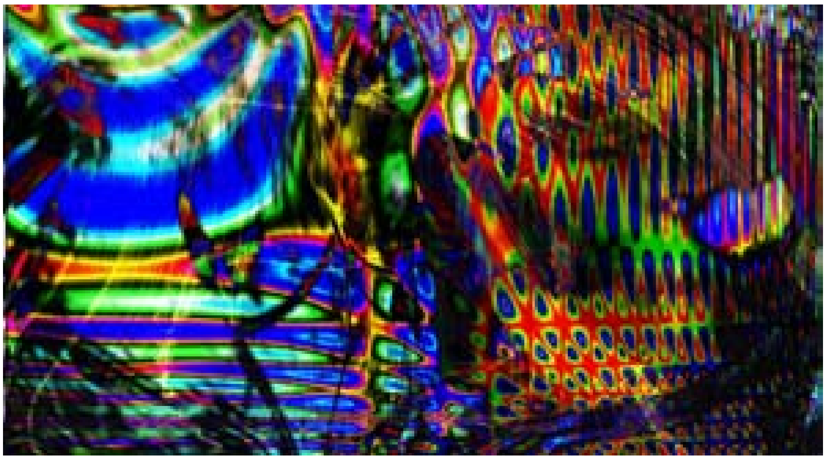

Figure 7 : A creation of the "beings paintings". © Alain Lioret. 2005. Extract of Galateia

10 Applications and perspectives

The techniques implemented here can be compared with reverse engineering. In addition to the artistic creation seen under the eye of other worlds (but also with their systems of thoughts, their means and tools), one can make use of it for many graphic applications. Indeed, as one explained, the method works with a large variety of tools (those having a language, methods of scripting or equivalent) and allows artists or technicians of the image to seek to generate images according to a certain configuration, with tools not intended a priori for that. The centers of interests are rather significant, because they must allow the creation of new fashions of returned images (2d and 3d), and involve the appearance of libraries of 2D filters, 3D shaders , procedural textures, etc. The installation of this type of technique in the form of plug-ins in great software must make it possible to the creators to make emerge new methods of creations, and to set up of the extremely rich but complex processes creative, so complex that it would have been impossible to implement them manually nor to even think of it...

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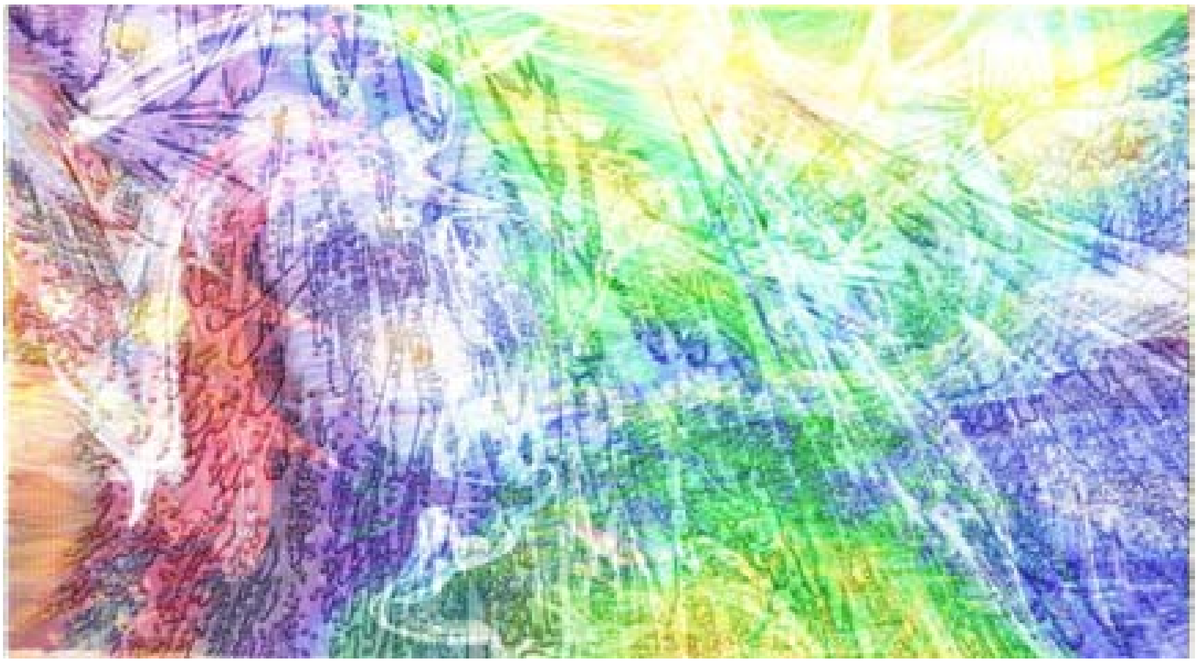

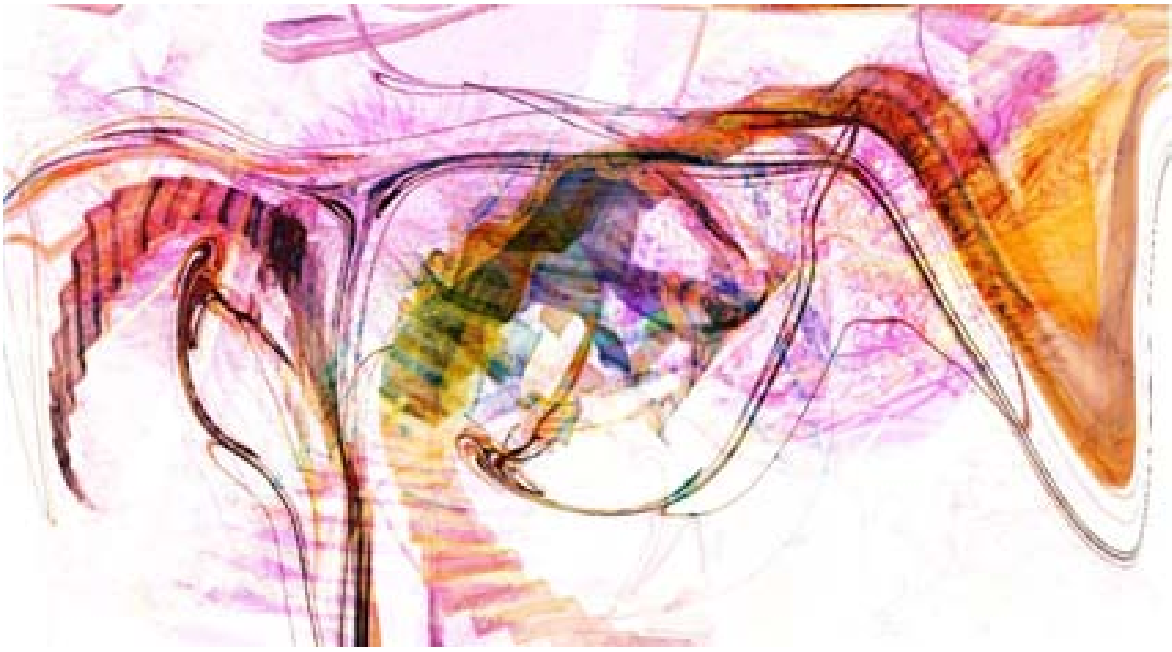

© Alain Lioret. 2005. Extract of Galateia.

Psst.....Wanna Buy an Algorithm?

The Proliferation of Generative Music Systems throughout Everyday Life and its Effects on the Music Industry

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Abstract

Generative music is created within a system as a result of the rules implemented by its creator. In computer based systems these rules, and therefore the music produced, may be further influenced by external sources converted into digital data. This combination enables generative music systems to create music for a specific environment or purpose. The adaptability of music produced by generative music systems could substitute many instances where linear music is currently used in everyday situations. After examining the issues surrounding the music produced by generative music systems, this paper reviews instances where generative music systems could be used to replace linear music systems in everyday settings and enhance the effects of music in those settings. Such settings include healthcare, personal fitness, other commercial setting such as restaurants, retail outlets, offices and factories, in the motor industry, in domestic settings and within the telecommunication industry. Since the “pure”[1], “unfixed” music produced by generative music systems is, in the UK at least, copyright free and therefore exempt from the usual public performance licensing procedures, after looking at linear forms of “environmental” music, the paper then goes on to examine the importance and nature of the algorithm within generative music systems and considers how the generative music composer could be remunerated each time music generated by his or her algorithm is performed in public. The title of this paper makes inference to the likely attempts that the established music industry will make to firstly ignore the idea of generative music systems and then to suppress their proliferation by attempting to outlaw such systems despite their legality. The paper therefore concludes by discussing some of the implications of generative music systems on the music industry.

This paper follows on from, and includes elements of, my MA thesis “Is the Future of Music Generative?” and acts as a precursor to my research degree at ARU in

1 The term ‘pure’ generative music is used in this paper to describe music that has been produced by a generative music system or process and not subsequently recorded.

Cambridge where I propose to examine the feasibility of using generative music systems as tools to assist music therapists and patient carers in health settings.

1. Introduction

“Generative music is commonly agreed to describe music in which a system or process is composed to generate music rather than the composition of the direct musical event which will result from that system. The generative composer has only indirect control the final musical result, and the creativity of the compositional process is found in the decisions about how the system will operate and the rules inside the system”(2).

As generative music is created by the composition of music within a system this means that musicians, recording artists, producers, and to some extent the composer, can be absent from the creation process. The generative music composer, besides defining the musical parameters within the piece, essentially separates him or herself from the creation of the final piece of music. Advances in computer technology have enabled generative music systems to be created where the generative music composer has more control over the rules he or she creates within the system or process and therefore the final music produced. The rules within the generative music system may be further influenced by external environmental changes converted into digital data. This combination allows generative music composers to create systems that can produce music for a specific environment or purpose. The adaptability of music produced by generative music systems could substitute many instances where linear music is currently used in everyday situations.

It is my belief, that the intention of creating a generative music system is to produce a unique piece of music each time the system is initiated or reset and therefore means generative music in its purest form is not recorded. As it is not recorded, although copyright subsists in the generative music system itself, no copyright subsists in the music that it produces. Since no music copyright exists within pure generative music the role of traditional music companies in relation to generative music such as collection societies, record labels and publishers, which rely on copyright subsisting within music to allow them to carry out their day-to-day business, is brought into question. The absence of a business model within the traditional music industry to support the proliferation of generative music systems means that a new model must be sought and developed from elsewhere.

2. I Am Not a Lawyer But…

The copyright status of computer related generative music systems and the pure generative works that they create seems, in the UK at least, to be fairly straight forward. For the purposes of UK Copyright Law a computer program is considered as a “literary work” which, according to Section 3 (1) of the Copyright Designs and Patents Act of 1988 (3), “means any work, other than a dramatic or musical work, which is written, spoken or sung”. Section 3 (2) of the Act states that “Copyright does not subsist in a literary, dramatic or musical work unless and until it is recorded, in writing or otherwise”. In the case of a musical work this would include making a video, tape, CD or digital recording or copy of the work as well as a musical score and in the case of a computer program a digital copy of that program. A computer based generative music system, then, is protected under UK Copyright Law. Section 12 (2) of The Duration of Copyright and Rights in Performances Regulations 1995 (4) states that “Copyright expires at the end of the period of 70 years from the end of the calendar year in which the author dies”. If the generative work that it produced were “recorded, in writing or otherwise” then as a “computer generated” work copyright would, according to Section 12 (3), expire “at the end of the period of 50 years from the end of the calendar year in which the work was made”. The pure generative music produced by the generative music system, however, is not fixed and therefore copyright does not subsist in it.

This does not mean that the creator of pure generative music is not deemed its author. Section 9 (3) tells us that “in the case of a literary, dramatic, musical or artistic work which is computer-generated, the author shall be taken to be the person by whom the arrangements necessary for the creation of the work are undertaken”. The author, however, is unable to exert his or her Moral Rights as set out in Section 77 of the Act because, according to Section 79 (2), “The right does not apply in relation to the following descriptions of work— (a) a computer program; (b) the design of a typeface; (c) any computer-generated work””.

In the US, the copyright position in relation to pure generative music is not so apparent. According to Section 102 a) of the US Copyright Act (5) "Copyright protection subsists, in accordance with this title, in original works of authorship fixed in any tangible medium of expression, now known or later developed, from which they can be perceived, reproduced, or otherwise communicated, either directly or with the aid of a machine or device." In the preceding definitions in Section 101 it states that "A work is “fixed” in a tangible medium of expression when its embodiment in a copy or phonorecord, by or under the authority of the author, is sufficiently permanent or stable to permit it to be perceived, reproduced, or otherwise communicated for a period of more than transitory duration."

In the case generative music systems, the nature of the music that the systems produce is often dependent on random choices made within the system. The question that arises, therefore, is are the random choices within the system “sufficiently permanent or stable to permit it to be perceived, reproduced, or otherwise communicated for a period of more than transitory duration” to be considered ““fixed” in a tangible medium”. My own feeling is no. The random choices are never fixed within the system as the intention is for them, and therefore the nature of the music created, to change each time that the system is reset.[2] But I am not a lawyer.

3. Applications

A number of generative music composition tools exist for general public consumption [3]. These include MuSoft's a Musical Generator (6), Digital Expressions' ArtSong (7), Nyr Sound's Chaosynth (8), FractMus (9), Algorithmic Arts' SoftStep (10), Sseyo’s Koan Pro (11)[4] and Madwave’s Madplayer (13).

2 At the time of finishing writing this paper I had yet to receive a response clarifying the situation in the States from the Legal Departments of both ASCAP and BMI.

3 The absence of both Max/MSP and Supercollider here is deliberate because they require greater technical skill to operate

4 All these applications and others are discussed in David Miller’s article “Game of

With the exception of the telecommunications industry where Sseyo's generative music engine enables generative ringtones to be created in real time within Tao's intent Sound System (iSS) and Madwave's Madmixer, which incorporates its MadTone Generator for creating generative ringtones, no other commercial applications of generative music systems, to date, have been found other than those that are used as music composition tools.

Generative music systems have two distinct advantages over conventional linear music systems. The immediate advantage to companies using a generative music system is that, in the UK at least, neither a PRS (Performing Right Society) (14) nor PPL (Phonographic Performance Limited) (15) license fee is payable as the pure generative music played is not fixed and therefore copyright does not subsist in it. The second advantage is that generative music systems are able to adapt and vary the music that they produce in real-time and therefore give the end-user greater control over the characteristics over the music produced.

Another possible application for generative music systems within the telecommunications industry could be "on hold" music. On-Hold music is an important tool in keeping customers on the line while waiting for an operator or customer services assistant. Studies have found that callers are likely to think that they have been forgotten if there is no music on the line and that music reduces the perceived waiting time (16) with callers staying on the line up to 20% longer if they heard music that they liked (17). Studies have also shown that callers tended to hold on longer if jazz, country or classical music was playing rather than pop or relaxation music (18) and that the choice of music played influenced the callers' image of the company (16).

PRS recommends that companies that use on-hold music change the music regularly, match music to customer profile and choose music to represent the desired company image. They also recommend that companies be unique in their choice of music and to focus on the value to the company by using the music and not the cost (19). Whatever genre of music is played there should also be an air of familiarity about it as "familiar music produces more discrete events in the memory than unfamiliar music thus increasing a person's estimate of time" (16). In other words music that is familiar to the listener makes time seem to pass quicker than when unfamiliar is played.

The detection of a caller's telephone number could instruct the generative music system to create appropriate music, based caller's preferences, while the caller is waiting for assistance ensuring that the music played is varied but of a style that is preferred by the caller so that the caller is willing to wait longer but the perceived waiting time is shorter.

In commercial environments such as restaurants and bars the style of music forms an image of the establishment in the mind of the consumer. While classical music creates an up market image for an establishment it is thought that jazz music attracts a more affluent customer (16). Customers in a cafeteria were found to be more willing to pay a higher price for food when classical music was playing in the background than other types of music (20). In the same study it was found that both classical and pop music may have increased the sales in the cafeteria as compared with easy listening and silence. Classical music was also found to appease rowdy or

Chance" (12)

aggressive behaviour in customers whereas heavy metal was found to have the reverse effect (16).

The tempo of the music played is also another important consideration in commercial settings. In the 1940s, an American company, Muzak®, developed Stimulus Progression programming, an "elaborate system that arranges songs according to tempo and time of day, taking into account the typical lulls that hit workers mid-morning and mid-afternoon" (21). In one study fast music was found to significantly increase the time spent drinking a can of soft drink (22) and managers of restaurants tend to play faster music at lunchtime and in the evening to clear tables more quickly as diners tend to eat quicker when faster music is played (16). Another study found that music tempo variation can significantly affect the pace of in-store traffic flow and dollar sales volume (23). Fast music was found to increase both productivity and morale of employees occupied with monotonous work. In a study at a voucher processing centre for a bank, fast music lead to 22.3% more vouchers being processed than when slow music was played (24).

Another important factor is the volume of the music played in the restaurant or bar. Music played at low volume tends to increase expenditure drinks (25) and tends to be most effective when it is quiet enough to be discrete but loud enough to suppress background noise (16). Music also reduces perceived waiting time, can facilitate conversation and alleviate uncomfortable silences (16).

In commercials settings such as restaurants and bars changes in local environmental readings could instruct a generative music system to create appropriate music that was faster at lunchtimes and in the evening in restaurants to encourage customers to eat more quickly and drink more and automatically adjust the volume of music so that it remained discrete no matter how many people were in the establishment. Additionally, if sensors detected that the restaurant was not full it could over rule the instruction to play faster music by playing slower music so that customers felt more inclined to linger longer and therefore give the appearance that the restaurant was always busy and therefore popular. Other possible applications include automatically playing more stimulating music in offices and factories at morning or mid afternoon lulls or if room temperatures rose to a level that were in danger of making the workers lethargic or in retail environments where appropriate styles, tempos and volumes of music are played depending on the time of day, the temperature within the shop or the number of customers within the shop. Booming music, for example, may not be appropriate in a shop on a hot Monday morning when customers are merely there to browse rather than buy.

Another possible application for generative music systems could be within the motor industry. One study found that for many people the car is the only place that they can listen to loud music without annoying other people (26). Another study has shown that the type of music played within the car can have a marked effect on driving behaviour (27). A driver playing loud music with a high tempo can either knowingly or unwittingly increase the speed of the vehicle thereby breaking the speed limit and potentially endangering the lives of over road users. Similarly, a driver playing the same music in a traffic jam could become irritated and stressed by being held up thus increasing the risk of “road rage” related incidents. An appropriate generative music system could automatically play music that both discouraged speeding by encouraging the driver to maintain a safe, sensible speed and also relieve the stress associated with being caught in traffic jams.

A generative music system, influenced by physical data gathered from within a vehicle and its surroundings, could create appropriate music with a tempo and volume that encourages driving at a safe and sensible speeds and when detecting the close proximity of other vehicles when travelling at low speeds play appropriate relaxing music to subdue driver stress levels.

In the home many people use music to accompany domestic or solitary tasks including housework, studying or resting (26). When music was used as an accompaniment to routine activities such as washing or cooking the effect of the music was found to increase positivity, present mindedness and arousal in participants of one study (28). The same study concluded that one of the primary functions of music in contemporary everyday life appeared to include the enhancement or distraction of attention from a mundane domestic task and that music was used to enhance states of relaxation. A generative music system could play music that was both appropriate for the activity that the individual was undertaking within the domestic environment and also play appropriate music based on other data such as the time of day, temperature within rooms or even the presence of a certain individual and based on pre-determined information regarding the individual's musical preferences. The application of such a system has been previously been presented and discussed by John Eacott and Mark d'Inverno in their paper "Embedded Intelligent Music or iHiFi – The Intelligent HiFi" (29).

Within the area of sport and personal fitness studies have shown that synchronisation of exercise to music has increased work output, reduced the rate of perceived exertion during exercise, increased enjoyment levels and enhanced affective states at both medium and high levels of work intensity (30).

Using physiological readings from the athlete a generative music system could create music within a work-out session with characteristics, such as tempo and rhythm, which were attuned to the ability of the athlete in order to sustain endurance and participation levels throughout the work-out session without the danger of overexertion.

Extensive research has been carried out within the health sector on the effects of music on people. These include the effects of music on physiological parameters such as heart rate, respiration rate, skin temperature, blood pressure, skin conductance, salivary cortisol levels and levels of Immunoglobulin A. The scope of this paper, however, prevents a detailed presentation of those studies[5].

Overall, however, studies have found that people's music tastes are highly individual with different types of music eliciting different moods. Music also counteracts stress and anxiety and promotes relaxation in patients. The type of music played can also influence physiological elements such as body temperature, heart rate, blood pressure, respiration rate and production of salivary Iga in patients (cited in 31).

Decreased stress and anxiety in patients could have positive outcomes for both patients and their carers. The feelings of stress and anxiety have a number of contributing factors including fear of pain or of the treatment outcome and also the

5 A summary of some of those studies relating to the effect of music on various physiological parameters is set out in Appendix 1 of the research degree proposal, entitled "Generative Music Systems as Tools to Assist Music Therapists and Patient Carers in Health Settings" (27).

patients' feelings of loss of control over their body and immediate environment (32). Physical reactions to stress and anxiety include restlessness, trembling, muscle tension, fatigue, shortness of breath, increased heart rate and elevated blood pressure that could lead to medical complications (33).

Decreased levels in stress and anxiety could also result in an improvement in the feeling of well being in the patient, a decreased length of hospital stay, decreased medications such as pain relievers and sedatives and an overall increased perception of the patients' stay in hospital (34).

A generative music system that is adaptable, autonomous, non-invasive and holistic could help the music therapist to create and sustain a dialogue between with patients and also help the health carer to sustain patients' comfort without the need for constant carer-patient monitoring or the over use of pain relieving drugs. My intention is to commence developing such a generative music system during the course of my research degree.

4. Is it "Musak®"?

Environmental music is not a 20th century phenomenon. It origins, in fact, lie within the church of the 17th century where improvised organ music was played to "maintain mood and concentration during inaudible portions of the service taking place at the altar and during quiet segments such as communion" (35). Much of the music played at garden and birthday parties and other celebrations in the late 18th century was specifically composed as background music "intended to blend in with the general ambience of the event rather than be listened to directly" (35). 19th century upmarket restaurants in Europe, and then the US, also used music in the background to enhance the client's dining experience. During WW II in England music was also played in defence plants with the specific intention of reducing fatigue in its workers (35).

The provider of environmental music that has dominated the latter half of the 20th century is Musak®. Musak®'s intention is to produce "music that is functional and to be heard but is not supposed to listened to directly" (35). Indeed, it considers the music making process to be more science that art creating music that functions as an integrated physical and psychosocial part of the overall music environment and is purposely non-entertaining, non-distracting and unobtrusive in nature (35).

Each fifteen minute segment of Musak®'s programming contains five or six recordings that have been analysed to give a "stimulus value", each value being "based on a set of numerical values derived from such variables as tempo, rhythm, instrumentation and size of orchestra" (35). The average stimulus value increases gradually over the fifteen minute period and is followed by a short period of silence because Musak® have found that constant sound can induce fatigue.

The purpose of presenting Musak® and its predecessors here is not solely used to justify the possible application of generative music systems in similar and other environments. Its presence is also used to illustrate that a generative music system could bring even greater benefits to the end user by delivering music in a more effective and organic way than a Musak®-type system could. The linear nature of the Musak® system means that it is unable to change the characteristics of the music it plays in real-time in the same way that a generative music system could because of its inability to take into account changes in the end user's environment such as fluctuations in room temperature, brightness, ambient noise and the number of people in a room.

5. Pay per Play

The delivery of algorithms, whether as the programme itself or separate files enhancing the function of the generative music system, and the payment thereof are important factors when considering the proliferation of generative music systems.

When looking for a model on which to base a delivery and performance accounting structure for generative music systems traditional music industry organisations do not provide very good examples. Both PPL and PRS, for example, have been lacklustre in their efforts to embrace advances in technology in order to create systems that can identify individual public performances of works by their members, preferring instead to refer to other data such as chart information to help them allocate license revenue. The consequence of this is that many members of PPL and PRS fail to receive royalties to which they are entitled.

Instead it may be necessary to turn to the mobile communications industry for a more suitable model. Here many products can now be delivered to mobile phones and other mobile devices. These, of course, include ringtones, trutones, pictures games, music, and videos both as downloads and together with television, streamed live. Payment methods include “pay as you go” or monthly with itemised bills delivered to your door. The development of a similar system could enable the passage of algorithms to be tracked around a network of generative music systems allowing a more accurate and reliable distribution of royalties.

6. A Crack in Ivory Towers?

In the UK, and in fact anywhere else, non-copyright works cannot be licensed. Copyright and the ownership of copyright are the essential building blocks of the music industry. A proliferation of sophisticated generative music systems, installed in both public and private places and producing pure generative music, could have a significant impact on various organisations within the music industry with many of them finding it difficult, if not impossible, to function. The immediate impact on PPL, PRS, record companies and music publishers would be a decrease in licensing income for public performance in commercial environments. Other areas that could suffer include licensing revenue collected from “on hold” music services. Record companies, MCPS (Mechanical Copyright Protection Society Ltd) (36) and music publishers would also find revenue from the sale and manufacturing of CDs decreasing as both commercial premises and the music buying public gradually turn to generative music systems. The erosion of MCPS and PRS revenue collected by licensing ringtones may have, in fact, already started because pure generative ringtones are copyright free.

7. Conclusion

The intention of this paper is not to herald the imminent collapse of the music industry due the development and dissemination of generative music systems. Its intention is merely to highlight the advantages that sophisticated generative music systems could have over linear music systems; the absence of copyright in pure generative music and the ability to adapt the music they produce in real-time. Both these advantages could, in time, give generative music systems a real commercial edge over conventional linear music systems enabling music to be delivered more effectively, and with greater benefits to, the end user.

The intention of this paper is neither to de-value the work of generative music composers by suggesting that they now turn their attention to simply designing a newer sort of wallpaper music to adorn the walls of McDonalds, Starbucks and Gap. The development of generative music systems will require the composer to acquire knowledge and skills from other disciplines in order to develop appropriate generative music systems. Nor is it the intention of this paper to proclaim the end of the creation of new music. In fact the generative music systems suggested may even be a catalyst for new works.

There is, however, one important factor that may impede the progress of the dissemination of generative music systems: people. Until people come to realise how generative music systems might benefit themselves and even their businesses, the music industry machine will continue to spoon feed the majority of the population with the manufactured, publicity and marketing led music it believes they demand.

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Using 3D Virtual Models in Civil Engineering Training: Interacting with the Construction Processes

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Abstract

The use of virtual reality techniques in the development of educational applications brings new perspectives to the teaching of subjects related to the field of civil construction in Civil Engineering domain. In order to obtain models, which would be able to visually simulate the construction process of two types of construction work, the research turned to the techniques of geometric modelling and virtual reality. The applications developed for this purpose are concerned with the construction of a cavity wall and a bridge. These models make it possible to view the physical evolution of the work, to follow the planned construction sequence and to visualize details of the form of every component of the works. They also support the study of the type and method of operation of the equipment necessary for these construction procedures. These models have been used to distinct advantage as educational aids in first-degree courses in Civil Engineering.

1. Introduction

Normally, three-dimensional geometric models, which are used to present architectural and engineering works, show only their final form, not allowing the observation of their physical evolution. In the present study, two engineering construction work models were created, from which it was possible to obtain three-dimensional (3D) models corresponding to different states of their form, simulating distinct stages in their construction. The use of techniques of virtual reality in the development of these educational applications brings new perspectives to the teaching of subjects in the area of civil engineering. The work described here makes up part of two on-going research projects at ICIST: Automatically generating model of the graphic representation of bridges [1], A. Zita Sampaio (main research) and Virtual reality in optimisation of construction project planning [2], Pedro G. Henriques (coordinator).

The visual simulation of the construction process needs to be able to produce changes to the geometry of the project dynamically. It is then important to extend the usefulness of design information to the construction planning and construction phases. The integration of geometrical representations of the building together with scheduling data is the basis of 4D (3D + time) models in construction domain. 4D models combine 3D models with the project timeline [3]. 4D-CAD models are being used more and more frequently to visualize the transformation of space over time. To date, these models are mostly purely visual models. On a construction project, a 4D-CAD environment enabled the team, involved in the project, to visualize the relationships between time (construction activities) and space (3D model of the project) [4].

In order to create models, which could visually simulate the construction process, the authors turned to techniques of geometric modelling and virtual reality (VR). The applications developed for this purpose refer to the construction of a masonry cavity wall and a bridge. These models make it possible to show the physical evolution of the work, the monitoring of the planned construction sequence, and the visualization of details of the form of every component of each construction. They also assist the study of the type and method of operation of the equipment necessary for these construction procedures. The virtual model can be manipulated interactively allowing the user to monitor the physical evolution of the work.

One of the applications developed corresponds to the model of a masonry cavity wall, one of the basic components of a standard construction. To enable the visual simulation of the construction of the wall, the geometric model generated is composed of a set of elements, each representing one component of the construction. Using a system of virtual reality technologies, specific properties appropriate to the virtual environment are applied to the model of the wall. Through direct interaction with the model, it is possible both to monitor the progress of the construction process of the wall and to access information relating to each element, namely, its composition and the phase of execution or assembly of the actual work, and compare it with the planned schedule. This model had been used to distinct advantage as an educational aid in Civil Engineering degree course modules.

The second model created allows the visual simulation of the construction of a bridge using the cantilever method. The geometric model of the bridge deck was created through a bridge deck modelling system. A system of virtual reality was used to program the visual simulation of the bridge construction activities. Students are able to interact with the model dictating the rhythm of the process, which allows them to observe details of the advanced equipment and of the elements of the bridge. The sequence is defined according to the norms of planning in this type of work. The aim of the practical application of the virtual model of bridge construction is to provide support in those disciplines relating to bridges and construction process both in classroom-based education and in distance learning based on e-learning technology.

2. Case study 1: Construction of a masonry cavity wall

Described here are the processes both of the modelling of an exterior wall of a standard building and of the association of virtual properties with the created model, the intended outcome being the interactive exhibition of its construction [5]. The model of the masonry cavity wall, including the structure of the surrounding reinforced concrete and the elements in the hollow area (bay elements), was created using a three dimensional graphic modelling system in widespread use in planning offices, namely, AutoCAD. The virtual environment was applied to the model through the computer system EON Studio [6].

2.1 Geometric modeling of the wall’s elements

The representation of this model of an exterior wall of a conventional building comprises the structural elements (foundations, columns and beams), the vertical filler panels and two bay elements (door and window). The structural elements of the model were created with parallelepipeds and were connected according to their usual placement in building works. Because this is an educational model, the steel reinforcements were also defined. In the model, the rods of each reinforcement are shown as tubular components with circular cross-section (Figure 1).

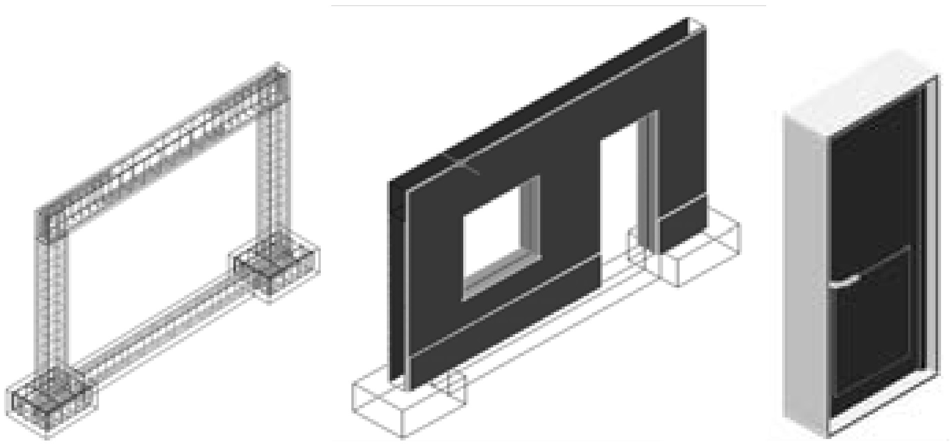


Figure 1: Phases in modelling the masonry wall

The type of masonry selected corresponds to an external wall formed by a double panel of breezeblocks, 11 cm, wide with an air cavity, 6 cm, wide (Figure 1). Complementary to this, the vertical panels were modelled, these comprising: the thermal isolation plate placed between the brick panels, the plaster applied to the external surface of the wall, the stucco applied on the internal surface, two coats of paint both inside and out and the stone slabs placed on the exterior surface. Finally, two usual bay elements (Figure 1), a door and a window, were modelled. The completed model was then transferred to the virtual reality system EON (as a 3ds drawing file).

2.2 Definition of the virtual environment in the evolution of a construction

Figure 2 presents the main window of the EON system. The sub-window to the left contains a table of nodes or actions (of movement, sensors etc) available in this system. The centre sub-window is designated a simulation tree: the objects making up a given scenario are presented in it, and the links between each object or group and the actions to be taken associated to each of them are also shown. It is therefore, through the use of this window that the simulation of the desired virtual action is programmed. In the sub-window on the right the links between the various nodes are established thus defining a network. In this network the nodes where the links originate and terminate are identified, as is the means of setting each action in motion.

In this system, the visual simulation of the building process of the wall, following a particular plan, was programmed. For this effect, 23 phases of construction were considered. The order in which components are consecutively exhibited and incorporated into the virtual model, translates into the method of the physical evolution of the wall under construction.

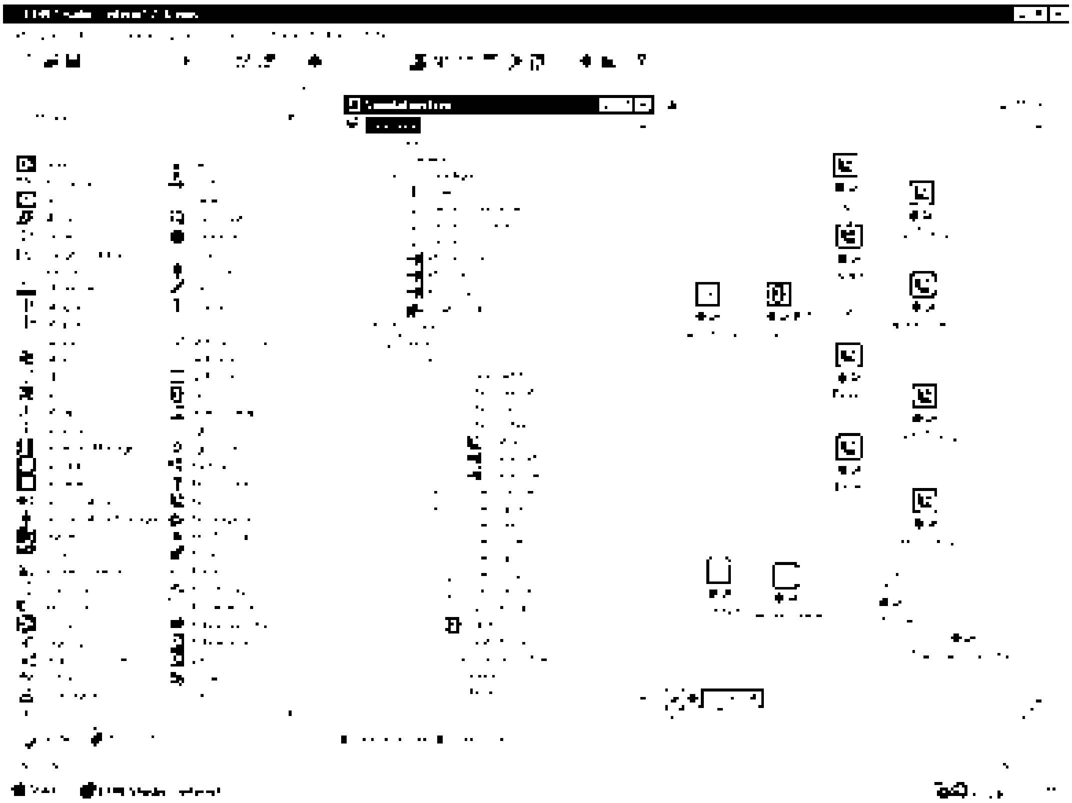


Figure 2: The main window of the EON Studio system

During the animation, the student can control the length of time that any phase is exhibited and observe the model using the most suitable camera and zoom positions for a correct perception of the details of construction elements. It is possible to highlight the component incorporated at each new phase and to examine it in detail (Figure 3).

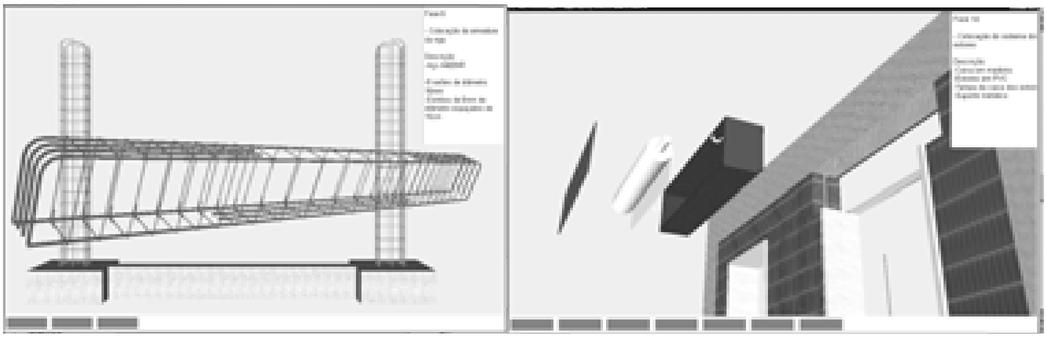
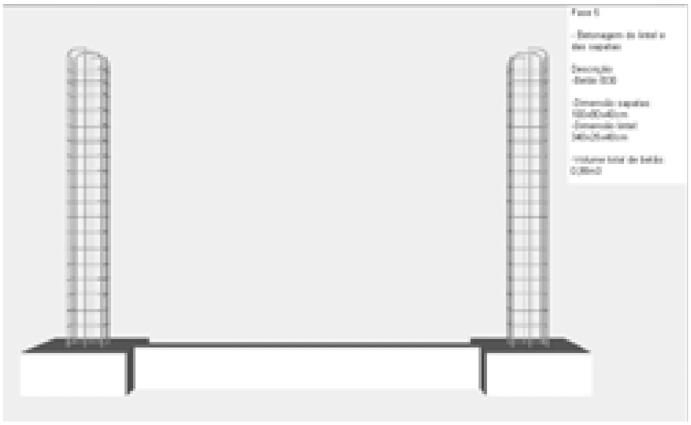


Figure 3: Exhibition of phases in building evolution.

Included, under the window in which the virtual scene is exhibited, is a bar, which shows the progress of the construction. Throughout the animation, the bar is filled, progressively, with small rectangles symbolizing the percentage built at the time of the viewing of that particular phase, in relation to the completed wall construction (Figure 3).

Simultaneously, with the visualization of each phase, a text is shown (in the upper right corner of the window, Figure 4) giving data relating to the stage being shown, namely, its position within the construction sequence, the description of the activity and the characterization of the material of the component being incorporated.



Phase 5
Cementing the lintel and foundation
Description:
Cement B30
Dimension of the foundations: 100x80x40cm3
Dimensions of the lintel cross section:

Figure 4: Presentation of text describing the exhibited phase.

3. Case study 2: Construction of a bridge deck

Throughout the bridge research project, a system of computer graphics was used, a system that enables the geometric modelling of a bridge deck of box girder typology [1]. This system was used to generate, 3D models of deck segments necessary for the visual simulation of the construction of the bridge [7]. In addition to the 3D model of each segment, models of the pillars, form travellers, abutments and false work were made. The attribution of virtual properties to the model of the bridge was implemented by using the EON Studio.

The North Viaduct of the Quinta Bridge [8] in Madeira, Portugal, was the case selected for representation in the virtual environment. In cross-section, the deck of the viaduct shows a box girder solution and its height varies parabolically along its three spans. The most common construction technique for this typology is the cantilever method of deck construction. This method starts by applying concrete to a first segment on each pillar, the segment being long enough to install on it the work equipment. The construction of the deck proceeds with the symmetrical positioning of the segments starting from each pillar. The continuation of the deck, uniting the cantilever spans, is completed with the positioning of the closing segment.

3.1 Modeling the elements of the construction scenario

The spans were created through the use of the representational system for bridges mentioned above. Geometric description can be entered directly into the deck-modelling program. To achieve this, the developed interface presents diagrams linked to parameters of the dimensions, so facilitating the description of the geometry established for each concrete case of the deck. The image included in Figure 5 shows the interface corresponding to the cross-section of the deck of the example.

The description of the longitudinal morphology of the deck and the geometry of the delineation of the service road, serving the zone where the bridge is to be built is carried out in the same way. The configuration and the spatial positioning of each are obtained with a high degree of accuracy. Using the data relating to the generated sections, the system creates drawings and 3D models of the deck. To obtain the definition of the deck segment models, consecutive sections corresponding to the construction joints are used. The configuration presented by the segment models is rigorously exact. Figure 5 shows one of the segments of the deck.

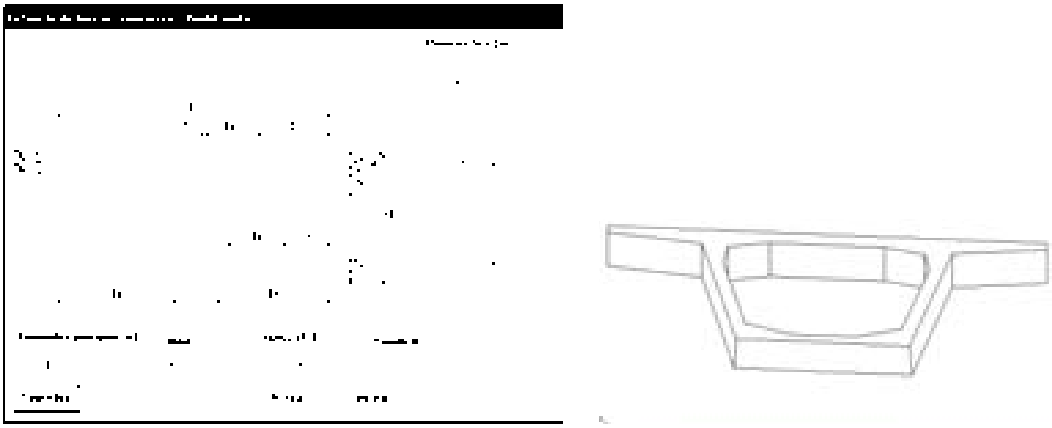


Figure 5: Interface of the description of the cross-section of the deck and the projection of the model of one of the segments.

To complete the model of the bridge, the pillars and abutments were modelled using the AutoCAD system. Based on research in the literature concerning abutments for the typology of box-girder decks, a model was created as shown in Figure 6. Then followed the modelling of the advanced equipment, which is composed not only of the form traveller, but also the formwork adaptable to the size of each segment, the work platforms for each formwork and the rails along which the carriages run (Figure 6).

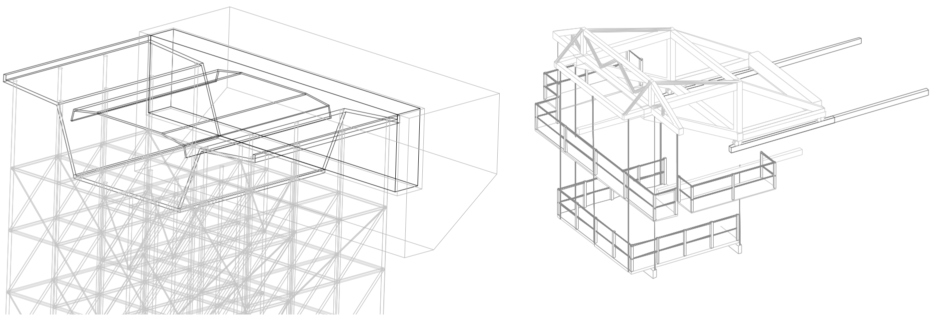


Figure 6: 3D models of the abutments, false work, scaffolding and advanced equipment.

As, along with the abutments, the deck is concreted with the false work on the ground, the scaffolding for placement at each end of the deck was also modelled (Figure 6). Terrain suitable for the simulation of the positioning of the bridge on its foundations was also modelled.

3.2 Programming the virtual construction animation

Once all the 3D models of the construction scenario had been generated, they were transposed, in 3ds data file format, to the virtual reality system. The definition of the construction sequence is based on a counter, which determines the next action when a mouse button is clicked. This connection is prescribed through a network of connections.

The first action consists of the insertion of the pillars in the initial scenario, which is composed solely of the landscape. The next step is to place one of the segments on top of each of the pillars (Figure 7). After this, a form traveller is placed on each segment. For the simulation of the first cantilever segment (in each span), the four form travellers, the corresponding work platforms and the formwork components are included in the scenario (Figure 7).

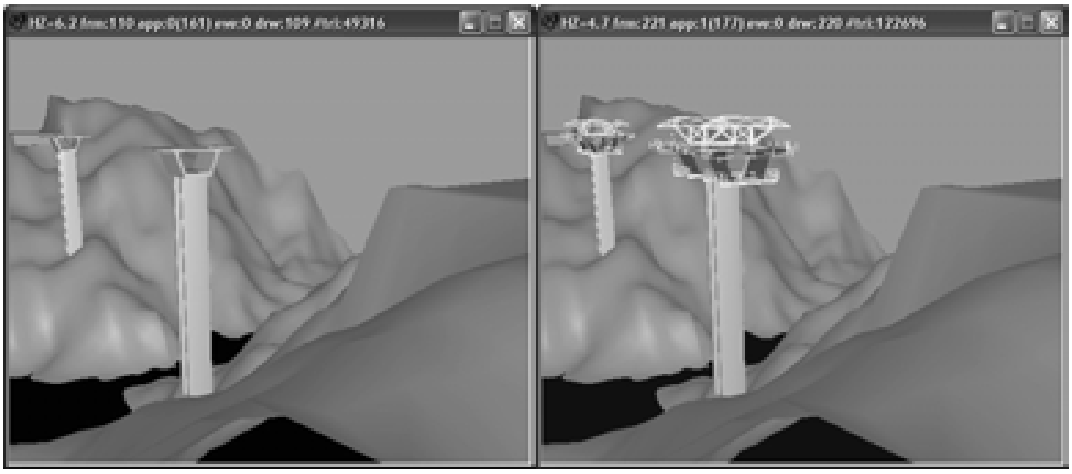


Figure 7: Placing the initial pillars and segments and the advanced equipment.

Once the first segments have been concreted, the construction of the cantilevered deck takes place. The construction of the deck is defined symmetrically in relation to each pillar and simultaneously. In each phase, two pairs of segments are defined. For each new segment the following steps are established: raising the form traveller; moving the rails in the same direction as the construction (relocating them on the latest segment to have been concreted); moving the form traveller on the rails, positioning it in the zone of the next segment to be made; concrete the segment (Figure 8). The user can observe all these stages. Finally, the zone of the deck near the supports is constructed, the false work resting on the ground (Figure 8).

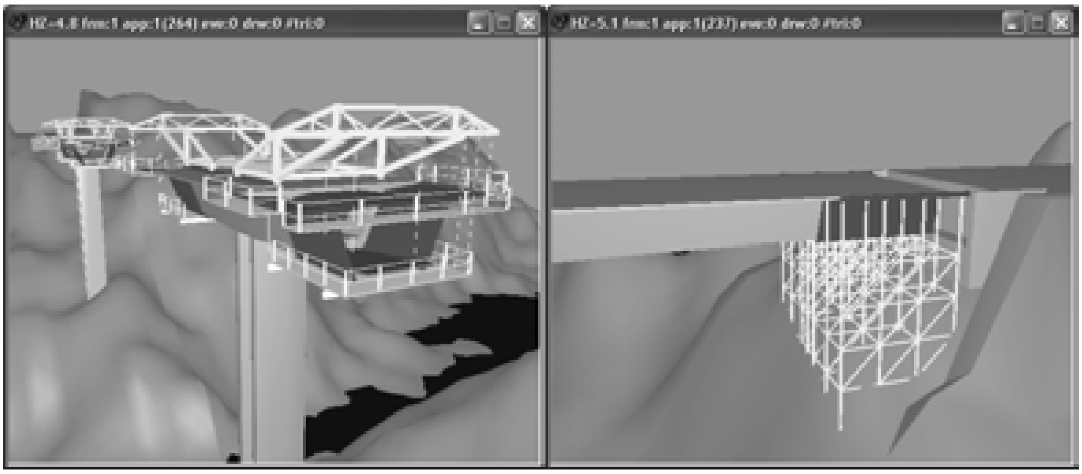


Figure 8: Movement of the advanced equipment and concreting above the false work near the abutment.

Moving the camera closer to the model of the bridge and applying to it routes around the zone of interest, it is possible to visualize the details of the form of the components involved in the construction process. In this way, the student can interact with the virtual model, following the sequence specifications and observing the details of the configurations of the elements involved.

4. Learning aspects

The models are actually used in face-to-face classes of disciplines of Civil Engineering curriculum: Technical Drawing (1st year), Construction Process (4th year) and Bridges (5th year). The teacher interacts with the model showing the sequence construction and the constitution of the modelled building element.

As in Technical Drawing, students have to define and represent structural plants using architectural layouts, they better understand the relations between the architectural configurations and the structural elements in a building, following the exhibition of the wall's construction. In Construction Process and Bridges, in order to prepare students to visit real work places, the teacher shows the construction animation and explains some aspects of the construction process of the wall or the bridge that in the work place they are going to see.

Essentially, the models are used to introduce new subjects. The students reflected on their evaluation works a better understanding of subjects concerning structures, bridges and construction. For instance, in a structural plant the representation of columns and beams is now better aligned. Or, the students' reports concerning visits at work places include now some aspects shown in the virtual models.

The students can also interact with those models. For that, the models were posted on the Internet pages of undergraduate Civil Engineering. The student will be able to interact with the application EonX, which can be accessed at http://download. eonreality.com.

5. Conclusions

It has been demonstrated, through the examples presented here, how the technology of virtual reality can be used in the elaboration of teaching material of educational interest in the area of construction processes.

The models generated represent building in two standard situations. The student can interact with the virtual model in such a way that he can set in motion the construction sequence demanded by actual construction work, observe the methodology applied, analyse in detail every component of the work and the equipment needed to support the construction process and observe how the different pieces of a construction element mesh with each other and become incorporated into the model.

These models are used in disciplines involving construction in courses in Civil Engineering and Architecture administered by the Higher Technical Institute of the University of Lisbon. They can be used in classroom-based education and in distance learning supported by e-learning technology.

6. Acknowledgements

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Generative Design in Architecture and Mass-Customization

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Abstract

In this study, the generative design in housing is characterized through the utilization of shape grammars. The functions and the relations within a chosen housing typology are described and different types are produced through the defined relations. Three main constraints are the number of inhabitants (room numbers and sizes), the number of storeys and the main module. In this case, cube is selected as the main module. Mardin is selected as a region to be focused on because of its grammatical housing morphology. Different colors are given to different functions; kitchens, living spaces, rooms, bathrooms, semi-open spaces and open spaces. Different types and variations are produced computationally, and by using this method, it is aimed to integrate the customers to the generative design process. This method is likely to emphasize variation and personalization and make a start to mass customization.

1. Introduction

“Generative design is a design methodology that differs from other approaches insofar that during the design process the designer does not interact with materials and products in a direct (“hands-on”) way but via a generative system.” [1] In this study generative design is used via shape grammars. Shape grammars are generative grammars which new shapes can be created by an initial shape, shape elements and production rules. [2] New shapes are generated using production rule or rules. Analyzing a house typology through shape grammars is also reasonable as well as generating new ones similar to Birgul Colakoglu’s dissertation for “hayat” houses. [3]

Parallel grammars are also used in which two or more grammars work together simultaneously. [4] Jose P. Duarté’s study for Malagueria Houses is one of the examples of parallel grammar. [5] In Malagueria Houses Duarté used Alvaro Siza Vieria’s grammar and new grammar together. Another property of this study is using mass customization and computation.

Mass customization and mass personalization is based on the variations of a design while mass production is built on the idea of serial repetitions in order to decrease the cost. In the twentieth and twenty-first century the paradigm shifts from mass production to mass customization by the help and development of digital technologies. Mass customization becomes one of the most “popular” methods in decreasing the cost. Variations are used instead of repetitions and different types within a language are created. The places, that have repetitive functions like houses, dormitories, offices etc., can be mass customized.

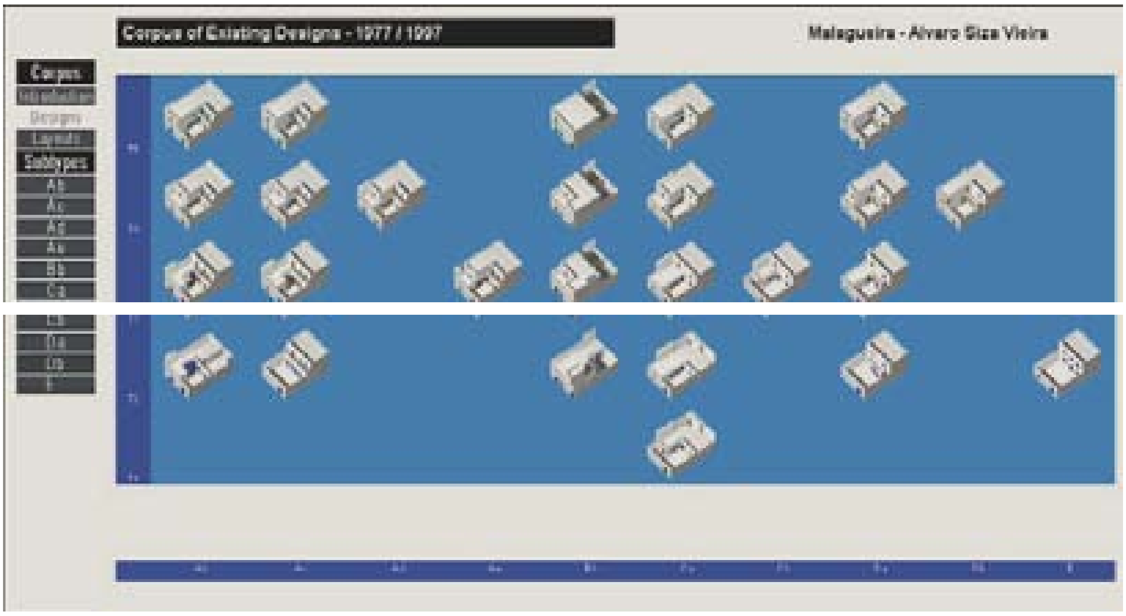


Figure 1 - Jose P. Duarté - Malagueria Housing

2. Mardin Grammar and housing

In this study generative design method of shape grammar is utilized for housing design. Mardin, having a grammatical architecture in original is chosen as case study for this project. The study is based on Prof. Fusun Alioglu’s dissertation on Mardin houses [6] and Hakan Ozbek’s master thesis on shape grammatical analysis of Mardin morphology. [7]

Mardin is a city in the south eastern region of Turkey. The old city is located on a sloping terrain looking towards the Mesopotamian Plain. Semi-open spaces “eyvan” and “revak” have developed under the effect of climate and play an important role in the perception of the city. The open spaces like courtyards, gardens, terraces and streets enclosed by walls give the void effect. The scenery of Mesopotamian Plain and the orientation play an important role in the configuration of these units. The places cause different effects according to their inclinations and location.

The morphology of the city is composed of units and their repetitions. The units are approximately 4m*4m (~13ft*13ft) because of the constraints of the masonry building system. All buildings with different functionalities have similar properties, so it is difficult to perceive the function in the general structure. Religious buildings or educational buildings are all composed of basic units.

Another important point is that the morphology of Mardin has evolved in time; developing according to the needs. This formation shows the cultural properties of the city inhabitants.

Figure 2 – Mardin

Crowded large families (adding a unit for the married son and the family expanding), respect (not blocking the view of other houses), conservation (the houses designed such that, terraces of other houses must not be seen) are the main rules for the development of Mardin. Also this formation has developed an organic structure for the city.

The main module -a cube- is one of the constraints, which is derived from the city morphology. Consecutively the number of the rooms, the inhabitants, the storeys will be considered. Large families are common in Mardin, as a result of traditional life-style of the city dwellers. As for the houses that are located on a slope, two or three storied houses are the most common type. Thus are the main limitations for the preliminary design described. However these limitations can be altered during the process, according to the outcome.

3. The Generation

The shape grammatical rules in Hakan Ozbek's thesis are the general rules of Mardin. These rules describe the relations between open (yards and terraces), semi-open (eyvan and revak) and closed spaces. They also describe their relations in the third dimension in related to stairs and stair types. The stairs are important elements because they connect different types of spaces with each other according to the needs.

These rules are function free rules. They are the main rules of Mardin morphology. In a specialized project like housing, new rules must be added. Mardin is on a sloping terrain so the number of stories is selected as two or three. Functions, accepted as additional constraint, are given different colors. Kitchens, living rooms, bedrooms, guestrooms and bathrooms are all given a different coloring. The functional relations are also described without undervaluing the grammatical rules. The shared places like kitchens and living rooms are in the first story, while bedrooms and personal places are in the second and third stories with a semi-open space.

Figure 3 – Legend

The number of people and room numbers are another main constraint for the generation. It is selected as four to eight people in the early generations. Room numbers can vary from two (for parents and two children) to eight (for parents, six children and a guest room).

Basic module	Cube - 4m*4m
Number of storeys	2-3
Number of people	4-8 (Room number: 2-8)

First generations constraints

The generations are made in 3dsMax environment by scripting. In the first generations, abstract models are generated. The two or three storied houses four various number of people with the functional relations and grammatical rules of Mardin are generated. "Random" is also used.

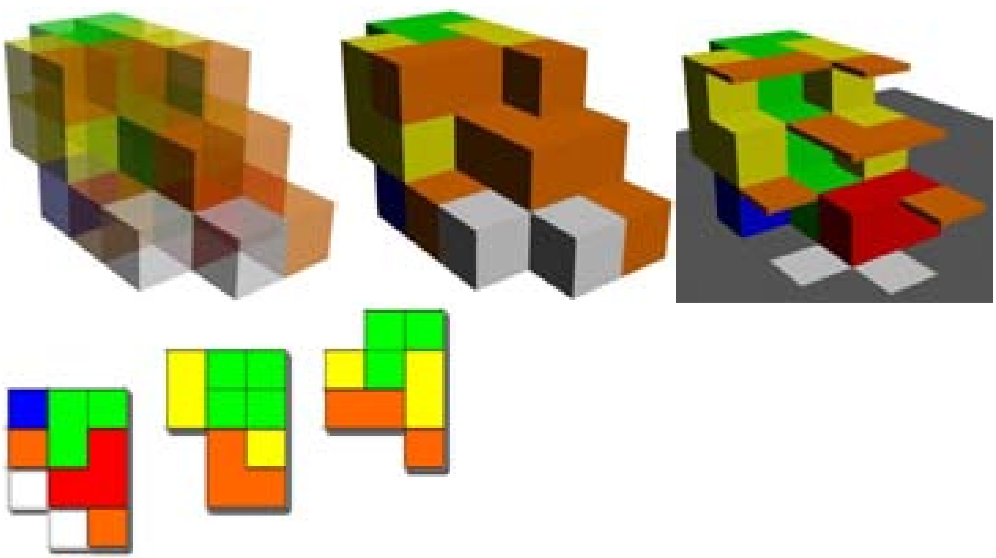
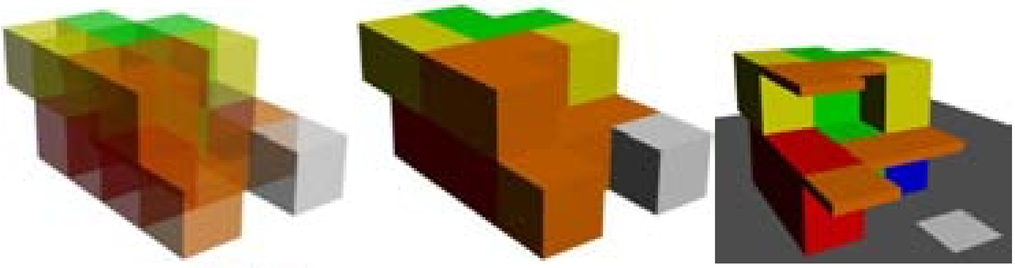


Figure 4 - A1/Three story building



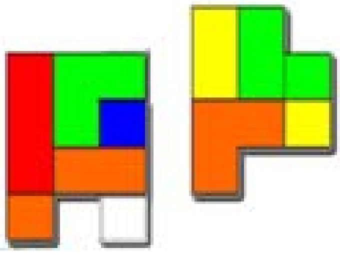


Figure 5 - C3/Two story building

After generating abstract models, plan types for each function are designed so that the abstract cubes can be solidified. For each function various plan types are designed. The plans can be selected individually or can randomly be placed. It is also possible to improve or change the plans.

4. Integrating Customers:

All abstract generations are done by the scripts which are written according to the constraints, limitations and assumed initial conditions. Later, when transforming the abstract design to a solid form, the abovementioned plans are also taken into consideration and used as parameters in the generation phase.

Integration of customers to the project is provided with an interface for this script. Via this interface, the customer is allowed to enter the parameters like the number of stories, number of people the house is expected to accommodate or the room numbers. Thus ultimate customization is permitted. With the help of this interface and the designer working with the customer, the abstract models or the solid project can be derived in the digital environment at minimum time and financial cost. It is possible to generate different variations with the same limitations. So alternatives can be generated.

After generating the houses or after selecting from the generations, modifications and manipulations can de done. Also with changing limitations and varying the initials new forms can be sought.

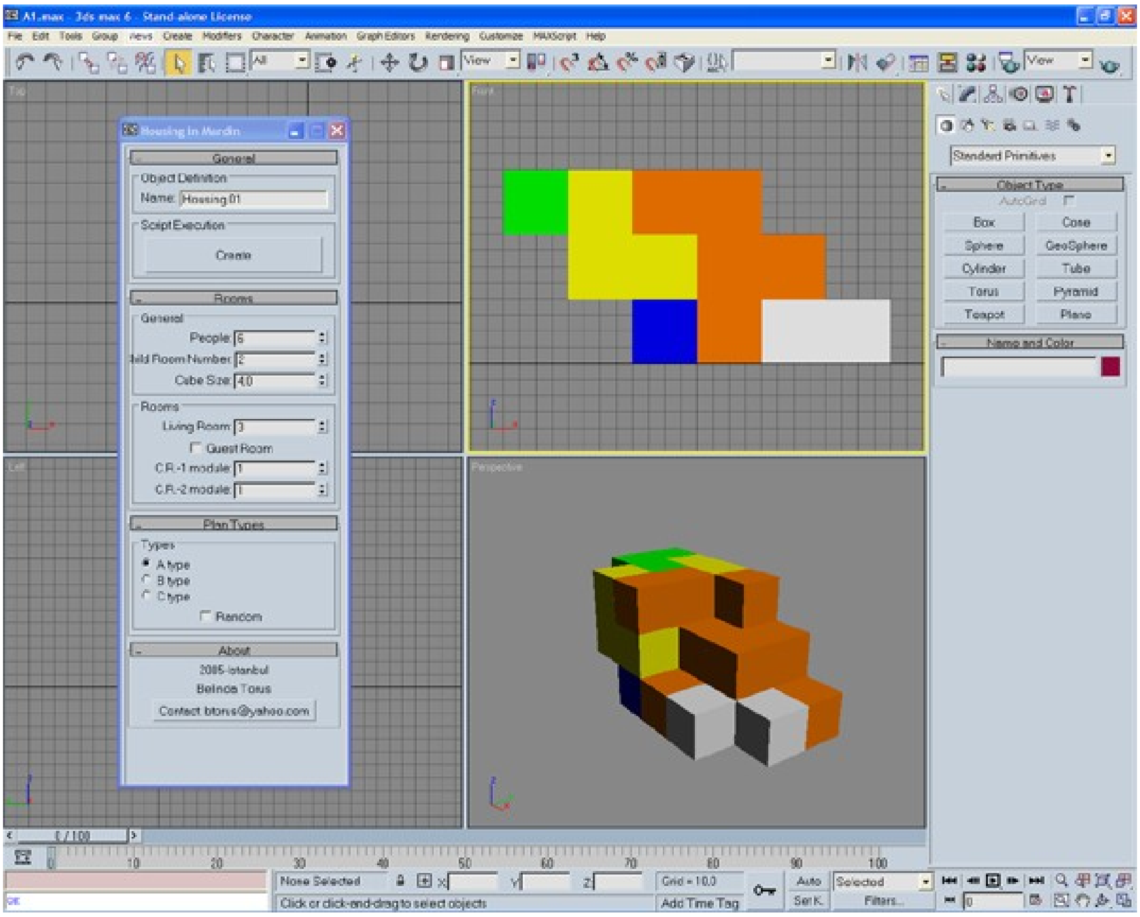


Figure 6 – Interface on 3dsMax

5. Conclusion

This study is the first step of an ongoing project in which generative design method and mass customization techniques will be explored for housing design. In this first section, solutions for housing for four to eight people in houses that have two or three stories is sought. Then with the shape grammatical rules of Hakan Ozbek's master thesis and some newly defined rules, abstract generations and variations are made. By designing plan types for each function, the generations are solidified. New models and alternatives within the same language are explored.

In the second section, the customer demands are integrated to the design process with the help of the script interface. The next step in the project will be seeking housing typologies for different numbers of people, stories, basic modules and plan types in the limits of Mardin grammar. The aim is to integrate it with the script in order to support mass customization.

More details can be added to the scripts and generations, like the window types and sizes, the wall endings, and the orientations. The script and interface can be improved by these details or according to the needs of the customers by the feedbacks from the customers.

6. Acknowledgement

I'd like to acknowledge and thank the academic and research stuff in Design and Computation Unit in Yildiz Technical University, especially my supervisor Assist. Prof. Birgul Colakoglu.

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Generating Artworks Using Previous Created Image as Coloring Palette

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Abstract

The image is one of the most frequent results of any computer method dealing with artificial creativity. The result of the generative art approach used in architecture, industrial design or art is an image on the screen with its form and color properties. The role of the color is important especially in the area of visual art. The artist influence on computer generated artwork could be within the range of values from zero to one. Low influence level requires the use of computational methods to define basic elements of an artwork. To define the colors of a picture, a large number of coloring methods are used and one of the most frequent is to apply a color map or color palette. To use a previous generated image as a coloring palette could be one of non-usual approaches in the field of art.

In the beginning of the paper some basic information about color systems and coloring algorithms are presented. Then it follows a short description of the program, which was developed with the intention to realize the basic idea of the paper with the accents to its main properties. The experiment results are described in five cases with image-palette used and selected examples of generated images. In the end there are gathered some statement concerning the relationship between the calculating algorithm and outside coloring palette and their influence over the generated artwork.

1. Introduction

Generative art as the creative method offers different approaches how to realize the basic mission of the idea of artificial creativity. The program code as the human creation, which causes the process resulting in a machine creation is the most important element of the generative method. Different coding types enable different processes and different results. One point of view could be the range of human intervention from outside during the process, which defines the interactivity level of the program. In this case the user of the program could have high influence to the final result. The next point of view is predetermination of generated results and in this case the pragmatic or algorithmic programming approach is discussed. The pragmatic concept is much more useful in the area of industrial design or architecture where the author of the program has very precise idea of the artificial object which could be produced. In this case the process has the task to find the best variation of the previous ideated result. The algorithmic concept leaves much more freedom to the machine and is usually time depending. Absolutely unpredictable results could be use only as artwork applying serious selection. In the case of artwork production the very important part of the program code is coloring algorithm. Very often authors use their own algorithms to define the color of the pixel as the final result of the basic program cycle. The purpose of this paper is to analyze all coloring possibilities and to make the comparison between them and the idea of using an image as the coloring palette.

2. Color systems overview

Since computers were able to produce color output the graphic software development has increased extremely. Nowadays the SW market offers a huge of graphic programs for design and artwork production. To use all these wonderful tools or even to develop ones own programs it is necessary to know and to understand color as natural phenomena and color as coding systems, which could be used to create graphic outputs.

Color is all around us, and the world without color would be a much less beautiful. Visible light spectrum is only a small portion of the electromagnetic energy spectrum. At one end of the visible spectrum there is red and at the other there is blue color. All the other are somewhere along the spectrum between blue and red [1]. In the middle of the spectrum there is green color. Those three colors (red, green, blue or RGB) are the predominant colors called primary colors. By mixing pairs of primary colors we get cyan, magenta and yellow (CMYK) as secondary colors. The last "K" means black as the mixture of cyan, magenta and yellow.

RGB is additive color system that means producing color by mixing light (screen case). CMYK is subtractive color system that means to produce color by mixing paint (printer case). To use colors inside programs is absolutely necessary to know colors code system. RGB code has three component values from 0 to 255. The next is hexadecimal color code system which is derived from RGB system and is used in HTML programming. Both systems, RGB and hexadecimal, can display 16.7 million different colors depending of the capability of used computer HW and SW platform. One of the possibility to see the comparison between mentioned code system, is to visit Visibone web page where are beside the color name, listed values for RGB, CMYK and hexadecimal systems for selected color [2].

Some color codes overview for programming use:

QBCOLOR: one-argument VB function which displays 15 different colors (values from 0 to 15)

RGB color code: three-argument VB function for red, green and blue (values from 0 to 255)

VB color code: one-argument function (values from 0 to 16.777.215)

HEX color code (HTML code): RGB components expressed by hexadecimal numbers (values form 000000 to FFFFFF)

The conversion from one color code to another is often used programming routine.

3. Coloring algorithms

The mode how to define the color of the pixel is the most important phase inside the process of image generating. Within the algorithmic approach usually the image form is not defined inside the program code but it is consequence of the pixel color combination. This is the reason that is nearly impossible to predict the image type before the first successful run of the algorithm. The pixel color is the result of less or more complex mathematical calculus called coloring algorithm or coloring formulas. By the time some typical methods has been discovered such as iteration systems, strange attractors concept, recursion mode and iteration of complex polynomials [3]. The iteration of complex polynomials has been widely experimented by the fractal art community. Any author can experiment with his own mathematical formulas and procedures to obtain his personal art style.

Technically there are two different types of coloring formulas: index based and direct coloring formulas. Index based coloring formulas return a floating-point number, which acts as an index into the color map or color palette and the color is not specified directly. The color map could be created inside the program or could be imported from outside. Direct coloring formulas calculate the color for each pixel directly [4]. In this case the coloring algorithm produces a single value for each pixel. Since color is a three-component item, this one-dimensional value must be expanded into three values using additional mathematical calculus.

As mentioned before the great part of researches and experiments of coloring algorithms use, has been done by authors of fractal programs. The most known and used is the escape-time algorithm, which is often the only option available in some fractal generators [5]. Its simplicity makes it a favorite for those who learn to develop fractal software. The algorithm itself is based on the number of iterations necessary to determine whether the orbit sequence tends to infinity or not. When the orbit of any value of complex number set exceeds a defined border region, it always diverged towards infinity. If the orbit sequence is stopped as soon as iterated number is outside the border region, then the coloring value for the escape-time algorithm is simply the number of iterations. In the case when iterated number converges the coloring value for the escape-time algorithm is the maximum of iterations defined in the program loop. Integer value as the number of iterations produces a banding effect similar to contour lines of topographic survey maps. So the artists have explored algorithms to hide this effect by using continuous coloring algorithms. To get more complex results is possible to use different region shapes, so called orbit traps. Many authors have created their own collections of coloring algorithms using traps as circles, ellipses, triangles, stars, squares and other geometrical shapes [6].

4. Program description

To present and realize the idea of using previous generated image as coloring palette I have developed an experimental program. It is about 70 KB, object oriented Visual Basic exe including presentation and demonstration part. The presentation part uses slide concept with some examples of created images attached. The demonstration part makes possible a real-time image generation using the basic idea of the present paper with short explanation of the procedure. The main concept of the program is to apply multilevel deformation of basic Mandelbrot fractal calculus using outside coloring palette.

The first level of fractal calculus deformation could be expressed with equation:

$z(n) = z(n+1)^2 + c * def1$

$def1 = F(zi,zr,ci,cr,r1,r2,r3,n1)$

where

zi, zr, ci, cr are current values of real and imaginary components

r1, r2, r3 are current distances between actual pixel and previous defined points

n1 is actual iteration value

The second deformation level is applied after getting the escape value of current pixel:

$n = n * def2$

$def2 = F(n,r1,r2,r3,rmax)$

where

n is final iteration value for current pixel

r1, r2, r3 are current distances between actual pixel and previous defined points

rmax is the distance between actual pixel and the most distant point

In the both cases for the function F, different mathematical expressions and trigonometric functions are used besides some random factors defined for the actual program cycle. Value n defines the position on the outside palette - previous generated image - from where the color of actual pixel is picked up. To get more complex results the value n could define the point on the line, sine curve, circle, spiral, or other curve. For this experiment I chose the sine curve with vertical-horizontal option as the color pick-up region.

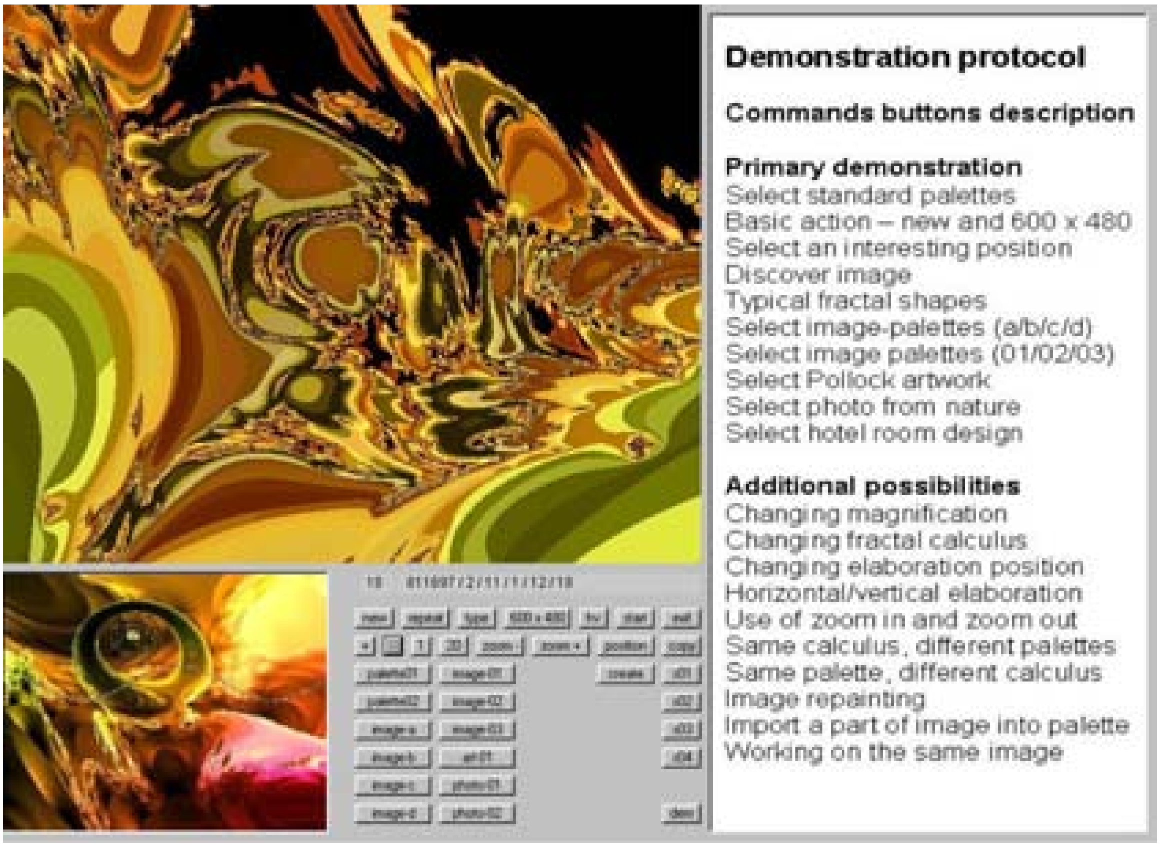


Figure 01

Program window is designed for the resolution 1024 x 768. The upper left corner is designed for the new image in two dimensions. The purpose of the lowest one is to select a good example, the highest one is an extend version of chosen image. Lower part of the screen is designed for image-palette and different command buttons (new image, image-palette selection, change magnification, etc). For the presentation version of the program, the right side of the screen is designed for short explanation of the approach. On the figure 01 there is screenshot of the program window.

Here are listed the main possibilities of the demonstration part of the program:

Selection of image-palette

Selection of the magnification factor

Selection of horizontal/vertical palette elaboration

Selection of fractal calculus type

Start of new creative cycle and repeat the action until good example

Open selected example in large window

Discover actual image changing position and magnification

Repeat the whole cycle using the same image (the same calculation)

Zoom-in and zoom-out in the image central position

Change the position of palette elaboration

Change image-palette within the same cycle

Recreate actual image using an other palette

Cut a part of actual image and past it into palette

Generate new palette in real time

For the experiment I chose five palette groups:

Standard coloring palette (two images with different gradients type)

Computer generated image – old: (four examples created some years ago)

Computer generated image – new: (three examples from recent time)

World known artwork: (Jackson Pollock – name, year)

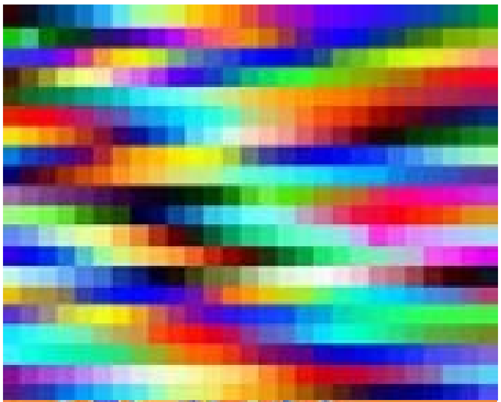
Photography: (nature and interior hotel room design)

The use of the program is simple on account of the friendly command interface (buttons with described actions) and of the short procedure explanation on the right side of the screen. After palette selection the program starts clicking on "new" button and in a small image appears on the upper left corner of the screen. The action has to be repeated until the image seems enough good to continue the experiment. Click on "600 x 480" button opens the same image in larger window. Now is the moment to select an interesting region on the image and click on it. This is the only interactive action, which has significant influence to the upcoming image. Depending on selected palette and magnification a new image appears, which is not at all similar to the previous one. The fractal self-similarity is reduced to minimum because of the use of deformation factors as mentioned above. Discovering action could be repeated until the result gives certain satisfaction in the sense of beauty and aesthetic. Additional possibility is to redesign the existing image using another palette. The results not differ only in colors but in the sense of forms too. To keep the identity of actual image, a part of it could be used as a palette for the next one. In this case the self-similarity is absolutely canceled, the form of the new image differs completely and colors remains the only connection with previous generated image. The whole process could be done with the same combination of mathematical calculus. The results observations confirm the role of coloring palette and its importance in the image creation process. New parameters for the calculation are generated only when the action "new" is applied. At any moment the program makes possible the restart from the beginning applying the same parameters including random generator seed.

5. Presentation of the experiment results

During the development phase of the program and afterwards I have create a great number of examples experimenting with all possible combinations. In this way I have collected a certain number of images based on each image-palette. Treating generated image as a free computer interpretation of image-palette the results based on each palette were most of all very different and far from similarity. The main criteria to make selection for this presentation, was the complexity of forms and colors in one side and aesthetic impression of the image on the other side. In other words, dealing with abstract artworks, the personal feeling could be the unique selection criteria.

Case 1: Standard coloring palette (figure 02) composed of small colored squares generated using simple program developed on purpose. There are different color gradient applied in each row with random colors in columns. Expected result could be mainly non-harmonized colorful image (figure 03).



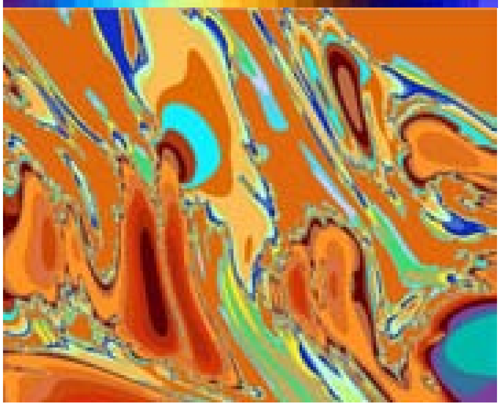
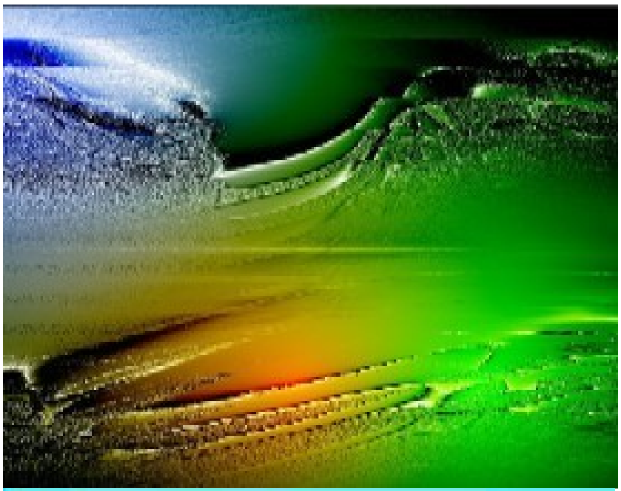


figure 02 figure 03

Case 2: The palette is a computer generated image using program called “Creator”, a summary of algorithms developed in last five years after transition from pragmatic to algorithmic approach (figure 04). The program is based on multilevel coloring routines composed of mathematical equations with no fractal concept use. The resulted image is color harmonized and composition equilibrated (figure 05).



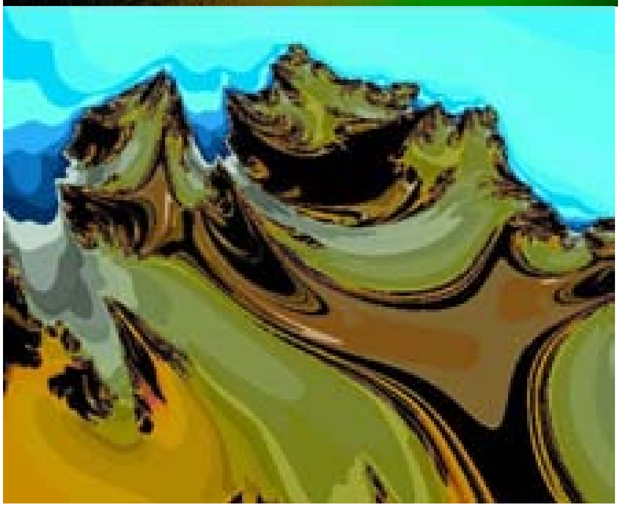


figure 04 figure 05

Case 3: The palette is a computer generated image using recent program based on combination between fractal calculus and previous developed algorithms used as deformation factors (figure 06). Regarding colorful and dynamic palette form, the expected result has to be variegated, but going deeply into image, very harmonized and beautiful areas are found (figure 07).

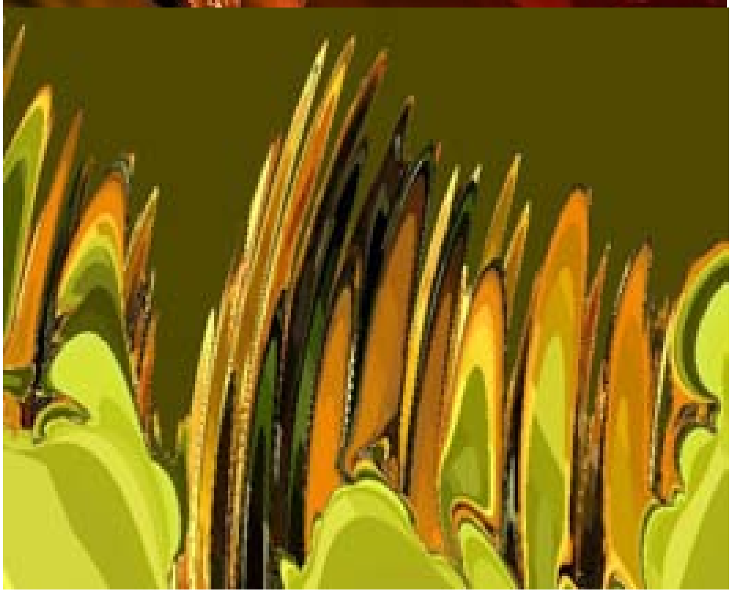


figure 06 figure 07

Case 4: There was a strong temptation to use one world famous artwork as a coloring palette. It was not easy to decide and finally I chose Jackson Pollock and his “The Key” from 1946 (figure 08). In this case I noticed unusual similarity and connection between the palette and the generated image (figure 09). The phenomena could be explained with Pollock art style.

figure 08 figure 09

Case 5: The idea to use an image as coloring palette could work good, when generating pictures for interior decoration use. The architect design of a hotel room or the photography of existing ambient could be enough good to produce abstract ambient-harmonized images which could create a suitable decorative style. The figure 10 represents a hotel room design and figure 11 a generated image which cold be used as a decorative framework.

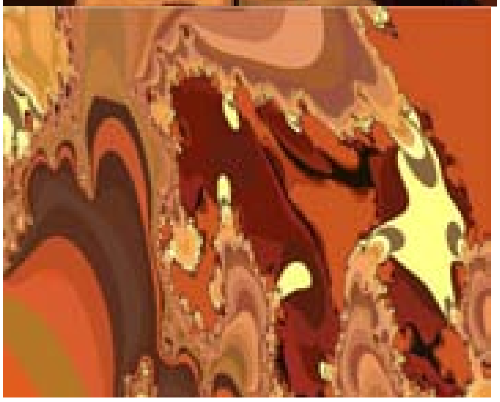


figure 10 figure
11

6. Conclusion

The concept to use a previous generated image as coloring palette confirms some basic facts often discussed in connection with coloring approaches but in the same time it opens some questions about the role of algorithms and color maps or palettes. The experiment described above doesn't reduce the importance of inside or outside coloring palette choice, but gives much more credits to the calculating algorithms. Redrawing an image changing coloring palette shows to the higher level of form-similarity than changing mathematical calculus and using the same palette. An open question is the role of the user of the program having in mention the interactivity of the program indicated by the choice of point of interest. Multilevel deformation of Mandelbrot basic formula causes a law step of self-similarity of the basic image so there are different areas with different form and shape types. To select one type or another (one location or another) could result in and absolutely deferent next-generation image (more orthogonal or more roundly shape elements). Described property makes possible to generated and endless number of very different images "child" out of one "image mother" if it is permitted to use this comparison. Being not absolutely autonomous, the method allows to the user to interact with the process and controlling some significant parameters (research region, palette, magnification) the average number of good results is higher. Discovering to be in a wrong way the user can repeat the process from the beginning using the same parameters. Having in consideration all these possibilities, presented program could become a very powerful tool to produce – generate pictures according to request characteristics. And here is the most important and significant question: “How much the generative process could be controlled to produce optimal results and remains enough generative?”

The research of the concept is still in the beginning but the results analysis has pointed at interesting creative niche inside generative method, which could influence the artificial artwork production in the future. Developing the method until the capability of real image decomposition to create a new one, using complex integration algorithms, cold open a new art paradigm, a free computer interpretation of the real world.

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[6] Collection of Coloring Algorithms, http://www.fractalus.com/fractint/dmj-pub.htm

GENERATIVE ART IN THE CITY

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Abstract:

This paper will consider esthetic issues raised by generative art installations at the Festival Premier Contact, organized in April 2005 by Le CUBE/Art3000 on the outskirts of Paris, France. At a time when coded interfaces have re-structured the relation between author, artwork, spectator and everyday life, we would like to analyze two installations in particular : one using photographic elements (Damaris Risch's « At A Distance ») and another relying on augmented video technology (Vincent Levy's « Ghosts »). Our focus shall be on the emerging role of interactive, generative art –signage in an urban environment.

We shall contrast elements of continuity and discontinuity between 20th century « photographic esthetics » (our term) and coded, "augmented", forms of representation. The status of image is at the center of our analysis, as well as role of the devices used to create both open and autonomous forms of representation. We shall focus on temporality as it relates to scale: programmed behavior in the context of pedestrian flows; opacity and slowness as a form of media identity; and the limits of generativity in a dialogic situation.

Conversations with a billboard

Outstanding examples of generative art work were featured in the « First Contact Festival » (http://www.festival-1ercontact.com/), set up this spring in the streets of the city of Issy-les Moulineaux, a hi-tech suburb of Paris. Organized by LeCUBE/ART3000 (France's largest multimedia art center) the Festival was curated by Florent Aziosmanoff, LeCUBE's Art Director. He selected a dozen artists whose work was framed in outdoor displays placed at strategic intersections of the city.

Each outdoor display contained a hard-drive, laser beams, discreet cameras, hiding the artifice enabling them to respond to a passerby's presence. The interactivity proposed was not of the simple stimulus-response kind. LeCube specializes in what is called, in French, « l'art comportemental, » or "behavioural art", self-generating work programmed to take into consideration a variety of external factors. It doesn't « wait » to be activated ; nor does it simply generate images without taking into consideration input from without. The work selected had both a degree of autonomy in relation to its environment and a capacity to respond to external stimuli, creating renderings in « real time » all while existing in reciprocity with its surroundings.

Within these parameters, the works were quite varied. Only three examples will be analyzed here, chosen for the different ways in which they illustrate the potential of these new art forms placed in an urban setting. The works raise difficult questions. These are more than experiments situated in a lab or gallery setting. Indeed, the curatorial intent behind the “First Contact Festival” is quite ambitious. It assumes that the general public is ready to include interactive art among its daily activities. It also questions the scope of imagery in an urban environment, challenging not only the use of images, but also the relation expected between images and their viewers.

Artist Damaris Risch‘s « A Distance », for example, consisted of a life-size self-portrait encased in an upright plexiglass display. Risch’s piece was structured around a semantic map, which organized more than 100 still photographs into related sequences. The piece was programmed with Virtools (used for creating interactive games) coupled with a neural network. The sequence of portraits displayed depended on ambient noise levels, the time of day, the « mood » of the work itself and the movements of the passerby. All these factors contributed the expression of the self-portrait, at times innocent, duplicitous, kind, or spiteful. The display promoted nothing. It was not a medium for selling a product, but a work which stood for itself, as a means of engaging the passerby in a silent conversation.

Ill. 1. Damaris Risch, “A Distance”, produced by the Atelier/LeCUBE (programming with Virtools by Didier Bouchon.) Photo @ Romain Osi, 2005.

A new form of « sign language »...for a new kind of sign?

One could argue that, yes, such interactive electronic signs are unprecedented in the history of art, and in the history of the commercial billboard. Since when has it been so easy to stop on a street corner and link up with an artificially intelligent portrait of a young woman?

then again, , Risch’s outdoor self-portrait, however seemingly responsive, is a manipulative device that provokes us into baring part of our own personality to...ourselves, at a moment when we are surrounded by busy strangers.

Life media vs art media

Is generative and interactive art in the streets that extraordinary a change in our urban landscape ?

Pushing art out of the studio and into the street is not new. Nor is transgressing the thin line between « life media and art media .»[6] Incorporating the « banal » in art has become standard procedure in the effort to renew academic art forms. A subway ticket in a painting,[7] LED panels fixed to the walls of a museum[8], or the sounds of traffic in a piece of music,[9] are all familiar ways of exploring the limits between the everyday and esthetics.

The city has had a constant role to play in this process. Electrical signage, the increasing presence of printed, multicolored posters in the streets, the glass displays of large department stores, all led to the emergence of what Gustave Kahn called, in 1901, "The Esthetics of Street Life."[10] Several years later, Marinetti, founder of the Italian Futurist movement, would claim that the city was in and of itself a « moving, ephemeral work of art. »[11]

It is important to note in passing that Marinetti was fascinated by the prosthetic nature of technology. In an essay entitled "Man Multiplied and the Reign of the Machine", he described, in visionary terms, the identification of man with machine, and machine with man. "Wings lie dormant in man's flesh." [12] He wrote of man's "powerful physiological electricity," [13] of a future when man could both externalize his dreams and find, in machines, a sensitive and intelligent counterpart. Augmented man and augmented machines were also part of the Futurist's "cityscape"— stage

6 Dick Higgins, one of the founding members of Fluxus, used these words to define the term "intermedia", which combines aspects of different artistic disciplines and media to create new forms, beyond established artistic conventions, quoted from the« Preface » , Postface, (New York : Something Else Press, 1964).
7 An early example can be found in the painting-collage entitled « Still Life with Bottle and glass », b ythe Russian cubo-futurist painter Alexandra Ekster.
8 See Jenny Holzer's Extended helical tricolor L.E.D. electronic-display signboard in two sections, site-specific dimension, shown at the Solomon R. Guggenheim Museum, (Selections from Truisms, Inflammatory Essays, The Living Series, The Survival Series, Under a Rock, Laments, and Child Text), 1989.
9The Italian Futurist composer and musician Luigi Russolo, wrote : "we must break out of this narrow circle of pure musical sounds, and conquer the infinite variety of noise sounds...Let us wander through a great modern city with our ears more alert than our eyes, and enjoy distinguishing between the sounds of water, air, or gas in metal pipes, the purring of motors) which breathe and pulsate with indisputable animalism), the throbbing of valves, the pounding of pistons, the screeching of gears, the clatter of streetcars on their rails, the cracking of whips, the flapping of awnings and flags. We shall enjoy fabricating the mental orchestrations of the banging of store shutters, the slamming of doors, the hustle and bustle of crowds, the din of railroad stations, foundries, spinning mills, printing presses, electric power stations, and underground railways." Quoted in Watkins, Glenn, *Soundings- Music in the Twentieth Century*, NY, Schirmer Books, 1988, p.236
10Gustave Kahn, *L'Esthétique de la Rue*, published by Fasquelle en 1901, quoted by Giovanni Lista in his Preface to Le Futurisme, (Milano: Arnoldo Mondadori Editore, 1980) p 19.
11 Filippo Tommaso Marinetti, quoted by Giovanni Lista, ibid, p 19.
12 Marinetti, in an article entitled « Man Multiplied and the Reign of the Machine », Ibid, p 112.
13 Ibid, p 113.

for liberated individuals to assert their autonomy and power in the face of the establishment.

The technology of representation itself has also been a factor in the opening up of traditional art forms to the outside world. The camera, a “picture machine,” is at the root of Futurist esthetics and the Futurist’s ambition to free the artist from institutional constraints. Poised half-way between the outside world and the roaming eye of the flaneur-become-picture-taker, cameras freed image-making from academies. One man, one picture-making device…and the world.

Today, cities today are jam-packed with an extraordinary number and variety of representations of men, women, children, cars, toys, clothes, perfumes, landscapes, often reproduced on a very large scale. The large images that surrounded us reinforce the “moving and ephemeral entity” that we call the city. They provide an imaginary stepping stone to a larger “body politic”.

They also contribute to what Guy Debord, the founder of the Situationist International (late 1950s) has called « the society of the spectacle. » By ‘spectacle’ Debord was not referring to images as decorative elements, but as mediating forces, determining social interactions and our view of reality:

“ In all of its particular manifestations — news, propaganda, advertising, entertainment — the spectacle represents the dominant model of life. It is the omnipresent affirmation of the choices that have already been made in the sphere of production and in the consumption implied by that production. In both form and content the spectacle serves as a total justification of the conditions and goals of the existing system. The spectacle also represents the constant presence of this justification since it monopolizes the majority of the time spent outside the production process. » [14]

Signs, the content they vehicle and their urban context are all elements of a common ideological framework.

The question then is to what extent does interactive, generative art in the streets of the city reinforce “the society of the spectacle”, or, on the contrary, help change our relation to the representations which surround us?

Private/public spaces

At the heart of such questions are issues of scale and the relation of private and public spaces.

Mediated extension of human presence in the city exists when we talk on a cell phone in public. Talking into a hand-held instrument, however, entails erecting invisible barriers around our public presence. It is as if we were talking out loud to ourselves. In such an instance, technology reinforces social exchange on a one to one basis, in a process quite independent of the esthetic issues raised by the scale of public signage. “Outdoor art”, by definition, transcends the private sphere, at least in part.

14 « The Society of the Spectacle », by Guy Debord, translated by Ken Knabb and available on « The Bureau of Public Secrets » web-site, http://www.bopsecrets.org/SI/debord/index.htmn, chapter 1, paragraph 6.

Jean-Pierre Balpe. “Fiction d’Issy”, Photo @ Romain Osi, 2005.

Of works shown at the “First Contact Festival”, one in particular straddled both ends of this public/private dynamic. “Fiction d’Issy,” a love story/installation by Jean-Pierre Balpe (professor at l’Université de Vincennes, Paris VIII) linked portable phones and networked, public signs. Passerby dialed up a special number; they then hit any key between 0 and 9 to read different sentences automatically generated by a program; they validated an option (or not) and then sent it off to the large yellow and black municipal bulletin boards. « Fiction d’Issy » had everyone wondering who wrote what over several square kilometers. (The entire ongoing novel is available at http://www.fictionsdissy.org).

In this instance, without a doubt, interactive and generative art creates a new balance of intentions, gestures and voices in a public space. The hybridization of scale and dialogue in this kind of “spectacle” is quite new. Generated content, created algorithmically — and so, in a sense, without human intervention, — is re-cast by an individuals’ desire to see a story move in one direction rather than another. A hand-held and private technology broadcasts this choice city-wide. “Participation” here is indeed enabled by technological means. It enhances man’s ability to affect his visual environment.

Augmetned images

There is a more subtle aspect to the hybridization of the productive processes characteristic of generative art-signage. It has to do with kinds of « image/signs » within each electronic billboard, mixing reality and « real-time » renderings.

The best example of this at the « First Contact Festival » was Vincent Levy’s « Fantômes » (which means ‘ghosts’ in French). His electronic billboard was, in effect, a « video-sign » and, like many video installations, it worked like a mirror, incorporating the spectator as an element of the sign itself. If a viewer lingered in front of the sign, his image, at first ghost-like, gradually became more precise; with time, the program would « hold on to it », and store it in memory. At different points in time, the program brought up images of previous viewers it had decided to « remember » and « represent » in turn. It also displayed images of fictional, pre-recorded characters, like a child dressed up as a clown.

Vincent Lévy, “Fantômes”, co-produced with LeCUBE/ART3000, programming Didier Bouchon with Virtools, Photo @ Romain Osi, 2005.

“Augmented video” of this kind isn’t just another « medium » but a mediator in a narcissistic game of representations. It isn’t a reflective mechanism, but a thinking one, making it impossible to ignore the fundamental shift that separates this “art in life” from 20th-century counterparts. The interactivity here is between spectators and signs endowed with an artificial intelligence that understands them. The work interprets their real presence as a kind of “sign.” It digitizes them into its own world, and asserts a presence of its own. Just as the spectator interprets the symbolic language of an artwork, here the artwork interprets the spectator’s world as a set of symbols. Part of our world—part of our body language or spoken language—has been digitized and has become food for thought for a sign-become-author-and-viewer both. In a sense, this new technology has allowed for us to participate in images and for images to participate in our lives, differently. One can’t help but recall Marinetti’s vision of man’s symbiosis with machines. This time, however, it is not man who is augmented by technology, but the image itself.

Dialogic form

The French new media theorist, Philippe Dubois, insists that new media are simply new tools for old themes. “La nouveauté éventuelle de celles-ci n’engage en rien leurs fins, donc leurs effets de representation…. Elle agit comme leurre, elle aveugle, elle détourne, en s’exhibant à elle-même comme sa propre finalité…Les dites “dernieres technologies” ne font en fait jamais rien d’autre que réactiver de très anciennes questions de representation….”[15] For Dubois, esthetic innovations are independent of the tools used.

Of course, when seen in absolute terms, a screen can be used for any purpose, including the most retrograde. And the “imaginary world” which we project upon the most rudimentary forms does indeed reveal how much meaning is in the eye of the beholder. The French media theorist Francois Jost insists that “la signification aussi bien que la valeur esthétique dépend de l’attribution d’une intentionalité. »[16] The understanding of intent lies in the mind’s eye: only the spectator can attribute « intention », be it artistic or not.

I would like to argue here that the transparency attributed to media by these two theorists is symptomatic of their overriding preoccupation with cinema and photography. The indexical nature of these media contribute to the way images in general have been understood. Philippe Dubois writes, « …les machines, en tant qu’outils sont des intermédiaires qui viennent s’insérer entre l’homme et le monde dans le système de construction symbolique qu’est le principe meme de représentations. » Hard to disagree there, but it’s the next step in his argument that reveals the influence of what are now « old media » on his thinking. He goes on to define an image as a relation between a subject and reality.[17] The word here that is most problematic is “subject”. Is the subject the artist or the viewer? The fact that one (the viewer) can so easily be substituted for the other (the author) reveals Dubois’ bias, and the influence of the photographic esthetic on his understanding of representation. Here, an image is a reflection of reality through the eyes of a beholder…who is holding a camera, and with whom the spectator identifies, quasi-seamlessly.

But what of the “behaviouristic” image, augmented by programming? What of the code behind the generated forms on the screen? What of the imaginary realm, - quite independent of any representation of the outside world, - created by a medium that resists and responds to the viewer, physically?

If one suspends disbelief for a split second, the image displayed in a piece such as “A distance” or “Fantomes” is more than a representation. It has a theatrical presence which changes its status of an “image” into that of an “imaginary character” that responds to us in a dialogic manner. The image displayed is only a facet of a hidden program, a coded set of intentions: the intention of an author-programmer, and that of an autonomous program capable of inventing variations within a given framework.

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15 Dubois, Philippe, Cinéma et Dernieres Technolgoies, Arts Cinéma, De Boeck Unviersité, INA 1998.
16 Jost,Francois. Le temps du Regard, du Spectateur aux Images, Méridiens Klincsieck, Paris, 1998, p 115.
17 Philippe Dubois, op.cit, p 23 « Si l’image est un rapport entre le sujet et le réel, le jeu des machines figuratives, et surtout leur accroissement progressif, viendra de plus en plus distendre, écarter, séparer les deux poles. »

In a more formal sense, the sign also represents itself. It has both a material and psychic opacity which are part and parcel of the imaginary identity of the represented interlocutor. Levy's augmented video piece illustrates this quite well: the piece selects what it wants to see, what it wants to record and what it wants to project. Part of its intelligence resides in its capacity to resist transparency, so to speak.

Jean-Louis Weissberg has repeatedly pointed out the new role of the spectator in digital interactive media, coining the French phrase "spect-acteur."[18] Thanks to code, the "reader" of interactive media determines the work's final shape. In the process, the "reader" becomes a "writer" of sorts, and co-author of the work. This added layer of intentionality changes the status of the image, no longer an interface between an extant world, a medium and an eye. It loses its indexical relation to the outside world. Authorship is shared with the medium itself, via code and the underlying ideas which determine the eventual shape of the representation on the screen.

With generative art, this imaginary "structure" determines a new type of dialogical form, with evident links to theater. (It is tempting to rename the Futurist's "electrical theater" and call it "electronic theater".) What is new here, however, is the transformation of actors into "agents", and the transformation of the stage into a sign, become dialogic medium in and of itself. Generative art augments the "image" to such an extent that ti can no longer be considered interface. It is a dialogic partner in an evolving and open "representation".

As for us, the passer-by, our role has changed as well. Of course, as "spect-actors" we retain part of our now familiar status when confronted with electronic art. However, we are no longer confined to a mouse-screen interface and the sanctuary of laboratories, desk-top or closed gallery spaces. By placing generative art at street intersections, the "First Contact Festival" has engaged art in an open, social process.

This raises many interesting new questions, in part evoked by authors such as Craig Saper[19] when discussing "socio-poetic" networked art's link to precedents such as Fluxus. However, the weight behavioral art as a medium in and of itself,— the weight of its interactive and generated code,— implies an entirely new esthetic field, far from the indexical realm of twentieth century technologies. Form, here, is not "open" in the modern sense of the word. On the contrary, it is thickly embedded in a form of technology which has given the "sign" a prosthetically enhanced presence. The outside world is a small element in a new set of mental and physical structures, attuned to a new, dialogically structured representation, with new rhetorical horizons.

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Agent Visualization

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Abstract

This paper is about software we are developing for an artwork come performance piece, which brings dancers, computer generated agents and an audience together in the same space.

The software negotiates the behaviours of dancers and the agents, adding a further layer of visualization to the performance as users learn to evade, engage, block or trap the agents. Thus experienced dancers would produce predictable reproducible visual effects while novices would produce random chaotic effects.

The agents use a visual field to interact with each other and the environment and have a mixture of adaptive and programmable behaviour which can be set and reloaded, including origins and destinations.

Secondary, but potentially more visible we introduce a particle field moving in a virtual space using the trails left by the agents. This has a number of parameters which affect the persistence and or attractiveness or otherwise of the agents trails to the particles, which run on two algorithms.

The first looks at the gradient of the virtual space, which is composed from the alpha channel of a texture altered by the agents, and the blue channel of the camera input, the particles life, direction and velocity are thus affected.

The particles can also set the gradient, so particles can group together to manage their own persistence.

As such, this is similar to the "Game of Life" algorithms and provides us with ample room for emergent phenomena.

The other algorithm is a simple pressure model which uses an advection and dispersal equation on all the particles, this can be used to produce "atmospheric" effects, though this algorithm works at the global level whereas the first algorithm works at a local level, the effects can be made to contradict each other.

All parameters can be set and saved and can be rerun in timed sequences, to enable a choreography to be developed in collaboration with dancers and musicians.

OpenGL Shader language has allowed the visualization and mixing of images to occur in real time to a high definition.

1. Introduction

The original brief for this piece was to devise a piece of art derived from work which had done here previously with “visual agents” [1], these agents have a limited intelligence and a programmable adaptable movement with immediate response to visual stimulation, provided using input from a live camera feed or as in [1] from sensors attached to objects.

There are three considerations within this brief, firstly to represent the agents, secondly to show them responding to the dancers, and thirdly to allow the system to evolve dependent on the behavior of the dancers and the agents.

The original inspiration was for a complex surface which moved in response to the movement of intelligent agents and dancers, thus an agent walking on the surface would raise or lower the surface at that place, pulling the area around smoothly, this could also be applied to the dancers movement, so that the whole surface became like a live Kohonen net.

As a secondary consideration a particle system was imagined, which could express an intermediate state between the two forms, or maybe as an expression of something else entirely, such as the atmosphere or mood of a section.

Whilst working on the particles it became apparent that here was something that was interesting in its own right, that the complexity of interaction and possibilities for aesthetic output was very large, that this was effectively a new palette for the artist or performer which enables the swift creation of interactive effect.

From my own experience as an artist I was reminded of the many different ways painters have attempted to simulate the effects of water and atmosphere, J.M.W Turner being an excellent example of a painter to whom the movement of water, clouds and light were central to his work. I have begun to imagine the possibility that it might be possible to produce the live interactive version of some of the effects explored in the painting, the clouds that move, the smoke which curls and the sea which swells…

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2. Method

2.1 Background

The original agents program as in [1] uses a simple texture to represent the world the agents live in, their vision uses a simple line drawing algorithm which has been altered to pick up, rather than put down, the colour of the individual pixels. A random sample of these lines is taken within the agents’ field of view, and the agents choose their direction based on this information. A number of parameters can be set to control, how far the agent looks or can look, the number of samples, the field of view, and the boundaries to the agents movement. This is done through a dialogue which is beyond this papers scope. When we use a camera, this texture is dynamically updated with the image from the camera.

2.2 Main implementation

The focus of everything in this paper is a single texture 1024x512 in size on which we create our effects. The multiple of 512 is because OpenGL textures are of this order. OpenGL was introduced to allow us to do certain parts of the calculation on the Graphics Card which has greatly increased the quality of the output. The 2:1

aspect ratio is good for projecting the final image within a studio or performance space.

These are fairly arbitrary, but are a useful device to reduce the complexity which is inherent in accepting input from different resolution cameras and outputting to different size windows.

We do one conversion on the incoming signal, to either reduce resolution or to stretch it, and then allow no resizing of the window. This texture then is an array of 1024x512 32 bit values, each 32 bit value is divided into 8 bits red, 8 bits green, 8 bits blue and 8 bits which normally store transparency but here we use to store the altitude of the surface. This altitude is very important as the variations in the altitude determine the movement of the particles, as such the 8 bits only allows 255 different altitudes, for the moment this has been ample. As it stands there are three different ways that the altitude of each pixel of the surface can be altered. There are then also different ways that the movement of the particles can be altered. To this end we use a dialogue which allows us to set all the different parameters and the different scalar factor we use to combine the different methods. Also this us allows us to set the number, life and visual appearance of the particles, as well as how this is all combined with the input from the camera. All these parameters can be saved and re-loaded, the program allows these files to be loaded sequentially for a timed period from a text file which has the name of the file and the duration on consecutive lines.

A number of variables and checkboxes from a dialogue are used in the program with the following effects. The name of the variable is written as it appears on the dialogue in parenthesis.

Methods of altering altitude

Agents movement

The agent position is loaded into this module as a source of particles, also the altitude can be set using the “Agent footprint” variable, by default this sets the altitude to an absolute value if the “abs/-“ checkbox is checked this becomes an added value. The “Size” box allows us to set the size of the affected area

Particles

The “Particle footprint” variable, by default allows us to say how much the particle will alter the altitude of the surface at the particles location the “-/abs” sets the altitude to an absolute value. The “Negative” checkbox reverses the sign.

Convolution or Filter

The “Convolute” variable, defines how the altitude and colour of an individual pixel is altered when compared to its vertical and horizontal neighbours.

This averages the four surrounding pixels then adds the present pixel value using this value as a weight. The result is then combined with the value in “Background 0-255” using the weight as supplied in the “Background (0-1.0)”. The background numbers then supply the method by which the surface tries to return to its original shape, while the filter smoothes the image, blurs the edges and provides the method by which holding down one part of the surface will slowly spread its effect with multiple iterations. This calculation is done on the GPU (Graphics Processing Unit) along with the methods which add the camera image to the texture, this saves significant time, allowing approximately ten times more particles than would normally be possible.

Methods of altering movement

The movement of the particle by three different agencies, the camera image and the altitude measure operate on pixel adjacency measure, while the pressure map operates over a larger scale defined by a grid size which is about 20 pixels.

The particle has an initial speed and direction when it is emitted from the agents' location, which is set in the dialogue.

Altitude

This compares the altitude of the current pixel to the altitudes in front, behind, to the left and to the right. In other words the adjacent pixel values are compared to the value to the current position of the particle to calculate the acceleration and turn of the particle. We then use the parameters “Speed up”, “Slow down”, “Turn left” and “Turn right” to alter the direction and speed of the particle depending on the relative weighted values of the altitudes.

Camera Image

If the “Add Image” check box is clicked the “blue” channel of the image is subtracted from the altitude of the surface. If the “Positively” box is checked the value is added. This gives a direct connection between the camera image and the particles. Thus it could allow a performer to have an immediate affect on the particles, as well as their control of the position of the agents who are the source of the particles. This might be very useful where the particles have long lives.

Pressure Map

If the “Use Pressure Map” check box is clicked the pressure map values are added to the altitude of the surface. The Pressure map is similar to the Altitude calculation except it happens on a larger scale. The whole texture is divided into a grid, each square being set at 20x20 pixels, when a particle is in a grid square the particles' velocity and direction are used to set, with all the other particles, the velocity and direction of the grid square. Thus, when a particle wants to calculate its new trajectory it looks at the grid squares in front, behind, to the left and to the right of the grid square it's currently within. The new direction is set proportional to the values in the different grid squares, weighted by the distance of the particle to the grid square and the current velocity and direction of the particle, this mimics some features of conventional CFD without ever getting into the computational complexity of such calculations. If 1.0 is entered in both edit boxes the velocity and direction are unaffected, so 0.0 in “Speed” and “Bend” is the maximum value. The “Attract” button reverses the behaviour so the particles are attracted to each other.

Life of Particles

The life of the particle is defined by the “limit p” variable, the “Life” variable and the “Restart < v” variable. The last of these is an absolute value, if the velocity of a particle is less than the number in the dialogue the particle is restarted. The first two values are combined; if the altitude of a particle is less than the number in the “Life” variable then the particle loses a life up to the number in the “limit p” variable. This supplies the mechanism whereby particles will continue to live as long as the altitude of the surface is above a certain value which could be determined by any of the factors which adjust the altitude ie other particles, the agent trail or the convolute function combined with values set for the Background.

Visual Display

The colour of the particles can be set with “Colour” “Fixed” and “Random” variables which set the colour of particles emitted at each agent location using a fixed and random component.If the “map” check box is used then these values are applied to the particles directly. The “prop speed”, “prop life” and “prop altitude” check boxes alter the brightness of the particles dependent on their velocity, their life left and the altitude of the surface they are on these can be inverted using the “prop invert” box.

Camera input

The variables “Mix Camera” and “Threshold” and their associated check boxes control the way we combine the camera image to our output, we can look at the camera image texels and see if the blue value is above a certain threshold, and then combine it with the image in the proportions defined in the “Mix Camera” variable. A further procedure takes the default value which controls the agent movement and shows everything which is visible to the agents, this is activated by just using the “Mix” checkbox.

Number of particles

By default the program starts with only a thousand or so particles, the Pressure Map is the main limitation on the number of particles, with this unchecked the limit seems to around 10,000 on a 2.8 GHz Xeon processor. If the number in “Number of Particles” is changed all the particles are restarted, this is useful if you have set particles which do not die, and need to reset them.

3. Results

Here I shall try to provide a brief resume of the main classes of visual effects and how they are obtained using the rules as they have been described, in some cases it is possible to extrapolate other possible visual effects or interpolate the others contained within, or in combination with others.

3.1. Using Altitude

This takes account of the ability of the particles to keep each other alive as they erode a path through the surface, this path is constantly changing, in much the same way as the path of the a river changes on a flood plain.

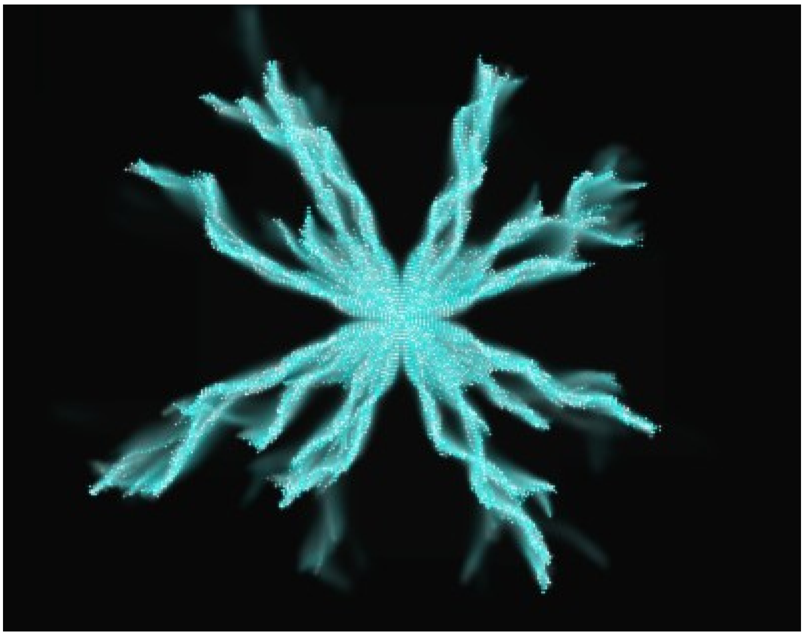

Fig 1

In Fig 1 we can see the particles emanating from a central point dividing themselves out into a number of different channels, the fainter marks show the remains of old routes.

The opposite effect is seen in Fig 2 where the particles are given a negative bend in respect to each other.

Fig 2

This can be changed into a spiral by making the left and right bend unequal, but more interestingly we can make free floating balls when we have one negative and one positive as seen in Fig 3, here, a group of particles are keeping themselves alive by forming a ball

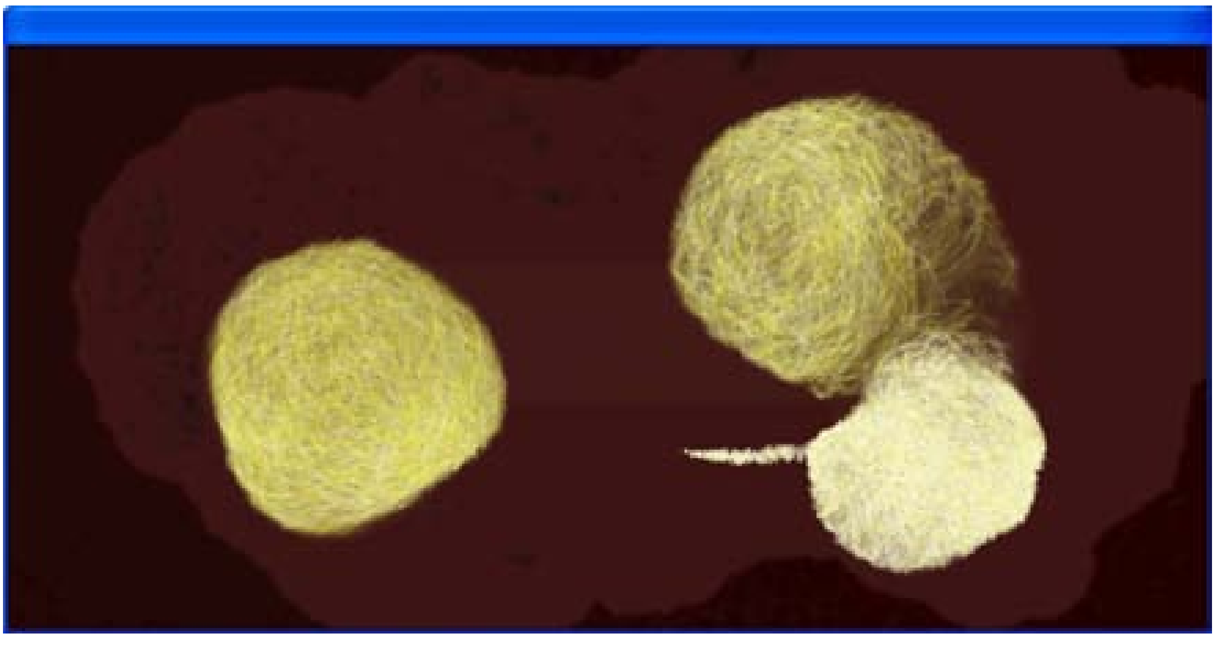

Fig 3

Several in fact, here also we are using the “prop altitude” feature which lightens or darkens the colour of the particle dependent on the altitude of the underlying surface.

Generally we have to very careful in setting parameters for keeping a group alive, it is very dependent on the time scale we wish to convey, for a slow moving example as in Fig 3 the balls decay over a period of a couple of minutes, but it is possible to conceive of accidental stable situations, which would last a good deal longer. The above situation was surprising, as one of parameters would not normally help the group to survive, i.e. the negative turn.

In fact it just meant that all the particles going the wrong way around were eliminated and we were left with all the particles which were turning right i.e. going around the centre of the group in a clockwise direction, which gave the appearance of a rotating ball of string.

3.2. Camera effects

To illustrate this, the following image was produced particles beginning to find the edges of the shelves and other areas of lightness in the image.

Fig 4

I have found this feature best when the image is still and then moves, as the particles “take up residence” in the lighter areas of the image, and when movement occurs a great number are released creating a blurring affect until they find new areas of light to exist within.

3.3. Pressure effects

Though this would be best illustrated with a number of images, suffice to say it is possible to produce both clockwise and anticlockwise vortices by altering the “Attract” checkbox.

A combination image then might be created as in Fig 5 where an initial expansion from the centre as in Fig 1 is followed by the application of the pressure system

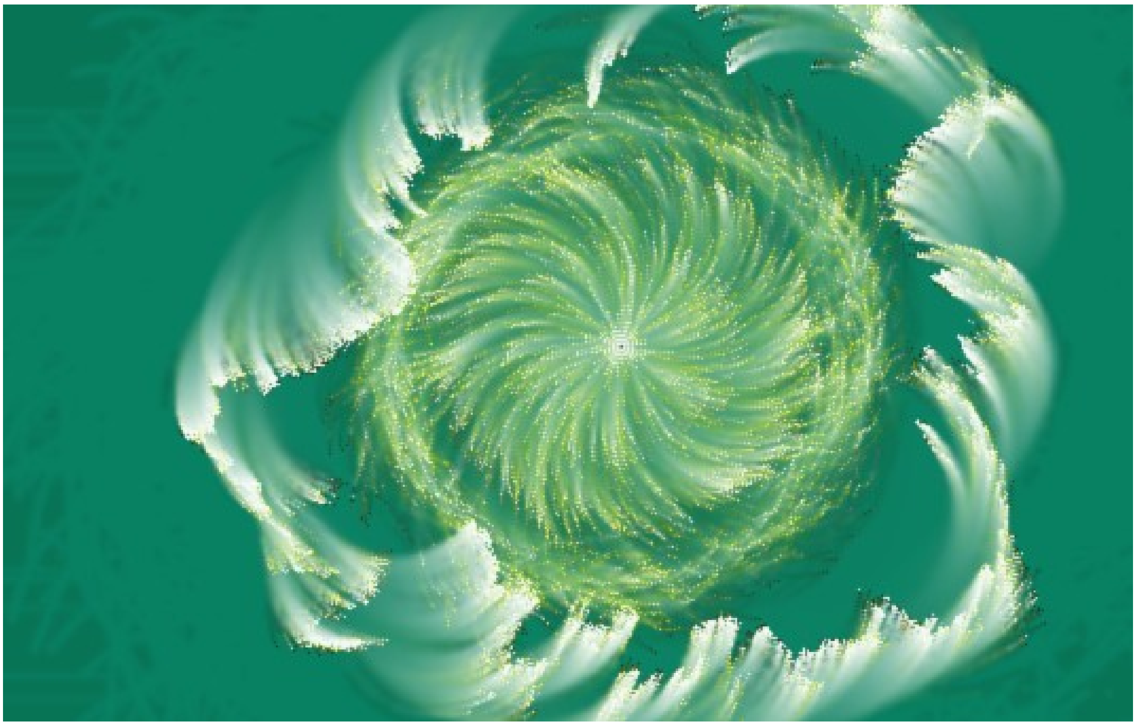

Fig 5

In conclusion, then, it seems the pressure system is useful for making fairly coherent vortices. When the speed of the particles is altered by the pressure system you get sudden eccentric changes in velocity and direction which can seem quite naturalistic. Also if there are several agents together we find that the proximity of other agents can lead to “handshake” effects, the particles of the two agents repulse each other, and you get a flare out along the axis of meeting.

The trouble with pressure system is the cost in terms of CPU time and errors in the programming, the clockwise and anti clockwise rotations are probably emergent behaviour of errors in the coding giving a tilt to right or left handed movement, it is also noticeable that the edge effect is incorrect in some features as the particles tend to fall towards the right hand edge.

3.4 Some worm effects

For these it is a matter of providing the agent with a tail, the agent footprint makes a dent in the surface, the particles live in this dent until the surface rebounds.

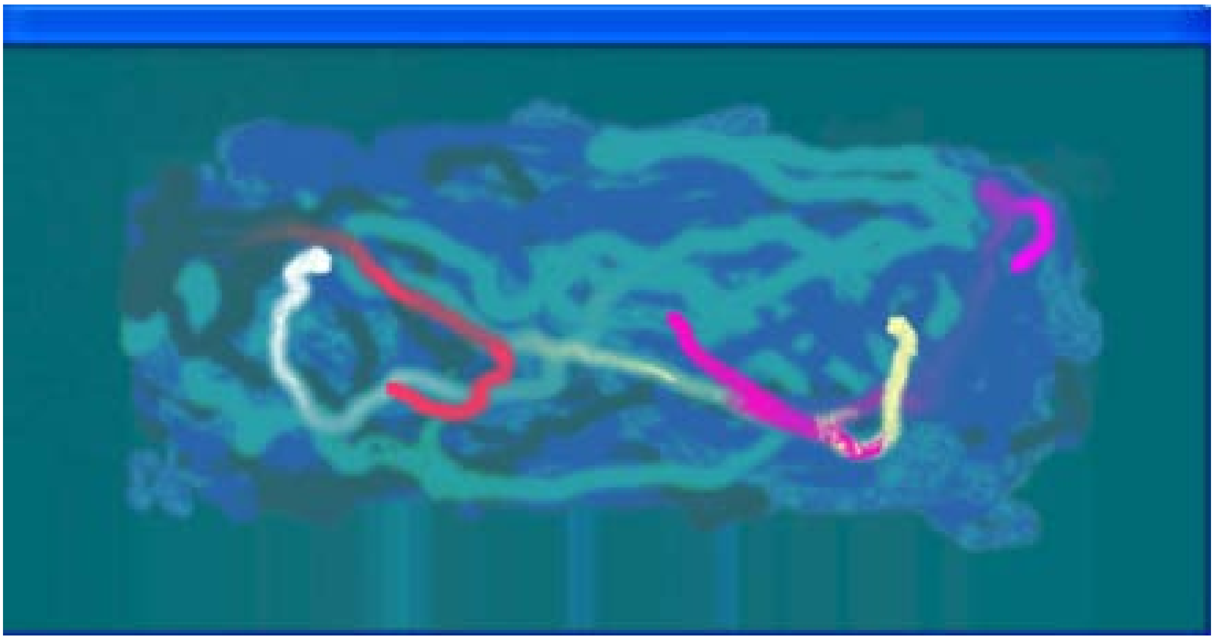

Fig 6

This also shows the cumulative affect of agent trails producing a layered spaghetti effect. One of the better effects is to set the colour proportional to altitude checkbox on which makes them appear as burns through paper. Also some colour mixing will occur where two or more trail intersect, as the particles emitted from separate agents live in each others trails.

4. Conclusions and further work

The difficulty of assessing whether unpredictable more naturalistic effects should take precedence of the more formal worked out effects is a question that only individual artists can take in particular circumstances. In this work we have tried to create a framework where multiple modes of expression are possible in a live and interactive fashion.

I use Turner as an example, for several reasons, firstly, he is a painter trying to produce illusions on a two dimensional surface, secondly the illusions he creates are largely constructed with smoke, light, water and the movement of these and thirdly he is very innovative in the use of paint to create these effects. As such this seems a fine point to start when we want to consider the methods by which we should use the illusions and the sense of reality as an underpinning to our intention to produce works of art. The audience must be convinced in some way that something “real” or important is taking place or they must be drawn into a conversation where their interactions are given another dimension.

My other reason for affection for Turner, is that in his later days, (it is now thought his eye sight was failing) he pushes the medium of oil painting off the limits of comprehensibility. This means that the image is so deeply buried within the layers of paint that the illusion itself is a will in the wisp, we find ourselves pondering the significance of the merest paintbrush of the dust settling on the surface of the paint, but even so, we are aware that someone, the artist, has been there before us. Here we have less ambitious aims, but we are dealing in time based illusions, we are looking at the tools for the smooth blending of colours that respond continuously to the real world, we are trying to put the naturalistic into the art in several ways, using the pressure map which could be I expect vastly improved if we used methods described in [2], also by using live imagery from a camera and lastly putting a level of “knowledge” i.e. the surface which is responding in real time to itself in a fairly naturalistic way. The camera and this surface could be better integrated, but this should really wait until all three can be combined in a more coherent and complete fashion.

I say all this with some caveats, as I think in a personal way that the noise in the system is the art. That the totally rational tool gives little margin for the artist to do totally unexpected things, and that we would be left with a device for manipulating live images, a sort of sophisticated circus mirror show. As it stands the slightly indirect connection between the camera input through the agent movement to the mass of particle movement helps it avoid this, but at the same time this could make it incomprehensible to someone seeing the work for the first time.

As it is the system will be tested with both knowledgeable people and those who haven’t seen it before to try and push the possibilities forward. This is happening as a part of a project called “Crossings” run by [3], it is hoped that input from this project will push this work in fruitful directions.

On another note there could be a few “technical” improvements made, these are:

The altitude of the surface could be held within a separate texture to provide a greater range of values than the 256 we are currently using.

It would be a good idea to spread the range of the filter and also to be able change the shape of the filter profile, this has some impacts on performance however, so we would have to be careful. An interesting shape might be the “cowboy hat”, with the dent in the top, local repulsion with global attraction. Again this would require significant programming of the GPU.

At present the whole surface can be tilted using the mouse which sets up this streaming effect over the whole surface, it can also be rotated so one can create symmetrical effects both in the x or the y axis. If the whole surface is formed of a number of polygons this effect could be repeated in different directions at different places in the image.

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Real-time Musical Interaction between Musician and Multi-agent System

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Abstract

The application of emergent behavior of multi-agent system to musical creation, such as controlling parameters of sound synthesizer and composition, has attracted interest recently. Although human control or programmed operation works properly, it is very complicated and seems overly monotonic. One of the features of a multi-agent system, self-organization, is suitable for controlling parameters of synthesizer and generating compositional rules. Furthermore, the system has the possibility to generate unexpected sounds and musical pieces in ways that an experienced musician would never try to generate.

In this paper, we report a research on a musical computer system, which generates synthesizer sounds and musical melodies by means of the multi-agent and interacts with human piano players in real-time. We show empirically that our interactive system plays attracting sounds. We also demonstrate that a human player feels that the interaction between the system and himself is very reliable..

1. Inroduction

The problem of techniques, deterministic algorithmic composition made by only strict rules which succeeded to traditional composition is that no possibilities that can generate unexpected besides wonderful results. One of the purpose for using computers in musical creation is to generate unexpected results that cannot be generated with traditional ways. Therefore stochastic composition techniques, using random values generated by computer as parameters of composition, has been widely used. L. Hiller and L. Isaacson composed a suite named "Illiac Suite" with very early computer "ILLIAC" using the famous stochastic technique Monte-Carlo [1], and I. Xenakis generated peculiar sound called "Sound Cloud" in his pieces by stochastic technique with computer[2]. C. Roads collected famous stochastic techniques and gave a detailed explanation of them in his book[3].

Although, ordinary stochastic composition using random values simply has a problem. The problem is that the output results from computers cannot be used for composition directly without the revision of composers or programming very strict rules for random value generation. Because of that each random output value has no relationship to each other. In general, correlations between each parameter are important in composition and sound synthesis. Thus directly using output for composition generates sometime inaudible sounds, also sometime no unbearable as a music, and often not interesting sounds.

Consequently, application of an "Self-Organization" of Multi-Agent systems, such as Cellular-Automata (CA) and Artificial Life (AL, ALife), in musical creation has lately attracted considerable attention. The relationship of each parameter is important in musical creation, as mentioned before. The self-organization property bears the possibility of generating correlated parameters. In general, emergent behaviors of CA can control parameter sets for composition and sound synthesis dynamically whereas eliminating the need for the revision of computer outputted values and manual arrangement. Furthermore, recent research shows that traditional composition models of classical music can be explained with the behaviors of multi-agent systems.

Ordinary stochastic techniques used today, which involves applying random values to each musical or sound synthesis parameters, usually produces non-musical notes or inaudible sounds. Therefore composer should revise the output values from computer or put strict restriction rules when generating random values in order to obtain applicable results. In contrast, self-organization property applied to music composition and sound synthesis reduces the possibility of generating chunk data in musical terms.

Some composers and researchers have tried to apply emergent behaviors of Multi-Agent system to composition and sound synthesis. P. Bayls and D. Millen attempted to map CA's each cell state to pitch, duration and timbre of musical notes[4,5]. E. Miranda noticed self-organizing functions of CA strongly, Then he constructed the composition and sound synthesis software tools called CAMUS and Caosynth[6,7]. In the Caosynth system, he developed mapping to apply CA to controlling granular sound synthesis. P. Dahlsted has been interested in behaviors of evolution of natural creatures. He made some simulation systems consisted of many creatures which play sounds, walk, eat and interacts with each other, even die and evolve in world. Finally developed mapping for the behaviors of creatures to sounds and composition[8,9]. He also has used IEC (Interactive Evolutionary Computation) actively for his composition based on the point of views of multi-agent evolution system[10-12].

2. Interaction between live computer system with human players

As we have mentioned in section 1, application of Multi-Agent systems to musical creation has yielded promising results. The self-organization function is very useful for controlling compositional and sound synthesis parameters dynamically. Dynamic sounds alternation is required especially in sound synthesis of recent live computer music which generates melodies and sound in real-time. Besides, techniques of dynamic controlling of parameters to generate interesting melodies and sounds in interactive live computer music, such as capturing human player's sound or performance information and computing interactive melodies and sounds, has become increasingly important in recent years. This is due to the new sound synthesis techniques, such as granular synthesis and granular sampling require huge set of parameters, and also melody generation in computers. It is very difficult to apply random values to these parameters directly in real-time manually, because that many case pure random parameter sets generate unmusical sounds with complicated synthesizer and composition algorithms. An ideal type of parameter sets is that each parameter alternates in time line and bears a strong correlation to each other. Therefore self-organization of each parameters works very effectively when applied to sound synthesis and melody generation in real-time.

Meanwhile, musical trials of real-time interaction between human players and computer system in musical works has also drawn considerable attention. Human's musical performance contains a huge amount of information, e.g. dynamics of articulation, tempo alternations in a melody and etc. Dynamical construction of sounds and melodies based on the captured musical information has been the typical way of creating live interactive musical works. These techniques are very exciting from the viewpoint of both performer and composer. However, programming of rules for sound and melody synthesis part is very complicated for real-time interaction. Because of the musical information captured highly depends on the condition and the mood of the performer. Also sound and melody synthesis require huge parameter set which have strong interdependence, besides dynamic alternation of parameters is needed to make unique sounds, but system operator is not allowed to control the parameters in detail. We thought that realizing musical interactions utilizing self-organization function helps the real-time parameter control, moreover performer and composer can get more interesting and musical sounds by means of self-organization of multi-agent system.

We mentioned above, some musical research and works done in the area of multi-agent systems. In these works, processing of multi-agent system and composition or sound synthesis is non real-time, results from the fact that processing cost of multi-agent system is large, so that its not feasible to process in real-time. However, in recent years, processing power of computers has increase dynamically. For 20 years ago, we could not imagine that real-time sound processing in multi-purpose processors with very small portable computers is achievable. And also, today we get the processing power to simulate any kinds of simple multi-agent system such as small CA and ant colony. Thus, now we have many possibilities to realize interaction between computer system utilizing self-organized functions and human performers.

For these matters, mentioned above, we tried to construct a multi-agent system which interacts with human player in musical terms. Then we observed interesting musical communication that the power of self-organization of multi-agent system and human players in live piece.

3. System Construction

3.1 Overview of the system

Our system consists of two computers, first one is for running the multi-agent system, and the next is for composition and sound synthesis. Two computer are connected via Ethernet with "OpenSound Control" protocol[13]. This enables a simple setup for the realization of a distributed processing environment. On a single computer there is the possibility of interference since the execution of multi-agent system requires high computational power which may lead to generation of noise or interruption in the sound synthesis task. OpenSound Control is widely used protocol for real-time live music creation, and in order the system to connect to other live computer systems.

For the realization of the multi-agent system, we adopted "Swarm Libraries"[14]. Swarm Libraries is a software package for multi-agent simulation of complex systems, originally developed in Santa Fe Institute. we introduced networking function with OpenSound Control to Swarm Libraries, then implemented functions to send and receive musical messages from other software.

For composition and sound synthesis, "Max" clones, "Max/MSP" and "PureData" was used. Max and Max clones are powerful software for real-time sound synthesis and control algorithmic composition. Also we have attempted to introduce other sound software to our system.

The order of processing is as follows:

Performance information of human player is captured with Max as sound signal or MIDI data.

The information is analyzed with rule sets that composer and performer programmed, then send to the next computer which runs the multi-agent system via network.

Multi-agent system, such as CA include the messages extracted from performance information, change states of each agent in the virtual world based on contents of the message.

At predetermined intervals, return information of agents states to music computer via network.

Music computer processes melodies or sound synthesis with information from multi-agent system, and publish with the speaker or send to an other instrument connected via MIDI.

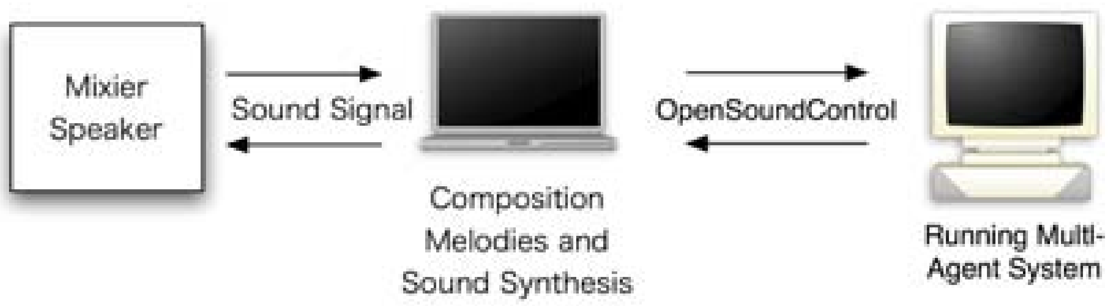

Fig.1. Distributed processing environment of our system

2.2 Examples of multi-agent behaviors, generating melody and sound synthesis rules

Purpose of this research is an attempt to apply multi-agent system to actual musical creation. Multiple behavioral rules for the multi-agent system are adopted in our system instead of restricting ourselves to a single rule. The idea behind this is that in practice composition of a musical piece accommodates several rules in sound and melody generation. Many algorithms are used for melody generation and sound synthesis while composing a piece in order to give a feeling of dynamic movement and represent a developing musical structure.

For generating behavioral rules for the multi-agent system in use, several rules are implemented such as 1D, 2D CA, Boids and Ant Colony. Boids is a simulation model for mimicking the movement of flocks and herds in which the behavior for each member of the group is governed by simplistic rules. On the other hand, Ant Colony simulates the behavioral models of and colonies for foraging tasks.

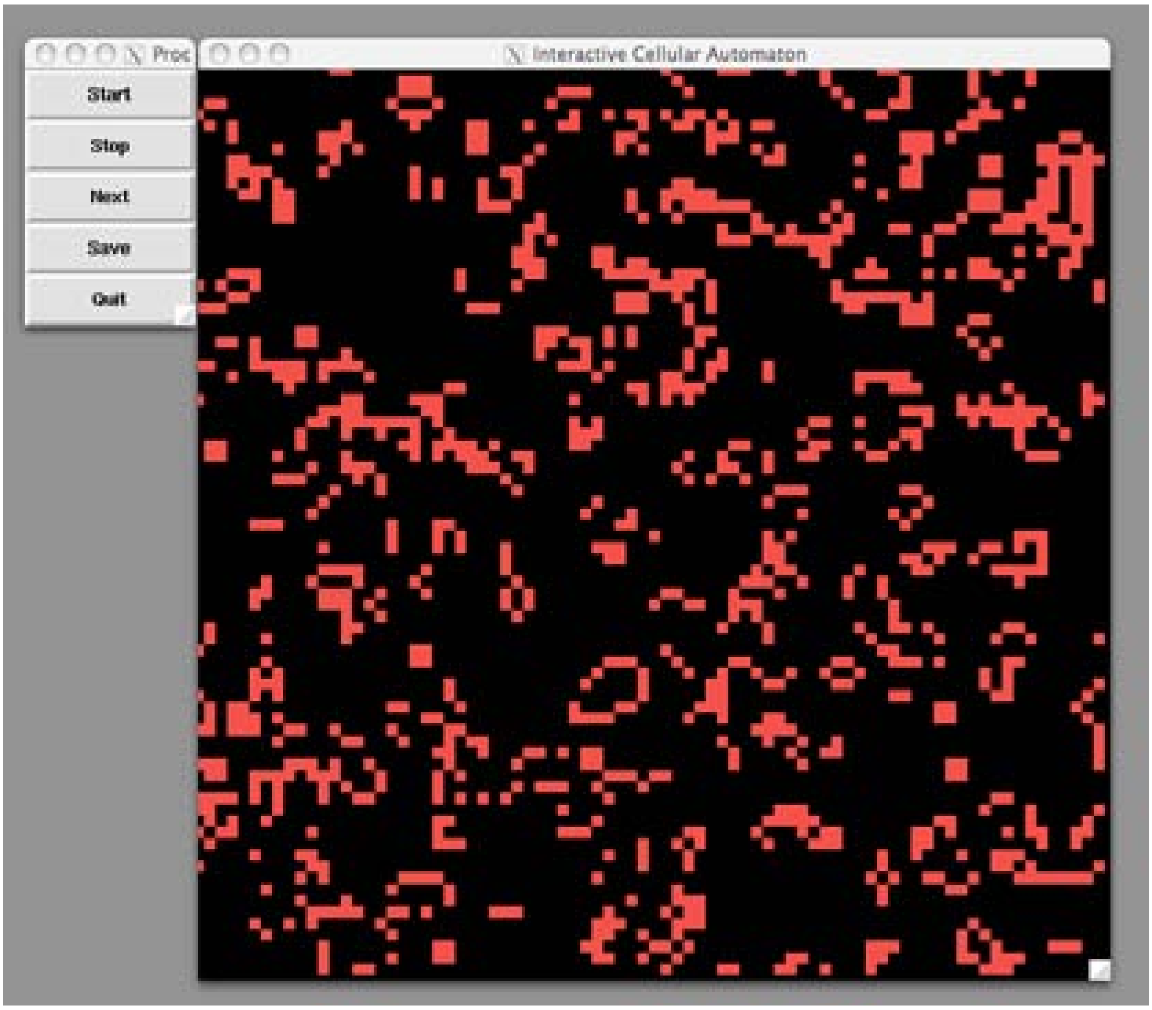

Fig. 2: Multi-agent system implemented. The 2D CA rule Conway's Game of Life is running.

In order to map the behaviors emerged in the simulations to musical melody generation and sound synthesis several mappings are produced. For instance, in the case of Boids simulation, each agent's behavioral exposition and location data are connected to a set of a white noise oscillators and a band pass filter. Specifically, agent's behavior, lateral position in X line, vertical position in Y line and moving speed are mapped to the three parameters of band pass filter, center frequency, bandwidth and position between the left-right channels, respectively. Moreover, during the musical performance, the frequency of key presses of piano is adjusted based on the agents moving speed. This enables a dynamically alternating sound cluster. Another metric employed in this approach is the distance between any two agents which is used for stretching the musical note created by the agents.

4. Composition and Performance of a Piece

4.1 Composition

We conducted an experiment to compose a piece with the proposed method. The piece is named "Fellow for MIDI piano and live interactive computer system."

The procedure of the composition is as follows: At first, we composed 6 very short pieces consisting of 16 or 32 bars and few notes using predetermined note sets with our software for composition by means of Interactive Evolutionary Computation(IEC) named "CACIE"[15]. Then a professional pianist is requested to actually play the computer generated piece with full articulations and the performance information is extracted as a MIDI file during the performance. In the next step, notes generated by the multi-agent system are sprinkled into pre-composed piece taking the MIDI file as input which is obtained in the previous step. Multi-agent system is build using "Conway's Game of Life" based on simple CA rules with fixed mappings. These fixed mappings uses the predetermined note sets to give a feeling of unity for the audience and performers. Finally, we rearrange a final piece using all the previously generated pieces by IEC and the multi-agent system considering an artistic sense.
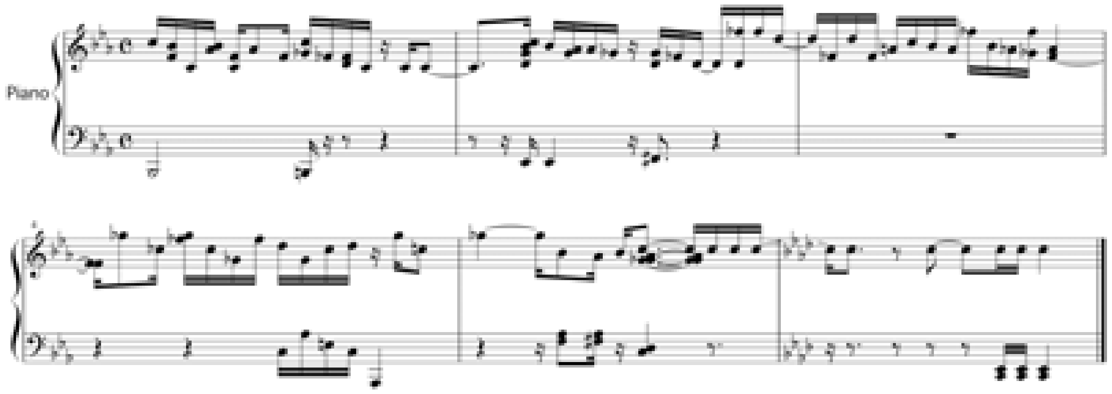
Fig. 3: A piece generated by the interaction between multi-agent system and performance of pianist.

4.2 Performance

Next, we explain the performance example with our system. In previous section, composition of the piece with our system was explained. We tried to perform the piece as a live interactive musical piece with our system.

Setting of the live interactive system for the performance is similar setting as mentioned section 3.1 and 4.1, MIDI piano is connected to musical processing computer. Input of the system is the pianist's performance information as MIDI signal, and outputs of the system are synthesized sound and played piano sequences which is generated in real-time with MIDI piano driven by MIDI signal from the system. Non-musical instruments were not used, such as a foot switch or MIDI sliders in the system. In this setting we tried to assure that interaction between the system and the performer is only in musical terms.

For the behavior of the multi-agent system, few 2D CA rules and Boids were adopted along with several mappings for melody and sound generation. These rules of multi-agent behavior and mappings for sound generation were designed to change based on the section of a piece. In addition we tried to extract some heuristics from the performance information to dynamically evolve the mapping and rules.

Fig. 4: Pianists play the piece the with multi-agent system

As a result of the interaction between the pianist performer and our system, performances such as four bars exchange in jazz were observed. There were precise musical correlations between the melodies played by the pianist and the system. Despite the simple mappings used in this experiment, no inaudible sounds ware encountered during the composition and performance steps. Furthermore we received positive feedback from the professional performer.

5. Conclusion

In this paper we conducted a research about a multi-agent system for musical creation which interacts with human players in composition and performance stages. As a proof of concept, using our proposed system we composed and performed a piece interactively with a professional pianist. As a result, the piece created received positive feedback from the performer.

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Composing Music Based on Interaction with Self-Similar Symbolic Tree Structures

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Abstract

This paper presents a method of composing music based on algorithmically generated structures, what the author refers to as “symbol trees.” These trees are created from initial seeds by “expansion” rules and contain properties of hierarchical organization, self-similarity and pattern repetition much like the organizational structures of L-systems. A graphical editor written for the purpose of interpreting these structures is used to facilitate interaction with them so that they can be musically expressed in a variety of ways. The environment is designed so compositional decisions cannot be made without their effects being dispersed and automatically reinterpreted in other areas of the composition. By composing “inside” of these structures, a balance is maintained between human intuition and automation so that the resulting artwork is a hybrid of both processes, each having control over the other while neither of them having complete control over the final result.

1. Introduction

Algorithms based on nonlinear dynamical systems are attractive for computer music composers because they contain properties of hierarchical organization and self-similarity found in both music and nature. A variety of methods have been invented for working with systems exhibiting complex behavior such as fractals and cellular automata. This paper demonstrates a method of composing music based on visual interaction with a similar type of non-linear system: tree-like structures produced recursively from initial seeds using small sets of expansion rules. These structures contain patterns of symbols which can be freely interpreted in an abstract manner, effectively constraining only certain decisions regarding form, repetition and variation. The composer has a large amount of flexibility and control while the underlying algorithm still largely determines the musical output.

To enable interaction with these structures the author has invented a software environment designed specifically for visualizing and working intuitively with them. Its graphical interface is tailored to facilitate the compositional procedure discussed in the sections below. When the symbols mentioned above are displayed in the editor they loosely resemble diagrams found in formal musical analyses, implying sectional divisions and repeating units. The user then places and manipulates colored blocks inside the hierarchical structure so that different levels in the tree represent and determine the behavior of musical material at different temporal levels (i.e. global, local and micro). Musical processes then combine within each other creating continuous variation within variations of gestures and motives.

2. Related Work

The author's software bears some resemblance to the Cellular Automata Workstation presented by Hunt, Kirk and Orton at the 1991 ICMC conference [7]. This workstation generates cellular automata patterns, displays them graphically, and provides an interface with which the composer can visually select rows and make alterations. Theoretical applications of nonlinear systems to music are discussed in papers by Bidlack [2], Di Scipio [4], Fagarazzi [6], and Mason and Saffle [9]. Beyl [1], Diaz-Jerez [5], Katrami, Kirk and Myatt [8], Miranda ([10] and [11]), Reinders [14], and Rossiter and Wai-Yin Ng [15] have also developed software to facilitate composing music based on cellular automata, fractals and other related phenomena. These tools map the patterns generated from the system into musical parameters such as pitch, dynamics and duration, or into input parameters for synthesis techniques such as additive or granular synthesis.

Although cellular automata were mentioned in the previous section, the technique of generating symbolic patterns used here more closely resembles the rewrite rules of L-Systems. In this approach the whole history of rewrites is preserved and used. L-Systems are explained in [13] and relationships between L-Systems and musical structure are discussed by Mason [9].

The software described above is implemented in Common Lisp and Java and makes use of the CLM [16] and CM [17] function libraries.

3. Compositional Approach

Composition begins by determining the rules that will be used to generate the "symbolic tree." These are referred to here as "expansion rules," since they determine the properties that result from expanding an entire tree from a single source or seed. They differ from rewrite rules in that a history of all of the expansions are preserved in the tree structure. The expansion rules manipulate a chosen set of symbols (for example, the letters A through D) which then become nodes in the tree. Although interpretations can vary, each symbol loosely corresponds to values within musical parameters such as dynamic level, tonal center, tempo, duration, rhythm, timbre, etc.. The expansion rules are defined by lookup tables or functions definitions. A rule/function receives a symbol as input (and possibly some contextual information) and outputs a corresponding set of symbols which then become the input symbol's "children." A few examples are given in Fig. 1 (the arrows indicate expansion, underlining designate the symbols being expanded and the question marks signify that any symbol may be present in that location).

A -> B C	A expands to the sequence of symbols B and C
A C|D -> B A	A next to either C or D expands to symbols B and A
B ? D -> A ? C	Any symbol surrounded by B and D expands to A, the

A -> B C	A expands to the sequence of symbols B and C
	same symbol, and C
? ? -> ? C ?	Any symbol repeated twice expands to the same repeated symbol with a C inserted between them

Figure 1

More complex rules are of course possible—for example, numbers may be used and subjected to mathematical relationships and constraints. In addition to these rules, the structure requires that a seed symbol or set of symbols be chosen to represent the highest level of the tree. The expansion rules are then applied recursively to produce successive rows of symbols. A simple set of expansion rules and an initial seed are given in Fig. 2 (the numbers 0 and 1 are used, the symbol "~" indicates a complement operation where ~0 = 1 and ~1 = 0).

? ? ? -> ~? ? or ~? ? ~? -> ~? ?	A 0 or 1 surrounded by either two 0s or two 1s is expanded to itself preceded by its complement
~? ? ? -> ? ?	A 0 or 1 surrounded by its complement on the left and itself on the right is expanded to itself repeated twice
? ? ~? -> ~? ~?	A 0 or 1 surrounded by itself on the left and its complement on the right is expanded to its complement repeated twice

```
seed = 1:
                                1
                0                               1
        1               1               1               1
    0       1       0       1       0       1       0       1
  1   1   0   1   1   0   0   1   1   0   0   1   1   0   1   1
 0 1 0 0 1 0 1 1 0 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 0 1 0 1 1 0 1
```

Figure 2

The horizontal direction in Fig. 2 represents time. Other factors that are discussed below determine how this is actually realized. Symbols that are at higher positions in the tree represent larger global sections and attributes of the piece while symbols at lower levels correspond to local or micro attributes. Recursive expansion based on a single, small set of rules insures that a perceivable amount of self-similarity exists between these levels.

Depending on how the expansion rules are defined, any level in the tree can contain a large amount of repetition and variation. By altering the expansion rules in different ways, one can develop a fair amount of control over how these patterns evolve. One can cause patterns to repeat and cluster into groups or symbols to appear in specified contexts.

4. Interpretations

Symbols are translated into music by assigning to them values within sets of musical parameters. Translation takes place by means of functions that input symbols and output the instructions and data used to render the music. These functions, referred to here as "interpretations," are grouped into related categories and subcategories which can be either dependent or completely independent of each other. An example set of interpretations grouped into related categories (similar to the one used in the electro-acoustic piece discussed below) is given in Fig. 3.

Grain timbral category (metallic sounds, wooden percussion sounds, horns and whistles, human/animal voice sounds, noise, synthesized sounds, etc.)—the grains used in Propagation described below have periods of sub-audio duration.

Specific grain source

Pitches (subcategories work together to determine pitches to select and transpose grains to)

Group of registers (sets of frequency ranges)

Register (chosen from group)

Scale

Chord

Interval or set of intervals

Pitch center

Tempo

Duration (large scale)

Duration (small scale)

Amplitude (large scale)

Amplitude (small scale)

Figure 3

The interpretations are arranged hierarchically to conform with the hierarchical organization of the tree. Each function in a category or subcategory may also consists of 2 or 3 inputs from different levels in the tree structure. This insures that as much of the hierarchical structure as possible is reflected in each of the interpretations.

5. Graphical Editor

Interpretations are assigned to different locations in the tree using the graphical editor, so that from left to right each one switches between higher and lower levels in the hierarchy. Fig. 4 is a snapshot of the editor displaying a small sample tree.

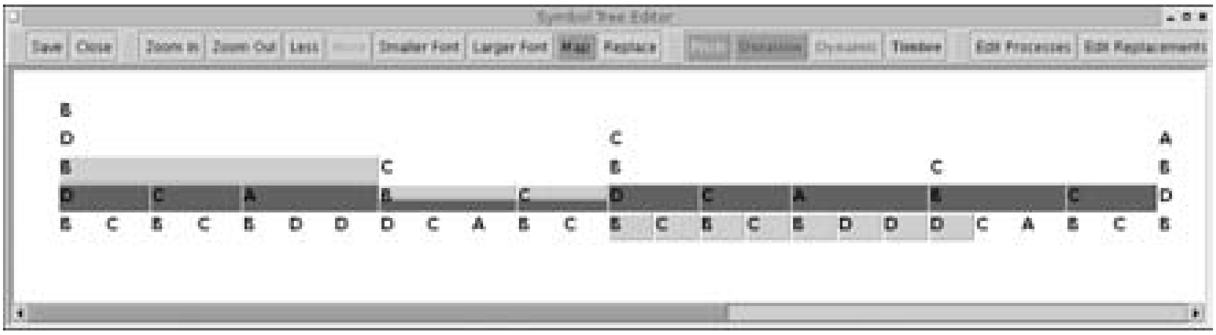

Figure 4

The shaded bars appearing on top of the symbols indicate interpretations. In this case, the dark grey bars represent pitch while the light grey bars represent duration. Fig. 5 shows what the musical result might be if the given interpretations are used.

	Pitch	Duration
A	C	eighth note
B	C#	sixteenth note
C	D	dotted eighth
D	D#	quarter

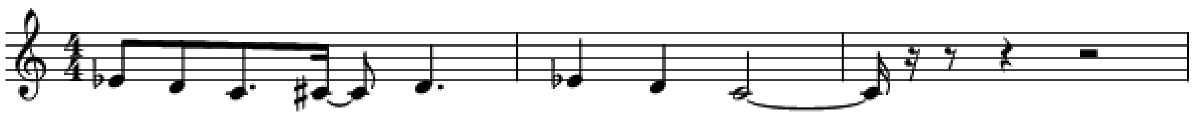

Figure 5

The program allows one to copy and paste interpretation assignments from one location to another, change or exchange symbols in sections of the tree, display alternate symbols (such as pitch letters or dynamic markings), generate random interpretation assignments, do statistical pattern analyses (either global or pertaining to certain sequences of symbols), and perform other manipulation functions. One particularly useful function inputs musical data (perhaps a sequence of pitches or a rhythm) and returns relevant sets of mappings to symbols so that interpretations may be tailored to make certain musical gestures appear.

6. Propagation

The author's piece Propagation for two-channel electro-acoustic playback was written using the procedure described above. There are four short movements, the first and last of which are each derived from a single tree. The second movement is derived from two related tree structures (two “variations” occur sequentially and present similar patterns with different timbres and pitch material). The third movement is different in that it is formed from a string of smaller related structures occurring sequentially in time, each governed by a single global tree structure which decides the timing of the sections throughout.

A method analogous to granular synthesis was used to generate the foreground material. The "grains" have periods corresponding to subaudio frequencies, and were extracted from recordings of natural sounds transposed to various pitch levels. The sources were organized into groups of related qualities (metallic, noisy, bell-like, etc.) to control selection of related timbres. Since eight symbols (A through H) appear in the tree structures, 64 total sounds sources were used, organized into 8 groups of 8 sources each. Eight chords were defined for each movement, each containing eight microtonal pitches transposed to up to eight different registral groupings. Eight spatial "distances" were defined along with eight dynamic levels, eight tempos, and eight grain periods. Another set of similar parameters were defined for background sound material. This sound layer was mixed by transposing the same source sounds and shaping the results with envelopes. Percussive bell sounds and other events were added at select locations where global changes occur in the tree structure causing drastic changes in content. The foreground material, however, is always the most prominent.

Fig. 7 contains two snapshots of the first movement in the graphical editor. The top snapshot shows the top four levels of the tree while the bottom snapshot shows a section of the lowest five or six levels (corresponding to slightly over one second of musical material).

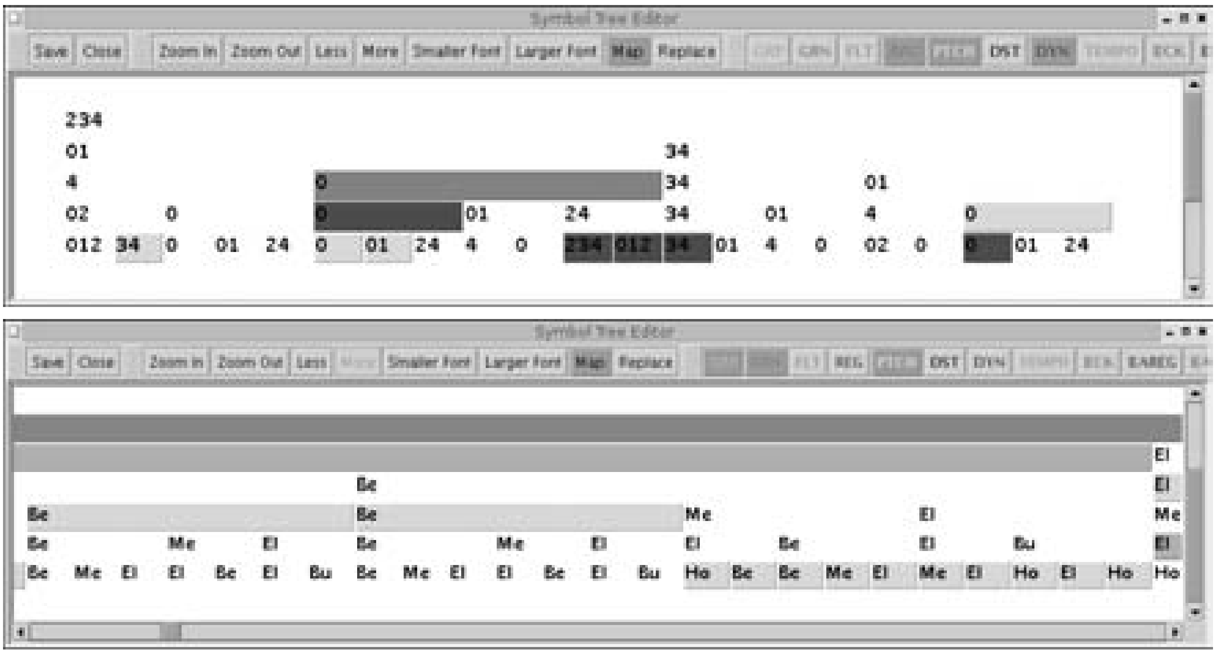

Figure 7

Each illustration is showing information related to the currently selected interpretation rather than generic symbols. In the top snapshot the numbers correspond to registral groupings. (The tree is truncated so that only the top five rows are shown.) Four registers are defined, numbered 0 through 4. 0 corresponds to pitches from approximately 30Hz to 75Hz, 1 corresponds to 75-200Hz, 2 corresponds to 200-600Hz, etc.. Pitch information is selected according to whatever register assignment is “active” at any one point. The medium gray block at the top, for example, indicates that the entire section of the piece represented by the “0” is to be in the lowest register (roughly one fourth of the way through the piece to a little over one half of the way). This is clearly heard and drastically effects the perceived form of the movement. The rest of the blocks indicating register assignments fall below the area where the tree is truncated, so do not appear in the illustration. The two other colors indicate interpretations for pitch and dynamics and appear where large sections of the piece are dominated by a static frequency or dynamic level (a button must be pushed to display pitch numbers or dynamic values instead of registral groups).

The lower illustration shows several assignments occurring at the micro level. The letter pairs here indicate timbral categories (corresponding to the sets of source file groups mentioned above) such as metallic sounds (“Me”) or bell sounds (“Be”). The light blocks at the bottom indicate grain selections within these categories and translate to a rapid, rhythmic shifting of timbre after everything is mixed.

7. Future Work

This and other methods related to non-linear systems work well with granular synthesis (or micro mixing) because one can easily perceive how the small granular units combine on multiple levels. The effects of the algorithm are harder to perceive in acoustic music since the results are largely mediated by notation and player/performance considerations. This will be the subject of further experimentation. The author is also currently experimenting with ways in which the composer's “interpretation” choices effect how the tree itself is generated.

8. Summary

This paper has presented a method of composing based on interacting with symbolic tree structures, using a graphical editor to express their content using assign functions or “interpretations.” By assigning interpretations to different levels the composer has control over which musical parameters are static and which are changing at any place in the piece. Changes always occur in accordance to patterns appearing in the symbolic structure so that similar musical events materialize at different tempos. The constant shifting of interpretations between hierarchical levels (global and local) produce sequences of similar motives and patterns in a constant stream of variation. Recognizable motives repeat constantly at different transpositions, dynamic levels, tempi, timbres, etc.. The musical surface that results can be rich in gestures and sounds that constantly reshape themselves and organize into higher structures. These aspects are audible and can be shaped into dramatic musical events that create and resolve tension as they direct the listener from the beginning of the piece through to the end.

The emphasis on hierarchy in both the symbolic structure and the interpretations (the relation between tonal center, scale, chord and pitch is a hierarchy, for example) accounts for much of the richness described above. Deciding where to assign interpretations is analogous in some sense to zooming in and out of the display of a fractal. The composer decides which details are heard at any moment and what musical aspects he or she uses to define larger phrases or sections.

The most important aspect of this approach is the context in which decisions must be made. A fair amount of exploration and experimentation is necessary for the composer to become familiar with the structures and to express the work's content through them in meaningful ways. In doing this, the composer must adapt his or her thought processes to a complex system that imposes its own interpretations beyond the composer's intentions. A balance exists where one aspect of the process is “modifying” the other to some extent--the effects of the system are filtered by the composer's decisions while decisions are in turn made in a context where they are distributed in a complex manner and may have uncontrollable consequences. The final product is a synthesis of the two elements.

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Generating architectural spatial configurations. Two approaches using Voronoi tessellations and particle systems.

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Abstract

It was one of the primary goals of the original Master’s programme in Computing and design at UEL in 1991 that we should work towards defining morphological generative processes for the conceptual design of architectural objects. These two papers offer a range of techniques which have been developed by two of this years MSc students (04-05) which show that we are getting close to this. The approaches range from computational geometric approaches (3d parametrics and voronoi diagrams) to emergent spatial orgaisation using agent based modelling. In many cases the resultant geometry is defined to the point where it can be transferred to advanced evaluation and fabrication systems, thus making this work sufficiently developed to begin to form a useful part in practical design processes.

Paper 1: Stefan Krackhofer Form evolution - organised spatial distribution

based on CA and Voronoi information

In my profession as an architect I aimed to develop a system, where space per se actively communicates its needs and reactions to changes in its environment. In contrast to many other professions and sciences; Architecture also has to create complexity and space. As such, collecting and processing of information becomes an important part of computable space in order to make and support decisions and consequently to change, adapt or manipulate space.

The implementation of a space-filling topological structure - the voronoi diagram - simulated the natural information exchange of particles in the environment. The voronoi approach subdivides the whole space into a set of sub-spaces according to the distribution of the objects. Each vertex represents a voronoi-cell and thus has its own Voronoi space which defines implicitly the spatial adjacency with the adjacent objects. Within the Voronoi cell, contained locations are closer to that object than to any other and thus creates a spatial relationship. The adjacent relationships between the spatial objects are reflected from the tessellation and are represented by the Delaunay triangulation.

The voronoi foam enables the collection of spatial information, the detecting of spatial characteristics which can be classified and organised into coherent pattern, as well as the manipulation of information and therefore space itself.

Supplied with the Voronoi information a new generated system starts to perceive and adapt and co-adapt itself to the environment according to its inherent nature (tasks or rules).

1.2. Introduction

Our environment as perceived is in a state of permanent flux, triggered by invisible forces of nature and the natural laws of feedback and relationship. Science describes, that naturally observed physical phenomena, from galaxies colliding with each other to quarks jiggling around inside a proton, can be explained by “fundamental interactions”, a mechanism by which particles interact with each other. Observing this mechanism closer we have to add, that particles do not directly interact with each other but rather generate a field, which affects the behavior of distant objects. Information or knowledge is transmitted through the medium of each particle’s individual field. The spatial environment can thus be understood as a complex system structured by relationships between particles. Consequently, we can note that the system’s manifestation as a spatial configuration communicates its inherent knowledge as visible information. Perceived space can thus be translated as a map of pattern of complex relationships between particles.

1.3. Personal Space

In my experiments I focused on the “field” and the data exchange within this medium. Exploring the field - the sphere of influence around particles, which I rather term the “personal-space” (PS), I derived a concept which is stated as follows: “Space is made up of particles and their relationships. Interaction and communication is made possible through their personal space and dependent on the neighbor relationship, based on CA principles.”

The developed analytical software tool generates a personal space around a vertex and detects its neighboring vertices for interaction. I translated this concept into reality by use of the computational geometries that are referred to as Voronoi diagrams and its dual concept Delaunay triangulation. However, in order to reach an authentic 3D description of space, the structures had to be translated into 3D. Thus, the Delaunay triangulation turned into a Delaunay tetrahedralisation and the Voronoi into a 3D Voronoi-cell.

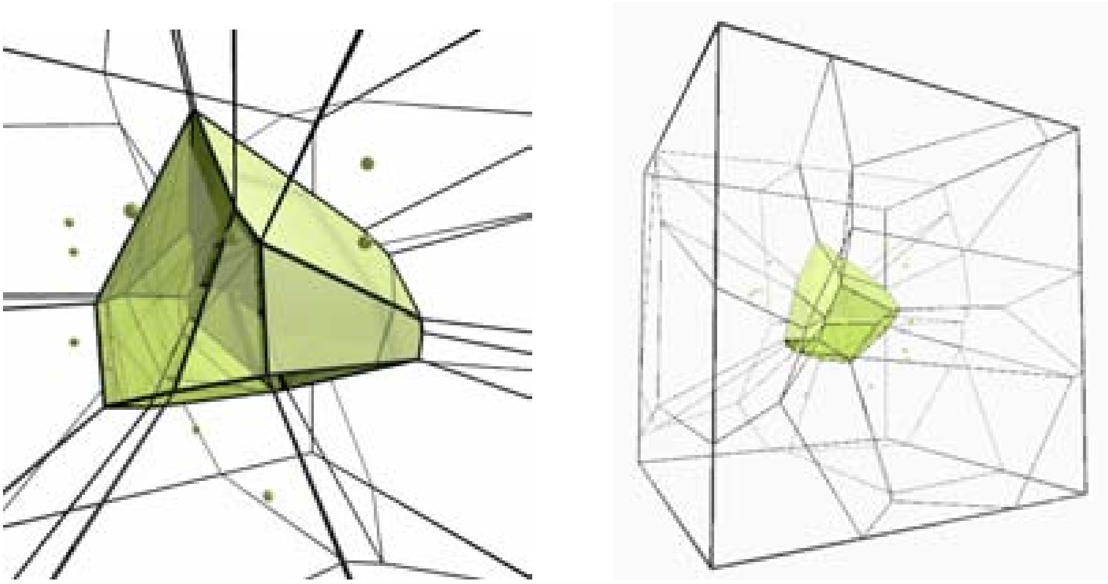


fig 1 3d voronoi

1.4. Description of the Voronoi approach

The Voronoi diagram generates a space-filling topological structure and is one of the most fundamental and useful constructs defined by irregular lattices, emphasizing its excellent applicability in modelling natural phenomena, the investigation of their mathematical, in particular, geometrical, combinatorial, and stochastic properties, and its computer-based constructability and representation. The Voronoi approach subdivides the whole space into a set of sub-spaces according to the distribution of the objects. Each vertex represents the center of a Voronoi-cell and thus has its own Voronoi space which defines implicitly the spatial adjacency with the adjacent objects (or the “influence space” of the objects). Within the Voronoi-cell, contained locations are closer to that object than to any other and thus create a spatial relationship.

1.5. Description of the Delaunay approach

The adjacent relationships between the spatial objects are reflected in the tessellation and are represented by the Delaunay triangulation, which maximizes the minimum angle of all the angles of the triangles in the triangulation. The triangulation of space defines the nearest neighbours of a vertex and generates a topological network.

1.6. Coupling of Voronoi and Delaunay

In coupling both approaches I generated a network of topological relationships such as connectivity, minimal-adjacency and maximal-adjacency. Further, the grouping and demarcation of equal or related entities can be conceived from the Voronoi-diagram.

The Voronoi foam enables the collection of spatial information, the localization of spatial characteristics which can be classified and organized into coherent pattern, as well as the manipulation of information and therefore space itself.

1.7. Application of the Voronoi foam

In the application, the procedure is described as followed:

During the initial - the preparation loop, all verity of the CAD–model are saved into “object” arrays and receiving the name of the object as their ID, which they are belonging to.

The observation loop generates the boundary condition for the system around the area which is defined to be observed. The user defines the boundary by drawing a box on the screen around the area of interest or the program chooses the edge of the CAD-model as its boundary.

Now the algorithm can start to compute the relationships by starting with the triangulation, followed by the generation of the Voronoi foam. Each vertex has its own Voronoi space and after checking the vertex ID, the vertices with the same ID are grouped together to evolve the object’s personal space. By now each vertex can receive information from their neighbors, since the system is based on CA principals. The information can be position, distance, volume, color, whether it is shadowed, temperature, ID, size of the whole object (bounding box), the amount of neighbors the neighbor cell has and so on.

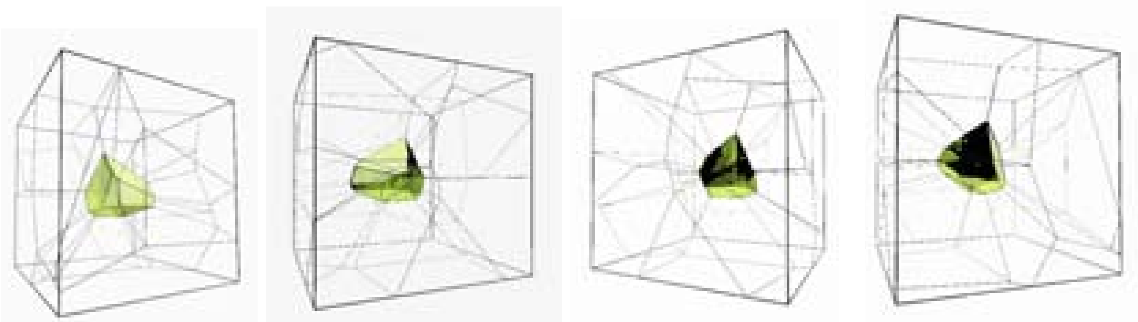
1.7.1 Way finding

The Voronoi foam was than implemented as the background information into navigation, especially way finding. In order to find the shortest way from object “A” to object “B”, all boundary vertices of “A” ask their neighbours outside their personal space and they ask their neighbours and so on till they find “B”. This search approach evolves a network of interlinked tree-structures. The path between “A” and “B” can than be drawn by following the branches of the network. By now the path is “as the crow flies” and has to be corrected to the space in between the objects.

1.7.2. Occupation analyses

Another application for the Voronoi foam is in the occupation analyses of space. In that case the search agents are themselves the centre of Voronoi cells. During the search the agents receive information of the surrounded cells. If the information such as distance, brightness, height, …fits their inherent needs, the agent occupies this position.

fig 2 3d voronoi showing spatial organisation within a cube



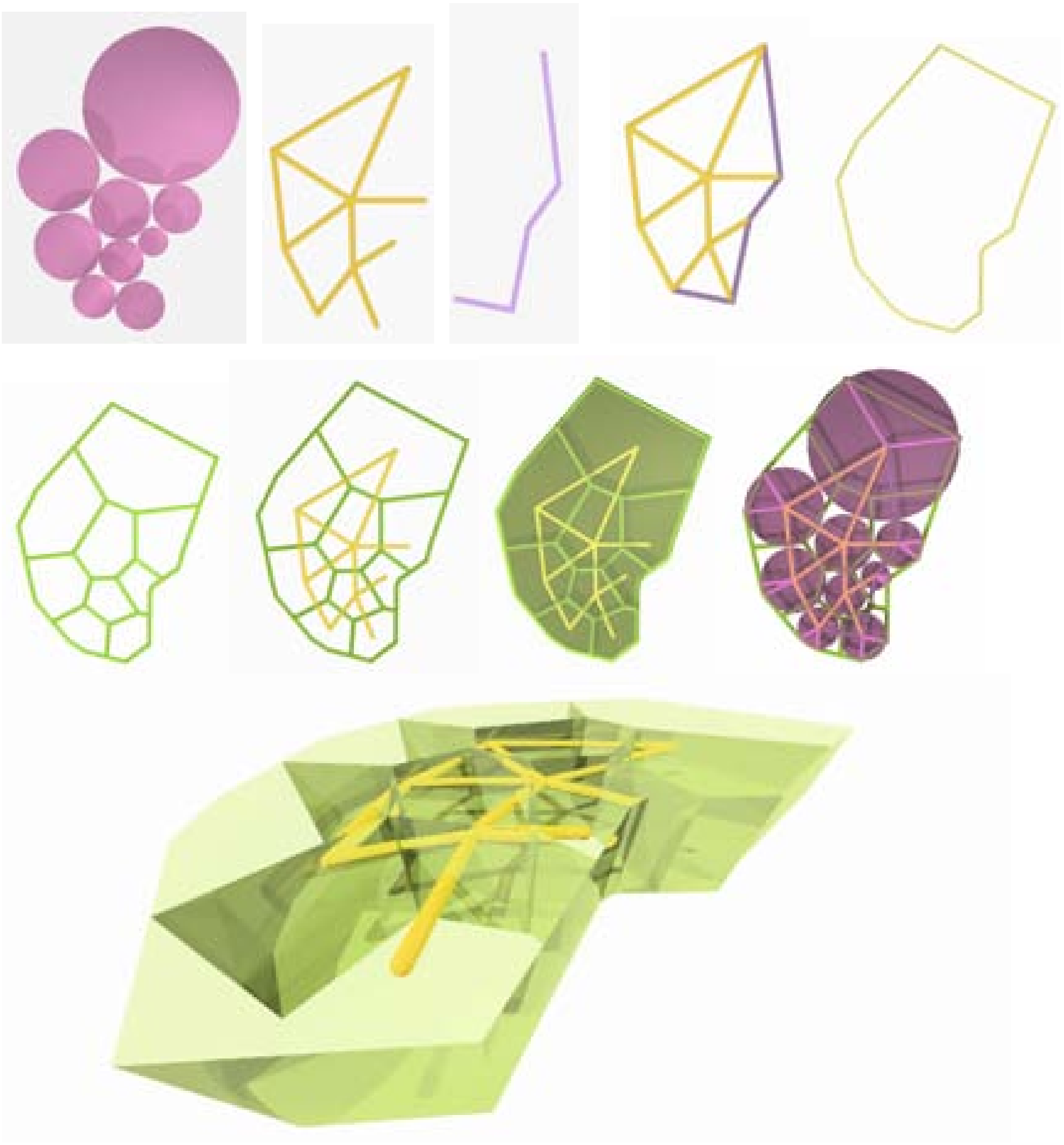
1.7.3. Space evolution

The active process of generating and evolving spatial forms demands the introduction of a process which leads to equilibrium among all entities of a system, the theory of self-organisation. In the context of architecture I find it more suitable to refer to this process as co-adaptation (structural-coupling) among the parts triggered by feedback.

“Form”, is the fixed goal in architecture and thus the aim was to develop an algorithm which generates “form” out of complex relationships among disorganised subsystems.

In order to apply a method of organisation, subsystems or functions have to be defined and set in dependency to each other and to general attractors. As such a clarification of the term “function” has to be found.

The Images below describe the process of space evolution. Starting with a self-organisation of functions followed by the application of the Voronoi foam.



1.7.3.1. Feeling a pre - Image of Function

Function can generally described as the accumulation of needs, however, if we were to define function accurately, we have to consider that this demands knowledge of the occupants, their needs and desires, consequently their feelings. In order to take human feelings as the core motive for architecture we have to analyse human behaviour in their environment or interview them in order to translate the results into an algorithm which generates the pre-image of function.

This would be accompanied with a tremendous effort, yet, worthwhile since utilisation, size, proportion, orientation, and neighbour-relationships could then be derived.

As such, an efficient way of accumulating relevant data is to obtain the information from tradition, building-regulations or in case of competitions, from the "raum-program".

Deriving the functions from the "raum-programm" was within the way I took. Starting with the translation of the "raum-program" into an array subdivided into sub-systems and organised according to their relationships. The sub-systems were then substituted by autonomous intelligent agents who have knowledge of their position in space, know who their nearest neighbour is, know who its aimed neighbour should be and its preferred orientation.

1.7.3.2. Self – organisation and boundary condition

By now the system is prepared and ready for the self-organising process to act on. Realising that we do not have the possibility of parallel computing, I decided to start the process, step by step, by increasing the fitness of one agent after another, until the topological network is reached. Followed by activating external attractors, such as feedback of the occupied space, sun, orientation and shadowing, which led to unexpected chaotic phenomenon and finally to the collapse of the system. It turned out, that the direct interconnection of subsystems did not allow any adaptation, since this would simultaneously result in the loss of fitness. In other words, the demarcation or boundary conditions had to be rethought.

The nature of the boundary between entities became a serious question. I observed that the highly fluctuating dynamics of interacting subsystems were triggered by small changes of their position, even when one subsystem was in equilibrium. This phenomenon caused an imbalance of the whole system and resulted in a permanent fluctuation, never (at least not for a very, very long time) reaching equilibrium.

Struggling with this problem I remembered how I started to design with paper and pencil (outside under the sun, relaxed, free and independent), even with wobbly strokes it was relatively easy to develop design. Or, do I now realize that the wobbly stroke was exactly the cause for a good development? Musing on this fact, I realised that the system demands a wobbly stroke. I came up with the concept of a precise system encased within a viscous medium that allows for uncertainties. If the optimal orientations of two functions in a precise system are incongruous to one another, the positions of the other functions are compromised as they are directly moved out of place by the local optimisation. Whereas, in a viscous medium, the functions are able to move freely around the centre of their axes without disturbing the adjacent functions, allowing for an overall optimisation. Consequently, we have to pay special attention to the medium as it assumes an active task and therefore requires a dimension; in other words, an embodiment.

First I rejected the idea that a system inside a system requires a system to exist, but I realised that this is exactly the case. The boundary maintains the equilibrium of its inherent systems even when the boundary's environment is fluctuating because it can absorb a certain amount of turbulences and stress.

Developing this idea of absorbing and balancing further in an architectural-engineering context, structural tasks can be assigned to the boundary-dimension. Considering that all systems are nested and exchanging information, force visualised as information can be trickled through the system so as not to irritate it but arrives at its destination where it can be absorbed.

In all, my concept illustrates the implementation of functional organisation with structural trajectories, which are enclosed within the boundaries. It is obvious that another dimension of feedback evolves within this constellation, which I would define as mutual (co)adaptation. Before the subsystems reached equilibrium they already altered the "form" of the whole system. The system feeds back the "new" information about "external"-forces which needs to be carefully diverted through the system. Continuing this process results in "general" equilibrium, or as I would call it in the vocabulary of architecture: aesthetics, where beauty originates from needs.

1.8. Conclusion

Generating spatial effects enabled through simulating phenomena of space, material, light, wind, sun, sound, or behaviour clarifies that architecture is increasingly becoming a simulation rather than a representation of space.

The study of architecture therefore has to consider simulation as a powerful design-tool, in order to understand and implement complex relationships. The educational nature of simulation shows itself when developed through the use of algorithms in programming, altering the study of architecture. In carrying out experiments and writing algorithms, I learnt that the ability to identify pattern is fundamental to the design process. As such, the personal interaction between student and algorithm supports an increase in the understanding and knowledge about patterns, their relationships and compatibility. This process trains one to work with pattern since experience can be gained from feedback, whether visually or accoustically, triggered by the students' decisions and actions.

The "system-view" of architecture which has the goal of designing a system rather than a form will change the way we study and practice architecture; and will likely lead to an increase of quality in architectural design.

In order to facilitate this shift, designers should strive for a conscious transfer of authorship. Following my experiments, my position evolve from the role of dictating the behaviour of subsystems to the role of coordinating them which can be illustrated by the following analogy: from an audience's point of view, the conductor dictates how the orchestra should play the music and is the driving force behind the musical performance. From the musician's point of view however, the role of the conductor is not to dictate but to improve the whole by coordinating creatively. He is merely piecing the entities together into a harmonious whole. He is no longer the centre of the performance / design but part of it.

As such, the definition of architecture is becoming more complex than before, but with the significant advancement that the architect is not the centre of change, but an important conductor in the system. The system “architecture” interpreted as a subsystem of our environment led to the research in nature. In all, nature is an open system with inherent invisible laws of feedback and relationships which strive for equilibrium. The tendency towards equilibrium is manifested in the process of self-organisation. The result of this unique process is form. Ultimately, nature knows best how to create form, not in the sense of a random shape as we commonly perceive form to be, but as an equilibrium between entities. If we are to be as good of a designer as nature is, we must find a way to successfully implement the process of self-organisation into architectural practice. The results of my experiments of self-organisation showed a promising first step in its applicability in architecture. Although the algorithms did not perfectly organise the entities, the final form was a satisfactory compromise.

We must realise that natural design is merely “good enough” to fulfil specific tasks in relation to its environmental system. It is barely optimised for these specific tasks, forever a good compromise between all entities in a whole.

I was able to exploit a sliver of the playground of biological evolutionary systems, yet there is so much still to be uncovered in Mendel’s garden of architecture.

Paper 2: AbdulMajid Karanouh Architecture, Agents, & Hyper-Surfaces:
High-Tech Building Envelope Generative Design

2.1 introduction

We have always admired and observed how natural systems are generated in nature and how different intelligent technologies and behaviours emerge during the generative process and how superior those technologies are to the ones we use to generate and construct our own designs and systems. We understand that all elements of any system found in nature, whether ‘live’ or ‘dead’ ones, take part in the formation and generation of the system’s complexity by the numerous interactions that take place among those different elements themselves and among other elements of neighbouring systems as well, thus establishing an infinite network of data exchange in its various existing forms, states, and magnitudes, connecting together not only all systems found in nature, but also all systems found in the universe. This might interpret the superior intelligence of natural systems in nature and the universe and the great harmony in which they coexist.

From nature we discover that all systems behave like swarms where groups of agents of various types and behaviours following simple rules can generate the simplest to the most complex forms and designs. For this purpose, we have to be able to design systems made up of virtual agents that can behave like swarms, self design, and self organize themselves and their positions and relationship in 3D space.

Computation may not be the best solution ever for this task, but its flexibility, data storage capacity, speed, and accuracy makes it a convenient choice for now.

Many complexities arise from generating nature-like form buildings of which one of the most critical and delicate case is the building envelope. Computation can help us explore ways to generate complex surfaces with integrated mapping, pattern, and structural elements and pave the way for Mass Customization.

Two different conceptual approaches can be used to develop generative design process;

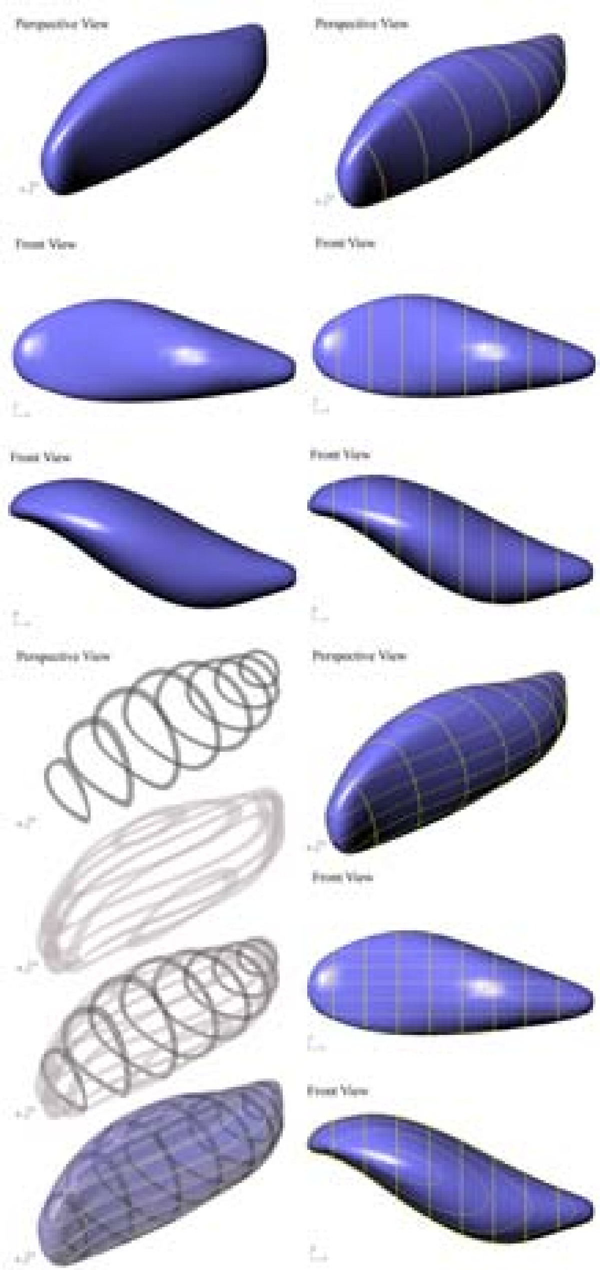
Emergent Generative Design: Agents will be given simple rules to follow with little movement restriction. The swarming behaviour of the agents will be left to self organize their position in 3D space from which some unplanned forms and structures may be expected to emerge.

Parametric Generative Design: Agents will be given more defined rules to follow based on mathematical relationships associated to controllable parameters where if one parameter of a group of agents is changed, the parameters of other groups will self adjust and the agents will self organize to accommodate the new modification.

Agents under Emergent or Parametric computation rules can represent anything from the users to the very finite building components and nodes interacting together and responding to abstract positive and negative mathematical force fields with controlled magnitudes.

With this bottom up approach complex systems and forms can be generated from simple, finite, less complex, and self organizing agents.

2. 2 Preamble



Designers in the architectural domain have mostly been interested in studying natural complex emergent designs and forms that involve inhabitants living in communities like the anthills, beehives, bird nests, and other similar systems and geometries which we generally refer to as Organic Forms and lately as Blobs. Free-form designs, generally known in the architectural field as Organic Architecture and lately as Blobs. The dominant formal vocabulary of blobs is their generally double-curved surfaces which have special functional, spatial, structural, and aesthetic characteristics compared to common buildings as we know them today.

Architects face several problems when dealing with blob designs, mainly as follows:

A- Design Concept

There is no established principle or theory concerning the design and production of natural complex forms that can be a useful source providing feedback to the designer especially in the conceptual design phase.

B- Structure & Pattern Integration

In a common CAAD environment, complex geometric forms generally exist as surfaces without structural, material, mapping, or functional considerations. Although several advanced CAAD packages are available now, still, the engineering and technical aspects cannot yet be tested in common design visualization software.

[Klinger 2001].

fig 3 some parametrically defined morphologies

C-Data Exchange & Fabrication

3D data exchange between CAAD/CAM/CAE applications has not yet become a standard process, thus the fabrication and production of the mass custom components is still considered as a major barrier by most practices due to this missing link of data flow and relative high cost, and thus avoid exploring further methods for generating blobs.

Design Automation using both Emergent & Parametric Generative Design can integrate the vast data related to A, B, & C by utilising agent based computation rules where different components are generated from different groups of agents. Each component is generally unique in size and position in 3D space. The data generated from the Design Automation process will be digitally used for Automation Fabrication and thus paving the way for Mass Customization [ONL 2003].

2. Conceptual Approach

Swarm Intelligence: Simple rules will be used and constantly modified to explore the various behavioural changes within one swarm, and the general behavioural changes among different swarms and those changes will result in various generated forms.

Bottom Up Design: By starting the design stage with the finest and simplest agents and elements that will gradually generate the whole complex system.

Biomimetics Extrapolation: A mix of biomimetic extrapolations will be demonstrated in one of the experiments to generate a form and its structure with CAD by using both implicit modelling and explicit programming oriented modelling.

2. Computation Principles

Agent: Based on the principles of Nanotechnology, Swarm Intelligence, and the Bottom Up approach for generating complex systems starting by less complex actuators, Agents will be used in groups of various types to represent various elements of the building envelope and various elements of the context.

Hill Climbing: as the Agents will be able to learn and adjust by changing their attraction or repulsion reaction towards other agents according to how they perceive the changes taking place around them and thus set their 3D space.

Self Organization Map, as the Agents of the Swarm will be self organized based on simple rules follow. The will be able to check their neighbouring Agents of the same Swarm, and the Agents of Neighbouring Swarms and self organize themselves according to their position in 3D space and the behavioural rules set for them.

Mapping, Agents will connect each other with elements according to different rules, thus generating different meshes, tessellations, patterns, and structural guidelines integrated into the generated envelope.

Fig 4 Netlogo project interface

2.3. Experiments

The experiments will be divided into two categories based on two different conceptual approaches and carried out with different software and programming languages; Emergent Generative Design using NetLogo 3D-Logo, and Parametric Generative Design using AutoCAD-Visual Basic for Applications (VBA).

2.3.1 Emergent Generative Design

The general idea of this approach is that no pre-determined forms are set in the computation code. Simple abstract rules are given for the agents to follow and unplanned collective behaviours might be expected to build up from groups of various types of agents and thus unexpected forms might emerge during the process.

The Turtle is the name used in NetLogo 3D to describe an agent. There will be 4 types of turtles used in the following experiments:

Common Turtles [CT] agents representing the surface nodes swarm as grey spheres

Unique Turtles [UT] agents representing the swarm that can only dominate the nodes swarm as yellow spheres

Supreme Unique Turtles [SUT] agents representing the swarm that can dominate the nodes and unique swarms as red spheres

Edge Turtles [ET] the agents representing the connections and mapping generated by the nodes as blue cylinders.

The force field around each agent is represented with another sphere of the same but slightly intensity reduced colour.

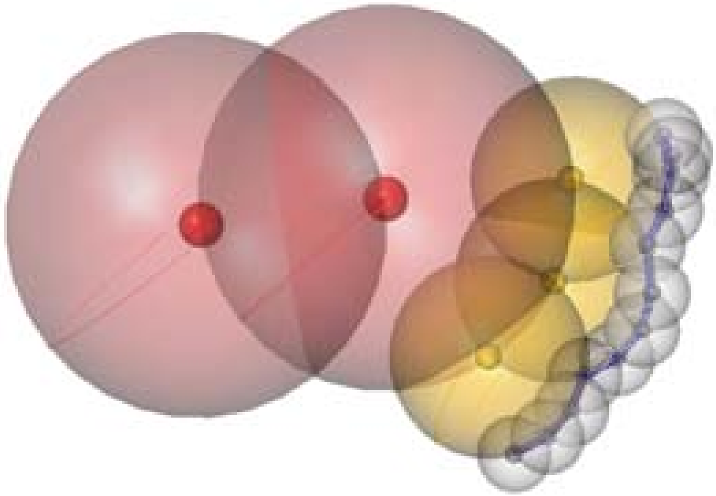
The Algorithm:

1. Each Agent scans every other agent and measures its relationship and distance to it.

2. Check own force field and other agent force field and compare to the separating distance.

3. If separating distance is greater than force field then travel forward 1 step module, Else repel backwards 1 step module.

4. Grey CT agent checks for closest neighbouring CT agent and connects it with an ET agent.



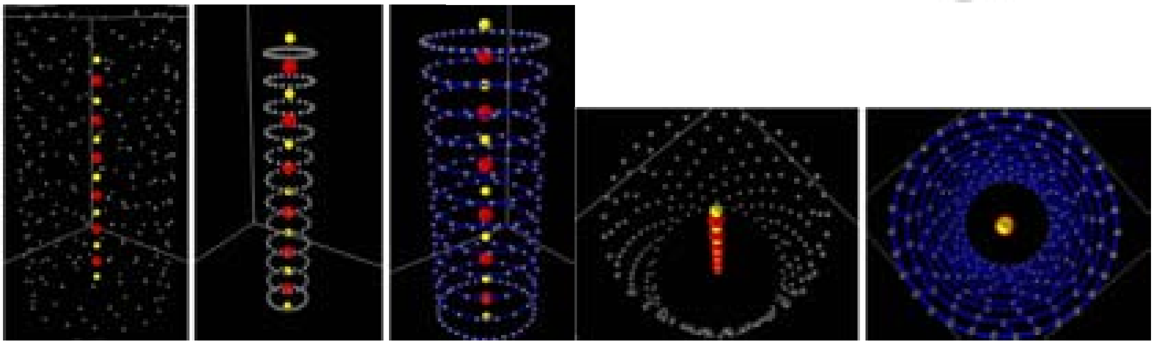


Fig 5 CTs forming spirals ETs forming basket-structure

Trusses emerged at each floor level

Trusses emerged at each floor level

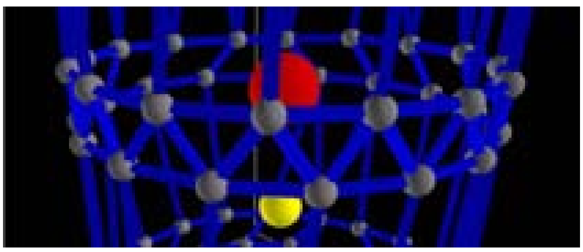


Fig 6

The image above shows the attraction and repulsion relationship between different agents. Notice that the Red SUT Agents are positioned at each others´ force fields bounding spheres and not being influenced by other agent types. The Yellow UT Agents are positioned at both their own and Red SUT Agent’s force field spheres and not being influenced by the Grey CT Agents. The Grey CT Agents are bounded by their own and Yellow UT Agents’ force fields and being influenced by the Red SUT force field. The Blue ET Agents are the cylindrical members connecting the CT Agents. The images in Fig 5 (representing a building with its core) and bottom Fig 6(representing blob of blobs) show clearly how different forms, patterns, and structures can emerge from the simple rules and relationships given to the agents to follow.

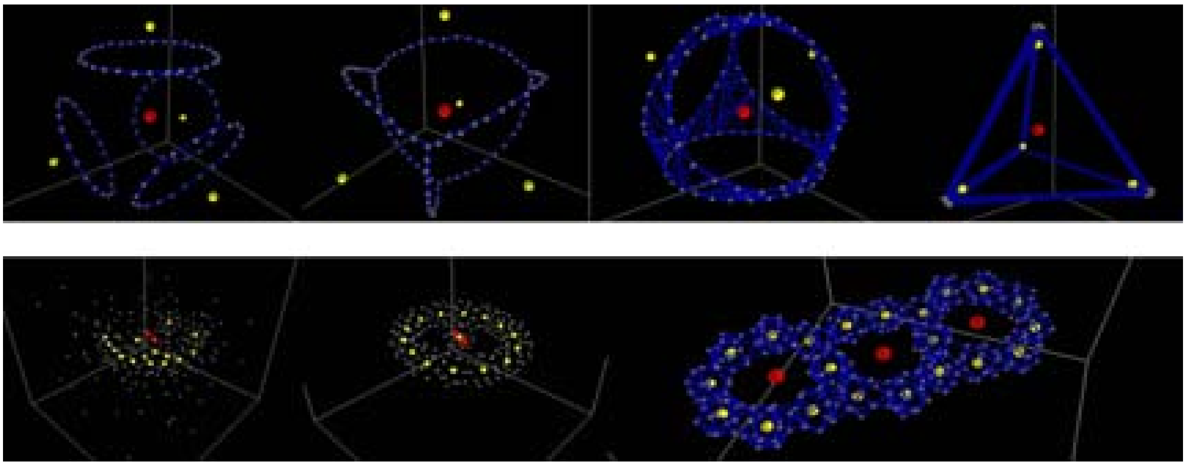


Fig 7 more emergent morphologies using Net Logo

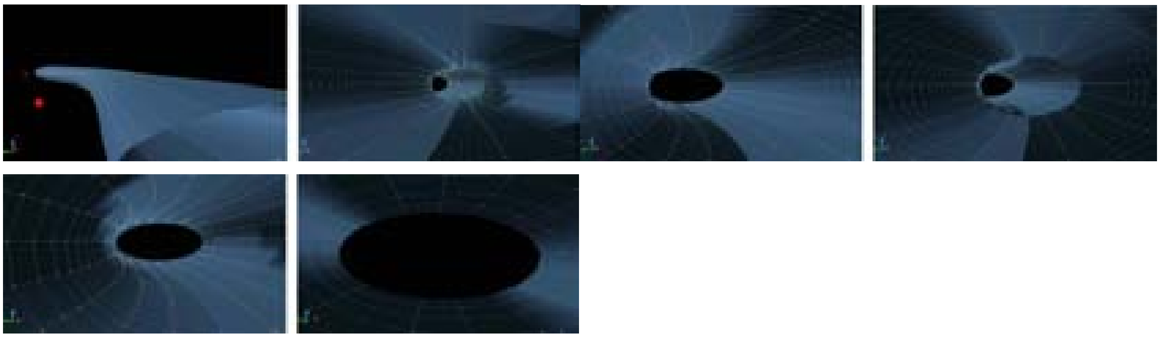
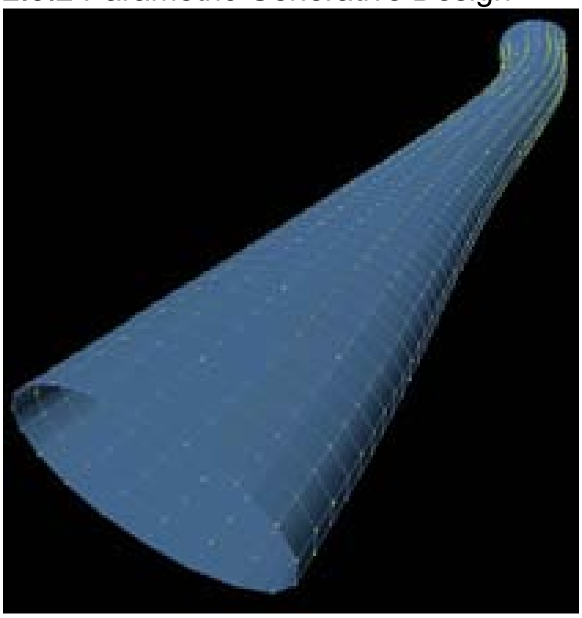


fig 8 steps 1 – 6 referred to in the text below

2.3.2 Parametric Generative Design

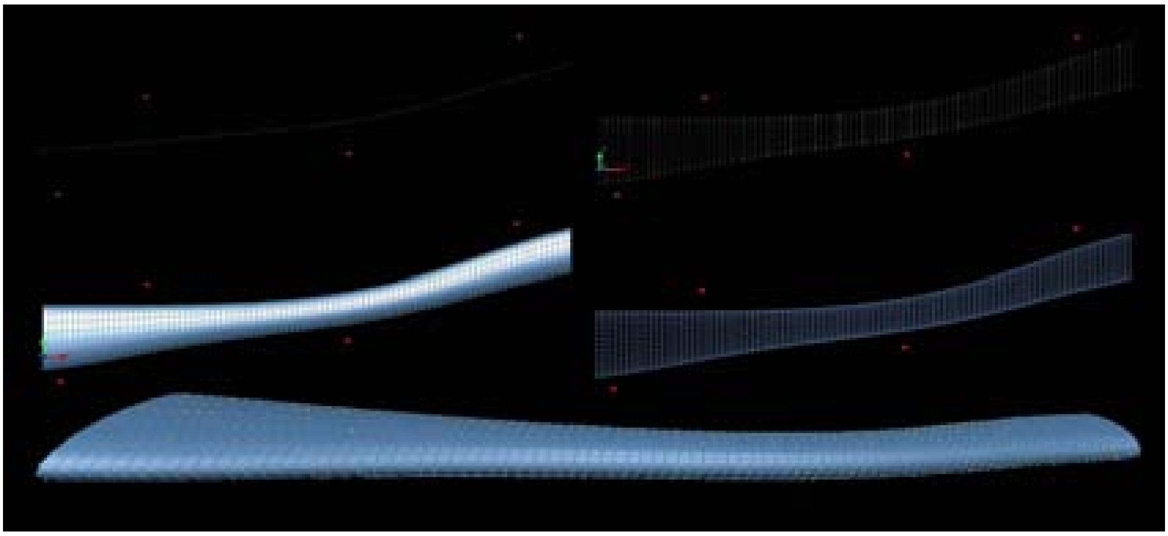


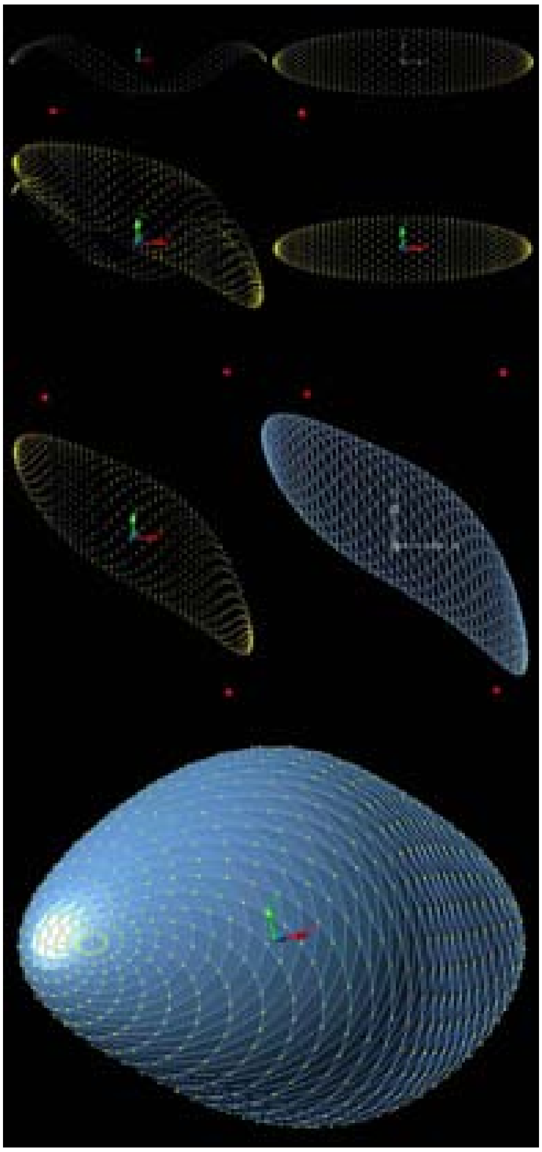
The concept of generating complex forms and mappings from simple rules will be maintained as a major part of the whole approach criteria in this section as well, but there will be no forms or mappings emerging unexpectedly. Everything will be carefully planned and agents will operate according to well set mathematical equations, and parameters. The exact position of each agent will not necessarily be predicted rather than the general form, mapping, and structure expected to be generated. The agents will still self organize and self learn, but restricted to follow a well defined order.

The Algorithm:

1- the ‘seed’ is set and the node-agents (yellow dots) take the form of a cylinder and are ready to interact

2- the source-agents are then inserted (4 red spheres in this case)





3- each node-agent will scan its surrounding checking its distance with the neighbouring node-agents simultaneously and the its distance to the source-agents consecutively

4- The node-agents will check each others' results, and will arrange themselves in order, starting from the closest node-agent to the source-agent (winning node) down to the furthest one.

5- The closest node-agent will travel the longest step towards the force-agent. The step is proportional to the distance between the winning node-agent and the source-agent. The rest of the node-agents will follow in with shorter steps according to a distance proportion parametric equation.

6- Upon each time frame or replication, the node-agents will again check the distances and rearrange themselves and reduce the magnitude of their next steps to accommodate the new conditions accordingly. This process as explained previously is called Self Organization Map and Hill Climbing self learning.

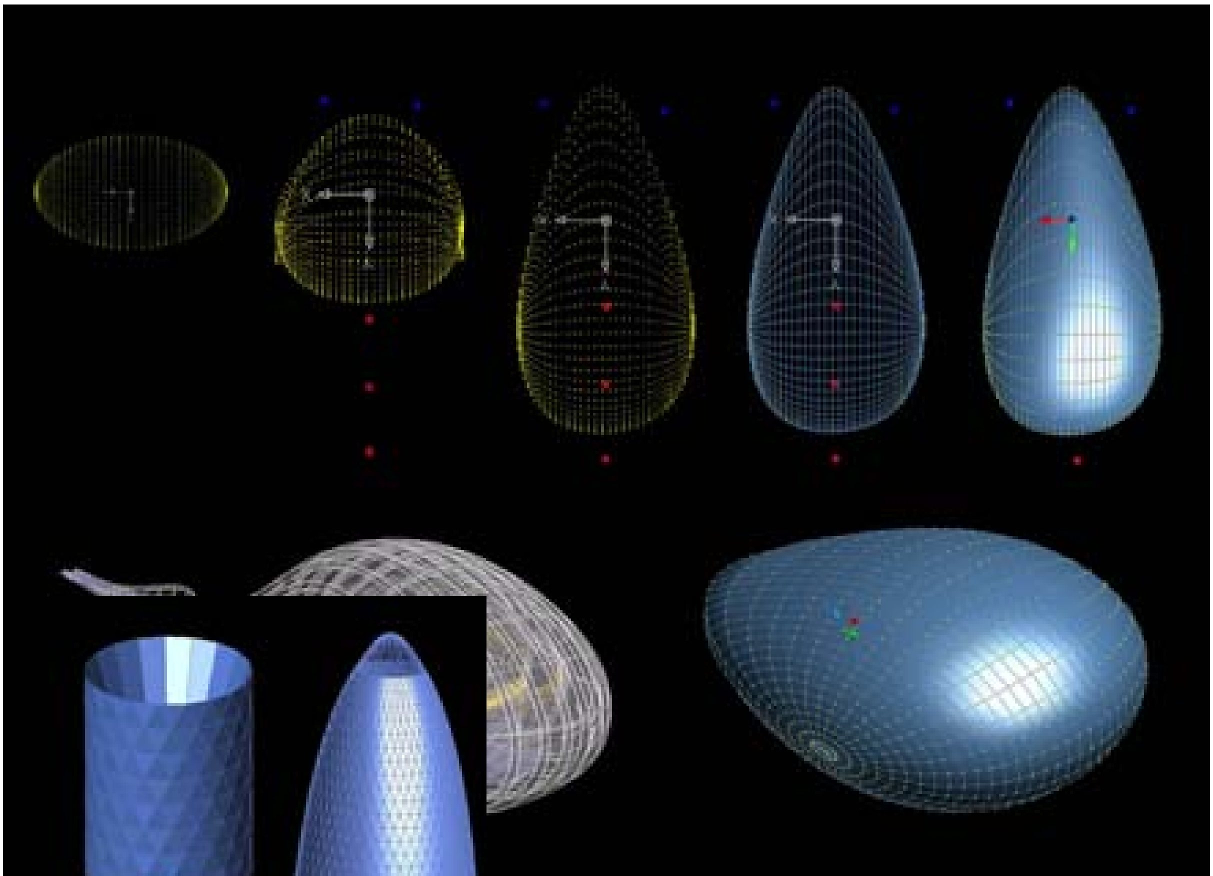
7- At the end of the final time-frame, the node-agents have already taken their final positions in 3D space. A skin is generated to wrap the point cloud determined by the node-agents.

Fig 9 parametrically deformed tubes (force nodes in red)

Image on the leftfig 10 shows the development of a complex blob from initially a spheroid. . This node-agents of the spheroid interact with the source fields (red spheres) and begin following parametric equations and rules and adjust their positions accordingly.

Below,Fig 11 initially modelled in Rhino, the concept was to develop a blob inspired from both the drop of water and radial structures like the sea urchin and spider web. The red source points represent the self weight of the water drop and the blue source points represent the drag force generated by the wind when freefalling. The positions taken by the node-agents at the end of the process are wrapped with a mesh.

Figure 10 complex blob from spheroid



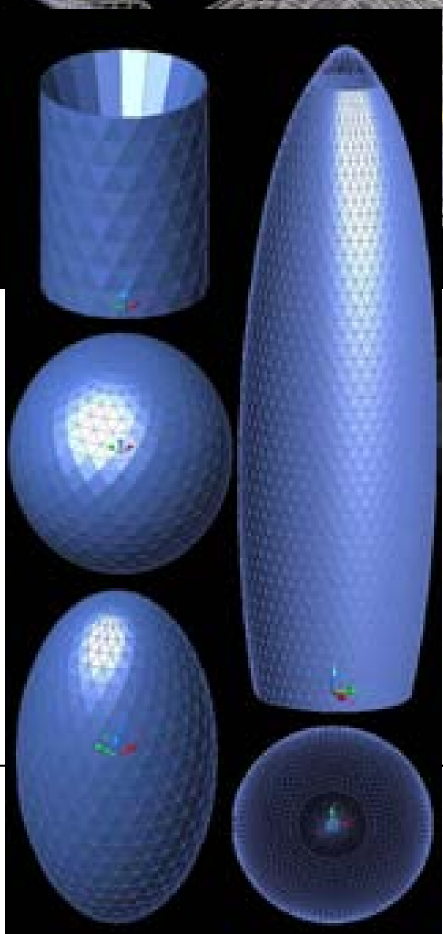


figure 11 see notes above

Fig 12

The images left show clearly the mathematical sequence followed to reach to a form similar to Fosters' Swiss RE

The below fig 13 on the right show clearly the mathematical sequence followed to reach to a form similar to Fosters' Swiss RE

Below Fig13 is a series of tests carried out to see how different meshes with different patterns can take shapes and forms generated from well defined mathematical equations. Dividing the agents into different groups within one mesh allows the user to insert more than one equation into one mesh, thus creating a more complex shape and also providing more control.

Fig 13

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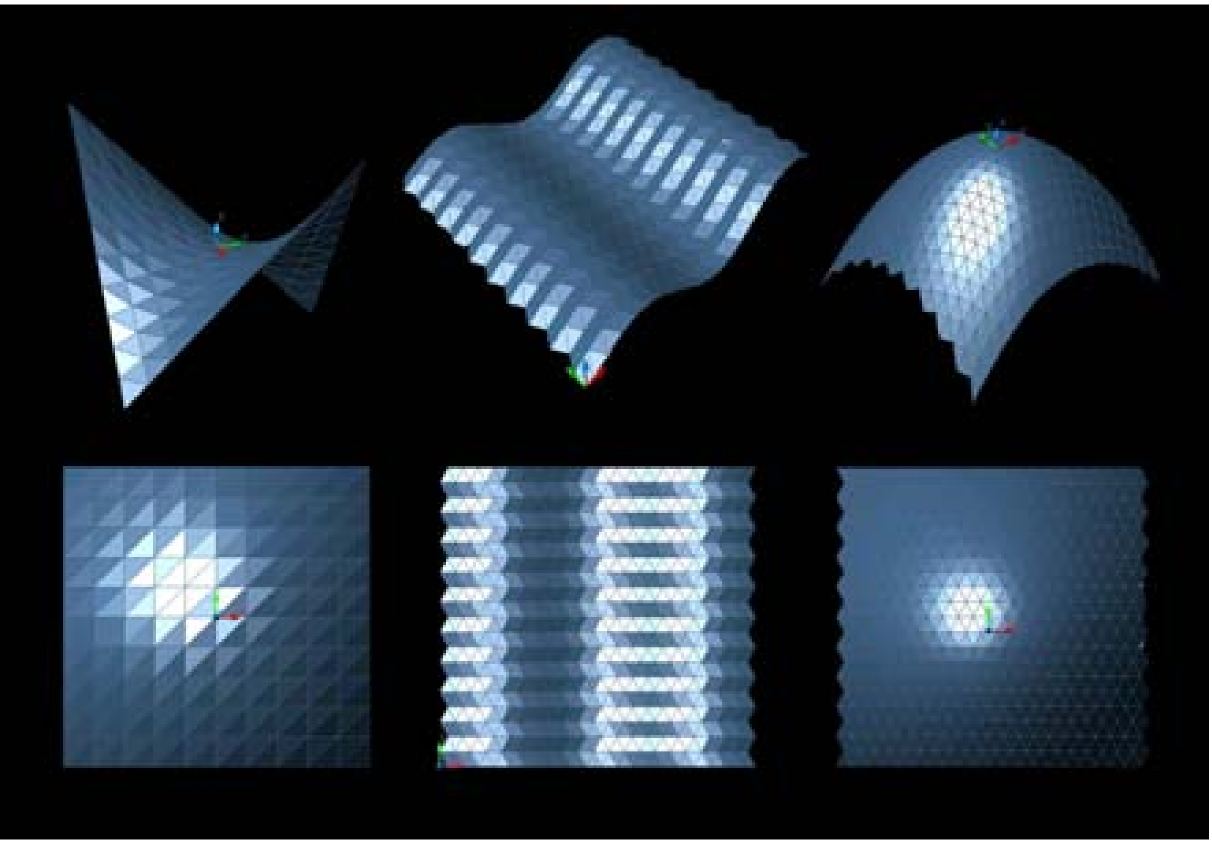

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section 2

Bob Berkebile and Jason McLennan, The Living Building-2004

Dennis Dollens, Toward Biomimetic Architecture, University of Florida • January 2005

ONL, Swarm Architecture-2003

ONL,, Acoustic Barrier-2001

ONL, Hyperbodies-2004

Jesper Hoffmeyer, The Swarming Body-1994

Yahya, Designing Nature-2004

Yahya, The Miracle in the Ant-2004

National Nanotechnology Initiative-2005

David Gordon Collective Intelligence in Social Insects-2005

Electronic Gallery as a Generative Space towards the Contribution to Art and Design Students and the Learning Environment

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Abstract

The environment of Art and Design Faculty is a unique setting of traditions, beliefs, metaphors, concepts and ideologies that has been practiced and layered creatively as the years go by. Today, Art & Design schools are sprouting all over the world where each offers a different content and approach to the basic design syllabus. But this was not always the case. Traditionally artists learned as apprentices to other experienced artists and entered family business. Later they entered academies that flourished and evolved according to time and technology. The product of these schools often goes coherently with the education experience and learning environment. Looking at the evolvement of art schools, the issue that keeps protruding is whether we have a collective node or a common space that can collect, archive, exhibit and bring together all design activities in one multifunctional space.

Multimedia has brought new paradigms to education where users are able to use the technology to create compelling content that truly represents a new archetype in media experience. The synergy of digital media is becoming a way of life where new paradigms for interactive audio-visual experiences of all communicative arts to date are increasingly becoming important.

The Electronic Gallery or e-Gallery of Faculty of Creative Multimedia, Multimedia University is under exploration to see how the gallery as a versatile hybrid container is able to cater for an educative environment which is growing and expanding with time and technology. It began with a basic space with the purpose of holding exhibitions, but as time and need evolve, the requirements require the gallery to be more of a generative space that can initiate art activities and education by being a platform and vehicle in acquiring knowledge and to hold various functions such as demonstrations, exhibitions, performances, discussions, classes, critique sessions, installations, archiving and others. More new media art and exploration can be created and held due to the possibilities offered by the gallery through its multifunction ability, its location and strategic accessibility for design students, its multimedia tools and equipment to suit different user and display different content, its role as a node and to bring together students with same interest in art to display and discuss their work, and lastly to generate the atmosphere and create a setting by offering a versatile space.

Creative ideas to enhance the learning environment will provide students a better setting for the deliverance and experiential organization design students are

associated with a given space, through electronic intelligence and functionality, will not only be more responsive and efficient, it will also be programmable for wider range of activities and new creative scenario for the art education.

1. Introduction

The meaning of generate refers to the act of bringing into existence of being and to produce something as a result of a process [1]. Space on the other hand means a blank or empty three-dimensional area provided for a particular purpose [2]. Thus the purpose of this paper is to research on generative space, what space is all about and in what ways it could generate art activities and education. Architectural and urban space act as containers to accommodate, separate, structure and organize, facilitate, heighten and even celebrate human spatial behavior. Space is also needed for a change of mood, to establish relationship, to separate activities, to suggest appropriate behavior and creates settings which consist of space, its surrounding and contents, the people and their activities [3]. Different space offers different purposes according to the needs and function of the organizing body while some space are unconsciously used for specific reasons due to strategic location and availability of users and means. A study on space reveals many astonishing types, function and category of space, namely physical, interior, exterior, conceptual, perceptual, multi sensory, perceptual psychological, pictorial, mental and virtual space [4].

At the Faculty of Creative Multimedia, the education syllabus implements a fusion of digital media and art with strong foundation of the understanding of traditional elements of art inclusive of lines, shape, texture and light, and also position, context, duration, sound, rhythm, color, temperature, size, motion, height, direction, interaction and meaning [5]. Students with fascination for electronic arts are encouraged to sharpen their skills and knowledge in analog art thus the keen notion in finding ways for students to upgrade their understanding by providing ample and well equipped spaces for the generation of art. At the same time, a high level of prominence is given to seek better quality in the electronic arts as they derive their energy and fascination from the relationship between artist and machine. Attempts to automate art are increasingly successful as developments take place in artificial intelligence, artificial creativity and artificial life. [6]

2. Research Objective

Research is conducted to investigate the purpose of the mentioned e-Gallery and what it aims to achieve in its generative concept. Started out as temporary exhibition unit during students' Portfolio Review, the gallery has evolved into a permanent electronic multi purpose hub that caters to the art education environment and is still growing to accommodate current technological requirements. The art education scenario at the Faculty of Creative Multimedia deals with analog and digital category covering the basic foundation art studies and five major branches of digital media art such as Film and Animation, Digital Media, Media Innovation, Interface Design and Virtual Reality [7]. The fusion of information and educative knowledge has set the art faculty community in need of a common node or platform of collecting and dispersing of art activities, thus the vital function of e-Gallery as a transformer of space that generates current technological information and knowledge. The study is also carried out to find out how the gallery is able to serve the current situation and provide for the future with the incorporation of additional functions, content and technology.

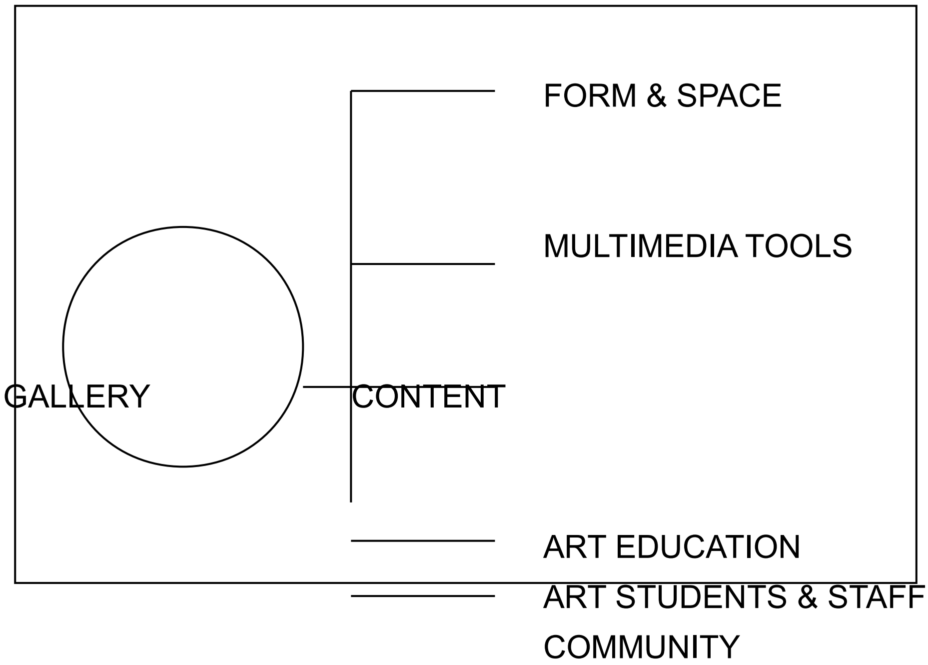

Figure 1. Factors that are considered important in the planning and running of an e-Gallery and form the basis of this explorative study. The factors derived from literature review and past researches.

3. Methodology

3.1 Background Research

To analyze the location of e-Gallery in relation to the surrounding physical buildings and open space.

To examine the function of e-Gallery towards contributing to surrounding spaces in the faculty.

To identify the physical space and function, the aid of multimedia tools, the content, the users and the art activity in the e-Gallery.

To discuss on how all contributing factor leads the e-Gallery to become a space generator for art community of the faculty.

Research Survey

Questionnaires were distributed to staff and students of the faculty as well as local and international visitors of the gallery.

Interviews were conducted with Head of Departments and personals related to the gallery to investigate on benefits and problems associating with the art society and gallery.

4. Findings

After a set duration of time allocated for literature review, case studies and research survey consisting of questionnaires, interviews and experiments to controlled groups and settings, several important findings were recorded. They are divided into:

Diagrammatic linkage on e-Gallery and surrounding on space and function to analyze the relation and impact between space planning and location towards a generative art environment.

Tabulation on e-Gallery's function, aid of tools, content and users. This case study concentrates on the art education and activity that ensues in the gallery focusing on space function and activities.

5. Discussion

Figure 2. Relationship between buildings and open spaces that contribute to the advantages of e-Gallery being a generative space to the faculty.

It can be seen that the location of e-Gallery being right at the entrance of the faculty is at an advantage. The balanced percentage of open spaces and built up areas allow indoor learning activities to over flow to the atriums and foyers of the gallery. The pedestrian pathways that converge to one point at the gallery generates physical factor that leads people to the gallery. Small pockets of atrium ascend gradually as it approaches the open foyer creating an outdoor gallery area to cater for over flow of activity.

Physical Space surrounding e-Gallery	Open Space
Set & Background Hall	Open Space
e-Theatre	Atriums
Design Studios	Entrance Foyer
Workshops	Recreational Atrium
Studio Labs	
Production Area	
Computer Labs	

Administrative Office Book Store Art Shop Café Amneties	

Figure 3. Correlation between e-Gallery and other spaces.

e-Gallery is supported by various multifunctional spaces essential to an art faculty. The location enables staff, students and visitors to pass by, acknowledge and participate in any events conducted. The planning of the buildings is linear with all blocks leading to the gallery resulting in an open space or entrance foyer in front of the gallery. This is in fact the main entrance to the faculty.

No.	Space	Function	Activity	Multimedia Tools	Content	Human Interaction
1	Foyer	Welcoming Area Over Flow Area	Introduction	Computer Kiosk	Faculty Introduction 5 Majoring Information www	Human and Machine
2	Main Exhibition Area	Exhibition Purpose Official Reception Seasonal or Main Exhibition Multi Functional Area	Exhibition Reception Multi Function	Computer Video Projector Audio Visual	Current Exhibition or Function	Human and Machine Human and Human

3	Analog Exhibition Area	Analog Art Works Painting Sculpture	Exhibition Archiving		Student and Staff's Art Works	Human and Art Works Human and Human
4	Presentation Area	Presentation on the Faculty or any Related Function	Presentation Discussion area	Computer LCD Screen Projector	Faculty Introduction 5 Majoring Information www Related Function	Human and Human Human and Tools
5	Discussion Area	Informal Discussion Mini Class	Discussion			Human and Human
6	Demonstration Area	Demonstration	Demonstration Presentation	Computer Projector Screen	Demonstration Information	Human & Tools Human and Human
7	Temporary Display Area	Temporary Seasonal	Exhibition	Computer	Temporary Works	Human and Machine Human and Human
8	Digital Interactive	Exhibition	Exhibition	Computer	Archiving	Human & Tools

	Area		Surfing Information Games	Touch Screen		

Figure 4. Tabulation on e-Gallery's Space and Function, Aid of Tools, Content and Users.

Activities that have been generated by the space includes exhibitions by staff and students of the faculty, seasonal and temporary exhibitions by invited artists, interactive and archived information for any users, presentations and demonstrations using the multimedia tools and projections, discussions, mini classes and talks organized for an appropriate number of audience. It is in current planning to add to the activities, educational happenings such as more installations of digital media, more interactivity in games and tools of transferring knowledge, more virtual reality and space simulators and the advancement of delivering basic information and knowledge so as to enhance it to become more creative and interesting. The activities can be enhanced if the allocated spaces are prepared and designed to accommodate them with implementation of modern technology.

6. Conclusion

A checklist consisting of attributes that influence and benefit essentially and fairly as well as disadvantage factors that does not contribute to the gallery in generating a hybrid hub for the art society is the key factor of conducting the study. The analysis derives from the questionnaires that were distributed and interviews conducted.

Checklist of Attributes that Contribute to e-Gallery to Enhance It to Become a Generative Space for Art Education and Activities

No	FORM & SPACE
1	Size of physical space is important and is determined by the functions and activities allocated.
2	The spaces can be divided into: i. Permanent and Temporary Exhibitions ii. Presentation Area iii. Demonstration Area iv. Discussion Area

	v. Analog Exhibition Area vi. Digital Exhibition such as VR, Simulators, Installations, Interactive Games and Archiving Database
3	The diversion is needed for better concentration of activities.
4	All spaces should be equipped with appropriate multimedia tools and gadgets with current technology.
5	The spaces should be accessible with proper planning with public and private spaces as well as spaces with high-end equipment should be under full security.
6	Adequate amenities should be provided for breaks such as café, resting area, wash rooms and outlets.
7	Libraries, reading room, surfing centre and such are a bonus if applied.
8	Multi Functions can all happen at the same time if different spaces are provided.

No	MULTIMEDIA TOOLS
1	All multimedia tools should be installed after a detailed survey on the functions.
2	Current technology in hardware and software should be applied where appropriate.
3	Number of usable tools for visitor's usage should be an ample number for comfort.
4	A variety of tools are needed to ensure creativity and outputs from students.

No	CONTENT
1	Content can be divided into: i. Analog Exhibition ii. Digital Exhibition iii. Archiving Database iv. Information about the Faculty v. Information on the 5 Majoring Offered vi. Interactive Activities such as Games, VR Simulation etc. vii. A channel to hyper link to other Art Community Centre.
2	Sufficient content will ensure satisfaction of different groups of user such as: i. Students ii. Staff iii. Local Visitors iv. International Visitors v. Art & Design Corporate Departments
3	Different level of age, gender and background group of visitors should be the main criteria for preparing content.
4	Content are also designed for different functions such as: i. Education ii. Entertainment iii. Art and Design Activities iv. Corporate and Management purpose

No	ART EDUCATION & ACTIVITIES
1	Identify what art activities should be held at the gallery.

2	Identify the space needed, the tools required and who will participate.
3	Activities that can be performed as such: i. Brainstorming or Discussion of Ideas and Projects. ii. Critique Sessions iii. Presentations and Installations iv. Exhibitions v. Archiving vi. Workshops and Seminars
No	ART STUDENTS AND STAFF COMMUNITY
1	Comfort and ability to concentrate on each function is essential.
2	When designing the space, allocation of human anthropology, human comfort space and human interaction requirements should be taken into consideration.
3	For exhibitions, all art works either analog or digital should be exhibited and installed for a targeted number of visitors at one time. A study on human comfort to use one particular space for a function at one time should be analyzed.
4	To create a community hub needs proper research on how to make the space work through: i. Activity ii. Multimedia Tools & Equipments iii. Space iv. A communicative community of same interest group v. Advertising and promotions

Figure 5. Checklist of Attributes that Contribute to e-Gallery to Enhance It to Become a Generative Space for Art Education and Activities.

e-Gallery generates not only basic activity found in an art gallery but more towards place setting in a campus where it creates more educational and social activities through its existence. The community is able to make use, participate and interact with the new ideas that transform an empty space into multifunction usable vicinity. The paradigm shift not only takes place indoor, but it subconsciously generates ideas and opportunities for the faculty and visitors in upgrading creativity, education and knowledge, use of multimedia tools to assist teaching and mode of exhibition and above all, it activates a society that is in need of a communal node to talk and discuss art. The exploration that has been done and in progress research translated into the checklist shows that the implementation and upgrading of all key factors may need more gallery space to accommodate more activities and creative functions as more multimedia tools are needed for a variety of purposes, especially the specific need of each faculty majoring.

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Plexus: an interactive story telling system based on the small-world networks model

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Abstract

In this paper, a story telling system, based on the small-world networks model, is presented. The idea is to generate a rich deal of stories, which in turn can be represented as real theatrical events.

The prologue is the main node, from which stories and character are generated, selected from many alternatives. Each character instantiates a sub-network and many paths can be generated, according to mathematical functions. Each story that a character performs is a node in a network (linked with the other stories and to the main node). In this way, the system creates a fractal narrative structure, with scale invariance, which can be reiterated ad libitum, thus producing webs of complex stories.

A first example of one of this web of stories that it is possible to generate will be presented during the conference, realized in multimedia and in a real theatrical play.

The performance has been realized by using the idea of experimenting the spreading of the information in a network of people, by using the technology of the mobile phone and other auxiliary devices. The experiment aims at demonstrating that the effects of technology are like an infectious virus, which spreads suddenly in the network. During the play and the multimedia presentation, many generative patterns, related to the fractal nature of the narrative structures will be presented.

1. Introduction

In order to put in evidence how people are connected, Stanley Milgram [1] sent some letters addressed to a stockbroker in Boston, Massachusetts, to a random set of people in Nebraska, with the instructions that the letters were sent again to the stockbroker, by passing them from person to person. People passed their letters to someone who was, in some social sense, related to the stockbroker. In this way, a good number of Milgram's letters reached their destination, and Milgram found that it was necessary an average of six steps for a letter to arrive from Nebraska to Boston. He concluded that six was the average number of passages separating couples of people involved, and argued that a similar separation might characterize the relationship of any two people in the entire world. This process has been called "six degrees of separation" [2] and it is now known as small-world effect [3]. Since then, many scientists begun to study social relationships in order to detect laws of organization, in networks. The concept of network is very important for modelling communication between individuals, the spread of an infectious desease in a community, the organization of DNA in biological world, the trasmission of information in neural cells and many other processes that take place directly between individuals or elements of a set. Later, Granovetter [4]studied the process of interconnectivity in a group, detecting strong and weak links. The first category ties familiar individuals and very close friends, the second puts in contact only individuals with a superficial relationship, which can serve as social bridges, for passing from a networks to another one. In the paper "Collective dynamics of smallworld networks", Watts and Strogatz [5] linked the study of social networks to the mathematical theory of graphs. According to this approach, a network contains many elements, called nodes, which are linked to each other by archs. The set of archs and nodes produces the networks. Watts and Strogatz explored the properties of connected networks of elements, independently of their qualities. They found similarities in real-world networks, individuating high levels of aggregation and low average of separation. The most important result they found is that small-world graphs, those possessing both short average person-to-person distances and clustering of acquaintances, show behaviors very different from either regular lattices or random graphs, thus producing a great quantity of different configurations in the links of these networks.

Instead, some networks show characteristics in addition to the small-world effect which may be related to their function. An example is the World WideWeb, which, according to Barabasi and collegues [6-8], appears to have a scale-free distribution of the coordination numbers of vertices. It is a network with a scale invariance (the organization is the same at different levels) which presents the following characteristics:

a. presence of nodes with a high number of links (connectors);

b. when a node establishes a new link, it prefers to connect itself to a node which has already many links;

c. exponential growth of nodes, which are called hubs.

These kind of networks can represent complex systems such as social, economic and biological networks and narrative models of cognition as well. According to Gazzaniga [9], the left and the right emispheres of human brain behave in different ways: while the left emisphere generates many false reconstructions of events, the right one produces true characteristics of stories. From false memories, narrative creativity has developed as an "interpretation mechanism". Humans use this mechanism not only for interpreting social events but also for representing them, as it happens when we tell a story. Narrative thought is a form of reasoning which grows in complexity and organization as brain developes, which has some methods for building up interpretative models of reality and for verifying them. So narrative is an important part of the way we interact with and make sense of the world.

According to Propp [10], a story is an essential description of events in a temporal unit, that are produced by characters, each of them having specific characteristics and functions in the story development. Propp has been a pioneer in evidencing the social networks that characters create in producing the plot. In recent years, traditional AI and innovative agent-based technologies have developed Interactive Storytelling systems [11, 12] as an indipendent research field. An interactive story telling is a stystem that allows a user to make decisions that can potentially impact the direction of a narrative. Brenda Laurel [13] defines an interactive drama as a "first-person experience within a fantasy world, in which the User may create, enact and observe a character whose choices and actions affect the course of events just as they might in a play. The structure of the system proposed in the study utilizes a playwriting expert system that enables first-person participation of the User in the development of the story or plot, and orchestrates system-controlled events and characters so as to move the action forward in a dramatically interesting way". Some key problems of this sector such as narrative control, the duality between characters and the plot, the user interaction with the story are progressively being solved and new prototypes are being developed [14], with the aim of exploring creative way of expanding the narrative search space [15], of representing the generation of non-linear networks of connected stories [16] and of creating characters, which live in virtual worlds, have embodied cognition and develop stories in a creative way [17].

In this paper we present an interactive story telling system, where the characters' tasks are organized by a small-world networks structure, in order to produce creative plots, to be represented later in a real situation. The aim of this system is to automatically generate stories linked to scientific themes and to represent them by alternative methods and techonologies, such as theatrical representation and Augmented Virtual Reality. The theoretical framework in which we designed the system is generative art [18], with the idea of implementing more complex interactive narrative [19], to be used as basis for the Interactive storytelling system characters and for actors in a real theatrical situation.

2. The architecture of the interactive story telling system

Two fundamental types of narrative, linear and branching, are used in computer games and education and training applications [16]. Linear narrative is a method in which a sequence of events is narrated from the beginning to the end of a story, without variations or possibility for a user of altering the way in which the story develops or ends. In branching narrative systems, there are many points in the story where some actions or decisions made by the user alter the way in which a narrative develops or ends. Branching narratives [20] are tipically represented as directed graphs, in which each node represents a linear, scripted scene, followed by a decision points. Arcs between nodes represent decisions that can be made by the user. The variability the user can experience in these kind of systems is scripted into the system at the design time, and it is thus limited to the knowledge the designer has of the user's needs and preferences and the user that makes the same choices at the same decision points in two consecutive sessions will have the same experiences.

The architecture of the interactive storytelling system, based on the small-world networks model, is represented in Figure 1.

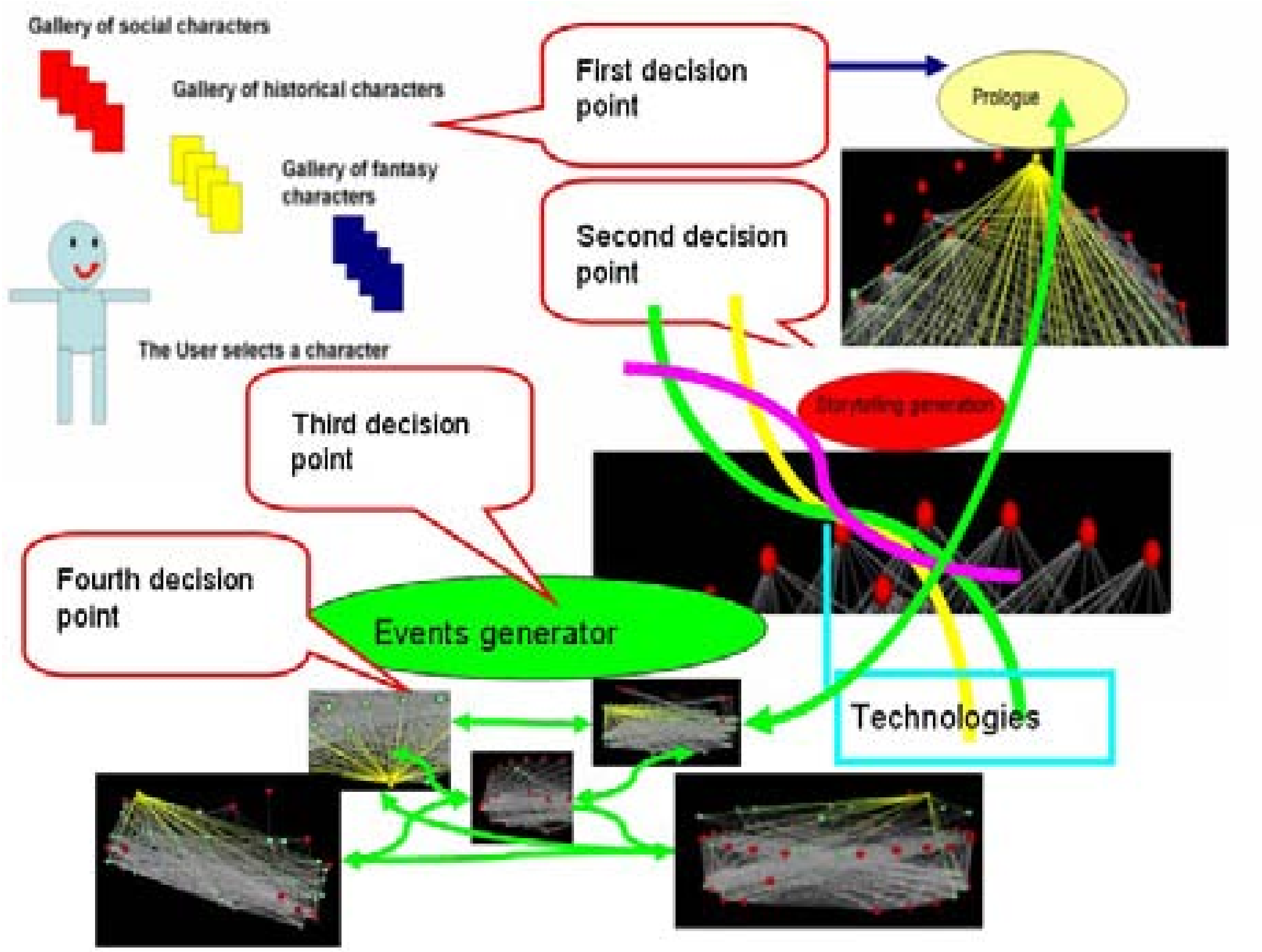

Figure 1. Architecture of the interactive storytelling system.

A networks of characters which are hubs are at first selected by the user. Characters are situated in historical, geographical and social contexts. The prologue is the main node, and it is connected with a set of written stories, with video and audio sequences, with virtual worlds. Each of these media has been stored in different databases. From the Prologue the user selects a story: this is the interactive story telling generator. Every possible path through the graph of this network represents a story. In turn, for each character the user can instantiate a sub-network, and many paths can be generated, according to a formal grammar. At this level the events generator produces audio, video or simulation, related to a series of events, which in turn represent a networks. In fact, each story that a character performs is a node in a network (linked with the other stories and to the main node). In this way, the system creates a fractal narrative structure, with scale invariance, which can be reiterated ad libitum, thus producing webs of complex stories. At each level of the architecture, the characters' galleries, the prologue, the storytelling generator and the events generator the user can make some decisions. This process develops the user's sense of control over the development of the story. In fact, the user can add elements at each level of the architecture and create arcs in order to produce creative connections within the plot in the branching story graph.

At the moment we have created a network of characters with different functions. The historical characters are hubs, since they are very important (Galileo, Einstein). So their mark-up characteristic is denoted by a yellow color code. There is a network of characters which are not hubs (the terrorist, the teen-ager, Penelope). These characters are involved in some social networks and have particular stories. So their color code is red. There is another network of fantasy characters, (the butterfly, the horse, the fish) which has been developed in the ESG research group (http://galileo.cincom.unical.it/), by using two-dimensional self-replicanting Cellular Automata. The color code of these characters is blue.

Other important elements in this system are connectors, which can be technological and/or belonging to a specific social network. For example, a mobile phone or the Internet allow the characters to add a new dimension in the story plot, which is, in some sense, related to the way individuals communicate by using new information and communication systems.

The events generator is a formal language [21]. In contemporary research, a formal language is a set of finite-length words (i.e. a string of characters), obtained from some finite alphabet, while the scientific theory which deals with these entities is known as formal language theory (Figure 2).

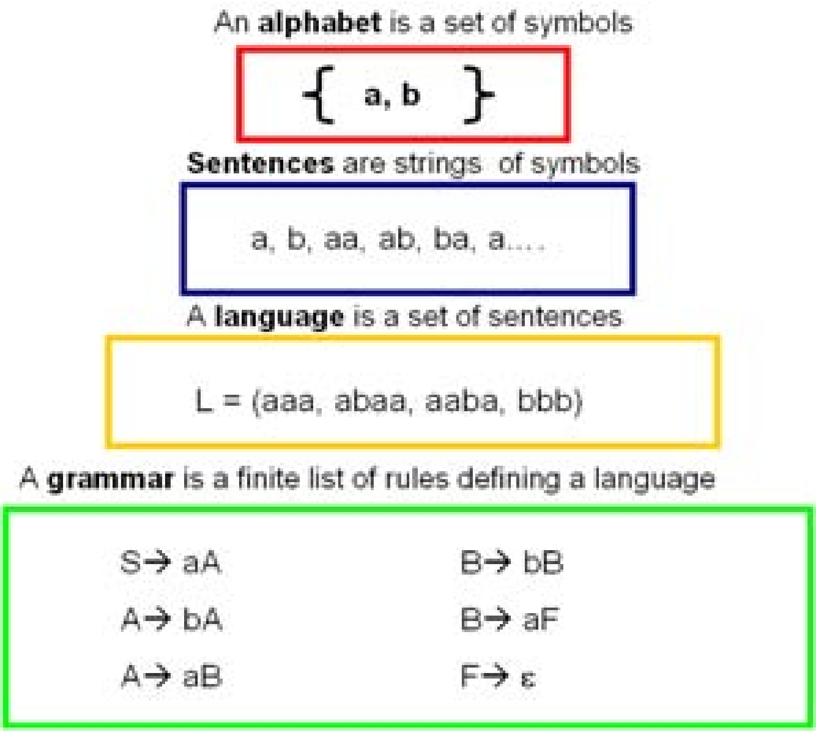

Figure 2. In this diagram, the basic objects of formal language theory (alphabet, sentence, language and grammar) are represented. Grammars consist of rewrite rules: a particular string can be rewritten as another string. Such rules contain symbols of the alphabet (here a and b), and so-called 'non-terminals' (here S, A, B and F), and a null-element, ε according to Chomsky's approach□. The grammar in this figure works as follows: each sentence begins with the symbol S. S is rewritten as aA. Then there are two choices: A can be rewritten as bA or aB. B can be rewritten as bB or aF. F always goes to ε.

This formal language creates paths and free walking in the branching story graph, allowing the user's sense of control of the storytelling system (Figure 3).

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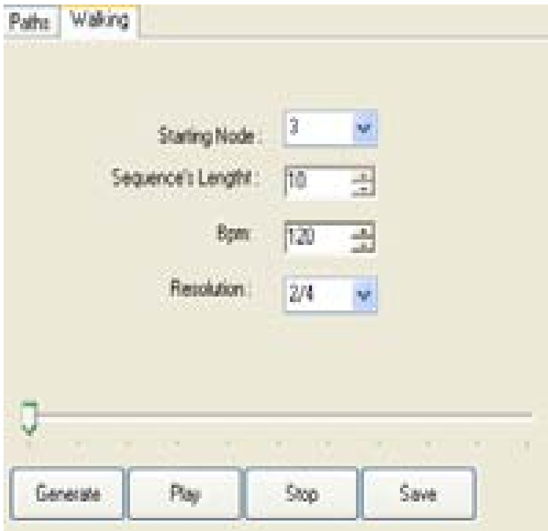
<td>
</td>
</tr>
<tr>
<td>Paths generator</td>
<td>Walking</td>
</tr>
<tr>
<td>Length From 2 To 3 = 2
2→0→3
2 → 62
0 → 60
3 → 63
Length From 4 To 6 = 2
4→0→6
4 → 64
0 →60
6 →66</td>
<td>Length From 3 To 34 = 9
3→13→31→53→43→46→19→14→31→34
3→ 63
13→ 73
31→91
53 → 113
43→103
46 → 106
19 → 79
14 → 74
31 → 91
34 → 94</td>
</tr>
</table>

Figure 3. The dialogue boxes for the user is interaction. In the system, the language is developed by using natural numbers.

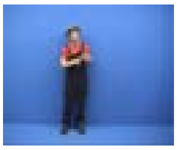
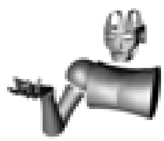
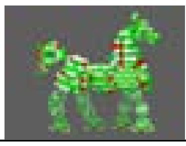
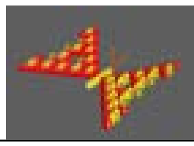
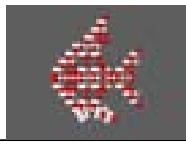
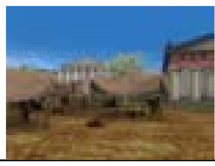
At each element of the path or of the random walking, the system associates to the formal grammar a set of media, which in turn are represented as 3D world or video clips.

In other words, the formal grammar instantiates a string in correspondence of which there is an audio-video sequence. The set of all the sequences produce the story. The grammar is context dependent. Changing the parameters of the choices, it is possible to generate new differents stories. For this reason this system fits well with the generative approach in arts. The user can add nodes to the network and create archs between past and future events, producing a generative and creative narrative that is different either from linear or brancing narratives.

Instead, the user's interface metaphor exploits a physical world model of the networks. The networks have geographical characteristics and they produce 3d graphs. Each element of the networks is settled on a spherical surface, determined by longitudinal and latitudinal coordinates.

3. An example

The story starts in a random manner from one of the hubs (the professor) and creates, by a decision-making system, the task of the other characters, producing events ruled by a generative grammar. At the moment, the caracters that have been developed are represented in Figure 4.

Gallery of Historical Characters			
			
Galileo		Einstein	
Gallery of Social Characters			
			
Teenager	Professor	Assistant	Revolutionary
Gallery of Fantasy Characters			
			
ALMMA Robot	Chaos Robot	Alice	Illusionist
			
Spider	Horse	Butterfly	Fish
Gallery of Settings			
			

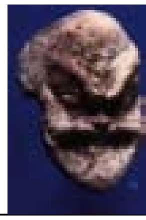
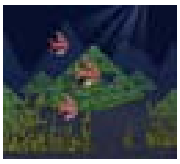
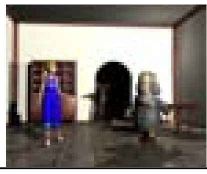
Greek House	Greek Theatre	Agorà	Greek Temple
Gallery of Greek Masks			
			
Hegemòn therápon	Pseudokóre	Kólax	Káto trichías
Gallery of Scenes			
			
Video ALMMA	Video Evolution	Galileo Room	Agorà

Figure 4.In this Figure, some of the characters, real and simulated which have been developed for the interactive story-telling system.

Figure 5. In this Figure, a scene of the first play produced with the system. As it is possible to see, we have used an historical character, Galileo, situated in a modern environment.

Er Professor: Welcome to Ycorporation. You have been invited to this meeting today to look into the results of our research: you will see the different functionalities of our net, aiming at the production of the brand new YMP: elegant design, for professionals always moving around, maximum simplicity and efficiency, multifunctionality… Dear colleagues and public attendees, you will be our testers. You will observe us carrying out three experiments, under my personal direction, on unaware subjects.

Afterwards you will decide if you want to invest your money to let us continue our research.

The project is about the interaction of nodes positioned on a net. The experimentation has been carried out involving the subjects, provided with decisional capacities, positioned on this canvass. The subjects have been provided with cellular phones, also known as mobiles, but not only, they were also supplied with additional technologies. The aim of this experimentation is to show the effects of technology and its contagious aspect; we will illustrate how it developed, by recreating net structures, analogous to the social and biological ones, describing it reticular forms and demonstrating how these models recur in each aspect of life.

We will spy the behavior of these subjects, of these figures, that will be the protagonists on this stage under our eyes: they will be considered as protagonists for you, but will be only experimental animals for me; men for you, laboratory mice for me.

All that each subject undergoes is analogous to what happens to the others. The breeding of the stories could be infinite, but we rolled dice and chose for you the following examples: a charming girl, Penelope, that weaving an intricate virtual thread, affects the real life of an adolescent; an unsatisfied worker who, in the attempt to dominate the events, joins a group of rebels, but cheats on his friends; and you will listen to the TV news about a company attacked at the heart of its business by means of a telematic assault.

The idea is to exploit the behavior of reticular forms, inserting in its mechanisms a random character, looking at what will happen at the end. The social net is the web that connects the movement, the crazy run of the subjects. I have woven for you this canvass, and I will control the threads, inserting a technological variable, and the subsequent explosion and reconfiguration of each system.

Figure 6. In this image, a piece of the text generated by the story-telling system, elaborated on a story written by one of the authors.

One of the story we have generated is about an experiment which a professor elaborates and makes, using human pearsons as laboratory mice. In Figure 5, a scene of the prologue of the generated story is presented, while in Figure 6, a piece of the dialogue of the professor of the generated story.

4. Conclusions and future work

We made a contamination of different elements, approaches and methods for creating what we have called melting tools, the electric theather, the music of the story, classical and fantasy 3D environments. The electric theater is the result of the interplay between old and recent approaches, the idea that it is possible to use a storytelling system to write a rough play which, after modifications and improvements, can be represented as if it were written by a playwriter. Also music is a very important element of the electric theater, as the music is generated by using a software based on the small networks model as well (see Campolongo, in the poster session of the GA2005 Conference Proceedings). Furthermore, the electric theater uses 3D environments, multi-agent based technologies and Augmented reality systems. Future goals of this research project is to develop the performance in Augmented reality, using the synthetic and the real actors and mixing the behavior of both types of characters for realizing a new form of generative art. Furthermore, we think to develop a new model of narrative, based on the Barabasi scale-free model of networks.

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FRACTAL BASED GENERATIVE DESIGN FOR HARMONY BETWEEN OLD AND NEW

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Abstract

In this paper, a computational design model based on the fractal dimension will be presented. Fractal dimension is used as a means of capturing the pattern appropriate at the compositional configuration of a historical architectural language and generating new forms, which will ensure the continuity of this language. In the first stage, architectural characteristics of a district with special architecture will be defined by calculating fractal dimensions in different levels. In the second stage of the model, this fractal values are used as input in computer program for producing form alternatives for the new buildings that will be designed in such places. This two-staged model, which is generated for the purpose of providing harmony between new and old, is applied to Chora, which is an important historical settlement of Istanbul. The generation process describes how to derive a compositional configuration from other forms with different dimensions, which can be generated by changing fractal dimensions.

1. Introduction

Computer supported design systems can generate different images during the early design process and provide useful inputs when searching for alternative forms of architectural design products. It is aimed that the generative approach which is used in this study will be used for supporting the creativity to produce architectural forms based on an existing architectural pattern. Providing harmony in architectural design between old and new is a great problem for cities like Istanbul, which are growing around historical core. New buildings must be both unique and conformed to the proportional feature of the old buildings. In this way the proportional characteristic of original pattern of a historical environment or of a special environment is protected. In the development of this approach, the following stages have been carried out:

Calculating the fractal dimensions of a historical city part for defining the architectural characteristic.

Using a computer model for generating form alternatives according to the fractal values [1].

Testing these form alternatives in the 3D model of this historical city part.

2. Fractal Geometry and Architecture

Geometry is the fundamental of the architectural discipline. It is a tool for describing thoughts of a designer for creating architectural product itself and its two and tree dimensional representations; drawings and models. For the purpose of creating architectural objects Euclid geometry has been used for ages. According to Bovill the reason of the influences of Euclid geometry being so strong in architecture is that architectural forms are man-made [2]. The researchers describe the relationship between Euclid geometry and architecture with the effects of mass-production in architectural design because the forms of building elements, which are produced with mass- production depends on Euclid geometry [3].

On the other hand the architectural design approaches based on nature revealed the effects of fractal geometry in architecture. Fractals - which were introduced by Benoit Mandelbrot in 1980s for describing the forms of natural objects, like coasts, mountains – have appeared in architecture with the details from a larger scale to the smaller one [4].

Although there are many examples, which based on fractal concept in the history of European, African, Asian and American architecture fractal geometry is begun to be used consciously in architecture with the new design approach in computational architectural design. Fractals could be represented by generative algorithms in computer with their major characteristics; developing through iterations, depending on starting conditions. In this way they could be used for designing forms, structures and surfaces alternatives [2].

In this study, fractal dimension is used as a means of capturing the pattern appropriate at the compositional configuration of a historical language and generating new forms, which will ensure the continuity of this language:

The aims of this study are:

To support the creativity of designers in early design phases;

To generate and give a preliminary ranking to the form alternatives

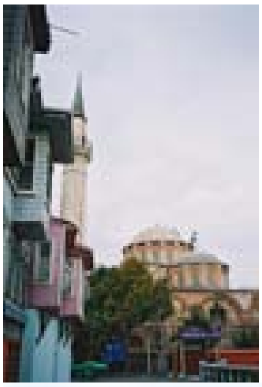
3. Case study

In the case study, fractal dimension is used in two ways. Firstly it is used for determining fractal characteristic of a historical district in Istanbul and secondly it is used within a computer model for creating new buildings forms, which have the same fractal characteristic with this place for providing the harmony between old and new. For the case study, Chora (Kariye) district has been chosen.

Chora

The Kariye neighbourhood is located in the district Edirnekapi in Istanbul. The word Kariye (Chora) meaning "outside of the city", or "rural" is derived from old Greek [5].

In Kariye there are many monuments of the Byzantine and Ottoman periods. Kariye Church (Figure 1), Tekfur Palace (Figure 2), and Kastoria synagogue are some of these monuments.



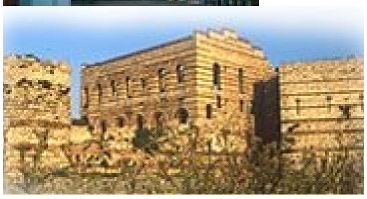


Figure 9.Chora church [6

Figure 2. Tekfur Palace [7]

Chora Church, the symbol of the district is built on the site of a chapel, which is located outside of the city walls, by Justinianus. Several additions and repairs, which were made between the years 1315 – 1320, formed the current shape of the building. The mosaics and frescoes examples in Kariye Church are regarded as the most beautiful of the last period of Byzantine art. In the surroundings of the church, traditional Ottoman houses and streets are located. (Figure 3)

■ (magenta)	The buildings of which fractal dimension is calculated
■ (blue)	The building in the place of which alternatives are generated
□	The buildings in the neighbourhood of the field study
□ (orange)	Historical buildings in the neighbourhood of the field study

Figure 3. Site plan of the Kariye Bostani Street

3.1. Kariye Bostani Street

The reason why this place is chosen for field study is the traditional architectural pattern of the street. There are both the examples of multi-storey buildings, which were built after 1950's and of low storey buildings of traditional Ottoman Architecture near the street. Although the pattern of the street is protected in a large scale, the effects of chaotic architecture of the environment can be seen on the street.

Figure 4. The Protected side's of the street

Figure 5. The Protected side's Silhouette of the street

On the both side of the Kariye Bostani Street traditional Ottoman houses are located. (Figure 4, 5, 6) All the houses on the one side of the street are two or three storied wooden row houses and have a bow - window (cumba) on each façade. (Figure 4, 5) On the other hand there are five or more storied concrete buildings, which are not in a harmony with these buildings, on the other side of the street. (Figure 7, 8)

Figure 6. The other side of the street

Figure 7. The other side's Silhouette of the street

In this study, a design model is suggested for providing proportional harmony between the forms of traditional buildings and new buildings and for protecting the street pattern.

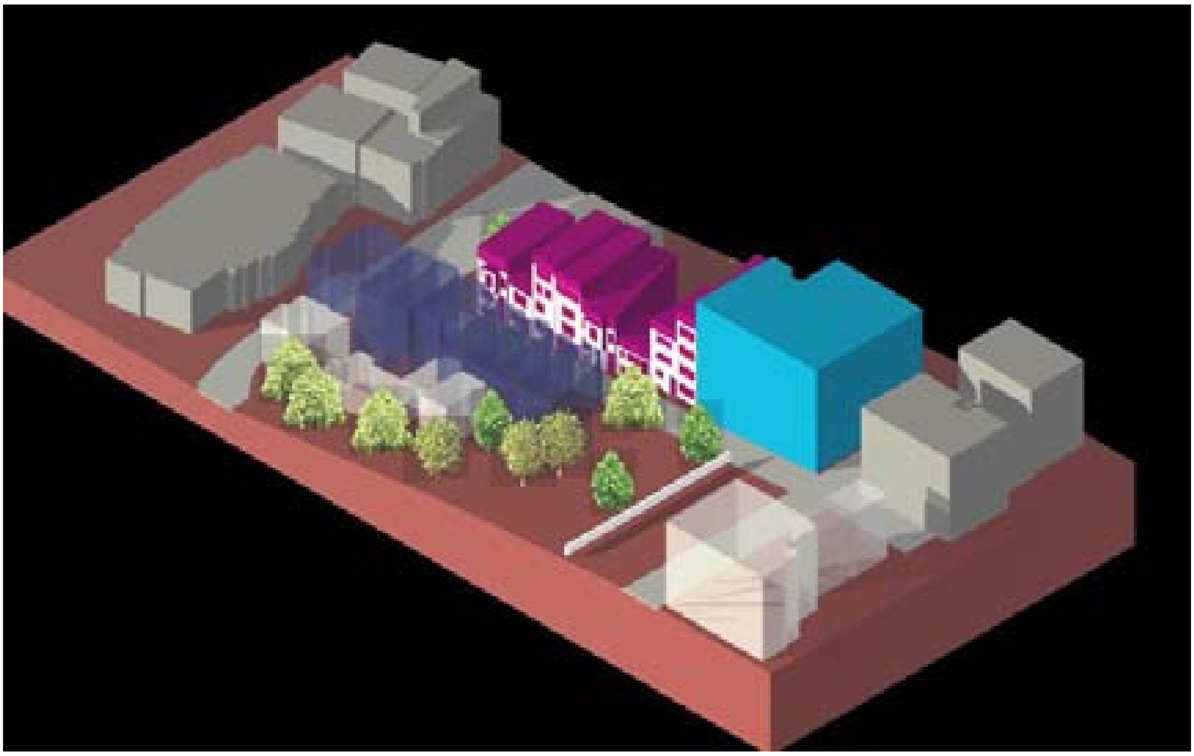


Figure 8. 3D model of the current situation of the Kariye Bostani Street

4. Generating new form alternatives in Kariye Bostani Street

In the generation process of new form alternatives a computer model has been used [8, 9]. The model starts with the analyses about the Kariye Bostani Street. Fractal dimension takes the most important role in the analyzing level. For defining characteristic features of the architectural language of the Kariye Bostani Street, fractal dimensions in plan, silhouette and building scale have been calculated [10]. The fractal values obtained by using Bovill's Box-counting method have been used as inputs in the computer program for composing alternative forms on the selected place in the street. (Figure 9)

With the aim of creating new forms according to the fractal values of the existing pattern, the place of the corner building which does not suit with the architectural characteristic of the Kariye Bostani Street is chosen for the project area. (Figure 7, 8 building with colour blue) The new form alternatives are generated in the 18mx18m square shaped project area by defining the number and dimensions of initial shapes on x-y and z axis. Therefore a grid system of boxes was superimposed over the project area on x-y axis [11]. In this way, dimensions of the initial shape have been defined.

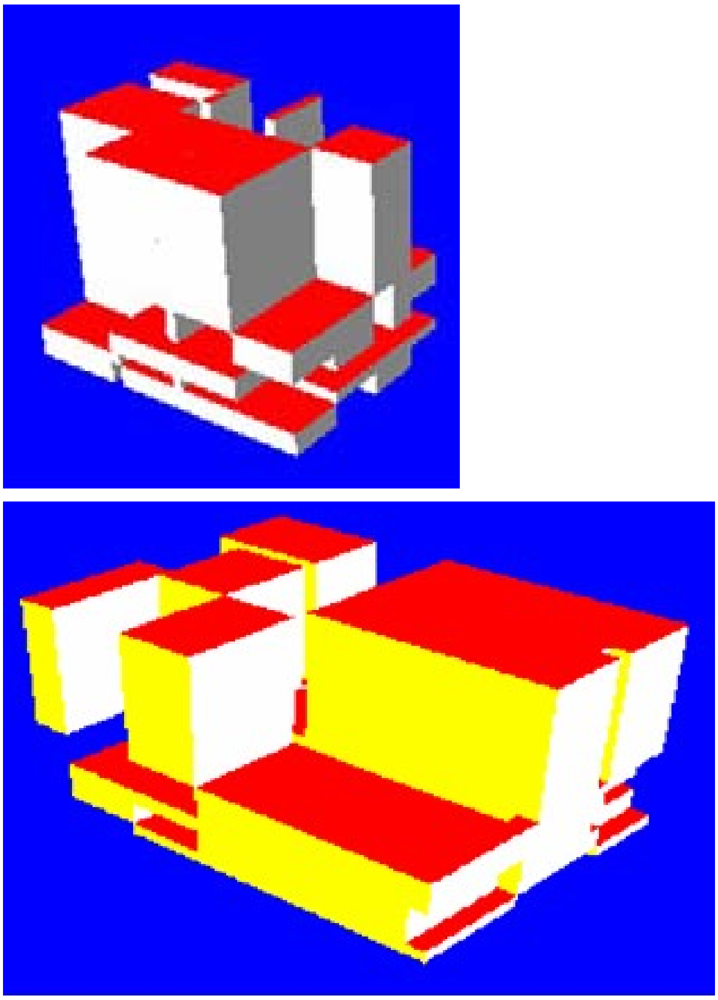


Figure 9. Form alternatives

In the next stage of the generation process two different initial shapes, a 3mx3mx3m cube and a as 3.60mx3.60mx3m square prism have been used for obtaining various design alternatives. In the last stage, fractal dimensions - which are calculated as 1.7 in the settlement scale and 1.2 both in the silhouette scale and building scale - have been applied to the initial shape for generating new forms. Finally, these generated form alternatives were tested on the 3D models of the Kariye Bostani Street and its surroundings, which were created in virtual environment. (In the first three alternatives, a 3mx3mx3m cube and in the fourth and fifth alternatives a 3.60mx3.60mx3m square prism has been used as initial shape.)

4.1 Form Alternatives

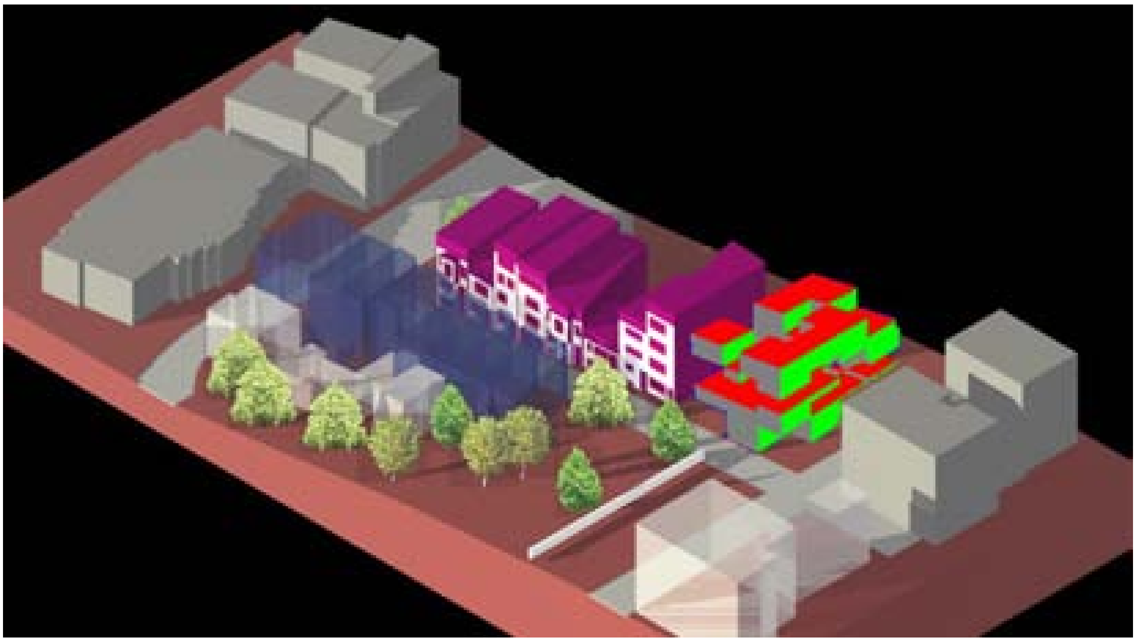


Figure 10. Alternative 1

Table 1. Fractal values and the number of cubical units on x, y, z-axis, which have been used in

Alternative 1

Fractal dimension	Cubical units on the x- axis	Cubical units on the y- axis	Cubical units on the z- axis
1.7	6	6	4

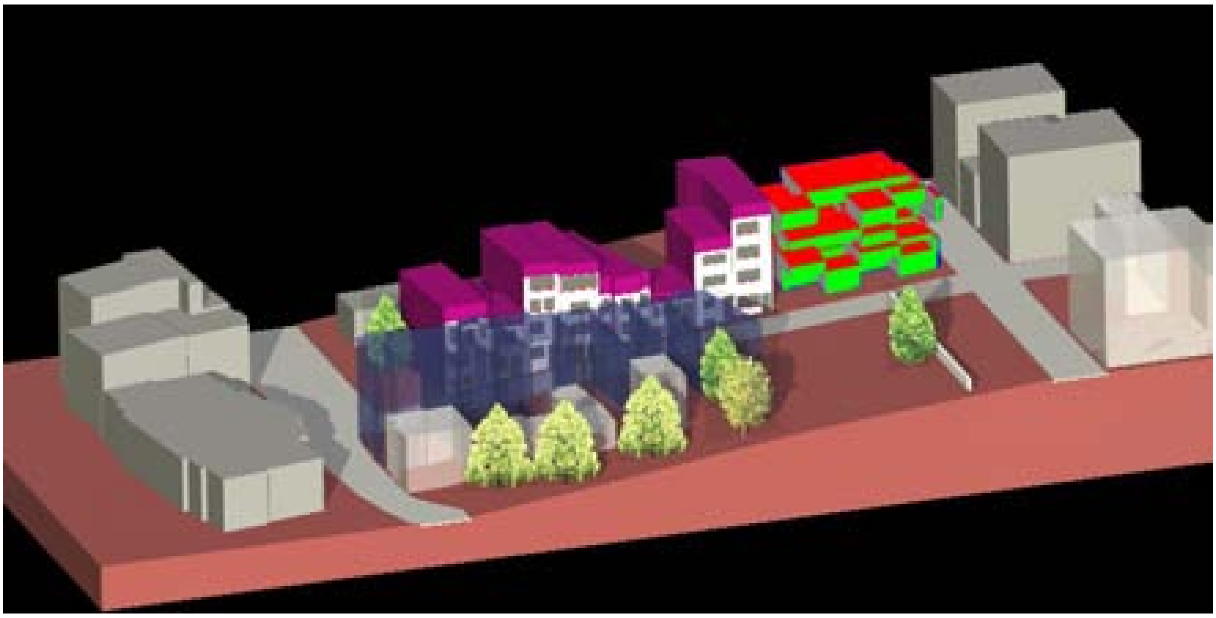


Figure 11. Alternative 2

Table 2. Fractal values and the number of cubical units on x, y, z-axis which have been used in Alternative 2

Fractal dimension	Cubical units on the x- axis	Cubical units on the x- axis	Cubical units on the x- axis
1.7	6	6	5

Figure 12. Alternative 3

Table 3. Fractal values and the number of cubical units on x, y, z-axis which have been used in Alternative 3

Fractal dimension	Cubical units on the x- axis	Cubical units on the x- axis	Cubical units on the x- axis
1.2	6	6	5

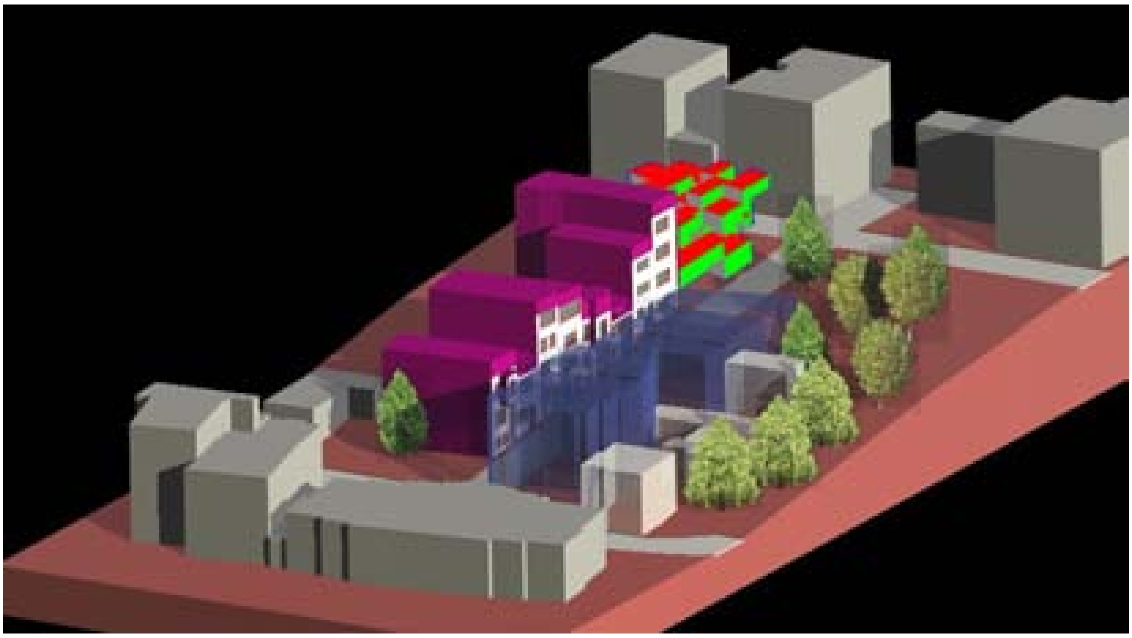


Figure 13. Alternative 4

Table 4. Fractal values and the number of box units on x, y, z axis which have been used in Alternative 4

Fractal dimension	Box units on the x-axis	Box units on the y- axis	Box units on the z- axis
1.7	5	5	5

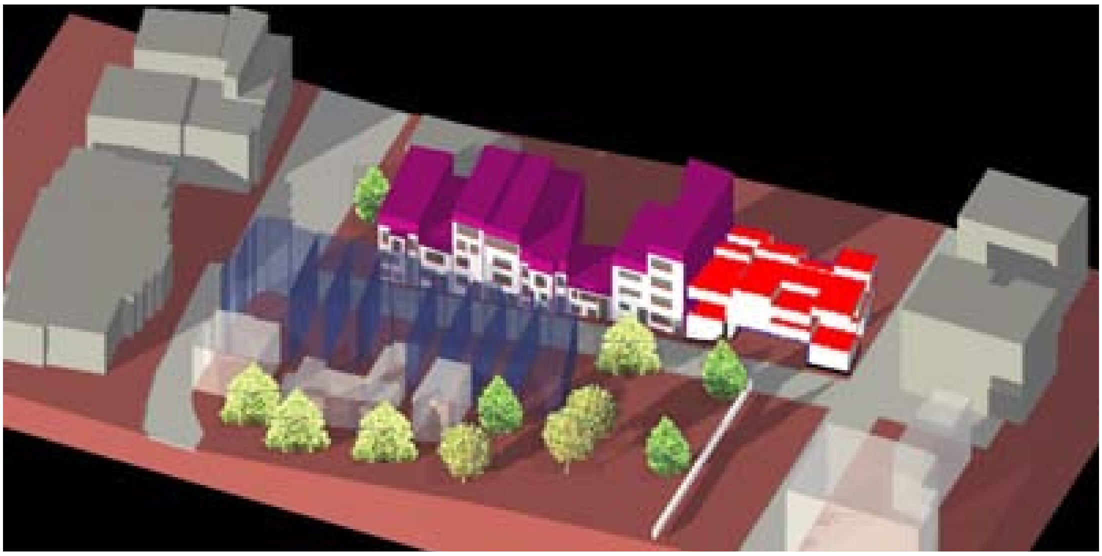


Figure 14. Alternative 5

Table 5. Fractal values and the number of box units on x, y, z-axis which have been used in Alternative 5

Fractal dimension	Box units on the x-axis	Box units on the y axis	Box units on the z- axis
1.7	5	5	5

5. Conclusion

One of the significant problems in architectural design is providing harmony between old and new. Fractal concepts have been come to use in many ways, both consciously and unconsciously, in the field of architecture.

In this study, by relying on the fractal dimensions of an existing architectural pattern a generative design approach has been suggested which can be used in the process of supporting creativity in the creation of new forms and for testing harmony between old and new .By using the fractal dimensions of elements found in a shape library belonging to the relevant architectural language, this approach may show the way to the creation of architectural forms which will ensure the continuity of the pattern.

Using digital technologies while searching for alternative forms in the conceptual design phase is a new approach based on the development of new technologies. Using digital media as design media gives the designer the opportunity to expand his/her imagination and innovations.

By placing the three dimensional form alternatives in the settlement model, harmony has been tested with the existing architectural language.

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Exploration into formal aesthetics in design: (material) texture

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Abstract

The connotation of aesthetics can include a number of aspects such as technological aesthetics, functional aesthetics, formal aesthetics, psychological and cultural aesthetics and so on. Formal aesthetics concerning shape, colour, materials, texture, space etc (and of course their combination) is the fundamental target that designers should exclusively achieve, which radically/directly determines the 'styling' of any 3D product and environment. Our research focuses on the systematic investigation into the material texture. Compared to colour, texture is a less identified property. Although an increasingly wide range of materials with abundant textures and surface effects are currently available in market, little has been understood about how human (both designers and users) respond and perceive them, either physiologically via their senses such as vision, touch etc or psychologically and culturally via their mind. This part of knowledge will enable design practitioners to take into consideration the rational thinking of texture creation and application as assistance to their innovative practice. Based on experimental research with speculative research, and combining with examples, this paper addresses a series of issues about texture, including the concepts of and clarification between texture and perceived texture (texture perception); the dimensions of verbal description of texture; psychophysical relationship between subjective feelings of texture and physical parameters of materials; also addressed is the resources and inspirations from where texture can be generated.

Key words: texture, aesthetics, materials, sensation and perception, design

Introduction

Aesthetics, usually defined as the branch of philosophy that deals with the nature and expression of beauty [1], has been recognised since antiquity and has continually evolved over time. The word beauty is commonly applied to things that are pleasing to the senses, imagination and/or understanding. It is often what an artist or a designer makes great efforts to achieve in their works, either for personal or mass interest and pleasure. Aesthetics can have different meanings from different perspectives of approach and study. For example, a designed and manufactured artefact can be judged as beautiful or pleasing because of its unique functions (functional aesthetics), the application of advanced technology (technological aesthetics), its fascinating form characteristics such as attractive shape, colour, texture etc (formal aesthetics), or its representation of life experience and social identity or a symbol of cultural reflection (psychological and cultural aesthetics). These aspects are twisted together in their contribution to the whole perception of product aesthetics. Figure 1 shows a kettle that uses smart material to give a particular function of indicating the water temperature. This is realised by the colour changes of the thermo-sensitive material at different temperatures. At the boiling point, the material turns into a red colour. The product gives you a sort of fun in addition to fulfil its basic function of boiling water. It is a trend for consumer products to have their unique personalities and evoke emotional feelings such as pleasure within the context of today's consumption culture. We can see from this example that how interaction between technology (smart technology), function (temperature indication), form (materials, colour), and culture (consumption culture, emotions and pleasure) contributes to product aesthetics.

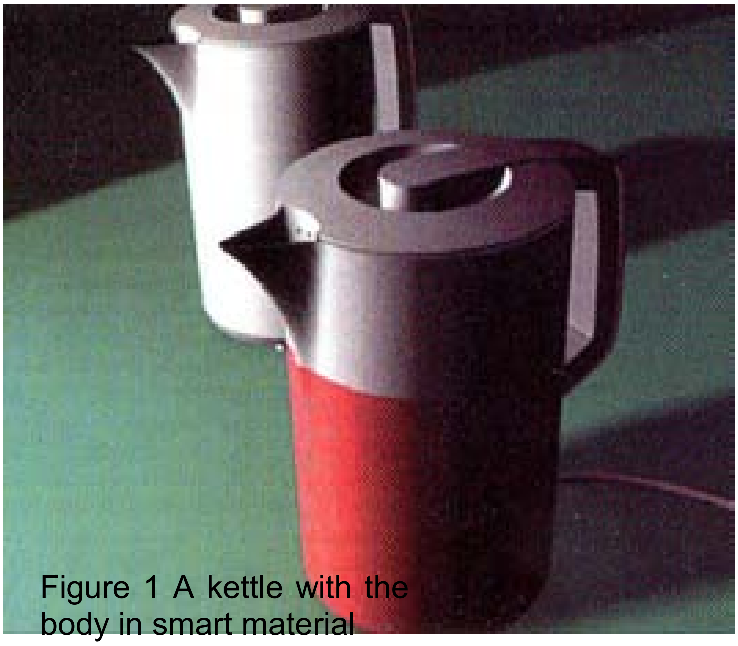


Figure 1 A kettle with the body in smart material

However, it is widely agreed that, in the first instance, aesthetic experience comes from the senses, or sensations [2], [3]. When we say that a colour is beautiful, a smell is nice, or a texture is fascinating, it is because the colour, or the smell, or the texture gives you the sensory pleasure to your sensory organs such as eyes, nose, skins/muscles, etc. In addition, they may evoke some positive associations with anything in your memory, life experience, social events etc. This is why formal aesthetics, which mainly concerns shape, colour, materials, texture, space and proportion etc (and of course their combination), is a fundamental goal that designers should try to achieve. These formal elements radically determine the 'styling' of any 3D products and significantly influences users' perception of the product's beauty and value.

Research evidence shows that the sensory and perceptual aspects of colour and sound have been widely explored. This is not the case with texture, particularly tactual texture, or smell and taste. Compared with the properties of colour, sound etc, texture seems to be a property that is more ambiguous and difficult to identify. We can use three dimensions of hue, lightness and saturation or the RGB parameters to describe and accurately specify and identify a particular colour. A series of standard colour systems such as Munsell, Pantone, NCS etc are available for colour specification in the market place. However, we tend to know much less about how to specify a texture, and even less as to how to identify a unique texture. Although due to development in computer science, it is possible to design, manipulate, and retrieve a texture, it is dominated in the case of two dimensional images or virtual images. Systematic understanding about texture in a wider range of areas, beyond merely visual images, and particularly including the textures of physical materials, has not been extensively explored. This paper has a probe into the material texture perception from the practical perspective of design. In this context, we will skip the black box that deals with the mechanism about how texture information is processed in the brain, but focus on a more peripheral aspect. This includes a texture's definition and classification; how people subjectively describe a texture; how subjective responses to texture can be related with objective texture parameters; and what are the sources for a texture to be generated in the design practice.

Concept of texture

The word 'texture' was originally a textile term, a quality of fabrics appraised and appreciated through the sense of touch [4] (Figure 2). The concept was then expanded to a wider range from a philosophical and cognitive angle of view. Cognitive scientists have recognised texture as a visual cue [5] that plays a significant role in a variety of cognitive tasks. A common use is in describing and differentiating between different kinds of objects, either two-dimensional for example an image, or three-dimensional for example wallpaper, furniture, carpets, sand, and grass etc. A working definition of texture in this context is the surface markings on an object or the 2-D appearance of a surface [5]. However, this definition is one-sided because texture is not merely a visual cue, but could be served as the cue of other senses. For example, texture should go beyond merely surface markings, and should concern other characteristics such as the moisture retention level, thermal conduction, temperature, softness or hardness etc. Texture, in a wider range of understanding, can also be used to depict the structure of other things such as a poem, a piece of music [4].

Figure 2 texture originally means tactual quality and feel of fabrics

Figure 3 surface texture of milled carbon steel (macro)

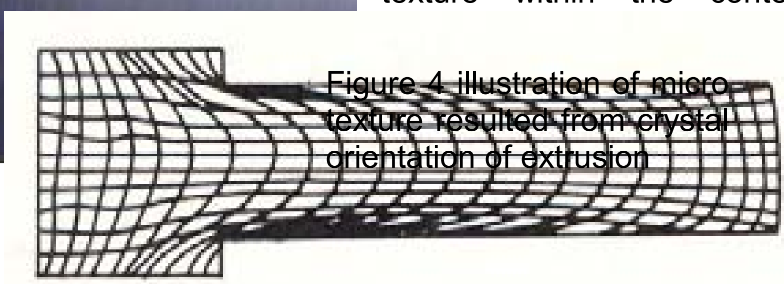


Figure 4 illustration of micro-texture resulted from crystal orientation of extrusion

Due to the standpoint of approaching the research from 3D design perspective, we would like to narrow down the meaning of texture within the context of physical materials. Within this context, texture can be understood from two aspects or two scales. On one hand, it is appreciated for a material's visual appearance and tactual feel at the macro scale (Figure 3). On the other hand, texture was transplanted to a more specific term in the study of materials science and engineering. In this field of study, texture means a particular orientation distribution in microstructure. When a piece of metal is deformed by some directional process such as wire-drawing, extrusion, or rolling, the constituent crystal grains acquire a preferred orientation.

This orientation is called texture [6] (Figure 4). The orientation can result in changes of material properties. Nevertheless, because of its micro-scale magnitude (the crystallitic grain size is usually from 1μm to 100μm or even smaller from 1nm to 100nm (nano-materials), texture under this context is difficult for a human to perceive directly by sensation. This texture can only be tested and analysed by means of specialist equipment such as an X-ray diffraction device or microscopy etc. However, these two aspects of material texture can be, although not always, related. For example, a shiny, transparent texture of diamond is related with its specific crystal structure where carbon atoms are arranged in a face-centred cubic lattice and with a regular tetrahedral structure. The various textures shown on the section surface of different types of wood are determined by their growing mechanism. At the rest part of the paper, we will focus on the exploration of material texture from the sensory and macro aspect.

It is necessary to discriminate between two concepts. One is texture; the other is perceived texture or texture perception. The former is objective, whilst the latter is subjective. We propose to define 'texture' as 'the geometrical configuration and physical-chemical attributes of surface or bulk of materials/objects'. Correspondingly, we propose a definition of perceived texture as 'a synthesis of physiological and psychological response and impression to the geometrical configuration and physical-chemical attributes of the surface or the bulk of materials/objects'. In this definition, the 'synthesis' means it is not simply 'A (geometrical configuration) plus B (physical-chemical attributes)' but 'A fusing with B', therefore the subjective responses to A and B would interact. Although under certain conditions (e.g. by vision), the response to geometrical characteristics may be dominant over physical-chemical attributes of texture, or the inverse, under other conditions (e.g., by blindfold touch). What's more, the subjective response will possibly go beyond these two aspects as can be found in our experimental research. The understanding of the correlation between the objective texture attributes (usually represented by physical parameters) and the subjective texture perception will provide the framework for creating suitable, aesthetic material textures.

Classification of texture

Texture can be categorised in different ways from different viewpoints. Following are some of the examples of texture categories:

Natural texture and artificial texture (according to the formation of texture);

Regular texture and random texture (according to the pattern of texture);

Visual texture and tactual texture (according to the perceptual modality);

Virtual texture and real texture (according to the representation of texture).

However, these classifications of texture can also be intersected. For example, a wood texture can be attributed as a natural texture. At the same time, it can be a random texture due to its freely scattered line-patterns. With a particular surface treatment, for instance, by a layer of other material coating (e.g. varnish, lacquer) on wood surface, it can also have the attributes of artificial texture. If presented as an image, it is a visual texture. If it is simulated by computer software, then it is virtual texture. When it is presented as the surface of a piece of furniture, it is visual plus tactual texture, and also a real texture.

Subjective description of texture

In the design field, knowing how people describe the sensory properties contributing to formal aesthetics, including colour, texture, sound smell, etc, will ensure a consistent communication language between designers and consumers and enable designers to establish criteria for a product if it is to achieve good sensory adaptation and aesthetic expectation. Researchers have tried to find the dimensions for texture perception in the cases of different material categories such as building materials [7], wood [8], paper [9] and leather [10], [11] etc. However, all the character dimensions (words or word pairs) of texture description are different between researchers and show a lack of a systematic classification.

From our experimental research, a {Dimension-lexicon} system [12] has been proposed to summarise the material texture description. It is generally accepted that the subjective description of material texture can be summarised into four dimensions: geometrical dimension, physical-chemical dimension, emotional dimension and associative dimension. Each dimension has a number of descriptive words that are most frequently used by subjects. These words are put into pairs that have bipolar meanings such as hard – soft, shining – non-shining etc, and are named as texture lexicons. However, the texture lexicons will slightly change in quantity, and frequency of being used when the controlled condition is changed. These conditions include sensory modality, material categories, subject background etc.

Geometrical dimension This dimension describes the subjective response to the geometrical configuration of a material surface. The texture lexicons within geometrical dimension include the description of a material surface in two aspects: One is the global, macro impression of the surface configuration, i.e. the surface pattern, such description as plain – bumpy, regular – irregular, repetitive – non-repetitive, line-scattered – dot-scattered, simple – complex etc. The other is the local, micro feeling of the surface configuration, i.e. the surface roughness, described as smooth – rough, fine – coarse etc. Therefore, a plain surface can be rough, whilst a bumpy surface can be smooth. Figure 5 shows an Aluminium texture that is globally bumpy but

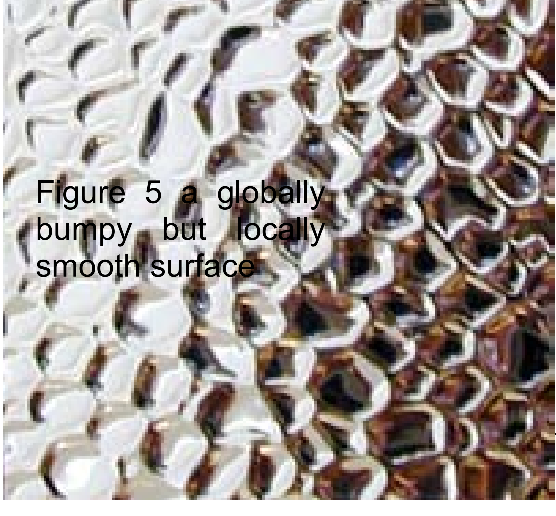
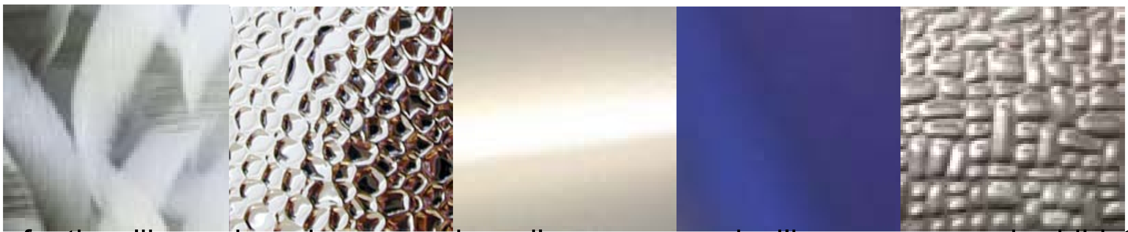


Figure 5 a globally bumpy but locally smooth surface locally smooth. However, the discrimination between the surface pattern (macro) and surface roughness (micro) is sometimes ambiguous.

Physico-chemical dimension This dimension describes the subjective response to the physical and/or chemical attributes of a material surface. It includes the dynamic characters that need energy exchange (such as mechanical, thermal, optical, etc) with environment and is time-related. High-frequency lexicons used in this dimension include such as: warm – cold, hard – soft, moist – dry, shiny – non-shiny, sticky – non-sticky, etc.

Emotional dimension This dimension describes the affective, hedonic, valuable feelings that are evoked by touching the material surface. High-frequency lexicons in this dimension include such as: comfortable – uncomfortable, lively/cheerful – dull, elegant – ugly, modern – traditional, etc. Subjects seem to be more sensitive to the emotional feelings under the visual touch conditions. However, when blindfolded, subjects are still equally sensitive to the feeling of comfort comfortable – uncomfortable when touching the material surface [12].

Associative dimension This dimension describes the subjective association from the material, i.e. to what existing things in the perceiver's life experience can the texture be compared. This description is beyond the description of geometrical and physico-chemical characteristics, and is much more individually dependent. Therefore the lexicons in this dimension are random, and have low frequency, but they are rich in description. Figure 6 shows some examples of such associative descriptions. Understanding of this association can be helpful in texture selection in order to integrate positive user experience to the context where the texture is applied.



a. feather-like b. honeycomb-like c. oily d. silky e. buddhist

Figure 6 associative description of material texture

Psychophysical relationship in texture perception

There are often certain physical parameters of materials that underlie or correspond to subjective descriptions of texture. It is the parameters that determine the objective side of texture. Understanding the relationships between the objective parameters and subjective responses will help to further identify the technical aspects of texture selection, to pinpoint particular technical processes for materials and surfaces with suitable parameters, which correspond to the maximising mixture of positive user feelings. This will have great significance in the new product development process.

This type of knowledge can actually be traced back into Psychophysics, the oldest stream of psychology that particularly explores the relationship between physical world and mental world. An example can be found in the study of sound, the physical intensity of sound is different with psychological intensity of sound. The latter is then called loudness. Loudness is a psychological experience that correlates with, but not identical to, the physical measurement of sound intensity. For example, an 80db sound does not sound twice as loud as a 40db sound, and the increase from 40db to 50db will not be judged as the same loudness increase as that from 70 to 80db [13]. Similar relationship needs to be explored in the case of texture.

We have conducted experimental research to find a relationship between subjective feeling of materials with physical parameters such as roughness and hardness [14]. It needs to be pointed out that the traditional psychophysical research focuses on two variables that address the same stimulus (say, roughness, or warmth, or softness etc), of which one is physical, and the other is psychological. In addition to this ‘one to one’ relationship, a ‘one to more’ or ‘more to one’ relationship is also worth exploring as long as this kind of relationship does exist. For example, people’s psychological feeling of a surface’s moisture could be related to a number of physical factors, such as different materials with different surface energy[20], or the same type of materials with different surface roughness, or the same type of materials but with different softness [11]. On the other hand, one physical parameter, e.g. the physical roughness, can correspond to a number of psychological feelings, e.g. subjective roughness, stickiness, warmth. The relationship between physical roughness and psychological roughness tends to conform to a power law [7] [14]. We are currently also investigating the quantitative relationship between psychological responses to material texture and the material surface gloss.

Resources & inspiration of texture generation

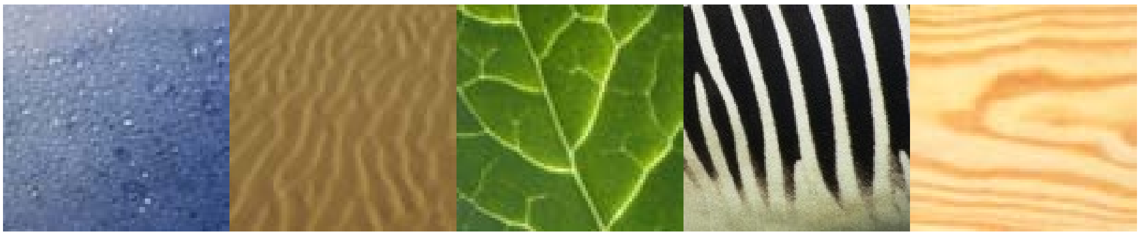
In general, when a designer makes a decision to use a particular texture, either a material texture in a 3D context or an image texture in a 2D context[21], the decision will usually be based on three aspects: knowledge, inspiration, and experience. Knowledge is rational, and inspiration is intuitive, whilst experience offers reference of synthetic information from practice. From the perspective of generating a visual effect of texture, there is little difference between material texture (3D) and image texture (2D). However, from the perspective of realising the visual effect on a physical surface, the decision making of texture selection will be more complex as there will exist certain constraints from the technical side (e.g. manufacturing processes). At the same time, not just visual attributes but also tactual feelings or other sensory attributes (sound, smell etc) need to be considered as well. In such cases, knowledge including the issues discussed in previous sections such as subjective description of and responses to a texture, psychophysical relationship of texture perception, material properties and manufacturing processes will be necessary. The following listed are mainly the aspects that will stimulate the generation of a texture (either a material texture or an image texture).

Texture learnt from nature

20 Surface energy (sometimes also called surface free energy) is defined as the energy required for creating unit area of a new surface. It influences the surface adsorption with liquid articles, which will be related with the feeling of moist.

21 2D image also reflect 3D information, here the meaning of 2D refers to as the media (screen, paper) through which the texture is presented, compared with the 3D physical materials/objects.

Natural texture is the texture formed by the natural forces such as a thunderstorm, wind, rain, river etc (e.g. the stone texture), or resulting from the internal atomic structure of substance (e.g. the diamond shiny texture) or by the original/primitive growing mechanism of life (e.g. the texture of leaf, wood). Figure 7 shows examples of some natural textures. No matter what kind of natural texture, such as the random linear texture of wood, or the smooth and marvelous texture of pebbles, or the fine, soft and wavelike desert texture, the leaf, the ice, the animal skin, … all the natural textures not only give us an enjoyment of beauty and harmony, but also give us abundant inspiration, as sources of creativity, particularly in the aspect of pattern.

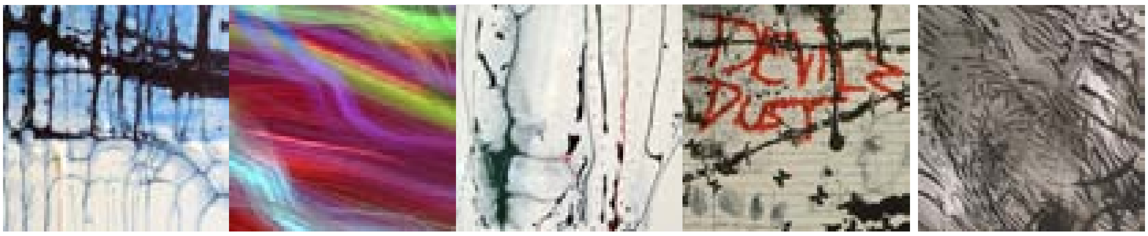


a. water drops b. desert c. leaf d. zebra e. wood

Figure 7 examples of textures existing in nature

Texture created from the mind, fantasy

In this case, texture is regarded as the component of any image in people's mind, which becomes a graphic picture when presented via a certain media. Any images in human brain will not come from a vacuum, but from their life experience and memory. But only the experience and memory are not enough so that not everybody can produce an astonishingly attractive image and become so-called 'artist'. Free Imagination and fantasy based on that experience is decisive factor. Here, people's accumulated life experience and sensitivity to art promotes each other. Examples of textures coming from this kind of fantasy are shown in Figure 8. A deliberate strengthened training in graphic presentation will be a worthy route to stimulate the creative thinking of a 3D designer, particular industrial product designer in their practice.

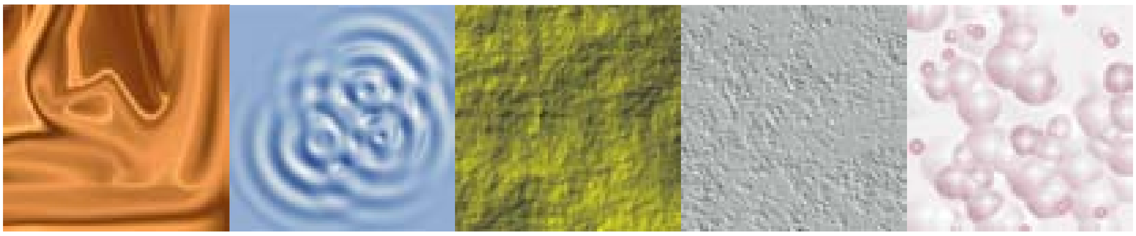


a. free texture 1 b. free texture 2 c. free texture 3 d. free texture 4 e. free texture 5

Figure 8 examples of textures from fantasy

Texture generated from virtual reality

In authors' opinion, the functional meaning of things existing in virtual reality at least has two aspects. Firstly, it is physical-reality targeted. In other words, it is the preparatory trial or forerunner for any events in physical world, with the purpose of as a testifier or communication for save time and expenses. Such examples include all kinds of CAD design. Secondly, it is virtual-reality itself targeted. As the feature of digital times, virtual reality has become a type of culture. People can enjoy a life style by making friends, playing games within the virtual reality. In either case, it is required that texture of presented images has satisfactory simulation with those in the real world. A series of computer software can make this available. In addition to vividly simulating the textures from the physical world, the digital tool can also produce any non-realistic texture, facilitating people's fantasy mentioned in 6.2. Some examples of virtual textures are shown in Figure 9.

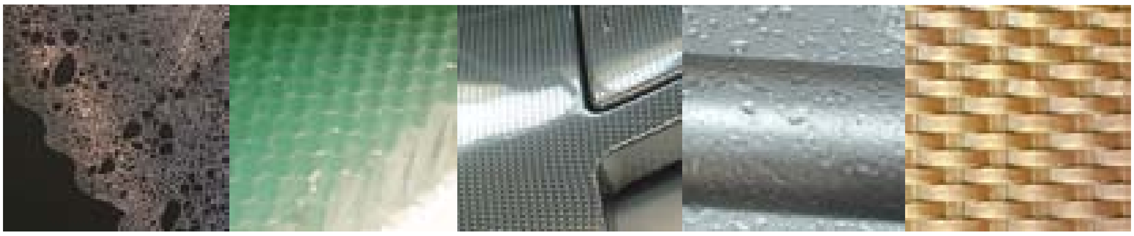


a. simulated silk	b. simulated rain drops	c. simulated foil	d. simulated concrete	e. simulated pearl

Figure 9 examples of virtual textures created from computer software

Texture resulted from advancement of science and technology

The relationship between a surface effect/texture and the innovation in science and technology is two directional. Most cases might be searching for a technical method to convert a texture from a drawing board to a 3D material surface. In these cases, the innovative technology can give the opportunities of realising different surface finishes and textures that were unavailable before. For example, through in-mould coating technology (Figure 10 c. and d.), various surface effects either for decoration or for specific functions (such as impact resistance, crack resistance) can be realised [15]. And it can be tailor-made in line with customer requirements. Figure 10 a. shows a texture resulted from a photo-etching process by which a photographic image is transferred onto a metal surface via either silkscreen or photocopy transfer. On the other hand, in some cases, the advancement in science and technology offer unexpected surface effects, which further stimulates creative practice. For example, nano-technology, by manipulating the micro-size of pigment grains, dramatically improve the look of plastics, inks, coatings, ceramics, cosmetic and personal care products, automobile and industrial finishes.

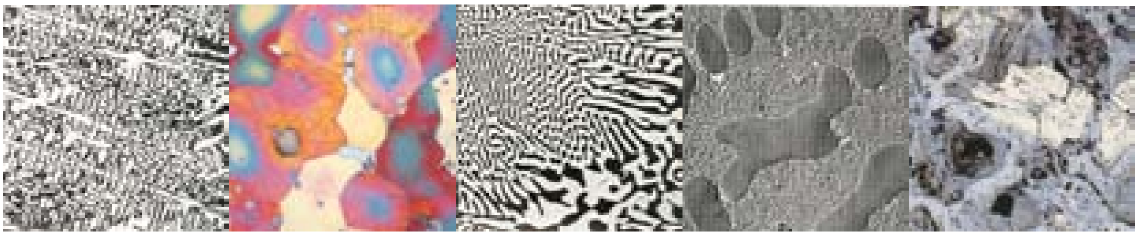


a.photo-etching b.silicon elastomer c.in-mould coating d.in-mould decoration e.3D pattern finish

Figure 10 examples of textures from innovative technology

Texture existing in the micro-world

Usually only a few people have a frequent contact with the micro-world. For instance, a material scientist often looks at the microstructure of a piece of metal; a life scientist examines the DNA composition of an organism sample. Most of other people will neglect this marvellous world. However, information and images within this micro-world not only can give us scientific proof supporting new knowledge about the macro world, but also is a source of inspiration for beauty and art. Sometimes, we can find the images from micro-world and macro-world have some astonishing similarities. Figure 11 shows some examples of the micro-textures observed from microscopy. In addition to appreciate the subtle beauty of the textures, we might be able to get some lessons and enlightenments.



a. etched Ni-Cu alloy b.etched bronze c. etched AL-Cu alloy d.etched Al-Si alloy e. etched cast iron

Figure 11 examples of micro-textures observed from microscopy

Texture derived from social events

Looking at the geometrical or spatial aspect of texture, in a wider sense, we can regard texture as the structural arrangement of the components consisting anything in the world, including the images of social events. These events emerge here and there from day to day. And the images of these events can also be a source of inspiration in texture generation. Figure 12 shows the textures of the night sky with various effects of fireworks. It is understandable that art practice and creation has a significant relationship with social activities.

a. fireworks 1 b. fireworks 2 c. fireworks 3 d. fireworks 4 e. fireworks 5

Figure 12 examples of textures from social events

Conclusions

Formal aesthetics is the fundamental aspect contributing to the whole perceived aesthetics of an artefact. Sensory adaptation and pleasure (from colour, texture, sound etc) is the core content of form aesthetics. Material texture plays a decisive role in the perception of the whole product's beauty and value. To understand and identify a texture, three streams of information are necessary: one, the objective parameters that determine the geometrical, physical or chemical attributes of the texture; two, the subjective description of texture and human responses to texture through different sensory routes; three, the psychophysical relationship between the above two aspects. Texture can be generated or learnt from nature, mind & fantasy, innovation in science & technology, virtual reality, micro-world and social events.

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New naturalness in planting design as a mirror of Nature.

BA. hons Garden Design.

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Abstract

How can a generative design model be applied to the historically complex art of planting design?

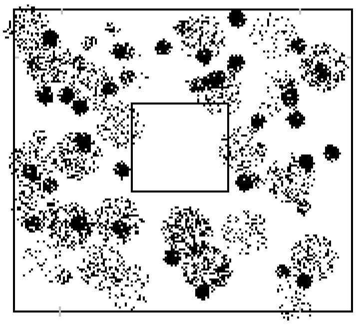
In studying the chronology of planting design it is evident that progress in this field has been slow and cyclical since ancient times. Man has been importing foreign plants since history began, studying their horticultural requirements and replanting them in their gardens. Gardens have been created for the provision of food and pleasure, their layout - a representation of their times.

However we have now reached the point where we have such a wealth of cultural, historical and technological information at our disposal that it is virtually impossible for the human brain to assimilate. Shouldn't the next step be to use artificial intelligence to take into account the natural constraints of the site, the possible plant choices and the desires of the client to produce a generative design using algorithms developed from these parameters? As environmental concerns become more poignant the way we create our surrounding landscapes is coming to the fore of our cultural and political consciousness.

By studying the historical development of western planting design we can see where the origin of today's approach has come from;

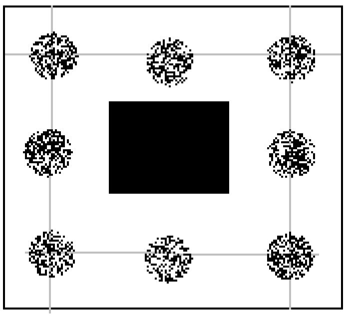
A historical study of planting design.

Figure 1. The gardens of Mesopotamia 18th Century BC .



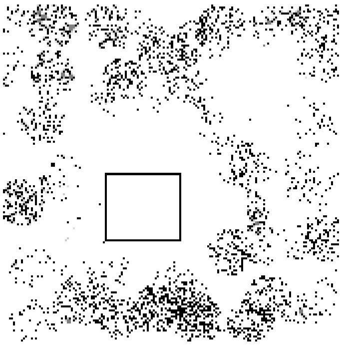
The gardens of Mesopotamia are the earliest historical reference we have to the planting of gardens. We know that their interest lay in attempting to recreate natural planting effects, as in the celebrated hanging gardens of Babylon, however we have no information how they applied this to an actual planting scheme.

Figure 2. The Egyptians 7th Cenury BC.



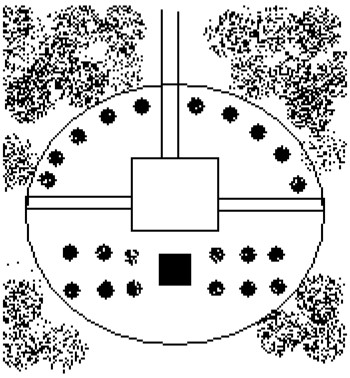
The Egyptians used a formal planting pattern with everything in neat rows, the plants were generally selected for their culinary or healing properties. There was however still a considerable interest in the exotic and imported plants from far a field.

Figure 3. The Greeks 4th Century BC .



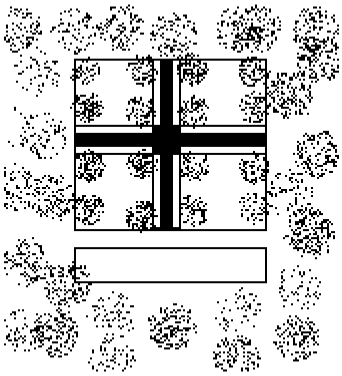
The Greeks shared the Mesopotamians love for nature. They felt the ‘Genus locus’ of a natural landscape was hallowed and sacred to be savoured in their natural state. Rather than trying to recreate this quality, they went to the source and built close to these spots. In the constant study of natural phenomena they marvelled at its complexity and chose to learn from it.

Figure 4. The Romans 2nd century BC.



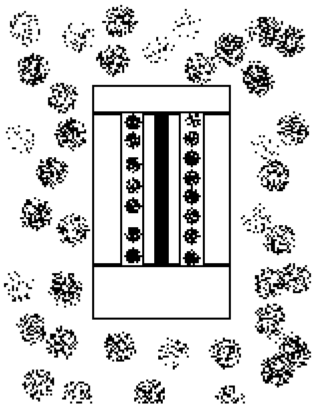
The Romans like the Egyptians favoured a more orderly landscape and they carved great promenades, pergolas and arbours out of the natural landscape; planting them with cypress, rose and vine in an orderly fashion. They created a symbiotic connection between the villa and this organised landscape. Man was at ease with nature, whilst bringing order and discipline to its seeming chaos.

Figure 5. The Islamic garden 8th century AD.



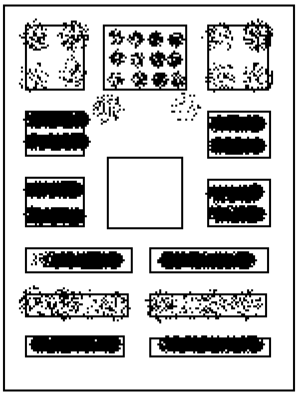
The Islamic garden applied symbolic meaning to four sided geometrical shapes, creating the fourfold garden ‘the Chaharbagh’. Plants were placed in an orderly fashion within the confines of the central square. Contrived planting was kept within the central square of the garden with more naturalistic plantings kept to the outer limits of the perimeter wall.

Figure 6. The Moors 11th century.



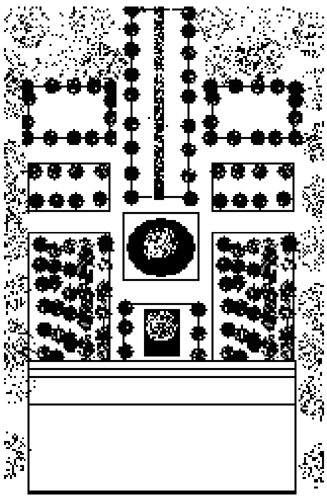
Plant variety had become more palatable by the time Moorish gardens really developed, water was used to create the main formal layout within the garden and more complex sequences of planting began to unfold in the surrounding garden beds. A strong emphasis was placed on flowers colour and scent. This is the first time that the sowing of mixed meadow seeds was recorded showing a delight in the ‘variety’ of nature.

Figure 7. The dark ages 15th century.



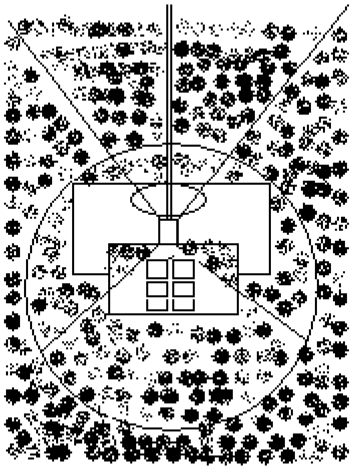
The dark ages saw a renewed fear of nature and the chaos in which it seems to exist. The gardens were walled, the planting design formal and structured. Plants men turned to writing books, huge developments were made in the nomenclature of plants and the study of their anatomy and horticultural requirements. The only way to plant nature was in an ordered and disciplined fashion to overcome the threat that it otherwise presented.

Figure 8. The Italian Renaissance 16th century.



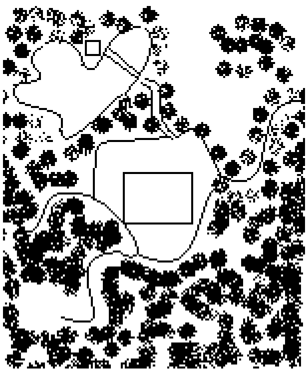
As man became more enlightened and educated so his dominance over nature and her chaos gained confidence. The Italian renaissance gardens saw the reduction of plant varieties used, formal gardens were laid out in a strict geometrical fashion, trees pruned into rational forms, nature was harnessed into mans' desired form. A good example of this type of garden is the Villa d'Este Pirro Ligorio.

Figure 9. The French Renaissance 17th century .



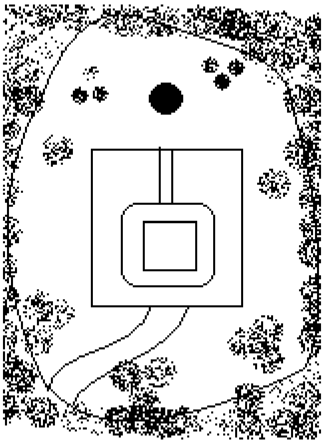
The sheer wealth of the French renaissance gentry and royalty meant they were able to lay waste to vast woodlands, move mountains and dig great lakes. Nature was a thing of fable and myth, now man stood god-like and all nature made to bow to his manipulations. Plant variety was reductionalist, the form and structure that could be made from them was more important, the epitome being Le Notre's Versailles.

Figure 10. The English Landscape Movement 18th Century.



The English landscape movement used the landscape artists approach to designing gardens; remodeling hills, woodlands, lakes and rivers to create his compositions. But although appreciated for its beauty, nature's variety was still not to be found here. Plants were used for their mass rather than for their natural effect. eg. Capability Brown's Stowe House Buckinghamshire England.

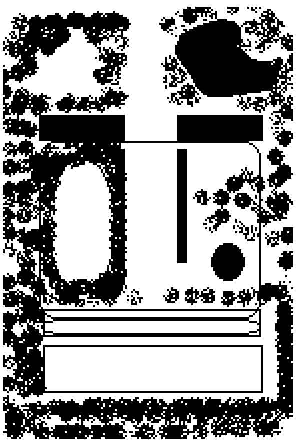
Figure 11. The Gardenesque style 19th Century .



With the dawning of the industrial revolution gardens were made accessible to a wider range of social classes and so we see the application of design on smaller gardens. To utilise these reduced spaces to greatest effect, plant selection became important. The change in scale meant that the plants were chosen individually for their flower, leaf and habit, and used in compositions, as in the landscape movement.

Humphrey Repton brought colour back to the gardens and developed the gardenesque style. But still nature was being categorised, analysed and formalised by man. Natures' own chaos pared down into careful compositions and seasonal colour charts.

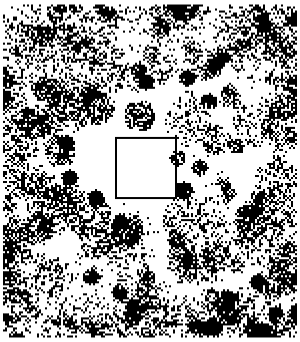
Figure 12. The English Promenade 19th century.



In this same century we see the expansion of the British Empire, travel was widespread and more and more exotic species were readily available. This reflected directly on the planting design of the era as the material wealth grew so we see the arrival of throw away gardens with bedding plants being replaced season by season to maintain the maximum colour and effect, regardless of cost.

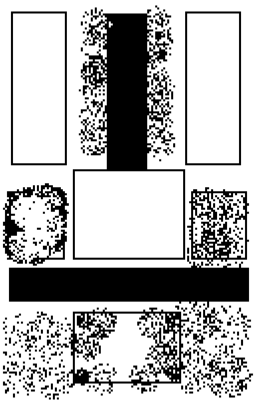
The Victorians were quite literally spoilt for choice so we see everything everywhere scenario creating a mismatched hybridization of planting design, in an attempt to create evermore impressive and extravagant gardens as in those of Joseph Paxton at Crystal Palace.

Figure 13. The Wild Garden 19th century.



Understandably this excess invited contradiction, William Robinson advocated the return to the ‘Wild Garden’ that would develop naturally ‘ … this term is especially applied to the placing of exotic plants in places, and under conditions, where they will become established and take care of themselves… it does not necessarily mean the picturesque garden, for a garden maybe highly picturesque and yet in every part be the result of ceaseless care.’ [1] Finally nature returns to the garden in all its complexity.

Figure 14. A return to formalism 19th century.

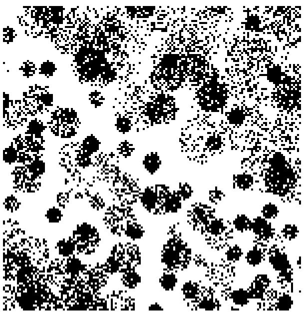


Sir Reginald Blomfield presented the contradiction championing formal gardens and declaring the landscape architect’s objective was not to ‘show thing as they are, but as they are not’. [2] Nature is separate to man and man makes gardens so why pretend it to be other.

Figure 15. Gertrude Jekyll-Edwin Lutyens 19th century

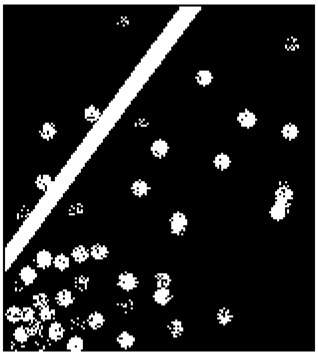
The partnership of these two approaches - the formal and the wild was perhaps the logical next step. Gertrude Jekyll and Edwin Lutyens [3], created their own style, using a natural approach within a formal framework. Plants were chosen primarily for their colour and flowering time along with their form and habit. The regenerating pattern if undesired could always be dealt with by the gardener. Robinsons' ideal is, therefore, still undermined by a desire for year round colour and harmonious colour combinations which were designed in accordance with Michel Chevreul's colour wheel.

Figure 16. Piet Oudolf 20th century.



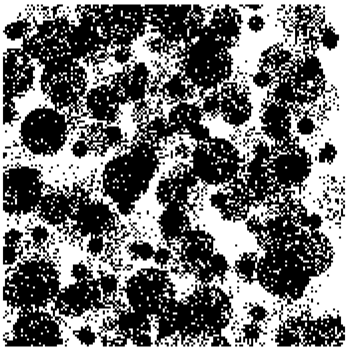
Todays great garden designers are taking the best of the old styles; Piet Oudolf [4], is following in Gertrude Jekylls footsteps and working with great swathes of colour, he has brought us a greater appreciation for the nature of a plant - its birth, life and death being used as an aesthetic, drawing us ever closer to nature. The regenerative nature of the plant is considered at a greater depth and the final result is much more self sustaining, the hand of the Gardener much less evident.

Figure 17. Gilles Clement 20th Century.



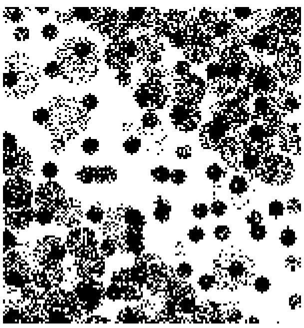
Gilles Clement in his ‘Jardins de Mouvement’ allowed the plants natural regeneration to occur, selected plants are permitted to run across a more formal garden back ground as at ‘Parc Andre Citroen’. highlighting the plants natural tendencies in this way.

Figure 18. Hansen and Stahl 20th Century.



Hansen and Stahl [5], published a book on perennial planting where the reader is able to choose their plant by environmental factors, allowing them to understand the plants’ natural habits, generating a plant list which can be further broken down into its aesthetic requirements; ie, I want a purple spring flower that grows in rocks under trees, by using this sort of information new and interesting planting combinations can be created. Apply a set of algorithms to this plant database and a long list will emerge, giving us too much information, we need to hone this process as Carla Farsi [6], suggested in her paper on aesthetics and complexity when a pattern becomes too complex it is too confusing for us.

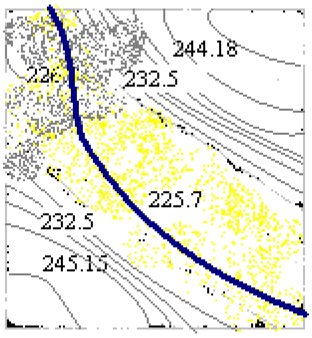
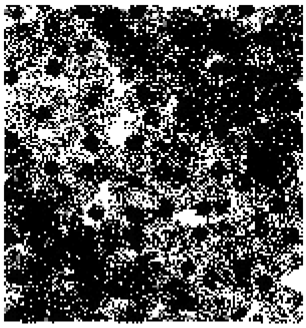
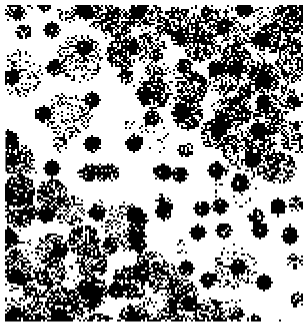
Figure 19. The New Naturalness 21st Century.



The algorithms in this case need to be sufficiently detailed to pare down this complexity into a pattern which is pleasing to the eye, belying that which created and is sustaining it. Perhaps specific patterns will emerge on the computer screen just as the bluebells in woodland emerge where one of the collections' species dominates and naturally leads to a both a self sustaining and aesthetically pleasing solution.

By linking an encyclopedic plant database with a graphic layout of the garden plan, a series of algorithms could be used to give the sufficient site information; soil, microenvironments, uses, etc. It could then graphically plot out a series of planting design solutions which the client could choose from. Each particular plot and client would produce an infinite set of fresh solutions.

Figure 20. Generative Planting Design Flow Chart.

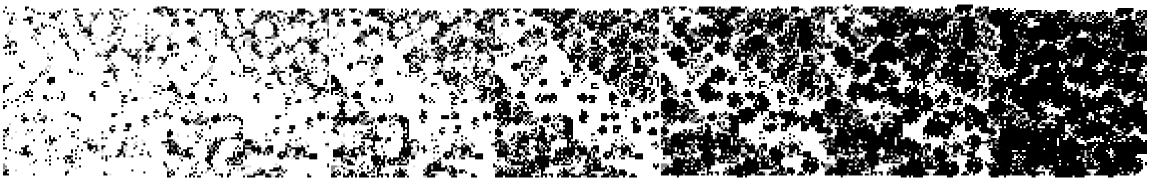
Environmental Factors.		Plant characteristics.		Client Desires.
	+		+	
- Climate		- Size in maturity.		- Style(Wild, formal, organic)
- Seasonal variation.		- Speed of growth.		- Irrigation or not.
- Daylight hours.	+	- Habit.	+	- Colours.
- Soil type.		- Flower colour.		- Period of flowering.
- Gradient.		- Period of flowering.		- Uses.
- Graphic garden layout.		- Leaf texture.		- Speed of establishment.
- Water.		- Regeneration pattern.		- Species origin.
		- Origin.		- Maintenance

A plants natural generative tendencies are such that we need to ask at which point do we take the computer generated design and apply it, do we allow nature to continue the generative design or keep following the computers model?,

Should the resulting solution show what the planting will be like when it is fully matured or should it show the planting in its juvenile state?

Will the program need to back track to tell us how to plant the garden so that in 20 years it will reach its optimum aesthetic value?

Figure 21. Timeline showing increasing natural complexity with time.



Year 1. Year3. Year 6. Year 9. Year 12. Year 15. Year 18.

This is not the static world of architecture where the materials may adjust with age as erosion slowly breaks them down. Gardens grow, plants compete for light and space. Soils are contaminated and eroded, infestations of pests or fungal attacks can destroy entire species, freak weather brings drought or floods, the wind and animals bring seed from other plants. It is certain the garden will not develop in the same way as the computer generated design.

Gardens generate, regenerate and create their own complex solutions. Throw a possible combination of plants well suited to naturalising in a certain environment and watch the process unfold. Should the gardener decide where to stop the progression so that chaos does not assume? Or through a generative approach to planting design can we come up with solutions which will find a natural equilibrium without the hand of 'the gardener' to keep things in order. Perhaps there is a case for the gardener to remove all weed species in the initial stages in order to allow the final establishment of the selected plants. But his role should be an ever diminishing task.

From the beginning of recorded history man has been working with plants to create gardens, either trying to harness nature or trying to replicate it, creating ever more complex planting solutions. The generative approach to creating a design solution has evolved from the study of complex organisms and systems in nature. By using the language of algorithms we can create an artificial system based on the in depth study of natural systems, new and creative highly complex solutions could evolve that work in harmony with the greatest generative artist – Nature.

References.

[1]. William Robinson The English flower Garden, 1883

[2]. Sir Regianld Blomfield The Formal Garden in England 1892

[3]. Gertrude Jekyll Colour in the Flower Garden 1908

[4]. Henk Gerritsen & Piet Oudolf Dream Plants for the Natural Garden 1999

[5]. Hansen and Stahl Perennials and their garden habitats 1993

[6]. Carla Farsi Visual Synthesis and Esthetic Values 2004

Mitchell M. Waldrop Complexity: The Emerging Science at the Edge of Order and Chaos 1993

Design Precedents and Identity, the exercises

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Abstract

This article shows the last developments in the research on the use of design precedents and its relation to the notion of identity which is carried out at the Faculty of Architecture, Delft University of Technology, The Netherlands. This research started with the author's PhD research defended in June, 2003.

This article gives first a summary of an account on how architects use and adapt precedents in architectural design; it provides the definitions of terms used in this approach. Second, it gives a summary of the research into the notion of identity and its relation with the use of design precedents. The main question in this part of the research was whether it is possible to use design precedents to embody a notion of identity in designs. In this part the definition of identity is crucial; because it gives the constraints and the strategy of the research. It goes without saying that we are searching for a critical use of the term identity, far from the picturesque and kitsch.

Third, this article shows two examples of the exercises carried out at the afore-mentioned faculty during the seminar Precedents and Identity on June 22-23 last. This seminar was divided in two main parts: lectures and workshops. We counted with the participation of lecturers such as Prof. Dr. Roberto Segre, from DPA/FAU/UFRJ, Brazil, Prof. Celestino Soddu and Prof. Enrica Colabella from Politecnico di Milano, Milan, Italy: Prof. Dr. Liane Lefaivre from Universitat fur Angewandte Kunst, Austria. The seminar was carried out to raise relevant questions on the role of precedents in expressing identity as well as in enriching our understanding of the notion of identity.

The final part of this article shows a brief evaluation of the exercises and gives new directions to the research.

1. Introduction

The objective of this article is to present the state of the arts of the research on design precedents and on the notion of identity carry out at the Faculty of

Architecture, Delft University of Technology. This article presents its insights and future goals by presenting two of the exercises carried out during the Seminar Precedents and Identity held at the afore-mentioned faculty. The main concepts developed in this research was presented in two earlier articles.

In the article “Breaking the Type (GA2003), Considerations toward the Production of Innovative Architectural Designs by Evolutionary Design Models”, I presented an account of how architects using design precedents might yield innovative designs. This account, which was developed during my PhD, Use and Adaptation of Precedents in Architectural Design, toward an Evolutionary Design Model, refers to ‘what’ and ‘how’ concepts, configurations, topology as well as structure was used and adapted in new designs. At that moment, the question on the architects’ intention (the ‘why’ question) was avoid to its maximum. This aspect was brought to my research when I started dealing with the notion of identity in design.

In the article for the GA2004 “Design Precedents and Identity”, I suggested that the notion of identity should be approached as a ‘complex system’ (Holland 1995) where numerous factors such as economic, political and geographic as well as cultural and morphological. Considering all these factors, one can say that there are always change and continuity over the years, no region remains the same. Indeed, if all aspects abruptly change at once, the system will probably collapse and a new identity may replace the former. Identity refers to control as well as resistance in society (Castells 2004) and whenever people lives or works in a society (virtual or real), there will be a certain (bad or good) identity or numerous identities in struggle with each other (controlling and resisting). The notion of Identity is not considered a static system or closed system, but impregnated by the local culture, changing over time (Moraes Zarzar 2004).

This paper shows, first, a summary of the main ideas; second, two examples of the exercises carried out during the international seminar ‘Precedents and Identity’. Third, it presents a short evaluation of the exercises and the structure of the exercises which our students are carrying out this semester during the course Method and Analysis and the research future goals.

2. The main ideas of the use and Adaptation of Design Precedents

In my former articles, I have being arguing that architects often explicitly make use of design precedents within an explicitly or less explicitly manner but in both ways frequently leading to efficient, effective, and/or innovative results. In fact, 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 (Moraes Zarzar 2003).

In the article “Breaking the type”, I argued that the process of using design precedents resembles in a sense the process of evolution in nature. In nature, the acquirement of characteristics takes place based on the transference of genes from one generation to another and the evolution depends on the transference of erratic copies of genes that generate novelties and more variation through time and the struggle for survival. In this way, these two processes are very different models. However, it is implicit in both models that there is use of past information which is developed during the ontogeny of a new generation (Moraes Zarzar 2003).

In nature the past information is passed to the other generation via the genes which copy themselves and are (partially) transmitted to the offspring. One might say that 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 such as “bottles, schips, and bottle racks “(Tzonis 1990) or also d-genes, i.e. concepts and principles.

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. In this manner, Instructions from a feature are isolated from their original design and transferred.

The configurational, topological or geometrical instructions as well as the 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 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. The main ideas on Identity and Intention

Identity is a concept which is very difficult to define. Identity refers to a multitude of aspects and their relationships. It refers to aspects from different domains such as economics, political, geography, social, cultural, but also “gender, age, ethnicity, life-style and locality” (Sparke 1986, p. 216). It refers to national, regional identity but also to groups, which sometimes do not belong to a territory, and to the individual self. It goes without saying that my research did not discuss all these aspects. The research focuses on how design precedents (configuration, topology, geometry) might express some of these aspects inherent to identity, in particular the social and cultural aspects. It focuses on how architects, using precedents, communicate ideas and answer the users’ need, and, in particular, it focuses on the effort to ‘create’ a new identity and/or to reinforce the extant one; as well as on the use of local potentials and critical import of technology and/or building methods.

In his essay “Identity and Environment: a Cross-cultural Perspective”, Amos Rapoport ask himself what in fact is Identity. He argues, “In order to deal with the communication of identity of groups and individuals one needs to examine the meaning of that concept. It seems generally agreed that ‘identity’ is a difficult concept to define. Dictionaries give multiple meanings, the two most relevant referring to the unchanging nature of something under varying aspects or conditions;

and the condition of being one thing and not another (Rapoport 1981).” He considers both relevant, but he argues that the second notion seems to be at the heart of the concept as it applies to the question considered in his essay: the communication of identity of groups and individuals. While I think that this second notion is not really clarifying much, I disagree in particular with the idea that identity refers to “the unchanging nature of something under varying aspects or conditions”. I think that identity refers to continuity but not a fixed situation.

In the article for the GA2004, I considered the dual character of Identity. I wrote that if on the one hand, with the notion of identity, we might think that we are giving a feeling of community to the inhabitants, on the other hand, identity seems to imprison people in an unchangeable chauvinistic environment or in a parochial picturesque regionalism. The later form of identity seems to be the one which Rem Koolhaas condemns at the beginning of his article “Generic City” (Koolhaas 1998). As a way out this dichotomy, I showed how in “Critical Regionalism”, Alexander Tzonis and Liane Lefaivre discuss the notion of Identity and the modernist technique of defamiliarization as a mechanism to arrive at an idea of Identity in design that was critically open to the import of worldwide elements (Tzonis and Lefaivre 1996) and I explored the idea of how this kind of technique would also help us to achieve a variety of high standard worldviews against the homogenization that globalization is bringing to us.

As mentioned in my former article, defamiliarization is a term coined by the Russian writer Shklovsky who was dealing with the notion of perception in art. According to Lee T. Lemon and Marion J. Reis in the introduction of Russian Formalist Criticism: Four Essays, "The purpose of art, according to Shklovsky, is to force us to notice. [The work of art] is designed especially for perception, for attracting and holding attention (Lemon and Reis 1965).” According to Shklovksy, defamiliarization is the main device to attract this attention, this perception, this awareness of the object. Shklovsky points out, says Lemon and Reis, that defamiliarization can make a reader perceive by making the familiar seem strange (Lemon and Reis 1965). Tzonis and Lefaivre proposed defamiliarization in a different way: as a device to be used for a critical regionalism where local potentialities are allied to a critical import of products/plans of globalization. The local potentialities are then recollected in an unfamiliar and not in a picturesque or kitsch way (Tzonis and Lefaivre 1990; Tzonis and Lefaivre 1996; Tzonis and Lefaivre 2001). In the article for GA2004, I was trying to make explicit how defamiliarization could be used as a technique to promote identity, one far from the picturesque.

To understand the use of defamiliarization of precedents and the degree in which it was applied by architects in certain projects, one should understand the architects’ intentions. Were they trying to create a new Identity of the place/building or to reinforce the current Identity of the place? Were they trying to develop their worldview, their formal vocabulary? Architects might recall precedents to create their worldview to help themselves in yielding structure, configuration and topology in an autonomous moment. With this approach they might, as Le Corbusier in his design for the Unité d’Habitation, create a new identity with precedents that didn’t belong culturally to the future users of the building (Moraes Zarzar 2004).

Defamiliarization seems to play an important role in the case of MGA’s Dr. Santosh Benjamin House (Moraes Zarzar 2004). Both, by Le Corbusier’s Unité and MGA’s Benjamin House, carry meaning and feeling in their expression. However, it seems that the recollection of MGA's precedents, in particular the verandah, carries more meaning and feelings for the dweller than Le Corbusier's precedents would ever do for the dwellers of the Unité (bottles, ships and bottleracks!). In the case of Benjamin House, one might speak about a critical regionalism and subsequently about the creation of an identity of resistance against the homogenization of design and of our cultures; an identity that has a dialectical relation with processes of modernization. In the case of the Unité, Le Corbusier used his precedents in his autonomous moment to create a new identity, a new life-style for the worker class.

By carrying out numerous cases, it became clear to me that: first, architects might create or reinforce an identity or to be somewhere in between these extremes. Second, architects might reinforce the identity of the place or reinforce the identity of the building in the context; or to create a design somewhere between these extremes. Third, to achieve their goals, architects might recall design precedents in a familiar or in an unfamiliar way; i.e. from a picturesque expression (false return to the Heimat) to a "strange" expression (the Heideggerian belief that we can not dwell in modernity any longer). Here as well, it seems that some architects also try to escape from these two extremes.

Finally, the mode of recollection of precedents varies. Architects approach their precedents in varied ways. In Classical Architecture, The Poetics of Order, Tzonis and Lefaivre show three kinds of approach: citationism, syncretism; and the use of fragments in an architectural metastatement (Tzonis and Lefaivre 1986, p. 281). They use these approaches in combination with classical architecture, but I generalized and used for the recollection of any (fragment of) precedent.

Next I am describing two cases carried out by the participants of the seminar Precedents and Identity on the Afternoon of June 22nd 2005.

4. Example One: Renzo Piano's Tjibaou or Kanak Cultural Center, New Caledonia, 1991-1998

The following description of the project is found in Renzo Piano's site. "The centre is composed of 10 " houses ", all of different sizes and with different functions intended as a celebration of Kanak culture: it is a genuine village, with its own paths, greenery, and public spaces, located outside and in direct contact with the ocean. The project addresses the exploitation of currents of air and the difficulties of finding a way of expressing the tradition of the Pacific in modern language, and embodies the decisive contribution of the anthropologist" (Description from Piano's official site: http://www.renzopiano.it)

The site informs that the major challenge of this project was "the task of paying homage to a culture while also respecting its traditions and history, past, present and future, as well as its sensitivities." As in the critical regionalism, on the one hand, the local potentials were taken into account but not in a picturesque way: "The idea was that, instead of creating a historical reconstitution or a simple replica village, it was preferable to strive to reflect the indigenous culture and its symbols which, though age-old, were still very much alive." On the other hand, the products of globalization, meaning European technology and expertise, were used "at the service of the traditions and expectations of the Kanak." According to the official website of Renzo Piano, the products of globalization were intended to be introduced critically respecting the use of building materials and building methods: "By no means should it be a parody or imitation of this culture, nor should it involve imposing a totally foreign model."

The idea of defamiliarization is clear (see illustration 1: hut and settlement). The mode of recollection of the precedents seems to be of a meta-statement, far from an easy citationism.

The project gives continuation to several concepts intrinsic to the Kanak settlements: "The structure and above all the functionality of Caledonian huts were reproduced and adapted, architecturally as well as socially. There are ten huts in all, each measuring between 20 and 28 meters in height, at the center of a nature reserve along the ocean shore. Each is interconnected by a footpath."

Kanak Cultural Center houses different functions than the traditional settlements. However, the setting of its activities and in particular, the pedestrian configuration of the path among the 'huts' are the same. The huts of Kanak Cultural Center houses permanent and temporary exhibitions, an auditorium, an amphitheatre as well as administrative departments, research areas, a conference room, a library and studios for traditional activities. The topology of traditional settlements was put to different use.

It is interesting to see that the preliminary project has a lower degree of defamiliarization (see illustration 1). The final project has a linear spatial configuration, while the former could be said to be a group of centralized spatial configurations. The timber structure does not hide the imported high technology of assemblage. It shows its "contradiction" and , in a almost Venturian way, it brings vitality to the whole.

In summary, one might say that precedents in this project were used to express, to embody identity in a critical regionalism. The first is the Kanak hut, which is used in a certain degree of unfamiliarity consisting on the high technology applied to construct the huts. The second is the settlement topology: huts are organized with a topological similarity and only pedestrians circulate from one hut to the other. there is also a variation of the size of the huts according to their functions analogous to the traditional settlements. This topology was put to different use and adapted to fit the program of a cultural center. One can say that the topology reinforce the local identity. Finally, the precedents were recollected as "regulatory genes" (Moraes Zarzar 2003a), that is: configuration and topology; and they weren't recollected in a citationist approach, but, as meta-statements reinforcing and creating a new identity at the same time.

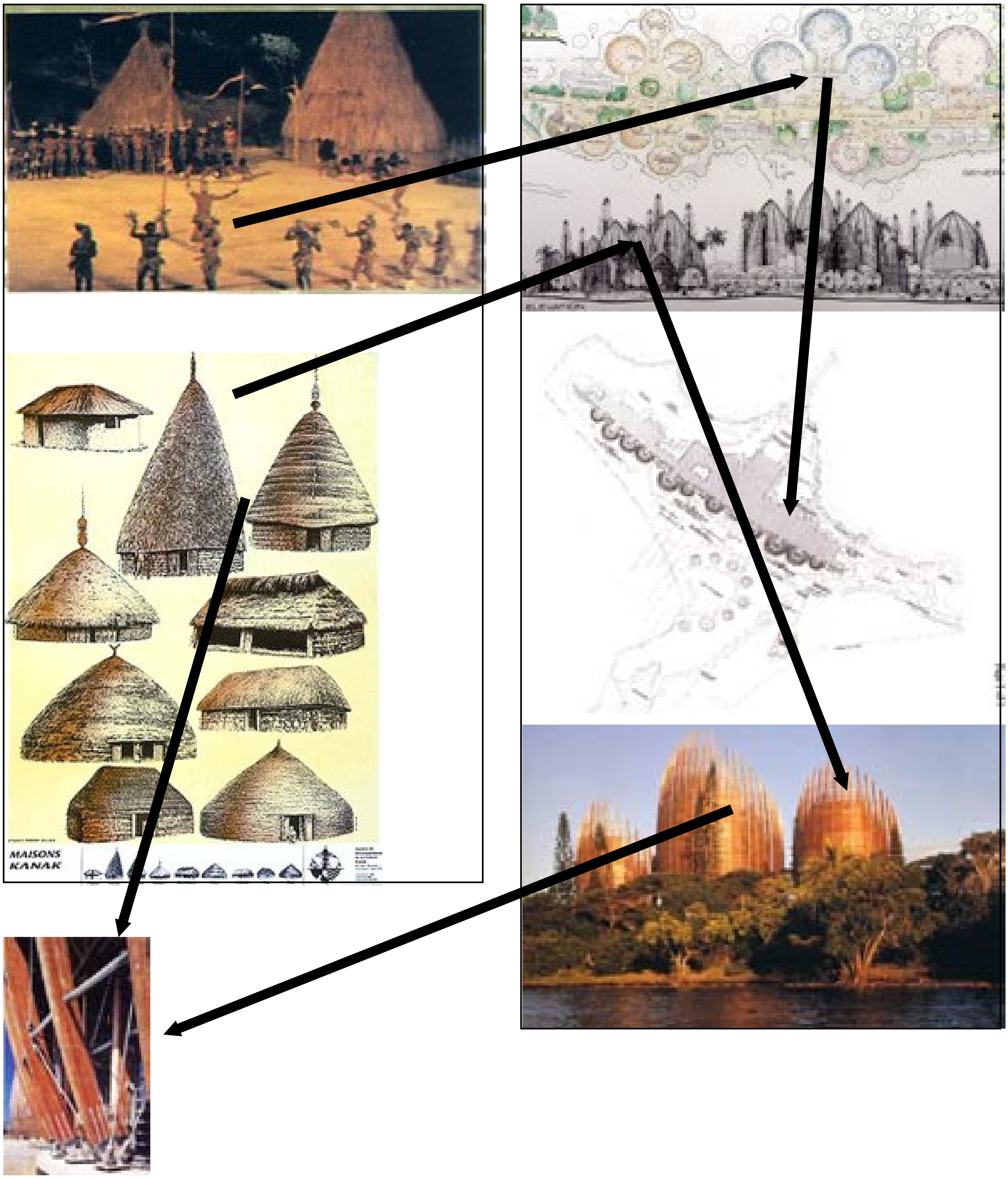

Illustration 1: design precedents and expression of identity in Renzo Piano's Kanak Cultural Center.

5. Example Two: Le Corbusier's Venice Hospital 1964-1965 (mostly based on the description of Mahnaz Shah)

This exercise was developed by the participants of the seminar "Precedents and Identity" on June 22 last as a continuation of the case carried out by Mahnaz Shah, PhD Candidate at the Architectural Association, School of Architecture, London.

Shah contributed to the seminar as the “observer” of a group of participants. The group’s objective was to explore the design precedents that Le Corbusier used in his Venice Hospital project.

In the archINFORM.net one may find the following description of the plan: “Planned in 1965 for the arsenal area at the edge of the city, the hospital was designed to extend the city's roads and canal networks, while simultaneously turning in on itself to create flexible, quasi-urban interior environments in the form of endlessly repeating courtyards. Upon Le Corbusier's death in 1965, Guillermo Jullian de la Fuente was commissioned to complete the building”; however, this project was never built (http://www.archinform.net/projekte).

Shah argues that the project aimed at redefining streets, even entire urban fabrics; their elements were objectified in the form of elevated street decks and a framework of circulations involving an intrinsic relation between the city of Venetia and the hospital, forming an architectural structure that replicates the city in its spatial flexibility and functional programming.

Looking for precedents in the conceptual and typological domain, Shah shows that “the relationship between the built object and the city – as explored by Le Corbusier’s Venice Hospital project – had developed during the twentieth century as early as 1933 by the participants of CIAM 4 to replace the existing urban environment with the conceptual utopian city that would allow its inhabitants to reconnect with the natural environment through building configurations that left ample space for light, air and transportation”. The concepts developed in the 1930’s as well the work developed from the studies on mat-building[22] at the CIAM 9, Aix en Provence, in 1953, for example, Alison and Peter Smithson’s "Urban Reidentification," [23] may be both considered conceptual and typological precedents of the Venetia Hospital. However, as Sarkis (2001) notes in his introductory note to the GSD Case “Le Corbusier’s Venice Hospital”, “Le Corbusier evokes his own Cité Universitaire of 1925 as one of the precursors of the Venice Hospital scheme”.

It seems that more contextual facts may have played a role in coming to the final ‘solution’ of this project. In 1934, says Shah, at the symposium organized by the Institute of Intellectual Co-operation in Venice, “Le Corbusier seems mesmerized by

22 According to Smithson (Smithson 2001, p.91), “mat-building can be said to epitomize the anonymous collective; where the functions come to enrich and the individual gains new freedoms of action through a new shuffled order, based on interconnection, close knit patterns of association and possibilities for growth, diminution and change.” Stan Allen summarized the characteristics of the mat-building, among which he mentioned: “a site strategy that lets the city flow through the project’, and “a delicate interplay of repetition and variation”.

23 Redefining the role of the street in urban planning Allison and Peter Smithson presented their ideas alongside Aldo van Eyck at the ninth meeting of CIAM (Congres Internationaux d’Architecture Moderne) in Aix en Provence in 1953 in a grille conceived as a proposition to abandon the concept of infrastructural zones (housing, transport, industry and, interestingly for our context today, leisure) which underpinned contemporary urban planning. - Alan Read, “return to sender: The Revolution of the Roundabout”, ttp://www.roehampton.ac.uk/artshum/arts/performance/green %20room/returntosender.html

the city of Venice in terms of it being in complete harmony with the human scale and proportions. His Modular may have been a step in understanding and capturing the spirit and identity of this city".

In the project of the Venice Hospital, argues Sarkis, Le Corbusier was able to synthesize seemingly irreconcilable attitudes like the vernacular, mechanization and modernist urbanization, and it was by rejecting the calls for formal indeterminacy that he managed to come up with the main mat (Sarkis 2001)[24].

Moving to the principle of organization of this building, Shah argues that the Unité d'Habitation at Marseilles (1951) also had a important role in it, in particular the role of the corridor as 'rue intérieure' (internal street).

According to Shah's descriptions, "In 1963 Le Corbusier made two sketches after visiting a number of Venetian art galleries, one depicting Carpaccio's Burial of Saint Ursula and another of a reclining Christ by an anonymous artist. The bed and the corpse is what Le Corbusier sketches in the Carnet – raised above the ground, placed on an elevated bed. These two impressions – the need to build without building and with special concern for the scale, and the image of a body elevated over the mundane – could be seen as starting points for the project."

Fitting this information to the structure of the concepts presented in the first part of the seminar, the participants came to the following conclusion. Le Corbusier's recollected his precedents as in the example of the Unité in a syncretism, combining elements and concepts of diverse domains to give form to this Hospital. However, the architectural structure that replicates the city in its spatial flexibility and functional programming was used reinforcing the identity of the place. What was recollected was mostly at a configurational level, "regulatory genes", such as the corridor, the pilotis, the "bed" of Saint Ursula raised above the ground. The degree of defamiliarization of the elements that he recollects from his own oeuvre seems to be lower than the degree of defamiliarization of elements recollected from the city at an urban level, i.e. the architectural framework (mat). The urban tissue has some essential characteristics of Venetia, but without its irregularities, its exceptions, its contradictions.

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indications; the form was spatial and th like
the ripples sent out by a stone dropped into a pond. No previous design had ever evolved so easily and so quickly." This then becomes the reason to read the Venice Hospital as something beyond the mat building. As De la Fuente mentions: This project is a kind of 'témoin' in which Le Corbusier introduces all his principles and theories, leaving the door open to what has to come after. […] the Hospital becomes the work that puts everything back in order." – Shah's notes

Illustration 2: Site of Le Corbusier’s Venice Hospital and bird's eye perspective of the project

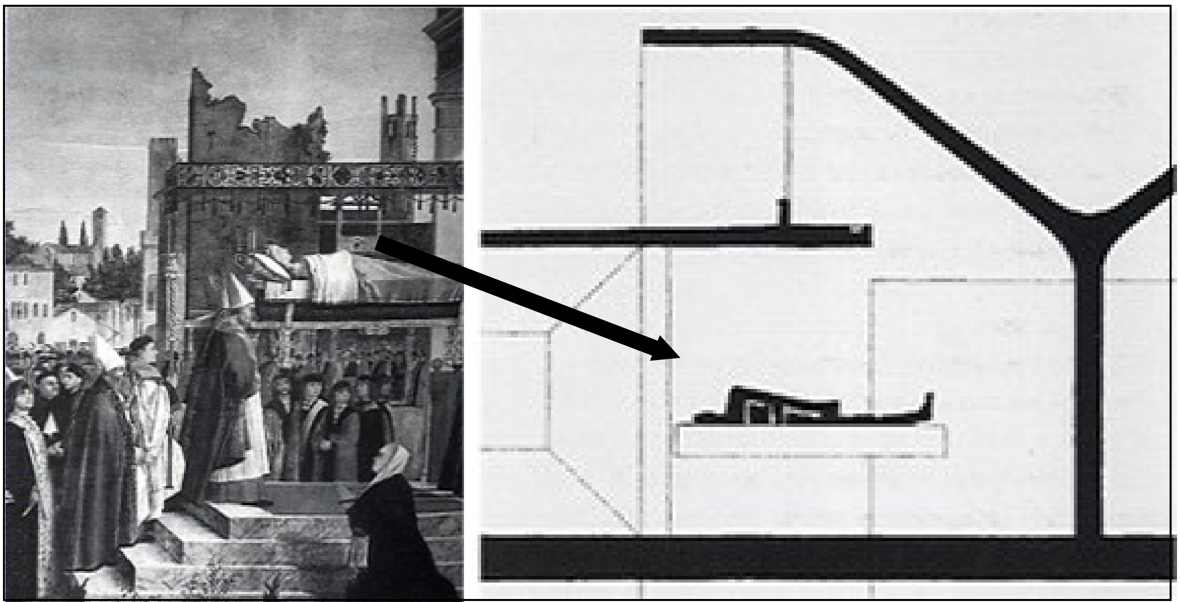

Illustration 3: Carpaccio’s Burial of Saint Ursula and Le Corbusier’s bed design: “the image of a body elevated over the mundane

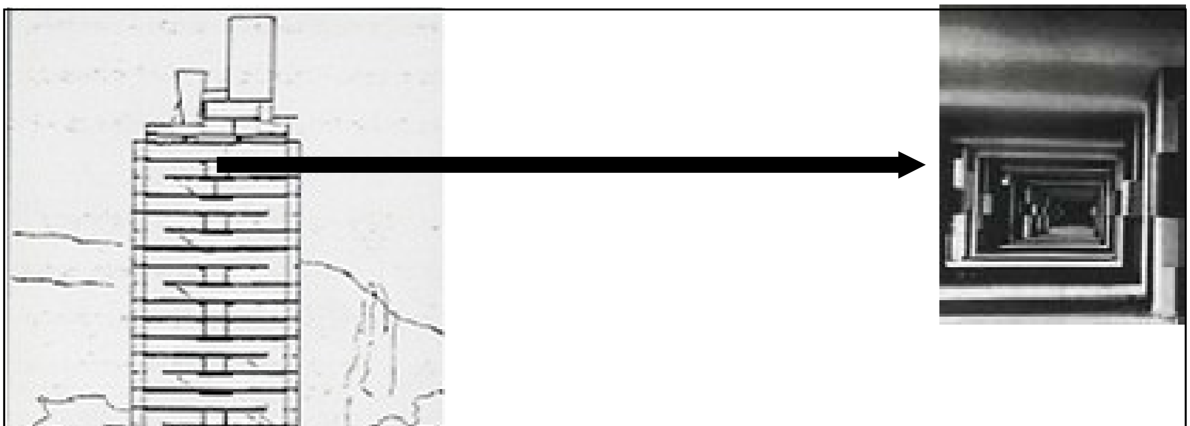

Illustration 4: the Unite d’Habitation and the role of the corridor as ‘rue intérieure’ (internal street) in Le Corbusier’s Venice Hospital.

6. Conclusions

The participants of the Seminar Precedents and Identity who took part of the workshops were enthusiastic with the results of the exercises. The results became indeed interesting, showing all the degrees of defamiliarization as well as that of reinforcement of identity vs. the creation of a new identity. But the results were not exhaustive. This occurs due to the subjectivity of the design precedents that we were handling as well as because of the limitation imposed by the time (one afternoon).

In September last, Ali Guney and I started a course called Method and Analysis at the Faculty of Architecture, Delft University of Technology with 150 students subdivided into 8 subgroups. We decided to apply the ideas so far developed (till the international seminar) with the advantage that now the students would have much more time to analyze the buildings. We could also use numerous projects at once.

We selected 12 buildings, presented them to each subgroup, and let them choose which projects they wanted to analyze (each 2 students analyzed 1 project). So far, each project have been analyzed 6 to 8 times with the help of numerous methods.

The course started with a spatial and functional analysis of the projects. In this part we used Francis D.K. Ching's method, Roger H. Clark and Michael Pause's method, semantic networks representing function and space, as well as Alexander Tzonis' Performance-Operational-Morphology reasoning system to explore the project. At this moment the students are carrying out the last assignment which refers to the use of precedents by the architect. They are doing this based on an analysis of the architect's oeuvre and texts with the help of the afore-mentioned methods.

We expect to find in some examples the initial intention of the architect and a link with the notion of identity: being that the identity of the building or of the environment. We also expect that the students start to see the degree of defamiliarization of the precedents and the degree between reinforcement and creation of a new identity. We pursue the same main question of my article for GA2004: is it possible to embody a critical notion of identity in designing by using design precedents? But, we hope to find this time some formative ideas that have been used systematically to embody identity. Maybe this way we can try at list to partially model the use of precedents in relation to the notion of identity.

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Otopia
The generative design of a computer sports performance

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Abstract

"Otopia" is a large-scale, new-media experiment, which combines the areas of computer games, sports and performance into a spectator-oriented concept focused and premiered in a dome tent at the Roskilde Festival in Denmark in summer 2005.

This paper presents and discusses the overall development and design of the concept. First, the project is introduced and a model of the concept is outlined. Then the basic design objects are presented and a discussion of their various forms is initiated. Special attention is given here to the way the design of rules has been used as a means of specifying the basic immaterial design form. This discussion leads to the suggestion of a rule-based model for the design of situations as a practical option for designers of new media forms in the future.

The project of Otopia was supported by the Musicon Valley Innovation Centre in the region of Roskilde, Denmark. This includes The Roskilde Festival, Roskilde Technical College, Roskilde Business College and Seelite Light design. The project was managed by Kenneth Hansen (creative director), Kim Sandholt (production manager) and Rune Dittmer (art director), all from The University of Roskilde.

Project website: otopia.ruc.dk

1: The concept of Otopia

Otopia is a combination of a computer sports tournament and a performance. It was premiered at the Roskilde Festival in Denmark in 2005. The name of Otopia is derived from the concept of Heterotopia, developed by French philosopher Michel Foucault [1]. Otopia ran for 3 hours on the first day and for 6 hours on the following three days. It took place in a large, circular dome tent, 18.5 meters in diameter and 11 meters high. In the tent, a large projection screen, 3 meters high and 11.5 meters wide, was placed at one end. On each side there was a smaller side projection screen. Under the large screen there was a stage with 6 computer stations on each side. From here 6 players on two opposing teams could play a form of virtual (European)handball/rugby with weapons. The game was developed as a modification of "Bombing Run" one of the level designs in "Unreal Tournament", a popular multi-player computer game on the net. The game was projected onto the panorama screen. The audience could move around freely

and watch the game on the screens: on the smaller side screens they could watch visuals from the VJs, black-and-white video recordings of the players, and information about the score. Each team had a DJ and a VJ. The DJ had the audio line out when his team scored, and the VJ had video line out for the two VJ screens when his team was in ball position. During play,

members of the audience could join the game by lining up to take over a game station. From the producer tower at the other end of the tent, a virtual TV producer, VR camera men, video managers and sound technicians managed the production. On the floor, two sports commentators provided commentary on the game. The sound was delivered primarily through a large number of wireless headphones available for all participants. The event closed every night with the song Otopia, sung by Danish mezzo-soprano Nanna Bugge Rasmussen.

Fig 1: The Dome. *11 m. high and 18. 5 m. wide, the dome was made up of self-supporting pentagonal space frames. The dome was positioned exactly opposite the largest stage at the rock festival, behind the audience section at the back, i.e. just outside the concert area.*

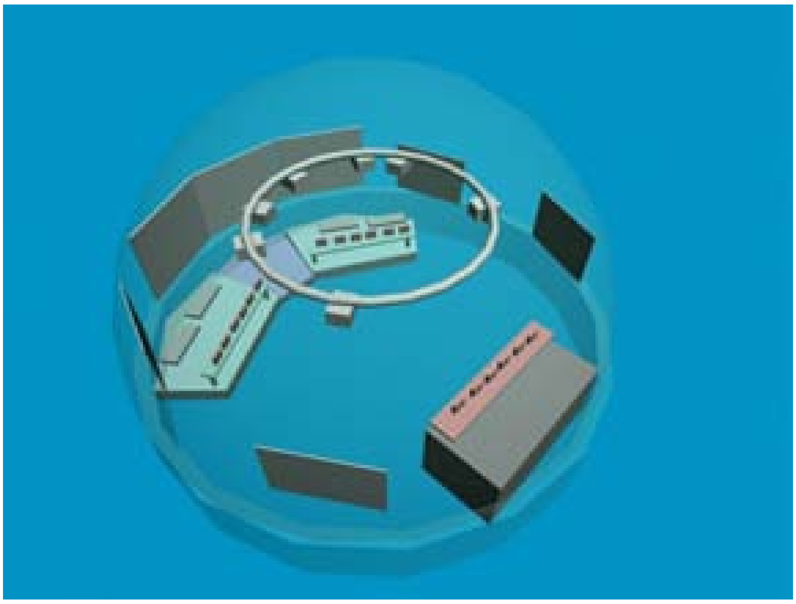


Fig 2: The inside. *Surrounded by 7 screens, two teams of 6 players competed from*

the two sides of the stage. From a producer "tower" opposite the stage, the producer team followed the game with virtual cameras and selected content for the screens. The middle 3 screens hanging over the players and over the DJs and VJs formed a

panorama. Here the spectators could follow the game. On the side screens, video clips from the VJs were projected, and, on the two screens nearest the producer tower, everybody could follow the score. Graphics: production manager Kim Sandholt.

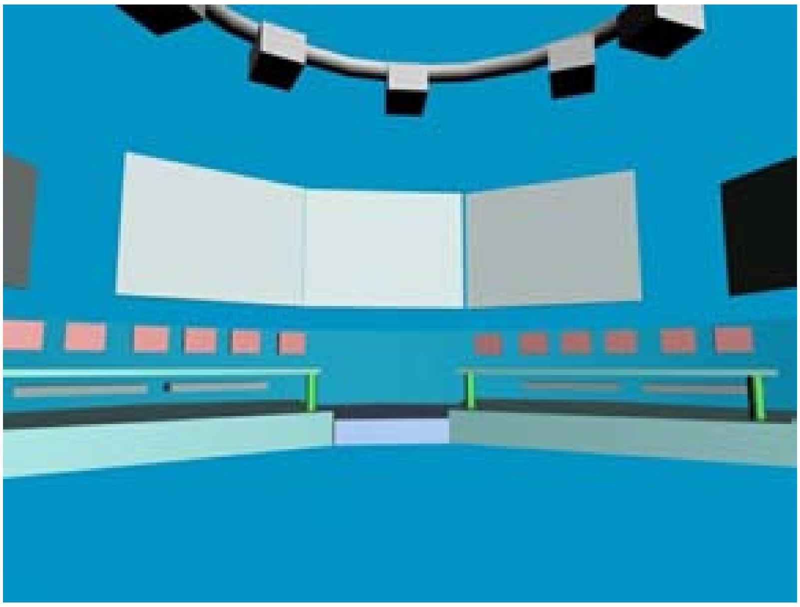


Fig 3: Spectator sport. *In front of the stage the audiencecould follow the game on the 11 m. wide and 3 m. high central panorama screen. Behind the players each team hada DJ and a VJ. The projectors were fixed on a circular rig hanging from the top of the tent. Graphics: Kim Sandholt.*

Fig 4: Construction. *The central panorama screen, 1.,5 meters wide and 3 meters high, was, like the rest of the scenography constructed by students from Roskilde Technical College (www.rts.dk). In the picture the students are busy assembling the*

construction.

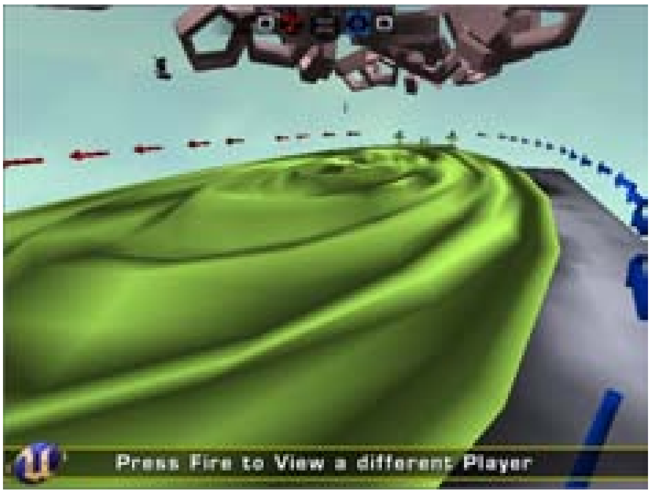


***Fig 5: Wave form.** The level design initially took the shape of a circular wave form as when a drop of fluid hits a fluid surface. This was inspired by popular astrophysical models of the universe. The arrows indicate the positions of two goals. To enhance the feeling of opposite ends, the circular form has been pulled into a more oval form. This also makes more room for the goals. Graphics: level designer Mikkel Thorsted.*

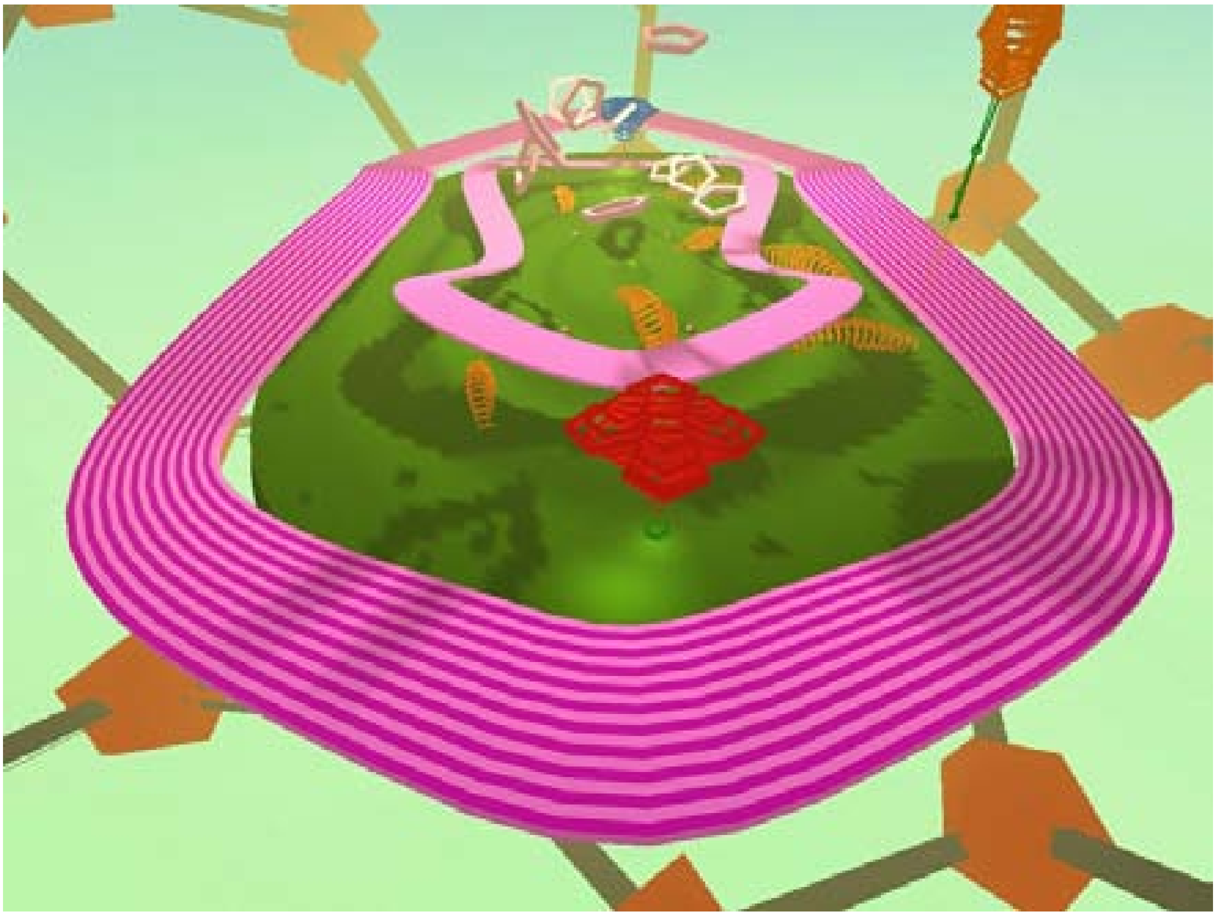


***Fig 6: The Court.** The final design shows the court surrounded by two running tracks. On the outer track players will move, cartoon style, at 2.5 times ordinary*

speed. In the ackground the space frames of the gigantic buckyball, a 3D model of the C60 molecule, in which the court is suspended. Inspiration is here drawn from work in nanotechnology [2] and from quantum computing, where the possibility of making quantum bits as trapped wave unctions in nanostructures is discussed. The

court is thus a kind of nanotechnological Riemann Sphere, an image of a two-state quantum system [3] where the shifts of state reflect which team has the ball. This is reflected against the goal of a possible superposition of the two states. This design idea is represented in the design principle of "synchronization" (see below). Graphics: art director and head level designer Rune Dittmer.

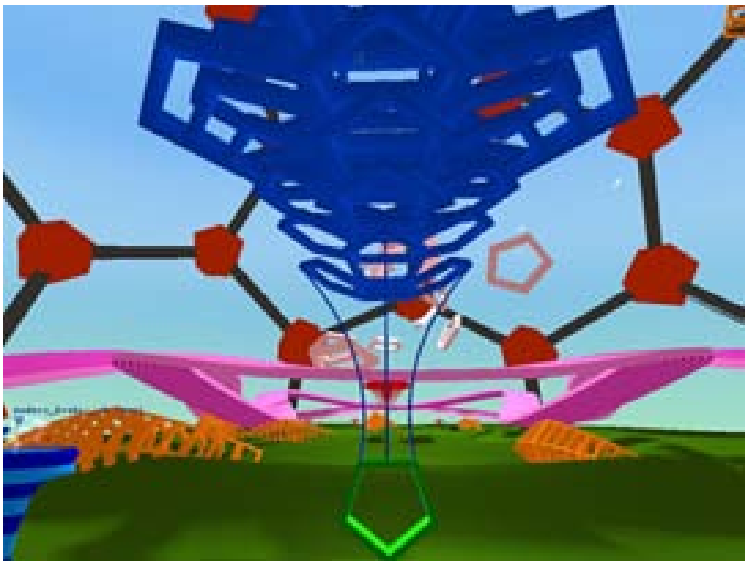


***Fig 7: The Goals.** With reference to the pentagonal isotropic space frames of the tent, the goals were designed as balloon-like meshes of similar, now weightless, structures hanging by themselves at each end of the court. Team players could jump the inner track, move on to the outer track and speed down behind the enemy goal. To jump from the outer track with the*

ball into the goal counted as two points. To approach from the front and throw the ball would count as one point. Team members spawned on the "tees", three on each side of their home goal (the one nearest the goal is visible to the left). Thus they could return quickly to the defence by letting themselves die at the other end, for example by running off the ground. Graphics by Rune Dittmer.

Fig 8: Complexity. *The first full-scale test revealed that experienced computer game players missed obstacles and hide outs. We therefore added more complexity by immersing entagonal airships skeletons into the ground. That reduced the general view, provided enhanced dynamics from depth, and added new intensity in near-combat situations. It was, for example, now possible to hide in or behind, run around or through objects, options the experienced players had missed. Graphics: Rune Dittmer.*

Fig 9: Concentration. *A player of the red team runs for the candy-coloured jumping ball that will take him to the faster outer running track. On the panorama screen at the back the virtual camera follows the player with the ball being chased. He is already on the running track. The*

small screen furthest back is the VJ screen of the opposing team.

***Fig 10: Music.** Behind the team a DJ is waiting for line out. Two "Otopia guides"are tanding by in yellow t-shirts to help players get started.*

***Fig 11: Line up.** The red and the blue team on the stage. At the back DJs and VJs. The blue light spots at the back indicate the team and the player in possession of the ball.*

***Fig 12: : On the stage.** Two red players running forward in the game. They can watch people dancing on the floor in front of the stage.*

***Fig 13: Heterotopia.** The event ended each day with a song about the universe and the enerative principle behind it. The text was taken from the Renaissance philosopher Giordano runo (see later). The video of the singer was projected on all screens simultaneously. The ffect was a mirror hall, a visualization of the heterotopia concept as described by Michel oucault [1], which has given the event its name.*

2. The design task

The design task could initially be divided into a set of basic forms:

Table 1: The basic design forms

Design object	**Form**
Game	Design document
Game-play	Rule book

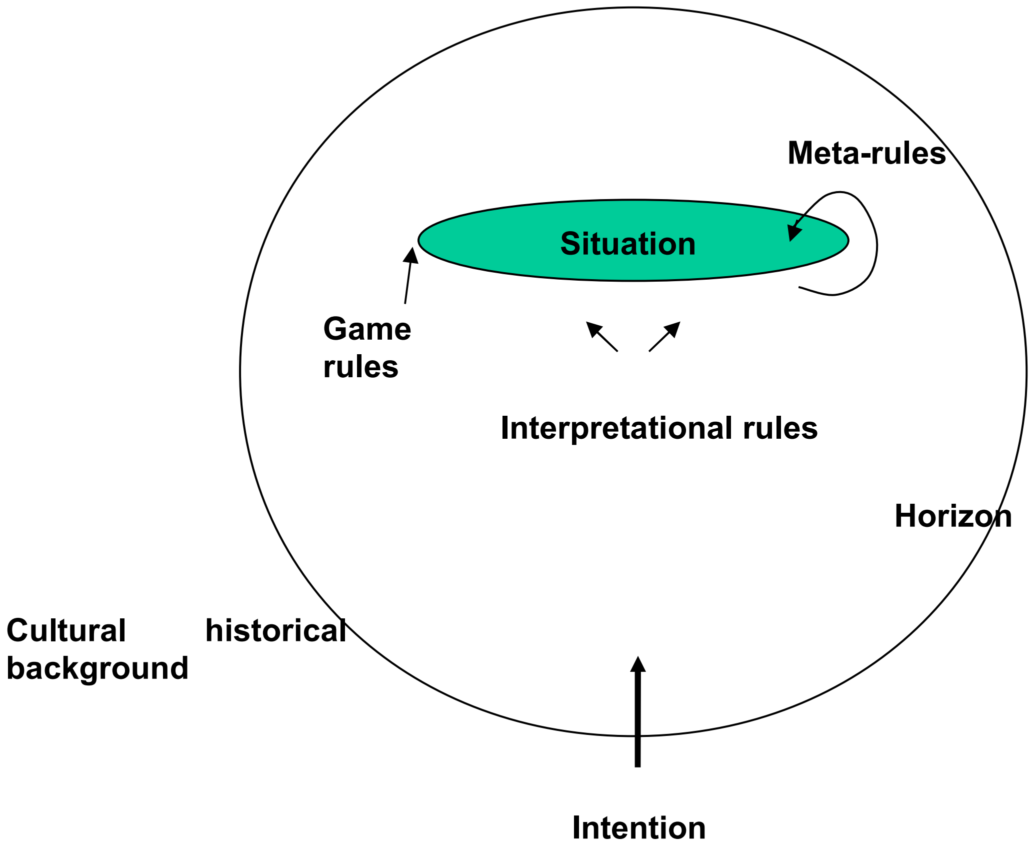
Storyboard	Visualization
Scenography (virtual)	Levels
Performance	Manuscript
Music	Composition
Song	Text and melody
Scenography (physical)	Model
Sound design	Control structure

2.1 Situation design

In my overall approach to the design objects, I drew on the perspective of what I have

previously designated "situation design" [4]. This approach is inspired by phenomenological and ethnomethodological work in human computer interaction where the focus is moved from the interaction with a computer to the interaction between people facilitated by technology [5]. In this tradition, meaning is indexical and embodied in a situation which can be described with the interpretational rules that people use to make sense of it. Combined with the form theory of Spencer-Brown, which defines form as a difference between a marked and an unmarked state and draws it as a circle [6], the design of a situation can be describes like this:

Fig 14: Situation design



Someone, for instance the designer, has an intention of starting a situation and makes a distinction, for example by saying: “this is play”. This accounts for the inner circle. Here the

inner side is marked. The situation has interpretational rules which reflexively govern the participants' expectations and performatively construct meaning and a shared performative space. This is basically a hermeneutic process [7].With the initial difference it is now possible to distinguish between playing and not playing. According to the German sociologist Dirk Baecker, such a system can be further formalized by defining rules [8]. For Dirk Baecker a game is a social system *per se*, and the rules are the border between system and the surrounding world. These rules can therefore be designed. The reflexive use of the game rules are themselves regulated by 2nd order meta-rules. These rules can also be designed. The use of rules and meta-rules are, I suggest, called the game play. The rules have been formed from the informational horizon of the project. This is the context. Rules and the reflexive use of them are embodied in the context and in the cultural historical background of the project. Inspired by Danish cultural sociologist Lars Qvortrup [9], whose work on a theory of knowledge follows the tradition of system theoretical analysis of social systems, and thus Spencer-Brown and Dirk Beacker, the design task can now be systematized in a set of operational levels:

Table 2: A system of operational levels

Level	Form	Object	Parameter
1st. Order	Action	Instruction	Motivation
2nd Order	Play/Game	Rules	Accountability
3rd Order	Organization	Meta-rules	Appropriation
4th Order	Culture	Rule collection	Openness

The designer, first, has to relate to the task of getting someone to act. If nobody acts nothing, of course, will happen. The design parameter for this is motivation. This can be done throughthe design of an instruction. Secondly, the designer has to design game rules which, reflexively, can be used to maintain and stabilize the situation. The rules need to be accountable. If they are not accountable, people will not be able to use them, and the situationwill eventually dissolve. If the rules are accountable it is possible to design meta-rules, that is, rules for the appropriation of the rules. Meta-rules should be flexible enough for people to appropriate them in the ongoing performative construction of the situation. For example, a meta-rule can regulate whether players should follow a rule in all cases or just move on when necessary. Thirdly, the designer must realize that meta-rules are grounded in a cultural practice, and that even this practice is part of a larger cultural assemblage. This is reflected inthe final design of a rule collection or a rule book.We thus have three kinds of rules: rules, meta-rules and ethnomethodological interpretational rules. Rules and meta-rules can be designed; the interpreational rules are what people have with them (including the designer) [10]. Game rules and interpretational rules can be isomorphic, in which case accountability problems disappear. The main goal of the design process could therefore be defined as the design of rules and meta-rules in relation to the interpretational rules of the users at the Roskilde Festival, and to collect such rules in a kind of rule book. In the following section, I present a brief outline of the final rule set. After that, I return to the discussion of the process of their design.

2.2 The rules

In the Dome tent, the 1st order instructions, printed on a piece of paper, were put next to all player stations. They were written like this:

Table 3: Instructions

The game is about: • Taking the ball and scoring • Helping your team and shoot the others. • Team play

Since there were only three instructions, the game appeared easy to master and the reader was

motivated to proceed, i.e. to take the role of a player. Instructions have a double role. In a 3rd order perspective they can also be used as a strategy. That is, as a rule for the use of rules and meta-rules. Used as such, they can form a whole new meta-game. Strategies like this were, however, never part of the design task in this case. Meta-game rules and the interpretationalrules of the rock festival were from the start considered somewhat non-isomorphic. Or to putit more bluntly: To drink and rock did not really call for a game of check. The 2nd order rules were not made explicitly visible to the participants. They are as today only represented in the rule book. In contemporary popular literature on computer games design, rules like these, for example, are divided into constitutional and operational rules [11], or into a division between constitutive and regulative rules [12]. These divisions refer back to speech act theory where certain speech acts establish the speech situation and others regulate it. In this case then, the rules can be listed like this:

Table 4: Rules

Constitutional rules
The game is played with a ball.
There is a goal at each end of the court.
The game is about scoring goals.
The game takes place on a court in an arena. The court is only virtual and displayed to theaudience in the arena.
The game is played by two teams of six players. The players stand in front of individual play stations on a stage in the arena. They are represented as avatars on the virtual court.
At game start the ball is placed on the play-off top in the middle of the virtual court.
At start the avatars of the players are situated on three tops on each side of their team goal.
This is also the place where they reappear (spawn) if they are killed during the game.

A player can score by having his avatar: 1) Jump with the ball through the back end of the goal. This adds 2 points to the score. Or 2) Throw the ball through the front of the opposing team's goal. This adds 1 point to the score.

Goals are automatically registered and the score is displayed on two screens in the arena.

All players can take the ball by running his avatar over it. All players can move the ball by letting their avatar run with it.

All players can make their avatar throw and catch the ball. Throwing to other avatars is making a pass.

If the ball is lost, it cannot be reclaimed unless another player has had it in position.

A player can tackle another player by letting his avatar shoot the other player's avatar.

A player can have three different weapons. One is the default weapon; the others are collected by the avatar during game play.

A player can make use of the candy-coloured running tracks by steering his avatar to a jump on the candy-coloured jumping ball. The jumping ball will bounce the avatar up in mid air according to the direction (the vector). The direction can then be adjusted so the avatar will land on the inner running track.

On the inner running track the speed is increased by a factor of 2.5.

From the inner running track it is possible to jump to the outer running track. The outer running track is meant for hiding and long-distance shooting.

Regulatory rules

A game is played to 10.

The winning team continues. The other team is replaced.

A team can only win three times in a row. Then both teams are replaced.

All teams have free substitution.

Each team has a VJ and a DJ. One VJ at the time can display visual in the stadium. One DJ at the time can play music in the arena. Scoring leads to DJ shift. Ball position leads to VJ shift.

As stated earlier, the rules can be divided as outlined. But, following the systematic outline above, it would seem more appropriate simply to regard the instructions as constituting the situation, and all the rules in total as stabilizing and regulating it. In this case the next level, the set of meta-rules, can be outlined like this:

Table 5: Meta-rules

Everybody can play the game

A game is played to 10 points.

The winning team continues. The other team is replaced.

A team can only win three times in a row. Then both teams are replaced.

All teams have free substitution during the game.

First person in a line of waiting players gets to play first.

Each team has a VJ and a DJ. One VJ at the time can display visual in the stadium. One DJ at the time can play music in the arena. Scoring leads to DJ shift. Ball position leads to VJ shift.

The game is regulated by commentators and, secondarily by guides.

These simple meta-rules regulate the behaviour of people in the arena, and generate what could be thought of as a tournament. This leads to the final level of the design schema: Meta rules should be appropriable in a way that will not stop or prevent the game play. But the meta-rules themselves are rooted in a social practice. This could be called the FIFA-model.

FIFA, The Fédération Internationale de Football Association [13], for example before an important tournament, will state the rules for regulating the soccer games according to the rules of soccer. A game leader, the referee, then uses the meta-rules in an appropriation of the rules in the context. But FIFA is also part of a larger whole: in the cultural context there is a store of interpretational rules that can be consulted in the design. The extent to which meta-rules are appropriable, rules accountable and instructions motivating rely heavily on how open the final design of the rule book is to the cultural practice in question. Though soccer is perceived differently in Brazil, Japan and Norway it is, indeed, possible to meet in a tournament. In the case of Otopia, the meta-rules were operated by ”Otopia-guides” and two “sports commentators”. The guides, dressed in yellow T-shirts, helped people get started by reading the instructions aloud and showing them the controls, and they helped in the ongoing replacement of players and teams. The commentators were actually stand-up comedians and could mediate the use of the rules in a non-serious way. They would often repeat the rules, or a selection of them, and they would often explain to the audience what was happening in the game by referring to a rule. The commentators would also announce the team exchange, and discover if a player was staying longer than permitted. Thus commentators and guides replaced the need for a traditional referee.

3 Generative design

In order to develop all these kinds of rules, the design process was in fact itself regulated by rules. This is what, in this case, constitutes the heart of the generative design approach: a rule- governed generation of rules in a complex environment. This approach owes heavily to the study of evolutionary computing [14] and the concept of genetic algorithms [15]. Generative systems are basically self-organizing and run by taking as input their own output. This can produce an immense complexity as is well known from, for example studies of models of cellular automata [16], [17], neural nets [18], Lindenmayer Grammars [19] or Artificial Life

[20]. When these kinds of complex systems run, it is not possible to predict determinalistically their end state. Final solutions can be modelled, however, as

forms of configurations, stabilized over time in a solutions space of possible outcomes. In the study of chaotic systems and in the general study of complex systems, these types of forms are often referred to as attractors [21]. An attractor is a state that the system will end up in if the basic operation is allowed to run long enough. A pendulum, for example, oscillating in a space without friction, can be described mathematically as a circle (the rule is for example: x = 1 – y). This circle is the attractor of the system. Since nothing affects the pendulum, the form is stable. In a normal physical space, the pendulum is affected among other things, by air molecules and gravity. At some point in time the pendulum will, because of this, come to a stop. The mathematical description of this is the spiral. The end point is the systems attractor. In the example of the pendulum, the process is constrained by the parameters of friction and gravity. These are the parameters of the abstract solution space. The configuration of form in the solution space of the parameters is called the fitness landscape.

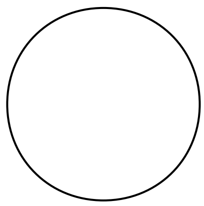
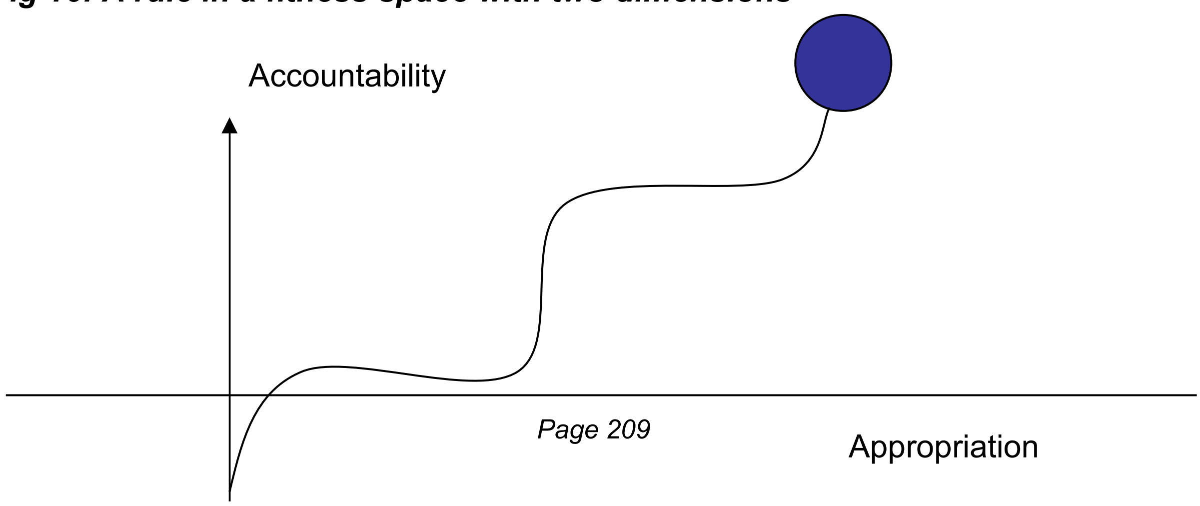


Fig 15: A rule: *A form stabilized in the solution space as a result of the generative design process.*

Following this, the rules of the generative design process are the attractor in the fitness space of the design parameters. The force running the process, the operation, is the cyclic design process. The design of Otopia can be viewed as a similar complex and dynamic generative process: the process generates an ongoing number of forms, rules, which can be tested for fitness. The fitness space has four dimensions expressed in the design parameters: motivation, accountability, appropriation and openness. These are the fitness values. All the rules then, the instruction included, are to be tested and described in relation to the four values. The fittest rule survives. This is the basic generative rule of the design. If we consider the parameter of motivation as a condition of the generative process, and openness as a principle, it is possible to model the process in a fitness space with two dimensions:

Fig 16: A rule in a fitness space with two dimensions



In the process the solutions will, as only illustrated here, oscillate between the two parameters but will eventually end up in the attractor of the blue circle. The circle represents a rule. This is the basic generative design process of Otopia.

3.1 The actual design process

How then was this rather abstract generative design process carried out in practice? The most basic difference from an evolutionary model is the time frame. All design processes have to stop at some time. In nature, processes can, in principle, continue for ever. In the case of Otopia this is obvious: The Roskilde Festival starts at the same time every year. The deadline was definite. As is often the case, the official ”go” for the project was given very late in relation to the deadline. Basically, this meant that we only had a little less than 3 months to develop and produce the event. I therefore chose to work with parallel processes instead of sequential phases in the organization of the work. This approach was inspired by recent work in the study of the development of multimedia systems that combine concepts from traditional models of movie production and newer models of software development [22]. The approach refers to design practices known as, for example, “extreme programming” and “rapid prototyping” where the main point is that the solution space is changing so rapidly and is so complex, and, at the same time, is so constrained by solid conditions (for example lack of time and money) that the design has to happen as an ongoing flexible oscillation between relevant activities. What was now the content of the activities in this case? The activities suggested in the literature were: identification, description, realization and testing. Applied to the case of Otopia, the activity of identification was a question of widening the horizon of the design form by gathering relevant information, and making a logical connection of known elements, that is, journalistic research and analysis. The research task was given to those people who had the time, while the analysis was performed in a dialogue with the three development teams: one for level design, one for sound design, and one for scenography.

The second activity, description, was pursued by organizing a series of workshops: one for the development of ideas, one for sound design and one for pre-production. These were supplemented by 3 open meetings with all participants, and smaller meetings when necessary.

The description was uploaded to a content management system and could be accessed by all members of the design teams. This was the design document. Through the content management system is was possible to edit the content when necessary and to allow monitoring when relevant, for example when communicating with the producers. Thus the content of the system always expressed the state of the development process. In the end it was transformed into the official website of the project (www.otopia.ruc.dk).

The third activity of “realization” is accomplished by implementation and production. But in this case, the implementation was an integrated part of the process, not an activity in itself.

The design was continuously tested and adapted in a complex environment which itself was in the process of being created. The festival emerged simultaneously around the design. Everything was in flux. Further, the concept of “production” indicates a mature structure of manufacturing. The structure of a “machinery” which can be started again and produce the same product again. In this case also, the machinery was generated simultaneously with the design. One of the goals of the project was to make a kind of “invisible theatre”, that is, a generative machinery that could, in the future, create other events and performances. This ambition is, for example, reflected in this paper. Otopia was an experiment for the uncovering of such generative formalisms in the organization and design of new media forms. Thus, a search for a traditional description of a, so-called, mature production would seem like a futile quest. Flow charts of the production line or an organizational diagram are useful, in this case, only as momentarily cognitive cultural models to think with; they do not constitute a total description of a formal whole. A notion reflecting a basic distinction in cognitive anthropology between models and theories: cultural models are good to think with, cultural theories are good to think about [23]. It would, however, be possible to have an office for the execution and coordination of generative formalisms, a kind of store of generative rules. The Roskilde Festival has such an office and will, of course, be able to add the generative rules of Otopia to its stock. A main point of this paper is, therefore, to make these rules accountable, so that they can be activated again, by the festival, or by other relevant parties.

3.2 Testing

The last developmental activity “testing” would normally, in multimedia productions, be carried out by evaluation and post-production. In this case, due to time constraints, only one full-scale evaluation was possible. This took place in a large studio in Roskilde (a former concrete factory). But since everything was continuously being developed only the basic setup could be tested. Further, a kind of pre-premiere was planned some days before the festival opening. But this, second, full-scale evaluation had to be cancelled, since too many unsolved problems remained. Thus the first full evaluation was at the opening of the Roskilde Festival (with only three hours on run time). During this evaluation the last technical problems were solved and the last design issues resolved. For example, it was through this process that the final meta-rules were stabilized, giving the regulative authority of the game to the commentators supported by the guides. But the full-scale evaluation was really a test of technical solutions and game play. The project had no time for a formal evaluation. This is true too for the use of a postproduction. Due to the special combination of complexity and constraints in the solutions space, formal concepts of evaluation and postproduction have to give way for a continuous testing of technical set up and rules. Testing was an integrated part of the generative design cycles. It created a practical selective procedure in the evolutionary fitness space. The activity of testing is crucial. A tighter time schedule could, arguably, optimize the design process, but since most participants were volunteers and the few employees were paid by the hour, early and strict testing would only have tested parts of the concept. A flexible testing approach with one full-size test and a final thorough test in the actual environment still seems like the optimal solution.

Fig 17: Testing. *A large studio, originally a concrete factory, was used for the first full size testing. In the back the stage is being assembled. To the left the level designers are putting up computers and, out side the picture, to the right; carpenters have put up a workshop.*

The testing was, as stated, aimed at selecting the rules. In the final test it was very obvious to what extent the rules fulfilled the design values. First and foremost, it was obvious that the game play was working. People played the game and continued to play. The rules were both accountable and appropriable. Secondly, the meta-rules of the tournament also seemed to work: people were able to join a team on the stage, and to leave again when they had to. Since these rules were regulating behaviour in the scenography, it showed that the physical design did not prevent the appropriation of the meta-rules. When told by the commentators to participate or to stop, people had no problems in moving along. On the whole, the design facilitated the flexible use of instructions, rules and meta-rules. It did not prevent it.

The most problematic part of the design, however, turned out to be the sound design. The festival, especially the architect and the music planners, had demanded that we use a wireless headphone system. We were not allowed to make what they, the music planners, thought of as a new music stage, and the tent was to be used again in the evenings, after the run time of the project, to host a large, so-called, “Silent Disco”, produced by the architect. In a silent discotheque everybody wears a headphone and can choose between three channels of music. The crowd thus dances in silence to three different pieces of music. This is a popular and entertaining concept, but it didn’t have much to do with the Otopia project. Since all music had to be delievered and listened to by headphone, it severely restrained the feeling of being a sports audience. People were not able to hear themselves and others cheer and shout, and they were not able to navigate in the tent using sound. Where were the commentators? Which DJ had the line out? Which team had the ball? Thus the accountability of the rules was, in this case, limited. This limitation was further increased by the run time schedule. Since the architect was producing a silent discotheque in the evening (and night), Otopia could only run in the daytime, between 2pm and 8pm. In the middle of the summer, the reflections from the sun at this time of the day were so powerful that the screen image seemed less colourful and less full of contrast than planned. This made the game less accountable and the experience of it less dynamic.

Finally, it was clear from the start that a producer tool would probably be difficult to develop. A producer tool would facilitate the selection of video feeds from the virtual cameras. Like in the TV-production of a soccer match, a well-designed producer tool would give the spectators a feeling of excitement, dynamics and overview. It would be a tool for the on-line narration of the game. We started out with the intention of developing such a piece of software, but, as expected, the development of such a tool was too complicated a task; it demands its own, probably more traditionally structured, development process. Instead of a software tool, focus was put on the producer team. This team of up to five people could navigate cameras, administrate the VJ screens and the two score boards, and manipulate a video switch that could switch signals between the screens on the fly. All directed by a producer. This construction meant that the production got better during the festival, as the team became more adept. In the end they were quite skilled and the production moved smoothly. The question of whether to aim at developing the software or the team might seem a matter of taste or temperament. However, in the light of the complex design space, it would seem appropriate to aim for a compromise: allow the team to get better tools in the future. This might be a goal for a future (post) production.

4 2nd order testing

To design the rules of Otopia was, as we have seen, basically a question of a recursive combination of rule elements in a rule form, and of testing this form in a complex environment constrained by the two parameters of accountability and appropriation. This involved the activities of identification, description and testing. Thus, one activity leads to another and the design task is about identifying the most relevant activity and moving on in a cyclic process, until a solution is stabilized. One cycle, then, would signify one oscillation between the two parameters. The last activity called testing is, we can see now, also a second order activity. By testing the design, it is possible to monitor, evaluate and regulate the generative process itself. That is, by testing the design, the oscillation, or the wave function, might be adjusted or tuned. A goal for this second order activity is, hence, to maximize the output of each cycle and to minimize the total number of cycles or oscillations. To address this goal, three development groups with, then, three different oscillations were started at the same time. Each group, one for level design, one for scenography, and one for sound design, was instructed to identify relevant form elements, to describe a design as necessary and to test it as much as possible. The task was to oscillate between these activities when relevant, and to keep moving. This was also true for the design task in general: to move the design forward was to shift attention between the three groups and, at the same time, to keep the final goal in view.

The general design space was primarily constrained by the deadline. Objects had to be constructed before they were thoroughly designed, the tent had to be decorated without knowledge of the tent shape, and the event had to be organized without proper knowledge of what the event was. Everything was developed simultaneously. Thus, everything was in a state of constant flux: to control or focus on an element in one corner of the design space led to unexpected formations in another corner. To control this design process called for 3rd order correlation. This is expressed in the 4th order principle of synchronization.

4.1 Synchronizing oscillations

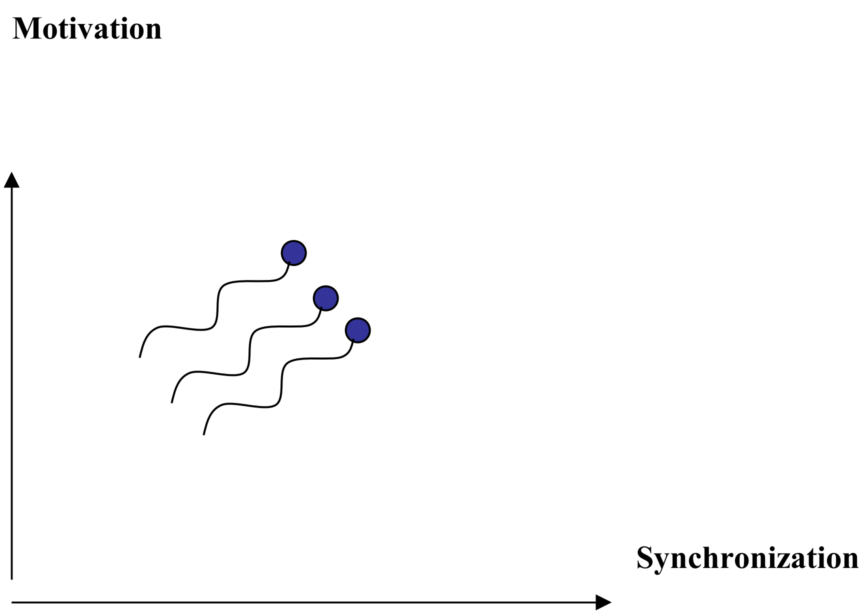
To ensure a correlation of all the oscillations, known and unknown, in the fitness space, the rule of synchronization was chosen as a fundamental generative design principle. Synchronization is a concept used in the study of complex systems to describe the complex behaviour of, for example, fireflies, bird flocks or fish schools [24], [25]. In cases like these, small and similar distributed instructions replace the need for a total algorithm or mysterious, transcendent communication abilities. This approach seemed to go well with the design task of Otopia which called for a correlation of generative processes, and it went well with the idea and intentions of the whole Otopia concept, with its focus on community and mutual reflections reflected against a Utopia [1]. The design in its totality can now be described as a hierarchy of rules:

Table 6: A system of rules

Level	Rule	Parameter
1st order	Instruction	Motivation
2nd order	Rules	Accountability
3rd order	Meta-rules	Appropriation
4th order	Principle	Synchronization

The rules and the meta-rule were generated in a fitness space with two dimensions: accountability and appropriation. The oscillation of the design process was itself generated in a 2nd order fitness space with the two dimensions of motivation and synchronization:

Fig 18: The design process in a 2nd order fitness space with two dimensions



In this 2nd order fitness space, the formation of the form of the rules oscillates between the parameters of motivation and synchronization. Thus, the overall design task was, in this case, to motivate people (many worked for free) and synchronize distributed creative processes. Furthermore, theconcept of synchronicity helped make the design meaning coherent. The song Otopia, which closed the event every day is, as an illustration, a song of synchronicity. Sung and improvised by Danish mezzo-soprano Nanna Bugge Rasmussen, it reflects the thoughts of renaissance philosopher Giordano Bruno [26]. The text asserts the boundlessness of the universe and discusses the place for a fundamental generative principle, that is, the place of God. Inspired by this discussion, the design of Otopia, ideally, allows a discussion of the possibility of a community of man in connection to a fundamental generative principle. The computer game takes place on a wave model of the universe and is less a game of winning than of playing. The game goes back and forth in an ongoing oscillation. Is there a point in this oscillation or is the oscillation the point? Can a synchronized state be reached? This is the basic question of the design.

Giordano Bruno laid the foundations for the later philosophy and radical pantheistic theology of 19th Century romanticism – for the romantic philosophers God was a ubiquitous principle in nature. In the case of Otopia, we ask if the romantic longing for a utopian unity with a transcendental order is a driving force behind new mediated, reflexive communities. The song was a tribute to the power and possibilities of a creative community. It paid homage to the specially generated and imagined space through which a paradoxical meeting of creative man is possible. The end of the song marked the end of Otopia: it closed the space and stabilized the point in the middle of the spiral: the last and final attractor.

5 Conclusion

Forms such as the ones discussed in this paper seem to be generated, adapted and stabilised concurrently in a complex environment. This is the evolutionary process that has been modelled. But the rules are not, neo-darwinistically, just made from the combination of elements in a generative process. Nor are they merely, ethnomethodologically, indexical forms of the environment. They are part of a process of processes, where all generated forms in the design context interact with each other and with the complex and changing environment [27]. To deal with a complicated design challenge as this, I have pointed to the use of a generative model of rule-based situations. The focus on situations is a practical tool to manage a design task that otherwise would seem overwhelming. Indeed, the project of Otopia indicates this. If this is the case, it would seem appropriate for the design of such new media in general, to require a similar approach. Thus I end this paper by a calling for the meta-design of new media in the future.

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The Generative Dynamics of X, Y & Z Coordination

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Abstract

The architectural work-in-progress titled the Phenomenological Garden has been exploring the morphological and integrative potential of cellular units generated by fundamental processes within natural phenomena. As part of the overall objectives of this project and the Forms Studies Unit at Carleton University's School of Architecture, students in the Crossings Workshop have been carrying out these explorations through projects that incorporate hands-on procedures derived from the research. The inherent properties of the cellular units, along with the nature of the materials and processes involved in these projects, allow for a generative and intuitive learning process to occur. Previously, the generative dynamics of two-dimensional cellular units have been explored (see the Paper: Generative Dynamics: Process, Form and Structure, 2004 Generative Arts Conference Proceedings). This paper will present the work that has emerged from the exploration of the X, Y and Z coordinate system as a fundamentally dynamic relationship within a generative cellular process.

1. Introduction

"In this brief account of coordinate transformations and of their morphological utility [The Theory of Transformations, or The Comparison of Related Forms] I have dealt with plane coordinates only, and have made no mention of the less elementary subject of coordinates in three-dimensional space . . . And that it would be advantageous to do so goes without saying, for it is the shape of the solid object, not that of the mere drawing of the object, that we want to understand; . . . But this extended theme I have not attempted to pursue, and it must be left to other times, and to other hands."

D'Arcy Wentworth Thompson [1], also see Fig. 1

Throughout the natural environment we find fundamental processes that generate versatile systems and patterns. These highly fertile, self-organizing and regulatory processes inherently exist within, and generate, the rich realm of natural phenomena. Simultaneously, they are composed of, and self-generated by, elemental geometric relationships that gradually evolve into versatile integrative systems with startling form and structure generating capabilities. Through the systematic analysis of the versatility and generative potential of these systems and their interrelated cellular patterns, new insights can be revealed into the emergence of complex morphological structure and form. The intrinsic nature of these dynamic patterns reveals that they are cellular configurations of highly ordered relationships.

The extremely dynamic undulations of the flow of energy are constrained within the apparently static stability of the pattern. This versatile constrained activity fluently encodes the emergent pattern with complex potentiality offering a multitude of possible or alternative 'readings.' The cellular units comprising these patterned networks innately contain the intrinsic attributes of the versatile processes that generate them. Inextricably, we are participants in, and surrounded by, this rich and dynamic matrix of natural phenomena. The inherent properties and characteristics of this generative matrix can be systematically explored allowing for the possibility of insightful understanding of its fluent potentiality. This analytical process offers new insights into the nature of the reciprocal relationship between matter, developmental processes, growth and form. Rich educational methodologies are offered through new procedures and techniques that can inherently allow for intuitive learning through self-discovery. The Phenomenological Garden project is a work-in-progress and in-process that has been inspired by these insights and the working procedures that they can reveal regarding nature's developmental processes. It seeks to explore the form and structure generating potential of these dynamic processes along with their elemental components, emergent integrative properties and pattern generating capabilities.

2. Elemental Cellular Dynamics

Through systematic analysis, the dynamic potential of basic geometric relationships has been explored, leading to the development of a series of flexible cellular units and hands-on analytical

procedures. Inherently, this allows for intuitive discovery to occur regarding the interrelationships between form, structure, and generative process. The cellular units are constructed using bamboo dowels and joining them together with rubber bands thus creating a very malleable joint. By combining these very flexible units together into three-dimensional configurations, the form generating potential of both the individual cells and the cellular assemblies can be easily explored. The flexibility of the joints and their complex three-dimensional relationships, generate a wealth of forms and structures through the emergent, transformative and organizing properties of the integrated assembly. The dynamic properties of initially two-dimensional cellular units have been explored (see the paper: Generative Dynamics: Process, Form and Structure, 2004 Generative Arts Conference Proceedings). These have been hands-on dynamic explorations of what were primarily graphic, two-dimensional and static explorations by D'Arcy Thompson [1] through his "Theory of transformations or the Comparison of Related Forms" (see Fig. 1 below).

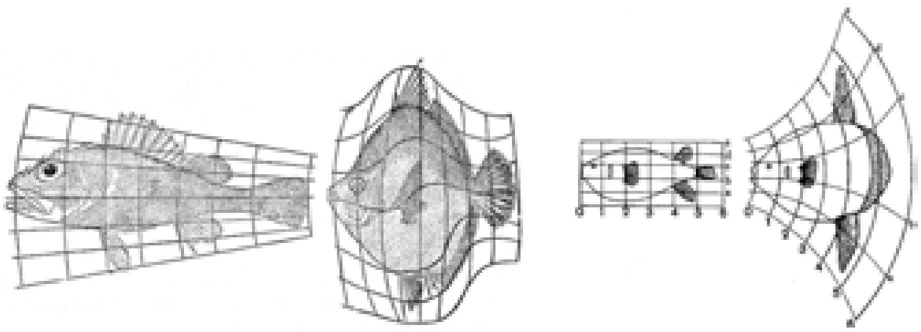
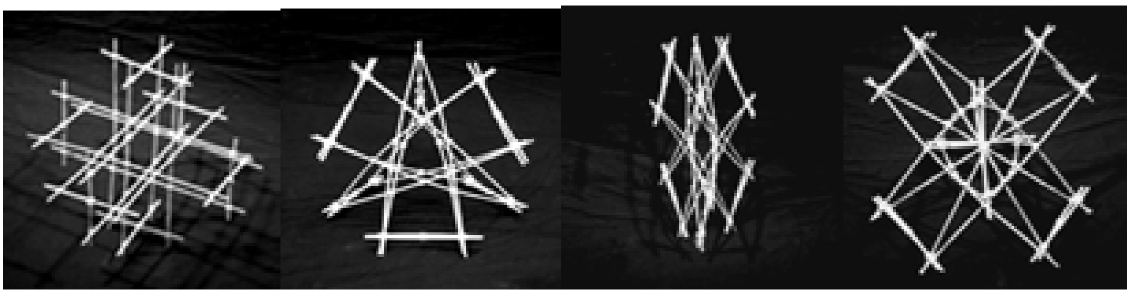


Figure 1: D'Arcy Thompson, grid or coordinate transformations of graphic depictions of biological forms [1]. As he recommends in the introductory quote above, Thompson's "extended theme" of three-dimensional coordinate transformations have been explored through investigations of the generative dynamics of such complex assemblies. The following is a presentation of some of the forms and structures generated from the emergent properties of several intrinsic combinations of a cellular unit that is a dynamic three-dimensional assembly of the X, Y and Z system of co-ordination.

2. X, Y and Z Co-ordination

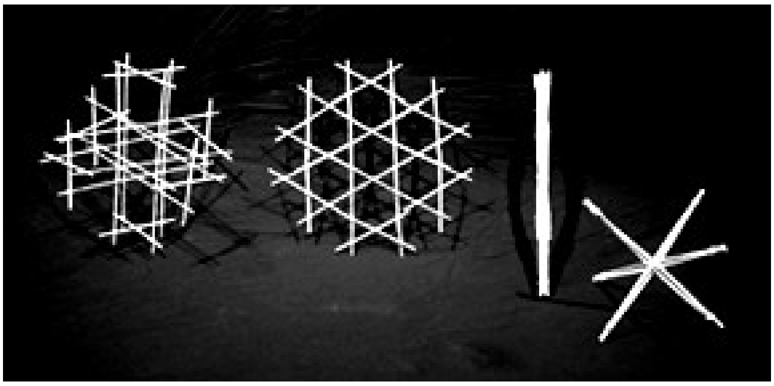
In Figure 2 we see four views of a cellular unit constructed with 12" and 5" bamboo dowels and joined together with rubber bands. The unit is composed of three surfaces (or planes) at right angles to each other with each surface being defined by four 12" dowels assembled into a grid of two pairs at right angle to each other and four 5" dowels, one at each end of the 12" pairs (see Figure 2 D). The three surfaces have a high degree of transformability due to the flexibility of the joints and each surface defines one of the X, Y and Z coordinate directions in three-dimensional space. Each surface can fully collapse along the two orthogonal diagonals of the assembled grid. They can also be warped into a transformable, collapsible and highly flexible hyperbolic paraboloid. Three-dimensionally, this cubic cellular unit (or module) is composed of several interacting degrees of freedom through the combination of flexible joints (a total of 42). From another perspective, this complex intermingling is also the interactions of the three flexible hyperbolic paraboloids within the three-dimensional assembly. In Figures 3 and 4 we see several configurations that can be generated from this dynamic interplay.



A B C D

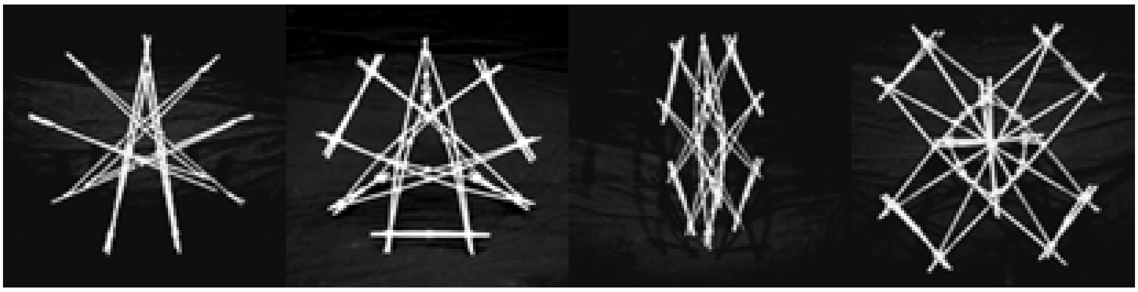
Figure 2: Views of the X, Y & Z Cellular Unit: 12" and 5" bamboo dowels and rubber bands. Three planes at right angles to each other: D clearly shows one of the planes with the central diagonal edges of the other two; B & C show views through the four diagonals of the cubic assembly.

In Figures 4 and 5 we see several of the transformations that can be generated from the cellular unit through a systematic hands-on investigation of its dynamic properties. In the Crossings Workshop, students have been exploring this cellular unit along with the forms, structures and dynamic properties that emerge when several of these units are combined. The numerous possible combinations lead to unexpected overall patterns and dynamic arrangements that generate new and diverse developmental directions for the assembling process.



A B C D

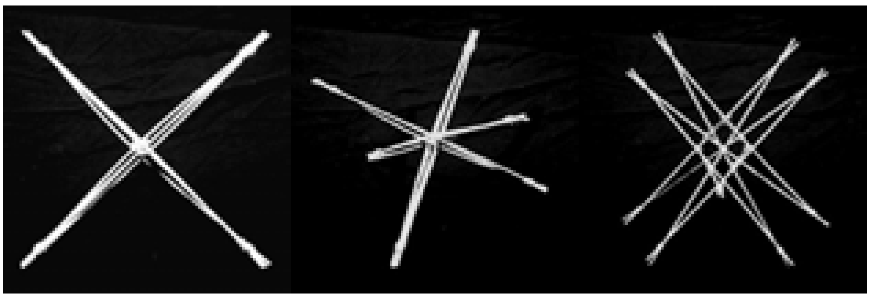
Figure 3: The Cellular Unit and several of its basic transformations. A: The Cellular Unit. B: Flattened assembly along one of the four diagonals of the cubic assembly. C: Collapsed assembly centered around one of the four diagonals. D: Collapsed X, Y and Z axes with 5" dowels removed (see Fig. 5).

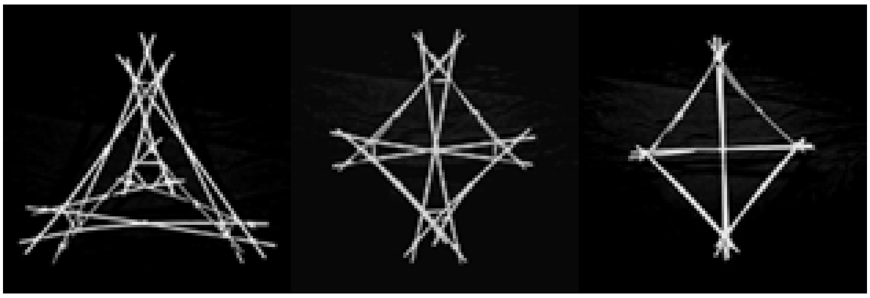


A B C D

Figure 4: Different transformations of the Cellular Unit. In A the 5" dowels have been removed. Each one of these configurations becomes the “modified” cellular unit that is then assembled together.

A B B





C D E

Figure 5: Different stages of a cellular unit that can completely collapse into the X, Y and Z axes (A & B) and gradually expand into a tetrahedron (C, D, E and F).

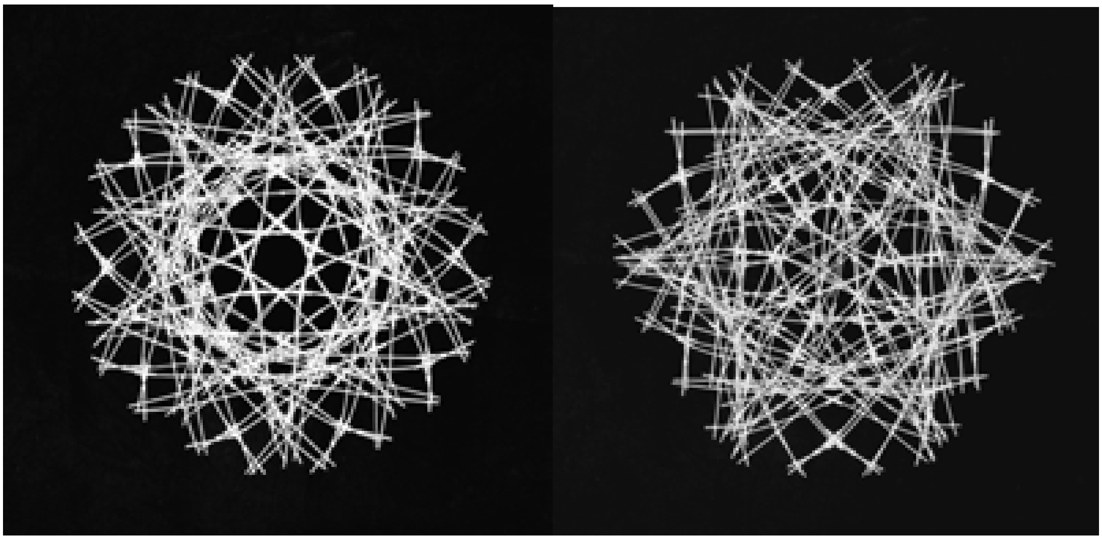


Figure 6: Two views of the same construction, by M. Báez, using the cellular unit shown in Fig. 3. The construction is a dodecahedron that emerged from the assembling process. Throughout the structure and the generated patterns one can discern the squares, pentagons, triangles, hexagons, cubes and tetrahedrons that are intrinsically embedded within the dodecahedron.

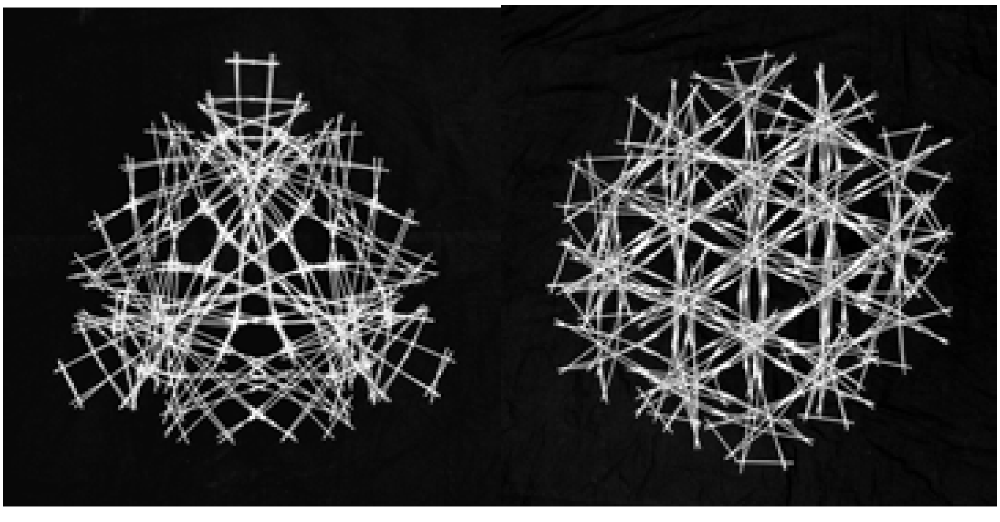
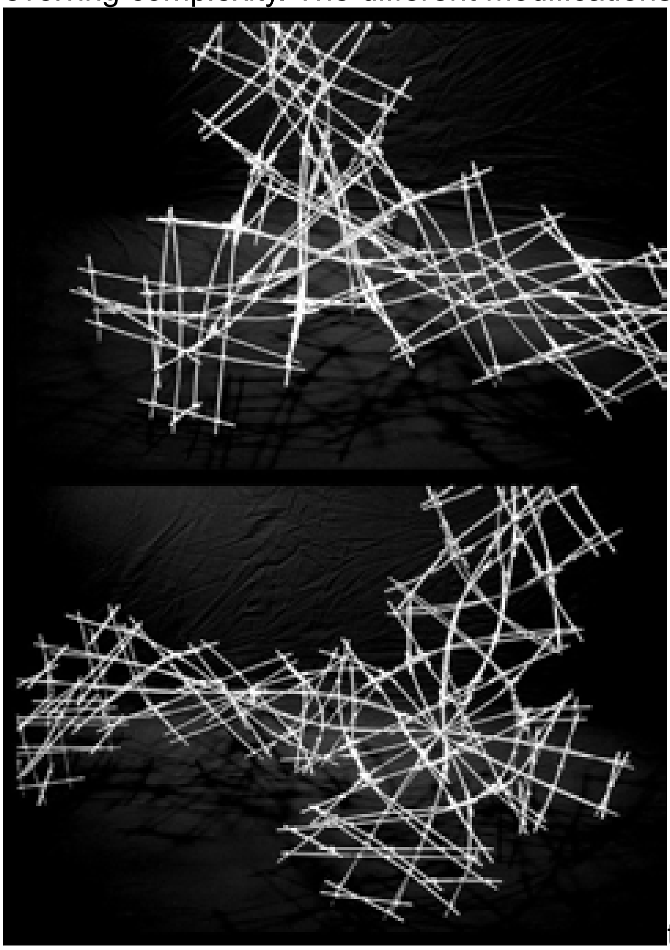


Figure 7: Cellular Constructions. Left: By M. Báez, constructed with the same unit as in Figure 6 and exhibits the same properties. Right: By Sarah Amirault,

constructed using the unit shown in Fig. 4 B. Different patterns are revealed throughout these constructions. The X, Y and Z axes can be clearly seen in the overall pattern of the construction on the right.

In Figures 6, 7, 8, 9 and 10 we see several forms and structures that can emerge as the assembling process gradually evolves into more complex configurations. Figures 6 shows two axial views of the same construction. This particular assembling process generated a dodecahedron that was not preconceived nor initially anticipated. Cellular units (as shown in Figure 3 A) were assembled together using their inherent properties as the guiding principles. Within the resulting three-dimensionally dynamic pattern of the form one can discern the complex interweaving of the rich geometric properties of the dodecahedron: cubes, tetrahedrons, hexagons, pentagons and golden rectangles (to name a few) in a reciprocally complex relationship. Several of these shapes can be discerned in the two views provided. Figure 7 is another construction generated through the same process as in Figure 6 and also reveals the same level of complex multilayering of forms. On the right side we see a construction that incorporates the cellular unit shown in 4B and the X, Y and Z axes of the initial cellular unit are equally prevalent at this level of evolving complexity. The different modifications to the original unit in Figure 2 lead to



the emergence of totally different complex patterns and dynamic properties.

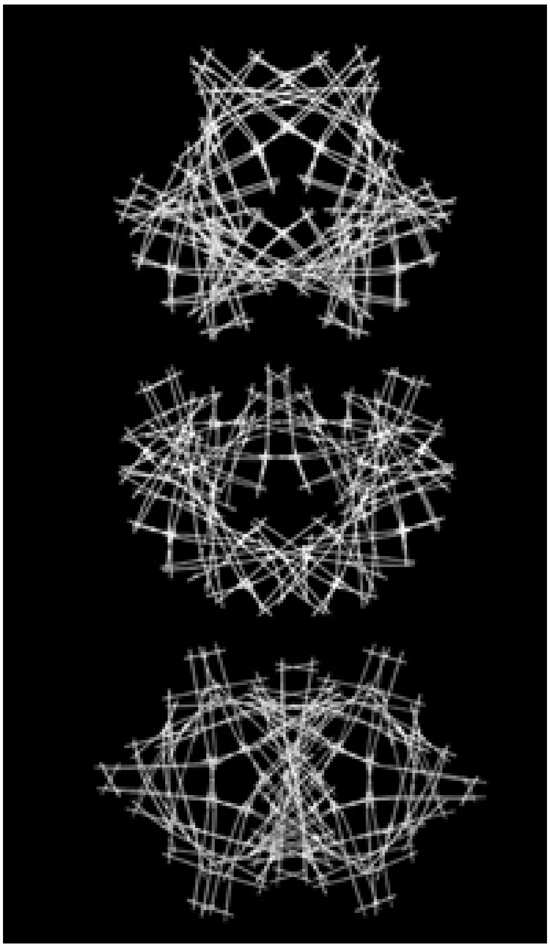
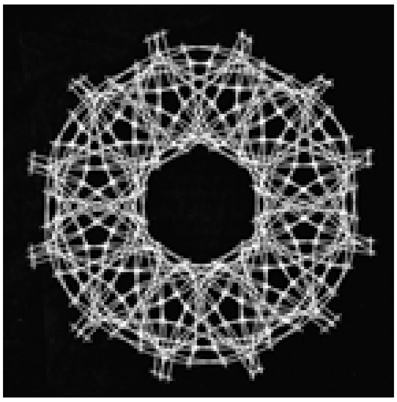


Figure 8: Cellular Constructions, Study models by M. Baez, constructed with the unit in Fig. 3. On the left are two views of the same model and on the right are three views of another.



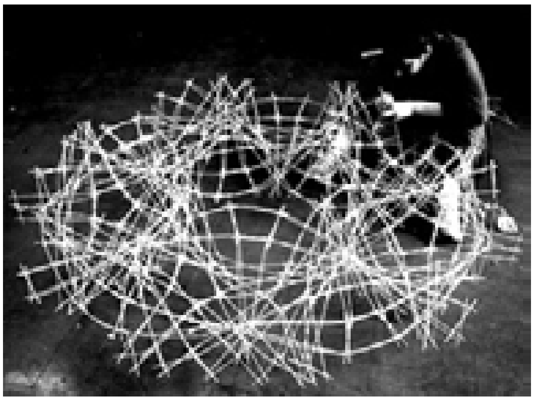
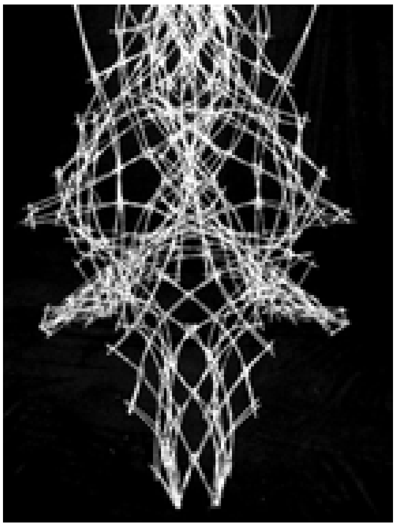


Figure 9: Cellular Constructions. Work by Ana Lukas constructed with the unit shown in Figure1. Top view on the left and under construction on the right.



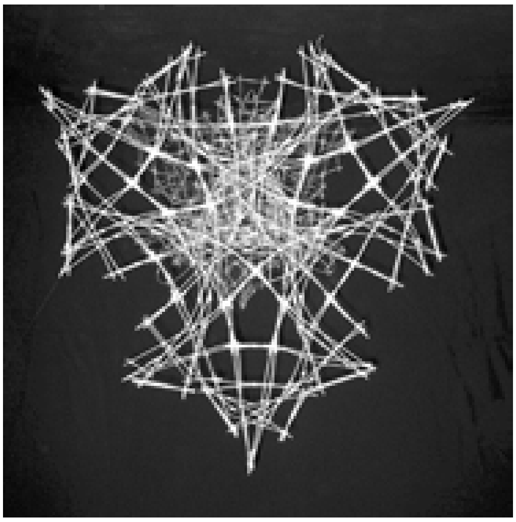


Figure 10: Cellular Constructions. Work by Michael Putman, Patrick Bisson and Rheal Labelle, constructed with the unit in Figure 3. Top view on the right and a side view on the left.

Figure 8 shows study models constructed with the cell shown in 3A. On both the right and left sides we see different views of the same construction. Figures 9 and 10 show views of two other constructions that have been developed to a more complex level than the ones previously shown. The transformability of the cellular units generates very different overall complexity throughout the larger assemblies. Figure 9 shows a toroidal construction that was assembled with the same unit and procedures used in Figures 6 and 7 (left side). The form shown on the left side of Figure 6 fits directly into the central opening of the form shown in Figure 9 (left side). By comparing the two views shown in Figure 9, one can see the dynamic diversity within the elaborate pattern. Figure 10 shows the most complex construction that has been made with the cellular unit used in Figure 6. On the right side we see the top view through the main vertical axis of the elaborate assembly and on the left, a partial side view. The elaborate pattern is ever changing throughout the structure. Overall, the emergent patterns are at times reminiscent of the patterns generated by vibrations in liquids and in thin layers of fine powder. Throughout all of these constructions, dynamic patterns emerge with an ever-evolving intricate level of complexity. Paradoxically, within the integrative interactions of this complexity lurks the simplicity of the original cellular units.

2. Conclusion

“We have been trained to think of patterns, with the exemption of those in music, as fixed affairs. It is easier and lazier that way but, of course, all nonsense. In truth, the right way to begin to think about the pattern which connects is to think of it as primarily (whatever that means) a dance of interacting parts and only pegged down by various sorts of physical limits and by those limits which organisms characteristically impose.”

Gregory Bateson [2]

The rich diversity found throughout nature's processes challenges our creative imagination and common sense because of its reciprocally related combination of dynamic complexity and simple organizing principles. The work-in-progress presented here, along with the broader goals of the Phenomenological Garden, inherently address this fundamental paradox through multidisciplinary research and an integrative working process. Such an approach offers new possibilities and directions to the fields of morphology, architecture and other creative disciplines at a time when there is an increasing interest in the broad implications of our deeper understanding of Bateson's "dance of interacting parts" throughout the physical world.

References

[1] D'Arcy Wentworth Thompson, On Growth and Form. Complete Revised Edition: Dover, p. 1087. 1992. Chapter XVII covers The Theory of Transformations, or The Comparison of Related Forms (P.1026-1095).

[2] Gregory Bateson, Mind and Nature, Bantam Books, p. 13-14. 1980 Second Edition. Duke University Press.

Generativity and the Question of Space

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Abstract

First, space is considered relatively to sensation, perception and representation. This leads to defining notions like dimension, limit or cut, motion, ordering or arranging of forms, and measure. Architectural space is examined through these notions, and the issue of emptiness, or void, is emphasised. Then some experiments (distance maps, and different growth processes) are presented in an attempt to contribute to defining a generative space.

Space

What do we call "space"? And, first, what do we deal with when we think or speak of "space"?Let's begin with very simple facts. In our human experience, we may distinguish at least four levels:

- first, there is the physical world around us (at least, we may suppose it exists);
- this physical world is known to us through our senses;
- the data coming through our senses leads to our perceptions;
- our perceptions lead to representations.

The way those levels have been ordered here is logical: if the physical world did not provide data to our senses, we would not be aware of anything. It is true that our senses are completed by all the devices we have invented to catch information about the physical world. Some of them are less acute than our senses (black and white photography, for instance), others go beyond (X rays radiography, infrared photography, etc.). But, most of the time, the results of these "sensing" instruments have to be "translated" in our human sensorial language to be understood (the result of a radiography is a translucent black and white film). So, as we cannot actually tell anything of the physical world without using our senses, we shall begin by (rapidly) studying our sensorial system.

Sensation

It is generally admitted that we have got five senses: the visual sense, the auditory sense, the tactile sense, the sense of smell, and the sense of taste; or, by way of the “actions” to which those sensations seem to refer (you may shut your eyes, or block your ears or your nose): seeing, hearing, touching, smelling, and tasting. This repartition seems natural, as each sense refers to a distinct organ: resp. the eyes, the ears, the skin, the nose and the palate. If our sensory organs were totally separated, the distinction would be unequivocal. But it is not really the case, and we know that our taste is affected when our nose is blocked. Disabled people, blind or deaf or affected by another sensorial deficiency, compensate their infirmity, partly, by relying on another of their senses: for “normally” seeing people, it seems really incredible to be able to “read” through the tips of one’s fingers, their sense of touching being too poor to allow such a skill.

Anyway, each sense can be distinguished (in any human language, this repartition is accepted), and each sense has its own specificity. For instance, the sense of view is a totally outer and even “at distance” sense, while touching implies. We can only see in a part of the universe delimited by the visual cone (roughly, in front of us) while we can hear in all the directions. Seeing is being affected by electromagnetic waves (light), while hearing is being affected by air vibrations (sound). This induces different kinds of sensations: low frequency sounds are felt, not only by our ears, but through our whole body, while light is not felt by anything else than our eyes (though infrared waves are felt as warmth by our skin).

Each sense is specific, but may refer to a multiplicity of phenomena: for example, our sense of touching allows us to know if a surface is smooth or rough, but also if it is cold or hot, though those two phenomena have little to do with each other when we refer to the physical world. For the visual sense, the primary data are colours, we must admit that colour as such is never separated from the characteristics of matter and is always perceived in space. Time-related events, like the frequency of sounds, or the wavelength of light, are not felt as such by us, but are translated in terms of, respectively, low or high sounds, and of colours.

However incomplete or lacking in some part our sensations are, they compulsorily give us a complete “space” (whatever this word refers to). That is not to say that becoming blind or deaf is not a handicap: that is obvious. But a daltonian, for example, does not feel a “hole”, a lack, in his own field or space of colours. We cannot imagine someone inventing or finding a “new” colour, different from the colours we already know. Such an idea is a “non-sense”, as Wittgenstein said [1]. Even if we know that a colour refers to a wavelength, and that there are wavelengths before and beyond those we can see, nothing on earth can make us “feel” those wavelengths as colours. Even if we have not actually seen all the colours at a certain stage of our life, new colours do not seem foreign to those we have already seen.

Moreover, the physical world, and particularly its spatial nature, is given as a whole. Sensorial data are not separately analysed by our brain, but contribute to a global perception.

Perception

In an article titled “Pourquoi l’espace a trois dimensions”[25] [2], Henri Poincaré defines what we have so far called a phenomenon (or even space) as a continuum: he takes the example of weight. This refers to our sense of touching (the idea here is not to use a balance, but to assess the weight of different objects by taking them in hand) and, moreover, to muscular sensation. We cannot distinguish between weights that are very slightly unequal: so we can make a “chain” of weights, each one slightly heavier than the precedent so that we cannot distinguish two successive “points” of the chain, though we clearly distinguish, for example, the first and the last. We can think of other continua such as the one of colour: with a computer you can easily find a chain of colours, indistinguishable one by one by the eye, and that goes, for example, from black to white, or that travels through red, blue, and green (fig. 1).

The most important characteristics of a continuum is that it has got a definite (integer) number of dimensions. The definition of dimension is topological and is made by recurrence, resting upon the notion of “cut”. The point is 0-dimensional; a line is 1-dimensional because a point makes a cut on a line: you cannot go beyond a point if you are on a line, a point cuts a line in two parts disconnected from each other; but a point, or any number of points, does not cut a surface: to cut a surface you need a line, so a surface is 2-dimensional; in the same way, neither points nor lines can cut a volume or space in separated parts, you can always find a roundabout way; only a surface or surfaces can cut a volume or space: so a volume, and space, is 3-dimensional. With this definition, you can prove that the continuum of weight is 1-dimensional, but that the continuum of colour is 3-dimensional: you can go continuously from black to white without passing by one particular colour, or even without trespassing any continuous line of colours, but a surface will block your way (fig. 1).

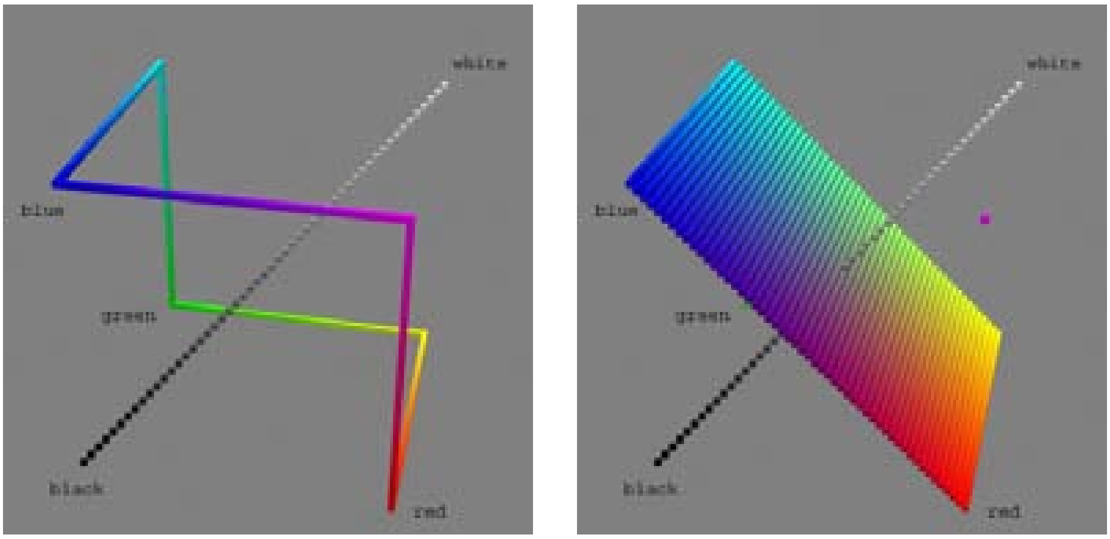

Fig. 1 The space of colours

Poincaré demonstrates that no one of our five usual senses, even if they are cooperating, is able to reveal to us the exact nature of common-sense “space”. The sense of view primarily furnishes our eye, and then our brain through the optical nerve, with rays of light, which attain the surface of the retina after having been

25 “Why space has got three dimensions”

focused by the crystalline lens: the visual sense is then bi-dimensional like the retina [26]; the "tactile" space, if we consider the whole of the skin, which is a surface, is also bi-dimensional at most, etc. To really be aware of the 3D nature of space, we must move, at least our eyes or our hand. To "read" the shape of an object with our fingers, we must move our fingers along its surfaces. To recognize our environment we must wander in it.

Human perception, through our senses, plus the kinaesthetic sense, reveals to us a 3-dimensional space, and not a more than 3 dimensions space. That is a fact, notwithstanding the "real" number of dimensions of the "real" space. For sure we can pursue the reasoning to, say, 4-dimensional forms or space, but to "see" what is a 4D object, we must project it in our 3D space (in the same way as 3D objects are projected in 2D by perspective). As displacements in 3D are translated by changes in the aspect of an object in a perspective (which is notably used in anamorphosis), displacements in 4D change the 3D object obtained by its projection from 4D to 3D. Poincaré suggested that if people in the future (his future, which is our present) learned to manipulate this projection in the same way as anyone does usual perspective, they would acquire an intuition about 4D space. That is actually possible nowadays with computers, and some people, in science or in art (Manfred Mohr [3]), have acquired such a skill.

Representation

We have encountered so far some notions that are inherent to the concept of space: dimension, cut, motion. The notion of form is implicit, because if there was nothing in any of the continua we have examined, at least points, these notions would be meaning less.

We have seen that the notion of dimension, inherent to that of space, is topological. That is to say that we need no Cartesian coordinates to deal with dimension. But, though we must not confuse dimension, in the mathematical meaning, and size, the continuum defined before leads to the notion of ordering, if it is 1-dimensional, or arranging, if it is 2 or 3-dimensional. Inside the continuum of weight, we may order weights (as points of this space) as lighter or heavier. We may even compare two weights and say that one is, for example, twice as heavy than the other. The weight space is 1-dimensional, and ordering it leads to a measure. The concept of colour (as others), generates its own "space" (independently from the physical space of figures and displacements), which we know is 3-dimensional, and that we can represent as well by a double cone with luminosity as middle axis, and saturation and hue as polar coordinates of the middle circle, as by a cubic portion of space with red, green and blue as basic vectors (fig. 1). We can say that this particular colour has more red in it than that other one, but we cannot totally order along a line all of the colours, or event arranging them on a plane, because this phenomenon is 3-dimensional.

Measure is applied to common-sense space, either 1-dimensionally (low/high, short/long, near/far, etc.), 2-dimensionnally or 3-dimensionally (big/little, large/small, etc.). We live on earth where there is gravity, and the configuration of our body leads us to favour a somewhat "natural" Cartesian representation suggested by words like

26 we will not discuss here the stereoscopic nature of vision, that Poincaré addresses in another paper

left/right, in front/behind, below/above. But space is not only the structure of the world in which we live (as we perceive it), it is also for us a way of thinking. The characteristics of the space of figures and displacements are commonly applied to not-spatial fields (politics, feelings, etc.) as a lot of metaphorical expressions in any language show. It goes in both ways, and spatial words get affected by qualities (right is right, so left should be wrong…).

Representation implies thought and language. Phenomenology and cognitive sciences study these relations. Human beings do not only perceive, they think and they speak. But may we not add that they also draw, paint, build, etc? Concerning space, may we not suppose that concepts rely not only to language but also to these actions, this making of forms? In addition, the physical world in which we live is not only natural. It comprises also all the human-made artefacts, which, for the urban modern human being, are even most of what constitutes his daily physical world. May we not suppose that this environment has an impact on the personal and cultural perception and representation of space? Architecture has a central place in this issue.

Architectural space

Architecture may be called “art of space”, because it is an art that deals with all the characteristics of what we call “space”: with cuts (or limits), motion, measure; with dimension; and essentially architecture is a form game (by analogy with Wittgenstein’s language game), its essential preoccupation is the arrangement of forms (or voids, as we shall see).

Limits, motion, measure

Architecture deals with “limits”, a notion which is linked with that of “cut” as Poincaré defined it. Making architecture is, partly, playing with the arrangement of limits, which are not inevitably limits for all our senses. A (shut) window constitutes a limit for our displacements and for our tactile sense (wind blowing outside will not touch our skin), partly for our hearing (outside sounds will be muffled), but not for our visual sense. “Playing” (it is actually a very serious play) with the limits means, for example, concerning the envelope of a building, exploring intermediaries between opacity and transparency, as architects like Herzog and de Meuron, Soler, among others, do, with experiments with silkscreened glass or weaved metal, etc. Between no limit and strict limit, architecture plays with all the possibilities.

Architecture deals with motion. Architecture is not a strictly visual art (as painting and sculpture) because it needs being explored, wandered in, it is not given by a unique point of view (or “point” of another sense): it is what Le Corbusier called “promenade architecturale”. It may even be said that the labyrinth, or maze, is at the chore of architecture, and we must then remember that its drawing resumes the trace on the ground of the ritual dance that Dedalus made on the esplanade on which it was later built [4]. Between the straight line, as the shortest way between two points, and the maze, as the longest, architecture explores all the possibilities.

Architecture deals with measure. Some authors even consider architecture as essentially the art of giving measures to space. The notion of measure comes from the notion of scale, of proportion, and the issue of proportion is crucial for architects like Rudolf Schindler, Le Corbusier (Le Modulor), Dom van der Laan, etc. Establishing a system of proportion is indeed part of the art of space that is architecture.

Dimension

Architecture develops itself in 3-dimensional space, which means it deals with all that is possible, conceivable in that space, as we have just seen. But architecture does not deal only with the space of figures and displacements (the topological and geometrical space). Architecture, as all human artefacts, is part of the physical world, and as part of the physical world, is complicated. Forms are not only geometric, they are made with matter, they have got a colour, a texture, they are illuminated, etc. In an architectural space, you do not only confront with geometrical measures, but you are also cold, warm or hot, you may even feel sad or happy, etc. All those sensations are weaved inside us, and we tend to feel or sense the physical world as a whole, as we have seen in the first part of this paper. For the designer himself, geometrical and even topological issues are not the only ones he has to deal with, but a lot of other constraints: sociological, economical, etc.

Some authors have tried to translate all of these constraints or issues as “dimensions” of an hypothetical specific “architectural space” (or “architectonic space”), more complex than the topologico-geometrical one: Moore and Allen [5], or Philippe Boudon [6], to which we must be grateful for having tried to establish a rigorous architectural theory (which he calls “architecturologie”). Boudon draws a particularly long and disparate list of such “dimensions” or “scales” (expanding its meaning, from its usual homothetic field, to all of the constraints or qualifications that enter in an architectural design): the geometric scale, the cartographic scale, the functional scale, the human scale, the model scale, the optical scale, the parcel scale, the semantic scale, the neighbouring scale, etc…

We should be careful in interpreting such disparate parameters as dimensions, because in well defined spaces, basic vectors must actually be not-collinear, independent, but this independence must have a meaning: we can say that “blue” is not collinear with “red” and “green” (no amount of red and green will give blue), but we cannot say that “blue” and “hot”, or “blue” and “acute”, etc., are not collinear, because such a sentence is a non-sense.

Arrangement of forms

Since modernist architectural theory [7], “space” is a key-word for architecture. Not that there was no space in architecture before. But the word was not used, and the concept was not emphasized. Stressing on “space” means that what is important is not so much forms, but rather what is between forms, and the relation between forms. Void, or emptiness, is more important than matter, which relies to Taoist conceptions. Ching [8] quotes Lao-Tzu in the opening of his chapter “Form & Space”:

“We put thirty spokes together and call it a wheel; but it is on the space where there is nothing that the utility of the wheel depends. We turn clay to male a vessel; but it is on the space where there is nothing that the utility of the vessel depends. We pierce doors and windows to make a house; and it is on theses paces where there is nothing that the utility of the house depends. Therefore, just as we take advantage of what is, we should recognize the utility of what is not." (Tao Te Ching 6th century B. C.)

It is true that man does not live inside solid matter, but in the void (a not airless void, though) that lies inside, outside, or between solid forms.

Dealing with void, or emptiness, is not easy. Some have proposed to invert the representation codes, i. e. to fill in black (in plan) the empty, free, spaces versus the constructed ones [8, p. 95]. This makes us see an urban or architectural space in a different way. To qualify space, void space, more accurately, Ching introduces the notion of "spatial field" [8, p. 97.], or "field of influence" [8, p. 98.].

Pierre von Meiss [9], in a similar way, insists on the void, or the "hollow":

"(…) pour l'architecte l'espace ou l'intervalle entre sol, murs et plafonds n'est pas le néant, bien au contraire: la raison même de son activité est de créer ce creux, pour contenir."[27] [von Meiss, p. 113.]

Meiss goes from Ching's spatial fields to "lignes de force" or force fields to better characterize architectural space.

Generative Space

We have recognised four levels so far, even if some are overlapping: the physical world, and then sensation, perception and representation. The representation level may get its own autonomy, more yet since the use of computers. Generativity [10] has to do with the autonomy of the virtual world of computing. What can we do concerning space and forms? Or, rather, what can "it" do? What forms does a generative space "allow". The virtual world of computer generativity lets us explore what happens when we imagine rules and let them develop by their own.

Distance maps

A first stage of exploration of space consists of trying to qualify the void, the emptiness, we have seen is at the chore of modernistic architectural space. The idea is to make sorts of maps of "emptiness" and to try to reveal the "forces" [9] underlying a given set of points.

In this first experiment we begin by establishing a set of "centres". The algorithm used here is very simple (and, anyway, fast and efficient): it consists of calculating the Euclidian distance between each pixel of the map (the "space" here is bi-dimensional and treated as a picture: hence the appellation of "map") and the nearest "centre" of the set, and of translating this distance in a grey level (fig. 2). This method has been inspired by the "medial axes" used by Gert van Tonder to explore the structure of Zen gardens [11]. If the set is a set of disconnected centres, the picture we obtain is a good approximation of a Voronoï diagram, the white lines emerging from the picture being possibly read as the lines of a Voronoï diagram.

27 "(…) for the architect the space or the interval between floor, walls and ceiling is not the nothingness, on the contrary: the very reason of his activity is to create this hollowness [cavity], to contain."

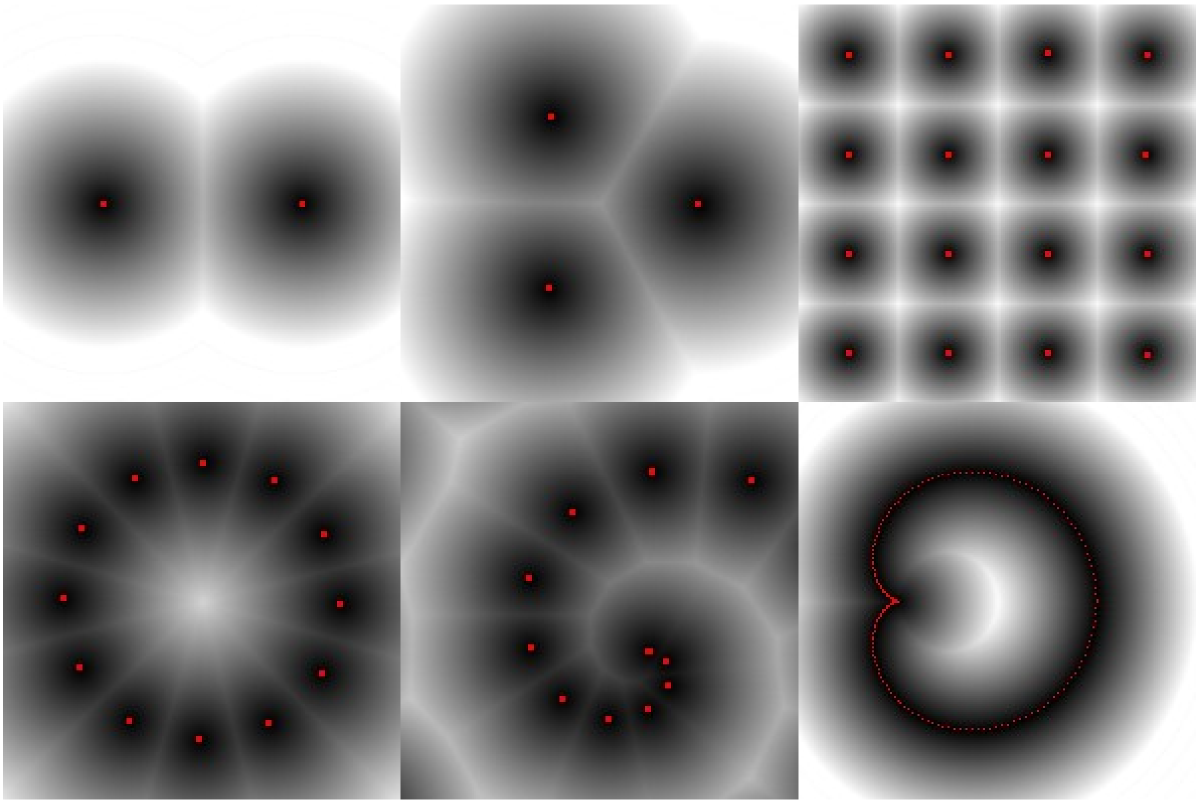

Fig. 2: distance maps of a few distribution of centres

If the “centres” of the set are more connected, and are grouped in forms or shapes, the picture we obtain (fig. 3) emphasises and verifies the intuitive “spatial field” as sketched by Ching [8, p. 135, 158] or the force field defined by von Meiss [9, p. 125, 127, 129].

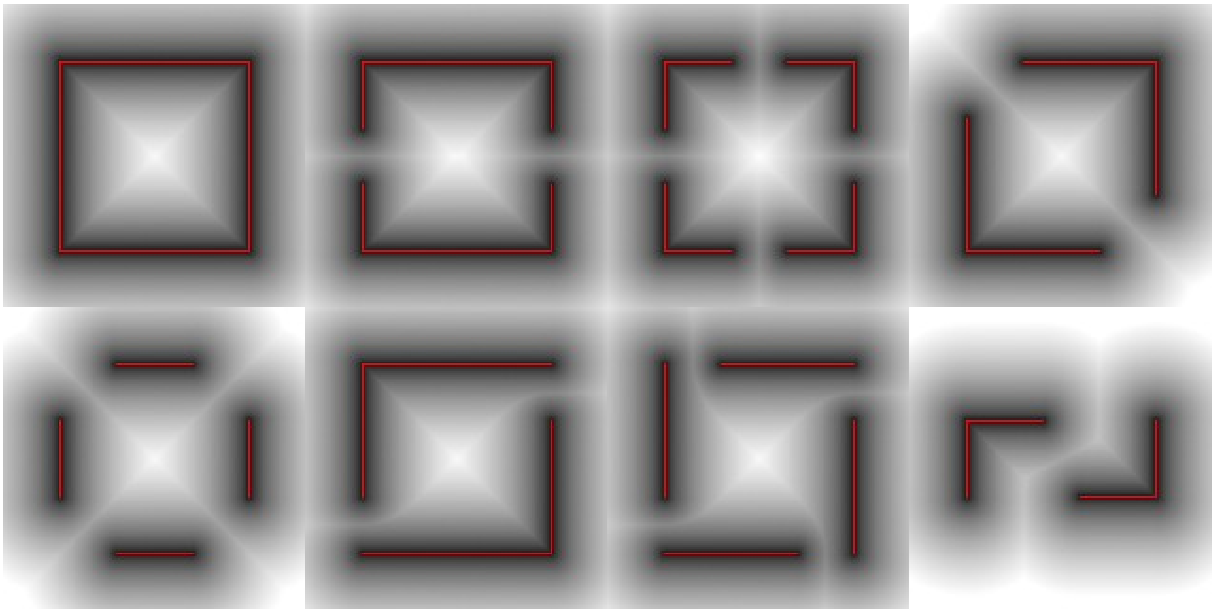

Fig. 3: distance maps of some configurations inspired by Ching [8, p. 135, 158]

The distance may be calculated in 3D-space. But then the issue of representing the results is more difficult. How to do a “map” in 3D? We meet here the limits of our perception: a map is a useful tool for us because it is 2D and that we are 3D, so we can see “inside” the map. But if there is information inside a real-life opaque 3D volume we are not able to see it (hence all the devices like radiography and scanners, etc.). We could imagine 3D space in a computer software that would apply, to each “pixel” in 3D, a given colour. But it is not what happens in most softwares[28], they rely rather on simplifications of 3D volumes constituted by faces inside which there is no “matter. After some not satisfying tries with levels of transparency, I packed a big cube with little cubes (15x15x15 of them), and decided on the presence of a little cube depending on the distance to the “centres” (fig. 4)

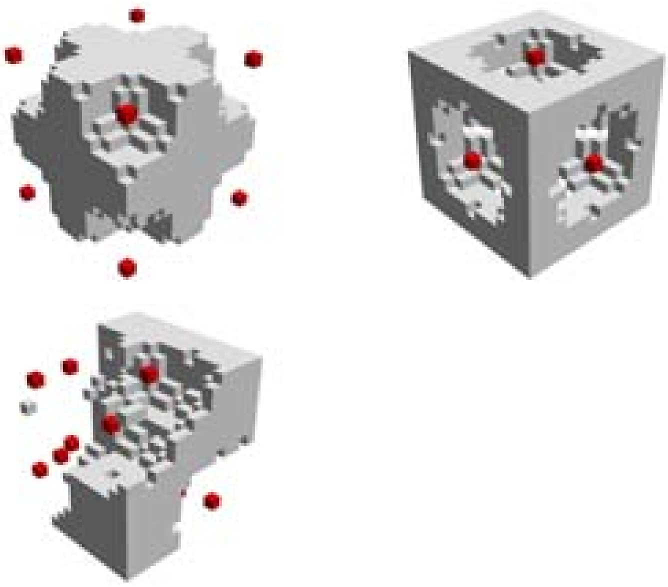

Fig. 4: 3D distance maps

After these experiments in 3D, I returned to 2D, and to randomness. The distance map algorithm was applied to a given random distribution of 20 centres in a square with a toric topology. A variant was obtained by translating the distance, or the level of grey, in the height of vertices of a mesh (fig. 5). The so-called centres are represented by spheres lying in the hollows of the “relief ” and the well marked creases of the mesh give a very good approximation of a Voronoï diagram.

28 with the exception of, for instance, POV-Ray

Fig. 5: distance map of a given distribution of centres and the related mesh

Growth and struggle for space

The distance map is not very “generative”. It reveals the nature of a given space, but there is no process involved, while generativity has to do with processes. I went further by trying to exploit some systematic experiments I made for other issues on the notion of growth[29]. Growth is a fundamental mechanism of all natural forms, whether organic or not. We then can look at all the primary ways of growing that the rules of space allow. A first idea is to use the cellular automaton known as Conway’s game of life and to fix the rules to obtain a growth from a unique starting cell. A cell has got potentially 8 neighbours: we can vary the conditions for a cell to appear if it has m1, or m2, or … mn neighbours (m1, m2, … mn being comprised between 1 and 8). Figure 6 shows some of the results at t=20. There is a great variety of configurations, even if the rules are very simple.

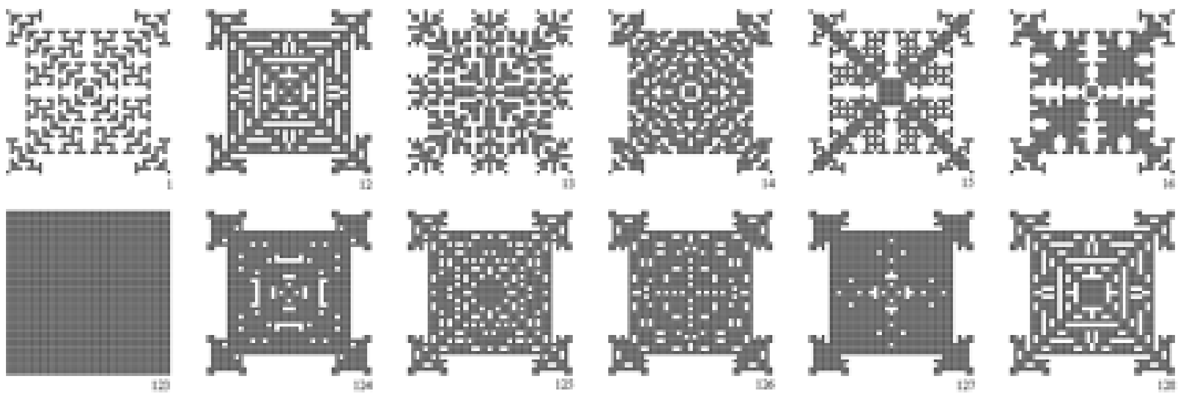

Fig. 6: results of game of life at t=20 (“124” means that a cell appear if it has 1, 2 or 4 neighbours)

Even if it is not the most interesting one, we will retain the “123” growth which results in a square growing by adding a layer at its perimeter at each stage.

29 those issues have to do with geomorphology and processes of accumulation and dispersion of sediments; see [12]

Rather than systematically explore the space of the CA at each stage, like in Conway's game of life, we can also do a random exploration. This leads to a model we will call "propagation" (fig. 7). Those previous models are "static" CA, cells appear or disappear but they do not move. Other CA imply motion of cells, or "agents". This motion is a random wandering, and the result is a growing cluster of cells. There are two ways of considering this growth: the cells may wander from outside towards the cluster, or they may wander inside the cluster towards the outside of the cluster. These two wanderings lead respectively to the well-known DLA model, and to a model we can call "proliferation" (fig. 7).

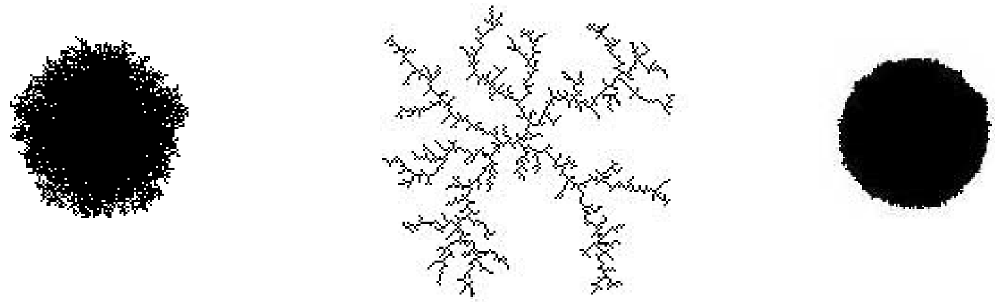

Fig. 7: "propagation", DLA and "proliferation"

I got the idea of applying those growth processes to obtain Voronoï diagrams in Paul S. Coates' paper for GA 2004 [13]. If we apply these models (the "DLA" model is slightly different because cells wander from random pixels without taking care of the distance to the clusters) to our previous distribution of centres, it looks as if each centre is at the chore of a "struggle for space" in different ways (fig. 8, 9, 10, 11).

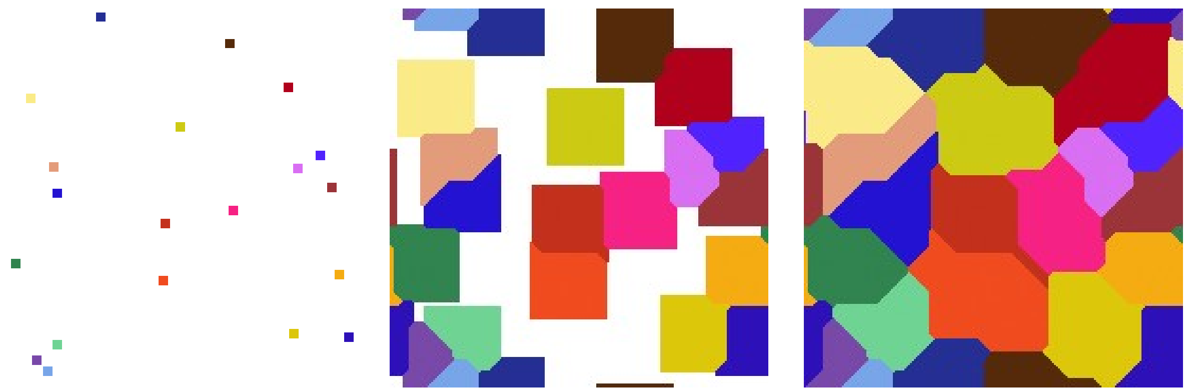

Fig. 8: game of life

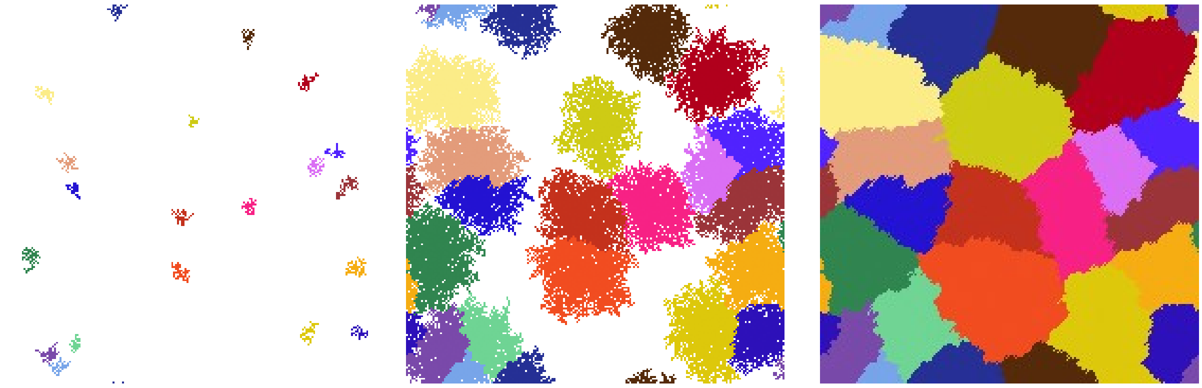

Fig. 9: “propagation”

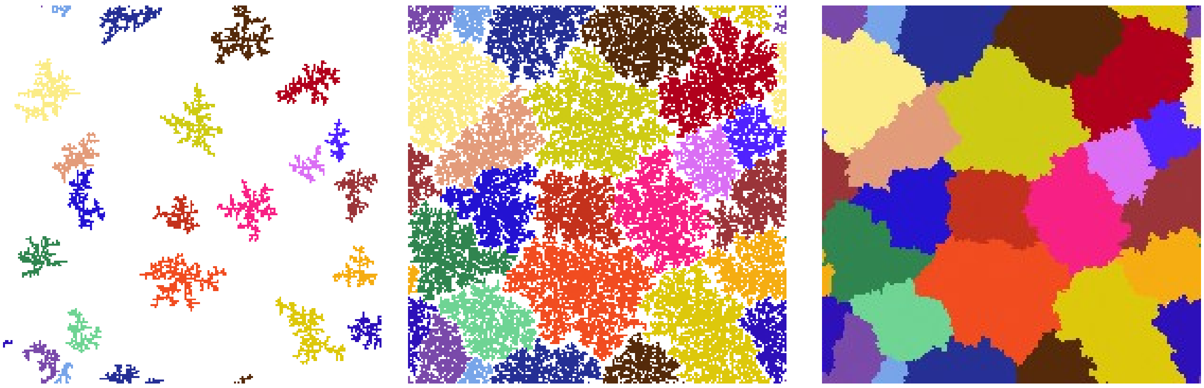

Fig. 10: DLA

Fig. 11: “proliferation”

We can note that all these algorithms are a lot slower than the distance map one. They let cells or agents look for the nature of a space that is easily described through the distance map.

Optimisation vs sophistication

Though they may be slightly different, the results of all the previous models are about the same, and they are the same even if they imply some randomness.

We will now return to the so-called “proliferation” model. It was applied previously to the given distribution of centres by generating each cluster independently: the wandering started democratically from each centre, so each cluster had an equal luck in the struggle for space. We may also start the wandering with any one (randomly chosen) of the cells (proliferation variant #2): the result is that the clusters grow unevenly (fig. 12). The bigger they are the more they grow. Struggle for space is here more of a jungle law!

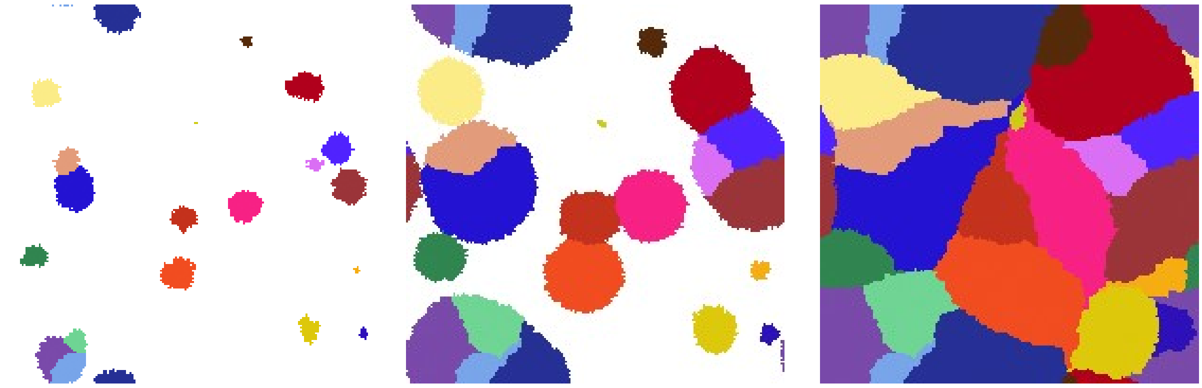

Fig. 12: “proliferation” variant #2

Now, each time we launch the process we shall obtain a very different result, though we start from the same set of centres (fig. 13).

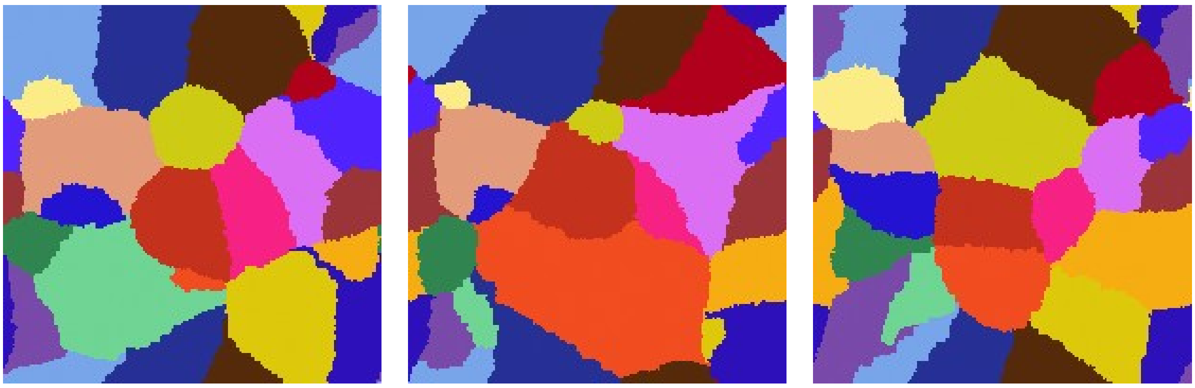

Fig. 13: some results of “proliferation” variant #2

We may consider these two kinds of struggle for space as an example of the alternative between optimisation and sophistication. To stress this point, let’s compare the two models applied to a regular distribution of centres (fig. 14, 15).

Fig. 14: “proliferation” applied to a regular set of centres

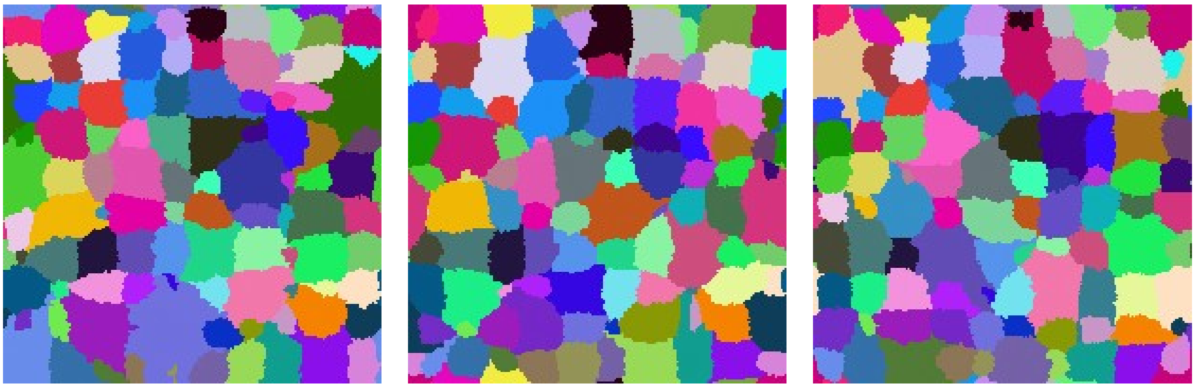

Fig. 15: “proliferation” variant #2 applied to a regular set of centres

Without surprise, the patchwork obtained by the first model is more or less a multicoloured chessboard, while those obtained by the second one are more sophisticated patchworks. In the chessboard all the patches are (more or less) squares of the same size, they have got 4 neighbours, their borders join each others by 4. If your goal is to optimise the use of space, the chessboard is a good answer (it yields an regular tiling of space). In the variant #2 patchworks, even though the set of centres is the same orthogonal distribution, patches are of various forms, they have got a various number of neighbours (even 1, because some patches are enclosed in another one,), their borders join each others by, mostly, 3. If your goal is to obtain a more sophisticated use of space, where, for instance, patches need to have a various number of neighbours, and a more natural-like configuration, the variant #2 is a better answer.

In conclusion, we shall open the discussion with some remarks, that will not be further elaborated here. These experiments may seem very foreign to architecture[30]. Actually the issue is space by itself, notwithstanding all the other issues inherent to architectural space. The issue is space because those experiments deal with arrangement of forms or voids, with limits, with motion (motion of the cells), with measure and proportion (the sizes of the patches). The space in which these models

30 They have to do with geography and the making of (human or other) territories, though, obviously… And eventually with art, if the colours are well chosen (they were randomly chosen here)

develop themselves (which we call generative space) is a virtual, computed space. It is a particular sort of space, in that it is not, actually, a continuum (pixels are discrete points, numbers with which computers deal are not real numbers). Moreover, these experiments have been mostly developed in 2D, for obvious reasons of efficiency.

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Metaforms Methodology for specifying and growing Structures of Forms for Aesthetic and Programming Content

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Abstract

Metaforms is a rule-based methodology for generating abstract and organic 3D forms (but capable of generating any forms expressible in symbol strings such as architecture music and text.) This paper introduces the conceptual basis of the methodology for 3D and describes its extensions to previous techniques for production systems. The generation of forms for a particular transformational syntax begins with a well-formed axiom of facts and a set of stylistic production rules which operate on the facts to produce a genotype. Facts correspond to transformations in 3D and particular locations for placeholder form components. Sets of rules fire by matching patterns on slots of facts which correspond to properties such as spatial orientation, position in the tree, and semantic description. There is an isomorphism maintained between the fact tree and a tree of Java transform objects which control appearance and behaviour in an interactive 3D (i3D) world. These Java objects are also used to calculate absolute 3D spatial state as the tree is traversed. This absolute state is then written into the slots of the transform corresponding to the component. Branches of the tree correspond to 3D transformations and leaves of the tree correspond to forms which are inserted in a later stage by population rules. The population rules map placeholder components to a phenotype of particular 3D forms expressed in syntax able to be rendered and programmatically controlled. The phenotype components consist of text or XML structures describing construction, property access and modification, method invocations and event bindings, and also include embedded annotations describing runtime semantics and operation. Phenotypes may be produced as static objects or made dynamic via a further stage of animation and variation using the programming interface to enable self-modification, movement and social behavioural interaction. The genotype syntax is intended to be an ontological universal for a particular domain such as 3D structures. In that case many individuals and groups could define domain specific genotype and phenotype structures and rules for behaviour so that same type structures may be capable not only of animation but also interactivity and breeding.

1. Introduction

The motivation for using generative systems for production of 3D objects is the difficulty and tediousness of modelling by use of tools and hand construction. The need for skilled labour on each individual piece using expensive tools drives up the cost of production and slows completion times. The situation resembles that of a

Medieval guild in which expensive skilled artists labour extensively at one piece at a time. Biology inspired practices and rule-based programming offer a promising solution. A production methodology based on 'growing' instances instead of building them is efficient and automated, and the expression of stylistic preferences in rule sets permits decision making by an inference system instead of by human interactivity and tool use.

The basic terminology is borrowed from genetics and corresponds essentially to biological meaning. The fact tree consisting of hierarchical 3D transform information is referred to as the 'genotype' which in biology refers to the inheritable information carried by all living organisms [1.] In the specialized meaning used in metaforms the genotype is an abstract 3D structure with either no associated form or perhaps merely a simple bounding box at each leaf in the fact tree. The 'populated genotype' is a genotype in which all components contain a non-trivial String slot form in syntax which can be rendered and made visible in 3D space. Production rules act on an initial genotype 'axiom' and through iterative operation produce a more and more complex genotype. The real or potential form associated with each leaf is referred to as a 'component.' The closest biological analogy is to some fine grain element of the body such as cell or organ. In addition to the tree of facts, a parallel structure of Java objects is maintained and used when traversing the tree to calculate accumulating 3D transform information such as translation, rotation and scale, which are written into transform slots of the components contained at the leaves of the tree.

The 'phenotype' of an organism represents its actual physical properties, such as height, weight, color, shape and so on. In metaforms the phenotype is an isomorphic mapping of the genotype populated with a 3D form at each leaf expressed in a specialized syntax which can be both rendered visibly and programmed. Phenotypes are created by a different category of rules called population rules. A clear distinction between genotype and phenotype is that genotypes carry only structural information whereas phenotypes carry both structural information and phenomenal information about rendered forms. The structural element of the description might be thought of as the objectified process of moving a component in 3D by a sequence of hierarchical 3D operations. The form of a component refers to its shape, material, geometry, surface, and animation and behavioral properties.

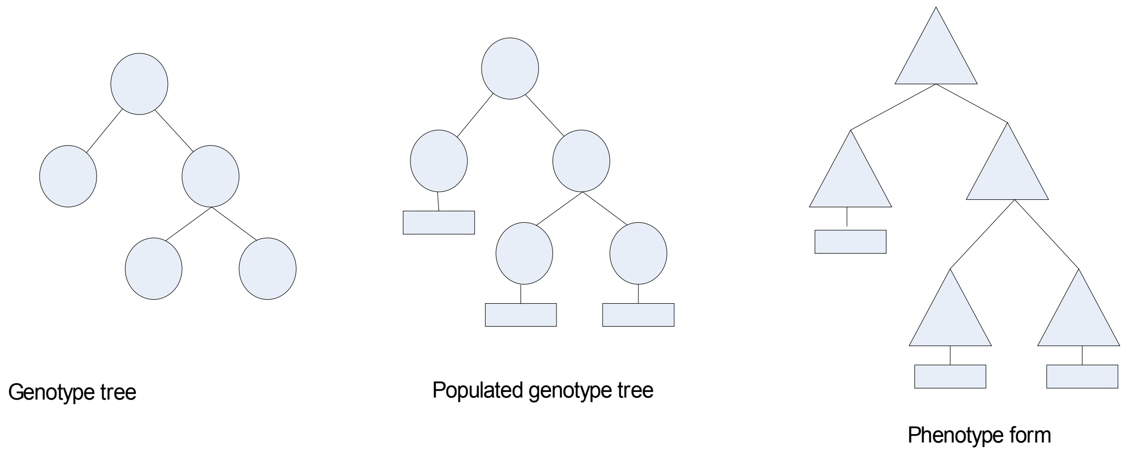

Figure 1

An organism's genotype is the largest influencing factor in the development of its phenotype, but it is not the only one. Even two organisms with identical genotypes normally differ in their phenotypes as can be seen in minor differences in identical twins. This divergence of appearance despite identical genotypes is emphasized in metaforms since arbitrary forms may be mapped by population rules to the leaf components of the genotype. In biological terms the phenotype in the proposed methodology has a very high degree of 'plasticity' because appearance is not strongly determined by genotype alone. On the other hand, a phenotype may be parsed in its specialized syntax and a genotype can be completely determined. This technique is used to synthesize very complex initial genotype axioms which determine much of the initial structure of the subsequent iterated genotypes and populated phenotypes.

It should be noted that genetic algorithms may be also be used as part of the metaforms system, but their actions are orthogonal to productions. The basic operations of crossover and mutation can easily be made part of the RHS of rules which select preferred tree nodes to perform crossover branch replacement or mutation modification of slot values. This paper will focus on rule-based development of single forms since genetic algorithms are extensively discussed elsewhere such as [7.]

2. Relations to previous work

There are two major streams of work which have advanced the subject of rule-based production systems. The strongest influence has been from Lindenmayer systems, or L-systems. A related stream of influence is the field of genetic algorithms and evolutionary artistic computation [2.]owever H This field is very important and interesting, but is orthogonal and not essential to the methodology of rule-based construction and population. There is a similarity in conceptual terms but production systems operate on a single genotype (or phenotype) and do not depend on the mixing of two or more individuals and the generation of populations. However genetic methods may advance the generation of content as an additional methodology applicable at any point in the production or population processes.

L-systems are based on rules for iteratively rewriting sequences of symbols for the purpose of describing the process of plant growth [3.] The key aspect of all generative systems is the encoding of rule-based processes in the development of forms. Predating L-systems is the mathematical constructions of von Koch [4,] and others including the great set theorist Sierpinski [5.] However, the early productions are abstract and fractal in nature whereas Lindenmayer began to propose rules for the organic productions of plant forms. A student of Lindenmayer,

Przemyslaw Prusinkiewicz, deeply advanced the scope and applicability of L-systems to computer graphics imagery [6.]

Traditional production systems use a tree traversal pattern match starting at the root and traversing the tree in pre-order fashion. These rewriting production systems share a parsing of a symbol string for rule matches and then substituting a matched substring by a new inserted string. Previous versions of metaforms also followed a similar technique. However the latest version uses a rule-based inference system which matches patterns on facts anywhere in the tree, and groups of rules can be applied as subsets in an orderly way triggered by previous rules. In addition, unlike production systems, metaforms transform facts contain a slot of 'ontological adjectives' which allow rules to match on semantic meanings in order to identify key structural locations or component qualities.

2. Rule-based systems

A rule-based system is a software system for reasoning about and transforming a dynamic fact base according to sets of rules. In the metaforms case rule sets capture stylistic preferences for iteratively defining and elaborating 3D objects as they develop in space. One possible view is that rules fire successively in time and the form developed is a sequence of time-based events each based on the context of the development to that instant. However, perhaps more accurate is to view the development of the 3D object as a collective set of internal transformations and variations from which a desired form emerges.

Rule-based inference is often used as the basis for 'expert systems.' In the case of metaforms the expertise captured in rule sets is a collective tendency to develop 3D form with certain stylistic preferences. Rule sets are then similar to swarms of tendencies operating on a potential form and in ways that social insects might construct a hive. There is no central control program but complex and intricate structures are produced by sequences of small transforms. Rules may act on any part of the structure in any iteration but the collective tendency is to produce a stylistic convergence influenced by the nature of the rules and the state of the developing form.

A rule-based inference system consists of a dynamic set of facts called 'working memory,' sets of rules called a 'rule base.' And an inference engine consisting of a pattern matcher, an agenda which holds the set of rules activated by matches on the present cycle, and an execution engine which fires one rule per cycle. A rule consists of a left hand side (LHS) 'antecedent' which is the specification of some state of fact(s), and a right hand side (RHS) 'consequent' which consists of actions such as method invocations, modifications assertions or retractions of facts, introductions of new rules, or modification of the set of rules able to fire in the next cycle.

RULE

```
(defrule <rulename>
 (LHS)  pattern to match against the fact base
    =>
(RHS) action(s) to execute if and when the rule fires
)
```

FACT

```
(deftemplate <factname>
     (slot <slotname> (type <typename>)(default<value>))

)
```

Figure 2.

Before facts may be created they must first be defined in the same manner that a Class must be defined before object instances may be created. Facts may be simple lists or may consist of typed name-value pairs called 'slots.' Slots correspond to fields of a Class.

Rules are the key behavioural element in rule-based systems and the circumstances which activate a rule and the actions taken define the effect of the rule. Rules must be defined individually but the actions of subsets of rules must be anticipated to achieve directed stylistic effects. In addition priorities for rules may be defined, and strategies for ordering scheduled rule firings may be set and both varied during the running of the system.

The system runs in discrete cycles with at most one rule firing in each cycle. One cycle consists of the following steps:

All rules able to fire in the present cycle are matched against the set of facts in working memory. Subsets of rules called 'modules' may be partitioned and only those rules in a particular module having 'focus' are examined for matches. The use of change of focus is very important for applying different subsets of stylistic and developmental rules at different phases of the structural development or at different locations in the structure.

All rules with a LHS matching some fact are placed in a list in the agenda in the order of firing priority calculated according to a number of factors able to be specified and even modified at runtime.

The first rule on the list (if it exists) then has its RHS executed which may modify working memory and take other actions such as adding to or modifying the structure or form. Thus at most one rule fires per cycle and that firing may invalidate other active rules. This completes one cycle of the process and the process repeats as often as desired.

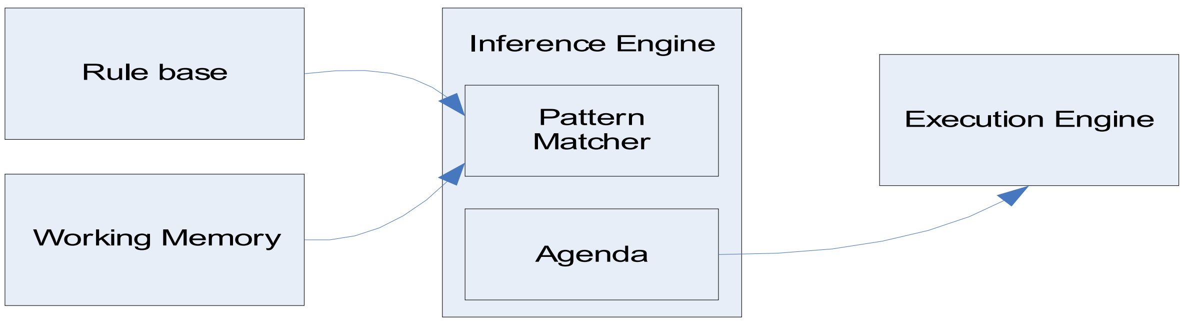

Figure 3.

Rule-based systems offer a new programming paradigm in which a large collection of tuned cooperating responses is able to guide a complex teleological purpose in effectively limitless circumstances and contexts, even some which the designer may not have imagined. Design expertise and stylistic preferences can be coded in the rules so that phenotypes produced by actions on genotype fact trees by rules from specialized stylistic modules produce similarly styled phenotypes but almost never are they identical.

The rule-based system used in the work described here is 'Jess,' written in Java and developed and maintained at Sandia National Laboratories by Ernest Friedman-Hill

[7.] A key feature of Jess is its interactivity with general Java applications. In particular, rules may have RHS actions consisting of method invocation on Java objects, and general Java objects may interact in detailed ways with the embedded inference system. Other means of interaction are via prepared script files written in Jess syntax, and interactively by entering commands also in Jess syntax. There is one main class in Jess called ‘Rete’ which controls all activities of the inference engine.

It is also possible to save the state of working memory, or even the entire inference system to a file or a stream which permits persistence of metaforms sessions in time and migration of systems across space such as the Web. In addition, forms may maintain a reasoning system able to modify its own structure and behaviour or modify other forms and interact socially.

3. Realization and behavior in i3D

As mentioned previously, there is an isomorphism between the fact tree and a tree of Java objects which exactly represents the fact tree genotype and calculates accumulated transform values during tree traversal. Mirroring the fundamental Rete class in the Jess environment is a fundamental class ‘Tree’ in the Java framework. This class performs all operations on the Transform tree. Given an initial axiom fact tree, or a tree of facts persistently stored and then later reloaded, Jess can send the array of facts to Tree to create a mirroring Java Transform tree. If rules fire that make changes to the fact tree, additional RHS Tree method invocations synchronize the Transform tree with the fact tree and then recalculate the accumulated absolute Transforms below the point of modification and then writes the new absolute values into the Components at the leaves below the change. These updates are then sent back to the Rete object to update the slots of the Component facts. In this manner each domain specializes in what it is best at doing: Jess does pattern matching and rule firing whereas Java does matrix, vector and quaternion calculations.

There is, however, another reason for the isomorphic Java framework to the growing genotype.

At any point it is possible to request a phenotype to be written from any tree node. In the simplest case a special file is written to disk. The type of this file is VRML/X3D/MPEG4 which can be rendered and performed by specialized i3D players such as the Octaga player (www.octaga.com.)

In addition, the Java Transform objects contain native methods which can communicate with the i3D Octaga player. I designed a special JNI (Java Native Interface) link which I implemented jointly with designers at Octaga. By this means new nodes created by rule firings can also be created in the i3D phenotype and appear in the player. Similarly, modifications to existing facts of a populated genotype can be immediately seen as a transitory phenotype in the rendered i3D space. In particular, changes to the populated String form in facts are communicated to the i3D player and modify the appearance and structure of the phenotype.

It is the mirroring Java Transform tree which also has direct communication to the animation and behavioural capabilities in the i3D scenegraph. Because the RHS of rules may directly invoke Java Tree and Transform methods the inference system acts as the 'idea' for the phenotype 'body.' The full triad is a Jess 'idea,' a Java Transform controller 'will,' and an i3D 'world.'

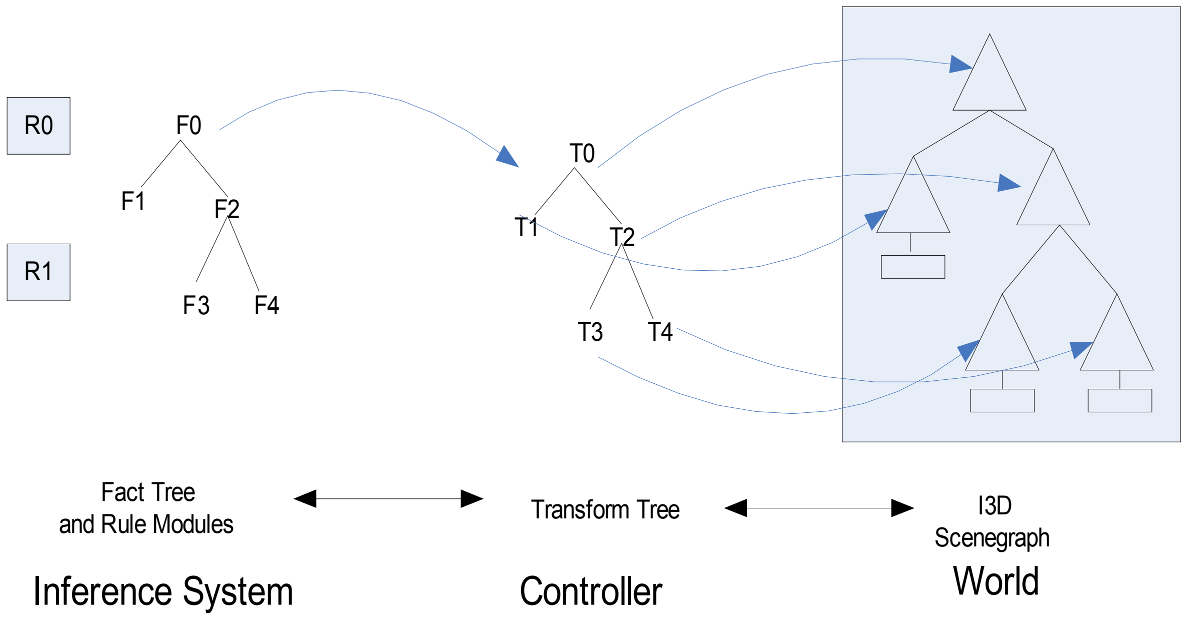

Figure 4

4. Operation of a Metaforms System

Metaforms is a process of creation and transformation so there is not one workflow path through its methodology. Also, since the process is cumulative and even sessional, it is better to think of the practice of form generation as an activity similar to the development and maintenance of software programs. In that respect the methodology resembles an integrated development environment with the possibility for extensions. Perhaps it is useful to recall the concept of action in the narrative theory of Aristotle. 'Praxis' contains not only the outward actions and events but also the inherent motivations which produce the outcomes. This motivational force in rule-based generative form creation is captured in two ways: the formulation timing of the use of the rule sets, and the formulation or choice of the axiom fact tree. Following Aristotle, the convergence of the metaforms methodology is a 'poiesis,' (roughly 'making),' and his Poetics itself is an analysis of the action of a poet in making a tragedy, and not simply an analysis of tragedy.

The fundamental interactivity of the process relies on the interactive interface offered by Jess, perhaps made simple and fast by a graphical user interface and search mechanisms for media assets including 3D components, image texture maps, and stored animation 'gestures.' Therefore the beginning of the session cannot be specified. It may be the importing of a previously stored session, or more simply, the importation of a fact tree which then serves as a de facto axiom. It may even be the simplest case of scripting the axiom directly and introducing that fact tree directly or by a script of that composition.

However it is presented to the inference system there are some specifications which must be made, similar to the need for ontological agreement before a communication based on symbols.

Specific to Jess, the ‘deftemplates’ must be registered in the system. These are the classes of facts able to be asserted. The structure of these facts corresponds isomorphically to the fields of Java classes, along with their accessors and mutators. Additionally it is necessary to define Jess functions to encapsulate actions common to many RHS of rules. These functions may contain direct calls to methods on Java objects such as Tree , the master static class controlling the maintenance and growth of the genotype tree.

Most critical is the definition of the modules of rules which are the actors of productions and populations. These are the specific subsets of styles and functions. They can be prepared and used or developed through experience, or developed genetically and valued by viewed analysis of effect.

Finally, after all the inference prerequisites, Jess can reflect its genotype fact base in Java by a static call to Tree ‘createTree‘ which mirrors the fact base by a tree of Transform objects able

to do calculations on the tree, modifications and recalculations, or insertions and retractions of fact Transforms and recalculations. A possible variation on this action is to view the default or populated forms of the genotype in an i3D viewer by sending down the phenotype syntax which can be rendered and viewed and programmatically altered.

A common procedure which may be illustrative is the following. Define or import an axiom of facts as an initial tree of facts which are then translated by Tree to a tree of Java Transforms. After that registration of facts and reflection to a Java framework rule sets modify and grow the genotype tree. In a further stage the default bounding box is populated by other rule modules by particular 3D forms. Finally, at any point in the genotype development a phenotype may be produced and viewed. Additional rule sets may be invoked which set animations and behaviours.

5. Conclusion

The metaforms methodology provides a powerful system for encoding stylistic tendency into rules operating on a tree of facts forming a genotype. The actions of these rules is analogous to the collective actions of a society of social insects, each never expressing a convergent goal, but together achieving a teleological purpose which is to produce variations of phenotype forms in a certain style. Rule sets can be grouped so that effects are specialized, and rules may also turn on and off modules to regulate the local influences according to conditions on the space or development of the genotype.

Furthermore, other cooperating rule sets may mark component placeholders by descriptive semantic adjectives expressing functionality or purpose, and further rule sets may then populate these component placeholders according to both absolute 3D spatial characteristics and semantic matches.

Next, behavioural rule sets may connect timers and interpolators and animation transforms for

movement and expression. Other rule sets may acquire output streams to destinations on the web and send their phenotypes and metaforms 'minds' to other hosts and environments able to reason in Jess syntax to appear and request to trade self-references with other entities of the same or similar types. Java reflection and annotation meta-information allow other rules to propose interaction or even breeding among any number of similar structures, and also cooperative or competitive social interactions. If all of these structures share the ontology of the encoded adjectives in the genotype nodes, then real communication and cooperation can occur and these migrating and fluent virtual entities may remake the virtual world.

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NHABITING SOUNDSCAPE
Architecture of the unseen world

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Abstract

In 'Space', the object - or architecture - is generated by a cumulative process of information (geometrical transformations, visual sequences, sound structure…) directly related to the psychological and physiological user's frames. Each interaction transforms the visible environment in a dynamic, elastic and multidirectional imaginary space. The relationship between the object-space system (geometrical and phenomenological determinate) and the body-mental projection system (subjective view /aural decoded data) induces new modes of perception strictly connected to the inner spatial geometry and its physical reflecting (aural and lighting) phenomena.

Sound as well light reveals cryptic information about the space via echo and reverberations. Those non linear physical process articulate the space along a dynamic and continuous medium and the geometrical space suggested by echo and reverberation not longer deals with Euclidean but with Multidimensional spaces. In this work, the conception of 'Space' explores structurally and visually the dynamic process engaged in a huge architectural volume (the Byzantine Saint Mark's basilica in Venice) by reflections of the acoustic rays produced by a polyphonic song and the following transcription of reflections phenomena into geometric parameters and shapes.

This process enhances how the same acoustic phenomena distorts the architectural space creating "ghost-spaces". These "unreal" spaces will exist even beyond the physical limits of real architecture. As a consequence this doubling process will destroy the spatial identity (perceptive level) as well as the centrality role of the subject (existential level). The space and the Ego will dissolve into a new geometrical and psychological pattern, mutable, dynamic and elastic.

Introduction

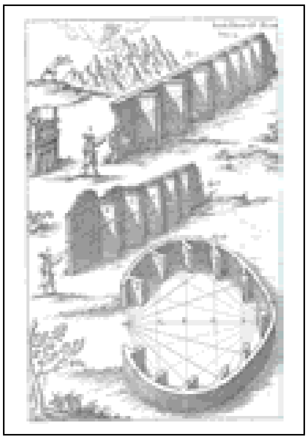
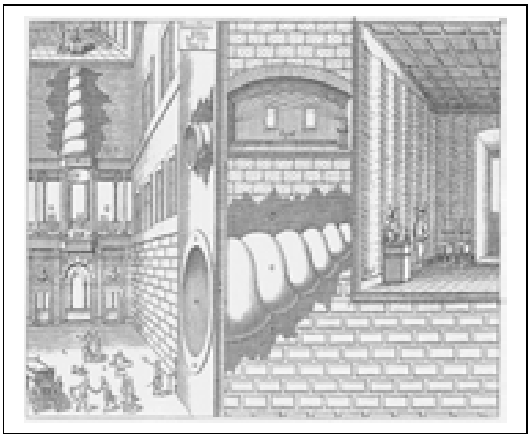
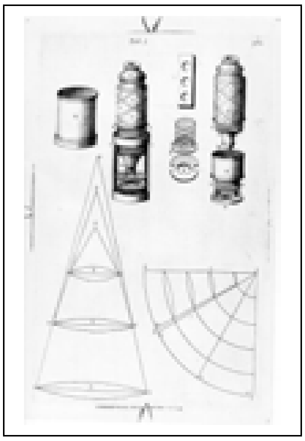
In space, the image of an object or architecture is built through the accumulation of information (geometrical, visual, aural). The strength of this process is such to create spaces which are imaginary, elastic and open to saundry directions; spaces existing beyond those really perceived and geometrically described by the Euclidean systems of geometry.

Our perceptive apparata have such a degree of sensitivity to be able to grasp, for example, small variations in light and sound, and, on the basis of these variations, elaborate a mental image of space, translating data such as volume and strength, brightness or reverberation period into parameters of distance, extension and depth.

Sound and light, perhaps due to their unsubstantiality, are, in fact, able to reach the essence of a space that is revealed through the reflexion of its light and sound. This paper explores the mechanisms — both physical and psychological — through which these reflexions induce our mental apparatus to deform the real image of a space, and analyses how and why these transformations generate imaginary architectures existing beyond the boundaries of the real ones.

Geometry as frozen music [31]

Music and light are partly a matter of solid geometry, in the sense that sounds and rays of light propagate according to definite geometrical patterns. Athanasius Kircher during the 17th century wrote that "(…) sound is a geometrical emanation of its source," stating, in other words, that the Euclidean theories were at the heart of the acoustic phenomena, and that it was possible to plot (through bundles of radial straight lines) the route taken by sound waves.

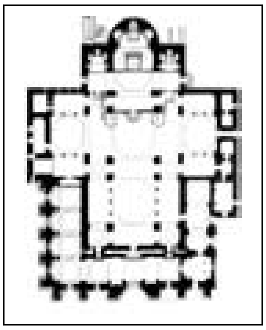
Left: Athanasius Kircher, Musurgia Universalis (1650), tome II, fol. 264, Iconismus XV. Middle: Athanasius Kircher, Musurgia Universali (1650)s, tome II, fol. 303. Iconismus XVII. Right: Athanasius Kircher, optical studies.

Another reason for investigating musical sound in terms of architectural geometry "has to do with the spaces within which sounds are produced and heard. A basilica, legislative chamber or concert hall, designed to reinforce and clarify musical and spoken sound, can be thought as an enlarged version of a musical instrument's resonator, or even of the human voice box. "Architectural acoustics" is a modern discipline, but the subject itself goes back into antiquity. The Greeks and Romans built indoor theatres for music known as "odeia"[1]. The spaces presumably sought to channel and amplify the performers' music and speech. As to outdoor structures, where the audiences were usually much larger, Vitruvius discusses the use of strategically placed sound resonators or boosters (Vitruvius, De Architectura, 5.5.1). Presumably when speakers and singers sounded those pitches, their notes were amplified or perhaps transmitted to a different part of the audience. The 16th century, while almost always quoting Vitruvius, embarked on its own elaborations of these ideas. The French natural philosopher and musical theorist Marin Mersenne

31 These notions involve what, with a bow to Friedrich von Shelling, can be called "frozen music," music that is somehow there but not audible, music whose sounds have been crystallized into the form of measurable visible spaces and solids. The musical ratios are simultaneously geometric relationships, so that the thing that "freezes" music into architecture is geometry [1].

[10] [11] begins his treatise Harmonicorum Libri (1636) with a short illustrated essay on architectural acoustics, maintaining that “sonic rays” (radios sonoros) are projected in conical form. The rays bounce off inclined planes and can be mapped onto screens using reflectors shaped like half-ellipses or parabolas. The reflectors focus and project sounds by locating the speaker or player at one ellipse’s two foci. Additionally, Kircher’s Musurgia Universalis (1650) is a landmark in the history of acoustic theory. He is particularly concerned with echoes and reverberations, writing about caves and classical buildings where strange, elaborated echoes can be heard, and about how echoes may be bounced onward for long periods of time. Kircher also reinforces the analogies, so common in the late Renaissance period, between music and light. According to him, sound — especially musical sound — is the ape of the light: sonus lucis simia est. He diagrams the geometries of the linea actionis phonicae, the line of ray of “phonic action”. For Kircher, acoustics — like optics —is a matter of spherical and conic sections. Following this method in its essence, we will start by considering the acoustic geometry of a wide volume like the one of a Byzantine church, St. Mark’s in Venice. Built in the 10th century, the church is of the Greek-cross plan, with transepts of the same length and vaults of the same height, ideally tending towards a circular space. Moreover, the whole church typology seems to repeat, almost in a fractal fashion, the same basic circularity, traceable (in decreasing scale) in the domes, vaults, apses, and even in the columns themselves.





Left: Venice and St. Mark’s basin. Middle: Interior of the basilica with the two choirs. Right: Basilica Plan

The sections also display in quantity what the ratio is among the radia of the respective circumferences that, following Fibonacci’s sequence, draw a parallel with the cochlis progression of the human aural apparatus [2]. There is, therefore, in St. Mark’s basilica, the intangible but consistant presence of an acoustic design, at times conscious, at times unconscious, that certainly influenced the centuries-old development of this building. The church, in fact, for the characteristics of its geometrical space and the kind of material covering it,[32] behaves like a huge

32 The upper part of the basilica is covered with mosaics laid with the Byzantine technique of hot fusion. Siliceous material was melted and laid in rectangular shapes; while the paste was still red-hot, a gold leaf was applied. After cooling, it was covered by another layer of melted glass to prevent the gold oxidation. Whereas the glassy paste behaves as a perfect mirror to both sound and light, the arrangement of the tesserae creates a rough surface which slightly reduces the wave front intensity, without affecting the composition of its frequencies [3],[4].

sounding box, amplifying the resonance of sounds, and extending the period of their echo. During the 16th century, composers like Giovanni Gabrieli [8] [9] and Claudio Monteverdi wrote the “Sonatas in Echo” which, exploiting the peculiar acoustics of the basilica, produced sophisticated effects of sound distorsion, such as the protraction of the echo, or the harmonic overlapping of a note with the reverberation of the previous one. In those same years, the practice of the salmi spezzati (‘divided or split psalms’) was introduced, which consists of arranging the choir on two different lofts, opposing one another from the two sides of the nave.[33] Whereas the choir’s splitting, in the field of acoustic phenomena, doubles the echo’s depth, the same phenomenon, in the field of sound perception, manifests itself in the image of an elastic space, deep, dilated beyond the visual spacial boundaries of the church. Hearing the echo of a sound expanding from side to side is as if the image of the basilica, with its columns and mosaics, transformed slowly into something similar to the sonority of the hollow belly of a grotto. Particular sounds, exalted by the acoustics of the building, have the power of evoking, so to speak, the idea of a space exceedingly wide, accelerating our imagination in a race towards infinity.

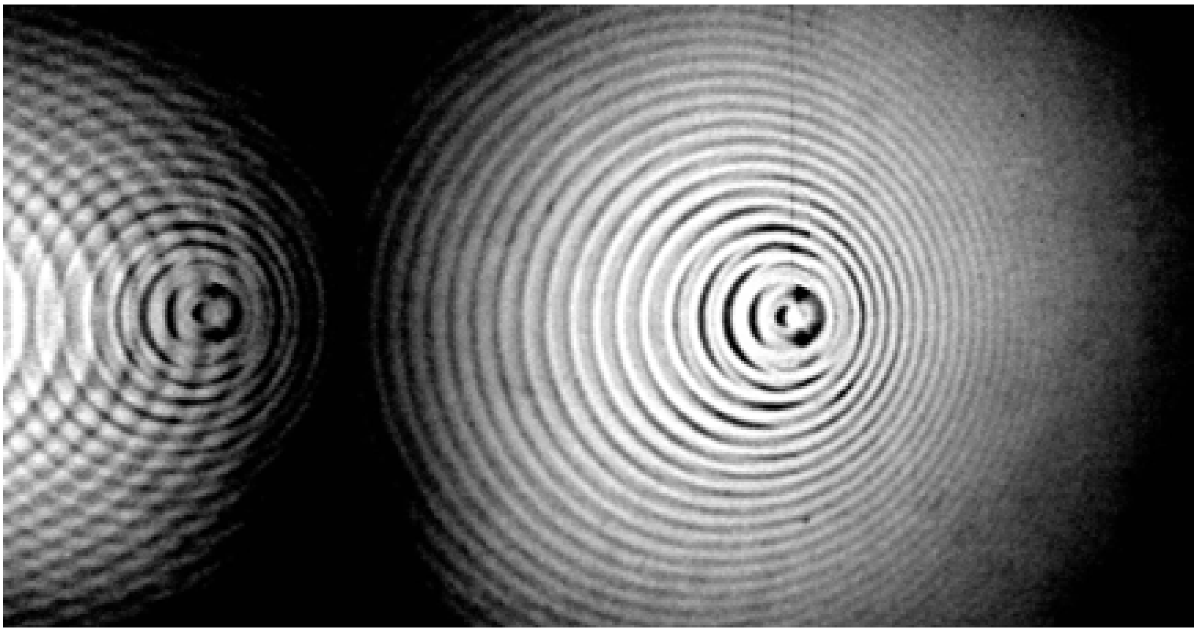
Acoustic Geometry

Euclidean Patterns in Aural Phenomena

The “Sonatas in Echo” imitate an acoustic phenomenon — i.e. the echo — that works through definite physical mechanisms which follow (Marsenne and Kircher) geometrical Euclidean patterns. But how do these mechanisms work exactly, and how can they, in the last resort, lead to the distortion of spacial perception? Let’s move in time and space, and imagine ourselves walking down into the tube, hearing a train arrive from a distance. Thinking we understand from which side of the corridor the train is coming, we are surprised to find that the sound heard from the left actually comes from the train arriving from the right. The reflection inside the

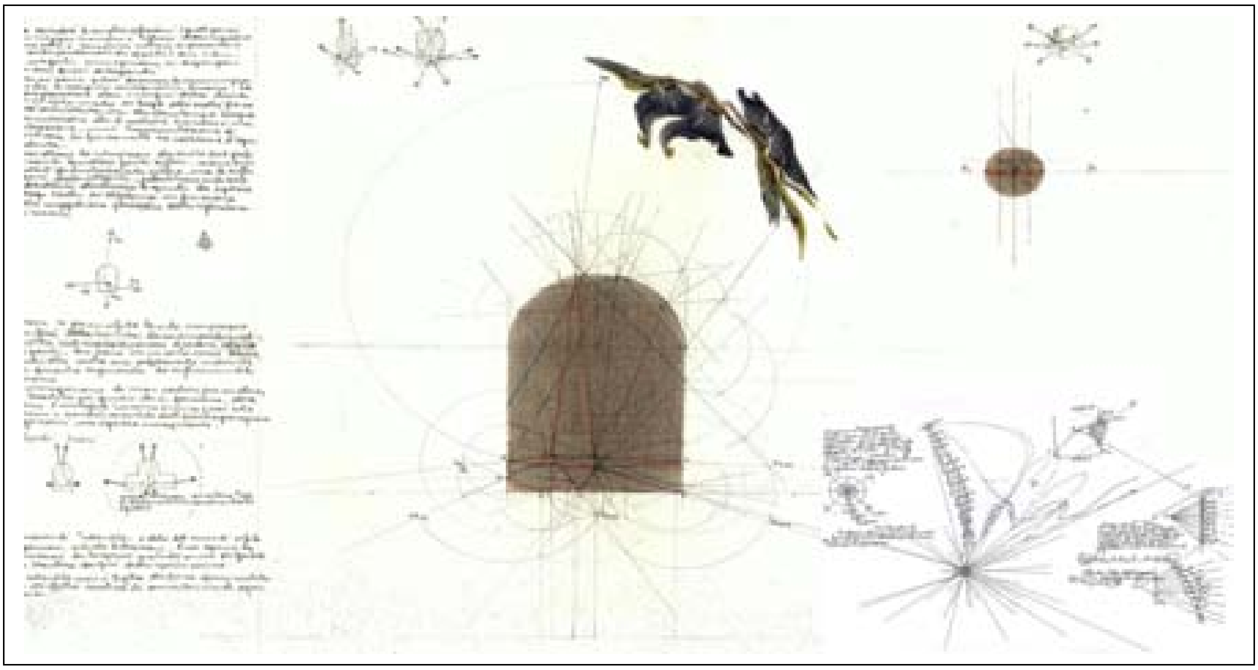
33 Laura Moretti wrote an interesting article [6] about the origin of the *salmi spezzati* pholyphony. In his travel notes, the Flemish Arent Willemsz offers detailed descriptions of the liturgical ceremonies in St. Mark’s basilica during the time of his stay in Venice in 1525. In his account of Vespers, Willelmsz writes: “There is a bench, preciously made, which is placed squarely in the middle of the choir. Here the precentors are sitting, and they alternate with one another, two together alternately intoning the psalms, very pleasantly and magnificently. And they sing splendidly, partly simple song (simplesanck), and partly fabridoen (falsobordone) on the other side; this is altogether very beautiful and magnificient to hear and to see” [5].

tunnel “deceives” our perception, driving it to represent the existence of a train where no train actually exists, and the deception lasts till our sight is able to verify the real train as it arrives



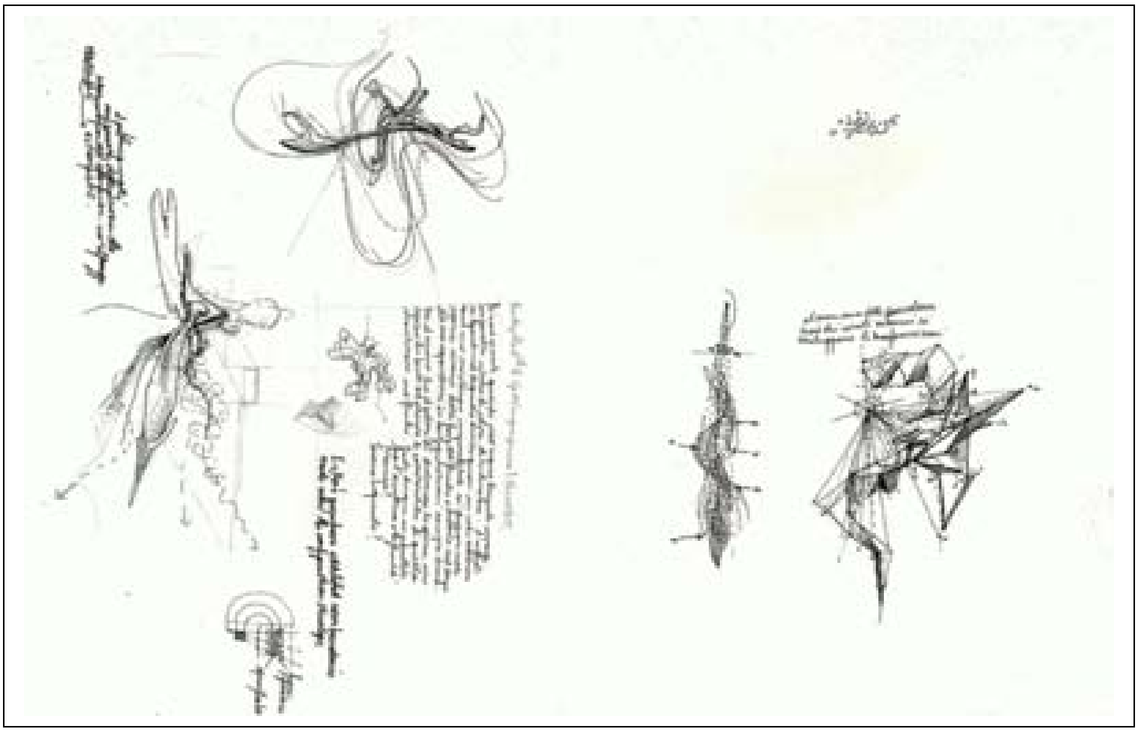
Reflected standing waves. The moment of overlapping is called interference, and it represents the sum of the single wave fronts.

opposite our expectation. The walls, like mirrors, reflect the sound rays, projecting their real source — the train — beyond the wall, giving us the impression that the sound is coming from an “imaginary” train (or a “ghost” train) that exists only by virtue of the reflecting wall. In Euclidean geometry, this phenomenon is well represented by conic reversal projections, and the example of the train in the tube demonstrates how Kircher’s acoustic geometry can faithfully represent the reality of sound phenomena. Going back to St. Mark’s, let’s consider the acoustic geometry of the basilica’s internal space; that is, let’s imagine placing the sound sources on the pulpits where the Salmi Spezzati were performed and leaving the spread of sound rays to trace their reflections along the basilica walls. Some reflections will cover the space of the church tens of times before reaching the listener located under the central dome. With every reflection, the geometrical space transfers to the incident wave part of its geometrical features, modifying the internal composition of its frequencies. The modified sound wave conveys to the listener the sound characteristics of the space that contained it during all the reflections. Considering, in the specific, the route of some acoustic rays, it is apparent how they travel far and wide through the whole space of the basilica, connecting different and opposing points of the church. Each of these points transfers to the wave its geometrical features which the sound moves elsewhere, reflection after reflection. The sound, acting as a sort of dynamic spatial memory, manages to connect images otherwise scattered at the time of their perception.

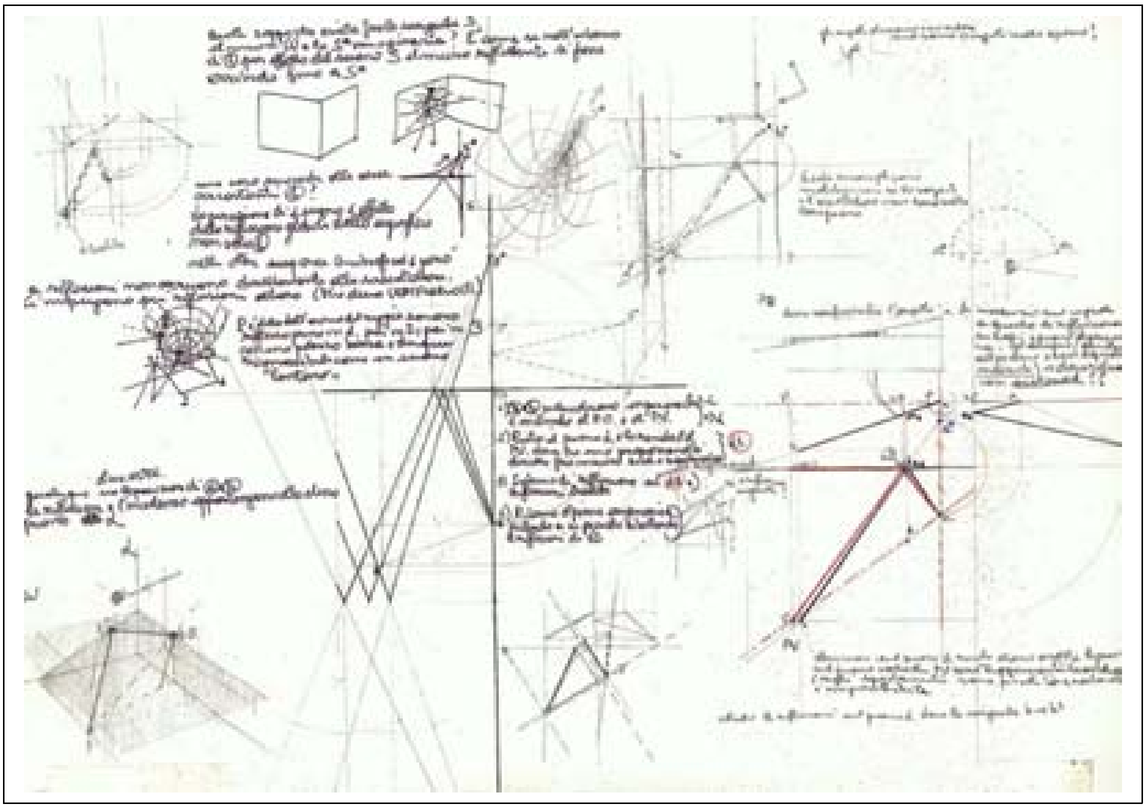


Preliminary studies of the propagation of acoustic rays in volumes with circular vaults. The drawing introduces the idea of a surface (top centre) that is moved away and distorted by the sound reflections.

An acoustic image is, therefore, characterized as the completely absorbing experience of a space, because it is capable of giving back to the observers, the moment they hear it, the interaction of a sound with the space that contained it, reflection after reflection. (…) A sound reflected and sent back from wall to wall saturates the internal volume of the basilica, and prolongs the impulse for many seconds. Going back to our example, a listener located under the central dome perceives the sound coming from each direction, reflected by the walls and floor, with decreasing volume and reverberation period. Cognitive psychology tells us that our sensory apparatus places a sound source (also invisible ones) farther away, the smaller it is in terms of sound volume. With the progressive decrease of the reverberation, the listener himself, although able to see the orchestra playing beside him, is instinctively lead to imagine it moving away, beyond the basilica's walls, beyond those walls which, like mirrors, reflect both the sound and its source. Extending the example, it is as if the whole space of the church dilates beyond St. Mark's, to the extent of reaching St. George island. Sound has therefore the power of deforming spacial perception, making space assume geometrical configurations that are complex and not linear, configurations of "ghost" spaces extending beyond the physiological boundaries of our sensory perception.



Acoustic geometry studies. A bundle of sound straight lines emitted by a punctiform source is reflected by the walls of a cubic environment, projecting the reflected source on a plane symmetrical to the original source. Below: a study of the projection of a sound ray, oblique to all the Cartesian axes xyz. Right: Preliminary studies of the representation of reflected sources. The resulting sonic space takes on the features of a cloud of points gathering in limited areas in the space surrounding St. Mark's.



Geometry of Acoustic Perception.

Towards a geometry of imaginary.

Sound sources emit standing waves which expand in all directions, and saturate the acoustic volume of the basilica. At the outset, this paper will take into consideration two sources, placed on the pulpits inside St. Mark's, where the choir singers used to sit. The geometrical procedure used to trace the sound rays consists of a straight line - incident on a surface - having the same angle as the reflected one, both on the plane and in space. As displayed in these diagrams, some reflections travel the church's length hundreds of times before finally reaching the listener, positioned under the central dome. A few rays seem to "get lost" in an endless series of reflections, as if they were trapped inside the resonance chamber of the north and south transepts. The procedure only includes the calculation of 5 rays, placed in each square meter of the basilica, reaching a total of 3,800 reflections covering the whole angle of the source. From physics, we know that the angle of incidence is equal to the angle of reflection, and the sound straight lines are arranged on symmetrical axial planes. Consequently, the real source is mirrored on the symmetrical straight line and moved beyond the surface at a distance d, which is proportional to the space existing between the listener and that surface. It is then evident that, as the number of reflections increases, the imaginary sources - those which are perceived as real - apparently move away from the listener, reaching a considerable distance that we can quantify, by means of geometry, as being equal to the sum of the single segments travelled by each acoustic ray[34]. If we apply this method to all sound rays and try to represent on a Cartesian plane all of the reflected sources (the red points in the final render and the letter “S” in the CAD studies), we are able to observe how they form "cloud"-like clusters, almost creating a force field within which the golden surface is passively distorted. It is as if the sound produced by a source and the reflection coming from the walls had "fluidized" the church's surface, progressively expanding it in a hazy and rarefied space.

Each geometrical projection establishes, through the sound rays, a biunique correspondence between the Cartesian space and the acoustic space. As already mentioned, a few rays get lost in the basilica's gaps, only reaching the surface after thousands of reflections and with a sound intensity close to null. Since the physiology of our aural apparatus allows us to pick up only the sounds above a certain threshold [13], many projections - theoretically possible - actually become pointless in terms of phenomenology, since they are impossible to decipher in images. To prevent transforming our imagination into an a-priori geometrical product

34 Some studies [13] [14] demonstrate how, for evolution reasons, our aural apparatus is adjusted to better perceive small differences in sound. Thus, we are more sensitive, both consciously and subconsciously, towards "background sounds," rather than sounds featuring high and distinctive frequencies. In the specific case of this paper, this observation confirms that even almost inaudible reverberations play a key role in the perception of sound phenomena.

35 I am partly referring to Spinoza's concept of Geometrical Ethics [15] [16]. In his Ethics, Spinoza states that human nature tends to identify itself with the necessary and rational order of the whole: a geometrical order whose rules organize the whole universe, both sensible and psychological. Referring to man, Spinoza says that our

, it is necessary to set a limit beyond which the task of the reflexive projections can be considered concluded. At this point, an extremely fascinating horizon opens before us, because the Cartesian unit that could once describe the basilica's physical space, if considered in terms of sound, becomes a discontinuous system of presence and absence. We find ourselves poised between a literal translation of Euclidean space and the beginning of the indeterminate realm of permanent transiency. The sonic space, originating from the lucid and crystal Cartesian geometry, evolves into an existential condition of suspension, forcing the subject into a state of aesthetic passiveness.

The Realm of Antithesis.

Contradiction in Perceptive Processes.

A sound’s echo dilates — during the period of its reflexions — a space already existing in the sight of the observer. As a consequence, the observers find themselves between, so to speak, two contradictory realms: an “objective” realm, connected to the sense of sight and conditioned by perspective; an “imaginary” realm created by echo and sound reflexions. From the geometric viewpoint, perspective and sound reflexion behave in ways as opposite as the spaces they generate. Perspective tends to compress differences in distance on the line of the horizon;[36] on the contrary, sound reflexion phenomena prolong the geometrical space in many directions, extending it beyond the horizon of the visible. The situation that comes into being represent a paradox — from both the Cartesian (two contradictory linear projections) and a psychological point of view. The doubling of space, in fact, triggers a process of internal division: it is as if our cognitive apparatus has to process contradictory data, albeit sensing their common origin [17]. Moreover, anthropologically speaking, the sense of belonging to a space is based on the univocal identification of all the sensory data gravitating around that particular environment.[37] The very principles of logic and Euclidean geometry are known as

species is a natural phenomenon following nature's general laws, which can be researched with mathematical objectivity: "I shall consider human actions and desires in exactly the same manner - Spinoza writes - as though I were concerned with lines, planes, and solids." (Ethics, III, "Preface").

36 The most illustrious example is possibly the church of Santa Maria in San Satiro, Milan. A space apparently as long as the church’s nave is actually 2 m long. Bramante’s optical illusion is obtained by physically compressing the intercolumnation’s space, according to the geometrical rules of perspective shortening.

37 One significant dimension of life is the human experience of place, which is the major focus of phenomenological work in environment-behaviour research [20]. In philosophy, Casey [18] has written two book-length accounts that argue for place as the central ontological structure founding human experience: "place, by virtue of its unencompassability by anything other than itself, is at once the limit and the condition of all that exists...[P]lace serves as the condition of all existing things...To be is to be in place".

principles of identity and non-contradiction; in the specific of our example, this means that being in a place excludes being at the same time in another.[38] .This study, however, demonstrates how some constructions, due to their geometry, compel the observer to experience the simultaneous existence of many spaces, causing a feeling of disorientation foreboding the loss of identity.

Antithesis and Rewriting.

The Sublime.

Like Kant, in his Critique of Judgement [39], we understand the ‘sublime’ as the aesthetic value created by the perception of something measureless and

Drawing on Merleau-Ponty [21], Casey emphasizes that place is the central ontological structure of being-in-the-world, partly because of our existence as embodied beings. We are "bound by body to be in place" (1994, p. 104); thus, for example, the very physical form of the human body immediately regularizes our world in terms of here-there, near-far, up-down, above-below, and right-left. Similarly, the pre-cognitive intelligence of the body expressed through action--what Merleau-Ponty called "body subject" — embodies the person in a pre-reflective stratum of taken-for-granted bodily gestures, movements, and routines, which is not self-contradictory in nature .

38 A central focus of phenomenology is the way people exist in relation to their world. In Being and Time, Heidegger [22] argues that, in conventional philosophy and psychology, the relationship between person and world has been reduced to either an idealist or realist perspective. In the idealist view, the world is a function of a person who acts on the world through consciousness and, therefore, actively knows and shapes his or her world. By contrast, the realist view sees the person as a function of the world, in that the world acts on the person and he or she reacts. Heidegger claimed that both perspectives are out of touch with the nature of human life because they assume a separation and directional relationship between person and world that does not exist in the world of actual lived experience. Instead, Heidegger argued that people do not exist apart from the world but, rather, are intimately caught up and immersed in it. There is, in other words, an "undissolvable and coherent unity" between people and the world. This situation — always given, never escapable — is what Heidegger called Dasein, or being-in-the-world. It is impossible to ask whether people make the world, or the world makes people because both always exist together, and can only be correctly interpreted in terms of the holistic and non-contradictory relationship, being-in-world .

39 Kant’s treatment of the Sublime comes under the more general framework of the reflective judgements, i.e. those judgements in which “given the particular you need to find the universal” (C.G., Intr., IV, pp 18-19). In other words, the determinative judgements are cognitive or scientific, as studied in the Critique of Pure Reason; i.e., those judgements that “scientifically” determine the objects of sensible intuition (phenomena) by means of universal a-priori Forms (space, time and the 12 categories). Reflective judgements are, instead, aesthetic judgements, that merely reflect on a pre-existing object by means of determinative judgements, and merely apprehend it through our universal need for purposiveness and harmony [23]. I would like to underline the use Kant makes of the term ‘Reflexion,’ which for him

immeasurable that generates within us an ambivalent frame of mind. It is exactly the perception of a space shown as limited by our sight, but proven to be immensely vast to our hearing which is ambivalent in this case. On the one hand, we are disappointed because the visual image cannot embrace the sweep of our aural image; on the other hand, we are fulfilled because our consciousness is driven to raise to the idea of an infinity suggested by this boundless acoustic space. The disappointment our imagination suffers the pleasure experienced by our reason, because boundless spaces have the power to evoke inside us — through sound — the idea of a superior infinity. In this sense, the initial phenomenological dissociation is then recomposed in a dynamic feeling able to transform the subject's physical smallness into a final awareness of spiritual greatness. In other words, becoming aware of the fact that the real sublime is not in the architecture we are looking at — with its twofold and ambiguous space [40] — but in ourselves, we convert the initial regard for the geometrical objects into a final regard for the subjects, i.e. for the supersensitive and qualified beings that we are. St. Mark's space, like the space of any wide, resonant geometry, is called sublime because it uplifts imagination so that it might represent those cases in which the mind is able to "feel the sublimeness of its destination" [41]. Initially depressive, the feeling of the sublime becomes exaltation, and our anguish turns into an active enthusiasm, able to project us beyond the immediacy of the phenomenon, beyond the confines of the geometrical space, and into the experience of pure space.

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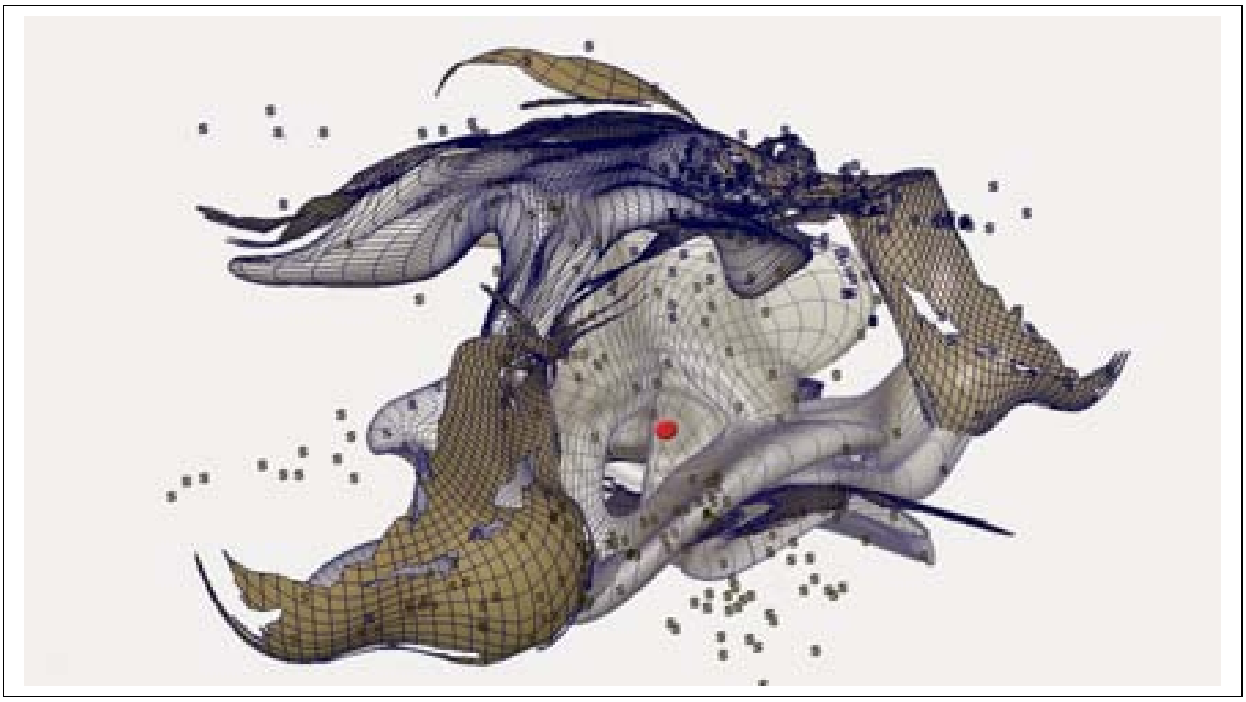
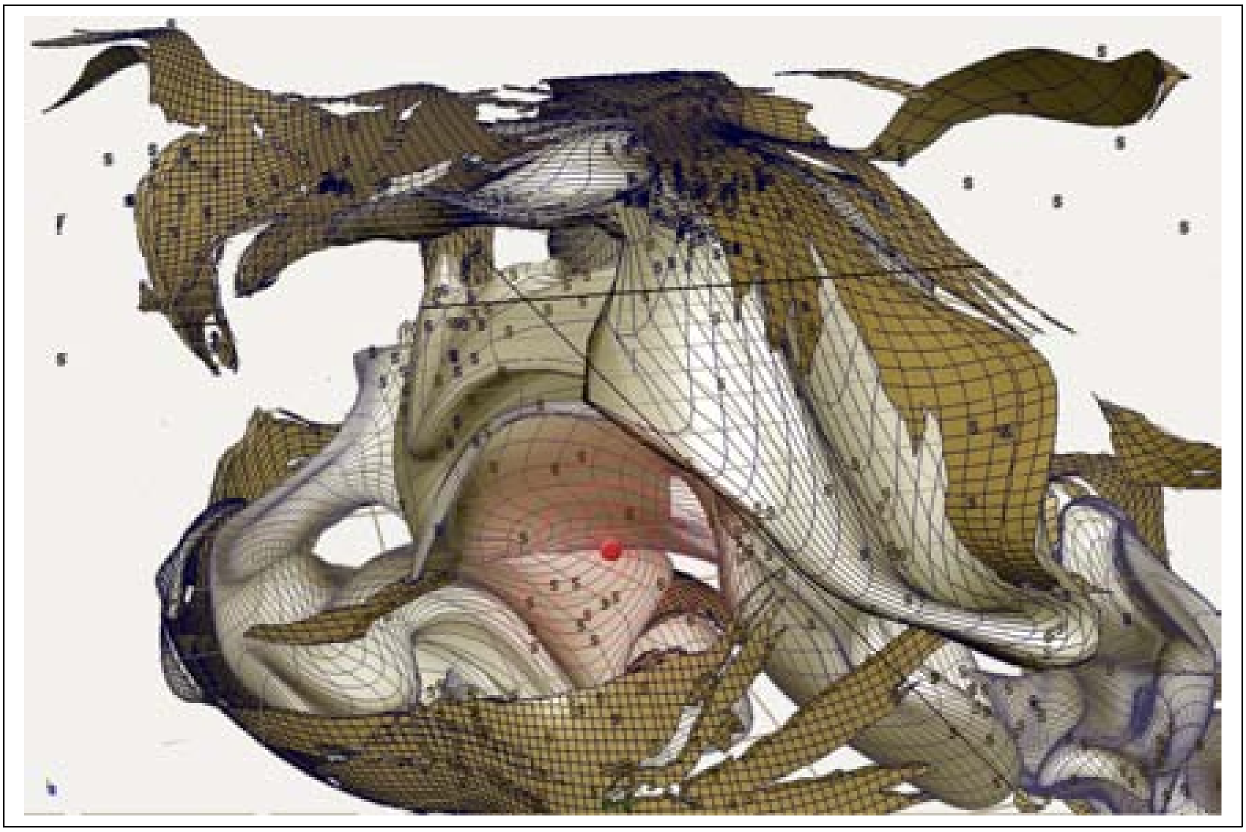
takes the technical meaning of an operation through which specific representations (geometrical, visual, and aural) relate to our mental faculties and principles with the aim of singling out among them a possible agreement (concept of purposiveness). In Kant's thought, this agreement always exists within the logic principles of identity and non-contradiction, under the assumption that a phenomenon will always provide univocal data (the image of a tree, of the mountains, etc.). In our specific case, the visual and aural phenomena of the same basilica (noumena) are to such an extent discordant that they destroy the Kantian a-priori Form of Space: the sight/hearing dissociation therefore destroys that (a-priori and necessary) representation of space which, according to Kant, is the foundation of all intuitions bonding us to the external evironment. This separation within the Noumenon (thing in-itself) opens the way to a weak version of the principle of identity itself, which can be considered as an identity of the parts, rather than an identity of the whole.

40 An assessment on part of the subject that, however, does not imply the depreciation of the sensible world, no matter how contradictory and antinomic it is.

41 Kant, C.G., Intr.,V, pp, 35-9.





First CAD model for the display of reflected sources (S letters). The light coloured nurbs represent the way the sources arrange themselves in space, showing the forces that determine the arrangement and justifying the subsequent distortion of the golden surface (light brown).

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The Space Between: Superstring Installation III

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Abstract

The main subject of this paper refers to a conceptual art work by one of us (MP), that was realized for the first time in Torino and later in Cetraro, in May 2005. It is at the same time an exquisite demonstration of how a clever mix of Art and Science is feasible and also a clear example of the cultural challenges offered by the fascinating and fast growing field of “Emergence in Art”. The artwork is in fact a creative and generative process, that - by means of physical interactions involving both the artist and the public - generates, step by step, an installation that is never ending, continuously changing and dynamically oscillating in space and time. This process intertwines Art and Complexity, giving space into Contemporary Art to the modern physical theory of “Strings and Superstrings”. By its very nature the ”Superstrings Installation” fully belongs to the current mainstream of “generative approaches to Art” as the most important outcome of the installation is not its “final state” (a state, in fact, which can even be inexistent, as the installation could in principle be an endless process and can be changed each time one adds a further string to the pattern) but rather the very dynamical interactive and creative process which step by step generates the installation itself.

The “Standard Model” (the current theory of Particle Physics) postulates the existence of four elementary “fundamental” physical interactions that are in turn carried by “elementary particles” grouped, according to precise symmetries rules, in suitable “families”. A different framework has been later proposed in Theoretical Physics, which tries to replace standard particles with so-called “strings” and “superstrings”. These are “extended objects” having one dimension, like real tiny elastic ropes which fill infinitesimally small portions of space. Strings – which might be “open” or “closed” - continuously vibrate in space-time and their vibrations generate observable excitations of the physical fields.

In much the same way, virtual strings formed by elastic ropes filled the space in the Exhibition Room, by means of an infinite process in which the public helped to generate intricate and never ending patterns. In essence, the room became wrapped in miles and miles of elastic string, going from floor to wall, ceiling to door, wherever anyone wanted to attach two end points. Attendees were able to enter and bounce around the space, the visual metaphor of the bound room being a pattern for space, like a “Wormhole”, i.e. a loop in space-time where we could as we exited one, see ourselves enter it. As a final output Art and Science merge through the emergence of the artwork itself.

1. The “Superstring Installation”: an Emergent Generative Artwork

This paper reports about a conceptual and generative art work, installation and performance that were ideated and created by one of us (MP) and realized for the first time under his direct guidance in Torino (Italy) on the occasion of the Workshop “Art, Complexity and Technology: Their Interaction in Emergence”, held in Villa Gualino, at the ISI Foundation, from 5 to 6 May, 2005 (see [1]). This “first superstrings installation” saw the enthusiastic participation of one of us (MGL) who subsequently suggested to repeat an analogous installation on the occasion of a slightly later scientific event, namely the Conference “Mathematics, Art and Cultural Industry”, held in Cetraro (Calabria, Italy) from 19 to 21 May 2005 (see [2]). This second performance was orchestrated “in loco” by MGL, via a telematic contact between MP in London and the Conference place, and it was accompanied by a living interview with the remaining author of this paper (MF). A third installation is now being organized by the three of us in Milano (Italy), on the occasion of the 8th “Generative Art Conference” (GA2005), held at the local Polytechnical University from 15 to 17 December 2005.

Petry is also in the process of organizing an exhibition in London (dates to be confirmed) on Art and Complexity, which will feature a further development of the potential for interactivity in the string installation. He proposes to add a live web cam to the site and will allow web visitors to tell real assistants in the gallery space which two points to attach a string. They will alter the real world from the virtual, and interact with the “live” members of the public in attendance. This will add another layer of complexity to the generative process.

The “Superstring Installation” wants to be – and in fact it is - a beautiful demonstration of how a clever mix of Art and Science is feasible, also providing at the same time a clear and self-explanatory example of the deep cultural challenges that are currently offered by the fast growing field of “Emergence in Art”. The installation is in fact a creative and generative process to be held and repeated at the suitable occasion of Conferences and Workshops seeing the joint participation of artists and scientists; an art work which - by means of physical interactions that strongly involve both the artist and the public - generates, step by step, a installation that is never ending, continuously changing and dynamically oscillating in space and time. It is therefore a true and genuine “generative process” that allows to intertwine Art and Complexity, giving space into Contemporary Art to the modern physical notions of “Strings and Superstrings”, which are among the most fascinating and challenging issues of current Physics of fundamental interactions.

The kind of structure that emerged in Torino, Cetraro and Milano - and will again emerge from further future re-propositions of this dynamical interactive

installation, wherever it would be again offered and repeated – turns out to be an evidently complicated and continuously changing structure. By its very nature, made of elastic ropes that cross each other in a fast growing and never self-repeating pattern, it has also deep relations with another branch of Mathematics, i.e. the so-called “Theory of Knots” (see, e.g., [3]).

In each one of the quoted occasions it has been (and again will be in later occasions) a beautiful example of “Emergence”. Moreover, it is fully embedded into the current view on “Generative Approaches to Art” since, according to the current definition of “generative art” [4], the most important outcome of the installation is not its “final state” - a state, in fact, which can even be inexistent, as the installation could in principle be an endless process and can be changed each time one adds a further string to the emerging pattern - but rather the very dynamical interactive process which step by step, piece of string by piece of string, generates the installation itself, together with its spatial and temporal relations with the surrounding environment (the embedding “space-time”) as well as within itself (the “internal space” of hidden degrees of knowledge).

2. Why Superstrings…?

“Strings” (and their “supersymmetric” partners, i.e. “Superstrings”) do belong to those fascinating and challenging fields of imagination that lead Mankind to wonder: “Which is the ultimate and intimate structure of the Universe which surrounds us…?” - “Are particles and quarks the smallest constituents of matter…?” – “Do space-time vibrations pass through evanescent point-like objects like particles are or, rather, is there any space in the Universe for something extended which vibrates as an elastic rope does…?”

And – moreover – “What do strings and superstrings have to do with everyday life and especially with the artistic sense of Nature…?” – “Should an artist and performer bother with such exotic concepts as strings and superstrings…?”

The “Superstring Installations” serve as an answer – an astonishing and emotionally intensive answer, indeed – to these last questions. It also allows to stimulate the imagination to run through this challenging field and – why not…? – to begin establishing a less dramatic interaction between Art and Science, two disciplines which could seem to be faraway from each other and, on the contrary, evolve and progress as intertwined parts of human thought (see, e.g., [5-7]).

2.1 Do Strings and Superstrings Fascinate the Artist…?

In a 2003 issue of “Scientific American” [8] a conversation with Brian Greene (the American scientist who several years ago ideated the very notion of “string” – see [9]) was published, with the title “The future of string theory”. There one can read a number of interesting statements, among which we like to quote the following: “A knot difficult to disentangle – String Theory seems to be the most modern and yet incomprehensible theory of Physics. At the beginning even specialists were annoyed by its extremely complicated formulation, while other physicists were rather skeptical about it because of its difficulties in providing concrete experimental evidences. The rest of the World, on the other hand, was totally unaware of its existence. String theorists were already at difficulty when trying to explain <<why>> the subject of their investigations was so exciting, so that an old dream of Einstein – a fully unified theory of reality – could be obtained, in order to open wider windows towards the understanding of deep questions like the very existence of Universe as we see it today”. Simple in fact as an idea as well as extremely complicated in its mathematical structure, String Theory is still today one of the most intriguing domains of investigation for Theoretical Physics. Many scientists believe it will be the ultimate answer to several fundamental questions of Theoretical Physics; others still remain doubtful about its real possibility to be the ultimate explanation of the fine structure of matter in the universe. Nevertheless, its scientific and philosophical validity is totally (at least potential) capability of giving a “unitary description” of all kinds of elementary matter, but also because of its intrinsic mathematical beauty, for the great stimulus it gave to deeper and deeper investigations about the fundamental forces which keep matter together, as well as for its somewhat astonishing contributions to the developments of specific branches of pure Mathematics. To such an extent that finally String Theory entered the imagination of public at large. Greene also states in [8]:“ … the <<external>> World begun to give some attention to String Theory. Woody Allen has made ironical claims on it in an article appeared in a <<New Yorker>> issue of July 2003. Probably it is the first time that someone has thought to Calabi-Yau spaces as an allegory of love stories at the workplace”.

2.2 Elementary Particles at Work

Modern Physics postulates the existence of a few elementary “fundamental” interactions (they are actually assumed to be four, according to a commonly accepted model of matter). A “classical” view on these interactions postulates moreover that the interactions themselves are carried by so-called “elementary particles” (together with their sub-particle constituents, called “quarks”) that are grouped, according to precise mathematical symmetries rules, in suitable “families”. According to this classical view on sub-atomic Physics elementary particles together with their sub-particles should be, in a sense, the ultimate constituents of matter; theoretically, they are taken to be points in space-time, having no shape nor any real dimension. Practically, they are considered to be extremely tiny objects, kinds of infinitesimal balls of matter whose physically sensible dimension is substantially evanescent.

The ensuing particle model is usually called the “Standard Model of Particle Physics” (see [9]). Among the particles that are better known to a general audience are “photons” (the particles which correspond to light propagation as they carry light around the Universe) as well as “electrons” and “protons” (which are responsible for electromagnetic interactions). Maybe less known, but frequently quoted also in divulgative reports on Physics, are “neutrinos” (which should contribute to the so-called and still mysterious “dark matter” existing in the Universe and considered to be responsible of several contradictory experiments of present days Physics) and “gravitons” (which are responsible for the attractive force between bodies, usually called “gravitation”). While at the time of Special and General Relativity (1905-1916) only two elementary forces where known – the gravitational and the electromagnetic force - contemporary Physics recognizes the existence of two other fundamental forces, called respectively “weak and strong electronuclear forces” (fully theorized around the ‘50s) which – altogether – are responsible of the cohesion of matter as it is experimentally observed in Nature. Electromagnetic and electronuclear theories are also called “gauge theories”, according to a fairly accepted jargon. According to the commonly accepted model, these four forces are the only “fundamental” ones (in the sense that all other interactions have to be generated by a mix of these four constituents); they represent the only fundamental ties between particles, which transport the interaction, and form the components of a still incomplete picture which Physics is currently trying to construct as a coherent and “unified” model of all interactions among the Universe components. A sort of “theory of everything”….. the ultimate formulation of which is still fugitive and represents one of the most important theoretical challenges of XXI Century Physics, still unresolved in its full generality.

2.3 Strings and Superstrings

Each theoretical construction aimed at describing “physical reality” should reasonably keep into account the need to describe the four forces mentioned in Subsection 2.2. above, as well as the need to obtain “particles” at least as a low-energy approximation of the theory itself. This is fairly coherent with current observations both at galactic and extra-galactic scale and at the level of particle accelerators in Physics laboratories. In the usual particle models - and in particular in the so-called “standard model” - elementary particles are thought of as point-like shapeless entities, like small round balls without any real dimension, that do not occupy sensible portions of space (better, of four-dimensional space-time). It is evident that this is not possible if a continuum model is envisaged, although a coherent theory of fields in which particles are small but not evanescent objects – having therefore a finite though small size and, accordingly, a tiny three-dimensional extension – is not satisfactory and in fact inexistent.

A different framework has been therefore proposed in Theoretical Physics, which tries to replace standard particles with so-called “strings”. These are “extended objects” having just one dimension, like real tiny elastic ropes which fill infinitesimally small (or even larger) portions of space (maybe ordinary space-time, or better a space-time of dimension even higher than four). Strings might be “open strings” (i.e., they are ropes with two different and separate endpoints) or “closed strings” (i.e., they are loops in space-time; ropes with the topology of a circle, or, if one prefers, open strings which have been closed by letting their two end-points coalesce in a single point). Strings oscillate and vibrate continuously in space-time – like real elastic strings do in everyday life and experience - and their vibrations are thought to generate excitations of the physical fields, i.e. the physical effects which a physical field theory should produce as “observables” that, in turn, could be described as ordinary particle states. Of course the Mathematics and the Physics of such theories are much more complicated and the model described above is just a toy description for non-specialists, but the intimate essence of the “Strings World” is exactly that one.

The terminology “superstrings” is just a jargon for specialists. It refers to an extension of string theory which keeps suitably into account the fact that particles are grouped into two main families, so-called “Bosons” and “Fermions”, that obey different and mutually exclusive statistical rules. These names come from the proper names of the famous scientists Bose and Fermi; the difference between these two kinds of particles refers to the validity of so-called “exclusion principle of Pauli” which, as mentioned, eventually separates particles into these two mutually exclusive families. Boson are described by mathematical objects which obey scalar, vector or tensorial rules of transformation; Fermions obey instead spinorial rules. All so-called “super-descriptions” of reality are based on suitable mathematical and physical frameworks that allow stronger exchanges between these two a priori somewhat separate worlds, i.e. a unified description of both kinds of matter in single unitary “packets” which strongly entangle Bosons and Fermions together.

3. The Installations at Torino and Cetraro

As stated in the Introduction, the artistic performance “The Space Between: Superstring Installation” is explicitly intended to be both a tribute to this fascinating theory of Physics, wiz. “String and Superstring Theory” – together with its philosophical implications – as well as a fantastic artistic experiment which we believe to be fully and appropriately immersed in the framework of “Generative Art”.

The installation was realized for the first time by Michael Petry at the Workshop “Art, Complexity and Technology: Their Interaction in Emergence”, held in Torino (Villa Gualino, where the ISI Foundation is located) from 5 to 6 May, 2005. The preliminary announcement of that Workshop, together with more information, can be found at the Home Page http://www.isi.it/conference-art.html. A detailed overview of the Torino Conference - where a few video traces about the day-by-day evolution of the installation can be seen - is found at the following Web page:

http://www.psych.lse.ac.uk/complexity/Symposium/TorinoMay05.htm.

The installation was re-sited (in collaboration with M.G. Lorenzi and with an accompanying scientific interview with M. Francaviglia) at the Conference “Mathematics, Art and Cultural Industry”, held in Cetraro (Calabria, Italy) from 19 to 21 May 2005; more details can be found at the Web pages:

http://galileo.cincom.unical.it/convegni/WSArte/

http://galileo.cincom.unical.it/convegni/cd_ma&ic/start.htm

and a few images of the installation are shown hereafter.

Figure 1: Cetraro - a participant at work in constructing a string of the installation.
At the next page, Figures 2 and 3: other participants at work in Cetraro

Figure 4: Cetraro – the Superstring Installation II

The best description of these installations is perhaps Petry's original commentary prepared for the first Torino edition: "This would be an interactive self-defining, ongoing project that would take place at the start of the conference and run throughout it. A final visual element will emerge from the participation of all the conference members, speakers as well as attendees. According to lead theorists (like David Peat) super strings run throughout the universe taking material from one end to another. Yet they interact on our perceived notion of the universe at such an infinitesimally small level, that we do not see or feel these transfers. Such strings are said to pass through our physical bodies continuously going through the space between atoms, and subatomic elements. Particles like neutrinos are so un-interactive that they pass through us without ever disrupting our subatomic elements. Petry asked each person to attach at least one section of string to different parts of the room (with either black or white tape provided) at the start of every session. They could of course do many, or use the break periods to make even greater interventions. In essence, the room became wrapped in miles of elastic string, going from floor to wall, ceiling to door, wherever anyone wanted to attach two end points. Attendees were able to enter and dance around the space. Often it is asked how artists can lead scientists to an understanding of the world, and while there are many examples, Petry would suggest that the visual metaphor of the bound room being a pattern for space, and yet a bound restricted space

Figure 5: Cetraro – the Superstring Installation II hanging from the ceiling

Figure 6: Cetraro – the Superstring Installation II as seen in the room

presents a paradox similar to that of the Wormhole. In a Wormhole, given the technology, we could as we exited one, see ourselves enter it. In a bound room, the depiction of freedom and its boundaries can be drawn and in a complex way. We might see Art and Science merge, through the emergence of the artwork."

It is important to remember that the piece was foremost an ARTWORK, not a model for a scientific theory. Many of the scientists in attendance made suggestions as to how it could be made more like a model, to which Petry continued to reply, "thank you for your ideas, but this is an art work, but that does not preclude you from making your own new installation that suits your ideology better". It was an interesting example of how the two languages (that of Art and that of Science), while using many of the same works, mean such different things by them. Petry insisted on the poetry of the actions and the strings in space, while the scientists insisted on seeing the object from a point of utility.

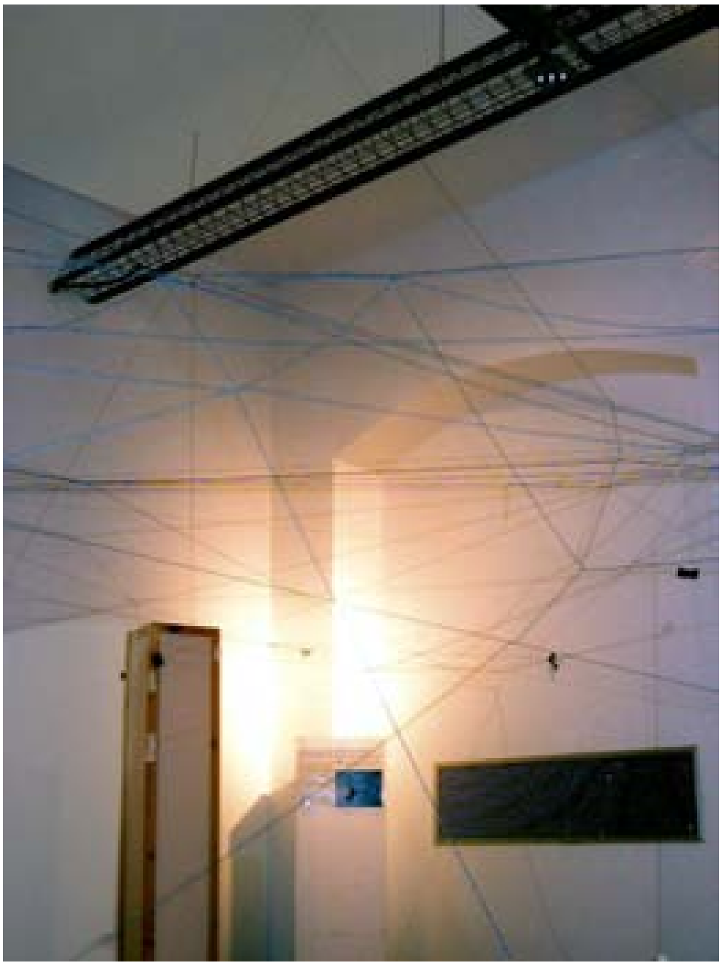

Figure 7: Cetraro – a view on the final outcome of the installation

As stated in the Abstract, the virtual strings formed by elastic ropes eventually filled the space in the Exhibition Room, by means of an infinite process in which the public and all participants helped to generate intricate, entangled and never ending patterns. Knots and knots of elastic material that, in virtue of their elastic properties, were induced to vibrate by all external interactions (even airflow or just by touch). In essence, the room became wrapped in miles and miles of elastic string, going from floor to wall, ceiling to door, wherever anyone wanted to attach two end points. Also closed strings could be obtained by a clever handling of the ropes. Attendees were able to enter and move in the space (ducking and bobbing in order not to collide with the real strings), the visual metaphor of the bound room being a pattern for space, like a "Wormhole". As a final output, Art and Science merge through the emergence of the artwork itself. As already mentioned, all these installations are genuine examples of "Generative Approaches to Art" since their most important outcome is not its “final state” but rather the interactive process which generates the installation itself.

4. References

[1] “Art, Complexity and Technology: Their Interaction in Emergence” – Workshop held in Villa Gualino (ISI Foundation, Torino, Italy), 5-6 May, 2005 - Web Page: http://www.isi.it/conference-art.html.

[2] “Mathematics, Art and Cultural Industry”, Conference held in Cetraro (Calabria, Italy), 19-21 May 2005 - CD-rom of Proceedings by M.G. Lorenzi - Web Page: http://galileo.cincom.unical.it/convegni/WSArte/

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[8] Il futuro della teoria delle stringhe; una conversazione con Brian Greene, Le Scienze 424 (Dicembre, 2003), pp. 44-49

[9] D.J. Griffiths, Introduction to Elementary Particles, John Wiley & Sons (New York, 1987) – See also the web page: http://superstringtheory.com/.

Signifier Signs in a generative process

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Abstract

Is there a possible relation between the new digital media's contribution and traditional procedures of composition (based on a conceptual elaboration), that would aim at reading contextual relations, and yet obtains shapes whose meaning integrates a formal enquiry with a semiotic one?

A first series of experiments investigates the role that the digital medium should have in the dialogue between local identity's multiple expressions of a very characterful location.

A series of thoughts looks at the entity of "the unexpected" as a creative contribution by the digital tools employed (apparently said entity is invalidated by the gatherings of practical experience, which seems to grant a rough predictability of the result of dynamic simulations, where the planner is choosing not only the interacting forces, but also the volumes, their geometrical characteristics and mutual relations between the elements in the scene).

The last experiment attempts to separate the three phases in the design process: the contextual, the semiotic and the functional analysis, letting the software to merge the findings into a unique result.

Inverted Cinematics allow to comply with the functional diagram, by translating the requirements expressed by the structural diagrammatic rule and by obtaining a flexible and yet functional bone-structure.

Parametrizing the context (on the basis of functional and visual relations), allows to define a field of forces where dynamic simulation can be performed.

Lastly, individual taste leads to the choice of a flexible "skin" (signifier) which is defined in tune with the meta-project's influence (signified), the latter being unconnected with the digital medium (prismatic elements vs. blob and organic shapes – "nurbs" exclusion).

Hence we could argue, on one side, that the evolving element could easily be represented as a poetic idea expressed by the architecture, and on the other, that the idea's shaping magnets are, in fact, re-interpreting the context.

The modelling software's dynamic simulation defines a signifing shape, obtained by the sum of the three initial aspects, and yet readable as a whole.

1 Initial points

The main idea was to combine the new input from the dynamic generative procedures and the attention to the contextual and semiotic relations. The main focus was the use of new digital tools to point out an architectonic composition made up of marks that highlight both the relations to the site location as well as the significant meaning expressed by the author.

The research was launched with Arch. A.Mognato in the occasion of a project for a biomass teleheating station, an experimental situation to which the following stated experiments refer. [1]

We ask ourselves if the formal research conducted through dynamic generative experiments is necessarily in contrast with the planner's control of the planning marks aimed at the double reading as cited above. We also ask ourselves if the attempt to direct the production of forms towards precise compositive objectives creates a limitation in the principal aspect accredited to the productive experiments, such as the occurrence of “the unexpected” and the break away from preconceived layouts.

1.1 Digital tools

One works by generative digital processes based on dynamic simulations compatible with modern modelling and animation software (3DSMax is used).

The procedures involved are those in which the design team is aided by an instrument that operates like an active matrix and offers an input that exceeds simple practical-managing advantages to encroach on the conceptual inspiration of the geometric topology and of the malleability of its evolving forms. [3] We assume the indisputable mutual conditioning that exists between digital technology and the creative thought that uses it. [4] We also assume supersession of the simple incorporation of an instrument in the design process in order to reach its conceptualisation. Finally, we assume, therefore, that the possible formal experimentations offered in this sense are to be probed in inseparable association with the instrument that makes them possible, and above all, conceivable. [5] That is not all.

What we must underline here is how the generative digital processes mutate the distinctive traits of the planner and the choices he carries out, since the generative process must be conceived by the planner more than does the final result that derives from it. The unexpected and unpredictable features of the final formal result are an integral part of creativity, as well as keys to breaking away from preconceived typological schemes. [6]

In fact, in generative procedure based on dynamic simulations, the architect sets the process and regulates it through the setting of parameters: the layouts elaborated evolve like an organism reacting to certain environmental conditions defined and varied by the planner based on his set premises. [7]

All that has been here prefaced alienates the direct assessment of architectonic marks by the explicit will of the designer.

1.2 Semiotic context and interpretation

Since an architectural project is perceived and experienced in such a way that is inseparably bound to the location in which it is situated, this second preface aims to frame the reasoning by proposing an interpretation of the location.

The proposed research in fact focuses on the relationship that we want to exist between the generated forms and the location for which they were made as an integral part of the significance of the architectonic signs. Using a common metaphor, we can say that the building location is like a complex layered text. [8] Assuming the opposition between the signifier and the significance, theorised by Ferdinand De Saussure [9], passing through a location intended as a group of signs means penetrating into a universe of contents transmitted to us. Particularly, a location site manifests itself as a complex articulation shaped throughout history. In it, in various sizes, natural elements and human works are shaped throughout time to the configuration that we find today. To every sign there is an associated content traceable to human projects as well as human perceptions of natural signs. In most cases, natural aspects and human works followed each other and were articulated in the centuries with occasionally an unaware conditioning by pre-existing features. Today's configuration is composed of signs that tell us not only of the latest evolution phase, but also in an explicit way, a memory of the ones that preceded it.

The decodification process of a location is generally very complex. Nevertheless, the inherited wealth of iconic forms of a society is inevitably the background from which an individual's perception of signs derives. For example, despite the fact that the casuistics of visual messages are mostly eradicated, a concave mark, which can recall a gesture of a hand, a nest, or a mother's womb, is a sign in which we immediately read a sense of welcoming and receptivity. Thus, even without the expectation of a complete and critical study, the contents are transmitted from a historical and recent package of expressive signs in virtue of the immediacy with which the figural universe communicates. This extremely immediate form of reading determines an integral social role of architecture and imposes on the architect an evaluation of the universes of transmission in which his work is situated.

From this point of view, the planning of an architectonic object cannot disregard the fact that the object adds a narrative to the complex urban or natural text into which it is inserted. The significant signs of which it is composed are an expression of a content that is manifested in the whole of that location.

1.3 Legibility of the architectonic text

In particular, we can dismantle the legibility of each architectonic work into two co-present aspects. On one side, a part of the signs that make up the work can harmonise with it or make it disharmonious to the context in which it stands – whether they be volumetric configurations, topological relations, rhythms, scansions, proportions of parts, materials and textures of a shell's skin. On the other hand, the poetic idea that subtends the creative process traditionally assigned to the planner is manifested.

2 Experimentations

2.1 Experimentations on single controlled phases

If used singularly, the digital instruments that converge to a dynamic simulation generally guarantee an excellent legibility of an idea through the forms generated. One can just think of the possibilities offered by a dynamic modelling software of which a planner can make use in the procedure for explicit manifestation of a chosen content: an initial conceptual intention (content) can be expressed with he help of instruments offered by the software that eludes the geometric rigidity of the forms, allowing a plastic and expressive modelling very similar to the sculptural approach. The choice of instruments used become, in such case, closely bound to the expressive objective pursued.

A very simple example are the space warps based on modifiers; deforming geometric space, they not only institute an immediate relation between their placement and position in the space of the object to which they are applied, but also they are a direct expression of the formal will of the planner.

In the following stated experiment, in the historical downtown area of the city, there is an associated space warp that bends space. A series of cubes move in the lot under the influence of attractive forces. In their movement each cube is deformed, taking on a form that is directly connected to the position assumed in space in respect to the historical downtown where the space warp is located. At the same time, the carried-out choice in regard to the type of space warp is reconducted by the planner's will to define an architectonic form that reaches out explicitly to the historical downtown.

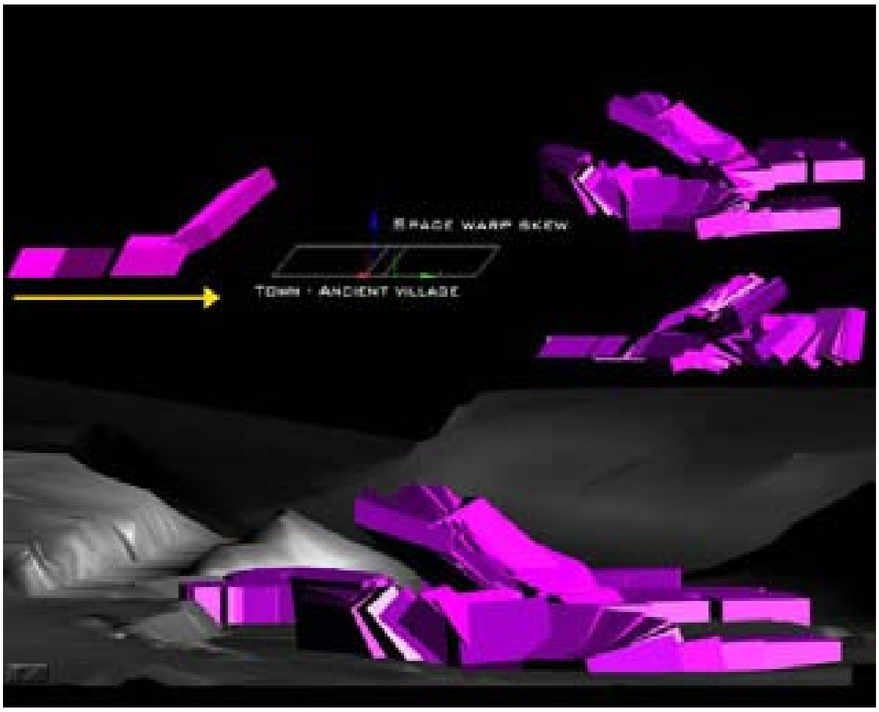

fig.1 – Snapshots of deformed cubes

In respect to the query of the research, these types of procedures seem to work well for single steps, even if in combinations.

In a second experiment, through a dynamic simulation with the use of particle flows, we analyse the visibility of the area surrounding it and the conformation of the terrain; on the basis of the different concentrations of particles, we identify two internal areas in the lot; we shape the urban directions and natural choices on the form of the areas and obtain three split forms. A dynamic simulation proposes the interaction of a series of cubes that move along the split ones; a third dynamic simulation deforms the obtained volumes in relation to the conformation of the facing slope.

It is a translation of traditional procedures operated by digital tools, induced by the semiotic interpretation of the urban text, but the generative process is still controlled for the single diagrammatic steps and does not consent the elaboration of a reacting form in its totality.

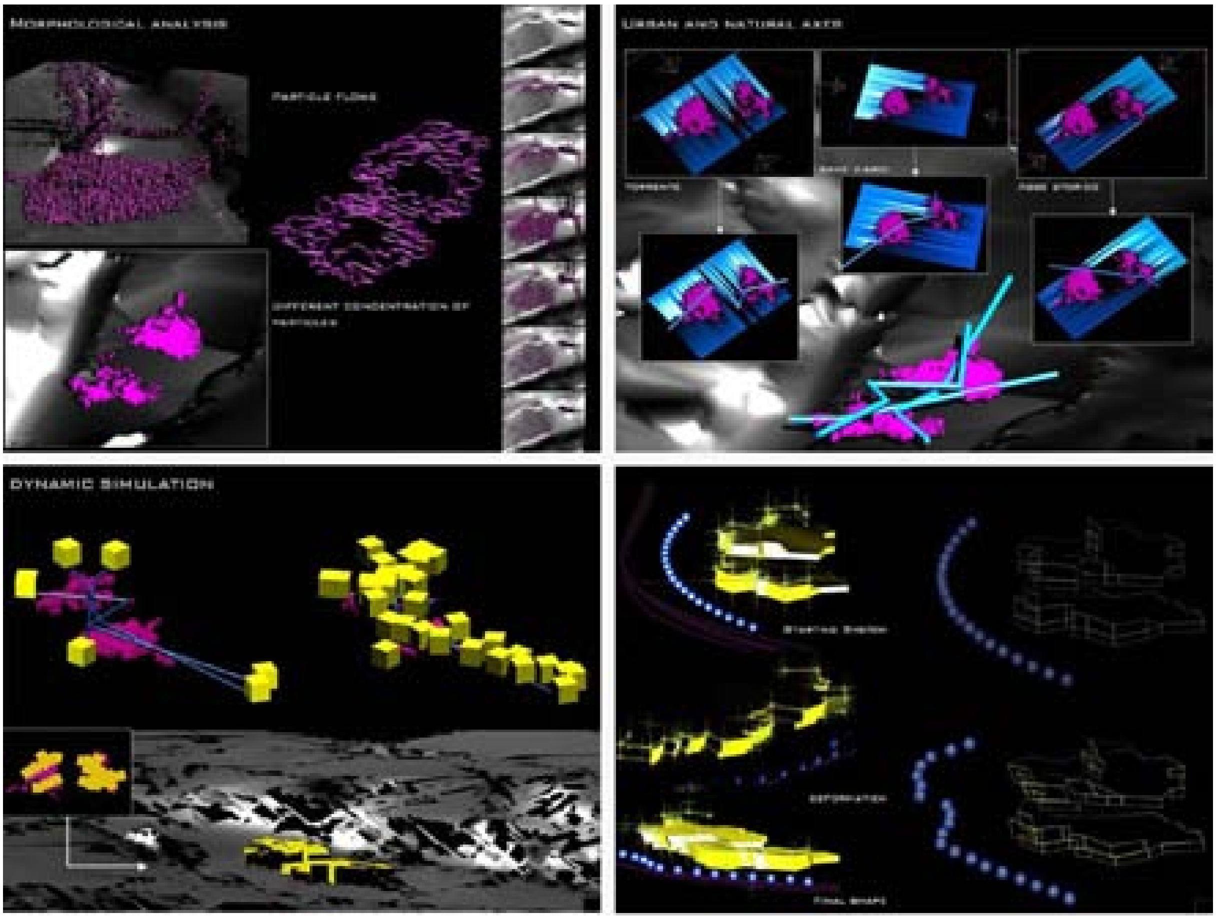

fig.2 - single diagrammatic steps of second experiment

2.2 Experimentations of contemporaneous interactions

In the last compositive process stated here we attempt to reach the unification of the procedure, the meaning, and the group of forms as a complex reacting organism.

Often complicating the processes and intensifying the relations between single digital instruments used in the formal definition, the elevated number of interactions tends to remove the formal result from the legibility of the initial intentions. To rectify this, despite making some phases contemporaneous, one must associate a defined objective to each of them.

1) The architectonic object is intended as an autopoietic organism. [10] Its internal function is interpreted on the basis of functional requirements that it must guarantee in virtue of its use's destination (biomass teleheating station). A diagram, through proportional circular areas and their tangents, represents respectively the fundamental functional components and their necessity for mutual connection. In such a case, three general sectoral domains are highlighted, subdivided internally into specific establishments (managerial domains composed of different offices, technical domain of vain machines and area of treatment of wood to burn).

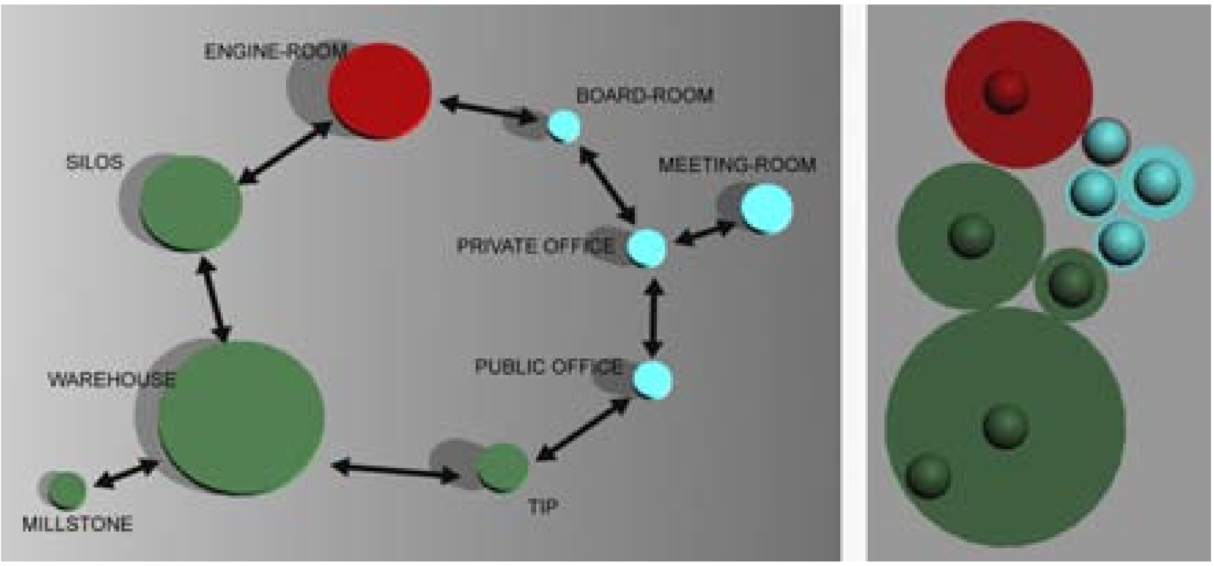

fig.3 – functional diagram

2) The context is interpreted on the basis of a historical and semiotic study of its signs and in relation to the project at hand, under the visual and functional profile. Each element extracted on the basis of these reflections is parameterized according to a proportional scale of positive or negative values and related ever so often to each functional element that makes up the project's diagram. In this sense, for example, the historical downtown assumes a positive value in respect to the engine room to which we want it to relate visually; and a neutral value for the Silos, while the purifier has a negative value compared to the offices nearby where the workers would be disturbed by its proximity; and so forth. The objective consists in an influence between contextual elements and those of the specific and proportional project in respect to each of the analysed relations.

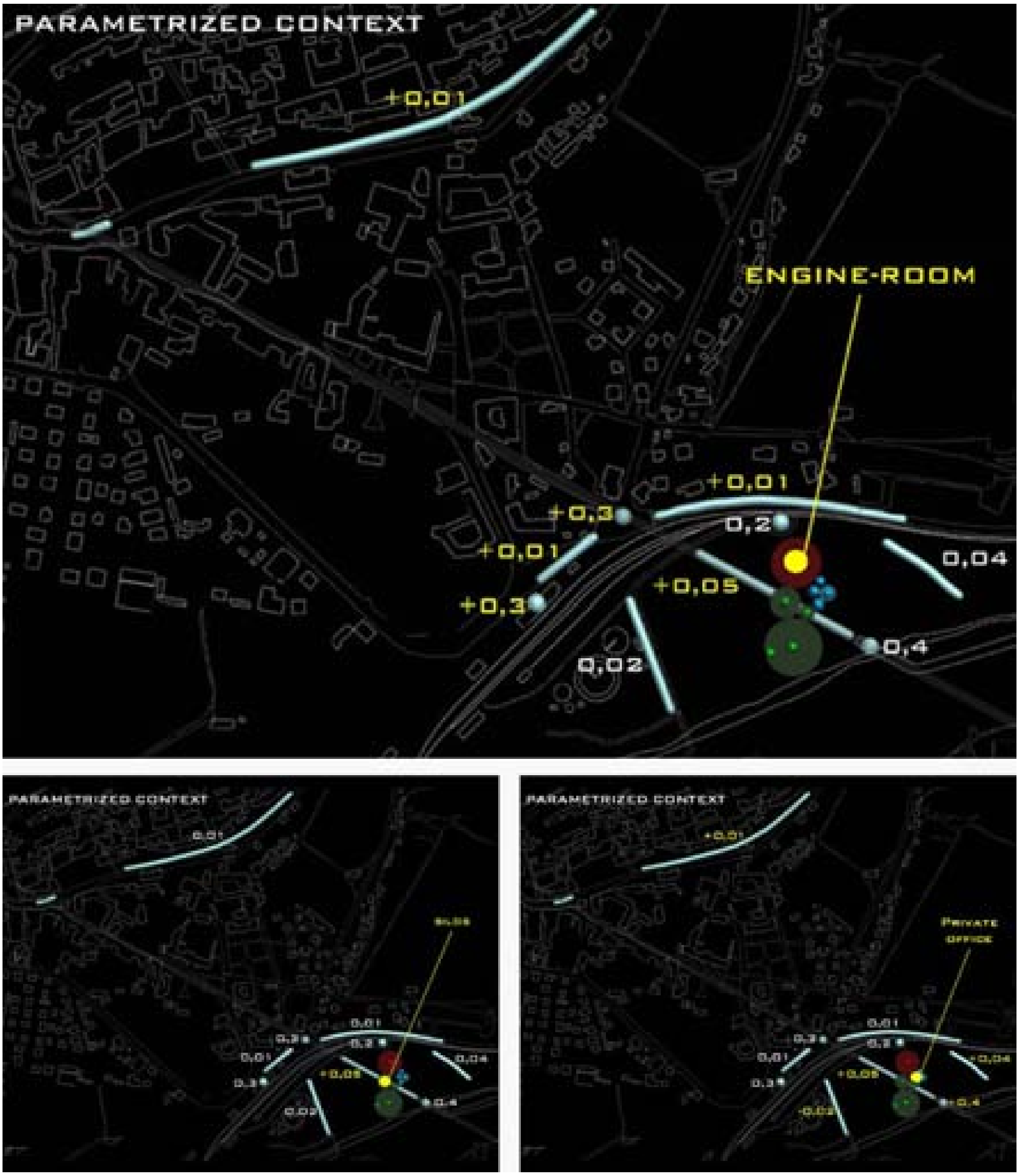

fig.4 – parameterized contest (3 of 9 combinations)

3) The project's intuition comes from location, in which the big acute layers and the topological realisations of the flaky ancient rocks suggest crystalline forms, expression of a personality that seems to us intrinsic to the pre-alpine landscape, inducing us to hypothesise a project involving acute protrusions and tensions.

From the operational point-of-view:

1) The respect for the functional obligations is guaranteed by a skeleton regulated by Inverted Cinematics. This sets rigid obligations that correspond to the necessity of functional tangency. Determining the position of the connecting-rods based on the distances and cyclical disposition of the functions and by conceiving the entire

skeleton on the functional diagram, the mutual position of the rods, their length, the freedom to rotate corresponding hinge joints and the general disposition, all translate expressed needs from the structural diagrammatic rules, allowing to obtain a structure capable of deforming itself still guaranteeing the functioning of the system.

fig.5 – skeleton (Inverted Cinematics)

2) The context translates to a field of attractive and repulsive forces, of diverse intensities on the basis of the parameterisation carried out, making each element of the context an attractor or buffer in regard to each single part of the project.

3) The project idea is associated to the choice of geometric entities on the simulation scene. One chooses to operate with prismatic elements, excluding geometrical nurbs and blobs that lead to fluid forms, extremely seductive in their abstractness, but strongly disharmonious with personal suggestions.

A dynamic simulation makes the system of forces interact with each part of the functional diagram. Each function, generically represented by a small sphere, reaches a point of equilibrium around which the motion generated by dynamic simulation becomes cyclical. At such point, it is associable to the ideal position of each function in relation to the significant points of the surrounding places in relation to it.

Corresponding each hinge of the skeleton to a sphere, the system is deformed by the imposed obligations.

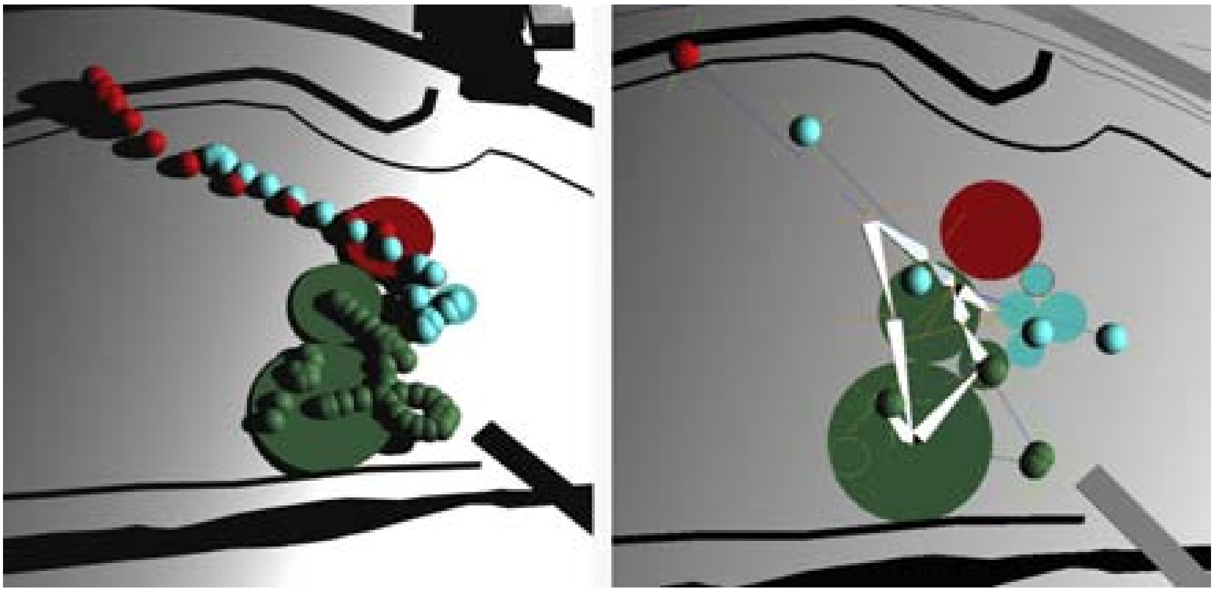

fig.6 – dynamic simulation

So, we obtain a system that condenses a complex group of project relations, overcoming the separation of the single steps previously analysed. Different possible formal expressions are associable to this.

From the guidance of point 2 (estimating the subject element to the evolution of the poetic idea that architecture intends to express) we clothe the bone structure with a prismatic skin. The deformation leads to the final compositive conformation.

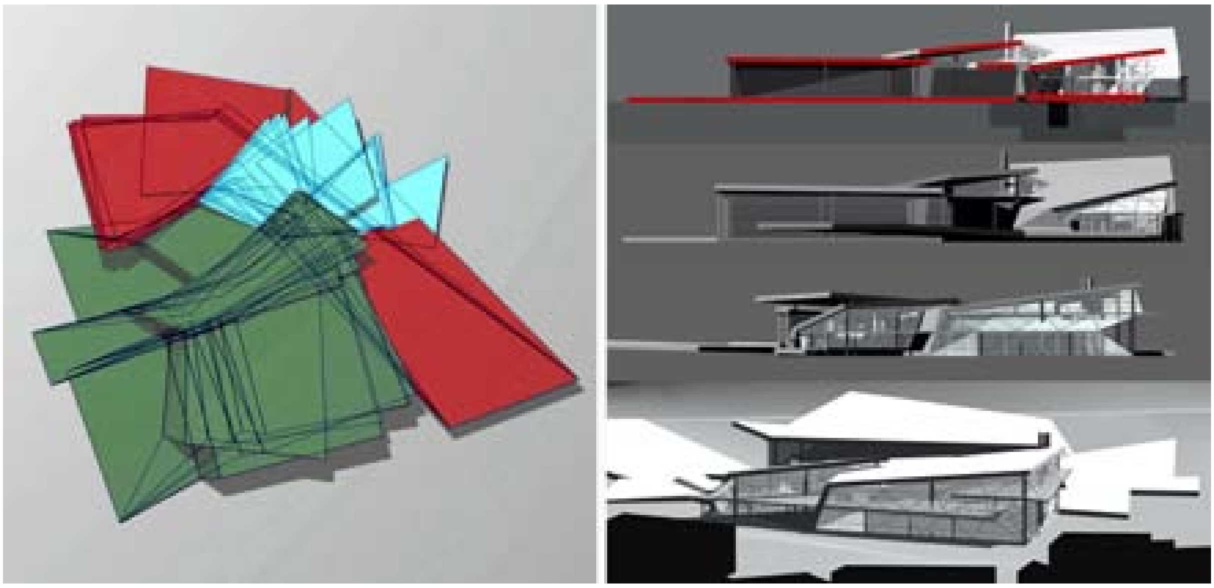

fig.7 – deformation of prismatic skin and final compositive conformation

Conclusion

Besides the will of the author and the interpretation that he proposes of the context, the meaning of the generated signs is focalised in relation to the creative contribution recognised of the informatic medium. The co-presence of the three contributions do not seem to us that it could degrade the digital elaboration of unexpected forms. These elaborate a geometry evolving with an infinite amount of freedom, despite remaining within legible contextual relations and manifesting an explicit expressive will of the author. The procedure is like a synthesis of the three contributions.

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Creating tiling by means of 2D graphics applications

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Abstract

Methods of creating patterns and ornament with the help of computer can be divided in to several groups. First way is programming or generating patterns and ornament. Other way is using of features and capacities of computer graphics software for the tiling. Such applications of 2D computer graphics as Corel Draw, Adobe Photoshop, and Corel Painter contain tools and mechanisms for crating tessellations, patterns, mosaics, and tiling. Tasks of paper are to classify methods of creating tiling in each application and discuss the problems and advantages of these methods. All methods we classify in to large group: filling methods and cutting methods. But each application has unique features for creating ornaments and tiling.

Introduction

Methods of creating patterns and ornament by computer can be divided into several groups. (A) Programming or generating patterns and ornaments and (B) constructing patterns and ornaments by graphics editors' tools. Programming patterns and ornaments by means of simple geometric objects, such as a point, line, rectangle, oval is a simple and spectacular method for explaining the main constructions of programming languages. Tasks where graphic is used are very convenient for explaining assignment statement, conditional branch, cycles, recursion, users' functions, and basic conceptions of object-oriented programming. Ornament and pattern programming tasks demand wide mathematical background and simultaneous using knowledge form different areas of mathematics. But ornament and pattern programming cannot be brought only to methodic aspect. Generating ornaments are a subject studied by computer graphics. The idea of constructing various ornaments and patterns lies at the basis of many developing computer games, where tessellations of different kinds are modeled. Such applications of 2D computer graphics as Corel Draw, Adobe Photoshop, and Corel Painter contain tools for creating tessellations and patterns.

We would like to examine methods of creating patterns in 2D graphics applications as well as problems, appearing in context with this process.

Let us determine some definitions. Such terms as tessellations, ornament, tiling, patterns are used synonymously. A fragment of a pattern is often called a motive, a tiling, a rapport. Further on we shall use such a term as ornament meaning a pattern, consisting of rhythmically regulated elements without visible connections, a recurrent element of an ornament will be called a pattern.

Let us consider some classes of mathematic tasks, which lead to ornament construction. In the process of choosing tasks we shall take into consideration the following thoughts: an ornament pattern can be constructed with the help of computer graphics applications, ornament construction mechanisms can be reproduced in the frame of the above listed applications. Studying mathematical tasks is aimed at:

To define what geometric figures can be used for constructing ornaments and how;

What are mechanisms of covering the surface with ornament patterns.

Periodic ornaments

Form of patterns

Let us confine ourselves to tasks of ornament and pattern construction, which totally cover the plane with non- intersecting fragments of an ornament or a pattern having a definite geometric form without visible lines of connection. Let us consider regular geometric figures as basic forms. This class of ornaments and patterns called regular tessellations.

Regular, semi-regular and polymorph ornaments and tessellations. If regular polygons serve as patterns and two adjoining patterns have a common side, or only a vertex, then possible forms of patterns are equilateral triangles, squares, and regular hexagons. Ornaments, constructed having these rules are called regular (Figure 1).

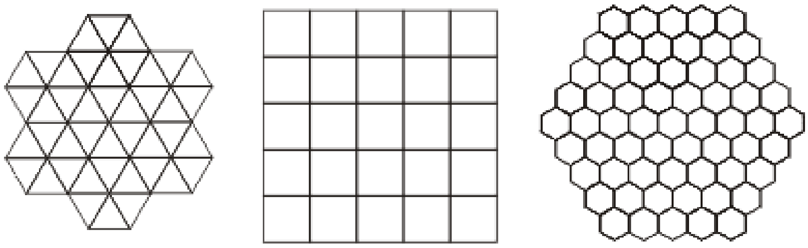


Figure 1. Regular tessellations

If each vertex closes on the same number polygons of the same kind and in the same (or the reverse) cyclic order, there exit eight options of covering a plane (Figure 2), namely: $3\cdot12^2$; $4\cdot6\cdot12$; $4\cdot8^2$; $(3\cdot6)^2$; $3\cdot4\cdot6\cdot4$; $3^2\cdot4^2$; $3^2\cdot4\cdot3\cdot4$; $3^4\cdot6$ ($3^4\cdot6$: each vertex of an ornament joins 4 triangles and a hexagon) [2, 3].

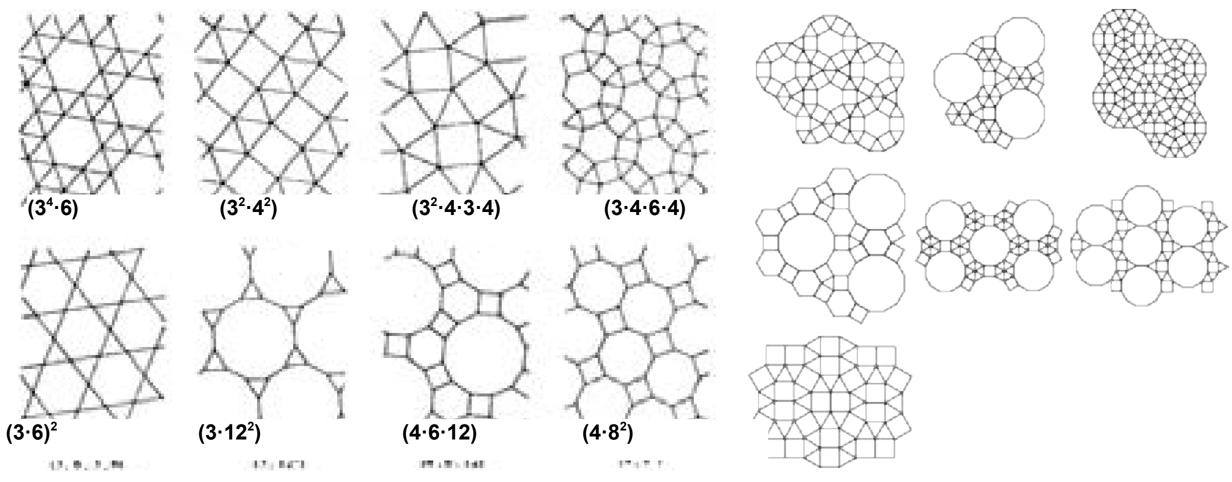


Figure 2. Semi regular tessellations

Figure 3. Demiregular tessellations

Tessellations of the plane by *two or more* convex regular polygons such that the same polygons in the same order surround each polygon vertex are called semi regular tessellations (Figure 2), or sometimes Archimedean tessellations. In the plane, there are eight such tessellations, illustrated above. There are 14 demiregular (or polymorph) tessellations (Figure 3) which are orderly compositions of the three regular and eight semiregular tessellations.

Transformation of pattern.. For two congruent tiles A and B in a tessellation, there will be some rigid motion of the plane that carries one onto the other. A somewhat special case occurs when the rigid motion is also a symmetry of the tiling. In this case, when A and B are brought into correspondence, the rest of the tiling will map onto itself as well. We then say that A and B are transitively equivalent.

Transitive equivalence is an equivalence relation that partitions the tiles into transitivity classes. When a tiling has only one transitivity class, we call the tiling isohedral. More generally, a k-isohedral tiling has k transitivity classes. An isohedral tiling is one in which a single prototile can cover the entire plane through repeated application of rigid motions from the tiling's symmetry group. Note that an isohedral tiling must be monohedral, though the converse is not true [1].

By definition, an isohedral tiling is bound by a set of geometric constraints: congruences between tiles must be symmetries of the constraints can be equated with a set of combinatoric constraints expressing the adjacency relationship between edges of a tile. They proved that these constraints yield a division of the isohedral tilings into precisely 93 distinct types or families,1 referred to individually as IH1, . . . , IH93 and collectively as IH. Each family encodes information about how a tile's shape is constrained by the adjacencies it is forced to maintain with its neighbours. A deformation in a tiling edge is counterbalanced by deformations in other edges; which edges respond and in what way is dependent on the tiling type, as shown in Figure 4.

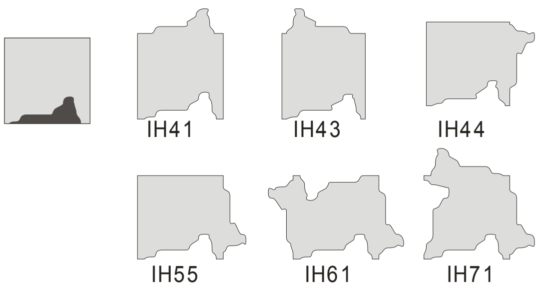


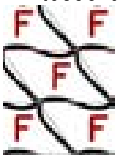
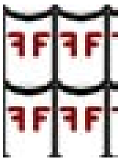
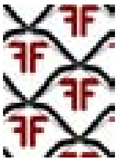
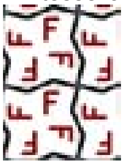
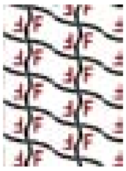
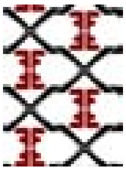
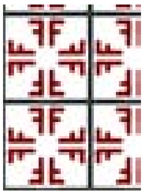
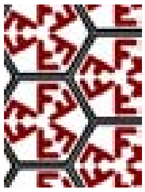
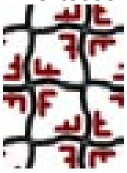
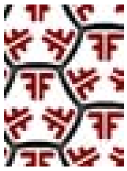
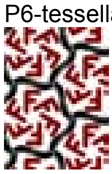
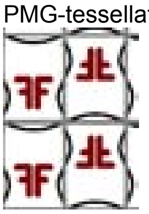
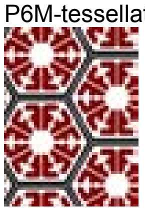
Figure 4. An isohedral tiling types

Isohedral tilings have the property that if you list the valence of each tiling vertex as you move around any given tile, the list will be consistent across all tiles in the tiling. This list is fundamental to the topological structure of the tiling and is called its topological type.

Methods of covering a plane with patterns

Symmetries. We know form mathematics, that there are three types of symmetries on plane: translation, rotation, glide-reflection. In reality meshes of regular ornaments, consisting of regular triangles and regular hexagons are identical. The it is enough to consider a square and hexagon, lying at the base of regular ornaments. Taking into consideration motion symmetries of plane in cells of regular meshes exist 17 types of regular ornaments (Table 1).

Table 1. 17 types of symmetries in regular tessellations [3]

Parallelogram (2x)	Rectangle(5x)	Rhombus(2x)	Square(3x)	Hexagon(5x)
P1-tessellations 	PM-tessellations 	CM-tessellations 	P4-tessellations 	P3-tessellations 
P2-tessellations 	PMM-tessellations 	CMM-tessellations 	P4M-tessellations 	P3M1-tessellations 
	PG-tessellations 		P4G-tessellations 	P31M-tessellations 
	PGG-tessellations 			P6-tessellations 
	PMG-tessellations 			P6M-tessellations 

Ornament construction using tools of 2D applications

Let as analyze possibilities of computer graphics applications and problems arising in the process of periodic ornament construction on the basis of regular meshes by means of the isohedral tiling.

Ornament construction in Corel Draw

Basis objects. The vector graphics applications Corel Draw is a complete let of geometric figures for creating ornament patterns: a rectangle, convex polygons with a number of vertex exceeding 3. Lines, Bezier curves, oval can be used for creating patterns.

Creating patterns out of standard figures. *Using auxiliary tools*, such as Rules, Grid, Guidelines and snap to them and snap to objects considerably facilitates calculations and the process of construction. One should remember, that a grid can be uniform and non uniform and guidelines can be turned.

Alignment of objects. Possibilities of alignment operation were expanded in the twelfth versions of Corel Draw taking into consideration grid and specified points. Types of specified points and their options were also expanded and it helps to align to join figures flexibility. According to the author's opinion alignment operation is more preferable in comparison with the usage, when logic functions or combine operation are expected to be used on aligned figures.

Constructing regular figures. Using CRTL key in the process of drawing a rectangle or polygon allows creating a regular figure. If there are some regular figures in pattern we recommend to create original figure out of equilateral triangles in order to construct a geometrically accurate ornament. There is no need in such case to create an equilateral triangle on the squire's or hexagon's side. The effect Blend can be used for creating regular figures.

Isohedral tiling in Corel Draw. A regular form of a pattern can be modified by mean of logical functions Trim, Weld, Intersection. Besides the direct effect Deformation can be used for pattern's form transforming. The tool Envelope (e.g. Single Arc Mode and combinations of keys CTRL and ALT) can be used for patterns distortion taking into consideration the rules of isohedral tiling.

Figure 5. Examples of ornaments, created with the help of isohedral tiling

Methods of ornament construction out patterns in Corel Draw can be divided into the following groups: methods of cutting, methods of filling, methods of deformation.

Methods of cutting. Primitives, closed and non-closed curves, groups of the above mentioned objects can be used as original objects for cutting. In the order to construct ornaments, which cover the plane totally, it is necessary to have a closed curve as the result of cutting. Corel Draw tools for cutting - logical functions – Intersection, Weld, Trim – is directly meant for cutting, truncation and changing a pattern form. Trim method can be used for creating patterns by means of cutting a plane (squire, oval) with lines. The operation Break Apart is used for the next division of the sliced. The effect Power Clip can be used as an tool of cutting.

Problems arising in the process of figure cutting. *A wrong object has been cut*. Order of objects is of great importance for the logical operation Trim. The "main" object among the selected ones in the object, which lies either lower than all objects or it is than last selected for the Trim operation.

Break Apart operation is used for separating a complex figure into simpler ones. There are cases, when a slice figure, after this function having been used, splits apart into many non-closed curves, thought it seems that the figure consist of closed curves (especially it the figure has been cut by lines or non-closed curves). In such a case it is impossible to cut the figure gradually, in several steps. Another way of avoiding such a problem is not to use lines and non-closed curves, cut change them in to narrow rectangles or, for example, to transform a non-closed curve into a closed curve.

It should be noted that the analogous function *Break… Group Apart* must be used also for objects, which have been created with Corel Draw effects. As a rule these effects can be applied to a “simple” object or a group of objects.

Power Clip effect. *This effect cannot be used.* Possible reasons are either no object has been selected before using the effect, or the selected object is too complex, e.g. one of the effects has been applied to it.

The object being clip has disappeared after the effect applying. Such a situation can appear it the effect itself has been tuned default with automatic centering option of the object being clip and the circuit.

The object being clip has hit into a part of the circuit. Such a situation appears when the circuit has not been grouped beforehand. (A lot of problems are described in [5].)

Methods of covering. Any of the object copying or duplicating methods, as well as Blend effect can be attributed to methods of covering. It is convenient to use copying and, especially, duplicating, if ornament patterns are arranged regarding the translation. If patterns have been rotated it is preferable to use Blend effect.

Let us describe methods of creating ornaments with the help of Blend effect. Two objects participate in blending. Objects can be (1) simultaneously simple; (2) simultaneous groups of objects with the same number of objects, and a group created as a result of gliding and simplified into a group of simple object can be such a group; (3) simultaneously simple or a group, but the centre of rotation has been moving into the point, which is the centre of the rotation.

It is convenient to use Blend effect not only when a plane is covered with patterns, but both for creating patterns themselves and creating templates for cutting figures.

Problems arising in the process of using Blend effect. The most frequent reasons of problem arising are the following: (1) the number of objects, meant for Blend is not 2; (2) Blend effect is fulfilled between a simple object and a group of objects; (3) objects taking part in Blend effect has not been simplified [4].

Methods of deformation. *Cloning.* Before Corel Draw version 12 cloning operation can be used for creating patterns and ornaments. In principle the sequence of actions is the following. One of the regular figures of regular mesh must be the Master object. Then one of the regular meshes must be constructing with the help of any methods of covering, by means of Master object cloning. Transforming of the Master object with of transitive equivalence (isohedral tiling) synchronously reflect all transformations of clones.

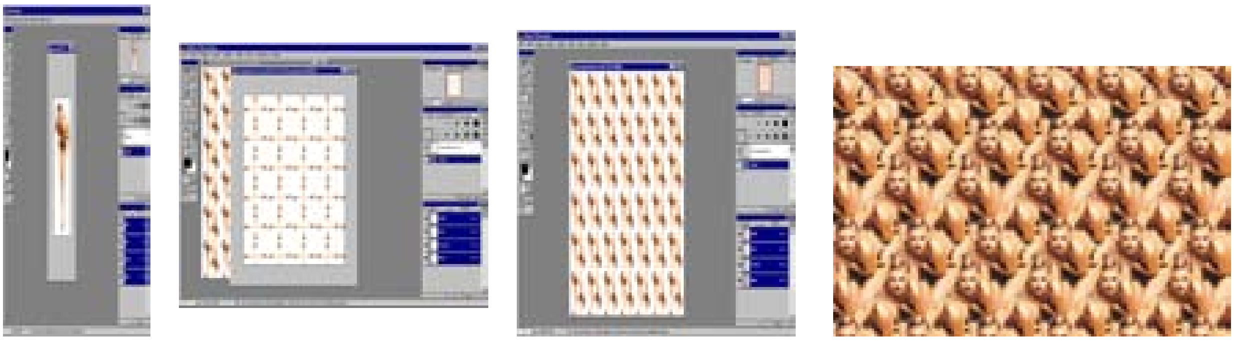
Ornament construction in Adobe Photoshop and Corel Painter

The tricks of ornament creation in Adobe Photoshop, Corel Painter are as a whole identical.

The built-in tools of working with patterns allow creating ornaments on the basis of a rectangular regular grid. The mechanism of patterns filling is transition. A pattern, if it is not a rectangle and does not coincide ornament cell should beforehand be created so that it completely coincides with selected image part.

The greatest concern is represented by ways of ornament construction without visible lines of connection on the basis of photos and other images.

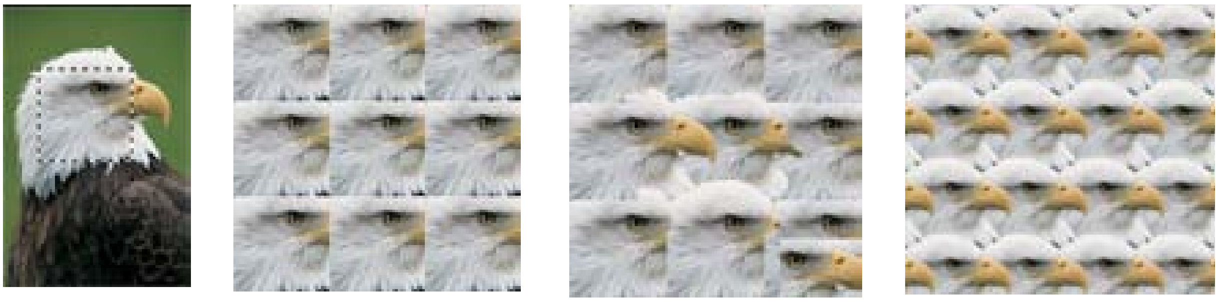
Usage transparency layer property in ornament construction. The part of the image, which must be as pattern should be located on a separate, transparent layer. As selection area it is possible to use only rectangular area and the selection area feather same as 0. As it is visible from a Figure 6B, C, patterns are beforehand constructed. The Figure 6D is obtained by multiple copying of a layer obtained by flood filling pattern from the Figure 6A. Pattern is in this case created with allowance for wide berths indispensable for creation of a lumen for underlying layers.



A B C D

Figure 6. Ornaments constructed with regard of layer transparensy

The second method is more time consuming and it is based on image section cloning with the help of Clone Stamp tool (Adobe Photoshop) or Clone Brushes (Corel Painter) and multiple applying of filling procedure. This approach was described in [4]. Figure 7 demonstrates the sequence of actions with the help of which a pattern can be constructed. The first example of a pattern (Figure 7A) should be chosen taking into consideration the fact, that a pattern must contain, if possible, a section of image, which is notably less than an apparent pattern (compare Figure 10f and Figure 7B). After the first filling by the pattern (Figure 7B) junction lines can be seen on the ornament. So it is necessary to smooth out these junction lines, for example, around the central pattern (Figure 7C), and then add all the lacking details inside the pattern using cloning tool. If a pattern of the same side can be defines on the image once more (Figure 7C), than filling should be applied once more, than the resulting ornament (Figure 7D) will not contains visible junction lines between patterns.



A Define pattern B Edit-Fill-Pattern C Construction of pattern D Ornament without visible junction lines

Figure 7. Creating ornaments using cloning tool

One more approach is described in [6], it is based on constructing a regular pattern out of fragments of various images taking into consideration the symmetric location of these fragments on a rectangular mesh (Figure 8).

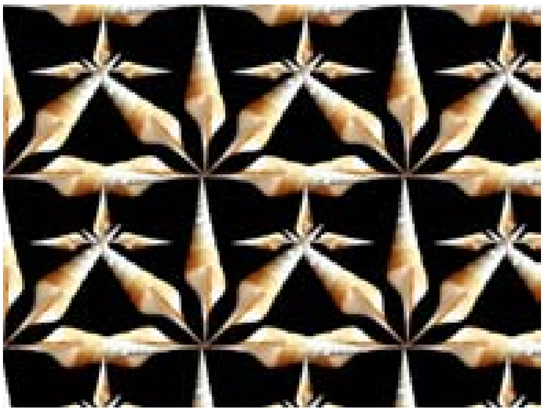
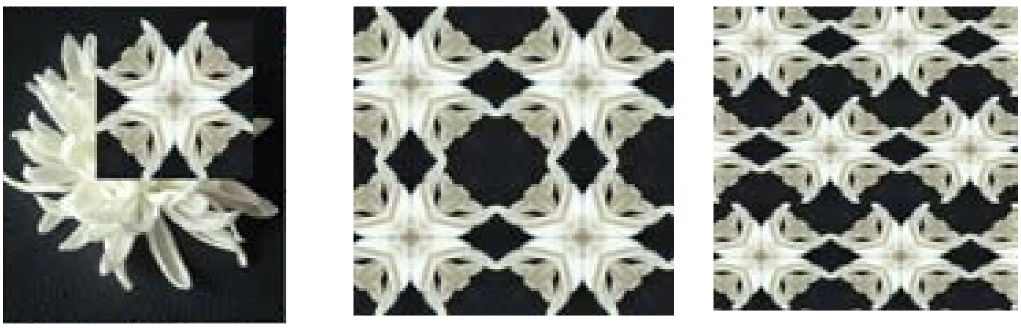


Figure 8. Ornament construction with the help of pattern construction

Adobe Photoshop is filled with patterns only on a rectangular mesh. Where the sides of patterns accurately coincide. Additional possibilities of Corel Painter for ornament allow vertical or/and horizontal displacement with simultaneous scaling of patterns (Figure 9B, C).



A Dinamic layer Kaleidoscope B C

Figure 9. Using dynamic layer Kaleidoscope for pattern construction in Corel Painter

Corel Painter has a dynamic layer “Kaleidoscope”, which generates fractal patterns on the basis of image (Figure 9A). It should be noted, that in order to construct patterns transformation abilities of cloning brushes can be used in Corel Painter (xRotate 2P; xRotate, Mirror 2P).


A


B


C

Figure 2. Mosaic and Tessellations, created in Corel Painter

Besides tools for pattern construction Corel Painter has a tool for constructing tessellation. Mosaics can be created with the help of traditional technique, placing multicolored tilings of different forms on solid grout (Figure 10A), or o the basis of image (cloning technique) (Figure 10B). Tessellations are constructed by means of image automatic cutting into irregular tilings (Figure 10C).

Acknowledgments

Ornaments, patterns, tessellations are an independent kind of art, based on multiple repetition of an image fragment and image division. At the same time ornament construction is a vast group of mathematics tasks.

In 2D applications of computer graphics tessellations and ornaments with a periodical mesh and regular patterns can be constructed with the help different methods.

In vector application Corel Draw there exist wide choices of tools, effects that help to construct and transform patterns of regular tessellations in accordance with the rules of isohedral tiling. Ornaments construction can be done by means of figure division into parts, or filling the plane with constructed patterns.

Ornament construction in bitmap graphics applications Adobe Photoshop and fractal graphics Corel Painter largely coincides and it is optimal for ornament construction on the basis of images. But Corel Painter contains additional tools for patterns, mosaics and tessellations construction.

The topic of ornament construction has been included into academic courses of “Bitmap Graphics Applications” and “Vector Graphics Applications” of the professional study program “Computer Design” at Daugavpils University.

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[VOILES | SAILS]
Self-Assembling Intelligent ~~-~~Lighter-than-air Structures

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Abstract

Through the use of flying automata~~s~~ (aerobots), the [VOILES | SAILS] project aims to port to the physical world some of the functionalities observed in artificial life systems, with a particular focus on simulations of assemblages and behaviors derived from the observation of animal societies (coral reefs, anthills) that can collectively produce high~~ly~~ performance~~t~~ structures with extremely limited abilities at the individual level. It involves a swarm of cubic robotic blimps floating in a large indoor space. Four aerobots (one 180 cm prototype and three 170 cm beta versions), equipped with sensors, ducted fans, wireless communication and a 40g fully functional UNIX computer, are currently flying. The current phase of the project aims to implement 6 to 12 self-organising cubic aerobots evolving in a semi-spherical indoor space within which an immersive environment will be generated through the use of a 360 degrees panoscopic projector. The cubes will interact between themselves, and to the local temperature, color and luminosity conditions within the sphere~~–~~; complex structures and behaviors will emerge from these interactions, creating flying architectonic structures for which we coined the term aerostatiles, in reference to Calder’s mobiles and stabiles.

1. Introduction

For~~rom~~ more than two decades ~~have emerged~~ methods of design have emerged, made possible ~~thanks to~~by the decreased costs of powerful computation, in which the designer does not specify the shape of the objects he or she wants to create, but instead declares a set of intentions, criteria~~s~~ or constraints with which the object must comply. These intentions must be formalizable, which means that they must be quantifiable in some way ; they are then input ~~in~~ to a computer equipped with appropriate software tools, which will generate whole families of digital objects that supposedly enforce the required criteria~~s~~. Many of these methods, such as genetic algorithms or neural networks, are now familiar to most of the generative artists. Though they may look like cutting-edge contemporary techniques, they are often based on simple principles, and rooted in analogies with phenomenon that can be traced ~~in~~ to very ancient natural or cultural phenomenon. Genetic algorithms try to replicate the model which explains the reproduction and evolution of gendered ~~organims~~organisms ; neural networks describe processes that occur in the brains of all beings equipped with a neural system ; both are hundreds of millions of years old. Cellular automata simulate many kinds of biological, geological or cultural processes in which the collaborative action of individuals with limited abilities generates sophisticated collective behaviors, or results in structures with a high degree of complexity. Examples can be found in phenomena~~ons~~ as different as coral reefs, anthills, fault propagation~~s~~ or urban growth. The ones that have been at the origin of our current works are much younger : six to eight thousand years. They correspond to the very roots of urban genesis, somewhere in Middle-East, in current Turkey, where for the first time houses made with age-resistant materials were agglomerated to form a single urban object of high complexity level. This accretive model has crossed the ages. Besides today's contemporary cities that grow according to a grand, simple geometric scheme, thousands of villages and ~~neigbourhoods~~neighbourhoods still evolve through accretive processes in which the location of buildings (houses and other types of constructions) is not determined by reference to a pre-existing grand plan, but through local rules of ~~assemblage~~assembly, involving neighbourhood conventions, compatibility of activities, relations between individuals or groups, access to sun, air and path~~e~~s, and socio-cultural norms that are not always explic~~it~~able. Most of these rules are simple, but their conjugate action generates very complex patterns that are almost impossible to decipher through standard geometrical analysis. As the re~~ader~~ may have noticed, this last sentence also describes one of~~t~~ the main characteristics of cellular automata.

2. Origin of the project

Like many other researchers [1] [2] [3], we decided to use cellular automata in order to better understand the formation and evolution of complex urban shapes, focusing on an urban phenomenon that represents today one half of all urbanization processes on Earth, namely the exponential growth of slums and squatter settlements. Many studies demonstrate that in certain circumstances, now rather well elucidated, they tend to consolidate and transform in official urban neighbourhoods. This evolution, which takes about forty years, has be seen by many researchers as presenting numerous ~~resemblances~~ similarities with traditional processes of urban growth that used to take centuries, an observation that is of the greatest interest for architects and urban planners.

After a few tests and studies, we came to realize that by playing with the parameters of our simulation tools, we could generate architectures and urban morphologies that had nothing to do with existing cities, but presented a tremendous potential on their own. To these~~s~~ potential architectures, we gave the name « computer architectones », in reference to Malévich's architectones in the 1920's. We then developed many generative tools, some based on cellular automata, others on genetic algorithms, other on different algorithmic processes, that were explored in many projects, including « Computer Architectones » [14], « The Cloud Harps project » [15], « The Sixth Diffractal » [14] (see fig. 1, 2, 3 and 4). All these works, presented in the form of architectural drawings, digital pictures, video animation, stereolithographies or large architectural sculptures, were intended to port to the physical world the potential of these « digital objets trouvés » discovered by exploring digital territories with these new tools and processes. It was during a meeting at Caltech in July 2000 between A. Martinoli, N. Reeves and G. Théraulaz (via tele-conference) that the idea came to port not only the results obtained by using these processes, but the processes themselves, to the physical world ; more specifically, to get the generative processes out of the computers and to have them implemented by physical robots, instead of digital ~~beings~~entities. This led to the development of an international arts/science/technology research program, called [VOILES | SAILS], aiming at the realization of flying rigid robots (aerobots) able to develop collective behaviors and to achieve autonomous self-reconfiguration through swarm-intelligent processes. Once completed, a robotic society of this kind will become a platform ~~both~~ for both scientific research and artistic creation, and a testbed for explorations in advanced collective robotics.

Fig. 1 (above left), « Coirault – First Mutation of the White Doe (1999), a computer architectone generated by an algorithm whose parameters coded the melody of a very old traditional song ; Fig. 2 (above right), « Gestatio o Slum / Opera » (1994), stereolithography of a computer architectone generated by seeding a cellular automata with a coded sequence of Monteverdi's « Orfeo » ; Fig. 3 (below left), « The Sixth Diffractal » (2001), architectonic sculpture with mirrors and prisms generated by an algorithm whose parameters coded Bach's XVIIIe Goldberg Variations ; Fig. 4 (below left), a Cloud Harp (2001-2004), a gigantic musical instrument *converting real-time the height and density of passing clouds into musical sequences ; the sculpture was obtained by coding an algorithmic design process with the geometry of a stratus cloud. All works by Nicolas Reeves and the NXI GESTATIO Design lab.*

3. Related studies

Many experiments have been made during the last years in different labs in the field of collective robotics, but experiment~~ation~~s with full 3D systems are far less frequent. Basic considerations of weight, energy, inertia and moments of inertia, resistance of materials, autonomy, trajectory computation, quickly develop into a wealth of sub-problems, of which many are still being explored. Attempts can broadly be divided in two categories : first, modular self-reconfigurable robots, in which simple modular robots self-assemble to construct a large automata ; different configurations of the small robots allow the large one implement different tasks or play different roles. To this category can be related 3D robotic experiments such as Hamlin and Sandersons' Tetrobots [1], Murata's Fracta [2], Rus and McGray's Molecule [3], Bojinov and al's Proteo [4], Michael's Fractal Robots concept (not implemented) [5], Yoshida's self-reconfigurable miniaturized robot [6], Ünsal and Khosla's I-cubes [7], Kurokawa's semi-cylindrical reconfigurable robots [8]. Second, swarms of robots, which again collaborate for task implementation or role playing, but are not necessarily~~y~~ connected by a physical link. They can separate and reassemble, but still act in a coordinated manner, like a swarm of insects.

Some examples of robotic swarms with full-3D capacities are provided by Morse and Belhumeur's attempt to generate a school of robotic fishes [9], and by ~~Alan Winfield~~the IAS lab's flocks of robotic blimps [10]. But to our knowledge, no attempts have been made to achieve self-reconfiguration within a 3D space. The [VOILES | SAILS] project aims to build a platform pertaining to both categories : the aerobots can either act as swarms of separated individuals, or as a reconfigurable systems where large robotic entities can be generated by « polymerisation » of individual ones.

All the experiments listed above have their own difficulties and constraints, which all point to some of the problems inherent in porting digital robotic organisms to the « reality platform ». A few examples : the Tetrobots are not completely autonomous, since some of their parts must be manually connected. The fracta is a nice piece of technological jewelry : units are made from a cube with connecting arms at the center of each face. They can assemble and climb on each other, and can actually implement 3D self-reconfiguration. However, their size (~~-~~about 25cm), weight (more than 7kg) and cost/complexity prevent the realization of large societies. Because of ~~its ~~their size, Yoshida's miniaturized robots have limited torque and short range of movements. Though another example of full 3D self-reconfigurable system, Kurokawa's robots use magnets for connections, which limits their number and strength. In collective robotics, the Morse and Belhumeur's fishes evolve in a full 3D environment, but need to be immersed in a liquid in order to counteract their weight by Archimede's force. ~~Alan Winfield flock ~~The IAS lab's~~of~~ blimps nicely implement collective translation~~s~~, but their geometry does not ~~allow~~allow for self-assembly~~age~~ or reconfiguration.

Technologically speaking, our cubic aerobots are relatively simple~~ at the technological level ~~; they mainly use of-the-shelf robotic components. Their shape allows for in-flight reconfiguration and ~~assemblage~~assembly. If their current size and load-bearing abilities limit the range of their potential applications, their characteristics allow us to use them for two different purposes: first, since they are ~~submitted ~~subject to very low weight and inertia constraints, they allow us to study and evaluate swarm-intelligent processes that will eventually be ported to other robot~~s~~ *species* ; second, flying cubes of this size can be directly used in many artistic or design applications.

The ~~next ~~following sections of this paper will briefly present the physical characteristics of the aerobots and the methodology we adopted to develop their behaviors, then show the results of recent experiments, and finally describe some of the artistic applications that we ~~currrently~~currently foresee for them.

4. The design of the aerobots

The acronym SAILS , coined by team member Alan Winfield, stands for Self-Assembling Intelligent Lighter-than-air Structures. The word VOILES is the French translation for « sails ». The Mascarillons are the first aerobots developed for this project. Like their non-robotic ancestors, they are made from a polyurethane helium bladder stretched between the inner edges of a cubic, ultra-light structure. All robotic and mechatronics equipment is located within the structural trusses.

Fig. 5 – Photograph of a Mascarillon M170 ready for take-off, May 2005. The white bladder is filled with helium, and is stretched within the ultra-light basswood structure.

The design is determined by a number of constraints, among which the weight-to-lift ratio holds the most important place and influences all other characteristics. The lifting force of helium at sea level, at normal pressure and temperature, is roughly 1000g for 1 cubic meter of helium. For instance, a large non-robotized blimp built in Moncton in 1998, based on a 3,30m-edge structure, could lift about 32 kg. The total weight of the blimp, made of extruded styrofoam, was about 30 kg, so the lifting force was 2kg, more than enough to keep it flying.

The size of the first robotized Mascarillon is 180 cm (hence the model name, M180); the lifting force is about 5300 g. This may seem a lot ; the M180 is actually quite large, and was designed as a prototype to allow multiple software and mechatronics tests with minimal concerns about flying abilities. The real challenge is actually to built the smallest possible blimp : reducing the edges by a certain factor decreases the lifting power by about the third power of this factor, and the following models, the M170, see its lifting power reduced to about 4500 g. Considering that the load includes the structure (about 1000 g), the films (about 1500 g), the CPU, the motor controllers, the sensors, the wireless card, the batteries, the motors and the motor ducts, the cameras, the docking devices, and all the wires and cables, it is easy to see that each element must be very carefully chosen in order to maximize its general efficiency.

Apart form theses hydrostatic considerations, several major concerns have to be considered :

1) - The necessity to obtain a perfect cube, with straight edges and flat faces. This is ~~first~~ primarily an art/architecture concern, since it relates to the intention of creating perfectly geometrical flying shapes ; but it is also induced by the fact that the cubes need to assemble while flying. If the edges are not perfectly straight, or if the faces become convex due to the internal pressure of helium, the cubes will not assemble properly.

2) - The self-~~assemblage~~ assembly properties. When two cubes connect to each other, they must still be able to use their motors to move in space. The air streams output by the motors of two connected cubes must add in order to maintain an adequate thrust. This led to the decision to place the ducted fans at the midpoint of each edge, and to guide the air streams towards the corners of the cubes with thin plastic or paper tubes.

Fig. 6 – Ducted fan in the middle of a triangular horizontal truss, showing the polycarbonate tubes that guide the airflow towards the corners of the cubes.

3) - The axial symmetry of the cubes. The cube is oriented in space : it has a top and a bottom. The mechatronics components are located within the bottom edges and corners, except for the four z-axis ducted fans, which are placed at the middle of the vertical trusses. In order to preserve horizontal stability and to ~~symmetrize~~ balance

the angular momentum of the whole cube, all elements are located within the center section of the trusses and/or at the corners of the cube. Each element must be counterweighted by another element located in the opposite corner or truss center. No helix configuration is allowed : no element can be located off the corners or off the middle section of the trusses, since his would introduce asymmetries in the angular momentum.

4) - The location of the sensors. This is a critical concern. The cube is by no way an optimal shape when it comes to sensory aptitudes, especially with large cubes such as the M180. Obstacle avoidance would ideally require 24 sensors (one for each axis on each edge), which is hard to implement for reasons of cost and energy requirements. The optimal sensor configuration is still being studied ; three 14-sensors Mascarillons are flying since August 05.

5) - The need for assembling and disassembling the cubes. Transportation of the cubes is a major concern : these big, hollow shapes would be very costly to move for a demo or an experiment, and since the trusses are also quite fragile, the structure must designed in order to allow the disassembling of the cubes, and their storage in small ~~protecting~~ protective cases.

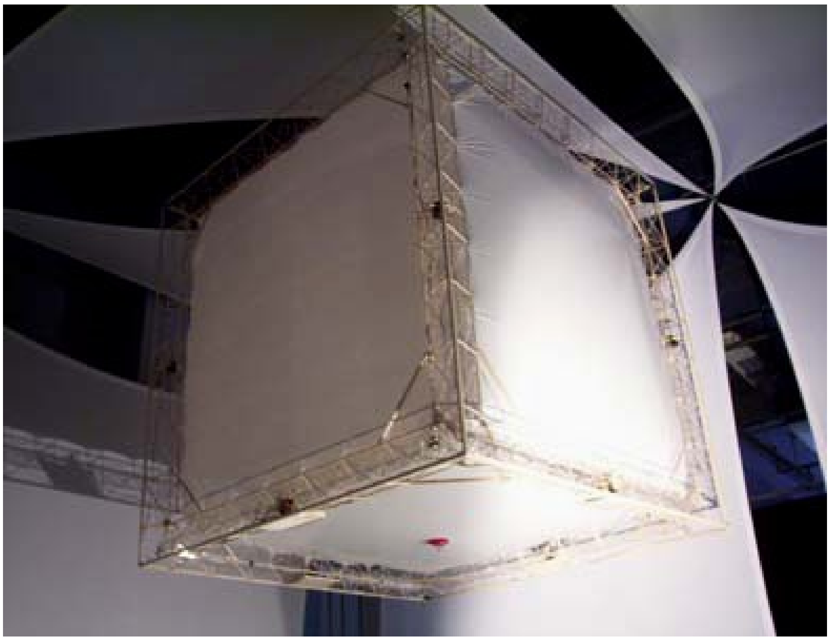


Fig. 7 - A flying Mascarillon. The ducted fans can be distinguished at the mid-points of the trusses. The red inflating valve appears on the lower face.

5. The structure

Like ~~for~~ all rigid flying objects, the structure of the [VOILES | SAILS] aerobots has to ~~fulfill~~fulfil lightness, rigidity and stability criteria. It must also be dismountable, in order to allow easy transportation of the aerobots for experiments, demonstrations or shows/performances. Many materials and configurations have been tried, from extruded styrofoam to carbon fiber. Extruded styrofoam (Fig. 1) shows a surprisingly good behavior to shear constraints, and has strong load bearing capacities for such a light material ; its cost and availability could have make it a primary choice for the project. Unfortunately, its stability ~~in~~ over time is rather ~~bad~~poor. Carbon fiber has unmatchable resistance and rigidity properties, but it was not suitable for this phase of the project because of its density (around 1.6) and price ; it is also difficult to work with. We are still planning to develop optimal fiber carbon structures for later aerobots. Considerations of cost, availability and workability finally led us to concentrate on light woods for the first flying cubes. Balsa structures were then tried. They were incredibly light, and showed a satisfying rigidity. But their fragility made them almost impossible to handle : some of the wood pieces were so thin that they could be ~~unvolontarily~~involuntarily broken by someone who would not even notice touching them. Next models were balsa-basswood composites ; they were abandoned for the same reason. The final trusses are ~~completely~~ made completely from basswood. On the M170 model (fig. 3), each truss ~~weigh~~weighs barely 80g each, which amounts to slightly less than 1 kg for the complete170 cm-edge structure.

Needless to say, we could not find in hobby shops pieces of wood with the proper dimensions and shapes : no shop would hold pieces with a 3mm-side equilateral triangular cross-section. We had to buy large beams that were cut on saw benches, with a 75% loss, since most of our pieces are thinner than the thickness of the saw blades.


Fig. 7 – Final design for the Mascarillons structure, made of twelve identical basswood trusses. On the left, two superposed 170 cm structures waiting to be equipped. On the right, details of a corner showing the nylon connectors that allow to assemble and disassemble the aerobot. The complete structure weighs about 1000 g.

6. Mechatronics and software development

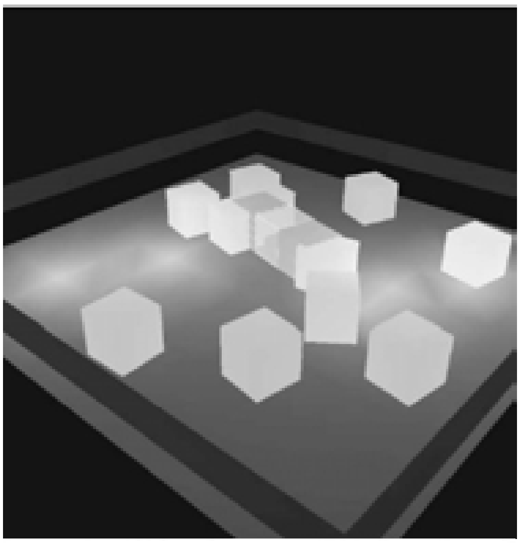
The Mascarillon's « brain~~s~~ » is the KoreBot card [12], a miniaturized full-UNIX computer, which weighs about 40g. Each blimps has its own IP address, turning it in a flying internet ~~site~~node. The fourteen sensors are sonars with a ~~six-meters~~six-meter range and a one-centimeter resolution; six of them (one ~~by~~ per face) have light-sensing ability. Eight small ducted fans are located at the midpoint of the vertical and lower horizontal trusses. Airflows are guided to the ends of the trusses through clear polycarbonate tubes.

Fig. 8 - The KoreBot card from K-Team, a full-UNIX computer with internet and wireless abilities weighing 40g.

Communications between the aerobots components uses the I2C protocol, while communication between ground and aerobots is wireless. In their current state, the aerobots do not communicate with each other : they can only detect each other. The difference between fixed obstacles and other aerobots is ~~made by~~determined by the software, by comparing ~~informations~~information coming from different sonar sensors.

Tasks that are ~~obvious~~ straightforward to implement on ground robots become real challenges in flying ones. Immobility is a good example : to make a ground robot stay still can hardly be considered as a « task », but it is actually a dynamic process for an aerobot, involving constant measurements and height ~~adustments~~adjustments. The same can be said for stopping a robot at a given position : reading from the sensors, the computer must anticipate the final position and stop~~s~~ the motors so that the inertia of the aerobot will be exactly compensated by the resistance of air, and so that the aerobot ~~stops~~ halts at the desired position. More complex tasks ~~still~~ require more sophisticated algorithms ; their study on real aerobots involves a ~~lot~~ good deal of time, large ~~experimentation~~ experimental spaces, as well as human and material resources.

To optimize this development process, we decided to undertake the development of the aerobots on several experimental levels simultaneously. Besides the real-robots experiments, two levels of simulations have been implemented with the Webots platform, a software tool which allows us to simulate a robotic systems with different degrees of abstraction [13] . On the ~~first~~ left picture below, the aerobots are represented by simple geometric cubes ; this ~~simple~~ elementary model allows us to explore different behavior rules, and to evaluate their ~~potentiel~~potential in the emergence of self-organization processes. Application of a particular set of rules leads to the formation of linear structures. This demonstrates how local rules have the potential to generate large-scale structures with a high degree of organization or complexity : no single cube knows what is a straight line, but the repeated applicattion of a same, single local process generates straight lines with many cubes. In the second example, the simulation becomes more precise ; it incorporates physical parameters such as mass, moments of inertia, range of sensors (the sensors beams are clearly visible), motor thrusts and so on, as measured from the real aerobot. Among other things, it has been used to implement stabilization algorithms (vertical and horizontal), and to allow two aerobots to stay side by side at a very short distance (a few centimeters), a process that is essential for the future development of docking procedures.



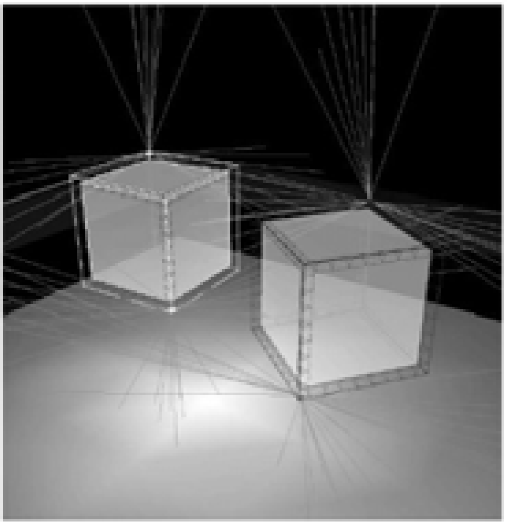


Fig. 9 and 10 – To different levels of simulation. On the left, simulation at a "microscopic level". The aerobots are represented as simple cubes with no physical properties. This model allow to study different strategies for generating self-reconmfiguration. On the right, the model gets closer to the real aerobots, and the simulation takes in account parameters that have been measured during experiments, such as weight, inertia, motor thrusts, sensor response... *Macroscopic level simulations, where the cubes are represented as clouds of points, are planned in the next phase. All simulations are implemented on the Webots platform.*

7. Results obtained ; planned and future work~~s~~

To comply with the general paradigm of bio-inspired systems, in which complex phenomenon emerge from individuals with limited abilities, we began by equipping the aerobots with only one kind of sensor~~s~~ (sonars), and tried to get maximum results from these before adding other sensory ~~aptitudes~~modalities. In their present state, our aerobots cannot detect their orientation, nor their position relative~~ly~~ to the ground ; they do communicate between each other. Despite ~~of~~ these handicaps, a ~~proper~~ clear software strategy allowed us to obtain the following results, which have all been observed during a public demonstration in Montreal, in October 2005 :

Obstacle avoidance ;

Vertical stabilization with less than 10 cm oscillations ;

Stabilization at a fixed distance from a wall with very small oscillations ;

Stabilization at fixed distance (about 10 cm) ~~-~~from another aerobot. A chain of three aerobots maintained this configuration for more than ten minutes.

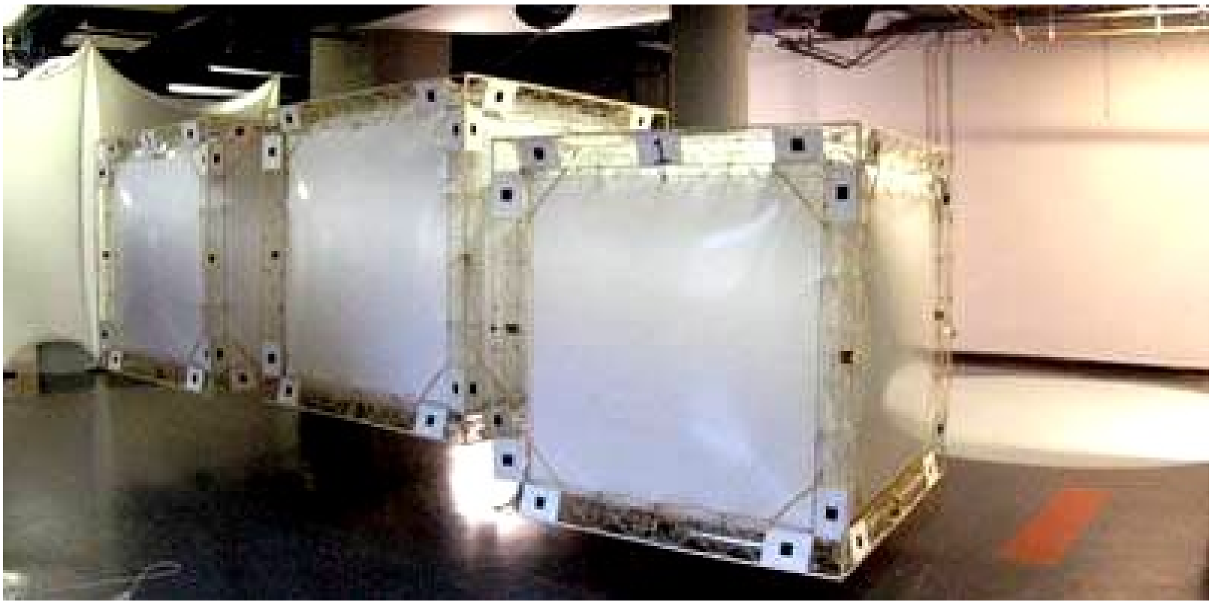


Fig. 12 – Three M170 Mascarillons aerobots in the process of stabilizing at a *short* ***distance from each other. This configuration was maitained for more than ten minutes, a result that opens the door to the next implementation of in-flight docking procedures.***

Many other experiments are planned with the current configuration. Future models will get progressively smaller in size (we are undertaking the development of a 162 cm model with a composite materials structure), and more capacities will be added once the experiments with sonars ~~will be~~have been completed. In particular, the need for the aerobots to measure their own positions relatively to fixed elements of the environment proved critical : they are very sensitive to micro-atmospheric and convection currents, which generates important positional drifts. An inclinometer and a compass will also be installed in the next models, allowing more sophisticated behaviors~~.~~

The [VOILES | SAILS] platform is dedicated to scientific and technological development in swarm-intelligence robotics and to research and creation in arts, design and architecture. Besides its remote origins in the study of complex urban shapes, it presents a more direct connection with architecture : an assemblage~~s~~ of cubic aerobots ~~generate~~ represents a flying construction~~s~~ that relates to the mythical idea of flying architectures, such as the Vimanas of ancient India, the celestial city that many cathedrals try to evocate through stone, light and stained glasses, the Albatros airship in Jules Vernes' Robur le Conquérant, Krutikov's constructivist flying cities.

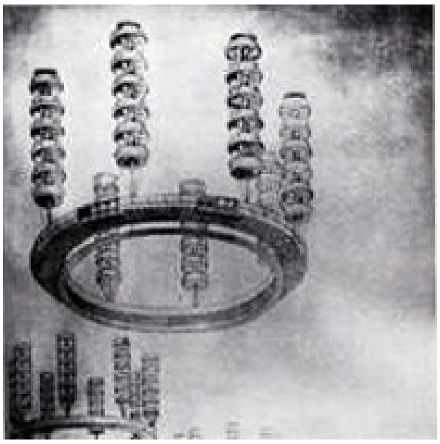
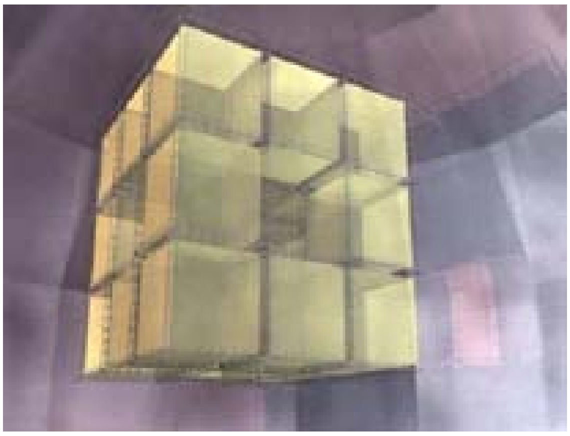


Fig. 13 – On the Left, Krutikov's constructivist flying cities ; Fig. 14 - On the right, "La Ville Volante", en engraving by G. Trignac. All flying architectures echoes the mirages of cities floating over the deserts, sometimes hivering over their own reflections.

The next phases of the [VOILES | SAILS] program involves the construction of aerobots with different shapes, including ~~asymetric~~asymmetric ones, that can be used to generate more complex reconfigurable flying structures, to create full-size models for architectural projects, or even as sculptures made from many aerobots floating still in the air, constantly readjusting their position to keep a given assigned configuration. To these sculptures we gave the name « aerostatiles », in reference to Alexander Calder's mobiles, suspended objects that are extremely sensitive to the smallest air movements and for which immobility is almost impossible to achieve. On the performance side, the Mascarillons aerobots will be used for hybrid choreographies, during which a swarm of aerobots will interact with a group of dancers, and where the nature of human-aerobots interactions will change or evolve according to data sampled from the environment.



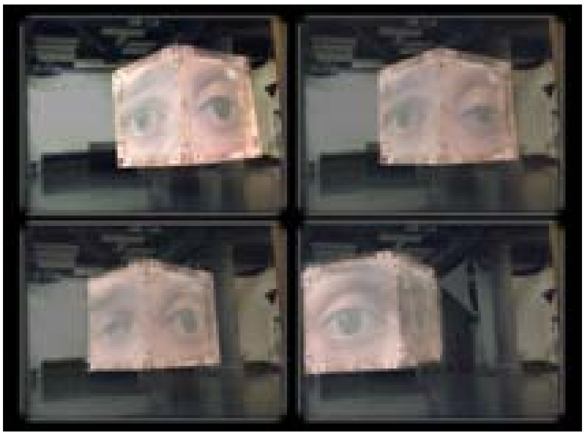


Fig. 14 (left) : prospective view of a large structure self-assembled by 20 Mascarillons. Fig. 15 (right) : dynamic projection of video sequences (blinking eyes) on a moving Mascarillon. the images follow the displacements and orientations of the cube

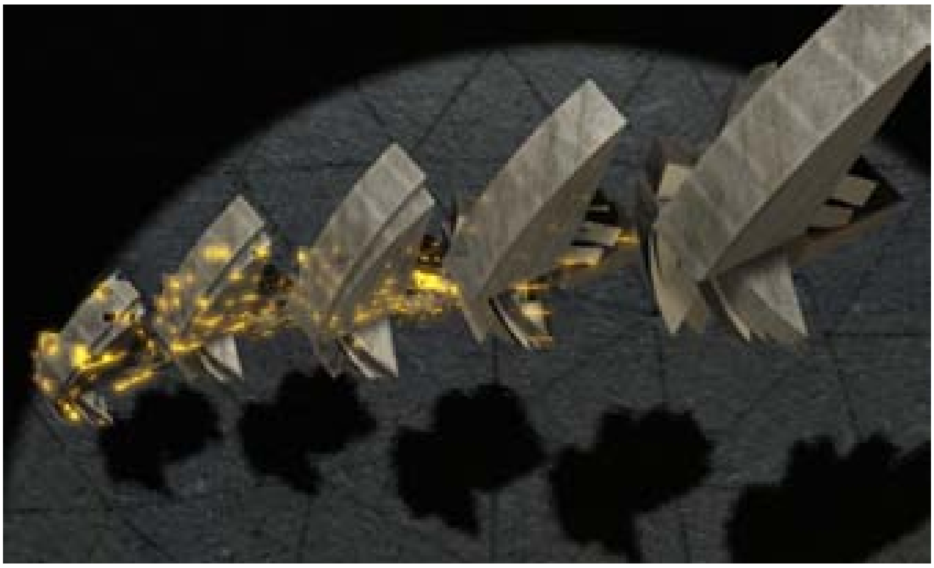
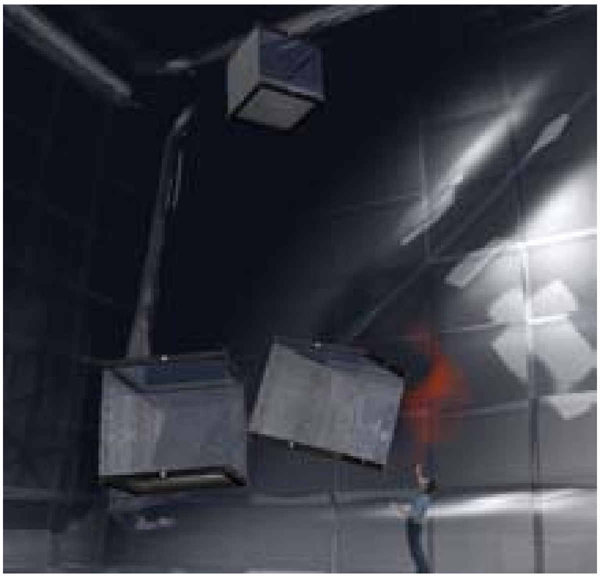


Fig. 16: prospective view of an aerostatile, a scultpure made with different non inter-connected aerobots. Lighting effects can easily be added.

The Mascarillons, as well as the next aerobots of the [VOILES | SAILS] project, will also be used as flying screens for adaptive dynamic video projections, using a software developed by one of our Montreal collaborators. Through the very short projection of calibration grids, this software can adjust in real time images and video sequences on distorted, undulating or moving surfaces, in order to constantly generate a perfect picture. Mascarillons assembled in many rows and columns will thus constitute a gigantic projection surface, which will be able to fragment in small elements that will eventually reconfigure ~~elsewhere ;~~elsewhere; the images and films will follow their displacements and rotations everywhere in space. Finally, covering some faces with metallized membranes will transform the aerobots into flying reflectors that can be located anywhere on a stage, allowing unseen lighting effects.



Fig, 17 – Prospective view of a dancer interacting with a flock of Mascarillons aerobots. IN this kind of performance, the modalities of interaction can evolve according to data sampled from the environnement : level of noise, temperature, lighting...

8. Outlook

Reconfigurable structures have long been a vision for architects and designers : the concept of an architecture/object which can self-adapt to environmental or programmatic changes (autopoiesis) and whose identity can differ according to the context (variable ontology) emerged in the last century, and is now underlying many exploratory works. As mentioned above, many researches using artificial life methods have attempted to understand, simulate or predict urban growth to evolve architectural shapes (Ramos, 2002) or to grow structures through algorithmic processes (Dollens, 2005); most of these attempts either remained at the level of computer simulation, or led to virtual structures that were transposed to material ones only after termination of all processes. Simultaneously, attempts to develop ground robots with self-assembling properties occur in different labs, but did not yet reach a point where applications to architecture/design could be realistically foreseen. Positioning itself at the crossroads of these attempts, the [VOILES | SAILS] research program aims to port the processes themselves - not only their results - to the physical world, first for gaining insights for future projects on reconfigurable architectures, but also to develop a first set of functional and reliable swarm intelligence based design/art objects, something that has never been done, and will also constitute one of the first out-of-the-lab applications of swarm-intelligent systems.

9. Acknowledgements

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More information on the [SAILS | VOILES] project can be found at www.mascarillons.org.

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Fractal components in the Gothic and in the Baroque Architecture

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Abstract

Fractal geometry describes the irregular shapes and it can occur in many different places, for example in Mathematics and in Nature. The aim of this paper is to present an overview which involves the fractal geometry, the property of self-similarity and the Iterated Function System (IFS) applied in two different architectural styles: the Gothic and the Baroque.

1. Introduction

In the different centuries the architecture followed the Euclidean geometry and the Euclidean shapes (for example, to realize the boards and the bricks). Thus, it is not a surprise that the buildings had Euclidean aspects. The geometric properties of the symmetry applied to the buildings and to the temples helped to realize the engineering calculus, and to obtain the structural stability. Some architectural styles, for example the Baroque, found inspiration by the Nature, and the Nature is manifestly irregular and fractal-like. So perhaps there is not difficult to find fractal components in architecture [1, 2, 3, 4, 5]. As this paper will describe, fractals appear in architecture to reproduce some shapes and some patterns present in the Nature.

This fractal analysis has been divided in two parts:

a small scale analysis, for example to determine the single building shape [4].

a large scale analysis, for example to study the urban growth and the urban development using a fractal point of view [6, 7, 8].

The small scale analysis observed:

the building's self-similarity, for example to find some self-similar components in the Baroque churches which repeat themselves in different scales,

the Iterative Function System (IFS), for example to determine some iterative fractal processes present in the Gothic style.

The paper is organized as follow: section 2 presents a short description on fractal geometry, in particular the self-similarity and the IFS. Section 3 and section 4 show the fractal components in the Gothic and in the Baroque architecture respectively.

Section 5 contains the conclusions, and the section 6 is dedicated to the references.

2. Fractal Geometry: the self-similarity and the IFS

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 [9]. The self-similarity is a property by which an object contains smaller copies of itself at arbitrary scales. "Similar" means that the relative proportions of the shapes' sides and internal angles remain the same. As described by Mandelbrot (1988), this property is ubiquitous in the natural world [9]. Oppenheimer (1986) used the term "fractal" exchanging it with self-similarity, and affirmed: "The geometric notion of self-similarity became a paradigm for structure in the natural world. Nowhere is this principle more evident than in the world of botany." [10]

Self-similarity appears in objects as diverse as leaves, mountain ranges, clouds, and galaxies. Figure 1 shows a broccoli (Brassica oleracea) which is an example of self-similar vegetable in the Nature. In figure 2 there is a Sierpinski triangle that is a fractal object which presents the self-similarity. It has been created using simple geometric rules.

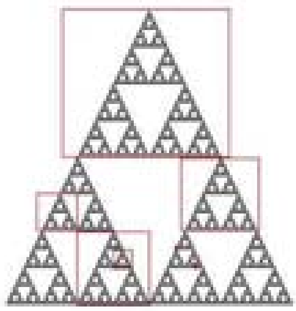


Figure 1. The broccoli is an example of self-similarity in the Nature

Figure 2. The Sierpinski triangle is an object derived by a simple iterative process

Iterated Function System (IFS) is another fractal that can be applied in the architecture. Barnsley [11, p. 80] defined the Iterated Function System as follow: "A (hyperbolic) iterated function system consists of a complete metric space (X, d) together with a finite set of contraction mappings w_n: X→ X with respective contractivity factor s_n, for n = 1, 2, …, N. The abbreviation "IFS" is used for "iterated function system". The notation for the IFS just announced is $\{ X, w_n, n = 1, 2, \ldots, N\}$ and its contractivity factor is $s = \max \{s_n : n = 1, 2, \ldots, N\}$."
Barnsley put the word "hyperbolic " in parentheses because it is sometimes dropped in practice. He also defined the following theorem [11, p. 81]: "Let $\{X, w_n, n = 1, 2, \ldots, N\}$ be a hyperbolic iterated function system with contractivity factor s. Then the transformation $W : H(\mathbf{X}) \rightarrow H(\mathbf{X})$ defined by:

$$W(B) = \cup_{n=1}^{n} w_n(B) \tag{1}$$

For all B∈ H(**X**), is a contraction mapping on the complete metric space (H(**X**), h(d)) with contractivity factor *s*. That is:

$$H(W(B), W(C)) \leq s \cdot h(B,C) \tag{2}$$

for all B, C ∈ H(**X**). Its unique fixed point, A ∈ H(**X**), obeys

$$A = W(A) = \cup_{n=1}^{n} w_n(A)$$

(3)

and is given by $A = \lim_{n\to\infty} W^{on}(B)$ for any B ∈ H(**X**).”

The fixed point A ∈ H(**X**), described in the theorem by Barnsley is called the “attractor of the IFS” or “invariant set”.

Bogomolny (1998) affirms that two problems arise [12]. One is to determine the fixed point of a given IFS, and it is solved by what is known as the “deterministic algorithm”.

The second problem is the inverse of the first: for a given set A∈H(**X**), find an iterated function system that has A as its fixed point [12]. This is solved approximately by the Collage Theorem [11, p. 94].

The Collage Theorem states: “Let (**X,** d), be a complete metric space. Let *L*∈H(**X**) be given, and let ε ≥ o be given. Choose an IFS (or IFS with condensation) {**X**, (w_n), w_1, w_2,…, w_n} with contractivity factor 0 ≤ *s* ≤ 1, so that

$$h(L, \cup_{\substack{n=1 \\ (n=0)}}^{n} w_n(L)) \leq \varepsilon \tag{4}$$

Where h(d) is the Hausdorff metric. Then

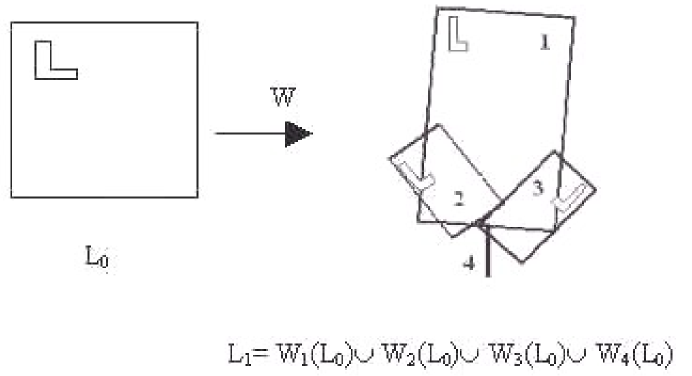
$$h(L,A) \leq \frac{\varepsilon}{1-s} \tag{5}$$

Where A is the attractor of the IFS. Equivalently,

$$h(L,A) \leq (1-s)^{-1} h(L, \cup_{\substack{n=1 \\ (n=0)}} w_n(L)) \tag{6}$$

for all *L*∈H(**X**).”

The Collage Theorem describes how to find an Iterated Function System whose attractor is "close to" a given set, one must endeavour to find a set of transformations such that the union, or collage, of the images of the given set under transformations is near to the given set. Next figures 3 and 4 show respectively, the first two steps to create an image of a fern using the IFS, and the Collage Theorem applied to a region bounded by a polygonalized leaf boundary [11, p. 96].



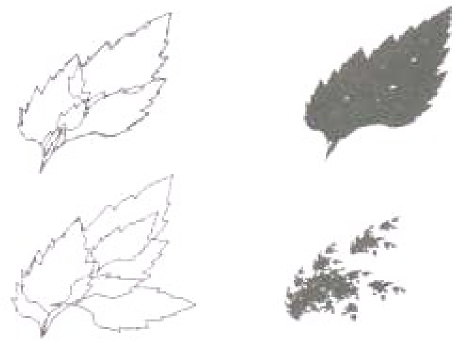


Figure 3. The first two steps to create an image of a fern [13, p. 116]

Figure 4. The Collage Theorem applied to a region bounded [11, p. 96]

The IFS are produced by polygons that are put in one another and show a high degree of similarity to nature, such as the fern presented in figure 5 [13, p.117]. The IFS form the connection between the true mathematical fractals and the Nature.

The next sections describe some applications of the self-similarity and of the IFS in the Gothic and in the Baroque architecture.

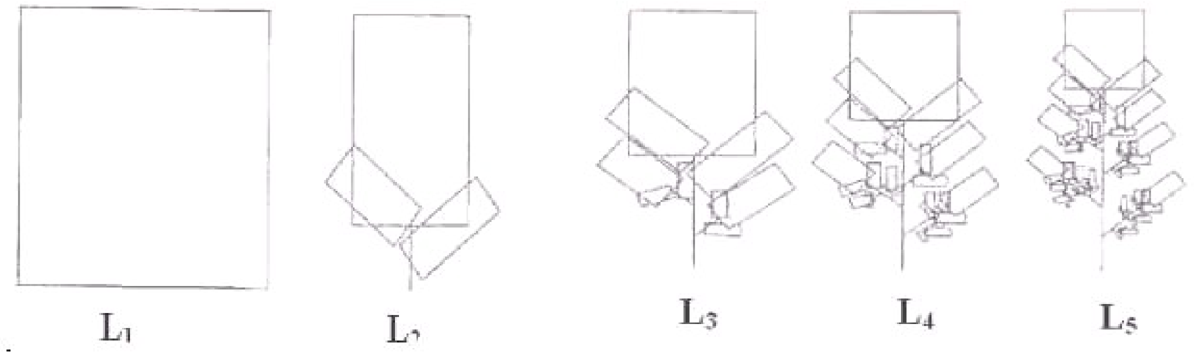


Figure 5. The first five steps to generate a fern using IFS [13, p. 117]

3. Fractal components in the Gothic Architecture

The Gothic is a style developed in northern France that spread throughout Europe between the 12th and 16th centuries. The term “Gothic” was first used during the later Renaissance by the Italian artist Giorgio Vasari (1511-1574) as a term of contempt. He wrote: "Then arose new architects who after the manner of their barbarous nations erected buildings in that style which we call Gothic".

Fulcanelli, the 20th century most enigmatic alchemist, gave another explication of the term Gothic, which is connected to the language of the alchemy[1].

1 Fulcanelli wrote: “Alcuni autori perspicaci, e non superficiali, colpiti dalla similitudine che esiste tra *gotico* e *goetico*, hanno pensato che ci dovesse essere uno stretto rapporto tra Arte gotica e Arte goetica o magica. Per noi *art gotique* non è altro che una deformazione ortografica della parola *argotique* la cui omofonia è perfetta. La

Some fractal components are present in the Gothic churches; an example is shown in figure 6 which reproduces the facade of the *Reims' Cathedral* (1210-1241, Reims, France). The white arrows point out the fractal components [13, p. 86]. The self-similarity is also present inside the Gothic Cathedrals, as shown in figure 7.

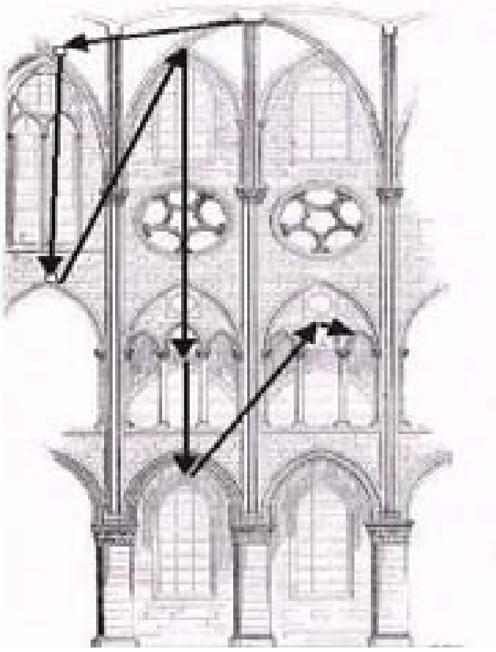
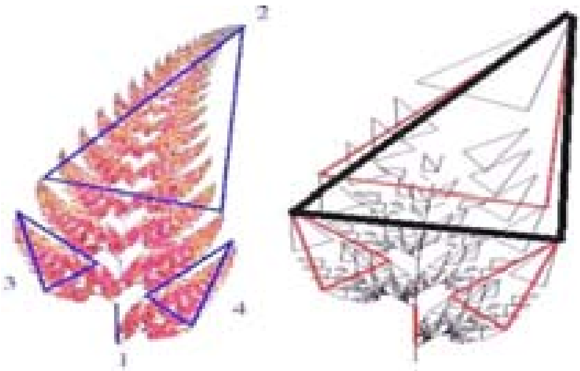


Figure 6. *Reims' Cathedral* (1210-1241) shows fractal components

Figure 7. *Notre Dame* (c. 1163-1250, Paris) shows a kind of the self-similarity

Gothic architecture can be observed using the iterative function system. The method is similar to the Wright's approach [15]. He dissected a fern in to similar part, and he marked some triangles on these parts which are similar to the whole, as shown in figure 8a). An affine maps was determined by how they map a single triangle to another triangle. This allowed Wright to convert out dissection of the fern into four affine maps. Figure 8b shows the original four parts together with a triangle corresponding to the whole fern, it is drawn in bold lines.

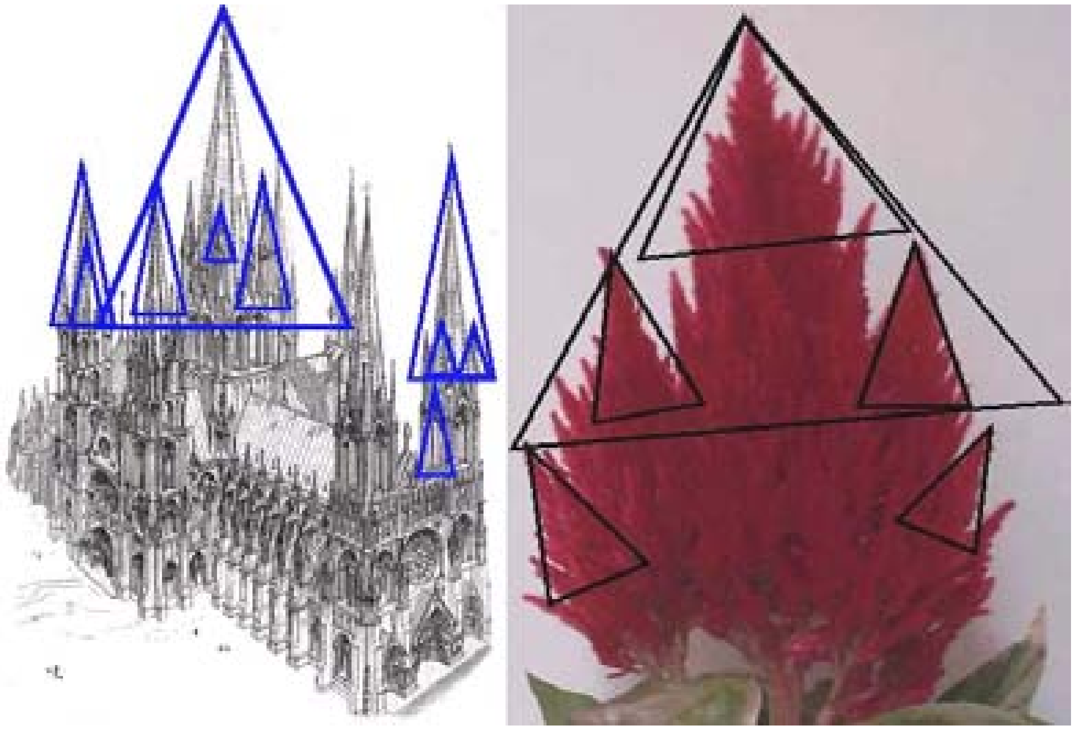


a) b)

Figure 8. Dissection of the fern into similar parts a), mapping triangles for the fern b) [15]

cattedrale è quindi un capolavoro d'art goth o d'argot." [14, p. 46]

Figure 9a illustrates an attempt to find a IFS which could generate the ideal Gothic Church conceived by Eugène-Emmanuel Viollet-le-Duc (1814-1879). The figure 9b is dedicated to applied the same approach to a flower (Celosia plumosa) with is manifestly fractal-like.



a) b)

Figure 9. An attempt to dissect a Gothic church in self-similar parts a), the same approach applied to a flower (Celosia plumosa)

In the Italian Gothic style there are many examples which show the presence of the fractal components. In Venice there are many palaces (*Ca' Foscari*, shown in figure 10, *Ca' d'Oro*, *Duke Palace*, and *Giustinian Palace*) that have a rising fractal structure; for this reason Fivaz (1988) named this town: "fractal Venice" [16].

Santa Croce, the church of the Franciscans in Florence, is one of the finest examples of Italian Gothic architecture. It was begun in 1294, in the period that served as the transition from Medieval times to the Renaissance. It has been designed by Arnolfo di Cambio (1240-1302), and it was finished in 1442, with the exception of the 19th century Gothic Revival facade and campanile. The church is simple basilica style with a nave and two isles. Figure 11 illustrates the west facade of *Santa Croce,* and an attempt to dissect it in triangles to find the IFS connected to the church.

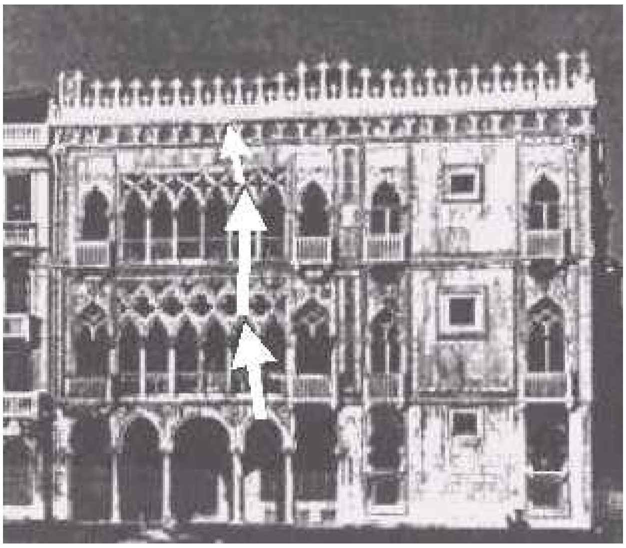


Figure 10. *Ca' d'Oro* (Venice, Italy) (1421-1440) shows a fractal structure

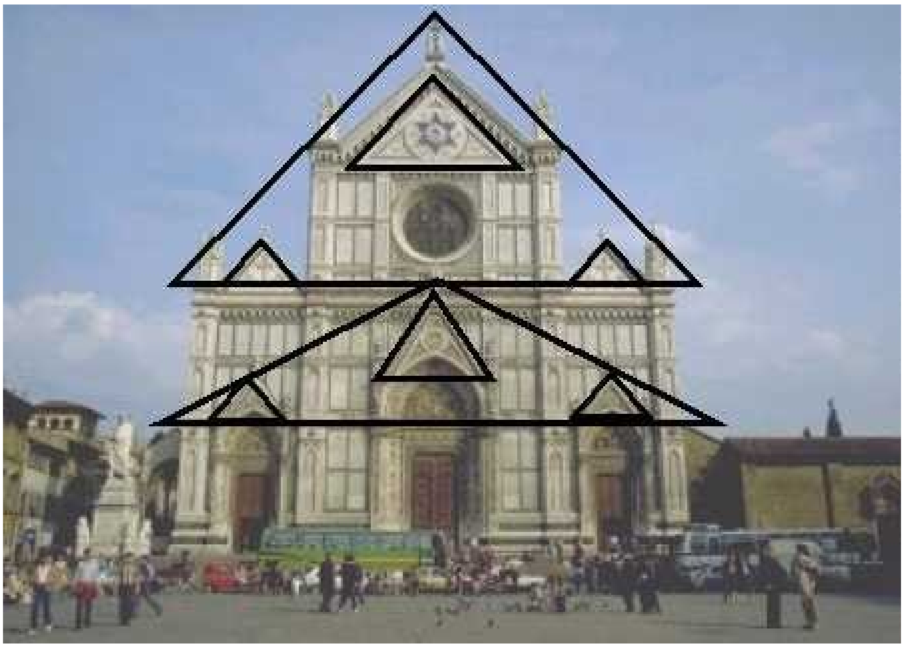


Figure 11. *Santa Croce* (Florence, Italy) an attempt to find the IFS

4. Fractal components in the Baroque architecture

The Baroque (1600-1750) was born in Italy, and adopted in France, Netherlands, Germany, and Spain. 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”.

This style suggested movement in static works of art, and it influenced important challenges in architecture [17]. Baroque architecture was based on the mathematics [18]. The Baroque architecture could be analysed using a fractal point of view [19].

Figure 12 shows a kind of self-similar components present in the which illustrates the plan of church of *Saint Karl* (1715-1737, Vienna) where the oval is repeated in three different scales.

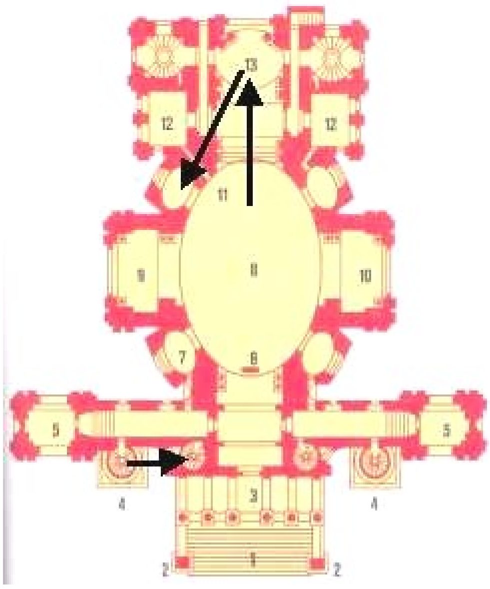
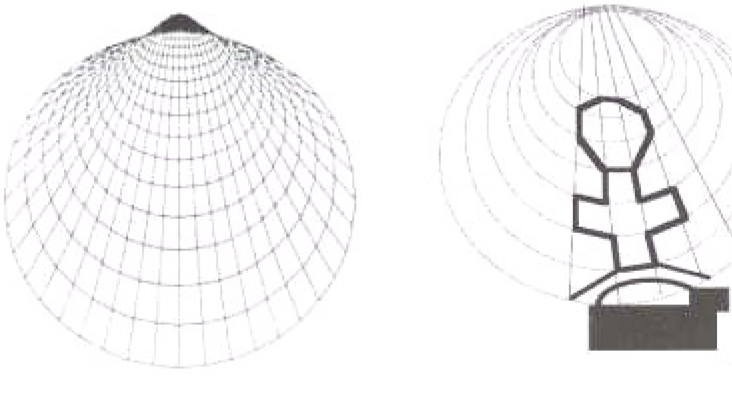


Figure 12. The plan of the church of *Saint Karl* (Vienna) shows some self-similar shapes

Another example of self-similar component is present in the church of *San Carlo alle Quattro Fontane*, conceived by Francesco Borromini (1599-1667). The Swiss architect used the octagons, the Greek crosses and other shapes for the coffering of the dome of *San Carlo alle Quattro Fontane*. The figure 13a illustrates the valve lattice of the shell (*Cakadia*) which provided the brunched coordinates that map out the Greek crosses and the octagons, shown in figure 13b, that Borromini used to cover the dome of *San Carlo alle Fontane*. The figure 14 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 [18]. Observing figure 14, it is possible to see the presence of two directional compressions, horizontal and vertical at the same time, over a (much shallower) dished plan. These compressions introduces a kind of self-similarity in the dome [19].



a) b)

Figure 13. The valve lattice of *Cakadia* a), the lattice used to map a detail in the Borromini's dome b) [20, p. 52]

Figure 14. Dome of *San Carlo alle Quattro Fontane*, Rome.

The arrows connect the self-similar shapes

An other example of self-similarity in the Baroque architecture is in the dome of Church of *San Lorenzo* (Turin, 1666-1680), designed by the Italian architect Guarino Guarini (1624-1683). Norwich (1975) wrote: "The Church of San Lorenzo, Turin, was begun by Guarino Guarini in 1668 for the Theatine Order, of which he was a member. The plan is remarkable for its curved bays pressing into the central domed space—an idea developed from Borromini—but the dome is even more remarkable. It is a masterpiece of ingenious construction—the ribs actually carry the lantern above them—which is also used to produce dramatic contrasts of light and shade" [21, .p 176]. Guarini used the octagonal star to define the bearing structure of the dome. The self-similar components are an octagon and an octagonal star which are repeated in different scales, as shown in figure 15 [22, p. 85].

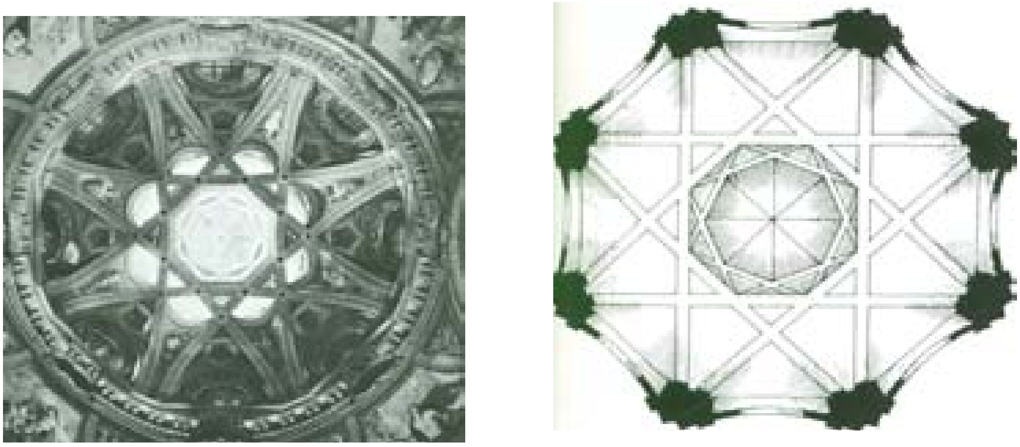


Figure 15. The dome of *San Lorenzo* (Turin, Italy) shows some self-similar components

5. Conclusions

Fractal geometry and its connection between the complexity can help to introduce the new paradigm in architecture [2, 5, 7, 8, 9, 10, 18]. This paper introduces only an approach to observe the Gothic and the Baroque architecture using a fractal point of view. The property of the self-similarity present in these two different styles has been chosen for an aesthetic sense; in fact the Gothic and the Baroque architects did not know the fractal geometry, because it is a recent discovery. Thus, it is possible to refer as an “unintentional” use of the fractal geometry.

The modern architecture uses the self-similarity appears in intentional way [1, 2, 4, 13]. The iterated function system applied in the Gothic cathedrals could help us to understand the generative processes of these complex buildings.

Recent studies reveal that the IFS could help to create a new pseudo urban models based on fractal algorithms [23]. Thus, it could be possible to encode simplified 2D½ city models using an IFS compression technique.

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Investigating Composers' Perceptions and Style through Musical Composition Games

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Abstract

Our models of the generative process rely heavily on the analysis and deconstruction of artifacts, on completed musical compositions. However, creators' and non-creators' perspectives of musical structure differ. Non-creators do not generally have access to the constraints and intentions that shape the composition process. Relying on experimental observation, we have conducted a study that compares the generative decisions, perceptions and preferences of creators. These experiments focus on creators' in situ definitions of rhythmic, musical structure, and suggest new ways that the generative process may be modelled.

Our data is collected through musical composition "games". Through games, non-creators can observe generative strategy and share a context with creators. In the music composition games, subject-composers faced similar constraints and degrees of freedom in the composing task making their responses comparable. The game format allows us to search for correlations between the responses of each subject and across experiments with varied constraints. Comparisons across creators and across generative contexts help us identify aspects of the generative processes that distinguish or unify composers.

Through the music composition games, we investigate the nature of generative strategizing, and observed different "styles" of perceiving similarity in musical structure among creators. The patterns produced in these games and the findings derived from observing how the games are played elucidate the roles of metric inference, preference and the perception of similarity in the generative process; lead us to a representation of generative decision tied to a creator's perception of structure; and suggest new ways to model the generative process and the styles of individual creators through measuring perceptions.

1. Perception and Structure

Creators' and non-creators' perspectives of musical structure differ. The patterns creators generate are intended to have particular features and particular relationships to other patterns. Patterns and intentions do not emerge from an infinite set of possibilities, but through constraints. Regardless of what was intended, the resulting musical structures can be perceived many different ways by non-creators.

Non-creators do not generally have access to the constraints and intentions that shape creators' perceptions and the generative process of composing, and our models of the generative process suffer from the resulting distorted view. We have conducted a study to explore composers' in situ perceptions of musical structure. [1] The following discussion begins with a generalized investigation into perception, intention and style in artistic artifacts, and then moves into music specific explorations.

Artistic intention is revealed through non-causal, non-incidental features. A work of art contains many causal features that are simply by-products of working in that medium. Photography, for example, uses real objects as subjects. Regardless of subsequent manipulation, real objects provide the basis for representation in this medium, and real objects bring certain non-intentional features to the work as do the camera's technical constraints like focus or field of view. By contrast, these causal properties do not exist in painting and drawing. Distinguishing causal features from intentions are essential for understanding the generative process and the mannerisms and styles of individual creators. [2]

As non-creators, our analysis of artistic intention rests in part on our ability to understand the context in which the creator creates - the constraints, variables, and degrees of freedom available in the moment of production. Any instance of perception, any view of structure within a medium, is filtered through a particular context. The context is all the interrelated conditions under which an object, or in this case an artistic gesture, exists. While non-creators may appreciate similar contexts, we cannot be certain we are sharing a context with the creator. Our understanding of the creators' intentions is at best skewed. As non-creators observing completed works of art we can only infer the artist intention. We do not know if we define structure within those works similarly.

Music and Art theory provide a basis for defining structure, but theorists examine artistic artifacts not artistic processes. The conventions of Western tonal harmony or formal features attributed to artistic style by art theorists are ascribed a posteriori to the act of creation. In the visual arts, architects Habraken and Gross suggest, "how we use 'designing' points not to an object of design, but to a process." [3] When we describe the generative process by relying on theoretical definitions of structure we squash the artists' intention or ignore it completely. We fail to recognize what subsets of features are significant to a creator at the moment of creation, and we do not fully understand the intended function of each pattern or structural relationship. These pertinent points of reference, the filters through which creators perceive, leave an indelible mark on creators' mannerisms and personal styles of expression.

2. Intention, Strategy and Style

Is it possible to recognize and characterize an artist's intention? Intention is executed through some artistic strategy that produces desired features or structures within a medium. As non-creators we cannot with certainty identify the intended features; but we can observe creators' actions, and therefore, strategy in action. When a draughtsman draws a line he intends to draw the line in a particular way and perceives it relative to other lines he has drawn or intends to draw. The craft of art forgery, that is the generation of works in the styles of established artists, provides a highly instructive inlet into intention and the generative process. The able forger possesses great insight into artistic strategy. Notorious forger Eric Hebborn (1934-1996) observed the distinction between intended marks and copies in the preparatory drawings of engravers. Although engravers' drawings are sometimes mistaken for preparatory studies by the original artists, Hebborn notes,

"All but the very best of these engravers' drawings can be distinguished from the original productions by a certain lifelessness in the line. Every line is meticulously copied, but in the process something of the spontaneous touch of the creative draughtsman is lost. The reproductive engraver does not as a rule really know how to draw, and can therefore only produce the outward appearance of the lines…" [4]

Hebborn attributed this difference to the speed with which a line was drawn. The engraver, by necessity, works much more slowly than the original artist. The spontaneity to which Hebborn responds is the product of more than the speed, technique and trajectory of the charcoal pencil as a line is drawn by the artist. An artist draws each line with particular speed, technique and trajectory because he intends something by drawing the line in this way. There is a strategy and execution. The speed of the engraver's stylus betrays the authenticity of the work in two ways. Not only are the traces overtly methodical leaving telltale signs of studied pressure variations, but they also divulge an unnatural languidness and a misappropriated attention in the aesthetic decision it attempts to imitate. The engravers and the original artists do not share a similar context. Furthermore, they do not perceive or define structure in either the original or the copy similarly. Successful forgers such as Hebborn can intuit the original artists' context and perceptions. Additionally, given similar constraints Hebborn could strategize similarly to produce comparable features and results without laboriously copying existing patterns. Still, Hebborn worked by intuition, and what is needed to better understand and model the generative processes is a more empirical approach.

3. Style and Structure

Forgery is not a craft generally associated with music. In music research, a more conventional way to study generative process is to analyze and deconstruct compositions, and subsequently synthesize via artificial or computational means compositions that resemble those analyzed. Unlike forgery, this approach is somewhat removed from artistic practice and has been primarily the province of music theorists. It has provided a sophisticated understanding of similarity in structure across works, and enumerated the variety of ways structure can be perceived in these works. Validation for modelling and synthesis technique comes from comparing features between real and artificially synthesized artifacts, for example, in the work of composer David Cope. [5] Based on an exhaustive analysis of a catalog of compositions, Cope created several music systems that generate pieces in the styles of famous composers. Cope's work provides us with ample structural analysis of the original artifacts, and a tremendous body of research about the computational modelling of musical structure and style. Nevertheless, it leaves us with unsatisfying answers about the human processes behind the generation of these artworks.

Detailed statistical analysis of artifact features such as intervallic relationships in the melodies of a particular composer are far more involved than any observations made by a human composer for the purposes of his or her own generative process, and lack the "spontaneity" Hebborn described. Additionally, the deconstruction process on part of the non-creator (and model builder) unavoidably emphasizes his or her own preferences for structural analysis. Such choices may make for compelling generative art, but limit our perspective on the generative process and how to model it. Our study attempts to move away from theoretical definitions of structures. But the further away we move from common knowledge, the less knowledge we share with the creator. As a result, we must construct experimental scenarios in which creators can reveal information about their perceptions and the saliencies of features within the patterns they construct to non-creators.

How can the non-creator gain access to the perceptions of the creator? The primary objective of our study was to tie a generative decision - in this case the creation of a musical pattern - to some measure of the creator's perceptions. Since we as non-creators are not privy to all the perceptions and constraints influencing a composer, this coupling of perceptions to generated pattern can help us to understand the influence of perception and constraint on the generative process. In particular, we will look at composers' strategies for conceiving of structure, their preferences for particular combinations of patterns, and their perceptions of similarity between patterns. Are there styles of perceiving, and do the intuitions of individual creators yield a distinct style that can be characterized? We will attempt to probe these questions through a series of perceptual and cognitive experiments that use musical games to collect information about the generative process in music.

4. Games

The process of generating music may be compared to playing a game with goals, constraints, rules and strategies. Games can serve as a model for the interrelated mechanisms of music creation to some extent, but also provide a format for an experimental technique. Games offer one way for creators and non-creators to share, at least in part, a context. Games are relatively well-bounded in that a set of constraints and objectives are pre-defined while outcomes remain variable. We have devised musical composition games in which the context, constraints and degrees of freedom available to creators is fixed and well-defined. In these well-bounded composition games, creators generate musical patterns.

Just as observers can analyze the actions of game players, we will attempt to analyze the actions of creators within composition games building on the knowledge of the constraints and goals that we share with the creator. The outcomes of games can be compared by looking at the outcomes of different responses to the same game and responses to games with varying constraints or goals. Patterns produced through composition games can be compared because the circumstances through which they were generated are comparable. This approach for analyzing the generative process has been used previously in Visual Design research. [6, 7] We have adapted this technique for musical settings, and also for isolating specific aspects of perception.

Our composition games are simple, sparse and rhythmic. We hope that simplicity will bring more clarity to some of the fundamental aspects of the generative process in music. In the next sections, we survey three different types of musical composition game, and report preliminary findings in each case. All the composition games are played on a computer using a graphical interface, and all the subjects in this study play an instrument or sing. They varied in age, gender, musical education and experience, instrument played, and genre preference.

5. Strategy

The objective of the first of the three game-experiments was to see if similar constraints would yield similar patterns, or similar strategies for generating patterns. Twenty-one subject-composers made looping, rhythmic patterns for us with simplistic sound samples that we provided. Samples consisted of a single onset of one timbre pitched to a C or G. In all the experiments, to create the patterns, subjects dragged and dropped sound samples on a graphical interface. The samples were seen by subjects as numbered, blocks, with no musical notation or waveform. Subjects could *not* modify the samples, only the times at which they occurred, and there were some constraints on the intervals of silence between samples. Some subjects were given via text target features to incorporate into their newly, generated patterns. Subjects were also given a questionnaire and asked to describe in writing their strategies for structuring the patterns the way they did.

An interesting thing appeared in the results. Although subjects generated very different patterns, we observed some similar strategies among creators for generating and describing structure in these patterns. Subjects often utilized objects external to the pattern that they were generating as structural templates. Subjects would then conceive of and perceive an overlap of features between this object and the pattern's features. These objects were often things like events, objects from the physical world and occasionally linguistic structures. As common, was a strategy that involved defining some internal relationship between sound objects contained within the pattern, for example, transformations, spatial or temporal relationships, or occasionally hierarchical relationships. These structural templates appeared to be the basis for generating structure. The next two game experiments take a far more bottom-up approach, and look at preference and the perception of similarity. Do musical creators share similar ways of perceiving structure?

6. Preference and Similarity

To collect responses that can be measured more consistently across subjects, for the next two experiments we used a set of nine rhythms (figure 1) as our set of musical samples. This further reduced the degrees of freedom available and the variation between patterns produced. Subjects added to or organized these short patterns. Henceforth, these will be referred to as the "nine." The nine, rhythmic samples are all two seconds. Intervals of silence at the end of the samples are preserved when they are concatenated together. Each sample has four attacks or sound events of one percussive, instrument timbre. There are no accents or alterations in pitch within each sample.

Because we are looking for similar perceptions across creators, and subsequently to better map their individual perceptions to the patterns they generate, we used a preference and a similarity test using these nine rhythm samples to establish a baseline for each subject and look for trends in the population. These were perceptual tests rather than composition games. We will use the results of the baseline in the analysis of the patterns produced in the games. Fourteen subjects participated in the baseline.

1	●	●	-	-	●	●	-	-
2	●	●	-	-	●	-	●	-
3	●	●	-	-	●	-	-	●
4	●	-	●	-	●	●	-	-
5	●	-	●	-	●	-	●	-
6	●	-	●	-	●	-	-	●
7	●	-	-	●	●	●	-	-
8	●	-	-	●	●	-	●	-
9	●	-	-	●	●	-	-	●

Figure 1: The nine, rhythmic samples used in experiments 2 and 3.

7. Preference Baseline Test

The first baseline test is for preference. The nine rhythm samples were combined into eighty-one pairs. Subjects were told to think of the pairs as antecedent-consequence or call and response phrases. The antecedents and consequences were pitched a fourth apart. They were asked to perform a total ranking of all eighty-one pairs. Subjects ranked the pairs for preference by clicking and dragging samples into preference order on the computer screen.

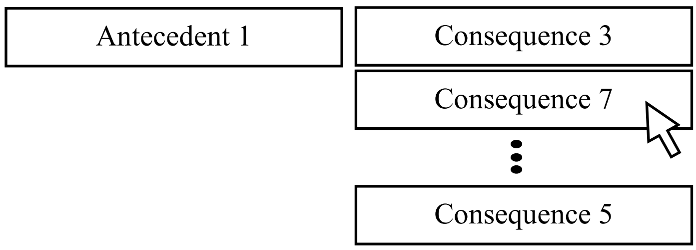

Figure 2: Preference Baseline Test

The results revealed a tremendous amount of variation in preferences both within the set of responses for each subject and between subjects. However, some trends did emerge. There were some antecedents for which a significant number of subjects chose the same consequence as the best sounding or most preferred. There were a few instances where subjects who agreed on good antecedent-consequence pair also agreed on poor pairings for the same antecedent. Age, gender, musical experience and education, instruments, and genre preferences were not good predictors of preference ranking in this case. These findings suggest preference and context are changing from antecedent to antecedent.

8. Similarity Baseline Test

In the similarity baseline test, subjects listened to pairs of the nine rhythm samples and were asked to rate each pair for similarity on a scale of zero to ten. Zero indicated that the pairs are not in anyway similar, and ten indicated that they are perceived as identical. These responses were then plotted using multidimensional scaling (MDS). This provides a good visual representation for similarity between patterns and a way to compare subjects' responses. The temporal position of the first two attacks within the rhythm appeared to be a crucial determining factor for the majority of subjects. The nine can be divided into three groups in which each of the three rhythms have the first two attacks in common. The most basic rhythmic inference subjects can make is to perceive metric subdivisions grouping rhythmic attacks in twos or threes. It might also be assumed that some subjects responded more generally to the features of regularity and density.

As a result, in most of the MDS plots we see the nine rhythms segregated into clusters in which the first two attacks are the same in the all within cluster patterns. But also, three different proximity patterns, or styles of perceiving similarity appeared the results. In type I, clusters of patterns 1,2,3; 4,5,6 and 7,8,9 are distributed in relative isolation from one another. This was the largest group of responses. In type II, two of the three clusters are proximal. This was the smallest category. In type III, the clusters are less distinct and all the patterns are grouped close to each other.

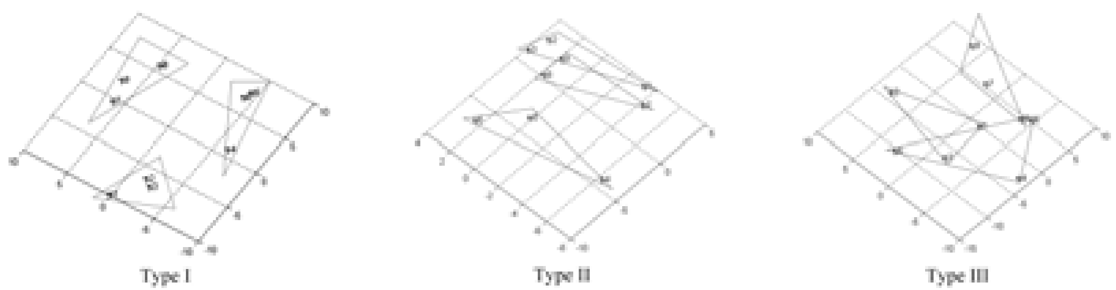

Figure 3: Styles of perceiving similarity. Examples of types I, II and III from left to right (clusters grouped to illustrate proximity)

Again, age, gender, musical experience and education, instruments and genre preferences varied within each category. We used the baseline data to analyze the patterns collected in the next two game experiments.

9. Make An Antecedent Game, Experiment Two

Experiment Two explores the connection between preference and context. In this experiment, the fourteen subjects created an antecedent pattern with four attacks and then ranked the nine, given rhythm samples in order of preference as potential consequences. To make an antecedent, subjects clicked and dragged samples into place (figure 4). These samples consisted of one onset of the same percussive sound used in the given nine consequences. Antecedents and consequences were pitched a fourth apart. There were some constraints on temporal subdivisions of the antecedent pattern, but more than nine rhythmic configurations are possible. The downbeat was required. After creating the antecedent, the nine consequences were shuffled into preference order. Subjects were asked to notate which consequence they thought sounded worst, in other words, which was least preferred as a consequence.

Subjects then made the least preferred consequence pattern the most preferred. On new workspaces, subjects generated new antecedents that made that previously least preferred consequence now sound best or most preferred. All subjects could make the worst better, but some could not make it best.

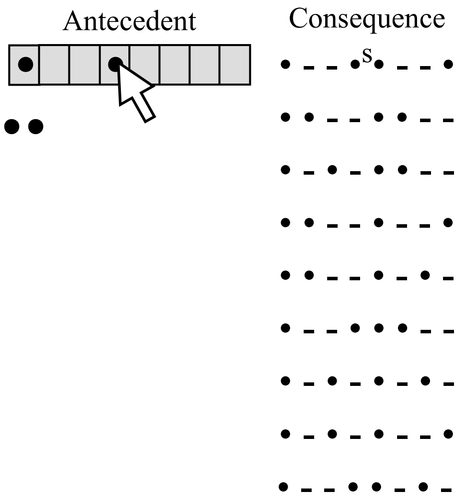

Figure 4: Make an Antecedent Game

As a result, we were able to plot out complete transitions from the preferred pattern combination in the first part of the game through configurations where the least preferred improves (figure 5).

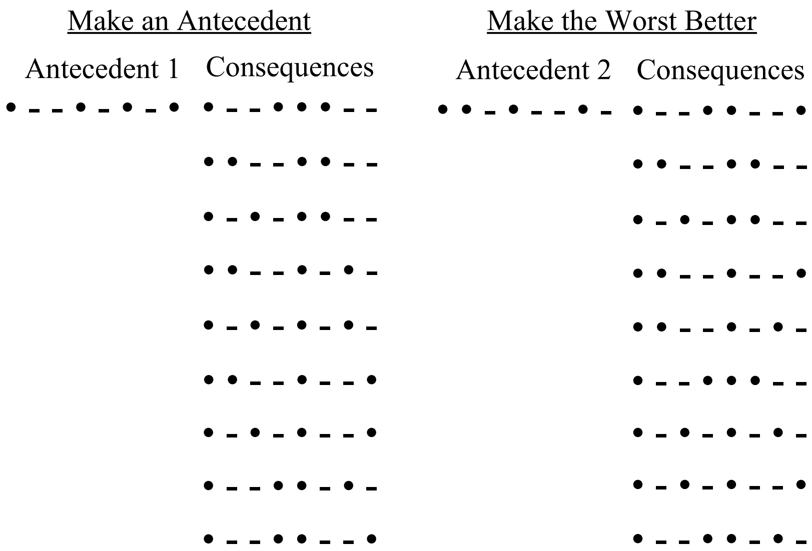

Figure 5: Tracking changes in preference from worst to best contexts

Interestingly, some subjects created patterns that work well for both the original and new antecedents. For example, in the chart above (figure 5), the second and third most preferred consequences are the same for both antecedents. However, there did not seem to be a correlation between the kinds of antecedents subjects created and their preferences for antecedent-consequence pairings and/or their perceptions of similarity reflected in the baseline tests. To address that problem, we created one last game experiment.

10. Chain Four Patterns Game, Experiment Three

This game used only the nine rhythm samples from the baseline tests. Ten subjects generated new, rhythmic phrases by chaining four of the nine together. Again, new patterns were generated by clicking and dragging samples into position. Subjects were free to use any of the nine samples more than once. Each subject created four pairs of chains. Chains within a pair were to be similar to each other, but had to begin with a different one of the nine provided rhythm samples. The first pair was to sound regular (whatever that meant to the composer), the second irregular, the third dense and the last sparse. After composing the chains, subjects were asked how many phrases they heard in each chain - in other words, whether they heard these chains as having four phrases, or had some other structure emerged.

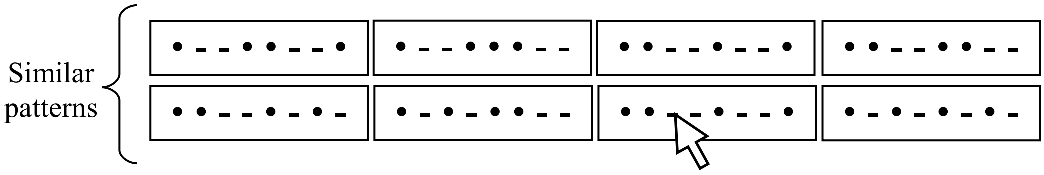

Figure 6: Chain Four Patterns Game

We then mapped on each subject's MDS plot the transitions between the nine given rhythm samples in each chain. What results is an interesting representation of a generative decision superimposed onto similarity space. The newly generated pattern can be directly compared to each subject's perception of structure.

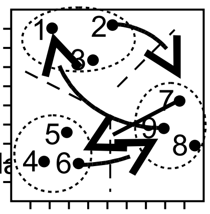

Figure 7: Plotting transitions across simil

These new chains can be divided into three categories: circular chains in which chains begin and end on the same rhythm; repetitive chains in which there is a repeated combination of patterns; and asymmetrical chains in which the first and the last rhythms are different. The majority of chains produced were asymmetrical. Also, new phrase structures emerged even though subjects had been familiarized with the individual, nine rhythms in the baseline. The majority of chains were heard as containing two phrases. Interestingly, subjects with different MDS plots, or different styles of perceiving similarity, followed similar strategies for constructing chains. Therefore, it is likely we are witnessing the influence of some higher-level criteria. In future, by further refining the constraints and limiting degrees of freedom, we can further refine the connections between perceptions and generated patterns.

11. Conclusions

Through the game experiments, we were able to compare creators' perceptions of structure and the patterns they generated. These preliminary results revealed three different styles of perceiving structure. Furthermore, we were able to track changes in individual creators' preferences as they generated patterns. We offered a representation of a generative decision mapped onto similarity space. Obviously, much more research is necessary to understand strategy, preference and similarity in even this sparse generative context. However, there are other form-bearing dimensions to consider, and we need to expand beyond preference and similarity and develop more complicated games.

Nonetheless, these preliminary findings hold implications for future simulations and syntheses of musical patterns with the mannerisms of particular creators. We offer not only new ways that the generative process may be observed, but also new types of representations for creators' perceptions. These maybe used to model the personal style and mannerisms of individual artists. The game-experiments provide insight into characteristics that correspond to the idiosyncrasies that distinguish creators as well as to the similarities they share. Also, elaboration on the analogy between games and the generative process and generative strategizing presents further potential for new models. Thus we, the modeller, are better equipped to face the challenges of synthesizing patterns with stylistically salient features.

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The Modular: An Analysis into Generative Architecture

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Le Corbusier tried to embed …ideas in Jullian's mind during their early discussion, but ultimately the most novel and powerful ideas came in the few sketches Le Corbusier showed him later. The key to the project was there, presented in a completely unprecedented way. Mazzariol added,

The young Chilean architect who for several years had been living like a moine in the atelier, realized in bewilderment that something quite unprecedented was taking place … Was this the beginning of a new architecture? The drawings were made of few strikingly precise indications; the form was spatial and the space developed in a regular movement like the ripples sent out by a stone dropped into a pond. No previous design had ever evolved so easily and so quickly.

Giussepe Mazzariol 1966

Introduction: Drawings to the Grid in Le Corbusier's Design Strategy

The core challenge in translating Le Corbusier's Venice Hospital project 1964-65 conceptual drawing remained in defining the order – the systematic content of the project defined by repetition and numbers - understood as a given, as a matter of strategy. This design strategy of systematic repetition remains the core element in identifying the dynamics of the city of Venice and its replication in the form of Generative Architecture.

According to Le Corbusier's primary assistant in the Venice Hospital project, Guillermo Jullian de la Fuente; the real question in the Venice Hospital project, arose at the level of tactics; on how to manipulate the number, the structure, the module and the pattern to become architecture – that generates its essential dynamics.

The above discipline was mastered by rigorous calculations and testing. Sometimes the precision of the building elements and their sequencing in extension were so complete that the building plans turned into virtual musical notations: One day while working on the drawings for a huge longitudinal section, which covered the complete atelier space in Venice, Jullian along with other assistants decided to 'play' the hospital building. Each member of the team selected a different sound and Jullian assigned to each 'instrument' a building element – piloti, ramp, vault, partition – as 'notes'. Then acting as an orchestra conductor, Jullian followed the section by keeping a constant rhythm.[2]

Although the above exercise in all probability seems possible, it is a highly subjective approach, an abstract rationality and therefore not feasible for further investigation unless taken as a *geometric and mathematical exercise* – with the key note being the

2 Quoted by Allard 2001, p. 32,and end notes p 35:

sense of or a return to *order*. In an attempt to understand this definition of order, it seems imperative to briefly examine Le Corbusier's architectural philosophy.

1.1 Spirit of Age – Spirit of Geometry

Le Corbusier architectural philosophy defined the post war 1914-18 sentiments, it was an era of strong reaction against the anarchy and uncontrolled experimentalism of the pre-war avant-gardes. As such, according to Colquhoun [2002], a '*return to order'* was deemed necessary. For some French artistic circles this meant a return to conservative values and for others it meant an embracing of the imperatives of modern technologies. The situation was further rendered complicated by the assimilation of cultural pessimists like the poet Paul Valery and technological Utopians like Le Corbusier both invoking the spirit of classicism and geometry.[3]

Banham [1960] believed that Le Corbusier defined a specific modern sentiment found in the 'spirit of geometry' with exactitude and order and its essential condition.[4] This sentiment according to McNamara [1992], equally sought to encompass more than a reductive functionalism derived from the logic of contemporary economic processes. The mix of the mass, the serial and the geometric provided a recipe for uncovering the gestalt of a higher aesthetic and spiritual order.[5]

Ozenfant, Le Corbusier's colleague in the 1920s remarked that, 'mass production had led to the desire for perfection'[6] thus implying that it led to an ideal model but not an end in itself. He maintained that all human perception is gauged through a geometric filter of sensations, and argued that since it is one of man's passion to disentangle apparent chaos, then mathematics, geometry and the arts are all forms of apparatus that reduce the incomprehensible to credible forms.[7]

According to McNamara [1992], the technological viewpoint of the avant-garde owed much to the mystical, theosophical and Neo-Platonic interpretation of art characteristic of Itten or Kandinsky. Schlemmer's diary entry of 1915 marked the impact of these ideas on his early artistic formulations: 'The line is traced with pure cold calculation; crystal appear; cubic forms. Universal application towards the mystical.[8]

Schlemmer referred to the path towards the incomprehensible in the simple basic forms – while Ozenfant subsequently proclaimed the transformation of the incomprehensible into credible forms. These somewhat mystical declarations could be readily channeled into rhetoric advocating the establishment of objective criteria necessary for the *new order* of rational precision, while still maintaining a pronounced spiritual emphasis. In response to the reformulations of these conceptions, Schlemmer raised what became a common concern amongst the

3 Alan Colquhoun, 'Return toOrder: Le Corbusier and Modern Architecture in France 1920-35' Modern Architecture 2002 p. 137

4 R. Banham, Theory and Design in the first Machine Age 1960 p. 249

5 McNamara, Between Flux and Certitude: The Grid in Avant Garde Utopian Thought' Art History vol.15 no.1 March 1992

6 A. Ozenfant, Foundation of Modern Art trans. J. Rodker, London 1931 p.217

7 ibid.,

8 Schlemmer, 'Diary – November 3, 1915, cited in Tut Schlemmer, ed., The Letters and Diaries of Oskar Schlemmer 1982 p.32

avant-garde – a search for fundamental constants found in 'credible forms.'[9]

It may have been this search of 'credible forms' in formulating an ideology of modern painting, that Le Corbusier along with Ozenfant developed many of architectural ideas/philosophy that was later documented in *L'Esprit Nouveau.* According to Colquhoun [2002], in *Apresle Cubisme* [1918] and in the essay 'Le Purisme'[10] an idea that played an important part in Le Corbusier's architectural theory was introduced, that of the *object-type.* In these texts the authors praised Cubism for its simplification of forms along with its method of selecting certain objects as emblems of modern life. Ozenfant and Le Corbusier claimed that, ' of all the recent schools of painting, only Cubism foresaw the advantages of choosing selected objects…but by a paradoxical error, instead of sifting out the general laws of these objects, Cubism showed their accidental aspects.'[11] Thus by virtue of these general laws, the object would become an *object-type* its Platonic forms resulting from a process analogous to natural selection, becoming 'banal' and susceptible to infinite duplication, the stuff of everyday life.'[12]

1.2 Geometry, Mathematics and Art Combined

According to McNamara, Geometry, mathematics and art combined to realize the universal forces – regulated, measured and complete and thus shifted everything from the domain of 'sensory origin to that which excludes natural doubt'[13] – corresponding to Wells pronouncement of the imminent movement 'from dreams to ordered thinking'.[14]

Le Corbusier similarly proclaimed an elevation to the spiritual in art. For him geometry represented 'the language of man'[15] and he aimed to transform it into a broad social vision encompassing every aspect of life. His starting point for this was 'that key site of modernity – the metropolis – as is evident in his *Voisin Plan* of 1925.'[16] In this proposal for restructuring Paris, a grid plan was devised as means of evoking the precise and harmonious relations that only become possible in the 'great epoch'.

As he wrote in *Towards a New Architecture*: the spirit of functional utility found expression in a sense of order: The regulating line is a satisfaction of a spiritual order which leads to the pursuit of ingenious and harmonious relations … The regulating line brings in this tangible form of mathematics which gives the reassuring perception of order.[17]

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9 McNamara, p. 64

10 L'Esprit Nouveau no.4 cited in Colquhoun 2002

11 Ozenfant and Jeanneret, 'Purisme' L'Esprit Nouveau no.4 October 1929, p.369

12 Kenneth E. Silver, Esprit de Corps: The Art of the Parisian Avant-Garde and the First World War 1914-1925 Princeton 1989 p.381-9 cited in Colquhoun 2002 p.140

13 J. Derrida, 'Cogito and the History of Madness' in Writing and Difference trans. Alan Bass, 1978 p.47

14McNamara p.64

15 Le Corbusier, p.68

16 McNamara, p.66

17

1.3 The Grid – the Modern Metropolis: Towards A Generative Architecture

According to McNamara, in the *Voisin Plan* Le Corbusier used the grid layout to bring the modern metropolis into line with the ideal relations that had only been glimpsed in mass production. The plan also revealed that social utility and aesthetic form could be identical in the grid. The plan lived up to its name by employing notions of bordering or neighboring as a central device. The design, however did not simply aim to suggest any continuum of adjoining patterns and endless additions – neighboring. Rather it sought to elaborate and weave the order of all orders at the base of chaos – this characteristics remains an important definition of generative architecture.

Voisin evokes a design which is at once, a founding base and also its most elevated and refined form. The grid thereby erases its imprint as artifice by mapping the structural form of the city which enables ease of passage through the chaotic energy of the modern metropolis.

Recalling the grand schemes of Sant'Elia, the project emphasizes conjunction and flow and acts as an 'inhering *mechanism* inseparable from the body of the world and operating on it *from within*.[18] The process of geometric filtering ideally constituted a form of dispersal rather than a centralization of the 'scopic drive'[19] it offered a creative silencing of the urban cacophony and the confusion of form.[20]

Hence the grid functioned as the ideal exemplar of the generative architecture; 'progressive' order, operating not as an aesthetic reflex but as the pure equivalence of the system it aimed to engender.

It also implied mathematical exactitude and the equality of all co-ordinates in an infinite extension,[21] thereby acknowledging the essence of uncertainty and change. Le Corbusier was very aware of this characteristic of the grid.

This characteristic of grid may have been the key element in Le Corbusier's final drawing for the Venice hospital project – juxtaposing geometric order with spatial programming into an emblematic generative architecture.

Retracings: From the Plan to the Grid in Le Corbusier's Design Strategy

Venice Hospital was planned in 1964 to be built in San Giobbe neighborhood, in the Canareggio area at the edge of the city of Venice, it was commissioned to cater for the acutely ill. The proposed hospital was unique in its design considerations, as the challenge was not just to design the hospital, but also to design the topography of the structure beneath the hospital - thereby creating a physical extension to the city of Venice.

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18 S. Kwinter, 'La Cita Nuova: Modernity and Continuity' Zone no. ½ p.98
19 M. de Certeau, The Practice of Everday life trans. S. F. Rendall, Berkeley 1984, p.92-95 cited in McNamara 1992 p.66
20 ibid.,
21 ibid.,

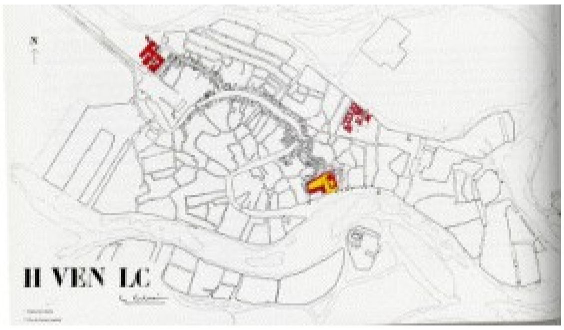

Figure 1: Atelier Julian, plan of Venice with new hospital [third project], 1966.

2.1 Rapport Technique

In the Rapport Technique discussed below, Le Corbusier evokes both the programmatic issue and the flexibility issue in discussing the design of the hospital. The report turns to the problem of horizontal circulation that sprawl would create and proposes mechanization as the means of solving it. By virtue of its location and its scale, the building turned in on itself and created its own interior subenvironments in the form of wards centered around courtyards that repeated in a seemingly endless manner. These courtyards were supposed to extend the residential areas of the city into the water, but also create an abstract, clear logic that reciprocated back onto the labyrinthine context of Venice.[22]

The Hospital is sited near the northwest end of the Grand Canal and extends over the lagoon separating Venice from Mestre. The decision to contain the wards in a solid wall and to light them from the roof is justified by the proximity of the railway terminal and the industrial squalor of Mestre. The building covers a large area and is comparable in its mass and public importance to such groups as the Piazza San Marco, the Ospedale Civile and the monastery of San Giorgio Maggiore. It therefore forms an important addition to that small but significant collection of buildings symbolizing the public life of Venice.[23]

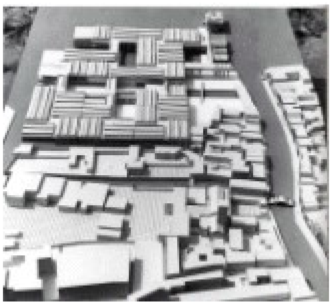

Figure 2: Atelier Jullian, model of the Venice Hospital, 1966

Unlike the assimilation of the Venice Hospital to its immediate surroundings and everyday life, Kenneth Frampton[24] points out that the Metabolist were unable to find

22 Hashim Sarkis, *Case: Le Corbusier's Venice Hospital and Mat Building Revival.* (2001)

23 Alan Colquhoun, *Essays in Architectural Criticism: Modern Architecture and Historical* Change p.35

24 Kenneth Frampton, 'Place, Production and Scenography: International Theory since 1962'*, Modern Architecture: A Critical History*. 3rd edition. p.280

such harmony in their work. According to Frampton, Kiyonari Kikutake's floating cities are among the most poetic visions of the Metabolist Movement, yet Kikutake's marine cities seem even more remote and inapplicable to everyday life…[25] Gunther Nitschke et al. had this to say when making an assessment of the Metabolist Movement in 1966:

As long as the actual building get heavier, harder, more and more monstrous in scale, as long as architecture is taken as a means of expression of power, be it of oneself or of any kind of vulgar institution, which should be serving not ruling society, the talk of greater flexibility and change-loving structures is just fuss. Comparing this structure [Akira Shibuya's Metabolic City project of 1966] with any one of the traditional Japanese structures or modern methods suggested by Wachsmann, Fuller, or Ekuan in Japan, it must be considered a mere anachronism, a thousand years out of date, or to say the least, not an advance of modern architecture in terms of theory and practice.[26]

Le Corbusier was determined not to unsettle the existing typology of Venice through his proposed Hospital project. Le Corbusier wanted to translate his perception of the city in his design, according to him; "one cannot built high; it would be necessary to be able to *build without building*. And then its necessary to find scale."[27] (emphasis mine)

Although Le Corbusier was not alone in his pursuit to find a balance between the concept of innovativeness and integration in his design solutions[28], his solution according to Colquhoun, combines the monumentality of the Hospital as part of the grandeur of the city with an intimacy and textural quality in harmony with the city's medieval scale. If built, it would have gone a long way towards revitalizing the "kitchen sink" end of the city which needed more than the tourist trade to keep it alive.[29]

Incidentally, Eric Mumford in his essay[30] believes, Le Corbusier's concept of 'ineffable space' as a new basis of architectural form, articulated in a 1964 essay, usually relied on the transformation of existing typologies.

In comparison, Candilis-Josic-Woods, were attempting to generate a new method of formal expression that loosely linked the various program elements in ways that

25 ibid.,

26 ibid., p. 283

27 Giuseppe Mazzariol, "Le Corbusier in Venice: His Project for a New Hospital," Zodiac 16 [1966]: 241

28 Aldo Rossi in a similar exercise writes on his contribution to the Gallaratese complex; In my design for the residential block in the Gallaratese district of Milan (1969-73) there is an analogical relationship with certain engineering works that mix freely with both the corridor typology and a related feeling I have always experienced in the architecture of the traditional Milanese tenements, where the corridor signify a life-style bathed in everyday occurrences, domestic intimacy and varied personal relationships. However another aspect of this design was made clear to me by Fabio Reinhart driving through the San Bernardino Pass, as we often did to reach Zurich from the Ticino Valley. Reinhart noticed the repetitive element in the system of open sided tunnels, and therefore the inherent pattern. I understood … how I must have been conscious of that peculiar structure … without necessarily intending to express it in a work of architecture.

29 Alan Colquhoun, *Essays in Architectural Criticism: Modern Architecture and Historical* Change p.35

30 Eric Mumford, 'The Emergence of Mat or Field Builing,' source: Hashim Sarkis, *Case: Le Corbusier's Venice Hospital and Mat Building Revival.* (2001) p.57-58

allowed to continuous flexibility and change.[31] As in the example of the sketches illustrating the design approach at Berlin Free University, 1964.

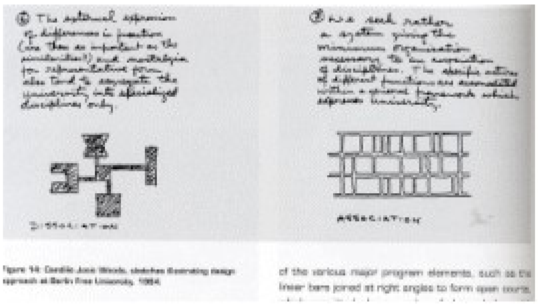

Figure 3: Candilis Josic Woods, sketches illustrating design approach at Berlin Free University, 1964.

Although this approach was different from both Le Corbusier and Blom[32], the idea of linking elements that form open courtyard and connect programmatic areas has been extensively utilized by Le Corbusier and Pierre Jeanneret in works such as the Centrosoyuz in Moscow, the League of Nations competition entry in Geneva, the Salvation Army Cite de Refuge in Paris and the Palace of the Soviets competition entry in Moscow, as Colquhoun had perceptively analyzed. Colquhoun identified how these projects begin to indicate a new urban pattern with multilevel circulation systems, which at the same time are adjusted to the particularities of each projects complex urban site.

Figure 4: Piet Bloom, “Noah’s Ark” project for urbanization of the Netherlands, shown at Team 10 meeting at Abbaye Royaumont, 1962; model photos and plan of one village unit.

In each, Le Corbusier perfected the technique of elementarization of the various

31 Smithson, Team 10 Meetings, 34 source: Hashim Sarkis, *Case: Le Corbusier’s Venice Hospital and Mat Building Revival.* (2001)

32 In many texts Blom’s project was depicted as a “snowflake shape that by means of unlimited repetition and undefinable scale served to subtly illustrate the analogy between house and city.” source: Sarkis, p. 21 illustration of Blom’s “The City will be inhabited like Villages” p.57 and “Noah’s Ark” p.59

major program elements, such as the linear bars joined at right angles to form open courts, which permitted a large number of plan variations with potentially infinite extensibility.[33] Le Corbusier was able to realize such projects only in greatly reduced form, but Candilis-Josic-Woods began to build such ideas in enlarged but at the time spatially limited projects such as the Berlin Free University.[34]

Although Eric Mumford in his arguments cites the example of the Berlin Free University, it must be noted here that in an assessment[35] of this University by Tzonis et al. The Berlin Free University is somewhat termed as a magnificent yet redundant structure in its present condition. Unlike Le Corbusier's proposed Venice Hospital it remains an isolated part of its immediate infrastructure, in terms of its scale as well as its functional programming.

Plan of the Venice Hospital

In terms of the plan of the Venice Hospital, Le Corbusier integrates the communication channels, the recreational and religious centers along with immediate hospital personnel space in the ground level of the hospital. According to Colquhoun, "The ground level accommodation occupies an L, with an isolated block contained within the arms of the L. The reception, the administration, and the kitchen occupy the L, and the nurses hostel the isolated block. A straight access system breaks through the L where gondola and car entries converge onto a common entrance lobby thrown across the gap.

Figure 5: Le Corbusier, Venice Hospital, first project [1964] level 1.

Figure 6: Le Corbusier, Venice Hospital, first project level 2a [1964]

The gondola approach route is bridged by a route linking religious and recreational centers at its extremities. There is an entresol containing extensions of the ground level accommodation….(similarly) the analytical and treatment departments are on the level 2a are arranged freely around the cores in an analogous way to the wards above.

33 Alan Colquhoun, "The Strategies of the Grands Travaux," in Modernity and the Classical Tradition (Cambridge MA: MIT Press, 1989), p.8-10

34 George Baird, "Free University Berlin," AA Files 40 [Winter 1999]: 66-71: Shadrach Woods, "Free University Berlin," World Architecture 2 (1995): 112-121

35 AA Press released book edited by Tzonis, Mostafvi etc.

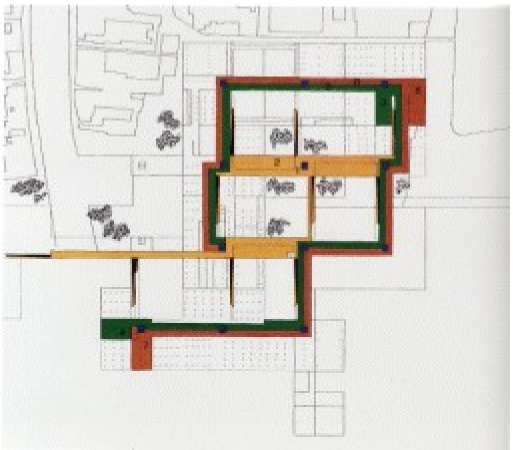 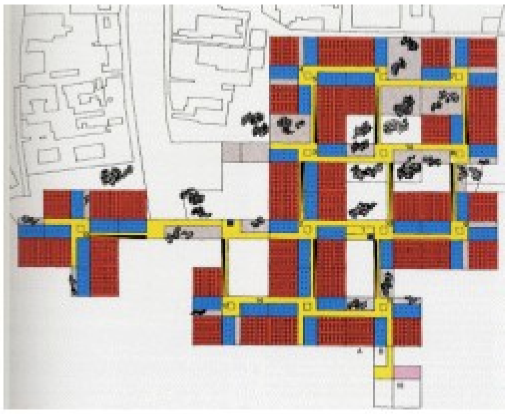

Figure 7: Le Corbusier, Venice Hospital, first project Figure 8: Le Corbusier, Venice Hospital, first project [1964] level 2b level 3.

Level 2b consists of a horizontal interchange system between all elevators points – patients using the central and the staff the peripheral, corridors fig…. The ward block which is occupies the entire top floor, is both the largest department of the building and represent its typical element, and organization allows this element to extend to the limits of the building with which it becomes identified by the observer, whatever position he may be in.

The basic unit of the plan and its generator is a square groups of wards rotating around a central elevator core – Le Corbusier calls a campiello. These units are added in such a way that wards next to each other in adjacent units merge, thus 'correcting' the rotation and making the independent systems interlock. An agglomerate of units creates a square grid with a campiello at each intersection. The plan differs from those isomorphic schemes where the unit of addition is elementary (as implied, for instance, in the roof of Aldo Van Eyck's school at Amsterdam).

Here the basic unit is itself hierarchically arranged, with biological rather than mineral analogies, and capable of local modification without the destruction of its principle… The concept of the top-floor plan is reminiscent of the Islamic medresehs of North Africa, where subcommunities of students' cells are grouped around small courtyard, forming satellite systems around a central court. As in the medresehs the whole dominates the parts, and the additive nature of the schema is overlaid with a strong controlling geometry.

The geometric as apposed to the additive schema consists of a system of overlaid squares and the golden-section rectangles. The smaller of the two squares established a center of gravity asymmetrical in relation to the scheme as a whole and related to it diagonally. This center is also on the intersection of the rectangles formed by dividing the total square according to geometrical proportion. The additive grid consists of eight units, which allows for division of the Fibonacci series into 8, 5, 3, 2. The center of the small square is the center of gravity of the treatment department and the main vertical circulation point for the patients around which there is an opening in the top floor giving light to the ground-floor court which wraps around the central core. As at the monastery of La Tourette, the traditional court with circulation around it is modified by a cruciform circulation system on its axis – a typical Corbusian superimposition of functional and mythic order.

Figure 9: Showing the Venice Hospital, geometrical schema(left), additive schema (right).

The central core (which from another point of view is merely one of a number of equidistant elevator cores) assumes a fixed relationship with the southeast and southwest faces of the building only. Conceptually, the building can extend on the northeast and northwest faces, and these are developed in a freer way over the lagoon to the northwest and the Canale di Cannaregio to the northeast, where one assumes further extension could take place. (Colquhoun notes that; between the first and second project a new site, became available, and it is therefore possible to see how extension has been achieved without detriment to the overall schema.)

The wards are grouped around the central light well in a wing over the lagoon, and form a U – shape over the gondola entrance to provide the echo of an avant-cour. From this "soft" side a bridge extends over the canal to an isolated ward complex on the opposite side.

According to Colquhoun; despite the uniqueness of this building in the work of Le Corbusier – a uniqueness that perhaps can be explained by the complexities of the problem and by the peculiarities of the site – a number of prototypes exist in his earlier work(that can perhaps testify to the feasibility of his design solution for the Venice Hospital). At the Villa Savoye in Poissy the flat cube, projected into the air and open to the sky, was first established as a "type" solution. It seems clear that this sort of "type" solution cannot be equated with the object-type discussed by Banham in his *Theory and Design in the First Machine Age,* since Le Corbusier frequently uses the same type in different contexts. However it can be assumed that Le Corbusiers' concept of type relates to a mythic form rather than to a means of solving particular problems, and that, as with physiognomic forms or musical modes, a number of different contents can be attached to the same form. A similar idea is apparent in the project of for the Museum of Endless Growth of 1930-39, also connected with the problem of extensibility as at Venice, though solving it in a different way. In the 1925 Cite Universitaire project a solid single-story block of studios was proposed, where the rooms were lit entirely from the roof."[36]

In the Venice Hospital patios are more than just the static result of a solid that has been carved out to gain light and air. Following the explorations started at the 1964 Carpenter Center in Cambridge, the interaction of the inside and outside spaces are consciously activated by means of layers of transparencies and visual fluidity that dissolve the void and penetrate the mass. The idea successfully solved the contextual difficulties faced in the Harvard Building by dematerializing the facades and the limits of the envelope, and projecting the surrounding buildings as the ultimate façade. In Venice this effect is intensified by the shimmering reflections of the sun on the water and its projections on the slabs, walls, glassed surfaces, and pilotis.

The idea of a building on pilotis extending over water, may stem from Le Corbusier's

36 Alan Colquhoun, *Essays in Architectural Criticism: Modern Architecture and Historical* Change

earlier interest in reconstructions of prehistoric lake dwellings in central Europe. The monastery of La Tourette resembles such schemes through the way in which the building is projected over rough sloping ground which, like water, offers no foothold for the inhabitants of the constructed world suspended above it.[37]

Thus in the hospital scheme the potential symbolism of these forms has been harnessed to a new and unique problem. The space of the pilotis forms a shaded region in which the reflections of sunlight on water would create continuous movement. Over this space, which is articulated by numerous columns whose grouping would alter with the movement of the observer, floats a vast roof, punctured in places to let in the sunlight and give a view of the sky. This roof is in fact an inhabited top story, whose deep fascia conceals the wards behind it. It is the realm of the sky in whose calm regions the process of physical renewal can take place remote from the world of water, trees and men which it overshadows. But apart from its suggestions of sunlight and healing, it has more somber overtones.

The cavelike section of the wards, the drawn representation of the sick almost as heroic corpses laid out on cool slabs, the paraphernalia of ablution suggests more personal obsessions and give the impression of a place of masonic solemnity, a necropolis in the manner of Claude-Nicolas Ledoux or John Soane.

Figure 10: Atelier Jullian, Venice Hospital, 3rd project; Detail Plan of patients rooms layout [level 3], 1966

Detail plan and section of typical patient cells, 1965

The analytical way in which the constituent functions are separated allows them to develop pragmatically around and within fixed patterns. The form is not conceived of as developing in a one-to-one relation with the functions but is based on ideal schemata with which the freely deployed functions, with their possibilities of unexpected sensuous incident, engage in a dialogue. The building is both an agglomeration of basic cells, capable of growth and development and a solid which has been cut into and carved out to reveal a constant interaction of inside and outside space. The impression of complexity, is the result of a number of subsystems impinging on schemata which, in themselves, are extremely simple,"[38] yet elegant as is evident in the Rapport Technique[39] by Le Corbusier. The Rapport is a detailed listing of functions of the Hospital – from outpatients, department to emergency services, to performance space, public square, hotel, school, shops, lecture rooms, chapel, and the morgue – and the different user group, each given their place in this tapestry, conveying a strong urban feel.

The Rapport[40] suggests strong emphasis on technological enabled circulation and

37 Hashim Sarkis, *Case: Le Corbusier's Venice Hospital and Mat Building Revival.* (2001)

38 Alan Colquhoun, "The Strategies of the Grands Travaux," in Modernity and the Classical Tradition (Cambridge MA: MIT Press, 1989), p.8-10

39Corbusier, Rapport Technique. Trans. Lucia Allais. source: Hashim Sarkis, *Case: Le Corbusier's Venice Hospital and Mat Building Revival.* (2001)

40 ibid., p.37

communication systems so as to make the vast horizontal spread operate tightly. The three main iterations of the Venice Hospital were produced between 1964 and 1966. “The broad strokes are set in the first, the programmatic complexities are worked out in the second, and in the third the construction logic begins to appear.

Fig…..illustrate respectively the projects’ conceptual outline, its urban density, and the programmatic compartmentalization and logic of internal circulation.

Programmatic consideration of the Venice Hospital Project

Below is a brief comparison of the programmatic consideration of the Venice Hospital as outlined in Le Corbusier’s Rapport Technique (1965) with Alex Wall’s “Programming the Urban Surface” (2001).

The Venice Hospital as opposed to the classical conception of hospitals built and organized vertically, was a ‘horizontal hospital.’ Three main levels were planned.

The first level, on the ground is the level of connection with the city; there one finds the general services and all public access – by water, by foot, and from the bridge across the lagoon.

The second level is the story of preventive care, of specialized care, and of rehabilitation. It is a level of medical technology. The third level is the zone for hospitalization, and the visitor area. The height of the level is 13.66 meters; this dimension corresponds to the average height of the buildings in the city….

The point of departure for the hospital was the room [cellule] of the patient. This element, created at the human scale, gave rise to a care unit, of twenty eight patients, which functions autonomously. This unit is organized around a central space of communication (*Campiello*) and four paths (*Calle*), which are intended for both circulation and inhabitation by patients in convalescence. Four units of care form a ‘building unit.’ *Through the juxtaposition of building units, this framework yields a horizontal hospital. Thus the hospital stops being a static organism and acquires a flexibility required both to follow the evolution of medical innovations and to accommodate the possibility of future growth. The hospital department can be interchangeable and will be used in accordance with the changing needs of the hospital*. The care units receive indirect natural light that helps to create the best possible conditions for the patients. On the same level the patient will find the conditions of the city life, upon entrance into the “Calle,” the Campiello,” and the hanging gardens.

For the patient, a more comfortable hospitalization represents, in fact a more effective cure, which is always more economical. This means that one must go beyond the step of curing and emphasize the preventive and rehabilitation capabilities of the hospital. This *process presumes a medical organization based on teamwork, and for this reason the second level is conceived in such a way that the medical services that it contains….can be used indiscriminately by all hospitalization services*. This level is exclusively reserved for the medical staff, except for the circulation space, which is directly linked to the first floor and is used for prevention and rehabilitation…

By opening the ground floor directly onto the city, one allows for a city-hospital encounter and facilitates the visual transmission of medicine towards the outside. In this way the outpatient … will find himself *within reach of all the services that facilitates their contact with a hospital (prevention, therapy, rehabilitation). The hotel, the restaurant, the cinema, the shops, etc,. will effectively enable this integration with the city*, allowing many patients to be treated without being hospitalized, and thereby allowing the beds available inside the hospital to be occupied more reasonably….. The *Unite de soins*, the *Campiello*, and the *Calle* serve to create relationship between the patient and the city.

The various specific functions – patients check in, emergency care, visitors, etc. - are all given a point of contact with the ground at level 1, which is organized vertically to lead to their corresponding levels and spaces. The horizontal network of shallow ramps on the fourth floor is reserved exclusively for the patients and medical staff; it ensures their circulation all the while prohibiting the passage of patients into the services areas where they do not belong. The fifth story is thereby left entirely for the use of hospitalized patients and their visitors."[41]

Similar design consideration is formulated by Alex Wall in his argument, according to him the "goal of *designing the urban surface is to increase its capacity to support and diversify activities in time – even activities that cannot be determined in advance – then the primary design strategy is to extend its continuity while diversifying its range of services*. This is less design as passive ameliorant and more as active accelerant, staging and setting up new conditions for uncertain futures.[42] He further believes that the "traditional notion of the city as a historical and institutional core surrounded by postwar suburbs and then open countryside has been largely replaced by a more polycentric … metropolis. Here multiple centers are served by overlapping networks of transportation, electronic communication, production and consumption. Operationally, if not experientially, the infrastructures and flows of material have become more significant than static political and spatial boundaries. The influx of people, vehicles, goods and information constitute … "daily urban system" painting a picture of urbanism that is dynamic and temporal.[43] The emphasis shifts here from forms of urban space to process of urbanization, processes that network across vast regional – if not global – surfaces.[44]

Unlike the treelike[45], hierarchical structures of traditional cities, the contemporary metropolis functions more like a spreading rhizome, dispersed and diffuse, but at the

41 Corbusier, Rapport Technique. Trans. Lucia Allais. source: Hashim Sarkis, *Case: Le Corbusier's Venice Hospital and Mat Building Revival.* (2001)

42 Alex Wall drew his formulation from James Corner, "Field Operations," (unpublished lecture notes). Rem Koolhaas, "Whatever happened to Urbanism?" in S,M,L,XL. (New York: Monacelli Press 1995), 958-97; and Stan Allen "Infrastructural Urbanism," in *Scroope* 9 (Cambridge: Cambridge University Architecture School, 1998), 71-79.

43 J.S. Adams, ed., Association of American Geographers Comparative Metropolitan Analysis Project: Twentieth Century Cities, vol,4(Cambridge, Mass., Ballinger,1976) and David Harvey, The Condition of PostModernity (Cambridge, Mass., Blackwell, 1989)

44 David Havey, Jusice, Nature and the Geography of Difference (Cambridge, Mass., Blackwell, 1996)

45 Christopher Alexander made similar argument in his essay entitled: The City is not a Tree." Dated…

same time infinitely enabling[46]."

According to Guillermo Julian de la Fuente, he tested the urban ideas considered in the Venice Hospital at a broader scale between 1969 and 1970 in a competition project for the renovation of the waterfront of the city of Cuomo.

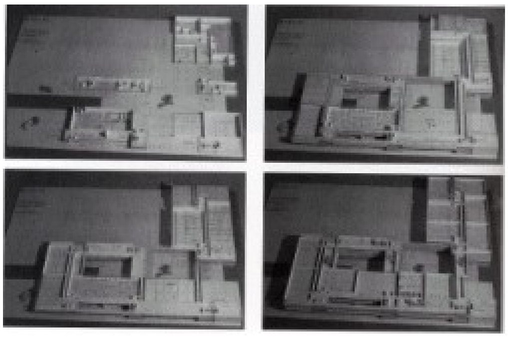

Figure 11: Jullian, sequence of models Figure12: Jullian, competition project for
the urban depicting spatial relations in patios renovation of Cuomo, Italy
1979-70.

Final Version 1970.

After visiting and analyzing the city, studying its Roman fabric, and reviewing the spatial relations of Giuseppe Terragni's work, Julian decided to deploy a new urban fabric that following Venice's example, included major public programs and amenities such as theatres, exhibition halls, and parks. "The structure is permeable to the lake underneath" he said. "Without facades, this structure is in reality conceived within the spirit of an open and flexible program."[47] For Jullian, the Cuomo project is part of the same research he undertook for Venice, in this case taking the Roman city as a starting point. Here the project is a reiteration of the Venice principles, but influenced by the existing plan of the city and its texture. For Julian, projects like Cuomo or Valencia are part of that continuous search for ways to operate at such scale, and these experiments generated a process of cross-referencing that always converged on Venice as a point of departure and arrival.[48]

As Julian puts it; "It is very important to remark that the idea was not to create a block or wall towards the city … In Venice there is this special characteristic called the "transenna," that is the way buildings water and light merge into a completely different condition where there are not single buildings any more but *generates* a whole architectural compound.[49]

This architectural compound is an active entity, the "activity becomes a way of describing both the presence of a building, as well as the presence of an urban field."

46 Giles Delluze and Felix Guattari, "Rhizome" in A Thousand Plateaus: Capitalism and Schizophrenia (Minneapolis: University of Minnesota Press, 1987), 3-27; and Corner , "Field Operations."
47 Perez de Arce, 120
48 Pablo Allard, 'Bridge over Venice: Speculations on Cross-fertilization of ideas between Team 10 and Le Corbusier [after a Conversation with Guillermo Julian de la Fuente]' source: Hashim Sarkis, *Case: Le Corbusier's Venice Hospital and Mat Building Revival.* (2001) p.30-31
49 ibid.,
50 Andrew Benjamin, "Opening Resisting Forms: Recent Projects of Reiser and Umemoto," in Reiser and Umemoto – Recent Projects. 40 Academy Editions, 1998

According to Hashim Sarkis, in the Venice Hospital; “the programmatic-change kind of flexibility caters to shifting functions within the building and to growth both outward and inward. Relocating departments within this framework is made easier by the layering of the hospital into three strata….The radical change in the Venice Hospital is in the way the building transform into a series of network themselves and these networks acquire their shape from an external rather than a programmatic source. The horizontal and block attributes of the hospital are juxtaposed against, rather than derived from, the program. They come from the city. The growth of the hospital is also made in increment of the city, not in increment of the internal module. Thereby articulating in essence an excellent example of generative architecture.

The urbanization of the building program made possible the consolidation of this scale of institution with modern life. This is one of the main attributes of the Venice Hospital and one that distinguishes it from other iconic mat buildings like the Berlin Free University.”[51] The Berlin Free University remained the key example in the ‘Rational Architecture’ sensibilities of the 1960s.[52]

Conclusion

As noted above, Le Corbusier’s city grids, domestic layouts and the Modular do merit a consideration, as an ideal example of the spatial innovations of the new sciences, thereby providing a homogenous, quantitative, infinitely extensible continuum.

Jack H. Williamson read this into the alleged ‘dematerialization’ of Le Corbusier’s interiors and christens it the ‘anti-object paradigm’. He considers this spatial development to be parallel to the loss of autonomous individuality under the new collectivist and determinist social and psychological sciences.[53]

Andrew McNamara similarly read Le Corbusier’s grid as an evidence of a desire to collapse all boundaries – natural, spatial, social and aesthetic – into an undifferentiated field. Le Corbusier is apparently committed to imposing this field at all levels, ‘to transform it into a broad social vision encompassing every aspect of life’.[54]

According to Richards; although the above readings may be applicable to other modernists grids, they are not applicable to Le Corbusier.[55]

In contrast to Richards, Stoppani in her essay entitled, *The Reversible City:*

Exhibition(ism), Chorality and Tenderness in Manhattan and Venice [2005]

believes that both Manhattan and Venice represent unsolved complexities for themodernist discourse in architecture[56] and therefore the Venice Hospital project

51 Hashim Sarkis, ‘The Paradoxical Promise of Flexibility,’ in *Case: Le Corbusier’s Venice Hospital and Mat Building Revival.* (2001)

52 please refer to my paper on Comparative Analysis: VH and BFU

53 Williamson, 1986, p.15-30, 23 mentioned in, Richards, 2003, ‘notes to pages 108-10’ p.239

54 McNamara, 1992, p.60-79, 65 mentioned in, Richards, 2003, ‘notes to pages 108-10’ p.239

55 Richards, ‘notes to pages 108-10’ p.239

56 Terresa Stoppani, The Reversible City:Exhibition(ism), Chorality and Tenderness in Manhattan and

did support Le Corbusier's articulation of an *infinitely extensible continuum*. And a ideal place to explore generative architecture.

According to Stoppani [2005], Anti-modern (Manhattan) and Venice Hospital project in its attempt at replicating the intrinsic program of the city may have pre-modern (Venice), resist the separations and classifications that the language of the Modernist discourse in a architecture imposes on the urban space…While the many different worlds of Manhattan coexist *because* they are separated and *con*-tained (held together and held inside) by the Grid, *Venice is regulated in her structure but is never contained inside a defined envelope: the interior of Venice flows, overruns, changes, constantly redefines its boundaries. The chorality of Venice is a collective and constitutive process*. Here even the voice of modernism capitulates.[57]

In *Sur Les Quatre Routes* (1941) Le Corbusier acknowledges:

'Venice is a totality. It is a unique phenomenon […] of total harmony, integral purity and unity of civilization.' 'Here everything is measure, proportion and human presence. Go into the city, in its most hidden corners: you will realize that in this urban enterprise one finds, everywhere, *tenderness* [*tendresse*].'[58]

Stoppani goes on to question whether this Venetian tenderness a product of its 'total harmony, integral purity and unity', 'measure, proportion'.

It seems Le Corbusier believed that this certainly was the case. Stoppani argues that; Venetian architectural tenderness – Venice making as a process – seem more attuned to the fluidity of current post-compositional trends in architecture.[59] Or more specifically generative architecture.

Le Corbusier's Venice Hospital project 1964-65 may have been the first and perhaps the finest example in this direction towards of generative architecture.

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57 ibid.
58 Le Corbusier, *Sur Les Quatre Routes* (1941), (Paris: Dënoel/Gonthier, 1970), p. 216 and p. 221.
59 Stoppani, 2005.

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Topological Approximations for Spatial Representations

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Marshall McLuhan once said in his book Understanding Media that *'Environments are invisible. Their ground rules evade easy perception.'* Evasive perception leads to fuzzy representations as shown through Kevin Lynch's mental maps and the Situationists' psycho-geographies. Eventually, spatial representations have to be described through abstractions based on some embedded rules of environmental interaction. These rules and methods of abstraction serve to understand cognition of space.

The Centre for Evolutionary Computing in Architecture (CECA) at the University of East London has focused for the last 5 years on methods of cognitive spatial descriptions, based largely on either behavioural patterns (i.e., Miranda 2000 or Raafat 2004) or topological machines (i.e., Derix 2001, Ireland 2002 or Benoudjit 2004). The former being agent based, the latter (neural) network based.

This year's selection of student work constitutes a combination of cognitive agents + perceptive networks, and comprises three theses:

Tahmina Parvin (section 1, *p.2*): an attempt to apply a Growing Neural Gas algorithm (GNG) - an extension of the traditional Kohonen SOM (self-organizing feature map) - to spatial representation. This follows as a direct consequence from previous work (Derix 2001 and Benoudjit 2004) where the rigidity of the simple SOM topology during learning became problematic for representation.

Renee Puusepp (section 2, *p.10*): an experiment to create a genuinely intelligent agent to synthesize perception. This work also uses the connectionist model as a basis for weighted learning. Agents learn to direct themselves through environments by distinguishing features over time using a type of weighted behavioural memory.

Timothy Lau (section 3, *p.16*): a route finding method as outcome from an ant-colony algorithm constraint through way-finding operations and an environmentally generated topology. This work was stipulated by 'live' architectural briefs to solve health-care lay-outs.

All three projects are in development and promise to be explored further. Their relevance cannot be underestimated at a time when so called 'smart' technologies seem to have been exploited and the demand for self-regulating 'intelligent' media is growing. This means for architects that they will need to understand the occupants' perception and their behaviours in more depth by using such simulation methods like the ones presented below:

+ section 1 +

GROWING NEURAL GAS. SELF-ORGANIZING TOPOLOGIES FOR SPATIAL DESCRIPTION

Abstract

Space can cognise itself from elements of social system and can be self-generative at the same time. Architectural space can be visualized as an autonomous, adaptive and intelligent-complex system coupled with other autonomous complex system. Adaptive behaviour of autonomous artificial system of growing neural gas is exploited as a model of cognitive process for built environment. Cognition can be defined in terms of ability to respond to the environmental events, and the 'stimulus' is the part of environment that is absorbed by the structure of the model. Space can be expanded, deformed, fragmented, decayed and above all self-organized by learning from constituent of environment.

Programs or events can be constructed by combination of actions and can be represented as point intensity on probability space. Space is constructed by intentional actions of individuals. Growing neural gas can be viewed as a 'distributed representation technique for the spatial description' of space, can learn and adapt itself according to point intensity on space.

Different space – time conditions can create topological displacement and variation in spatial character.

In general, the discussion is about the morphology of growing neural gas as an artificial autopoietic system and how it can couple to relevant features of the environment, as a two-way learning mechanism. The model's synergetic construction of topology is a mental construction towards a theory of space.

Space can be viewed as open, complex and self-organizing system, which exhibits phenomena of non-linearity and phase-transition.

The notion of spatial cognition

Spatiality refers to mental perception of space, mapping environment and behaviour.

Spatial analysis is about the interrelationships between behaviour and properties of the man-made environment. It is about the techniques that objectively describe environments. This description can be related to specific local level phenomena of human behaviour such as vision, movement, perception, action or particular global phenomena of complex system.

Cognition or 'knowing' is the perception of environmental change. It is the design process in nature and artificially intelligent system. Pointed out by Herbert Simon, *any entity, be it natural or artificial, that devises courses of action aimed at changing existing situations into preferred ones* (whatever they might be), *can be said to engage in design activity* [Simon, 1981].

Cognition can be modelled as the embodied, evolving, and interaction of a self-organizing system with its environment as a design process in nature. Time-dependent cognition is an essential component of life or artificial life. All living systems or artificially living systems are cognitive systems. Cognition is simply the process of maintaining itself by acting in the environment.

Maturana and Varela define 'cognition' in terms of basic ability to respond to environmental events. Design is a cognitive activity that all humans, other living beings, and the intelligent machines, are engaged in. The nature of design activity is highly diversified, as the underlying cognitive processes involved in different domains are fundamentally different.

Space is a container, and action is what we do within it. A kind of natural geometry is generated by actions and movements on space. As an example, a group collectively define a space in which people can see each other, mathematician defines it as ‘convexity of space’, and represents it by points on space.

Formal and spatial aspects of architectural and urban design are known as ‘configurational’ research techniques, which can easily be turned round and can be used to support experimentation and simulation in design. This way is one kind of attempt to subject ‘the pattern aspect of elements in architecture’ to rational analysis, and to test the analysis by embodying them in real designs.

Spatial scales can be local and global. The local scale deals with immediate neighbours and global scale deals with overall spatial configuration.

Graph-based topological model in archiectural spatial analysis

Graph-based operationalizations of space, which are used for mental representations of environment in the field of architecture and cognitive science, describe environment by means of nodes and edges, roughly represent to spaces and their spatial relations. Edges implement relationship between nodes. Graph-based model is flexible, extendable, and its’ generic framework with straightforward algorithms help to solve specific higher-level questions regarding architectural spatial issues.

Mental representations of space cannot be seen independently from the formal and configerational properties of the corresponding environments. At the same time, formal description of a space as used in architecture gain rationality by incorporating results from cognitive research, which give the prediction and explanation of actual behaviour of the system. Graph- based diagrammatic analysis deals with theory of space gives quantitative expression to ‘elusive pattern aspect’ of architectural and urban design. It is a ‘neutral techniques’ for the description and analysis of the ‘non-discursive’ aspects of space and form. Graph based models are used for quantitative comparisons between spatial configurations in order to identify the essential properties in terms of function or usage. It is considered as strictly formalized description system of space. Beside applied research, graph investigations in architecture particularly concentrated on methodological issues such as the analysis techniques on arbitrarily shaped environments on variable scale levels and on the formalization and automation of the graph generation process within certain complex spatial system.Turner, Dexa, O’Sullivan, & Penn (2001) have proposed visibility graphs in different way to optimise the computational graph analysis. Visibility graphs replace the isovist as node content by inter-visibility information translated into edges to other nodes. Visibility graphs are useful to predict spatial behaviour and affective qualities of indoor spaces.

Neural networks and graph-based topological representation

Knowledge is acquired by the network from its environment through a learning process and Interneuron connection strengths are used to represent the acquired knowledge. The every single unit could be the metaphoric representation of an individual entity and lines could be communication links. A neural network can be represented as a graph consisting of nodes with interconnecting synaptic and activation links.

Self-organizing neural network: Growing Neural Gas

Self –organizing neural network models were first proposed by Willshaw & vonder Mlalsburg (1976) and Kohonen (1982). The networks generate mappings from high-dimensional signal spaces to lower dimensional topological structures.

The "growing neural gas" algorithm of Martinetz & Schulten (1994) seems to produce compact networks, which preserve the neighbourhood relations extremely well. The network has a flexible as well as compact structure, a variable number of elements, and a K-dimensional topology. The algorithm is considered as spetio-temporal Event Mapping (STEM) architecture. It can be viewed as decentralized model of human brain learning process or decentralized model of cognition.

Martinetz (1994) introduced a class of Topology Representing Networks (TRN), which belongs to Dynamic Cell Structures (DCS), build perfectly topology preserving feature map. DCS idea applied to the Growing Cell Structure algorithm (Fritzke 93) is a more efficient and elegant algorithm than conventional models on similar task. Growing Neural Gas (GNG) is a class of Growing Cell Structure. It differs from Growing Cell Structure through its less rigid topological definition.

GNG only uses the parameters that are constant in time. It employs a modified Kohonen Learning rule (unsupervised) combine with competitive Hebbian learning. The kohonen type learning rule serves to adjust the synaptic weight vectors and Hebbian learning establishes a dynamic lateral connection structure between the units. The new model of growing neural gas can be said the extension of Kohonen's feature map with respect to various important criteria (Fritzke, 1993a).

Two basic differences with Kohonen SOM:

1 The adaptation strength is constant over time. Specifically used constant adaptation parameters e_b and e_n for the best matching unit and the neighbouring cells, respectively.

2 Only the best-matching unit and its direct topological neighbours are adapted.

Neural gas as a connectionist model (Donald Hebb 1949)

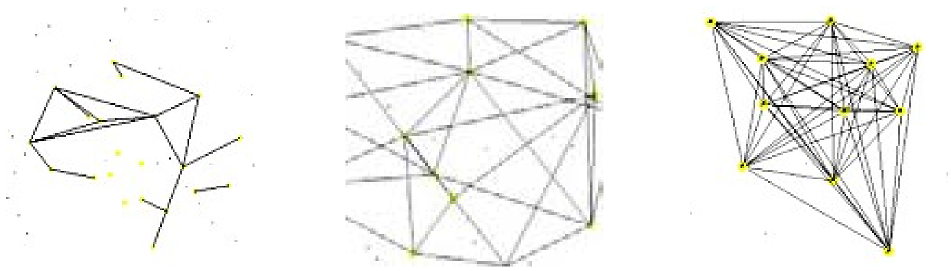
Brain operation can be modelled by means of a network of interconnected nodes. Each Node takes the sum of its inputs and generates an output. The output is determined by the transfer function of the node, which has to be non-linear. The connection (synapse) between any two nodes has certain ‘weight’. The information flows only in one direction. Complex behaviour emerges from the interaction between many simple processors that respond in a non-linear way to local information.

The characters of connectionist models are:

1 High level of interconnectivity

2 Recurrence

3 Distributedness (described algorithmically)



sparsely connected fully connected richly connected

GNG connectionist model consists of a large number of units, richly interconnected with feedback loops, but responding only to local information.

The process of autopoiesis

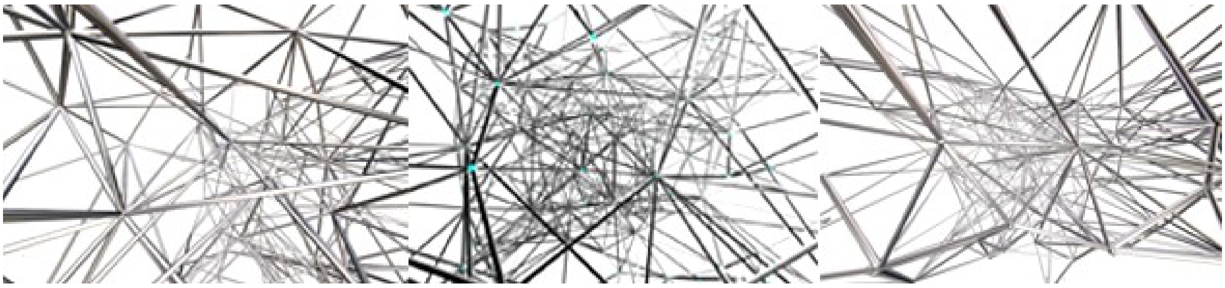
An answer lies in the pattern characteristic of all living systems is autopoiesis, a network pattern in which each node is a production process that produces or transforms other nodes. The entire network continually produces itself. The pattern & process of interaction are called autopoiesis & cognition. Thus, autopoiesis is the pattern by which life emerges in dissipative systems and cognition is the very process of life itself.

Virtually autopoietic system can be understood in terms of networks or systems with very simple rules of interaction. These simple rules can lead towards immensely complex sequences. Networks are systems composed of interconnected parts. Relationships between parts are circular (closed loop). This causes feedback because the actions of each component "feeds back" on itself. Both positive and negative feedback is possible.

Autopoiesis generates a structural coupling with the environment: the structure of the artificial system generates patterns of activity that are triggered by perturbations from the environment and that contribute to the continuing autopoiesis of the system. Maturana argues that the relation with the environment moulds the "configuration" of a cognitive system. Autopoiesis is the process by which an organism continuously re-organizes its own structure. Adaptation consists in regenerating the organism's structure so that its relationship to the environment remains constant. An organism is therefore a structure capable to respond to the environment. Autopoiesis is a self-generating, self-bounded and self-perpetuating process.

Growing neural gas as a autopoietic representation of space

Growing Neural Gas can be an advance tool for visualization of emergent spatio-temporal correlations between different entities on space. The point intensity of signal space can represent activity intensity on a three dimensional space. More program intensity will generate more signals on space, which means more stimuli to enhance the system operation.



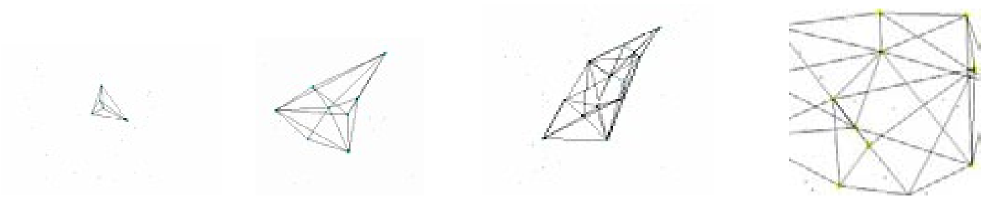
Self-organizing growing neural gas

Model description

Current work

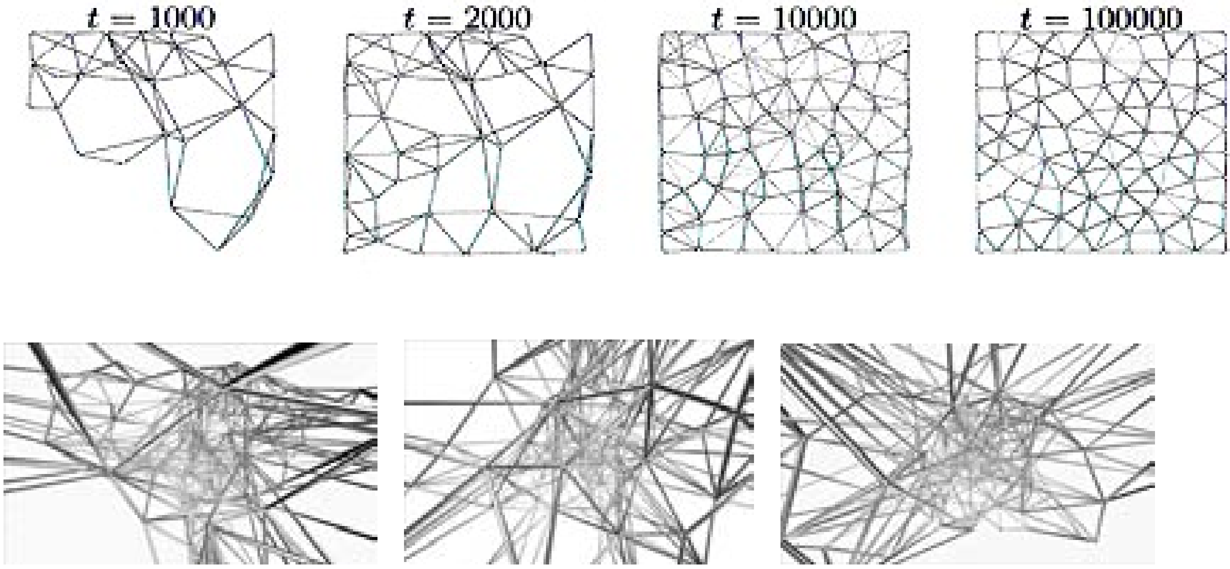
Initially, the model is an unsupervised self-organizing growing neural gas algorithm. It has some randomly moving points on three dimensional spaces, which are denoting the signal intensity on the space. The signals movements are based on Brownian motion.

The network start with more than three units (k > 3), that means with connecting edges it forms a hyper tetrahedron, which ultimately lead towards k-dimensional simplex.



k-dimensional simplex

At first the system shows a chaotic way of growth and decay and topological displacement. But after a certain period of time, after it has reached to the maximum growth level, self-organized itself within the three-dimensional signal-space. It gives a topology preserving networks of nodes. In this self-organization, every unit deals with its compact perceptive field with its' nearest neighbours, which ultimately gave a compact volumetric topological expression of the space.

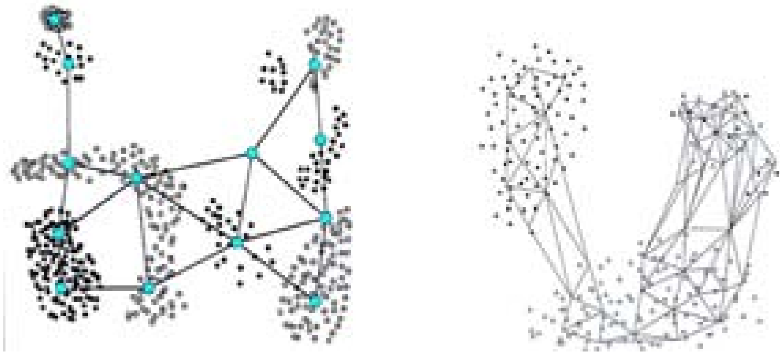


GNG Topologies after thousands iterations

Projected work

Further work will combine the GNG with a supervised Radial Basis function (RBF) which will give more potential flexibility to the model and to the clustering of elements.

Otherwise, the Ant-based clustering algorithm and growing neural gas networks can be combined to produce an unsupervised classification algorithm that can exploit the strengths of both techniques and can be more flexible to describe autopoietic space. The ant-based clustering algorithm detects existing classes on a training data set, and at the same time, trains growing neural gas networks.



GNG with Radial Basis Function

In later stages, these networks are used to classify previously unseen input vectors into the classes detected by the ant-based algorithm. The advantage of this model above GNG model is that the dimensions of the environment don't need to be changed when dealing with large databases.

CONCLUSION

In this discussion, the goal was to establish self generating growing neural gas as an tool to visualize autopoietic complexity of architectural and urban space. The model is exceptional for its' growth process through cognition, the occasional death of units and self-generation; all of which belong to the core concept of life. The initial model is a simplest form of growing neural gas model and an abstract representation of design space.

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+ section 2 +

Synthetic perception. Processing spatial environments

Abstract

The way we perceive the environment around us is inseparable from our decision-making and spatial behaviour. Learning to find one's way around in a foreign city does not rely only on one's cognitive skills, but it is also dependent on the clarity of urban layout. Computational models have proven to be highly useful in simulating various aspects of sensory-motor conduct, and help to explore the fundamental principles of environmental behaviour. The proposed paper employs algorithms to assess intelligibility of spatial arrangements, and suitability of these algorithms to elucidate the processes of cognitive mapping. During the exploration of digital models, semi-autonomous agents develop a set of formal rules to interact with the environment.

Introduction

Architectural space is full of cues. These cues, either intentionally designed or randomly established, determine the way people use the space. If features of space happen to give misguiding signals, space becomes inefficiently used. One can argue that environment has some sort of intelligence that communicates with its inhabitants; one can even claim that people are capable of magnifying this intelligence. There can be a certain kind of embedded intelligence in the environment – an intelligence that makes the environment literally speak or automatically adjust itself. However, speaking of traditional urban environment, there can be only embedded intelligibility. The intelligibility of space determines the capability of being understood by an intelligent inhabitant. In other words, the space does not contain any self-explanatory information *per se*; it is the observer who carries the meaning with him. From that point of view, the space is unconscious medium like a piece of paper. Merleau-Pointy [1] sees intelligible space as an explicit expression of oriented space that looses it meaning without the latter.

Spatial behaviour is very much affected by one's knowledge of the space and vice versa. The perception of space is never static but evolves over time. Perception is locked in a reciprocal dialogue with the movement of the inhabitant. The way the environment coerces us to move, can be more or less in conflict with our natural movement, which is defined by the proportions of our body and by the speed of the locomotion.

An organism's ability to learn is strongly related to its position in the evolutional timeline. Higher organisms have less intrinsic behavioural patterns, and depend more on their experience. Environmental learning involves obtaining appropriate sensory-motor conduct, and storing spatial information for future use. In literature, such stored environmental data structures have been referred as cognitive maps [2] and environmental images [3].

This paper considers cognitive mapping – also known as mental mapping – as a method to collect, restore and retrieve environmental information. Maps are representations of the environment, acquired through direct or mediated perception. Psychologists and geographers have used the term 'cognitive map' for decades in context of way-finding and environmental behaviour [4].

The cognitive map possesses a kind of continuity; a certain procedural or algorithmic sequence that we follow in order to get from one point to another. The map is more a routine-like description, a behavioural description of an environment rather than a structural description of surroundings. From architects' and city planners' point of view, it is worth studying the process of cognitive mapping and its major shapers, because it could reveal the fundamental principles behind environmental decisions.

Artificial perception of space

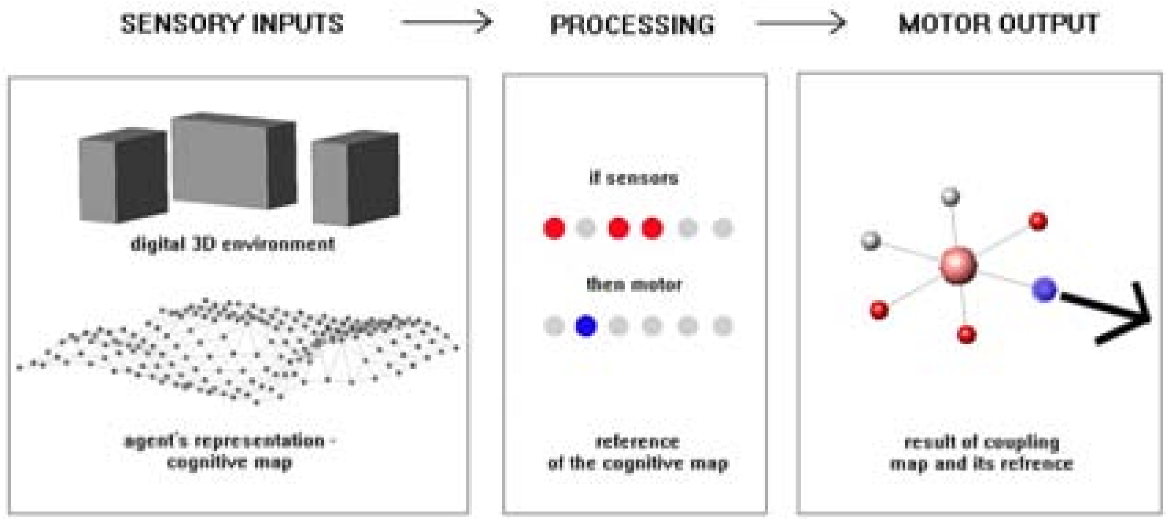
This paper explores a contingent way to approach processes of cognitive mapping using computational methods. It is impossible to explain the full range of natural cognitive mapping with computational models, but these models still provide some helpful insights. The usefulness of these maps is best displayed in unravelling wayfinding difficulties within multi-agent environment. The proposed algorithm tries to exhibit essential parts of cognitive mappings such as collecting, storing, arranging, editing and retrieving environmental data.

Flow of the algorithm

The algorithm under review benefits from several well-known concepts. The goal of the agents is to find a way to an assigned target point while interpreting sensory input and leaving some trails into the environment. Successful agents are awarded by upgrading their value; the value of a non-successful agent is reduced to minimum.

Agents are using a combination of computational *cognitive map*, which is agent's representation of the environment, and syntactic instructions that determine how that map is interpreted. An agent is 'born' *tabula rasa* – the evolution of the map and the reference to it happens during its interaction with the environment. Conception and fade-out of cognitive data is simulated using pheromone trail algorithm – last visited spots contain more information than formerly visited ones. Syntactic instructions have to develop and change according to this dynamic environment. The pursuit of targets is facilitated by trivial vision. If the visibility line between the agent and its target is clear, the agent takes an automatic step towards the goal.

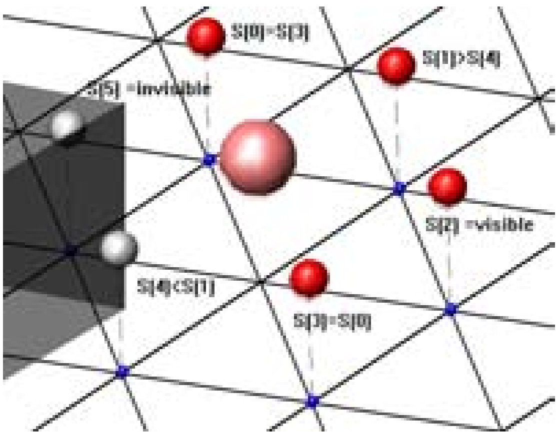
Besides individual learning, the development of an agents' syntactical instructions also takes place at a phylogenetic level. Evolution of agents is similar to evolution of Braitenberg's vehicle type 6 [5]. A single agent is chosen for reproduction. However, in the process of reproduction only 75% of syntactical instructions of the agent have been transmitted to its *offspring*. The selection of the *parent* agent is partly up to chance – the best (by value – see above) of a subset of randomly selected individuals gets the honour to be copied.



1. Input-output coupling. Agent obtains input from digital environment and from the *cognitive map*. Output is generated interpreting input according to syntactical rules (reference of the *cognitive map*).

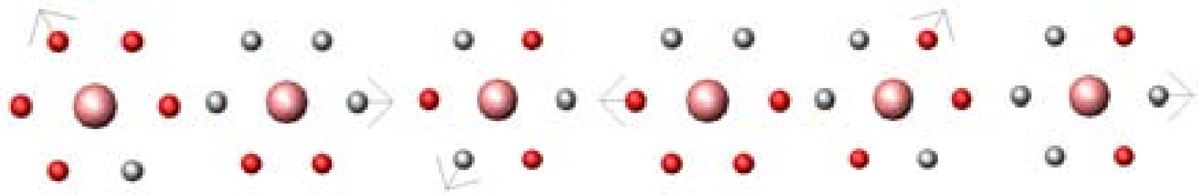
Design of the agent

The design of the agent is fairly simple. The visible entity of the agent consists of the central 'body' and six sensors attached to it to form three symmetry axes. The consideration behind the hexagonal design was to give agents sufficient liberty of motion retaining the symmetry and thus leaving undefined the *front* and the *back*. Sensors are combined into three identical axes which have a major influence over the activation function (see image no 2). Each sensor-axis has four possible states: two polarized states (only one sensor active), both sensors active, and both sensors passive. All three sensor-axes together yield to a sensory space with 64 possible input combinations. Sensor morphology is invariant, which means that the body plan of the agent is not capable of evolving over time.



2. Sensory input. Sensors acquire their value from the closest nodes. The value is then compared to the value of diametrically opposite sensor. Red sensors are activated.

The output space, or the motor space, is much smaller containing only six possible directions. The agent can take only one step at a time, and cannot combine different directions. Although the motor space is relatively small, the mapping of inputs to outputs results in 384 different combinations. The agent's behaviour is simply controlled by a list of input-output matches, and is completely undefined when the agent comes into being. The agent has to create the controller itself by interacting with the digital environment constantly comparing the input-output mapping (henceforth: *syntactic memory*) to environmental affordances. The *syntactic memory* consists of two layers: long-term and short-term *memory*, where the latter acts as the verification layer to buffer to the long-term *memory*. In addition to the controller, the agent possesses some persistence in its action – if the sensory input appears to be unfamiliar, the agent continues in the previously chosen direction.



3. Syntactic instructions. Agents gain different syntactical instructions to map inputs to output. 75% of these instructions are being passed to 'offspring' to maintain diversity and explorative ability.

Design of the environment

The term 'environment' obtains ambiguous meaning within the context of digital computers. In most cases, digital environments are just representations, and therefore leave some room for human interpretation. Although, in order for true intelligence to emerge, people in the field of embodied cognitive science strictly insist on using the world as its own model [6]. The complexity of cognitive mapping, however, encourages exploitation of virtual worlds.

This paper addresses the digital environment from the agents' point of view, thus omitting the observer's perspective. The three-dimensional data ceases to be a representation for agents, and becomes adequate *environment* for them. Agents, in turn, create a representation of this *environment*, which can be interpreted as a *cognitive map*. The *map* is laid over the *environment* only for observational considerations, but it can actually be an integral part of the agent.

The *cognitive map* is a hexagonal network of interconnected nodes. Each node contains one or more values (or *vectors*). If stepped on by an agent, these vectors are adjusted according to the success of the agent. A node is just a passive piece of information – agents gain meaningful knowledge by comparing adjacent nodes. Nodes also have a tendency to forget their values gradually causing the information on the *cognitive map* to fade away.

Observational notes

The progress in agents' behaviour and development of the *syntactical memory* and the *cognitive map* tends to follow a standard pattern. As the first meandering agent finds a way to its target, all nodes of the *cognitive map* the agent has stepped on are positively adjusted. When the agent tries to repeat the same route, it may turn out that instructions in the *syntactic memory* do not match the modified *cognitive map*. Thus, new instructions have to be invented to 'read' the trail left behind by the first agent. If the next agent is capable of finding the target in slightly changed situation (with positively adjusted nodes), it reinforces the trail on the *cognitive map*, and appropriate reference have been generated to interpret this map.

Certain features of the *environment* facilitate wayfinding, especially those that suit the agents' 'anatomy' and gestural traits most. It is not always the shortest route that becomes most popular – it is usually the most suitable route for particular kind of agents.

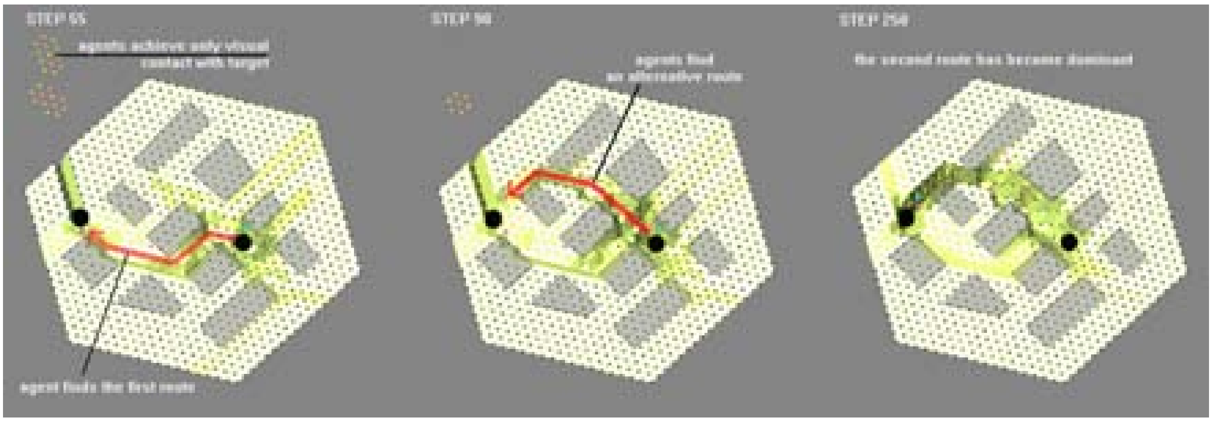
Few interesting behavioural phenomena can be pointed out:

a) Agents acquire different techniques to move around in the *environment*. Some of them try to keep away from environmental obstacles, others, in contrast, obtain 'wall-following' tactic.

b) Some agents tend to travel to locations where they have clear visual contact with their target, without actually getting closer to the target.

c) If a route to the target has been found, some agents still keep exploring and finding other ways than the established one. The firstly discovered route does not necessarily become the most used one.

d) Unplanned competition between different 'species' occasionally takes place. The nature of pheromone trail algorithm prevents agents to use the same trail in both directions. One way 'traffic' tends to force the other way out



4. In search for targets. Environmental features have crucial role in competition between popular routes. It is not always the shortest route that is preferred by agents.

Conclusion

The results of the undertaken computational experiment are not comparable to behaviour of biological organisms and organizations, which are vastly more complex and beyond the reach of the present work. However, even simplified and abstract simulations can guide us to towards a deeper understanding of some mechanisms behind complex systems. In that light, simulated artificial agents become a simplistic synthetic species.

Synthetic perception of architectural space is potentially a powerful concept. Besides the speed and the accuracy, it could help us explicitly define essential design parameters, and critically assess our own methods of work. Although computational models are far from displaying similar performance to human perception, we can learn a lot about ourselves by simulating some aspects of spatial behaviour. Computational experiments could reveal some fundamental rules of interaction between inhabitants and their environment, which are likely to hold true also in more complex context. As Kelly [7] points out, complexity has to be build bottom-up using simple comprehensible units, rather than deconstructing entities that perhaps have evolved over million of years.

Perception is a prerequisite of any intelligent action. If an architect desires to employ a semi-autonomous agent to automate some design tasks, artificial perceptual mechanisms obtain crucial importance. The agent has no use in generating spatial organizations if it is not capable of reacting to spatial stimuli

Possible alterations and future orientation:

· Evolution of agents' sensor morphology and body plan

· Agents with neural network controllers to 'learn' intricate concepts

· Agents generating spatial constructions

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+ section 2 +

Route finding for the Built Environment

Abstract

The task of designing a well-planned group of spaces, still possess a fundamental problem for designers of the built environment. In our cities and buildings, the chaos of multiply users and their routes through the built environment seems to be getting worse, not better. Much of the problems with poor route planning logically fall on the heads of those who design and allocate the uses for each of the spaces in the first place. But how much of the blame can be put upon the designers? Many such problems only become apparent when the building are built and put into use. How can we predict when and where the interactions of users moving through the proposed spaces will result in congestion and problems, especially when the spaces that we can create become more and more complex?

Introduction

There has been a great deal of research into wayfinding and perception of the built environment done in the past 10 years. But, as Ruth Dalton observes in the second chapter of her paper on such studies…

"There has been little research undertaken into direct relation wayfinding performance back to the design of the Environment."[1]

Due to the heavy amount of information that has to be embedded into the plans, or the crippling computational expense for programs of this nature, most wayfinding programs are tested after plans and spaces have been finalised. This means that the results of the experiments have little or no effect on the spaces tested. If a tool can be developed that doesn't require the user to spend larger amounts of time embedding information into the plan, and has agents that use little computational processing power, then I believe that testing can happen much earlier on in the design process of the building. Proposed plans could be tested for the efficiency of important routes, adjusted according to the issues that the tool highlighted and then tested again.

How do I plan to achieve effective results whilst avoiding the same problems and pitfalls that are common to similar programs? I hope that, by drawing on emergent phenomena found in nature, I can find a system that gives me solid and replicable results, whilst minimising computational costs. By the term *emergent*, I patterns and outcomes that happen without any apparent cause or leader (One classic example of decentralized, emergent phenomena would be the way that flocks of birds file together in unison. Until the last 15 yrs, the accepted explanation to this was that there was some kind of leader bird in the flock. Now, however, this approach has given way to a decentralised explanation that is based on interactions between individual birds within the flock, Resnick M. 1994).

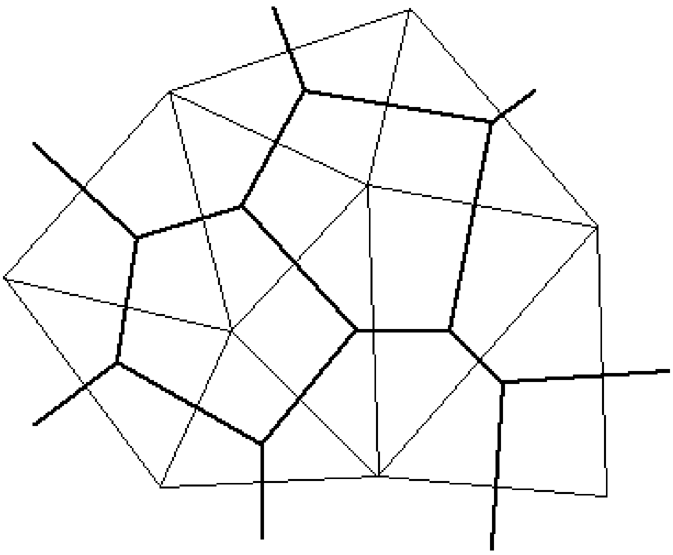
Flock of birds in flight

Plan recognition

First, I need to find a way of forming a grid of patches that can hold its location, and whether or not it was a walkable or non-walkable surface (i.e. a wall or part of an open space). My solution stems from my observations of bubbles. A soap bubbles film is a perfect example of a minimum spanning surface. An important characteristic of a minimal spanning surface is that they are

"Surfaces of minimal surface area for given boundary conditions" [2]

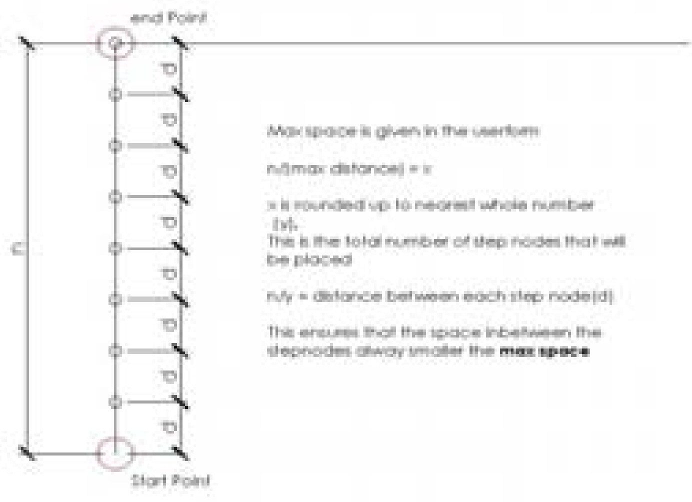
In general terms we can say that the molecules in the bubble skin are evenly spaced throughout the film. This would make logical sense, as the solution is the same throughout, therefore the modules and bonds would also be the same. Each modulus could be seen as seeking an equal distance with its neighbouring molecules. These properties are seen in the tessellations found in Voronoi fields.



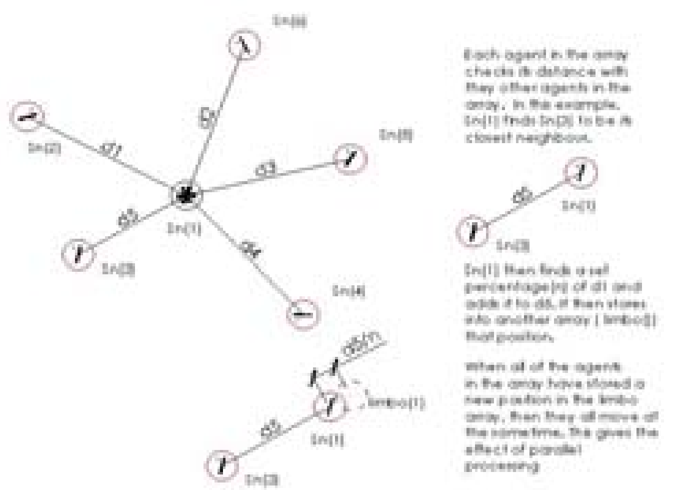
a Voronoi field

With an array of agents that have the similar properties to soap film molecules, I hope to find a quick and effective way of creating a grid, or *field,* of patches. By having either wall properties (places that can not be walk on or through) and space properties (places where one can walk), these agents will form the stepping stone for the next array of agents that will move through the spaces.

The key part of this section of the program lies in the agents creating the even tessellation throughout the plan. This solution to this problem turned out to be theoretically, very simple. After marking out the walls in the plan and dropping groups of agents within the spaces each agent starts by takes a step of a random length in a random direction.



From there, they have a simple goal: to be of equal distance with his neighbours. To get the agents to spread through the plan, they are repelled from one another and the wall-nodes. To break down the processes even more, each agent need only be concerned with its closest neighbour. When its closest neighbour is identified, it moves n% of the total distance between itself and that neighbour.



In order for this to work, each agent needs to perform the search and move at the same time. As true parallel processing can not be achieved on conventional, single processing computer, we mimic the parallel computation by get each agent in turn to find its close neighbour, and store its next move in a “limbo” array of positions. Only when all the agents have found their next position do the agents then move and update their positions visually. Over a period of time, we get the even tessellation of agents.

Route finding

Now that the program has “read” the plan, how does it move through the spaces? The idea of looking at the behaviour of insects that function in large colonies, such as ants, termites and bees, when tackling wayfinding problems, is something that has been widely researched and well developed.

The analogy in social insects to our “routing” problem, would be the way that some species of insects *self organise* to exploit a food source that is closest to their nest. As the authors of “Swarm Intelligence” point out,

“Many ant species have trail-laying trail-following behaviour when foraging” *[3]*

This process of trail-laying and trail-following can be distilled into a program. It stands to reason that if social insects can finding “better” routes to food sources in an uncalculatable variation of situations and terrains, a program based on these emergent phenomena could be just as effective and flexible.

The bases of an A.C.O (ant colony optimisation) algorithm is that it takes each ant as in individual entity. This entity has very simple properties, like the ability to move, lay a scent (pheromone) and also pick up a scent in its local environment. As the ants move away from their nest, they move in a more or less a random sweep until they find a food source. When they have found a food source, they starts dropping a scent and head back to the nest. Over time more ants pick up the scent and follow it thus reinforcing the scent. The evaporation of this scent is just as important to the algorithm as its reinforcement as explained by Bonabeau, Dorigo and Theraulaz.

“*In the field of ant colony optimisation and swam intelligence, common wisdom holds that pheromone evaporation, when occurring on a sufficiently short time scale allows ant colonies to avoid being trapped on a “suboptimal” solution, as is the case for Linepithema humile (a specie of ant found in south America). This is because maintaining a well-marked pheromone trail is more difficult on a longer trail”* [4]

A.C.O algorithms have been used to solve problems like

- *Quadratic Assignment Problems*, the problem of assigning a given number of facilities to a given number of locations so that the costs of the assignment are minimized

- *Job/shop scheduling Problem.* If there are a set number of machines, and a set number of jobs, how can operations be organised so that no two jobs are being processed by the same machine at the same time, thus minimising the time it takes for all the jobs to be completed?

- *Graph colouring problems.* What is the colouring scheme for a graph that needs the least number of colours?

There is also the TSP (travelling salesperson problem) that has become the benchmark for A.C.O algorithms. If a salesperson has n number of cites, what is the shortest route he can take to go through every city only once. The solutions to this problem have been used in telecommunication networks to great effect.

To read more about A.C.O (ant colony optimisation) algorithms and other such phenomena, please take a look at the excellent book, “swam intelligence” that I have referenced at the end of this paper

Here are the rules that I use in my program:

- the number of agents start at a minimum of 50 agents

- initially, our agents have to take random steps on any available step-points (all nodes that Indicate an open space)

- when an agent has found the goal (food source) it then beings its’ way back to the nest.

- when the agent gets back to the nest, if it has made it back within a required numbered of steps, then the route is show and the step nodes that are in that route are weighted (this acts the same way as the pheromone scent)

- the required number of steps back to the nest from the goal will decrease with each successful return so that, overtime, the routes shown will tend towards the shortest.

- the weight of a node with a scent on it will decrease over time. This allows the program to get itself out of a “sub-optimal” route.

To make this process of wayfinding clearer, lets break the program down into steps. A start point, end point and any via points (points that have to be touched whilst going from start point to end point) are placed on the plan. Then the searcher agents follow these steps:

1 Finding their 5 closest neighbours.

2 Each step node has an agent-type value that distinguishes the nodes into wall nodes, step-nodes, and start point, goal point and via point. The searcher agent checks each one and all nodes, apart from the wall nodes, are collected into an array.

3 The array of eligible candidates for the searcher agents’ next step is then effectively put onto a chance wheel. The different step-nodes could be weight differently (how the step-nodes are weighted will be discussed later), giving them a higher chance of being stepped on.

4 A random number is chosen and the step node with that number in its segment of the wheel is the winner. The agent moves to that step-nodes position.

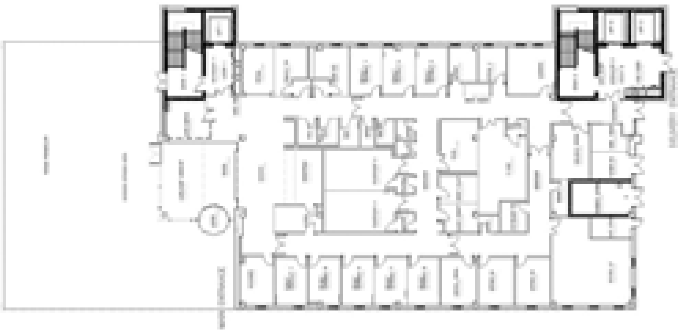
When an agent has found its way to the goal it then starts to find its way back to the start point. From this point it keep track of how many steps it takes and the route it takes back. If it makes it back to the start point while also checking all the via points and doing so within a given number of steps, then the route it has taken is show on the screen.

The step-nodes along the “winning” route are given a scent that gives them a heavier weight when they are placed in the chance wheel. (This acts as the pheromone scent*).* Each step-node also has a timer, and its weight will continue to decrease to zero after a while if it does not continue to be part of a winning route. (This forms the evaporation of the pheromones over time). As the step counter decreases, each route that wins becomes shorter, and the route that the agents take between A to B also decreases. The weighting of the routes allows the chance of the agents to follow the shortest current route to increase whilst also allowing the agents to have a chance of shortening the route via altering the route with random steps.

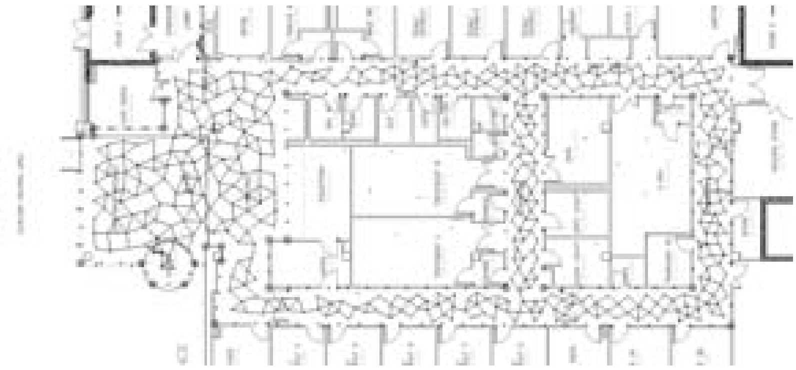
After one route has been successfully found, it can be saved. Any areas in the plan that the user would like to block out to prevent other agents moving through particular areas in the plan can be done so (this is useful if you want to give your first route sole access to a given corridor. The following routes found on the plan would then be found without interfering with this primary route). A new set of agents can then be let loose with a new starting point, end point and via points.

Test Cases

With the main components of the program in place, I thought that it would be a good time to test my program in what could be seen as a real project. An opportunity was opened to me to run my program on the plan of a real project that is being worked on by Aedas' research and development department. The project is to do with a new hospital in London. Here is an image of the ground floor of the hospital.

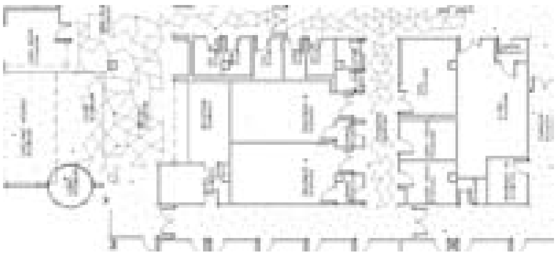


Firstly, we simplify the plan and place wall nodes to define the area that we want to test. We then seed the first array of agents that create the tessellation throughout the plan. To make sure that all the areas that I wanted to test can be reached, I ran my program, but turned the layer with the agents' paths on. This shows me if all the areas could be reached. With this done, I could start testing.

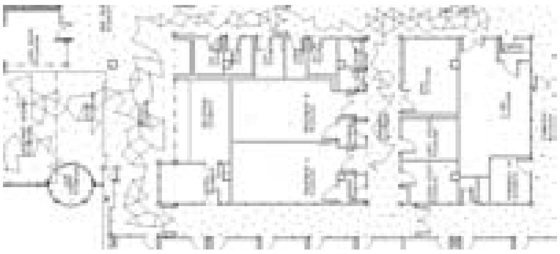


I decided to do a simple test that consists of choosing two destination points from the main foyer. The first route would be the primary route. I would then block out the corridors that the first route used and then run the second route twice: once without the blocked out corridor, and then again with the blocked out corridors.

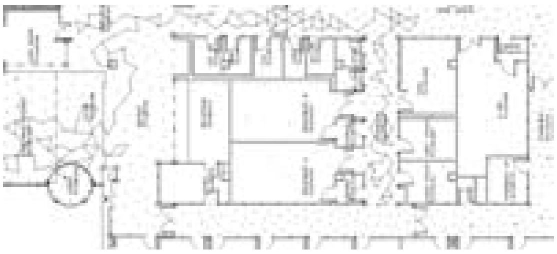
Firstly I asked the program to find a route from the main entrance to "Treatment Room A". Below are different routes the program took to get to its destination:



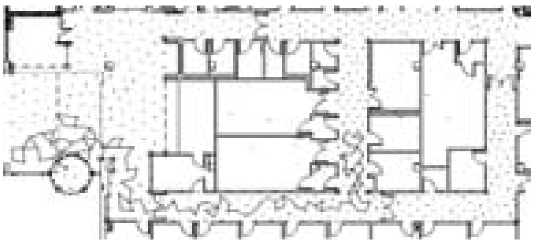
route A



route B

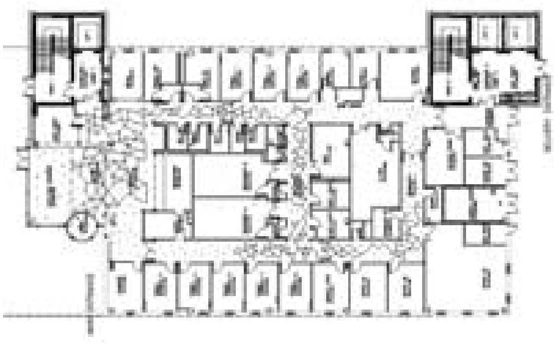


route C

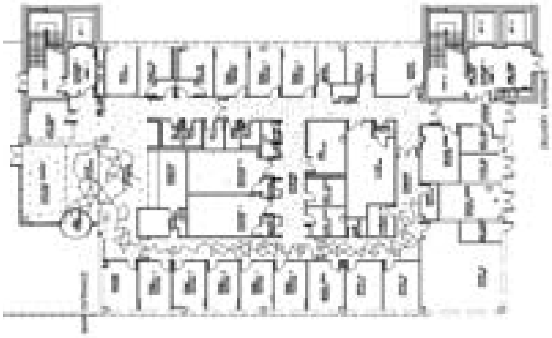


final route

In the next test, the program should find a route from Entrance to “Pharmacy store”:



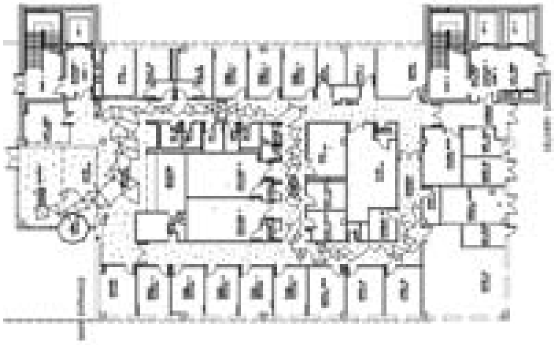
route *n*

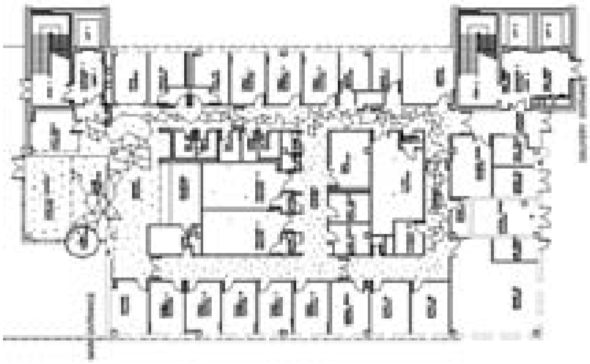


final route

Notice how the final route also uses the lower corridor to get to its destination.

Finally, same destination was chosen again, but this time the route along the lower corridor that the first test established was blocked off:





route *n*

final route

We can see that because the left half of the lower corridor is not available to it anymore, it changes its route to find the next best thing. Although this has been a simple experiment, we can see that the program can read the plan and find a good route between given points in the plan.

Conclusion

The progress that I have made in the short time that I have worked on this program has been promising. I have been able to cover the main goals that I set my self at the beginning of my research:

1 Read a plan quickly and easily.

2 Implement the A.C.O to help find routes between a numbers of points.

3 Save the plan and reuse it again to compare different routes.

Further Development

By being able have multiply routes running simultaneously could result on seeing areas of congestion “as it happens”. I would like to start to refine the selection process of the agent’s next step. Perhaps by introduction a simple system of sight and distance, the movements of the agents can progress towards being less erratic.

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A molecular collision model of musical interaction

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Abstract

This paper speculates on the potential of a limited set of interacting particles to produce interesting temporal structures in a two dimensional world. Particles exchange information locally though global complex behavior emerges spontaneously. The imaginary physics of the world is described in an ensemble of 2D arrays. An autonomous genetic algorithm continuously aims to optimize the arrays in an effort to maximize diversity. In addition, an external user may interfere in a subtle way; external gestures are integrated into the arrays in proportion to their strength. A quite elaborate mapping scheme creates relationships between complex system behavior and parametric MIDI events.

1. Introduction

The present paper formulates a generative system featuring native internal dynamics open to disturbance by unpredictable actions from an external user. It follows the general working hypothesis of much Alife research; life-like phenomena can be studied by building distributed systems composed of many interacting components. Complex global behavior emerges spontaneously from a collection of simple local interactions between the constituting elements. These elements vary widely in dimension and character; consider for instance, communicating newsagents living on the Internet, social forces between people in a given society or molecules engaged in a chemical reaction. The behavior of such systems cannot be envisaged from a critical analysis of its components; in particular, the mutual relationships between components will force a global unpredictable functionality.

In addition, various cognitive abilities have been characterized as distributed, self-organizing systems (Minsky, 85). The fluid dynamics approach of (Hofstaedter, 95) suggests the study of cognitive processes, including creative decision making, as processes of molecular interaction. Again, coherent structures appear from the random flux of continuous interactions amongst molecules. Our work adopts the metaphor of colliding molecules as a first principle and thus also relates to recent work in artificial chemistry (Dittrich, Ziegler & Banzhaf, 01).

Our application proposes a model of musical man-machine interaction based on the real-time interpretation of particles interacting in a closed container. The container may be either of imagined toroidal shape or feature reflective walls. The internal physics of the system, i.e. what happens when any two particles collide, is represented in a 2-dimensional array. The array instructs particles to move in particular directions. The user interferes with this innate behavior by modifying the array through physical gestures. The user does not exercise explicit control but rather disturbs the expression of an otherwise autonomous, internal physical law. The basic idea here is to synthesize families of waves of variable coherence and periodicity. The complexity of the waves follows a law and the user has only limited and indirect instrumental control over the quality of the wave propagation process.

2. Motivation

The present experiment grew from earlier work with cellular automata (Beyls, 04). CA are idealized systems to study complexity in natural and synthetic phenomena but as models they are discrete both in time and space. However, one could actually interpret embedded particles in CA as interacting molecules (Hordijk, Crutchfield & Mitchell, 96). This work interprets domain borders of space-time diagrams in one-dimensional automata as particles. Still earlier work by Ed Fredkin suggests CA as models of ballistic computing. The billiard ball model has great musical potential since its novelty consists in focusing on the detailed evolution in time of an individual microscopic state – in contrast to studying macroscopic quantities based on a statistical distribution of states (Toffoli & Margolus, 86). This collision model successfully performs logical operations using mirrors as routers.

Now, in an effort to generalize, we may think of particles as responsive objects of arbitrary complexity and even equip them with some form of long-term memory. Consider, for instance, people meeting and interacting in a public space. Social behavioral patterns will surface spontaneously. However, the work described here takes the atomic route to complexity engineering; the objects we use feature a single instance variable – the angle of movement -- and cannot remember former actions (no memory).

Related work

The discipline of artificial life has spawned many incarnations of distributed computational models. According to the field of application we speak, for instance, of particles, molecules, agents or artificial creatures. Particle systems have a long history in the computer simulation of complex natural phenomena. They are instructive, early examples of studying complexity by considering relationships amongst small buildings blocks – in contrast to using differential equations. More recent work by (Reynolds, 87) describes the flocking of birds (boids) as an emergent process. The Swarm simulation environment developed at the Santa Fe Institute (Minar, Burkhart, Langton & Askenazi 96) is also a significant example.

The swarm and boids ideas was recently adapted for musical purposes by (Blackwell & Bentley, 02). Swarmmusic is an interactive music improviser. It maps the positions of particles/boids to positions in MIDI space. An external human improviser may act as a temporary target for the swarm. Style-scripts provide additional parametric control over the nature of the interaction thus further conditioning the musical output. Earlier work of the present author has addressed the potential of real-time man-machine interaction in virtual worlds. Four different agents oriented systems aimed at interactive composing are documented in (Beyls, 97).

3. Formal definition

For our purpose, a molecular system is characterized as a tuple *{M, R, A}* where *M* is a finite and fixed size collection of basic molecular building blocks and *R* denotes all possible interaction rules. *A* specifies an algorithm incorporating additional parameters conditioning how and when the rule *R* will be applied. Note that the interaction vessel itself is assumed to remain fixed, it is of no qualitative concern to a formal description.

We consider the density of molecules to be fixed (8 in our implementation) and, for clarity; we shall modify a molecular feature (the angle) instead of changing the concentration and/or type of molecules.

The system activity is formally summarized as:

$$system = \{ M , R , A \}$$

$$A = S = array_{(12,12)}$$

$$M = \{ m_1 \ldots m_8 \}$$

$$a_m \in \{ 0 \ldots 11 \}$$

$$D_{(m_1, m_2)} < S_{(am_1, am_2)} \Rightarrow \left(a_{m_1} \leftarrow R_{(am_1, am_2)}, a_{m_2} \leftarrow R_{(am_2, am_1)} \right)$$

The algorithm *A* is equivalent to *S*, a sensitivity matrix. It holds numerical values expressing a threshold for interaction between any two types of molecules to take place.

The vessel contains 8 molecules defined by *M*. All molecules move in a direction defined by their momentary angle. The state space of angles is discrete and has a resolution of 30 degrees, so relative angles range between 0 and 11 to cover full circle. Note that angles are spread out evenly in that circle. Note also that the angles resolution has a very strong impact on the potential temporal complexity of the system as a whole; higher resolution will expand the state space in an exponential way. (This will be addressed in future implementations).

Interaction rules *R* are also described explicitly as regular arrays of 12 by 12 elements. The angles of interacting molecules receive specific interpretation. Both angles are interpreted as to index locations in the array -- to retrieve the new values of both respective angles. The array is a simple and compact way to represent how 12 different types of molecules potentially interact. The state space of all possible matrix rules is huge (12 expt 144 is a 156 digit number!) and thus considered virtually infinite.

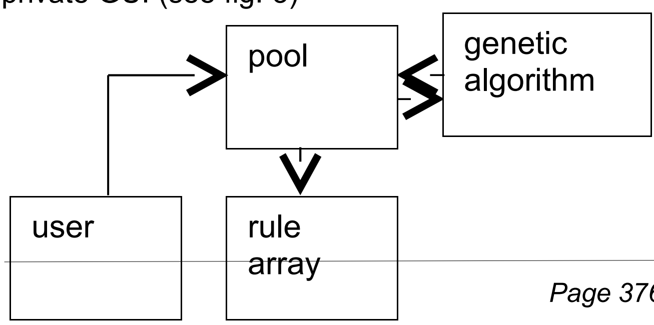
The effect of the rule array is qualitative control over molecular collisions. Now, interactions between molecules become effective when their physical distance is less than their mutual interaction threshold defined by array *S*. When interacting, both molecules will update their angle. For clarity, sensitivity values *S* are symmetric in the current implementation, though unequal sensitivity values would certainly add higher degrees of non-linearity to the system.

4. Implementation

The array

The above figure shows the systems architecture. The central 2-dimensional array acts as a lookup-table rule, which molecules in the vessel address. Interacting molecules modify the vessel as a whole thus conditioning posterior interactions. This creates a complex dynamical system; a simple simulated universe is tightly coupled with the expression of a virtual physics defined in an array. For simplicity, we assume the initial conditions (molecular positions) to be random. Also note that we are dealing with a non-reversible system (Prigogine, 84). The future is captured in a deterministic device (the array) though the global system behavior may appear to feature chaotic attractors.

Once set in motion, the couplings between rule array and the vessel -- completely disconnected from the user -- may orchestrate the sustained synthesis of interesting waves for hundreds of generations. The array values (0~11) are mapped to 12 different colors in a private GUI (see fig. 3)



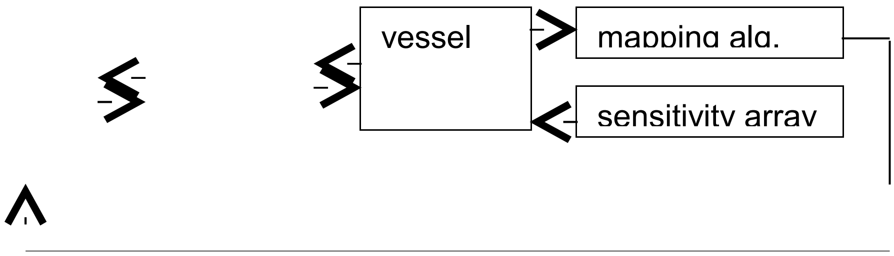


Fig. 1. Global system architecture. Observe the two loops incorporating the user.

The user

The actions of the external user speculate on the possibility to issue qualitative control over this global behavior albeit in an unusual, indirect way. A user provides gestures in 2D space; consider MIDI input of a sequence of (pitch, velocity) events interpreted as a trajectory (x, y) in 2-dimensions. The current implementation uses mouse input; the user draws some gesture (limited to maximum 100 coordinate pairs). The gesture is analyzed instantaneously when a mouse-up event occurs; analysis includes relative length, angularity, traversed distance, total surface used and acceleration/deceleration. Given a fixed sampling rate, we obtain information about the character of a gesture, and consequently, about the motoric personality of a given user.

Now a gesture modifies the current array plus some of the other arrays in the pool. The amount of change plus the number of arrays modified is stochastically proportional to the total length of all segments in a gesture. In addition, the change in an array is computed following an interpolation algorithm. That is, the previous contents of an array strays partially into the future. Therefore, arrays also function as long-term memories.

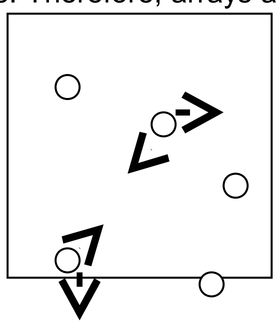


Fig. 2 Prototypical example: two objects interacting according to their current angle of movement. Thinly drawn arrows denote angles at time T, thick arrows denote angles at time (T+1).

The vessel

The simulated vessel is the environment holding molecules moving in a given direction at constant speed. At every cycle, every molecule checks whether any other molecule is within its sensitivity range. If positive, the angles of both objects are viewed as (x,y) pointers in the array. The retrieved value (0~11) will set the new angle (0~330) of that molecule. In case we are dealing with asymmetric affinities, some of the neighbor molecules will change their angle if their sensitivity is high enough. When more than two molecules are within interaction distance, all neighbors will be evaluated sequentially, the last value retrieved will finally affect the new angle. The sensitivity between any two angles is expressed in a 12 by 12 sensitivity array. However, most of the experiments reported here use a fixed sensitivity value for all angular affinities.

The pool

There is a small critical mass of 8 arrays, one of which is copied into the currently exploited array. A background algorithm switches continuously between the arrays when the ‘delta flag’ is true. During every time frame, the specific array also traces the quality of its performance; it counts the total number of interactions plus the number of unique instances of angles-histograms encountered (see Fig 5. History track of angularity histograms). The fitness of the array will be directly proportional to the diversity in histograms. Arrays are chosen at random conditioned by the number of times they were chosen before; the selection probability is inverse proportional to the number of times used in the past. All arrays are visualized in a graphic user interface (see fig. 2), small arrays on top are selected by pointing and the two numbers separated by a colon indicate respectively the nr-times-selected and the accumulated total fitness.

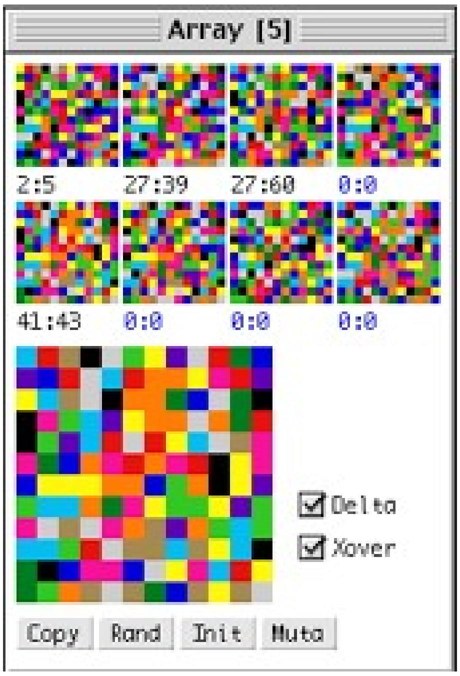


Fig. 3 Rule array selector and visual feedback interface.

The user implicitly steers a complex dynamical system from the observation of the cumulative effect of (1) rule array selection and (2) rule modification, as described above. The user’s evaluation is purely subjective; one tries to discover relationships between global system behavior and spontaneous user activity.

The genetic algorithm

When the ‘Xover’ flag is set, an autonomous genetic process will act in parallel. The genetic interpretation and action is straightforward: arrays are viewed as genotypes subject to standard crossover and mutation operators. The arrays are first sorted according to fitness, the two fittest are considered parents in the breeding process yielding 8 fresh arrays. A small amount of mutation helps prevent premature convergence into a more or less uniform pool.

So both the user and the GA contribute to the interactive development of interesting, propagating structures. Actually, a particular type of man-machine cooperation emerges; the GA clearly aims optimization by creating arrays that often look quite similar; they converge to some spot in genetic space. On the other hand, user activity both selects and modifies some arrays, often profoundly disturbing the GA instantiated structures. The system thus permanently fluctuates producing patterns of variable regularity. User initiated actions have two effects; they tend to favor short-term disorder while also influencing long-term behavior since some of the modified arrays will survive in the next generation. Machine initiated activity can be described as background autonomy according to the single criterion of global system fitness.

The general advantage of the genetic approach is twofold. First, it allows managing the external effect of complex processes without fully understanding the internal machinery orchestrating them. Second, genetic algorithms may generate constructive material that could not be anticipated by an external observer -- so they function as generators of surprise in an otherwise stable system.

For musical continuity, we rely exclusively on the arrays. The system as a whole exhibits a certain inertia; arrays are modified by interpolation and the genetic activity spawns offsprings that inherit features of their parents as they were living in the previous generation. In other words, the perceived melodic continuity is an implicit byproduct of the global systems behavior – it does not result from any form of melodic memory. Consequently, coherent melodic form issues from the accumulative forces of explicit physical gesture and implicit genetic evolution.

5 Mapping procedures

The mapping process defines an imagined relationship between an abstract pattern generating system and an evolved, elusive cultural system we call music. It is the most crucial yet the most difficult component of any generative music generator. We could view molecules as interacting harmonics articulating some complex sound, we could view the molecules as controlling a black box sound synthesis algorithm of arbitrary complexity. However, we shall try to map system dynamics into a melodic sequence with given tonality. The mapping process avoids momentary absolute values and favors using the first derivate of the current situation. In other words, the variable distances between molecules rather than their position are considered. The mapping proceeds as follows:

```
(defmethod create-melody-slice ((self cawp))
  ;; only 1 situation of max 7 events
  (clear-events (melody self))
  (loop with position-distances = (position-distances self)
        with angle-distances = (angles-distances self)
        with interacting-lists = (mapcar 'interacting-p
     (subviews self))
        with all-durats = '((4 2 2) (16 8 8) (2 1 1 2 1 1)
   (8 2 2) (8 1 1 1 1))
 with durats  = (take all-durats
                         (mod (loop for el in interacting-lists
                            sum (length el)) 5))
        with ahist   = (angles-histogram self)
        with maxv    = (apply 'max ahist)
        with posmaxv = (position maxv ahist)  ;; 0 to 11
        with countv  = (count maxv ahist)     ;; min/maj
        with tonaltype = (if (zerop (mod (apply '+ ahist) 2)) 0 1)
        with scale = (nth (+ posmaxv tonaltype) 24-scales) ;; global
        with st = 0   ;; start-time
        with chan = 0 ;; midi channel
        with d        ;; event duration
        initially (format t "~a ~a ~a ~a ~a ~%"
```

```
            ahist posmaxv countv tonaltype scale)
      for i from 0
      for cell in (subviews self)
      for interact in interacting-lists
      for p in position-distances
      for a in angle-distances do ;; a is signed
      (setq d (/ (take durats (+ a i)) 10))
      (setq chan (if (< p 100) 0 1))
      (when interact          ;; length of list > 0
        (cm::insert-object    ;; insert timed midi event
(cm::new
  cm::midi
            cm::time st
            cm::keynum (+ 36
            (* 12 (round (/ (point-v (view-position          cell)) 40))) ;; octave
              a) ;; angle
          cm::amplitude (if (plusp a) (+ 100 (random 20))
                          (+  60 (random 20)))
            cm::duration d
            cm::channel chan)
         (melody self)))
      (unless (< p 100) (incf st d)))) ;; conditional chord
```

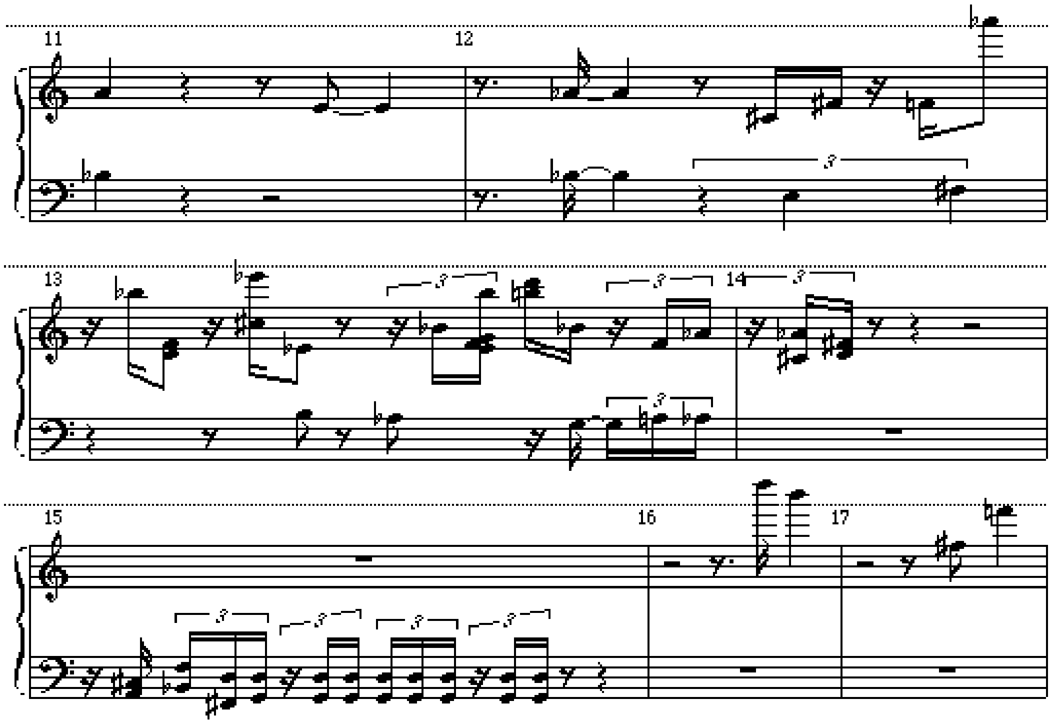
The method *create-melody-slice*, sent to a CAWP object (acronym for *continuous automaton wave propagation*), creates consecutive short melodic sequences. The physical configuration of the cells is significant, though we avoid reading and interpreting the structural pattern as if it were a conventional musical score. Note we are dealing with two different but parallel timing processes. The first one concerns the internal clock controlling the timing of the simulation including the real-time visualization. Timing is set by the user -- up to about 10 updates per second. The second process handles MIDI events at a much slower pace; both processes are concurrent though not synchronized. The melody object sends a message when it has finished playing its current contents, this triggers the *create-melody-slice* method and this process repeats indefinitely. One could say that the mapping procedure occasionally samples the current situation of a virtual world. The (dis)similarity of the melodic output will thus reflect how much the world changes from one generation to the next. Let's address the mapping algorithm in detail.

The *position-distances* and *angle-distances* are the first derivate of the respective instance variables, angle-distances are signed values. *Interacting-lists* holds a list of all the current neighbors of every cell, if any.

All-durats is a local library of relative duration units, a short stylistic ensemble of building blocks to be exploited by the algorithm. *Durats* is the selected element from that library; the selection pointer equals the total sum of all neighbors of all cells, modulo 5 (i.e. number of sublists in all-durats). The local variable *ahist* is the current angles-histogram, 12 elements wide of which *Maxv* holds the angle that is most expressed in the current situation and *posmaxv* is the position 0~11 of that value in the histogram. *Countv* is the number of times the *maxv* value occurs in the histogram, it says a lot about how specific that value is and, in addition, it is a hint to the diversity of the histogram.

Our system is built inside a larger framework for musical experimentation (written in Lisp -- Digitool MCL 4.2) that provides many resident composition, pattern processing and analysis tools, including tonality libraries of arbitrary complexity. However, the current implementation builds on Western tonality and uses a simple global variable *24scales* holding all major and minor scales in all pitch-classes. These libraries are precomputed for computational efficiency. The algorithm decides on major tonality if the sum of all values in the current histogram (modulo 2) is even, else it is minor. A specific scale is then retrieved from the scale library using a combined influence of pitch-class (set by *posmaxv* -- very conveniently in the range 0~11) and tonality.

The algorithm now loops through the various lists; the position-distances are considered at a threshold of 100, a value derived by trial and error. For instance, if the distance between two consecutive cells is less than 100 pixels, MIDI events will sound on channel 1 (a value of zero in the program) else on channel 2. In addition, the same mechanism exercises a grouping of events, controlling the start-time of new MIDI events. Thus, chords are always sounding on channel 1.

Finally, a new MIDI event is instantiated on the condition that the cell under consideration is actually interacting, if not, a rest is implicitly generated. The pitch of the event combines 2 forces: octave position follows the vertical position of the cell and the signed angle value adds an interval (-11 to +11) to derive the final pitch. The sign of the current angle-distance conditions the loudness of new events.

The figure above shows a short score excerpt of a typical molecular interaction sequence. The global, uniform sensitivity in this example is 15 pixels. We notice the complex interlocking of rhythmical patterns. A point attractor is passed through starting at measure

15. The expressive qualities follow exclusively from the interpretation of a small group of objects moving in 2D space.

6. Experimental results

The complexity of the temporal patterns varies widely; given fixed and uniform sensitivity, it is directly proportional to (1) the number of different angles at any moment in time and (2) the number of cells that change value at every cycle.

Our model is considered a tool to experiment with interesting temporal changes – not so much to help construct artifacts with a given finality. We focus on qualitative descriptors such as stability, diversity, sensitivity and relational affinity. Our model is built as a synthetic world with private physics, an imagined micro society. Most important, it expresses non-linear relationships between its components. This implies coherent yet unpredictable behavior; minute external disturbances can indeed entail massive consequences. From the work of [Prigogine & Stengers, 84] we know that order can arise spontaneously out of disorder through the process of self-organization. This principle is scale invariant, it holds for ant societies as well as galaxies – we shall bring it into play it in terms of an abstract social system.

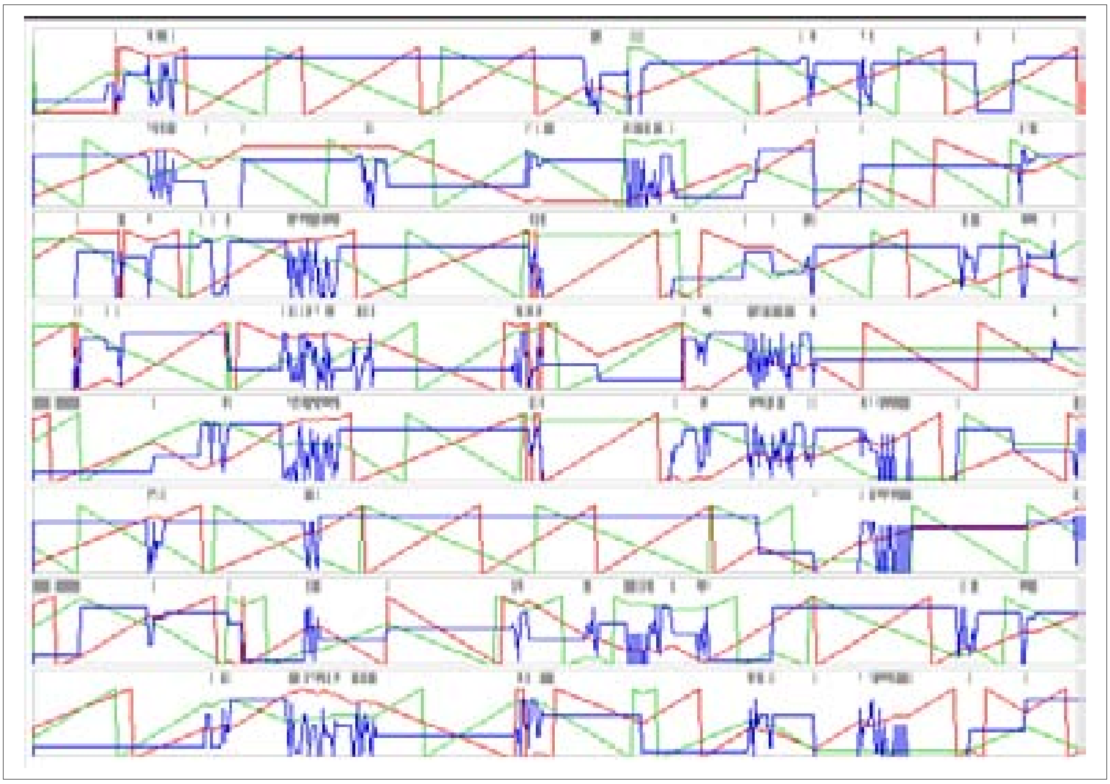


Fig. 4. History track of physical position and direction

Our experiments prove that social constructions occur spontaneously. For instance, given the right initial conditions and the right rule array, a few cells will cluster and move as a group, incidentally, similar to gliders in a 2D cellular automaton. At every process cycle, the net effect of all cells executing a private rule will be a coherent cluster of cells moving in a single direction. Now, a cell approaching the cluster may interact with its closest component and implicitly reconfigure the previous social construction. In other words, collective cycle attractor behavior is destroyed temporarily. According to the rule, communicating particles may simply bounce symmetrically, act as a catalyser in a group reaction or engage in circular motion… Many complex temporal patterns emerge that could be described formally using the notion of *temporal profiles*. A profile would capture the rule and the initial conditions and would then consider the cell's trajectories and perhaps interpret them as a collection of tightly coupled breakpoint-envelopes. These envelopes could very well control a Fourier synthesizer, the result would be the expression of social control amongst harmonics. This idea awaits further implementation.

Figure 4 documents 600 cycles of an interaction process with 8 molecules in a container without reflecting walls. A single random rule matrix is used. The sensitivity matrix holds random values in the range 1 to 30. There is no gestural input from the user, so the internal dynamics develop in isolation, as a closed system. Green and red lines respectively denote x and y coordinates and blue lines show the momentary angles. The gray patches indicate when a particular molecule is actually engaged in interaction. The gray patches at the top of each graphic pane make it possible to detect chain reactions. Qualitative oscillations of angle values are clearly observed. So there is evidence that this type of complex dynamical systems may support modeling wave propagation. According to the contents of the rule array, the waves may either sustain or lead to a single angle value, the latter being equivalent to point attractor behavior.

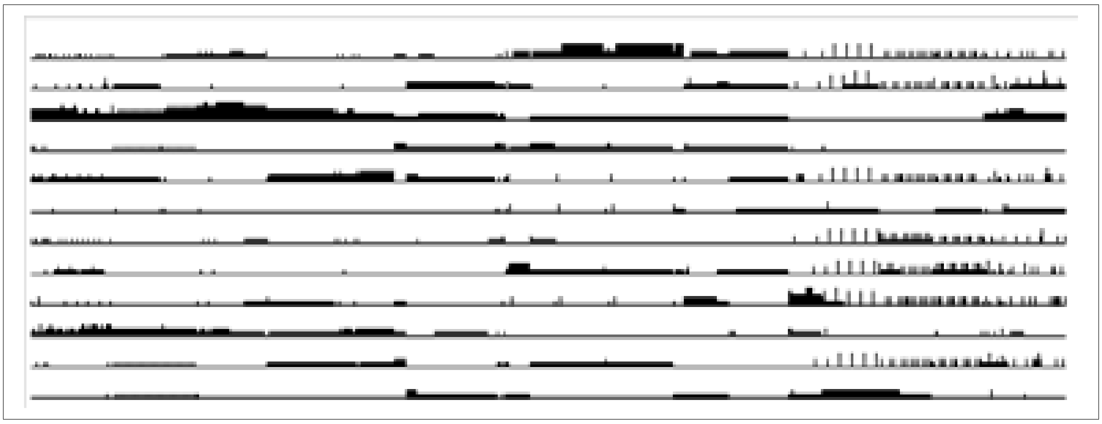


Fig 5. History track of angularity histograms.

Figure 5 shows 12 data tracks in time, 600 generations long, each track represents an angle from 0 to 330 in steps of 30 degrees. Angle histograms are computed at the end of every process cycle; this provides information of which angle values are in use, reflected in the density of the track (1) in addition to how many instances (2) of these angles are being used, reflected in the thickness of the track. The sensitivity array is uniformly filled with a fixed value of 15, which means a global sensitivity value of 15 pixels.

A subtle user gesture at around generation 400 slightly modifies the current rule and forces a new type of waves to appear. First, past behavior is gradually acknowledged and second, amplitude and periodicity gradually build up towards a regular pattern. After a few generations, the internal dynamics will modulate that pattern and it will evolve according to the nature of the modified rule. One could say this constitutes a second kind of macroscopic behavior; waves appear to interact as bigger constellations; in effect, a neat example of emergent behavior.

7. Conclusion and outlook

This paper documents early experiments with an object oriented collision model supporting musical experimentation in real-time. It can be considered a continuous cellular automaton, a form of ballistic computing or an example of artificial chemistry. Anyway, the key notion here is *emergence*. Interesting temporal structures appear from the expression of a simple rule captured in a 2D array. These structures are thought of as propagating waves. The role of the user is quite subtle; one does not tweak a series of black-box global variables, in contrast, one shares forces with a genetic algorithm acting in parallel. So implicit autonomous actions as well as explicit user activity steer the relationships of an ensemble of objects moving in a 2D virtual world. Imagine a virtual physics of which the expression and evolution is partially controlled by an external user.

The system acts successfully as a generator of interesting waves of variable periodicity, even when operating according to the following constraints:

a fixed and uniform sensitivity range for all cells,

a fixed step size for all cells

a fixed density and energy of cells,

a discrete and small set of potential actions i.e. only angles change

no changes introduced by angle inversion when bouncing a reflective wall, and

genetic background activity is switched off.

It proves that the economy of expressing simple angular relationships in an array does indeed suffice to support interesting, non-linear dynamic behavior. However, further work is needed to classify families of automata and to study the impact of initial conditions. Automatic classification could even be addressed in an unsupervised offline algorithm since complexity criteria are explicitly available.

The work documented here is implemented in Macintosh Common Lisp using the functionality of the MIDI drivers in Common Music (Taube, 97). Our implementation challenges Lisp for real-time work. No doubt, Lisp is the most powerful symbolic programming language yet it has trouble coping with the pressure of real-time control – to the best of our knowledge, just one effort aims to connect the universal power of Lisp with the optimized number crunching efficiency of Max/MSP [Garton]. More work is needed to design robust multi-purpose, concurrent computational environments using symbolic programming languages.

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Non-linear projection of IFS attractors: symmetry breaking and symmetry restoration

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Abstract. A method is proposed in which iterated function systems are combined with non-linear tree projections. A form is initialized by a linear tree which projects to the attractor of an iterated function system. Curvature fields are associated with the line segments of the tree, by which a non-linear, three-dimensional form is obtained. Then, a method is proposed that breaks the symmetry of the resulting form at different levels. After symmetry-breaking, an operation of symmetry restoration can be applied in order to obtain forms in which branches converge to a limited set of points.

1. Linear projection of an attractor of an iterated function system

Consider the Sierpinski triangle in Figure 1. It is obtained as the attractor of the iterated function system defined by the transformations f_1, f_2 and f_3 which transform the plane into itself, and with $f^x_1(x, y) = 0.5\ x$; $f^y_1(x, y) = 0.5\ y$; $f^x_2(x, y) = 0.5\ x + 0.5$; $f^y_2(x, y) = 0.5\ y$; $f^x_3(x, y) = 0.5\ x + 0.25$; $f^y_3(x, y) = 0.5\ y + 0.5$. Suppose that an initial point R is randomly chosen in the unit square. If this point is subject to a large number of transformations from the set $\{f_1, f_2, f_3\}$, and if these are applied in random order, then the entire figure appears (if the initial point is not on the attractor, the first few tens of iterations are to be left out of the figure). This is the usual way to generate attractors of iterated function systems. Figure 1 was generated in a different way. The initial point R had coordinates (0.5, 0.5). Then, this point was subject to all combinations of eight transformations $f_{k1} \circ f_{k2} \circ \ldots \circ f_{k8}$ (with $k_1,\ldots,k_8 = 1, \ldots, 3$), so that $3^8 = 6561$ points were generated. Suppose that the point obtained after application of a particular combination $f_{k1} \circ f_{k2} \circ \ldots \circ f_{k8}$ on R is denoted $P_{k1,k2,\ldots,k8}$. The first index of this point corresponds to the transformation which is applied last. Its predictive value with respect to the location of the point is largest: it specifies that the point is on the k_1-th transform of the attractor. The second index refines this place: the point is on k_1-th transform of the k_2-th transform of the attractor, and so on. Therefore, points differing in the last index k_8 only are close to each other; points are usually further removed if more early indexes are different.

A linear, ternary tree of which the endpoints coincide with the points on the Sierpinski triangle is generated in two stages. First, the tree is constructed in the plane of the triangle. Subsequently, the starting point S of the tree is moved out of this plane, while the endpoints of the tree are remaining at their place. Intermediate branching points are drawn toward S as a function of the branching level. In the second stage, a three-dimensional linear tree is generated by connecting all lower level branching points with the three corresponding higher level points (Figure 3).

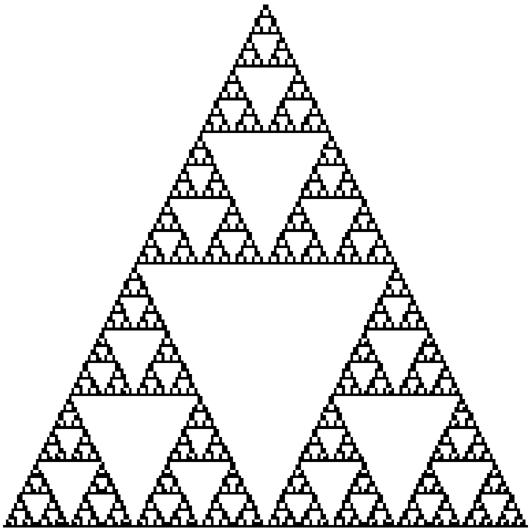

Figure 1. *Points on the Sierpinski triangle obtained by combination of eight transforms*

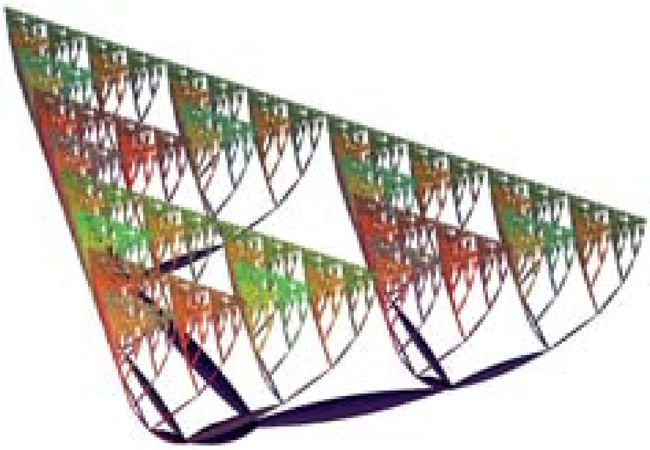

Figure 2. *Three dimensional linear tree-projection of the Sierpinski triangle*

2. Definition of fractals fields over the attractor of an iterated function system

Consider the point $P_{k1,k2,\ldots,k8}$ on the Sierpinski triangle. A field $f_{k1,k2,\ldots,k8}$ is defined as a function of the value of the indexes $k_1,\ldots,k_8$. The general form of this function reads:

$$f_{k1,k2,\ldots,k8} = \square_{\{s=1,\ldots,8\}} b_{s,ks} \qquad (1)$$

This expression means that, for each of the eight transformations involved in the definition of $P_{k1,k2,...,k8,}$ $f_{k1,k2,...,k8}$ is increased by a quantity $b_{s,ks}$ (s=1,...,8; k_s=1,...,3). The quantities $b_{s,ks}$ depend on the level s for which k_s specifies the transformation, and on the value of k_s itself. For the present choice of eight levels, and of an iterated function system defined by three transformations, this means that the field expression (1) includes 3.8=24 parameters. Variation of these parameters leads to different fields, and hence in the next section to different non-linear forms.

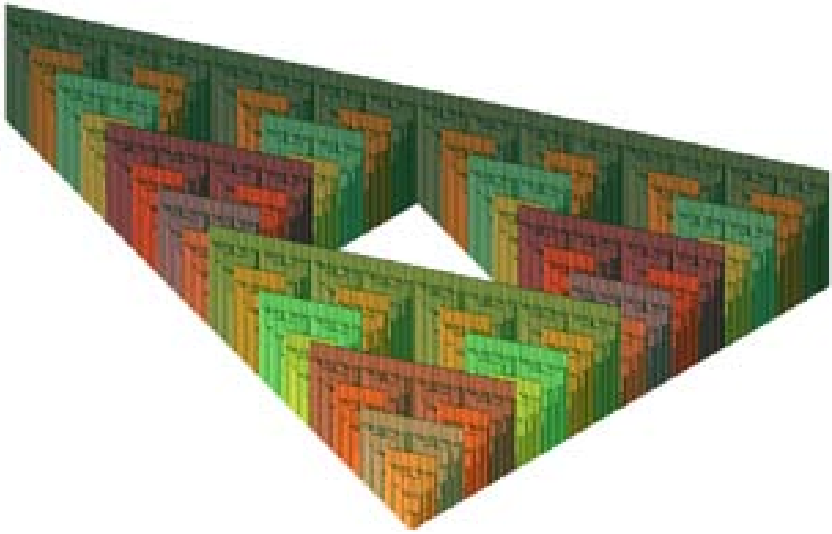

Figure 3. Field defined by $b_{s,ks}$=1 if k_s=1 or k_s=2, and $b_{s,ks}$=3 if k_s =3

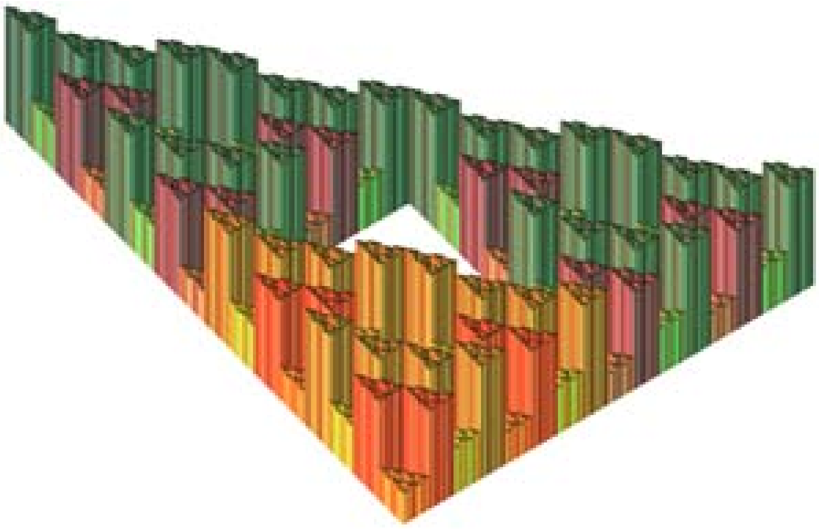

Figure 4. Field defined by $b_{s,ks}$ = Rnd. $(9 – s)^6$, and with symmetrization

3. Generation of non-linear forms by field-induced curvature

In order to insert curvature in a linear tree, it has to be analyzed into spatial variables. Because of the fact that we want fields to directly induce curvature, a tree will be described in terms of angular variables which are associated with line segments. Consider the s-th level branch with endpoint $P_{k1,k2,...,ks}$ (s=1,…,8). Suppose that this branch is divided into N segments of equal length. The unit vector along the n-th line segment is denoted $e^n_{k1,k2,...,ks}$ (n=1,...,N). This vector is specified by two angles ($\square^n_{k1,k2,...,ks}\square\square\square^n_{k1,k2,...,ks}$), where $\square\,^n_{k1,k2,...,ks}$ is the angle between the x-axis and the projection of $e^n_{k1,k2,...,ks}$ on the horizontal plane, and $\square\,^n_{k1,k2,...,ks}$ is the angle between the z-axis and $e^n_{k1,k2,...,ks}$. For all segments along the branch (except for the first segment), the differences in angles can be determined: $\square\square^n_{k1,k2,...,ks} = \square\,^n_{k1,k2,...,ks} - \square\,^{n-1}_{k1,k2,...,ks}\,\square\square\square\square\,^n_{k1,k2,...,ks} = \square\,^n_{k1,k2,...,ks} - \square\,^{n-1}_{k1,k2,...,ks}$ (n=2,...,N) (see [1]).

By coupling these differences to fields, the trees are made non-linear. Two fields in agreement with the previous section are taken. These are coupled with the horizontal and the vertical differences in angles, respectively.

$\square\square\,^n_{k1,k2,...,ks} = \square\square\,^n_{k1,k2,...,ks} + \square\square f\,^h_{k1,k2,...,ks}$; $\square\square\,^n_{k1,k2,...,ks} = \square\square\,^n_{k1,k2,...,ks} + \square\, f\,^v_{k1,k2,...,ks}$

($\square$ and $\square$ are coupling constants)

The quantities $f^h_{k1,k2,...,ks}$ are called horizontal fields; they give horizontal curvature to the linear branches. Similarly, the quantities $f^v_{k1,k2,...,ks}$ curve branches by modification of the angles of line segments with the z-axis.

The procedure in which trees are curved by fields can be iterated. After an object is obtained by coupling of fields to angular differences, a linear tree can be constructed so that its final level endpoints coincide with the final level endpoints of the object. Then, this linear tree can be curved in accordance with field definitions, and so on. After a few iterations, this process usually leads to forms of high complexity. Figure 5 was generated for three iterations. Figure 6 illustrates a run of the program in which vertical fields included a harmonic factor of horizontal angles. In Figure 7, all fields included a harmonic factor of vertical angles

Figure 5. Form obtained after three iterations

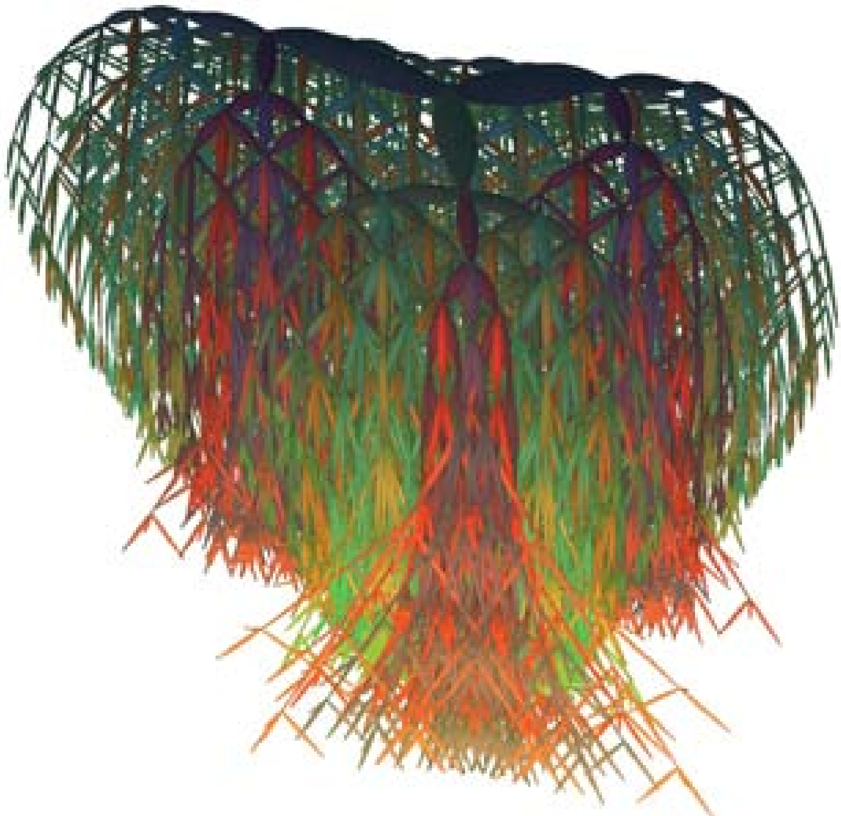

Figure 6. Run of program for vertical fields with harmonic factor of horizontal angles

Figure 7. Run for fields with harmonic factor of vertical angles

4. Symmetry restoration

Suppose that, in some or other context, one aims at a form that has less divergence of endpoints. This can be obtained by an operation in which endpoints are drawn together in sets of 3^k points. Subsequently, branching nodes at lower levels are moved in proportion with the average movement of higher level nodes. Consider the form in Figure 8. For k=1, the first stage in the convergence process is obtained; it is shown in Figure 9. At final stage, all endpoints point to the same point, as is illustrated in Figure 10.

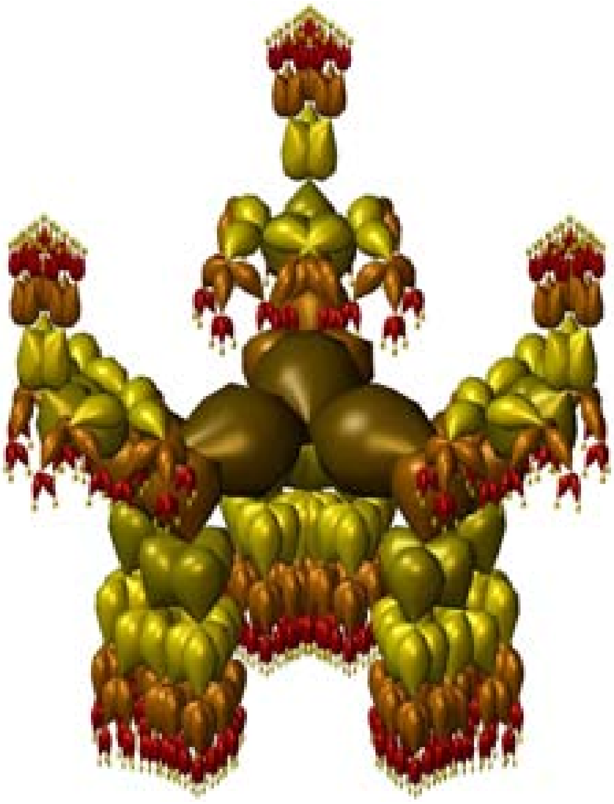

Figure 8. Initial form before symmetry restoration

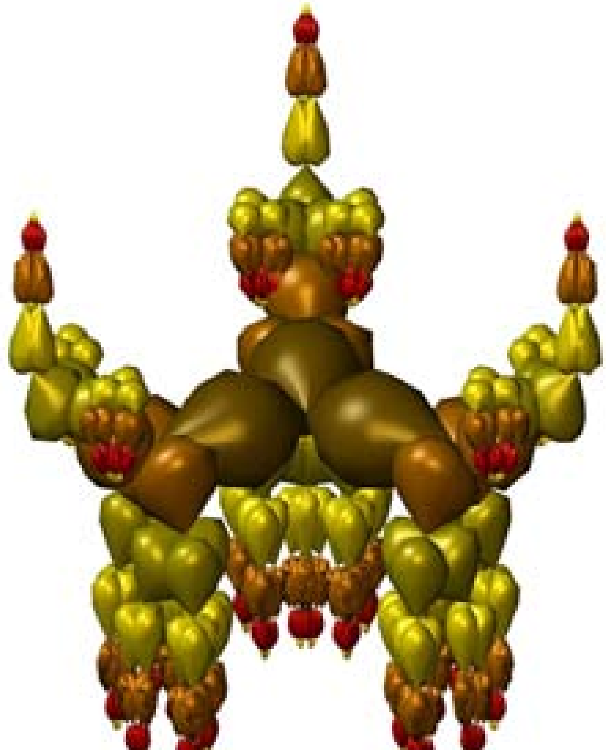

Figure 9. First stage of convergence process

Figure 10. Final stage of convergence process

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Co-generative 3D Form: The Framework of Co-generative Design System

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Abstract

Generative design system develops the purpose that is can generate a large number of design plans. Generative design system can let designer unceasingly explore the new design plans. At present generative design system, they all only have one kind of generative mechanism. Therefore, one can't provide enough feasibility for designer to explore new plans. So, in this paper, we propose a framework of Co-Generative Form System (*COgenForm*). COgenForm is a 3D form exploration system that invokes two set of generative mechanisms. This system used co-evolutional characteristics to build the steps and framework of co-generative design process. This system includes two groups of generative mechanisms and these will evolve and interact with each other. Using this system, the form exploration and generation process can be more dynamic and more alternatives.

1. Introduction

Generative design system offers an important mechanism for combining both design generation and computation mechanism. But, most of generative design systems developed require either well-defined design problems or the design knowledge embedded should be logical sound.

This limitation with its computational strength allows generative mechanism to be explored with logical expression and operation such as SEED project [1, 2]. In addition, generative design system can also take advantage of current artificial intelligence trend such as genetic algorithms and then generate form and shape anonymously, such as GENR8 [3] and Agency-GP [4] with evolutionary agent-based mechanism

One thing for sure is the generative mechanism will be the keys for generating design as well the representation (or exploration metaphor and design rules) for the generated design. Different generative mechanism and representation will generate different design alternatives. Among those, two main generative mechanisms often mentioned are evolutionary-based mechanisms and symbol-based mechanisms.

Most of the current research trend regarding of generative design system is focusing only one generative mechanism. This makes the development simplified and computable. On the other hand, the trade-off is to sacrifice the feasibility and inter-relation between different generative mechanisms. If there is a mechanism that can incorporate more than one generative mechanism, the system generated or the design generated by the system might be closer to design process.

Therefore, in this paper, we proposed a framework of co-generative design process that can incorporate two different generative mechanisms and a generative system for form-exploration is proposed and implemented.

2. Co-evolve and generative design

For generative design process model, one mechanism called co-evolution is adapted for its integration between two diverse evolutionary steps. While proposed by [5], Maher described the co-evolution as a cyclic process that sketches the influence between two species in the natural world. In recent years, the concept of co-evolution has been applied in different domains, such as co-evolutionary learning [6] and game developing work. The model of co-evolution design is comprised of three characteristics:

(1) Two design problems extend in parallel way.

(2) Design problems can affect each other via in intercourse way.

(3) One design problem will keep changing while changing another one’s answers.

General speaking, generative design systems are comprised of four elements: (1) the design representation (2) a generation engine (3) an expression engine (4) evaluation and selection mechanism. The generation engine is the main part of the mechanism of evolving, and new design instance will be generated within the evolving steps. In this research, we combine these two mechanisms (generative design system and co-evolution model) into the generative engine and make them affect each other through the features of co-evolution process. The process that combines these two mechanisms is called *co-generation*.

The strategies applied for combining generative design system and co-evolution model are:

(1) Only have two groups of generative mechanisms in the co-generative process;

(2) The representation of two mechanisms should be the same or interchangeable;

(3) Under the same representation, the factors or rules must be different;

(4) One of generative factors or rules to change that because has another one;

(5) Using evolutionary concepts to combine two groups of generative mechanisms, and the generative factors and rules-like genes. There will Influence each other like crossover and mutation. We show the co-generative process in (Figure 1). In this framework we presented main part was co-evolve mechanism.

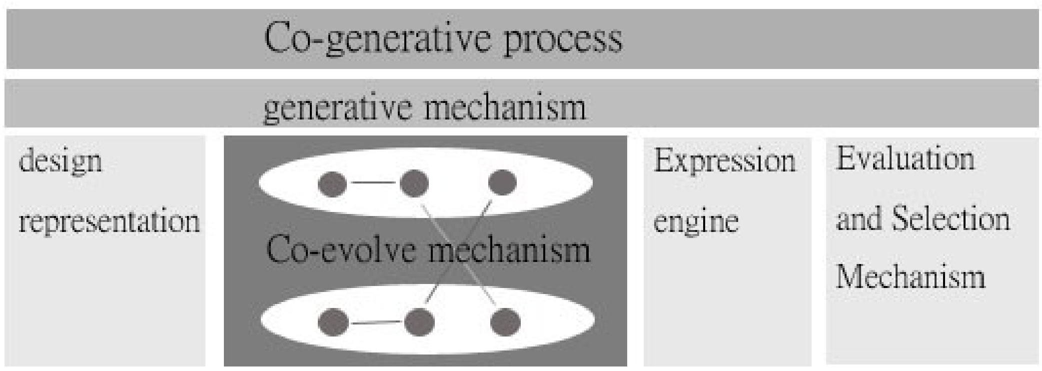

Figure 1. The framework of co-generative process

3. An implementation framework

For testing the computability of our framework of co-generative process, we implement a design system for the purpose of 3D form exploration. The implementation steps of a design system using co-generative design process are described as following.

3.1 The framework of co-generative design system

In this section, we presented framework of co-generative design system, in figure 2. In this system include four parts, representation、generator engine、expression and evaluation and selection. The main part is generator engine that compiled two mechanisms and co-evolved each other.

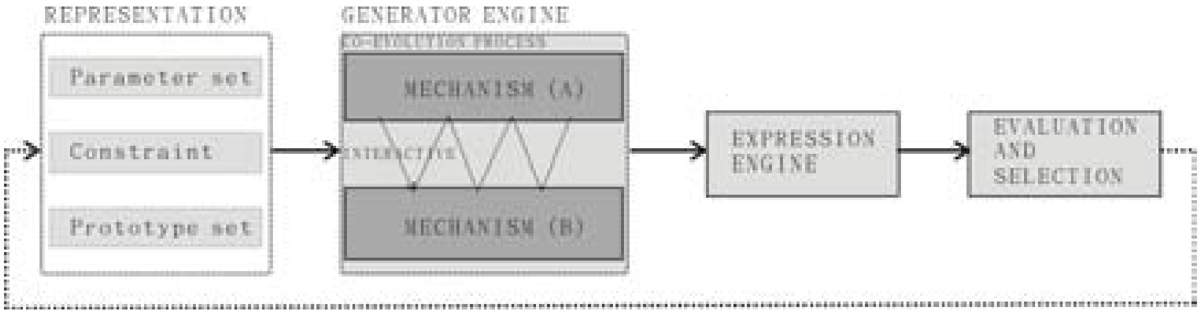

Figure 2. The framework of co-generative design system.

3.2 The steps

Three steps are applied for our preliminary implementation are selecting two three-dimensional form generative mechanisms, developing the inter-relationship between these two mechanisms, and the selection operators based on the mechanisms and representation chosen. The details of each step are described below.

First, two groups of generative mechanisms will be chosen according to the principles that their representation must be the same or interchangeable. In addition, each other can generate form by oneself or the other. In this research, two groups of generative mechanisms set up are L-System mechanism and Rotate.

Secondly, co-generative design process must be able to let two groups of generative mechanisms interact with each other in co-generative process. We used the evolutionary concepts to combine these mechanisms. Generative rules or factors such as gene are defined and they will interactive with each other through mutation in the example shown in the example.

Finally, user-controlling strategies the generative process is divided into two parts: 1) controlling the timeline, and 2) adjusting the rules and parameters of design. User can also decide when to process the mutation among generative processes, in figure 3. Both two generative mechanisms will keep generating alternatives according to the set rules until the user stops the timeline. Once stopped, user can import other generative mechanism to change the rules or the generative form. Thereafter, the natural selection will be decided according to the user satisfaction of the results.

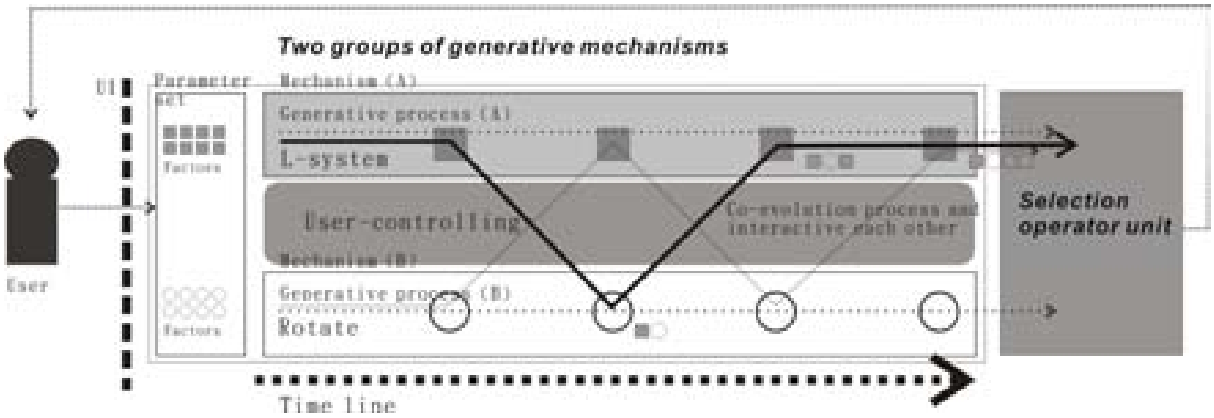

Figure 3. User controlling strategies in co-generative design system.

3.3 Implementation

A co-generative 3D form system called *COgenForm* is implemented according to the analysis above. COgenForm is comprised of four elements: (1) Two groups of generative mechanisms (L-System mechanism and Rotation mechanism); (2) Co-generative interaction; (3) Selection operator unit; (4) User interface. This version of COgenForm is implemented using MEL/Maya. MEL (Maya Embedded Language) was the main programming language of COgenForm.

4. An example

A housing design is used as the application of COgenForm. The requirements of this housing design are (1) a 3-bedroom apartment which it located at Taichung central park; (2) participants need to discover diverse form strategy for fulfill the function and site requirements. We provide the system COgenForm lets a designer with architecture design background to test this project. The purpose of this housing design is to explore more alternatives and more possibilities with two parallel logic form generative mechanisms. The results are shown in Figure 4. It shows two generative processes A and B. Process A uses L-system and Process B uses rotation features as the mechanism to generate free form of housing design. The top left window shows the generation 22 of a sequence of alternatives using L-systems, and the right is the generation 55. The timeline and parameters of generation process are shown at the left side of the windows.

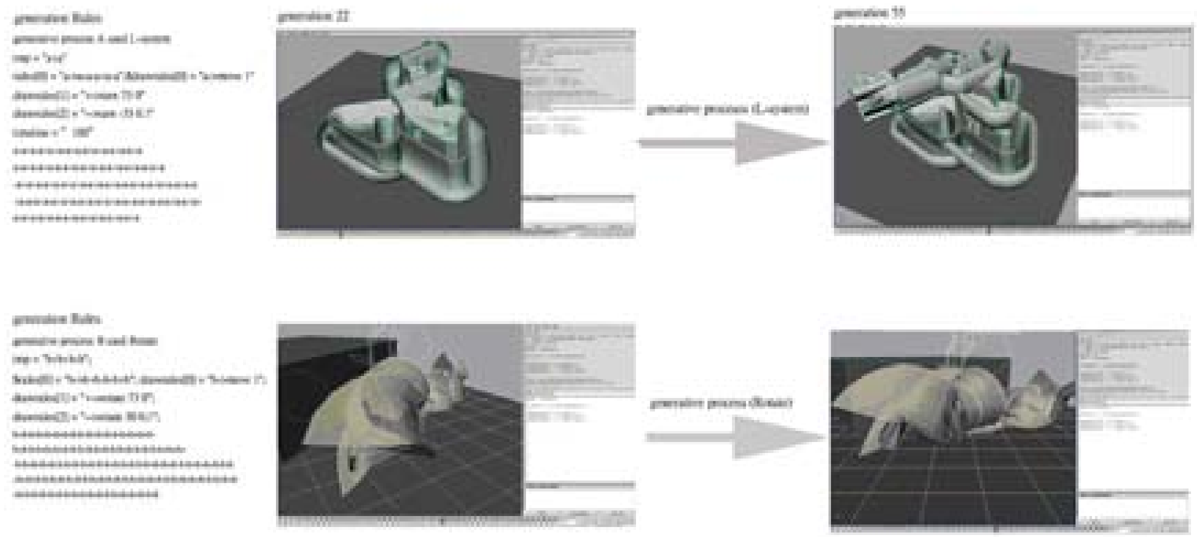

Figure 4. Two generative process that are used L-system and rotate

In Figure 5, we show how combine the two generative processes with mutation and user controlling. This situation occurs once designer decide to mutate the design mechanisms. The Generation 82 of process A is then generated by mutating both mechanism *a* and mechanism *b* based on its parent node.

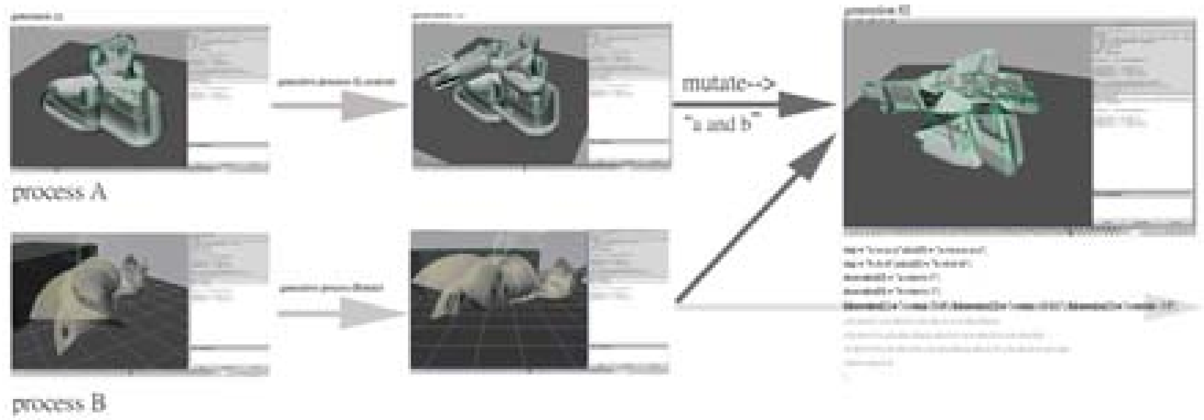

Figure 5. The co-generative process with mutation operations

5. Conclusion

In this paper we present a "co-generative form" framework and generative system called COgenForm. Via the feature of co-evolving, the generative engine of COgenForm includes two groups of generative mechanisms and through the influences and stimulation between each other. COgenForm enriches the varieties and possibilities of the children generation and its processes as shown in example above. Therefore, the inspiring results that inherit both mechanisms are shown in the display.

By directly manipulating these mechanisms, designers can discover more alternatives or detours from the original fixed generation patterns. The computability of applying co-evolution metaphor onto design generation is clear and useful. As well, as its constraints by the representation and the mechanisms of it are also unleashed in the paper.

In the future, more generative mechanisms that fulfil the four requirements of co-generative process can be implemented in COgenForm. And the interfaces of COgenForm for the users can be evaluated and argued through the refinement of the system. Hopefully, it can make the form generated by COgenForm be more inspirable and interesting.

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Designing to Live:
The Value of Inclusive Design in the Future Society

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How do designers work with communities, respond to constraints, and maximize ownership by users and other stakeholders? Designers promote exemplary projects with an emphasis on participatory design, universal design and social responsibility.

Design expresses the economic, social, political and cultural complexion of our society. It renders an image of the conditions of our society and the communities that directly profit, or are contingent to its benefits. In this sense, it communicates a vast amount about the priorities and values of our society. Nigel Whitley's *Design for Society* (1993) critically asserts this observation in an attempt to establish a foundation for a more socially-responsive development of design. [1]

Traditionally, the principal role of the designer was to increase the sales and profitability of a product. However, in today's society there is a paramount need to broaden the awareness of the designer with respect to the economic livelihood and sustainability, of urban inner-city communities in America as well as emerging nations.

Community Partnerships

I believe the physical features and aspects of inclusive design are improving the quality of life. Well-being is only the beginning: Infrastructure and facilities programming offer opportunities for earning income which, in turn, enhance the general economic health of a community. But, the most important element for success is commitment by all, resulting in a true sense of partnership. The benefits are that people obtain an improved, healthy and secure living environment without being displaced. Experience has shown that urban upgrading projects are associated with strong social and economic benefits.

My-point-of-view affirms what the renowned economist-philosopher and author of *Small is Beautiful*--E.F. Schumacher--believed when he called for a reassessment of the role and status of design in society. Schumacher states: "What is at stake is not economics, but culture; not the standard of living, but the quality of life" (Shumacher in Eliahoo, March 1984, Designer Ethics in *Creative Review*, 44 The physical features and aspects of inclusive design in improving the quality of life and well being is only the beginning:
Infrastructure and facilities programming are offered to increase income earning opportunities and the general economic health of a community.

The most important element for success is commitment by all: the city, the community, and the families. A sense of partnership must be developed among them. Secondly inclusive design must meet a real need - people must want it and understand the value.

Implementation will require getting the institutional arrangements right:

> give incentives for agencies to work with the poor,
> keep everyone informed and coordinate between stakeholders
> define clearly the roles of the various agencies.
> keep upgrading going, sustainability concerns must be a priority in financing, institutions, and regulations.

The benefits are simply that people obtain an improved, healthy and secure living environment without being displaced.

Recognizing title and security of tenure makes a positive contribution to both the economic prospects of the poor, as well as to the national economy. Experience has shown that urban upgrading projects are associated with social and economic benefits that are particularly high.

Designers must enhance their value and broaden their influence in our society. This may be achieved if we are able to meet the challenge to find ways to mobilize the necessary resources to promote the creation of job skills training, mentoring, and capital recycling in low-income communities. This effort could be further facilitated by conducting a workshop/symposium that addresses this issue. The workshop/symposium could be sponsored by industry and local design offices. Additional professional design and business organizations, such as IDSA could endorse the idea, and act as an executive advisory board for the planning and development of such an event.

Decisions are Based on Universal + Sustainable Criteria

Over thirty years ago the artist Richard Hamilton wrote a book entitled, *Popular Culture and Personal Responsibility* in which he defined an ideal culture as, “one in which awareness of its condition is universal” (Popular Culture and Personal Responsibility, 1982/1960, n.p.).

Good design can be achieved by focusing the efforts of designers to develop products and environments that will be more inclusive--as opposed to preferential--in enhancing and facilitating the areas of urban community development. Basic universal design principles advocate designs that can benefit the widest range of users in areas such as public health, recreation, housing, skill building, education, and business development schemes.
The late Selby Mvusi, a prolific Black South African industrial designer wrote in 1963:

“The truly excellent designed object is not the object that is rare or expensive....This rightness of form and function before and after the object is made is both individual and social. It is in this sense of that society and culture intrinsic elements of design.

We do not therefore design for society or for that matter design in order to design society. We design because society and ourselves are in fact design.”

“We do not design for living. We design to live.” [4]

What's Next?

How do designers work with communities, respond to constraints, and maximize ownership by users and other stakeholders?

Promote exemplary projects with an emphasis on participatory design, universal design, and social responsibility.

Find ways to mobilize the resources to promote the creation of job skills training, mentoring, and capital recycling in low-income communities. Designers can influence change and redefine the priorities and values of our society through such indirect methods.

Conduct workshops and symposia that address these issues...ones that are ideally sponsored by local industry and design offices. Additional professional design and business organizations could endorse the idea and act as an executive advisory board for the planning and development of such an event.

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From design to production: Three complex structures materialised in wood

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Abstract

This paper explains some concepts used by the designtoproduction group at the Chair of CAAD to materialise complex form by example of three recent projects that were realised in collaboration with different partners: First, a platform for the exhibition “Inventioneering Architecture” in San Francisco, where a NURBS-surface was translated into the geometry for 1000 individually shaped rafters forming a doubly curved surface of 120 square metres. Second, the realisation of a sculpture designed by Daniel Libeskind for the University of St. Gallen where the “algorithmic” form was taken as a basis for organising and rationalising the construction and manufacturing process for over 2200 different parts. And third, the design and realisation of a spherical pavilion for the SWISSBAU-fair in Basle composed of some 300 different quadrilateral frames, whose geometries were generated and optimised by means of artificial life methods. All three works were manufactured on a computerised five-axis-router.

Introduction

In contemporary architecture a strong current is observable towards organic, non-orthogonal, free and complex form. Both, planners as well as their clients strive to extend the possibilities of architectural geometries. The designers on one side are heavily supported by ever more powerful 3D CAD-modellers to help with form finding and are eager to use this potential. On the other side computerized (CNC) fabrication technologies enable the creation of individually parameterized parts for almost the cost of a standardized mass product. But in between those two sides often insurmountable challenges arise when it comes to detailing: Since free forms consist of a large number of individual components the planning effort scales with the number of parts, often not even linearly. The amount of border conditions to fulfil and plans to draw is in many cases out of the ordinary planning process. Sometimes this is avoided by creating “quasi-free” forms from a limited number of repetitively used components whose regularity is not visible at first sight, like in the Beijing Swimming Stadium by PTW Architects [1,3] or in the Melbourne Federation Square Atrium by

Lab Architecture [5]. This rationalisation reduces the realization costs as well as the error rate in fabrication but is not always satisfying the intentions of the designers.

By introducing a continuously digital chain from form finding to fabrication, the designtoproduction group at the Chair for Computer Aided Architectural Design (CAAD) at the ETH Zurich seeks to rationalise not only the structure itself but also the process that leads to the materialisation of this structure. This ranges from innovative approaches to generate irregular structures that adapt to external pre-conditions by using methods from the field of artificial life [8] until the automatic generation of the code that directly controls CNC manufacturing equipment. We will illustrate this approach in the three following case studies that were all realised in the year 2005. By example of those cases we define a process in six steps from design to production in the second section of this paper.

Doubly curved: Exhibition platform for “Inventioneering Architecture”

Doubly curved surfaces pose especially tricky problems to manufacturing. Usually they are either accomplished by approximating the continuously curved surface with a polygonal structure (e.g. the roof structure for the Milan Fair by Fuksas [6]) or by assembling deformed sheet material on a supporting structure (e.g. the BMW Pavilion by Franken [2,4]). When Instant Architects designed the stage for “Inventioneering Architecture”, they first thought of a third principle: milling the doubly curved terrain of the 120 square metre platform out of foam material and coating it with plastic. But it turned out that production costs would be well over the top of the available budget.

„Inventioneering Architecture“ is a travelling exhibition of the four Swiss architecture schools (Zurich, Lausanne, Geneva and Mendrisio) that was first shown at the California College for Arts and Crafts (CCAC) in San Francisco and is now touring the world. For this project the office Instant Architects in Zurich designed a stage, which resembles an abstract crosscut through Swiss topography. This doubly curved platform measures 40 by 3 metres with varying heights up to 1.5 metres. A footpath meanders along the surface, passing the exhibits (Fig. 1).

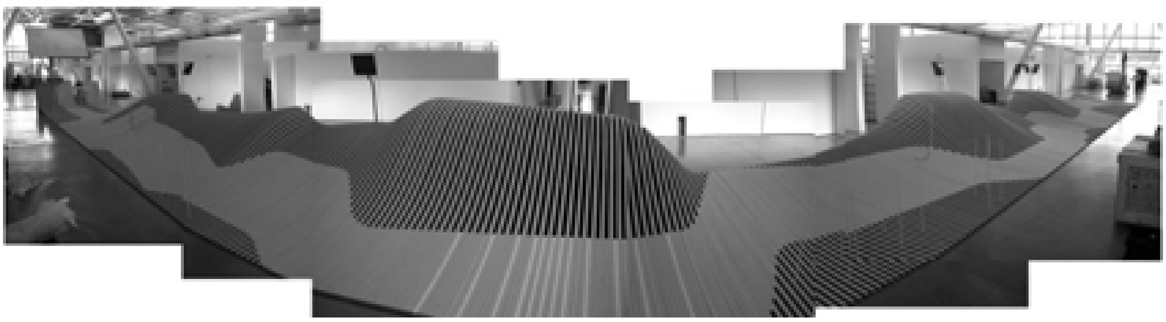


Fig 1: The 40m long exhibition platform at the CCAC in San Francisco after assembly

In order to meet the budget requirements, we proposed to assemble the hilly platform from 1000 individually curved rafters that were milled out of 40mm medium density fibreboard (MDF). They are assembled in comb-shape, so that their overlapping sections form the closed surface of the path while the exhibition area is marked by gaps. By choosing a rather cheap material and implementing a continuous digital chain from the definition of the surface geometry in the CAD software Maya until the control of the five-axis CNC-mill that the parts are manufactured with, production costs could be lowered significantly.

Fig 2: part of the 1100 individually curved rafters optimally positioned on MDF-boards

The detailing was developed closely after the capabilities of a five-axis router. The platform is divided into 40 millimetre wide cross sections, each describing the upper surface path of one rafter. The milling tool follows this path and rotates around it at the same time, cutting out a so called “ruled surface” that follows the topography of the platform both along and across the section. Thus it is possible to manufacture a three-dimensional, doubly curved surface from two-dimensional sheet material at very low cost. The rafters are connected by dowels and supported by perpendicular boards.

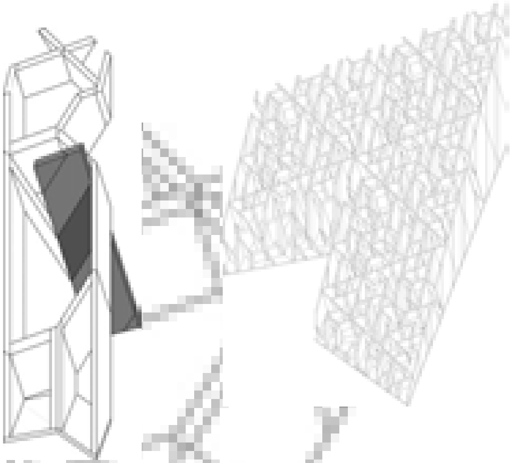
Since the structure consists of roughly 1100 individually shaped parts (Fig. 2), the crucial point was to automate the translation of the platform geometry into the geometry of the single parts and finally into the steering code for the computer controlled mill. This was accomplished by a set of scripts in the CAD-package Vectorworks. The first script imports the original design defined as a NURBS-surface in the modelling software Maya, reads the coordinates of the platform’s cross-sections for every rafter and determines the angles of bank. A second script translates this information into the milling paths for all 1000 rafters, also including all drillings for the dowels. A third script arranges and optimises the rafters on the MDF-boards and generates the so called G-Code, the programs which control the five-axis CNC-router. 120 MDF-boards sized 1.0 by 4.2 metres were used to fabricate all rafters within roughly 50 milling hours.

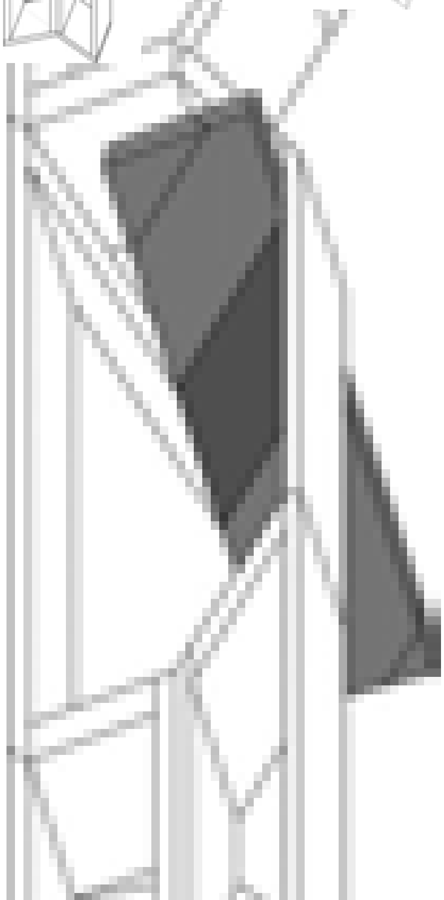
Complex puzzle: Libeskind’s Futuropolis Sculpture

The second project to be introduced here is substantially more complex than the Inventioneering Architecture platform. First, the structure consists of twice as many individual parts – summing up to 2200 in the end. Second - and more important - the geometry was not defined explicitly as a NURBS-surface but implicitly in the form of geometric production rules. The digital chain thus had to start one step earlier, by generating the geometry of the structure.

“Futuropolis” is a wooden sculpture designed by New York architect Daniel Libeskind for a workshop he held at the University of St. Gallen (HSG) in October 2005 (Fig. 5). HSG, a renowned business school, introduces its new students with a freshman week every year. In 2005 the aim of the 5-day workshop was to conceptualize a “City of the future” and visualize the ideas by help of the complex formed towers of the Futuropolis sculpture.

The design is based on a triangular grid, where a 98 tightly packed towers form an ascending volume of up to 3.8 metres height. The towers are built from roughly 600 wooden boards that are intersecting the sculpture at an angle of 25 degrees and show the same pattern as the footprints of the towers. Thus, the boards are





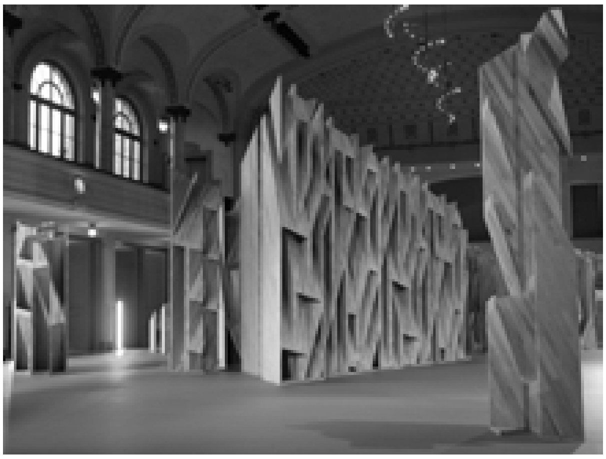


Fig 3: constructive principle: one board intersects several towers

Fig 4: the detailed and structurally optimised sculpture

Fig 5: Libeskind’s Futuropolis at the concert hall St. Gallen

cut into almost 2000 wooden polygons by the perpendicular faces of the towers (Fig 3). To realise this design within the given time and budget was not possible by means of traditional craftsmanship, so again a complete digital production chain was set up.

The first challenge was to find an appropriate construction method to connect the boards of each tower so that maximum structural integrity could be guaranteed at minimum production and assembly costs. By using aluminium dovetail-connectors, the number of connection details could be reduced to only six variants with eleven subtypes, whose mitres and notches can be milled by a CNC-router.

The second challenge was to generate the exact geometry of all 2164 parts, including the bases where the towers stand on. A completely parameterised CAD-model of the sculpture was programmed in Vectorworks, which calculated the outline of all parts by closely following the algorithmic design rules given by the architect (Fig. 4). The appropriate connection details where automatically assigned to the edges, the parts were numbered and arranged on boards (Fig. 6).

The third step was to translate this geometry information into the steering code for the CNC-machine. Since the boards had to be turned around in the middle of the production process, two G-Code programs per board had to be generated by a script. Also the exact widths and lengths for calculating the material costs and for preparing the raw boards were automatically exported as data-tables. The sculpture consists of 360 square metres of 32 mm thick boards, altogether almost 11.5 cubic metres of birch wood. Total milling time summed up to about 200 hours, the assembly took roughly 500 man-hours.

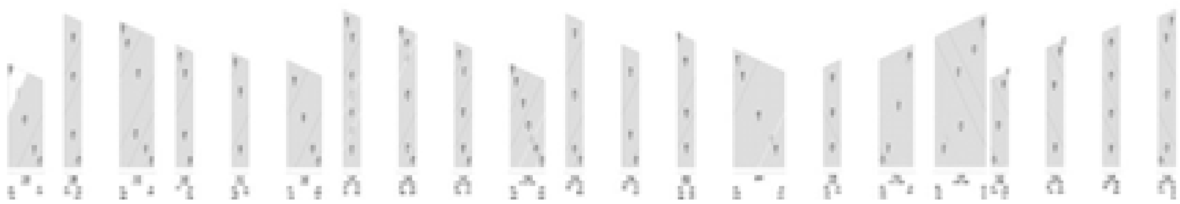


Fig 6: Futuropolis consists of 628 boards, each containing parts of various towers

Organically optimised: The CAAD Swissbau Pavilion

Like in the second example, the digital chain in this case started with the generation of an explicit geometry from an implicit set of rules. But instead of having „geometrical rules“ that deterministically defined the final geometry like in the Futuropolis project, this time „functional rules“ were used to generate a unique optimised geometry for a given environment by help of a self-organising process [7].

The CAAD Swissbau Pavilion was designed and built to show the potential of the digital chain on the Swissbau 2005 fair in Basel (Fig.8). It has the form of a sphere with two metres radius and reaches a height of three metres. It is assembled from quadrilateral wooden frames, each consisting of four wooden boards standing perpendicular on the surface of the sphere. But while in a traditional coffered dome a regular structure dictates the placement of openings, here the frames are required to adapt their size and angles to the deliberately asymmetric placement of windows.

To generate this adaptive geometry, an interactive software was programmed in Java that simulates the growth of a quadrilateral mesh on a sphere following simple rules: The edges try to align with the positions of the predefined openings and the floor level, while at the same time every mesh attempts to optimise its size and angles. The simulation of this process is running in real-time and can be influenced directly by the user. Under certain circumstances the structure can locally alter its topology by inserting or deleting meshes until it reaches a stable state (Fig. 7). The resulting geometry of nodes and edges is then exported to an XML file and used as the base for the rest of the digital chain.

The subsequent steps are analogue to the first two examples: a script reads the XML file into the CAD-software Vectorworks and generates a 3D-model of the pavilion with the exact geometries of all 320 wooden frames and their 1280 parts. All parts are automatically numbered and a second script arranges them on the raw boards used for milling. The G-Code for controlling the CNC-router is exported automatically for every board and already includes information for drilling the holes and milling the unique part-id into the boards.

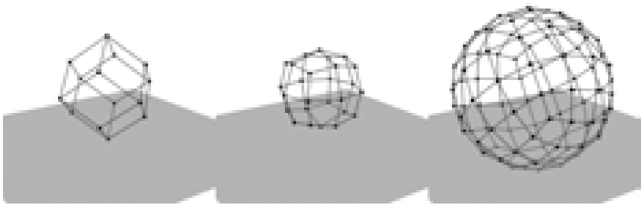


Fig. 7a-c: Starting configuration and growing mesh

Fig. 8 Materialising a simulation: the assembled pavilion

The designtoproduction-process

From the experiences gained in the described examples we define a process, which leads from the design to the production of complex structures in six steps. It starts right after the design and it ends just before production, tightly filling the gap between the designer and the manufacturer, negotiating their respective requirements and building a sustainable connection. The aim is to implement a “digital process chain” that contains all necessary information in one (or more) parameterised digital model(s) and allows for CNC manufacturing of many individual parts without having to manually design every variant.

Definition of geometric, functional and constructive requirements

It all starts with design-input. The first step in the process is to carefully identify the requirements of shape, function and construction together with the designers. Depending on the type of project the focus may be shifted between those three topics. In our examples, the Futuropolis project was dominated by the very detailed description of the geometric principle whereas in the other two examples only the overall shape was given and the geometry of the single parts could be modified. The Swissbau Pavilion especially illustrates this by self-organizing its components around the given openings (function) and optimising the size of the meshes (construction). For the Inventioneering Architecture platform the overall geometry was predefined and functional requirements were given by the footpath across the structure and the need for easy assembly and shipping in a standard overseas container but there were no prerequisites at all for the construction method. This stage defines the “playground” for finding a solution.

Definition of materials and constructive details

Going on from the definition of requirements, the next step is to identify adequate materials and construction methods. Already at this stage the “other end” of the process, the production, kicks in. External manufacturing specialists – in all our examples carpenters with a high degree of experience on CNC-tools – are integrated in this early phase in order to find optimum solutions for all questions of material and constructive detailing. This is especially necessary to identify points in the production chain, where material properties can be exploited and cost intensive manual labour can be avoided. For example the dovetail-connectors used in the Futuropolis and Swissbau project made it unnecessary to clamp the freshly glued parts for drying and thus saved an immense amount of work. Another important issue within this phase is to reduce the number of different details. In the Futuropolis sculpture there are 15 different variants of two to eight boards meeting at one point. After optimisation it was possible to build all those connection alternatives from only six different types of board-cuts. In the Swissbau-Pavilion there is only one single parameterised connection detail: a mitred cut with a notch for the dovetail. The mitre-angle of course changes from part to part and is essentially never the same.

Definition of the structure’s geometry: start of the digital chain

Up to now the process resembles very much the usual way of gradually bringing a design to the building stage. In the third step however this is fundamentally changed by introducing the first link of the digital chain that will connect the design directly to the production. After the constructive details are fixed, the next step is to exactly describe the structure’s geometry. For highly complex structures there are three different ways to do so:

Explicit definition by design

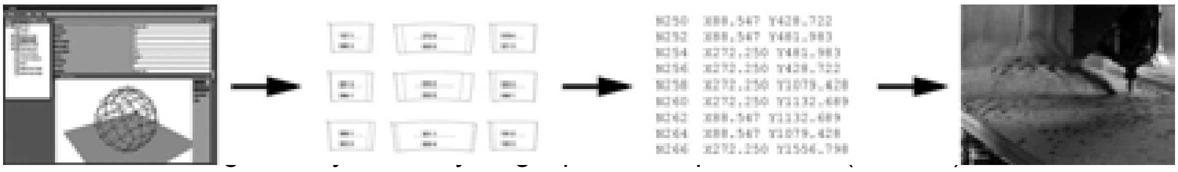
In this case, the geometry is already entirely defined (digital) model of the shape. In the Inventioneering Architecture project for example, the form of the stage was designed by creating a NURBS-surface with the modelling software Maya. The landscape was explicitly shaped until it fitted the requirements of the designer and then cut into sections. The built result matched this geometry exactly, because the coordinates and curvatures of all the rafters could be directly read from the NURBS surface.

Implicit definition by concept

A more abstract way of defining the geometry is to give a description of the concept how it is derived. In the Futuropolis project the shape was not explicitly defined (although a three-dimensional CAD model existed) but was given as a set of geometrical production rules: “Take this shape, extrude it vertically, intersect it with an inclined plane, extrude the intersection perpendicular to the plane…” and so on. From this algorithmic description an actual algorithm was programmed that could generate the exact geometric description for all 2200 parts in a few seconds. Something that would have taken weeks if attempted manually and had to be repeated after every minor change of the design.

Generation by optimisation

The most sophisticated form of defining the geometry was implemented for the Swissbau project. Instead of a deterministic algorithm that ends with the same outcome every time like in the Futuropolis sculpture, a non-deterministic approach was used, that optimises the geometry by using a dynamic simulation system. Depending on the parameter setting at the beginning and the user interactions, the system ends up in a different state every time it is run. But it still produces a result matching the predefined requirements every time.



c. Generation of production code (G-code) (2.5)

d. Production on a CNC-machine

Generation of geometry for every single part

After defining or generating the exact geometry of the structure with one of the above methods, this “abstract” description has to be translated into detailed geometries for the single parts. The optimisation program for the Swissbau pavilion for example returned only the coordinates and edge-relations of the generated mesh. The actual geometries of the boards forming the quadrilateral frames were then generated and numbered automatically upon this information by a different CAD-script. In the Futuropolis project, the cutting angles and connector-geometries were added to the board outlines in this phase. Thorough quality control is done at this stage because systematic errors in the previous steps are likely to become visible here. If possible, 1:1 prototypes of selected components are produced to identify problems. Also the net material demand can be calculated.

Optimisation for production

In the next step the parts are optimised for production, usually by arranging a multitude of parts on a board of raw material so that the waste is minimized. Also additional details for production are added, for example holes for fixing the boards on the table of the router machine. In the Swissbau pavilion this holes were later also used to connect adjacent frames by bolts, so they had to be placed exactly in order to match. On the manufacturing side, the material can now be prepared e.g. by cutting up the raw boards into appropriate chunks. Also arrangements for numbering the single parts – e.g. by sticky notes – and the generation of assembly drawings take place at this stage.

Generation of production code

The production code (“G-code”) for the CNC-machine is the final result of the digital production chain. G-Code is basically telling the machine which tool to choose and where to move it. Usually, this is programmed by the manufacturer on the basis of detailed construction drawings. For the automated generation of the G-code in our digital process chain, only a single exemplary part of the structure is processed this way and the resulting code is used as a prototype for the other parts. A final script is created which generates the appropriate code for all parts from the optimised CAD-model. Those codes are then handed back to the manufacturer and fed directly into the five-axis-router to start the production.

Conclusions

After having realised three different projects we are able to sum up some results that became very clear. Quality, flexibility and efficiency were the main issues in all the projects. The potential of the presented process to resolve those issues actually made it possible to realise the projects, which would have been too complex and cost intensive otherwise.

Quality

With CNC manufacturing it is possible to achieve a level of exactitude that is not within reach of manual work at this project scale. By implementing a digital chain this quality can be maintained throughout the whole process, which essentially makes it possible to create structures from a few thousand individually shaped parts which fit to the tenth of a millimetre at every contact point. Usually the tolerances of the CNC machines are very reliable and the material tolerances (especially when working with wood) are much more challenging. At the same time the digital process requires an algorithmic approach to quality management with more bug-fixing in software development than measuring of fabrication tolerances. The generation of geometries and fabrication codes by software mostly leads to either entirely correct or entirely flawed results but the flaws are sometimes difficult to detect due to the complexity of the structure. Plausibility checks have to be carefully designed and performed after every step of the process.

Flexibility

Since the whole process relies on a parameterised digital model, it responds very well to changes. Late design alterations as well as other changes are no problem as long as they lie within the boundaries of the model. In the Futuropolis project for example, it turned out that the delivered material was two millimetres thicker than expected, which changed the geometry for all 2200 parts. The new G-Codes for the CNC-router could be generated practically over night, so the production schedule was not influenced.

Efficiency

For all three examples, detailed calculations provided by the manufacturer showed how much it would have cost to fabricate the projects on the same CNC-machine but without a digital chain delivering the machine-ready data. In all three cases the figures are impressive: the reduction of manufacturing cost ranges from 72% in the Futuropolis project up to 83% in the Swissbau project. Primary cost factor in the “conventional” CNC-process is the programming of the G-Code and the optimisation for production, which were completely taken off the manufacturer’s shoulders and done much more efficiently by the use of parameterised CAD-models. When considering the expenses for consulting and programming in the six designtoproduction phases, the saving potential is still around 25 to 50 percent of the total budget.

Future work

All three presented projects were executed in wood by the same fabrication partner on a five-axis router over the last year. We are aware that there are many more CNC machines to work with and an infinite number of different materials. However we think that especially in woodwork there is a huge potential to improve CNC-manufacturing, mainly because of the three-dimensionality of the material as opposed to for example laser cutting of sheet metal. In the nearby future, we would like to transmit our experience from exhibition and interior projects to a building scale. We expect to face three challenges:

Scale – Is it possible to “scale” our working process regarding the size of the parts and their number? How do bigger machines and material dimensions influence the process?

Scope – Is it possible to cover the design and production of a whole building with digital chains or is this method rather suitable for separate parts of a building such as a façade or a roof construction? What are the criteria to decide between manual and digital workflow?

Organisation – So far we have worked with rather linear production chains and just one manufacturing partner, without interfaces to other planners and producers. Can a linear digital chain become a "digital network", addressing all the planners and companies involved in the building process?

Credits

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Biomimesis and the Geometric Definition of Shell Structures in Architecture

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Abstract

In architecture the concept of biomimesis (bios, meaning life, mimesis, meaning to imitate, also known as biomimetics) can be applied to the design of tree-like, web-like, skeleton-like, pneumatic and shell-like structures.

Shell structures may be constructed from masonry, concrete or a grid of steel or timber members – a lattice or reticulated shell. The paper examines the philosophical, æsthetic, structural and environmental criteria to be used to decide whether biomimesis is appropriate. A strategy is described for the generation of organic forms in which a three-dimensional computer model is produced using a combination of interactive sculpting and analytical relationships. The inspiration behind this approach is the geometry of seashells.

1. Introduction

A shell is a three dimensional curved structure which resists load through its inherent curvature. There are numerous shell structures in nature; eggs, skulls, nuts, turtles and seashells, are notable examples [1]. A shell's structural behaviour is derived directly from its form, thus when designing a shell-like structure, the fundamental consideration is the choice of geometry. This not only dictates the æsthetics, but the overall efficiency and behaviour under load of the structural system. The basis for curved geometry, as discussed by Williams [2], can be sculptural, geometric or defined by a natural physical process.

There are many precedents of the use of natural forms and phenomena as the basis for architectural geometry. Techniques for forming optimum shapes for pure tensile or compressive structures have been developed using physical models. Antonio Gaudí aspired to create optimal structural forms using inverted string models, taking his inspiration from Gothic architecture in Spain.

A string, when suspended at each end and allowed to hang freely, forms a catenary, a curve of pure tension. Using this principle Gaudí formed pure compression geometries by inverting the form of the hanging models. Gaudí also experimented with suspending cloth, allowing it to sag to create three-dimensional vault surfaces. Throughout the twentieth century architects and engineers, including Torroja, Nervi, Candella and Isler, explored the design of thin concrete shell structures. Figure 1 shows a service station in Deitingen-Süd, Switzerland, designed by Heinz Isler. Much of Isler's free-form geometry was generated using inverted hanging models similar to Gaudí's. Isler also went on to experiment with pneumatic membrane models, creating what he called 'bubble shells', where the geometry was defined by air inflated membranes [4].

In 1964 Frei Otto founded the Institute of Lightweight Structures at the University of Stuttgart. Here Otto and his team undertook extensive research into natural forms and processes, generating and inspiring optimum structures [5]. As well as shell structures, lightweight or optimum structures include membrane structures, cable-net, geodesic domes, inflatable and air supported structures, and lattice or reticulated shell structures such as the grid shell pictured in figure 2. As well as building on the historical precedents of inverted hanging models for rigid compression structures, Otto pioneered the use of soap film models to generate minimal surfaces defining the optimum geometry of tensile structures (figure 3).

Further examples of biomimesis in architecture may include Calatrava's bone like structures [6], Meinhard von Gerkan's tree-like roof of the Stuttgart Airport passenger terminal or perhaps Nicholas Grimshaw's geodesic domes of the Eden project in Cornwall, which bear a striking resemblance to the hexagonal lattice of a diatom, pictured in figure 3.

Figure 1: Concrete shell structure designed by Heinz Isler [3]

Figure 2: Grid shell roof covering the Great Court of the British Museum in London
Architect: Foster and Partners, Engineer: Buro Happold

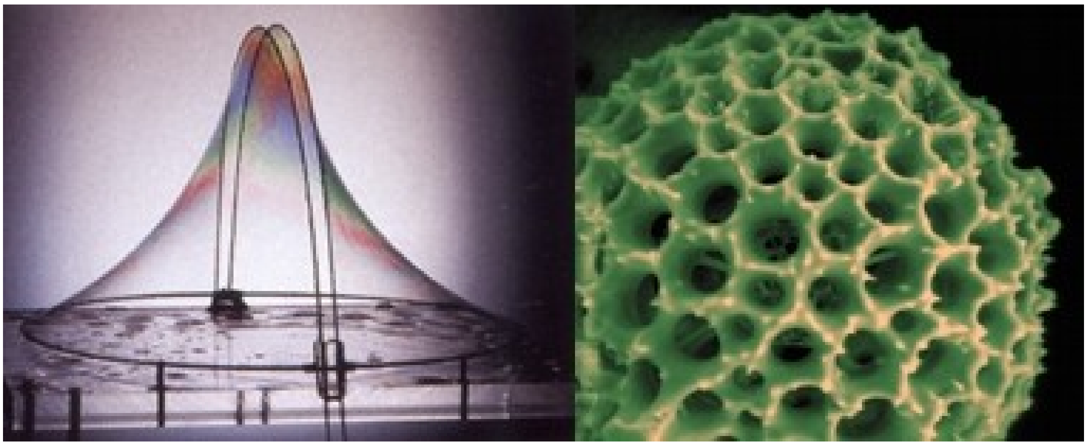


Figure 3: (left) Soap film experiment producing minimal surface [5]
(right) Diatom, analogous to a geodesic dome [7]

Although there are numerous examples of where biomimesis has been successfully applied to architecture, the potential is far from being exhausted. There are endless different structural forms played out in nature, however in most cases the complexity of these forms renders geometric modelling problematic. Yet as computer-aided design and computational analysis techniques are becoming more powerful, greater interest is focused on these forms and even complex structural behaviour is modelled successfully. It is the aim of this paper to describe a method for modelling seashell forms with an application in architectural design.

As described above a shell's inherent shape defines how efficiently loads are resisted. Loads applied to a shell surface can be accommodated through two actions, through bending and through stretching [8]. Bending forces are carried through moments and shear forces, and stretching forces through axial thrusts and tensions. The later of these phenomena is called membrane action. Membrane action is much more efficient than bending, and therefore a shell will work by membrane action if it can, however to determine whether a shell can or not depends greatly upon its geometry and support conditions. Membrane action also relies on bending stiffness to prevent buckling. Therefore in order to understand the structural behaviour of seashells a complete understanding of their geometry is required.

2. Geometry of Seashells

Seashells are formed in nature by growth at the shell's free leading edge. Their increase in overall size is achieved purely from successive addition of material to one end only [9]. From inspection of actual seashell cross-sections, the older previously formed parts of the shell remain, on the whole, unaffected and geometrically unchanged once produced (as illustrated in figure 4).

Figure 4: Cut cross-sections of a selection of seashells found in nature

A simple seashell may be considered as a surface of revolution formed along a spiral path about the shell's axis. The generating cross-section is of constant shape, but increasing in size by a constant ratio as the section sweeps the curve. For centuries biologists and mathematicians have explored techniques for describing and dissecting this shell geometry into simple terms.

The origins of theoretical seashell morphology can be traced back to the work of Moseley, who derived equations for calculating the volume, surface area, and centre of gravity of planispiral and trochospiral shells [10]. Moseley's equations were reformulated by Raup with the application of displaying shell shapes using a computer [11]. Raup described the geometry of seashells using three parameters, which he called W, D and T. These terms were later elaborated by Dawkins [12], renaming them flare, verm and spire, respectively.

Flare, Dawkins explains, is a measure of the expansion rate of the spiral, verm controls the rate of increase in size of the cross-section and spire is the rate of displacement along the axis of the shell. Figure 5 illustrates the effect on the overall shell geometry for changes in these different parameters, using an ellipse as the whorl cross-section. However it is clear from observations of actual shells (figure 4) that the cross-section is more complex than the input of three parameters allows. Fowler *et al.* [13] were first to implement free-form cross sections, using a Bézier curve [14,15] as the input.

All these approaches model the shell as a single surface, a two-dimensional object, embedded in three-dimensional space. To the writers' knowledge little work has been done on accurately modelling the cross-section of the shell, showing the thickness of the shell wall and the complex solid volumes that are formed down the internal spine. As described above shells as a structural mechanism are incredibly sensitive to variations in geometry. It is this paper's intent to create a method for generating a three-dimensional shell model which includes the thickness of the shell material, thus providing a model which can form the basis of a three-dimensional structural analysis.

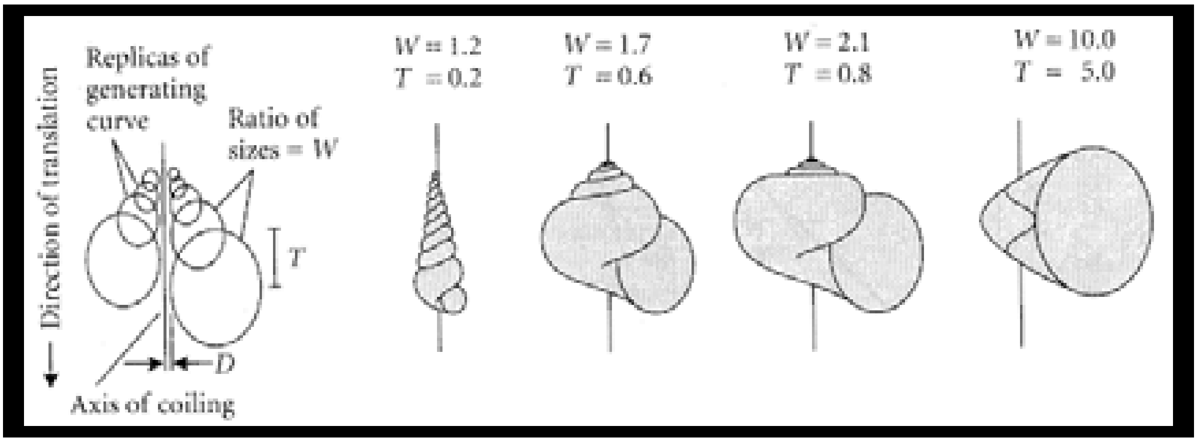


Figure 5: Shell geometry controlled by parameters flare (W), verm (D) and spire (T) [11]

3. Construction of the shell model

The basic approach to modelling the shell's solid cross-sections was to first generate the internal whorl surface which forms the cavity in which the gastropod lives. A portion of this surface could then be offset defining the outermost surface of the shell. The volume between these two surfaces would then form the geometry of the solid material which forms the shell.

A parametric model of the shell was set up using the cross section of a single whorl as the input. In a similar approach to Fowler *et al* [13], the shape of a single typical whorl was defined as a B-spline. A B-spline can be used to approximate a smooth curve from a small set of control points [14,15]. Figure 6 shows a B-spline of order four, and its control polygon.

From the definition of a B-spline the curve is parameterised along its length, with respect to parameter μ with a range of $0 \leq \mu \leq 1.0$. $\mu = 0$ and 1.0 refer to the start and end of the closed loop respectively whilst the point $\mu = 0.5$ is half way around the length of the curve.

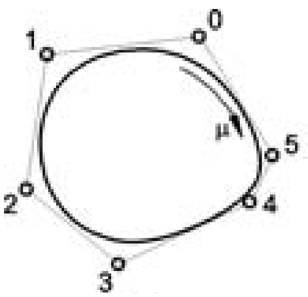
Between the values $\mu_{begin} = 0$ and μ_{join} the whorl B-spline is offset by a given thickness to form the outer surface of the shell. The outer surface is parameterised between ϕ_{begin} and ϕ_{end}. A single whorl cross-section in its local coordinate system is illustrated in figure 6.

The ribs on the external shell surface, as illustrated later in figures 9 and 10, were generated by superimposing a sine based function on to the surface normal component of the position vectors.

The shell surface geometry is defined using cylindrical polar coordinates (*r, θ, z*), which can be expressed in terms of Cartesian coordinates (*x, y,* z):

$$
\begin{aligned}
x &= r\cos\theta \\
y &= r\sin\theta \qquad (1) \\
z &= z
\end{aligned}
$$

The path along which a shells whorl cross-section follows is a logarithmic spiral and it is the geometric properties of this curve that define the overall geometry of the shell. A logarithmic spiral is a curve which forms a constant angle between its tangent and radius vector at any point. Hence logarithmic spirals have the alternative name *equiangular spirals*. Figure 7 illustrates the constant λ which defines the rate of spiral for any such curve.



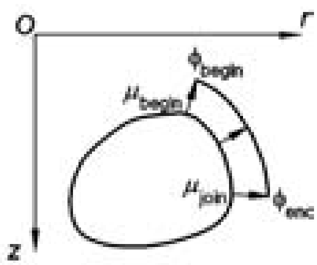


Figure 6: (left) B-spline and its control polygon
(right) single whorl cross-section

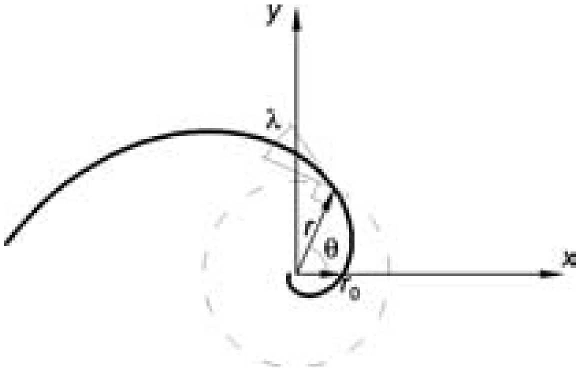


Figure 7: Geometry of the logarithmic spiral.

The relationship between any two points on a logarithmic spiral can be described by the formula below:

$$\tan\lambda = \frac{1}{r}\frac{dr}{d\theta} \quad (2)$$

giving

$$e^{\theta \tan\lambda} = \frac{r}{r_0} \quad (3)$$

where r_0 is the radius at $\theta = 0$.

From observations made from real seashells the growth rings, which correspond to the whorl cross-section, are not radial and do not even lie in one plane. They are curves in three dimensions. This means that the shell's rate of spiral, λ, as previously illustrated, is required to be such that the point ϕ_{begin} on the current leading edge cross-section must lie coincident with ϕ_{end} on the preceding section after slightly less than one revolution about the major z-axis, i.e. $\Delta\theta = 2\pi - \theta_{join}$, as illustrated in figure 8 and expressed in the following equation (4):

$$r(\theta, \phi_{end}) = r(\theta + 2\pi - \theta_{join}, \phi_{begin}) \quad (4)$$

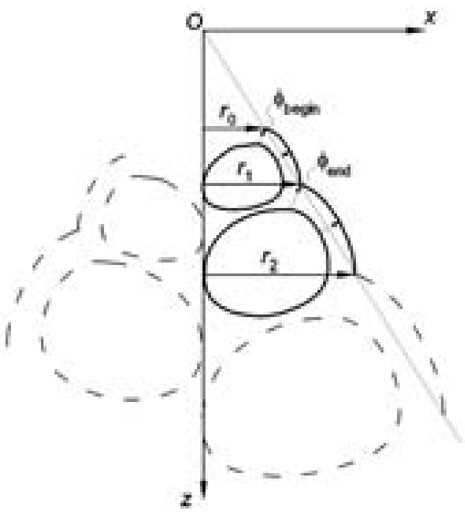


Figure 8: Geometric relations of the shell surface

Thus λ is controlled by the relationship:

$$e^{(2\pi - \theta_{join})\tan\lambda} = \frac{r_1}{r_0} \qquad (5)$$

where:

$$\begin{aligned} \lambda &= \text{rate of spiral constant} \\ r_0 &= \text{radius to point } \phi_0 \\ r_1 &= \text{radius to point } \phi_0' \\ \theta_{join} &= \theta_{shift} \text{ at point } \phi_{join} \end{aligned}$$

The growth constant is applied to the whorl by transforming its coordinates using the formulae below, based on the cylindrical polar coordinate transformation (equation (1)):

$$\begin{aligned} x &= e^{\theta \tan\lambda}\, r\cos\theta \\ y &= e^{\theta \tan\lambda}\, r\sin\theta \\ z &= e^{\theta \tan\lambda}\, z \end{aligned} \qquad (6)$$

Figure 8 illustrates the sequential increase in size of the cross-section, starting from an infinitesimal size at the origin.

The shape of the whorl, the value of ϕ_{end} and the offset thickness are all parameters easily measured from actual seashell cross-sections and it is from these inputs that the whole three-dimensional shell geometry can be generated. Figure 9 illustrates a good correlation between the real natural seashell on the left and the computer generated model on the right.

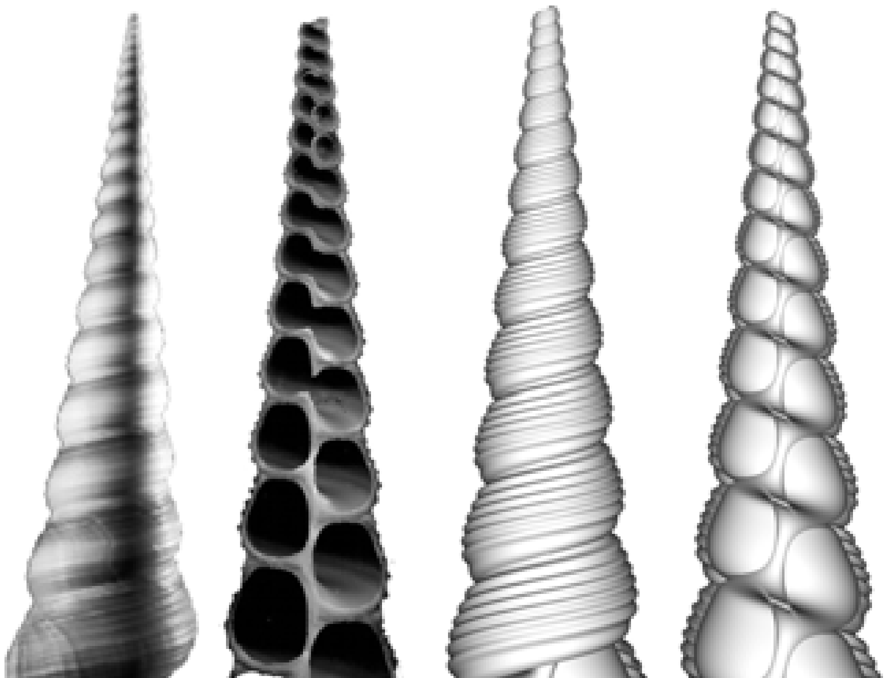


Figure 9: (left) scan of a seashell found in nature
(right) computer generated shell model

4. Conclusions

Seashells were investigated as three-dimensional structures as part of a study into biomimesis as a basis for architectural form. Previous seashell models have accurately captured the external surface of the shells, generating realistic images; however our research has placed emphasis on the shell as a volume. Figure 10 shows a three-dimensional model which has been clipped to reveal the central third of the shell, illustrating the incredibly complex volumes and voids which are generated internally. The next phase of the research is to understand the structural implications of this geometry and thus suggest a set of inspired architectural forms.

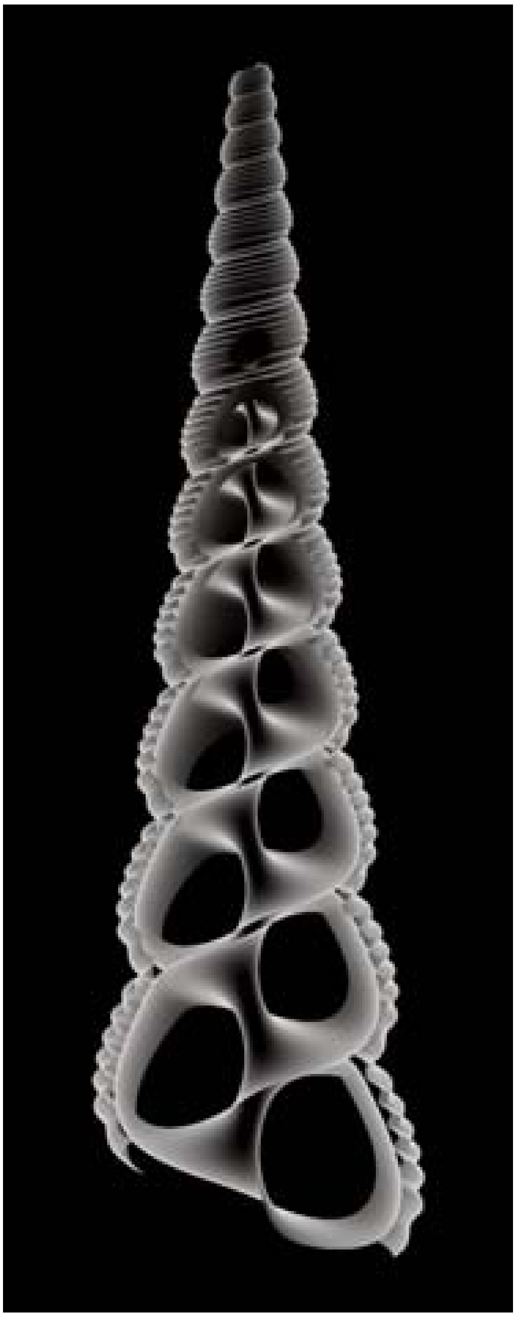


Figure 10: Three-dimensional shell model with two cutting planes at third points

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The Reconstruction of the Center Square of Chang Shou Park - A Practical Case of Generative Design

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Abstract:

This paper introduces the project of the reconstruction of the center square of Chang Shou Park, in which the concept of "Generative" is experimentally applied. The author successfully provides a comfort, lifeful and harmonic space with varied details and forms by the method of "Generative". In the paper, the author also proposes some preliminary ideas about the collection of the basic element(s) from a real urban space and about the way to develop the basic element(s) in a real urban space. The author hopes that these ideas can contribute to the development of "Generative" method, especially to its development in China, where Generative Art (GA) is a quite new and unfamiliar thing.

1. A Brief of the Case

1.1 Information about the Park

Invested by the government, Chang Shou Park was established in Jan. 2000. Located in the Pu Tuo District, Shanghai, with an area of 4 hectares, it serves as an important public space for the local communities and the city. The park is just beside the Chang Shou Road, one of main roads of the city, and is no more than 3 kilometers away from Shanghai Railway Station. A lot of people visit the park every day and an official or unofficial activity is held every week.

The survey of Chang Shou Park

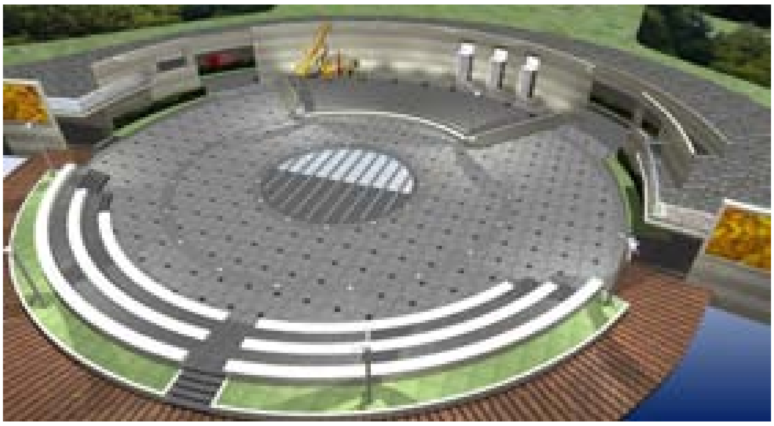
1.2 About the Reconstruction

After 5 years of its establishment, the local authority plans to turn the park into a sculpture park with a theme of “Harmony” by the reconstruction of the center park and the installation of more than 20 sculptures made by artists from all over the world. There is a sculpture made of glass in the center square now and it will be removed because it has partially broken. The authority hopes that the square will be a good place for the citizens to take part in a variety of activities after the reconstruction and that it is more convenient to hold performances there. A new sculpture named “Harmony” will be placed in the square.

2. How the GA is applied

2.1 The Solution

From the rendering rendered by 3ds Max below, you can see the new sight of the park's center square.



The survey of the square

The major changes are as followings:

A lifted stage for performance is established with a curvy background made of stone. Clean water flows from a pool on the second floor, through the three rectangle holes of the background and into the pool on the ground. The water is recycled with the use of a hidden pump.

The original broken sculpture is removed and the ground is be repaved so that people have enough place to do exercises, to dance or do other things. The center pattern of the ground is specially designed. It not only looks similar with the removed sculpture but also has certain meaning which will be discussed later.

The curvy stand for audience is build so that people can have a good sight of the performances even they are not able to sit near the stage.

Next, well talk about how we come to this solution and how GA is applied.

2.2. The collection of element:

Element is the basic unit that can generate numerous "possibilities" through a certain process. The Collection of the element, the author thinks, is the most important phase of the entire process of GA because that it decides the points where the process of generating starts from and the direction towards which it will go.

First, as for a design of a real space, the element(s) should be characteristic of the place, related with the history, culture that the place belongs to. Or, it will be difficult to generate "possibilities" that is identical. Only if the element(s) is meaningful, then the "possibilities" can be meaningful. The process shows designer's comprehension of the place.

Second, the element(s) should be as simple as possible , even should be of impartibility. That is because the simpler an element is, the easier it is to compound and the clearer its character is. It's just like an atom, which is extremely simple, can make up of almost everything of the world.

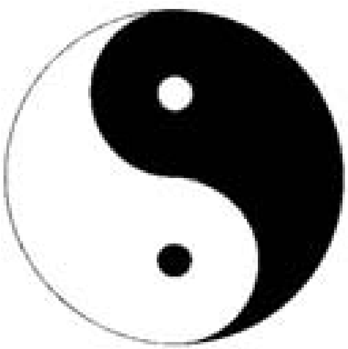
Thirdly, we can choose a special line or a special shape as the element to generate, just as many GA artists have done, however, we think that a certain kind of concept, an idea or a kind of faith and so on can also be taken as an element, which may even be a more ideal element.

Why?

Buildings like architectures or squares may have many different kinds of forms. However, all the buildings of the same area are the outcome of the working of the people in that area. They contain a kind of collective spirit when they were built by the people. At the same time, these buildings have inner connection to each other. People of the same area usually have similar faith, similar education background, similar thinking and similar characters, that is, each society has developed its own spiritual civilization. If we choose a fragment of its spiritual civilization as our element, then the consequent generated “possibilities” will be more identical and has much deeper connection to the things around it because all the other things are, in fact, the existing “possibilities” generated by the same spiritual civilization.

In the case of Chang Shou Park, we find that the original glass sculpture has a certain connection to the Chinese traditional theory of “Yin” and “Yang”. The sculpture’s “negative” shape and “positive” shape can be separately thought as "Yin" and "Yang"


The original glass sculpture



The symbol of the “Yin and Yang”
Yin and Yang” Theory is Chinese traditional thinking of the universe. It reflects the basic rules of everything in the universe. The black part represents “Yin”(阴) and the white part represents “Yang” (阳) ,meanwhile there is a black dot in the white part just as there is a white dot in the black part. The theory thinks everything has two sides which are both opposite and transferable.

2.3. The development of the element

Then, with the help of 3DS Max, we develop this concept (element) of “Yin” and “Yang” in the aspect of material, texture, size, color, shape, dimension and so on.

For example:

The main pattern of the square’s ground continues the concept with two material-glass and stone.

We use black and white stone tiles with different size to pave other parts of the ground.

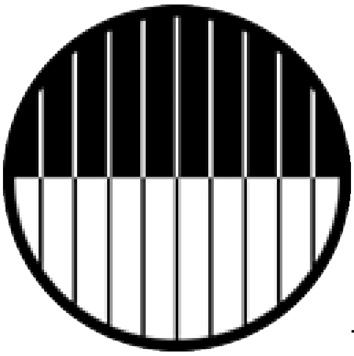
As for the background, we use a kind of special stones with many small holes.

We make the tiles into two kinds- one is smooth and the other is rough- so that, you can see the subtle lines on the background.

People can see the distant sight or sky through the rectangle holes of background, which is attributed to the combination of the “negative” shape and “positive” shape.

The combination of waterfall and the stone background is another form of “Yin” and “Yang”

……



The simplified main pattern of the square’s ground

3. Conclusion

By the method of GA, we have worked out a solution that makes the public space with rich and varied details and forms. Each detail or form has the same inner spiritual connection. The solution develops the context of the place, contains the spirit of Chinese traditional culture and displays the theme of "Harmony".

"NATURAL SELECTION: A STETHOSCOPIC AMPHIBIOUS INSTALLATION"

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Abstract

This paper discusses emergence as a complex behaviour in the sound domain and presents a design strategy that was used in the creation of the sound installation *Natural Selection* to encourage the perception of sonic emergence. The interactions in *Natural Selection* are based on an algorithm derived from an innately sonic emergent ecological system found in nature, that of mating choices by female frogs within a calling male frog chorus. This paper outlines the design and implementation of the installation and describes the research behind its design, most notably the notion of embodiment within a sonic environment and its importance to the perception of sonic emergence.

Introduction

A fascination for models derived from natural organisms has a long history of influence within the arts. In recent years, there have been numerous implementations of algorithmic systems that model the phenomena of emergent behaviour. In an attempt to reproduce the necessary conditions for emergent behaviour to occur, these systems employ bottom-up strategies through the definitions of simple rules for the behaviour of local agents.

In the context of sound design, a potential problem with many of these systems is that the algorithms they are based on do not derive from sound but typically from a system that exhibits perceived emergence through the application of graphical (Boids) [13] or evolutionary (Genetic Algorithm)[1] models. The implementation of these algorithms to a sound world is then based on a more or less arbitrary mapping procedure between a graphical and a sonic model.

The installation described here attempts to sidestep issues pertaining to the mapping of graphical to sonic emergent systems by designing the work through a carefully selected natively sonic emergent environment with special consideration given to the notion that the phenomenon of emergence is manifest in the dynamic listening system of a perceiver embodied within the environment.

We have argued elsewhere [3] that the modeling of emergence is linked to how we perceive it. In the context of emergent sound we feel it is important to model behaviour that features intrinsic aspects of emergence in the acoustic domain, in contrast to arbitrary mapping between domains.

'In the same way that behaviours such as flocking are better understood from a distance, we argue that sonic emergence can only be perceived when considering the listener as an agent of that very behaviour. The ear does not act as a stethoscope, listening in from the outside, but rather as a participant in a space in which it takes the role of one, of many agents.' (Davis and Rebelo) [3]

Ecological Model

This installation is based on the listening ecology found in the model of female frog mate selection within a calling male frog chorus. Through a study of current research into the mating of frogs we have found that female frogs select a mate from within the male frog chorus according to information afforded to them through the temporal and spectral characteristics of their calls [5]. Frogs have a complex auditory system that is designed to help them recognise and respond to calls of their own species. They have a variety of different calls for such situations as mating, distress, release, warning, rain and definition of territory. The calls for different species are distinct in temporal and spectral characteristics. This helps the frogs recognise calls of their own species within a dense chorus [11].

The mating calls of frog species under study can be characterised by four main parameters: dominant call frequency (the frequency with the highest spectral intensity), pulse rate, call rate and call duration. With dominant call frequency relating to frog size, pulse rate relating to the ambient temperature of the environment, for example the water temperature, and call rate and call duration relating to the preference of each individual animal [8]. The characteristics that were found to have the most effect on female choice of mate, were dominant call frequency and call length [8]. It was found females preferred longer lower calls, the pitch of the calls having a strong correlation to the body size of the males and thus their successfulness in mating. It has been found by Wollerman that a “female frog could detect a single male’s calls mixed with the sounds of a chorus when the intensity of the calls was equal to that of the chorus noise” [14]. Given that there is a 6dB fall off in the intensity of the signal with each doubling of distance away this means that for an average spaced chorus (0.08 males per metre^2 [14]), the female can only distinctly ‘hear’ between three and five males at any one time

This installation is based on a simple model of the interactions found between the male frogs in the chorus with the user taking on the role of the female. Each male frog is represented by a mechanical ‘sound object’, which consists of a resonator excited by a motor. These sound objects have been designed to represent the four main characteristics of the male frogs call: the size of the resonator being linked to the dominant call frequency of the frog; the pulse rate is variable dependent on lighting conditions (each “frog” is fitted with a light sensor the output of which is affected by the user’s location causing disturbances to the light source); the call duration is fixed but different for each frog.

The Algorithm

The rules that govern the local interactions between the males are based on research that suggests that female frogs prefer 'leading males', i.e. males that are perceived by the female to be calling in front of the other frogs. [7]. To produce this effect the male frogs listen to their nearest neighbours (the others being masked by the noise of the chorus) and consciously alter their call rate so as not to coincide with other males. To model this interaction each “frog” has a set call rate which is modified through the application of an algorithm based on a resettable oscillator. Each of the frogs is wired to its two nearest neighbours to resemble the listening conditions in the wild [11]. If a “frog” 'hears' a neighbour making its call, by virtue of receiving a current down a wire it resets its oscillator to 1 thus inhibiting its own call and lengthening or shortening its own call rate. The local interaction between the male frogs is the algorithmic structure that has been set up to exhibit emergent results. The temporal form of the piece is not only governed by the frogs own set call rate but by the interactions of the frogs with their nearest neighbours.

'Form is a dynamic process taking place at the micro, meso and macro levels. When properties not explicitly determined by specific parameters emerge at different levels, we witness a pattern-formation process. In this case form is not defined by the algorithmic parameters of the piece but results from the interaction among its sonic elements. in a general sense higher level forms or behaviors resulting from interaction of two or more systems' [9]

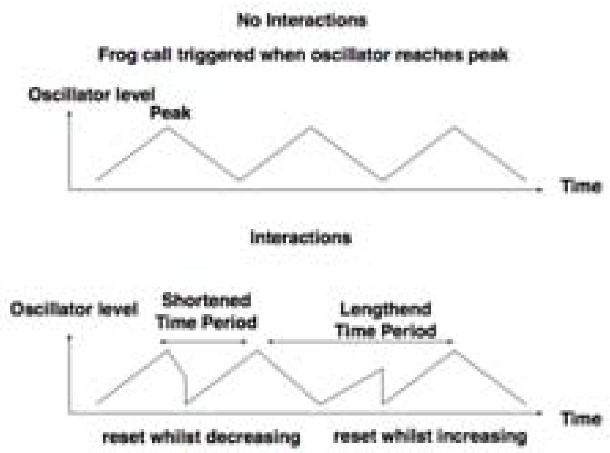
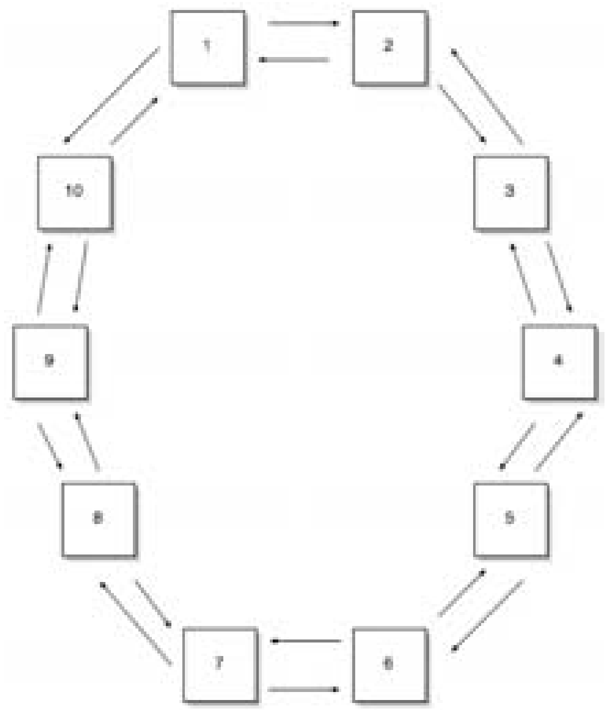


Fig 1 Resetable Oscillator Model

2.2 Design Considerations

This installation attempts to promote a ‘learning through interested interaction approach’. [12], thus there are no instructions or rules set out for the user to follow and there are no prescribed levels or modes of interaction. If this approach is to work it is important that the installation compels the user to interact through generating interest in the sound objects, it is also important that the user feels free to approach these sound objects and that the spatial setup of the installation allows for a liberated mode of enquiry. Since there is no statement of artistic intention for the piece the mode of communication between the sound objects has to become apparent through interaction and investigation. To make this communication explicit a network of wires suspended between the objects suggests links and interactions within the installation space. This suspension is well-over head height and suggesting an enclosed but accessible space, hopefully encouraging visitors to “enter” the space inhabited by the sound objects.

The sound objects were first laid out in a circular form, [Fig 2], so as connections to their two nearest neighbours is easily obtained. The order of the sound objects is then shuffled [Fig 3] to generate a more non-linear spatial structure, so that it is now possible to stand within the proximity of a small cluster of sound objects, or to move to a more open space dominated by fewer objects. We will argue later that this facility for the user to define their level of engagement and embodiment within the piece is important in leading the ear in the perception of emergence.



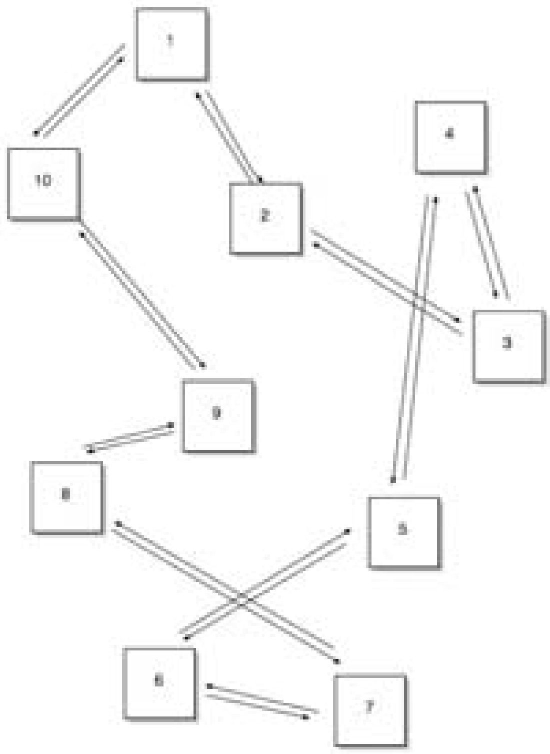


Fig 2, Interaction Layout 1

Fig 3, Interaction Layout 2

Figures 4 – 7, Photos of installation at Música Viva Festival 2005, Portugal, detailing set up and interaction.

Embodied Perception

An important design feature of the installation is that the female frog, the one who makes “aesthetic” judgments of the males, is actually embedded within the environment herself. This embodiment within the environment is important to the aural perception of emergence highlighted in Edmud Husserl’s [5] notion of zero point of orientation:

"the body then has, for its particular Ego, the unique distinction of bearing in itself the Zero point of all these orientations. One of its spatial points, even if not an actually seen one, is always characterized in the mode of the ultimate central 'here': that is a here which has no other here outside of itself, in relation to which it would be 'there'" [4]

Husserl's 'Zero point of orientation' places our own 'lived-body' as the zero point of reference, such that everything, be it actually perceived or even imagined is orientated towards it. Notions such as near and far, left and right are now considered with reference to this Zero point, far becomes far from my body and left, left of my body in such a way that all perceptions have their pole of reference contained within the body. The understanding of emergence in the aural domain can benefit from Husserl's work in respect to a shift away from a Cartesian top-down perspective of the world to one in which the observer/listener perceives the world only in relation to him or her own body.

'Whereas one can be a (visual) observer, treating the world in front of us as a spectacle viewed from a certain perspective, aural stimuli are mapped around our own body. This difference in role raises issues of engagement and participation, which place the ear in a rather unique position. It is the trajectory performed by the ear, from a subtle tilt to the movement of the body as a whole, that becomes an active participant in the perception of an auditory scene.' [3] Thus in this installation the user is encouraged to take on the role of the female frog, moving amongst the males, going on a journey through the sound world, searching out sounds that they find aesthetically pleasing and constantly shifting their listening from a micro (single frog) to a macro (chorus of frogs) level in the hope that this level of immersion within the environment will help develop the perception of emergence.

'the perceiver is a an active searcher for information available for him and suitable for this physiological constitution. Beyond the fact that the environment shifts the stimuli, also the perceiver shifts it as he moves his body head system around.' [10]

Levels of Interaction and the Perception of Emergence

An important design feature of this installation is that interaction is present on a number of levels. The sound objects interact on a temporally structural level with each other; the user interacts with the sound objects disrupting their sound; the embodied user also interacts in traversing the environment on a spatial and perceptual level.

These varying levels of interactions were designed to encourage a perception of emergence that becomes manifest when the perceiver is forced to change their frame of reference with respect to the subject matter, as outlined in Cariani's [2] concept of emergence as emergence relative to a model.

'Once we have fixed our observation frame we can talk precisely about emergence: whether the behavior of the physical system has changed with respect to the frame and in what ways it has changed' [2]

An example with a graphical model of emergence such as Craig Reynolds' Boids [13], is that it is only when you take a step back and view the system as a whole that the pattern formation between the agents on a global level becomes observable, and it is in this perceptual state change of the user that emergence exists.

This can be linked to Holenstein's critique of Husserl's Thesis of the Zero point of orientation in which he expands the Thesis to suggest a structure that consists of a plurality of orientation in which "...the most powerful figure in each context functions as the zero point of orientation of perception. Its power is founded in gestalt and sense function. In order to obtain the role of zero-point, it must dominate the rest of the perception by virtue of its gestalt or special meaning that is attributed to it no differently than to objective things." [6].

It can be argued that principally in the audio domain the 'lived-body' centralises as the zero point of orientation as it is functioning as the dominant figure of perception. In 'Natural Selection' however, the visitor is encouraged to alter their level of engagement with the sound world from the micro (frog) to macro (chorus) level, to seek out certain sounds within the environment and approach the sound making objects. On interacting with the sound objects however their light source is cut off and the objects' sound is disturbed or discontinued. This then encourages the user to lose interest in the sound object they have chosen and listen again on a more macro scale taking in the sound of the whole chorus of sound objects from their new position relative to the user. The visitor is thus presented with a plurality of orientations and is encouraged to alter their zero point of orientation oscillating between localizing on themselves (the 'lived-body'), a single sound object, a spatial group of their own making or the installation as a whole.

Conclusion

We have discussed the notion of embodiment in the context of the perception of emergent systems in the sound domain. The installation "Natural Selection" served as a vehicle for practice-based research in the area of emergence and its perception. By investigating natural emergent systems, which manifest themselves primarily in sound, we can gain some insights into the possibilities of sonic emergence. From the research presented here as well as in earlier work we can identify the importance of the notion of embodiment. Thinking of the body as part of an emergent system rather than as an observer, suggests an approach that is different from most of graphic-based modelling work. 'Natural Selection' proposes a hybrid world which attempts to suggest a level of engagement based on the notion of a sound ecology.

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The physical side of liver diseases

Measuring irregular bodies: a need for medical disciplines

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Humanitas, Milano

Introduction

Let me begin my speech saying that quantitative definition of the tissular lesions of the living being organs further more than an anatomo- clinical problem is an epistemological medical question.

During the course of the XX century – the longest in the history of mankind – and the first few years of the XXI, scientific, technical and technological progresses in medicine have developed by means of a process of notion implosion clearly represented by the metaphor of the *Cube (Sponge) of Menger* (Fig. 1), which vividly expresses the indefinite possibility of increasing a cube's inner surface (the number of notions) without increasing its volume (knowledge as a whole)

It can be held that this behaviour of the notions concerning the architectural changes occurring in tissues affected by pathological events is a consequence of many causes. One of these is the use of imprecise, semi-quantitative investigative and control procedures that offer no guarantee of repeatability, thus leading to erroneous and confused results. Another cause is the tendency to approach research in a reductionist manner, an approach that has engulfed myriads of studies producing notions relating to the predominant idea of the last century of the existence of injective relationships between the microscalar and macroscalar events occurring in a living object.

The reductionist approach to research, whose basis was inherited from the determinism of the illuministic thought of the XIX century, is now being questioned [1-3] by the theory of *multiple scale causality* (MSC) [4]. This new school of thought, which is based on the Theory of Hierarchy that is already used in the fields of ecology, biogeography and geomorphology, affirms the following four postulates verifiable in space-occupying systems:

1) the specificity of laws, processes and controls at each individual scale, from the molecular to the organismic level;
2) the non-transferability of processes and controls from one scale to another;
3) the rarity of finding one-to-one identities between laws, processes and controls operating at different scales;
4) the own degrees of entropy at each scale level.

The implosive advance of medical knowledge (i.e. its continuous falling back upon itself in studying what is already known) is due to the fact that it is confronted by phenomena it cannot explain on the logical bases available to it.

Immediately after the middle of the last century, Herbert Feigl [5] had the idea of using a hierarchy to define the degree of cognitive maturity of a discipline with the following logical principles:

1. purely qualitative or classificatory concepts;

2. semi-quantitative concepts, or those concerning the ordering of what has been classified;
3. entirely quantitative (metric) concepts.

The case of hepatology

If we adopt this classification, and do not consider a prejudice inherited from XIX century physics the fact that the maturity of a scientific discipline is a function of quantitative concepts that uses, we can say that hepatology entered the first phase of cognitive maturation in the 1960s, when it classified chronic hepatitis using purely qualitative, classificatory criteria [6].

The dynamics of chronic hepatitis was simplified using a purely qualitative model, which implied a series of three successive, perceptible and measurable events:

1. the tissue destruction (necrosis) determined by the causal agent, followed by hepatocellular regeneration;
2. the inflammatory reaction around the destructive event, expressed by the presence of clusters of specialised cells (Fig. 2; in current clinical use, the almost simultaneous nature of the two initial phases has led to them being unified under the term “necro-inflammation”);
3. scarring, perceptible by the presence of collagen tissue phanerizable with Sirius red stain [7], which repairs the effects of necro-inflammation when hepatocellular regeneration is ineffective (Fig. 3).

This purely qualitative description constitutes the foundation of the 1960s classification of chronic hepatites as persistent, aggressive or cirrhosis.

Hepatology entered the second phase of cognitive maturity at the beginning of the 1980s, when Knodell *et al.* [8] suggested ordering the chronic inflammatory state into categories of severity based on semi-quantitative histological evaluations of necro-inflammation and cicatricial fibrosis entrusted to the experience of the observer.

Today, the advances made in virological, clinical and therapeutic knowledge demand the introduction of purely quantitative concepts that allow:

1) operational definitions of the equality of defined intervals;
2) the determination of both the zero point and the unit of scale;
3) the metric measurement of measurable magnitudes that produce scalars expressing concrete scientific variables.

According to the Feigl view the fact that they have reached the point of presenting such needs shows that the hepatological disciplines have entered the most advanced phase of cognitive maturity: in other words, hepatology has come of age. Furthermore, it indicates that concrete, objective knowledge of the tissue lesions caused by the etiological agent can only be obtained from a liver biopsy.

Aside form its costs and risks, the use of liver biopsies is mainly criticised because of the uncertainties due to the subjective nature of the descriptions of the structural lesions of a bioptic fragment of hepatic tissue, even when the evaluation is made by highly expert pathologists (Figure 4).

Moreover, success rates of about 50%, and the costs and undesired effects of the new antiviral therapies justify the attention that health authorities place on the criteria for selecting patients with HCV-dependent chronic inflammation to be treated. The subjective descriptions of the structural alterations in liver tissue, and evaluations dependent on the skill of the observer, no longer seem to be sufficient, which is why we have concentrated on the metrical measures of the elements of chronic hepatitis observable in biopsy pictures.

Measurements of liver histology components

As a model for our measurements, we used the classic sequence of the three physical observables of *cell necrosis* → *inflammation* → *fibrosis* used for the 1960s classification to reproduce, in simplified terms, the dynamic phenomenology of chronic HCV-dependent hepatitis. These three histologically clearly distinguishable elements of the dynamic sequence were considered Hilbertian spaces, and attributed their geometric properties for the purposes of measurement.

There are no known purely quantitative methods for estimating the necro-inflammatory process. We measured the tissue lesions determined by this process by means of triangulation using Delaunay's algorithm (Fig.5).

The few attempts [13-15] to quantify fibrosis using the International System (IS) meter can be criticised on the following grounds:

1. it is a unit of measure that only evaluates the smooth objects of Euclidean geometry, which are very rare in Nature. The linearity of the IS meter makes it so unsuited to measure such objects that Harold M. Hastings & George Suhigara in 1998 [16] were driven to point out that the results "often held out as approximations or caricatures of natural forms that may be essentially complex and irregular";
2. the choice of the surface to measure is interactive, and therefore subjective;
3. available metrical computerised measurements are too long, nevertheless they regard limited tracts of the surface of a bioptic section.

For these reasons, fibrosis as a whole was measured by correcting the linear meter with the fractal dimension *(D)* of each collagen islet. The terms of this correction has been discussed as we have considered the collagen islets forming fibrosis asymptotic fractals [17, 18], the perimeters of which tends to have finite values. The fractal dimension was obtained by the box counting method, using the formula

$$D = \lim_{\varepsilon \to 0} \frac{Log N(\varepsilon)}{Log(1/\varepsilon)} \quad (1)$$

where D is the fractal dimension, ε the length of the side of the box, and $N(\varepsilon)$ the smallest number of boxes of side ε required to cover the outline of the objects [19].

Because of its irregularity, the outline of a collagen islet always consists of a complex (broken or mixed) line, thus making its fractal dimension fall somewhere between *1* and *2*.

A specific algorithm was used to improve the measurement of the perimeter and the time necessary for the entire measurement process (10 seconds/mm^2 of bioptic tissue) [12, 18, 20]. *Ad hoc* developed software focused and digitalised the histological section, thus making it possible to identify and measure the following "observables".

1. The sum of the metric surfaces of a histological section covered by the set of inflammatory cells grouped in clusters or dispersed in the hepatic tissue: this was

defined the true inflammatory area. The extension of the inflammation can be used to define the activity of the process [20];

2. The sum of the metric surfaces characterised by the irregular shapes of collagen islets, with characteristics that make them belong to the family of asymptotic statistical fractals, also known as truncated fractals [17, 18]. Their set constitutes the fibrosis (Fig. 3), whose metric value stages disease progression: i.e. a method for determining the path covered by the process from its beginning and the distance from its end [12].
3. The wrinkledness of the collagen fibres which establishes their age (it is inversely proportional to age) [18];
4. The classification of the collagen fibres on the basis of their size (length and thickness) which can be used as an index of the speed of the process [18];
5. The metric surfaces occupied by the physiological liver parenchyma in disease-free livers, or by its fragments in cases of advanced chronic hepatitis and cirrhosis. The sum of these surfaces was defined the parenchymal area [12].
6. The fractal dimension [16, 19].
7. The changes in the relationship

fibrosis/parenchyma

which can be used in defining the new concept of architectural harmony and its loss (disorder) that occurs in liver tissue during the course of the disease towards cirrhosis. We have expressed [12, 21, 22] the laws governing this relationship using a mathematical model suggested by the Theory of Categories (Fig. 6).

Measuring the disorder of hepatic tissue

There are no known purely quantitative methods of estimating the variations in the configuration of liver tissue (*i.e.* its “architectural alterations”) in the two dimensions of a histological section.

In an attempt to quantify this parameter, we started with the metric definition of the natural percentage of parenchymal and (fibrous) collagen support tissue in disease-free livers, which was obtained by measuring these two basic components of hepatic tissue in biopsies performed in order to ensure the disease-free status of livers destined for transplantation.

Liver tissue harmony and its canons

The measurements of the two basic components of hepatic tissue were *1.34-3.00%* of natural support collagen, and *98.66-97.00%* of parenchymal tissue. These results are similar to those already known in the literature [23].

We assumed the rounding of this metric proportion to *3%* and *97%* as the predicate of the canon underlying the natural architectonic harmony: *i.e.* the morphofunctional equilibrium and configuration from which is formed the order and lobular organisation typical of liver tissue

Measuring liver harmony disruption

It is intuitively conceivable that every disruption of this canonical metrical proportion disrupts liver tissue harmony by generating dysharmonic states leading to disordered tissue configurations.

Fractal geometry suggests measuring the disorder due to this dysharmony via Hurst's exponent, using the Euclidean dimension of the space belonging to the object (in our case, a line or plane) and its fractal dimension according to the formula (*2*)

$$H=E+(1-D) \qquad (2)$$

in which *H* is Hurst's exponent [24, 25], *E* the Euclidean dimension of the object, and *D* its fractal dimension.

The information concerning the configurational disorder of the liver tissue as a whole provided by Hurst's exponent involves an error of no more than *14%*, and is the most representative of the status of the entire tissue of the organ under examination. It has in fact been calculated that the error in fibrosis (i.e. the cicatricial state) is about 43%, and that that of the wrinkledness of the fibrosis (an index of the aging of the scars) is about 27%.

Brief final comment

The use of theoretical structures belonging to the fields of physics, geometry and mathematics, as well as those of irregular bodies and computer science (the last used not only as a means of calculation, but also as a means of experiment), indicate that the hepatological disciplines are beginning to face problems which, in the terms of the metaphor mentioned at the beginning, can be considered as being outside the Cube of Menger. It may also be a sign that their future has begun.

Put briefly, three concepts can evoke and specify this condition: *globality*, *dimension*, *complexity*.

Globality: no longer in the sense of groups of forms of equilibrium in the various spheres of knowledge, but in the sense of the theory of the universal classification of all structures of equilibrium.

Dimension: no longer in the sense of generic intuitions scratched from the pioneering studies of Georg Cantor, Hilde von Kock and Giuseppe Peano, but with the conception of fractals in the sense of Menger-Besicovitch.

Complexity: no longer as a notion of complicated interdependence and stability without rhyme or reason, but one of the natural presence of non-linearity in the evolution of phenomena within the context of processes that are simultaneously chaotic and deterministic.

The evolution of mathematical thought, which Kurt Goedel has already brought out of its "cube", also highlights the fact that its pragmatics and logic are no longer only aimed at calculating or defining the phenomenological world, but tend to be infused with wider-ranging knowledge.

In this scenario of intellectual ferments and turbulence, anyone wishing to hazard making a historical parallel with the time in which we are living could perhaps consider the moment when medieval thought was overwhelmed by the explosion of the Renaissance, centered on the thought of three figures who can be collocated outside it:

- Galileo Galilei, the energetic essence of the universe;
- Francis Bacon, the end of metaphysics in science;

- William Shakespeare, the universality of metaphor in knowledge.

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FIGURE

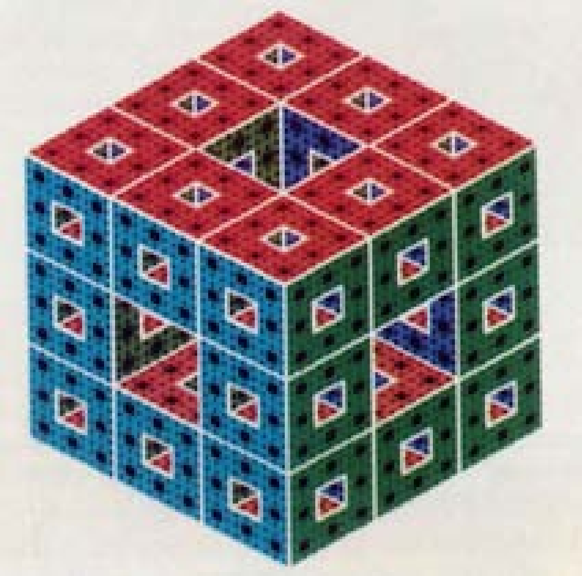

Figure 1. The cube (sponge) of Karl Menger.

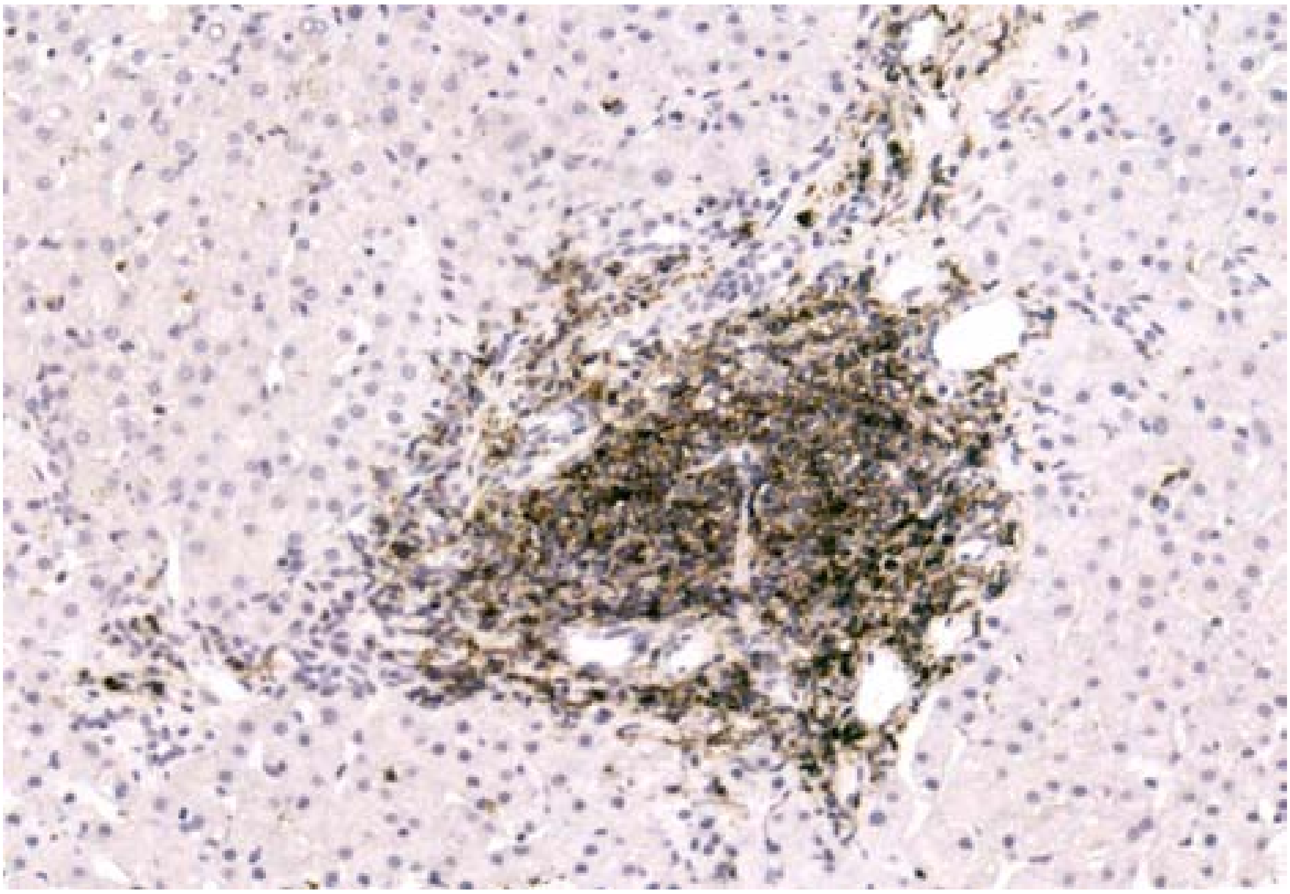

Figure 2. Prototype of inflammatory cluster recognized in a liver biopsy sampled from a patient affected by chronic C virus-related hepatitis.

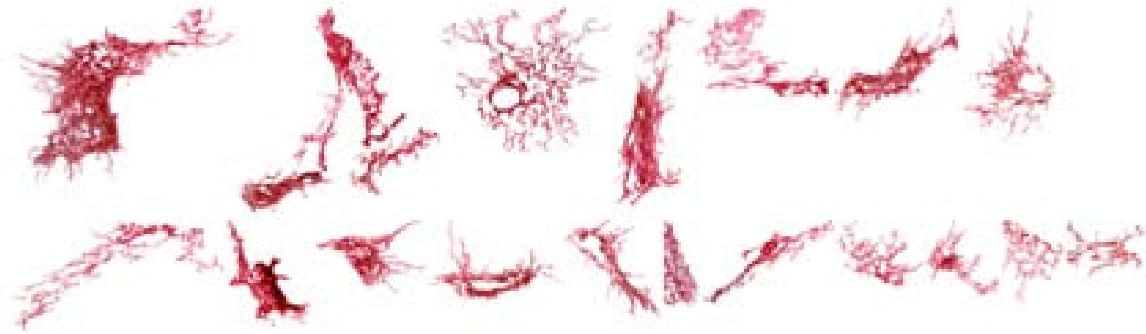

Figure 3. Example of liver scars in form of Sirius red-stained irregularly shaped collagen islets. Their set makes-up the so-called liver fibrosis.

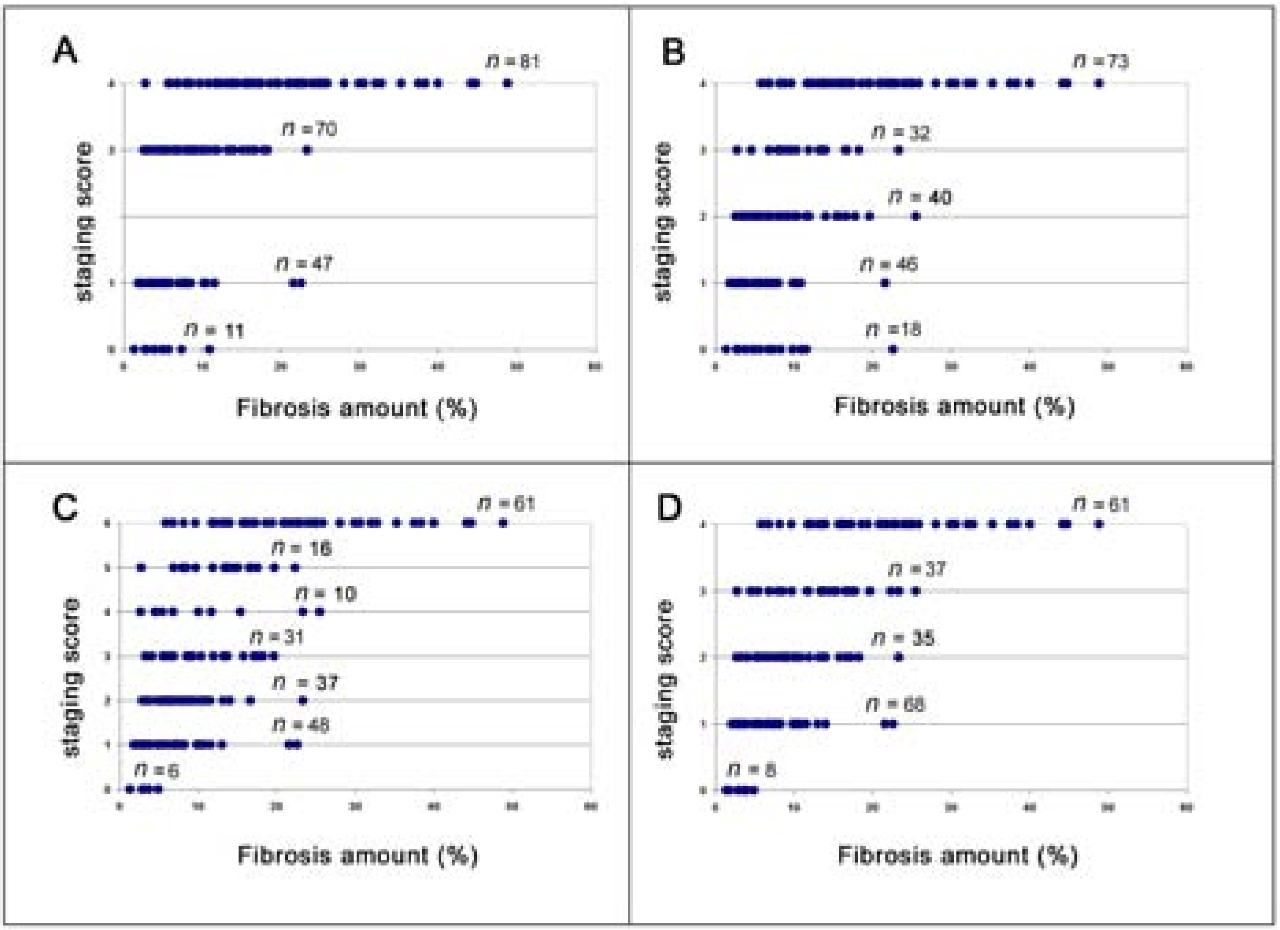

Figure 4. Comparison of the state portraits obtained using the scalar values of the fractal-rectified meter areas of fibrosis projected onto the state spaces of each (A) Knodell HAI [8], (B) Sheuer [9], (C) Ishak [10], and (D) METAVIR [11] category ordered by ordinals in function of the severity of the lesions defined by the subjective opinion of the observer. The state spaces of each category are represented by the real number line and each point reported on it is the scalar of one measure performed on a biopsy specimen. All of the graphs highlight the robust overlapping of the data referring to different categories. (The figure was reproduced from the reference 12)

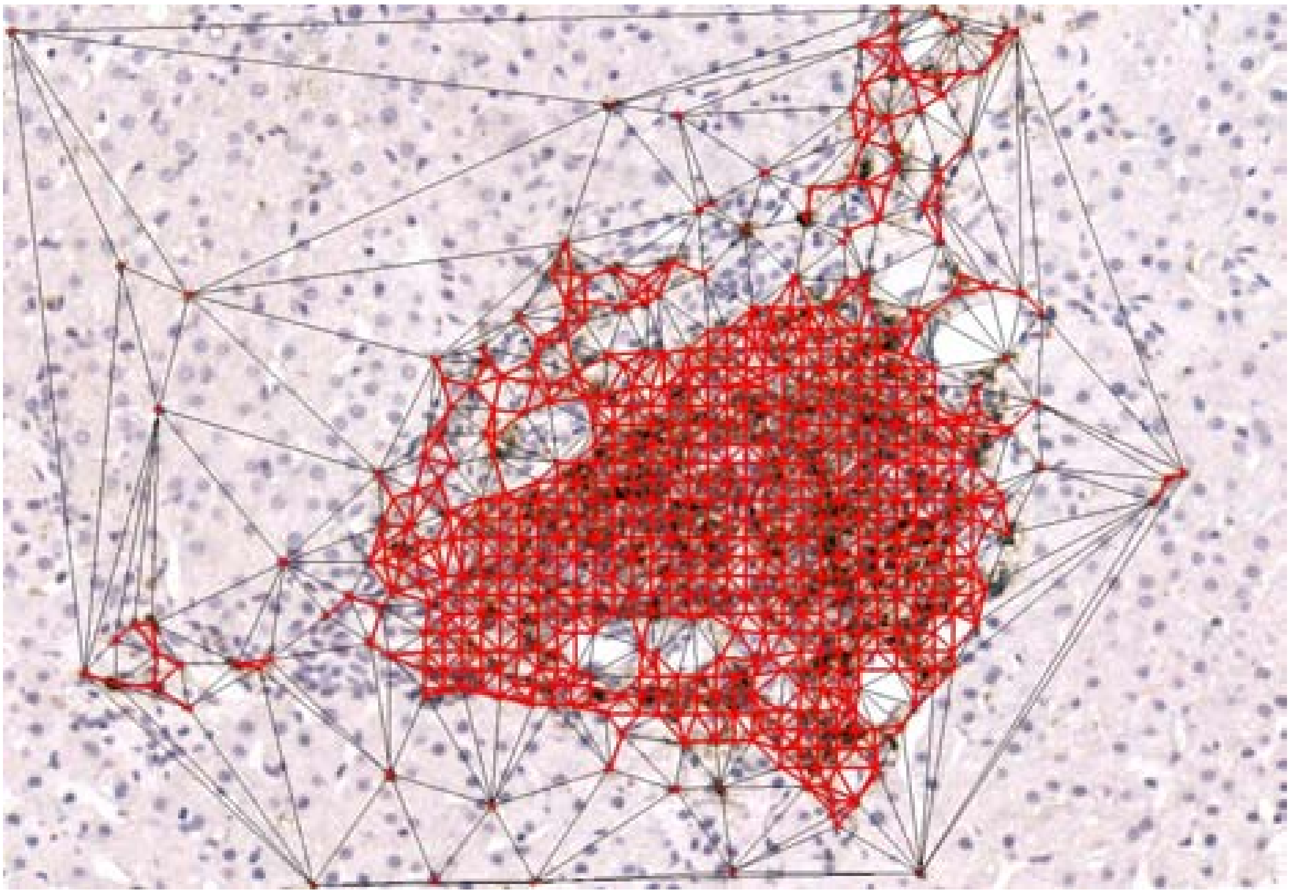

Figure 5. Cluster of inflammatory cells triangulated with the Delaunay's algorithm.

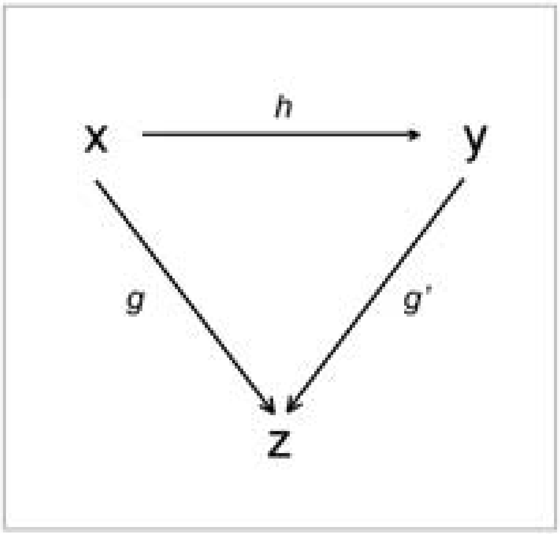

Figure 6. Categorial model of the harmonic state of liver tissue, in which Z denotes the harmony of the natural architecture of liver tissue, x the metric space covered by fibrosis, and y the metric space covered by the parenchyma. *h, g* and *g'* are function which regulate the x, y, Z relationships.

Transient Spaces

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Abstract

"Transient Spaces" is a time-based video which visually and sonically explores the spaces of transit. For most people, an airport, but or train station is a non-place—a necessary connective towards a somewhere else—an experience better measured in (waiting) time than in space. In these spaces, time and space are removed from the routine, and a traveler relates to their loss of control by embracing a virtual fluidity of place and time. Paradoxically, this constructed nonchalant participation in reality is offset by a heightened awareness of the particular and the shifting boundaries of socio-cultural distinctions.

This work is a video installation that interactively and iteratively processes digital video and audio clips, primarily based on train stations and riding on trains. Three principal narratives are articulated, developed and intertwined—consciously blending filmic constructions of vignettes and dovetailing the narrative with formal musical ideas of sonata form development and variations. Disparate and virtual constructions of sonic spaces imprint their presence on the visual imagery and the result is projected into the gallery space.

1. Non-Place

A primary concern that Transient Spaces explores is the conception of *non-place*, in particular the definitions of non-place that are raised by Michel de Certeau and Marc Augé. Communication technologies, personalized audiovisual enclaves, and the progressive deterioriation of shared regional meanings are all contributing to the increasingly normative experience of non-place as a cultural apprehension of both time and space. Whether experienced as a mode of transit between source and destination, or as the constructed walls of inward-directed experience, a non-place is more than an absence of communal history, symbols, and codes of behavior—a non-place is, in Augé's words, a world "where a dense network of means of transport which are also inhabited spaces is developing, where the habitué of supermarkets, slot machines and credit cards communicate wordlessly, through gestures, with an abstract, unmediated commerce; a world surrendered to solitary individuality, to the fleeting, the temporary and ephemeral. [1]" Non-place designates two complementary but distinct realities: spaces formed in relation to certain ends (transport, transit, commerce, leisure) and the relations that individuals have with these spaces.

In his book, The Practice of Everyday Life, Michel de Certeau writes about the incarcerated phenomenology of traveling in a railway car as an illustrative metaphor for the experience of non-place [2]. We used the following excerpted text as the initial basis for the piece:

“Only a rationalized cell travels. A bubble of panoptic and classifying power, a module of imprisonment that makes possible the production of an order, a closed and autonomous insularity—that is what can traverse space and make itself independent of local roots.

Inside, there is the immobility of an order. Here rest and dreams reign supreme. There is nothing to do, one is in the state of reason. Everything is in its place … Every being is placed there like a piece of printer’s type on a page … This order … is the condition of both a railway car’s and a text’s movement from one place to another.

Outside, there is another immobility, that of things, towering mountains, stretches of green field and forest, arrested villages, colonnades of buildings…”

2. Concept of Work

Augé’s text provided a set of themes and polarities to explore in our work—in particular we were drawn to the condition of order, the relationships between text and the railway car, and his discussions of the interior-exterior dividing characteristics of the railway car’s window glass and the train rails. We decided to develop a vocabulary of video-processing methods for the work that could be used to visually control and vary amounts of (dis)order, based on the variable probability and scale of vertical scanlines. This set of techniques, developed with the Max/MSP/Jitter programming environment, would serve to unify the structure of the work, which we decided to organize into three “characters” that would each be given their own expositions in short vignettes, followed by a number of short vignettes in which these ideas would intertwine and be developed—an exercise in form based on integrating and finding connections between visual/filmic metaphors of coalescing plots and the exposition and development principles inherent in musical sonata form.

The three characters in the work were identified as: (a) horizontally moving train rails and power wires (shot out of moving trains with a camera pressed to the window, Figure 1), (b) the de Certeau text excerpts (Figure 2), and (c) imagery of people moving through train stations (Figure 3). Each character is introduced separately and there are two component layers of the soundtrack. A processed recording of walking through a train station (passing in and out of proximity to several conversations) plays throughout the entire work as a base layer, while each short vignette additionally has its own characteristic sound materials. The sounds are analyzed by the programming for dynamic variations which are used to control the probability and scale of the vertical processing, and to trigger changes in the brightness, contrast, and saturation.

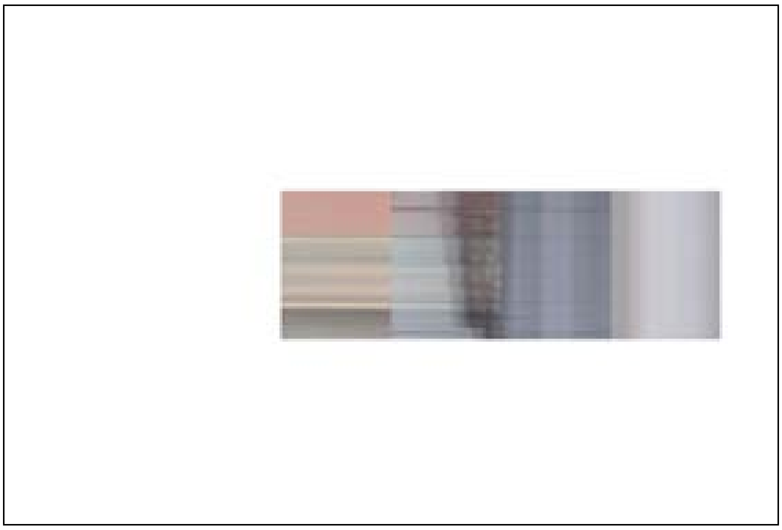

Figure 1. Rail and overhead wire imagery.

Figure 2. Text excerpts.

Figure 3. People in transit.

3. Developmental Processes

As noted above, the primary generative techniques employed in the work were the use of analyzed audio material to influence the video processing. This was accomplished using a Jitter software patch, part of which is shown below in Figure 4:

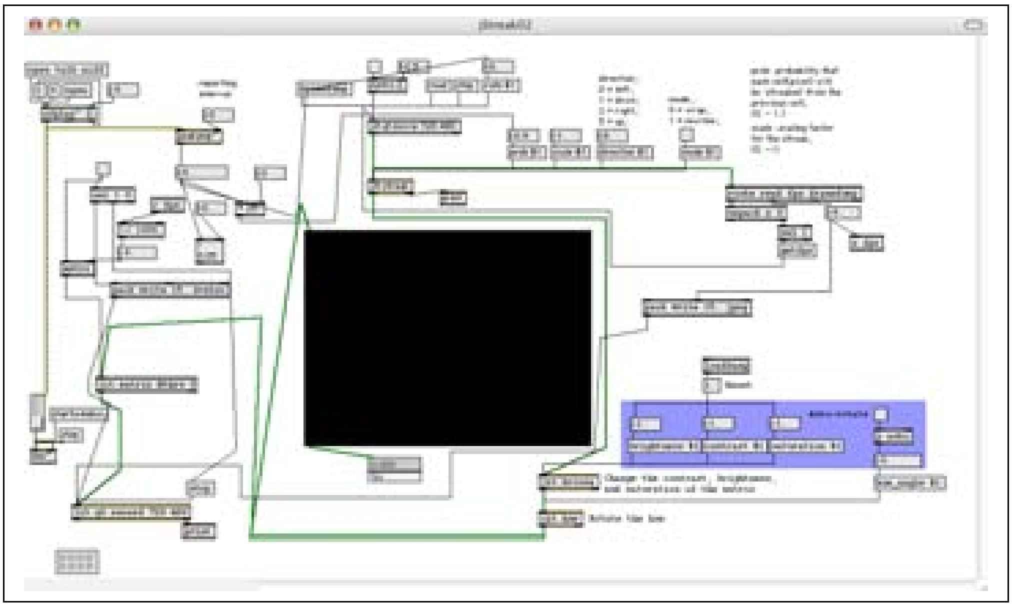

Figure 4. Jitter patch used for video processing.

In the beginning three sections of the work, some streak-based processing was used on the imagery, initially presented as two or three overlapping semi-translucent placards in a larger white background. After much experimentation and refinement of the programming, we were able to determine several behavioral ranges of the probability, scale, brightness, contrast, and saturation settings that led to compositionally desirable and aesthetically resonant motifs.

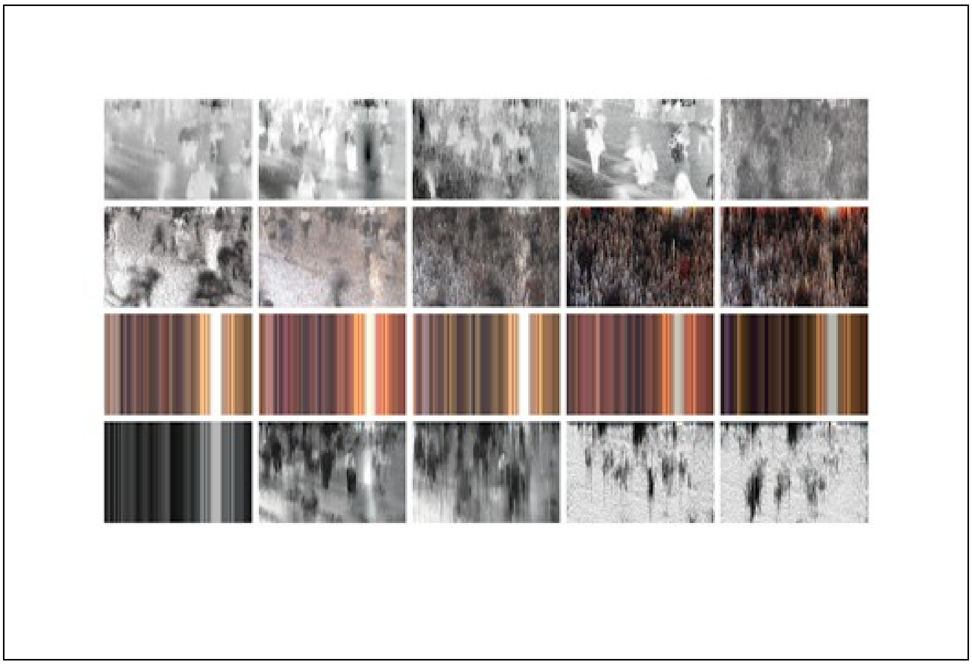

Figure 5. Frame sequence: people to bars

Figure 5 illustrates one such range as part of a sequence, presented here as a grid of video stills (such stills were used as the basis for several large print works hung in the gallery). An initial setting of minimal saturation, moderate streaking, and high brightness was used to depict the moving figures as anonymous and ghost-like. A progression was developed in which the people rapidly transform via rain-like vertical streaking into a horizontally shifting pattern of color bars, establishing a contrast with the horizontal motifs inherent in the rails and wires.

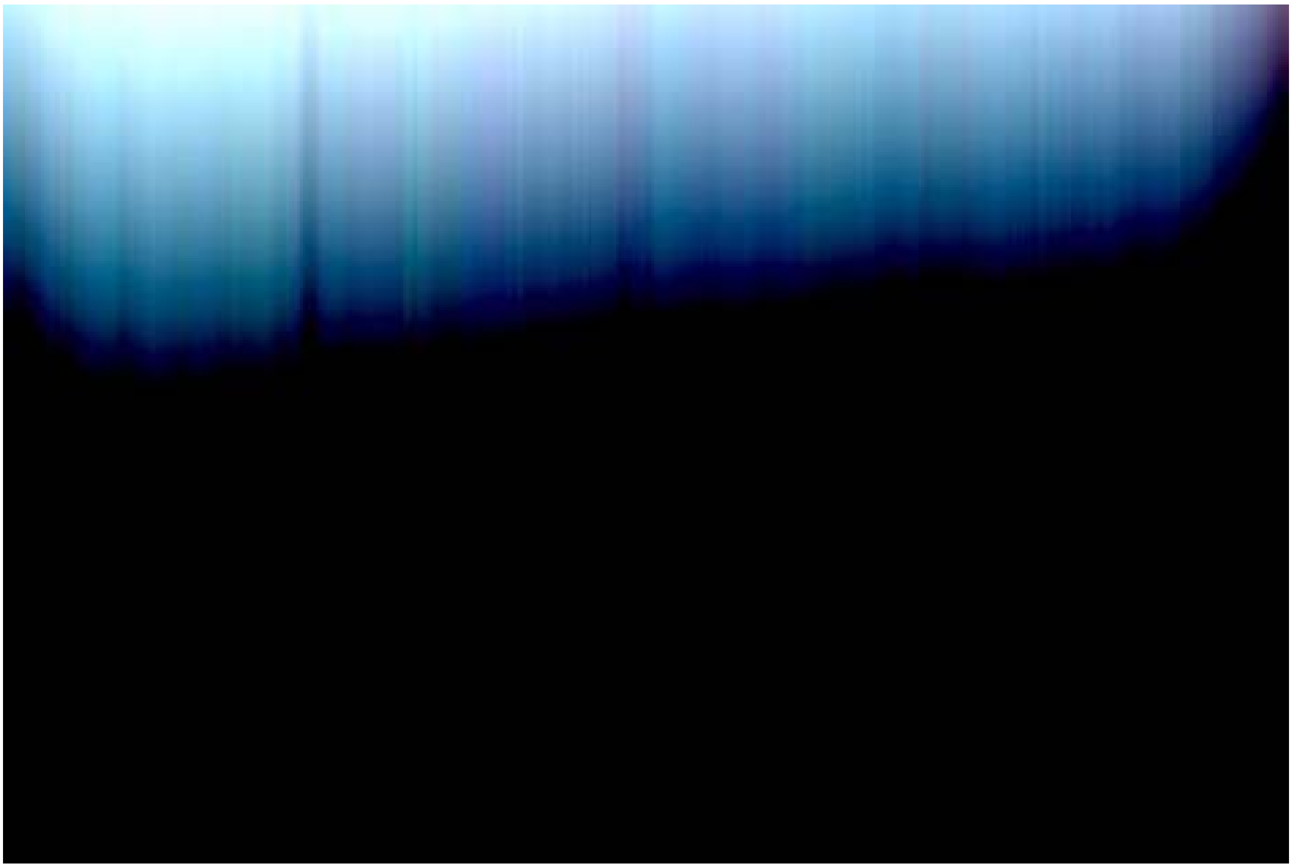

Figure 6. Noisy wave artifact.

Figure 6 illustrates another phenomena produced by very specific interactions of the settings, the processing, and the audio-derived analysis data. Similar to the unexpected emergence of the color bars, and also verging on the threshold of random noise, a rippling wave would appear along the top third of the screen for a short while, before breaking up into noise, vertical bars, or a heavily streaked version of the source imagery.

In each of the latter sections of the work, additional techniques were employed to develop and interrelate the material, a task made inherently challenging by the need to avoid any sense of repetition when using a particular video clip more than once. Some of these techniques included using additional low-opacity layers of material at the same time, varying the speed of the footage, using perspective, extending the text material into a virtual 3-dimensional space (Figure 7), and iteratively processing moments previously seen with the same Jitter patch and different settings.

Figure 7. Three-Dimensional text moving to vanishing point.

4. Conclusions

By creating an environment where audio is made to influence the video materials, we are mostly interested in discovering emergent and unpredictable behaviors that we would have been unlikely to discover using traditional means. We are interested in finding a balance for the cross-media influence that is not explicit or overt, merely perceptible at a level just beneath the surface. The construction of any time-based audio-visual work is a formal and visceral challenge that must derive its own logic of necessity, syntactical and semantic coherence, and informational unpredictability via the means of its form, materials, and their relations. We have found generative tools an asset in interrelating materials, building micro-macro structural relationships, and iteratively developing and combining materials.

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Applied Prototyping and Critical Practise.

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Student projects of the postgraduate courses in Ravensbourne, contextualized in applied prototyping and critical practise, or how to avoid reinventing the wheel again and again in art and design.

Abstract

This paper discusses the experiences made when starting to work with new students from Europe, Asia, South America and Arabic courtiers on a postgraduate course (1Year), in context of new media. It discusses the different approaches, successes and shortcomings in teaching this subject by presenting some projects of last years courses. My motivation to choose this subject came from, last years discussions at the Generative Art Conference addressing design and identity in context of a city or society, which I had the feeling led to nowhere. On one hand the terms have been used like art, but ignore the historical process of art related to identity. We have a western history from Dadaists, Situationists, Viennese Actionists, Fluxus and Happening art to Performance art or the process in media art from video –computer, TV-Radio, net art to software art. Most presentations showed the involvement of intensive software skills but lacked the understanding of contextual issues in art and design. The reason for this may have something to do with the time and energy investment left for the project or the self positioning as specialist in a chosen subject not looking beyond the borders of software driven – visual related outcome.

Why to teach critical Practise

Students coming from non Western education systems have little idea about media history, media theory or even a critical approach towards using media at all. My impression is that students coming from Western education systems have each year fewer and fewer understanding of the above mentioned areas. It seems that in western colleges the theory side of teaching disappears more and more. So the status is that non western educated students do not know for example Mc Luhan and western students may know the name Mc Luhan but have very limited understanding. My argument is without critical approach to society, to design, to architecture there will be no process just stagnation if theory teaching is not included in the curriculum. It is not enough to change the form and propose different aesthetics but it is necessary to propose a very personalized unique and individual idea grasping the beat of time which can lead then to new patterns and expressions.

We all know how crucial it is to keep a balance between practise and theory teaching on a postgraduate course, the research and the works of students can very easily slip to either become a some how good dissertation but a not so interesting practical project, or a some how interesting project but a weak theory based dissertation. This is a lot depending on the interest of the teaching team, or the strategy of the department. Do they want to have academically well formatted papers not to put much emphasis on visual or contend related output, or is the emphasis on practical projects which are not likely to be seen academically proper in our educational system?

Why we teach critical practise is to generate awareness about the important relation of critique and innovation. Students have to know the key achievements in the media art or design related fields. The tendency if they are not aware of processes and thoughts from the past is that they are reinventing the wheel again and again. Through media theory teaching and critical practice we try to avoid this. Students have to evaluate there idea/project/argument against the current status of society and against existing thoughts in the same subject, thus evaluating and understanding what the difference they are proposing is.

Other usual reactions are that I can’t change anything, designers/artist are primarily not here to change something but to show an example, a scenario, to make a proposition how things could be. Most of the time projects from students are far too big just to be implemented into real life; they would need a floor filled with programmers, marketing people, bankers and lawyers. So the emphasis here goes also for minor proposals or slight changes which can make the big difference.

How we teach applied prototyping

The process from idea, concept to object is very difficult and can often fail, because of the fear and obstacles of the physical space.

It is sometimes far easier to keep things in written form rather than building a “house”. The mistake in general is to keep projects very long in the theory level and leave just too little time for experiencing the theoretical idea in practise. We emphasize and support students to move fast back and forward from theory to practise and back and forward again.

We call this applied prototyping

The process leads from

1. Text based proposal, research finding facts and figures,
2. First sketches, to collages and pictures.
3. Video prototypes
4. Spatial prototypes – experiential design
5. Final project proposals

The duration of this process is limited to 2 days; students have to come up with a project presentation at the end of these sessions. I am sure this is nothing new to you, but my findings are that this exercise succeeds and fails with good and experienced staff. If you assign the wrong staff to this form of teaching the entire outcome can fail. The ability of abstract combination and response techniques is very important, leading the students to other styles and genres of expression. Mostly students’ tendency is to present “political correct” ideas, if you ask them to make the opposite they come up with references from bloody computer games. The understanding of non conformist thinking, the importance of creating discrepancy, subversive and non mainstream motivated ideas is widely unknown and ignored. Interestingly it is wide spread in the art and design area that the opposite to main stream and political correctness is the aesthetic of war, so mainstream is “nice peace” and non mainstream is “ugly war”, I do not want to go deeper here because that would mean a second paper, but this is an interesting subject.

Examples

Generative art approached from a different angle.

Jee Oh

http://jee.manme.org.uk/

GORI.Node Garden is physical & ambient data visualization as a network garden in which each plant grows up fed by communication data. It has plants with blossoms and roots which retrieve data to feed the garden during 'watering time' when each plant vibrates, similar to how plants move when the breeze blows on them.

GORI.Node Garden approaches a different aspect of Information Aesthetics. It visualizes a node within social network using visual metaphors in order to explain the concept of 'Information Ecosystem'. The project also aims to be presented in a living environment, getting out of screens and sharing space in which we are living that people feel more familiar with the idea of 'Environment follows data'.

*GORI means 'an open hook' in Korean and it is often used to represent human relationships. Here it is used to express the image of 'fastening or loosening the relationship at your will'. Here, GORI is presented as individual mobile number which identify person.

Daniel Miller

http://www.corrugationstreet.com

Corrugation Street-- is an experiment in collaborative and generative storytelling and networked narratives. It's a soap opera that you can help write. Get involved in making the story. Be a co-author, co-illustrator or a researcher. Change the subject of the story, the mood, or the look and feel. Create your own unique version of the story, told in your own personal way. Your selections decide how each scene in the story will look. The subjects and search terms you choose decide which pictures and RSS feeds are pulled in live from the Internet. It's impossible to predict what results you'll get, but your choices will have a big effect on the story. Add your own RSS feeds if you have particular subjects you'd like to add to the stories, and you know the RSS link. If you'd like to add your own image, whether on the internet or on your own computer, add the URL or file path to include it in the story. When you click the 'Make my story!' button, the generator script gets busy. Text and pictures are generated from the Internet, processed and mixed in with my story.

Shan Ying

http://www.lo-co.org.uk/

Shanyin.Hun Farmer Brows Journal

Farmer Brown's Journal

Farmer Brown's Journal is an online community aimed at the flattening of food supply chains. In Kent, the "garden of England", local farmers' markets are an example of decentralised food supply chains and the preservers of local tradition.

By providing an online space with direct communication between producers and consumers, Farmer Brown's Journal tries to build links between local consumers, producers and the public. The goals are to help local producers/ farmers sell their produce outside the grip of supermarkets, give consumers real choice and understanding in what they buy, and help them find quality local produce. The data extracted from users will be visualised on a map of Kent as an indicator of the growth of community. The figures present the social relationship between the user and local markets; and also reveal the possibility of business.

Kalle Korman

http://keikei.manme.org.uk/projectblog/

http://www.browsedelicious.de/

browse.delicious is visual browser that let users explore and browse through a sample data-set of del.icio.us (social bookmarking system), to see and understand the connections and relations of its entities. The sample data-set consists of 150 persons, their tags, and bookmarks. Through browsing, the relations of each selected entry and its related entries are shown. This shows where the chosen tag, bookmark, or person is situated, and a person's interests and connections can be seen.

4. Applied prototyping Examples

http://wiki.maidm.com/index.php/ElevatorVideoPrototypes

Conclusion

Without knowing the history and without a critical approach there's no innovation, and without applied practise there's no experience in real life.

The question is how to find identity, firstly to look at yourself and then view the outside, observing traces on the skin of the city, then listening to the sound of a city. Students have to find their own method to transcript or map this process into form and function. This is the identity of the people which are inhabiting it, your facts and finding will lead to new art and design. But if you as an architect will find someone who pays for it is another question.

Biological dynamics in performance space (bio-performance)

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http://www.geocities.com/melanitis2004/Garden1.html

In this paper I attempt to investigate biological dynamics in the field of performance space. I use my term 'bio-performance' [1] in an effort to describe performance procedures deriving from genetics. In a large-scale performance work entitled "The Garden" (partially performed in Athens, 2005, videofile:

http://www.geocities.com/melanitis2004/Gardenvideo.html), the music interpretation of the genetic sequence (antenappedia gene) of a mutant fruitfly consists the environmental sound (background layer).

A dictionary definition [http://www.wikipedia.org] of the term 'genetic algorithms' is that they are "typically implemented as a computer simulation in which a population of abstract representations (called chromosomes) of candidate solutions (called individuals) to an optimization problem evolves toward better solutions. Traditionally, solutions are represented in binary as strings of 0s and 1s, but different encodings are also possible. The evolution starts from a population of completely random individuals and happens in generations. In each generation, the fitness of the whole population is evaluated, multiple individuals are stochastically selected from the current population (based on their fitness), modified (mutated or recombined) to form a new population, which becomes current in the next iteration of the algorithm."

Though, in what way such representations may be used in the artistic process? Perhaps an innovative way to use genetic algorithms is when they operate within a work without -at least in the first case- been so evidently noticed even if they formulate the structure of the work. [Heraclitus r. 54: An unapparent harmony is stronger than an apparent one.] [2]

Concerning "The Garden" and "The Diffusion of The Elements" performances, space is not considered to be 'a place of action'. Instead of this, we might consider it as a field with inputs and outputs where interactivity interlinks the assortment of the elements. As explained later, technology concealed inside the elements aims to provide an interconnection between various space qualities.

The music evolution procedure paradigm used (explained below), is that of 2 genetic pools interchanging data (inheritance (the notes stay for some time in pool 1) mutation techniques inspired by evolutionary biology such as inheritance, mutation, natural selection, and recombination (or crossover).

INTRO

Every performance involves an agent, acting within a spatial configuration serving as its container. Their interaction triggers the "event". This threefold set of "agent-space-event" is dynamic and perpetually interactive: it develops in time by means of formal modifications. The event, i.e. the interaction between the agent (figure) and its spatial configuration (environment), occurs as a kind of mutation- hence the performance proceeds in an evolutionary mode: a series of figural and spatial changes which is represented by sequences of their transformations.

"Might not the dancers be real puppets, moved by strings, or better still, self propelled by means of a precise mechanism, almost free of human intervention, at most directed by remote control ?" Oscar Schlemmer

The distinction between geometrical and functional space in performance theory was emphasised by Oscar Schlemmer in his works and lectures at the Bauhaus.[3] Geometrical space refers to linear constructions and orbital dancing methods, whereas functional space invokes the response of the agent. Schlemmer's "Dance in space" and "Figure in space with Plane Geometry and Spatial Delineations" performances, intended to transform the body into a "mechanised object" operating into a geometrically divided space, pre-existing the performance. Moreover, the proposition for the remotely controlled dancer of the mechanical ballet might serve as an endeavour to reform the body into a receptor of information that comes from the container space. Hence, movement is precisely determined by the information from the environment.

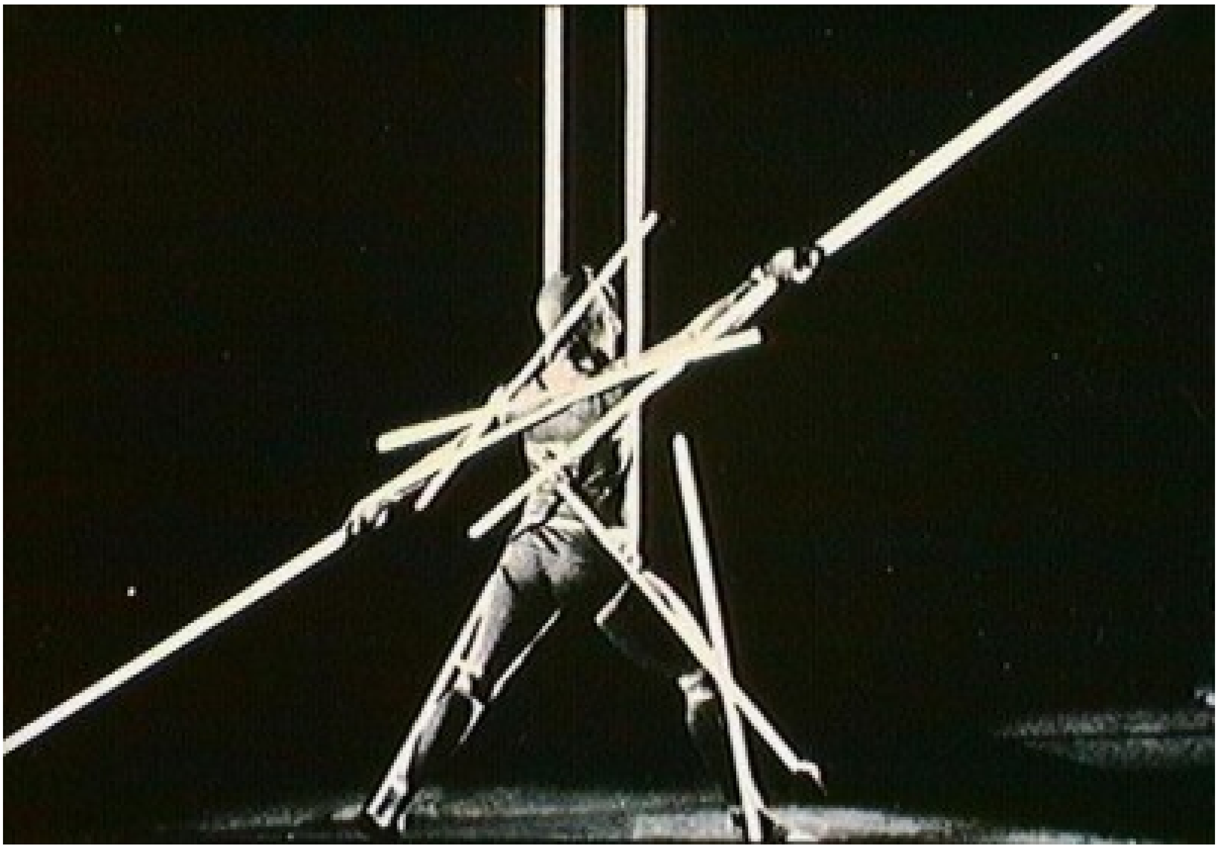


Fig.1. Oscar Schlemmer, "Slat Dance".

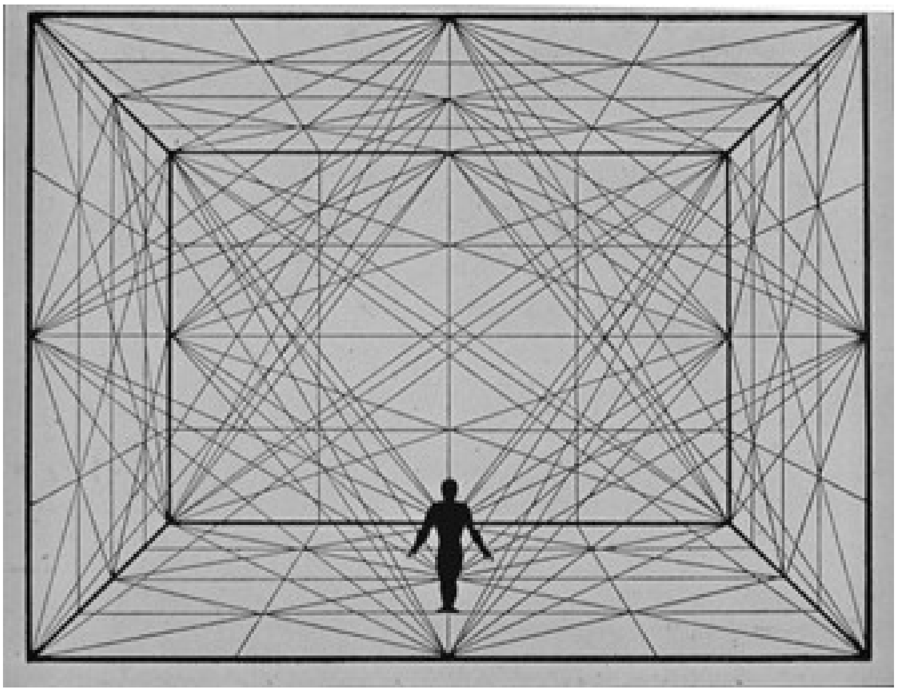


Fig.2. "Figure in Space with Plane Geometry and Spatial Delineations."

Fig. 3.The dance from the film "Vita Futurista",1916, by Marinetti, Balla,Corra.

The Futurists proposed the system of human-machine and their interactions as the model of new aesthetics. They manifested an expansion in time and space for the body that emerged from the power and the glorification of the machines.

Umberto Boccioni, in his manifesto named "Absolute Motion + Relative Motion= Dynamism 1914", writes: "Absolute motion is a dynamic law inherent in an object. The plastic construction of the object must here concern itself with the motion which an object has within itself, whether it be at rest or in movement? Relative motion is a dynamic law which depends on the object's movement. It is quite incidental whether we are talking about moving objects or the relationship between moving objects and non-moving objects. In fact, there is no such thing as a non-moving object in our modern perception of life."

Marianne W. Martin in "Machine Aesthetics and the Dehumanization of Art" : "Marinetti hoped that the artist would overcome his physical limits and 'merge' into the infinite of space and time' and initiate 'the mechanical kingdom' supplanting 'the animal kingdom'. Appropriately enough, Marinetti also envisaged the accompanying evolution of a new being, an immortal superman who will be 'mechanized' with replaceable parts.' " [4]

2. PERFORMANCE PROPOSAL

Bio-performance, a theory based on the conception of the "analogical body" (as opposed to digital), attempts to re-establish the corporeal status of experience de-depending the body from the domination of simulations or virtual allusions.

Performance has to be defined as the dialectical mechanism between body and context. The concept of performance is based on interaction, in the sense that the body of the performer is dynamically -and non-reversibly- transformed by the environment, as well as the environment is transformed by the movements of the performer. Interaction occurs and evolves because the body does not have an overview of the context. Hence the body needs to move. Movement in turn, causes transformation of the spatial configuration as well as of the body itself, a perpetual process. The question then becomes what are the operations for these alterations? Do they fall into patterns and/or other regularities? Here is the point that we have to reverse the question. We do not have to leave the body move voluntarily, but the genetic algorithms might provide a grid for their trajectories in space, so these patterns are varieties inside our evolutionary pathway.

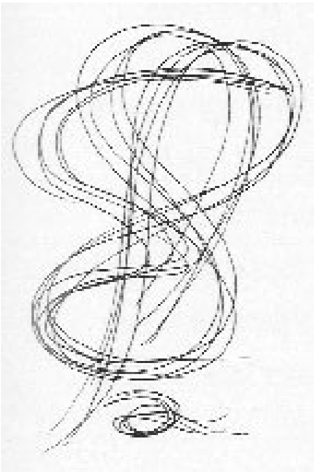


Fig.4. Drawing from the Bauhaus.

THE AGENT

From information systems to bio-information processes- the invasion of information on the body.

Within the borders of bio-capitalism, biotech is formalising nature into molds, mechanising organic systems, applying informatics in the bio-organic level. Placed within this framework, information is transformed to bio-information which is mechanically imposed on the body, potentially altering its developmental perspective. As P. Rabinow claims in his essay titled "Artificiality and Enlightenment: From Sociobiology to Biosociality" [5]: " the object to be known- the human genome- will be known in such a way that it can be changed. This dimension is thoroughly modern; one could even say that it instantiates the definition of modern rationality". Genetic information, due to its complexity, provides a source of transforming the body into a complex system which brings about unpredictable outcomes.

If a performance theory aimed to present the body as a bio-analogic system, all representations and interactions should be replaced by competitive systems and evolutionary processes.

A substantial discrimination between the geometrical space of Oscar Schlemmer and bio-performance may be observed in their relationship with the body :

Schlemmer/Bauhaus	Virtual Reality performances	Bio-performance
space= soft {As Schlemmer puts it: "a space filled with pliable substance in which the figures of the sequence of the dancer's movements were to harden as a negative form." The body of the dancers obtain an 'object' quality, moving in a rather predictable way. [3]	The body "disappears" and is remotely controlled. Its feedback is determined by external information or through interactions.	body= soft, malleable. The body should have a "liquid space" movement within space.

In the bio-performance, the information is perceived from the outside, processed by the body and exported to the initial source (the environment) [6] . Environment though, is a complex concept, that may include self-derived parts or functions of an organism which can potentially be activated in relation to it. (e.x some genes within an organism may be part of a gene's environment)[7]. In this sense, performer and environment become comparable entities. The concept of the performer owning an altering body whose form is perpetually dissolved and recomposed, leads us to consider performance as an organism.[8] The technique of this transformation is realised by emphasizing its bio-analogical responses.

Schematic of the performance space

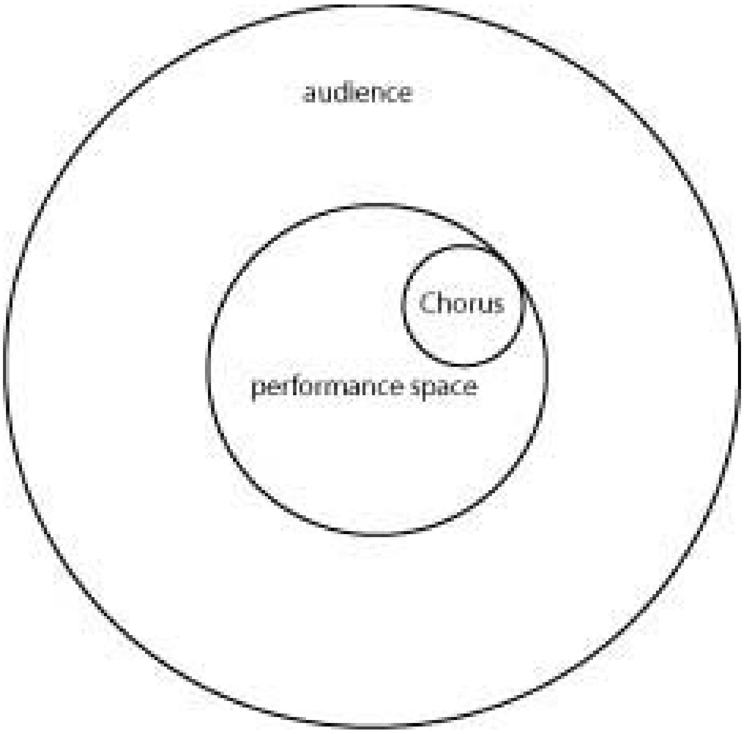
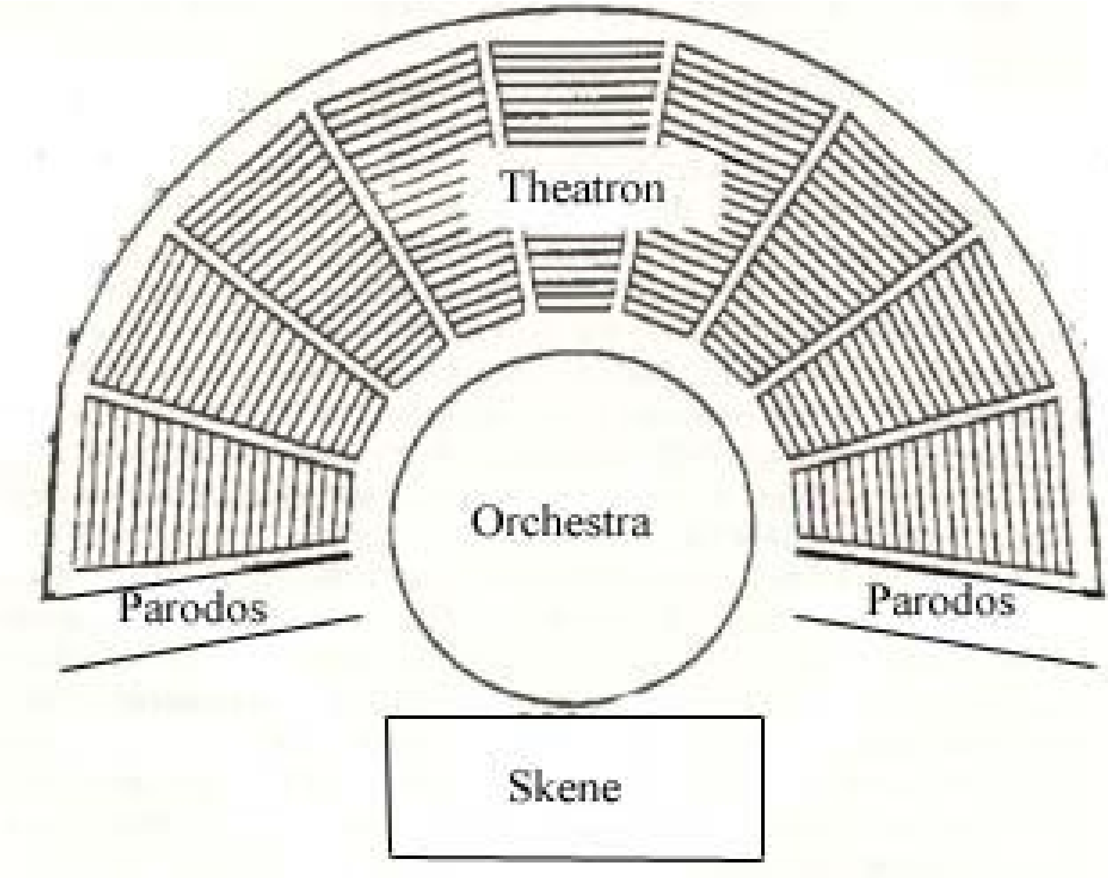


Fig. 5, Diagram for the spatial arragment of the Garden performance. Below, Fig. 6., the ancient Greek Theater diagram with Orchestra, Theatron["theater," lit. "place for viewing," from theasthai "to behold" (cf. thea "a view," theates "spectator") + -tron, suffix denoting place. ,)], Skene and Parodos.



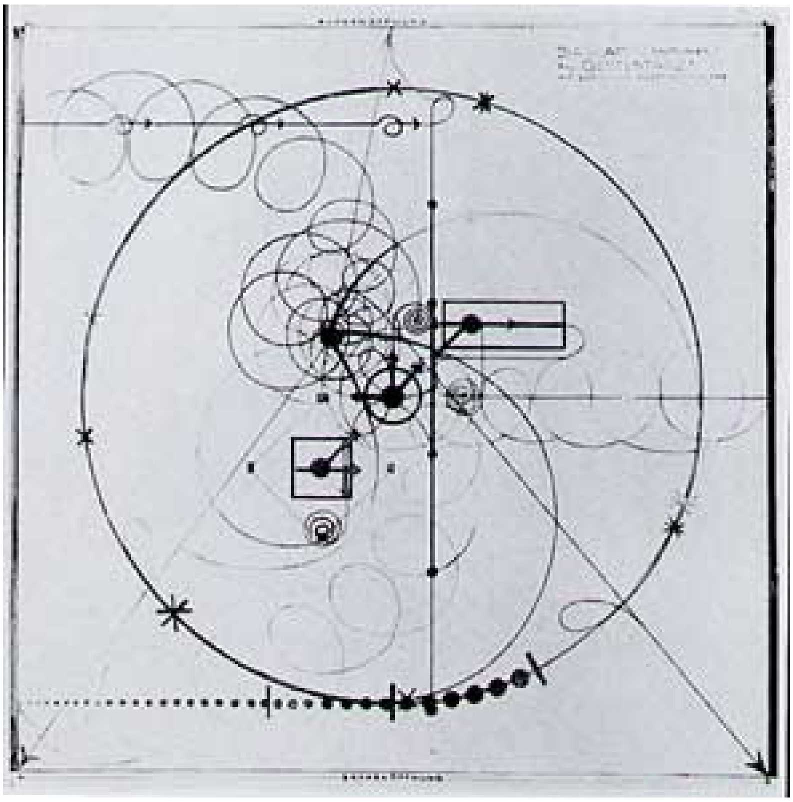


Fig. 7. Schlemmer's stage diagram for Gesture Dance,Bauhaus, 1926

Chorus and the sound synthesis of the performance

'Music is sound, that is, movement. The goal is to bring sound itself to life.'

Xenakis, in Balint Andras Varga, Gesprache mit Iannis Xenakis, trans. Peter Hoffmann. p.62

ancient drama	Chorus of the ancient drama	narration/singings/dance

bio-performance	Chorus of 3 women	singing: aischrologia (=abuse words)

Transformations through codifications (encoding letters inside the notes)

Encryption of the word "BACH" inside the fugue from J.Sebastian Bach at the last work Art of the Fugue/Die Kunst Der Fuge.

The third theme of the unfinished four-part fugue starts with the sequence from Si-La-Do-Si minor ("BACH")

Fuga_a_3_Soggetti_Contrapunctus 14.aif ________________

Fuga_a_3_Soggetti_Contrapunctus 14.aif(Fragment 6:00-6:03)____

Less visible in Contrapunctus 4____

Contrapunctus 4(bar135-136) played by the viola

Also in Contrapunctus 11, at the satrt of the anti-theme with eights (after the initial fugue theme) and finally forms the 3rd theme of the fugue

Genetic algorithms (real-time DNA transcription) in the Garden performance

The sound synthesis consists of three sound layers:

1. the background 'environmental' synthesis, based on the DNA sequences of the mutant fruitflies. *sound file (through MAX/MSP) [file: backgr3.aif]*

2. the 'male' foreground synthesis based on the thermal scanning of space. Thermal outputs are transformed to skirl real-time sounds (through MAX/MSP) *[file:Thyrsus20050528takeB.aif]*

3. the female chorus, consisting of seven women which periodically sing a synthesis based on the names of the 4 DNA bases (adenine (A), thymine (T), cytosine (C) and guanine (G)) resembling female abuse, as women practised in ancient Thesmophoria. *[file: femaleChorus1.aif]*

The series by which the four proteins appear in time, is the DNA chain. The DNA chain is transcribed to syllables (parts of the names) of the four proteins. Each singer sings one phoneme at a time.

The mutant fruitflies/ background 'environmental' synthesis

One of the most striking mutations in Drosophila is the conversion of antennae into legs by the gain-of-function dominant mutation, Antennapedia.

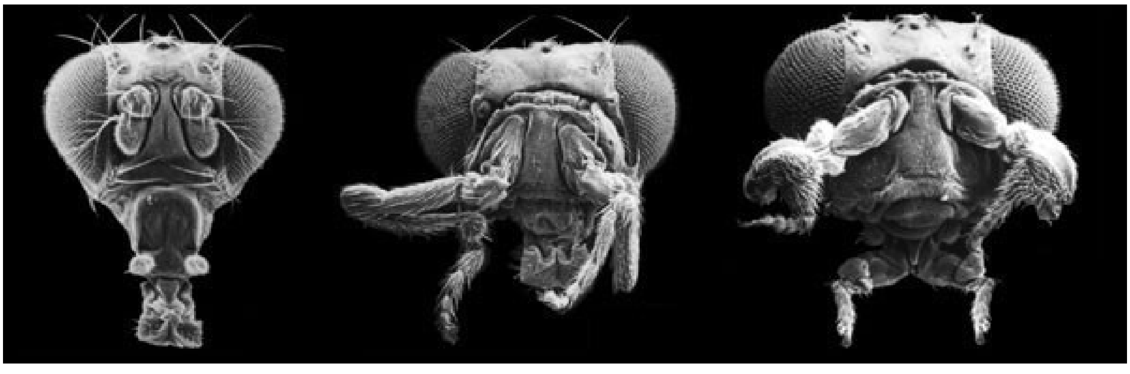


Fig. 8. HOMEOTIC TRANSFORMATIONS involving the Antennapedia Complex (ANTC)

Adult fly heads: wild type, antennapedia (antennae transformed to 2nd thoracic legs) and a double mutant proboscipedia/ antennapedia (antennae to 2nd thoracic and proboscis to 1st thoracic legs).

How music is derived from the DNA sequence of the mutant fruitfly

Music Fly

The DNA of a fly (894 bases) is used as a base for the production of music. A specific algorithm was designed for the interpretation of the DNA code. This music piece is then arranged to aesthetic preference and transformed to a new DNA sequence which becomes a representation a "music" fly. This new organism could even be produced /in the lab as new organism /or as a computer model.

The 894 bases of the antenappedia gene:

1 atgacgatga gtacaaacaa ctgcgagagc atgacctcgt acttcaccaa ctcgtacatg

61 ggggcggaca tgcatcatgg gcactacccg ggcaacgggg tcaccgacct ggacgcccag

121 cagatgcacc actacagcca gaacgcgaat caccagggca acatgcccta cccgcgcttt

181 ccaccctacg accgcatgcc ctactacaac ggccagggga tggaccagca gcagcagcac

241 caggtctact cccgcccgga cagcccctcc agccaggtgg gcggggtcat gccccaggcg

301 cagaccaacg gtcagttggg tgttccccag cagcaacagc agcagcagca acagccctcg

361 cagaaccagc agcaacagca ggcgcagcag gccccacagc aactgcagca gcagctgccg

421 caggtgacgc aacaggtgac acatccgcag cagcaacaac agcagcccgt cgtctacgcc

481 agctgcaagt tgcaagcggc cgttggtgga ctgggtatgg ttcccgaggg cggatcgcct

541 ccgctggtgg atcaaatgtc cggtcaccac atgaacgccc agatgacgct gccccatcac

601 atgggacatc cgcaggcgca gttgggctat acggacgttg gagttcccga cgtgacagag

661 gtccatcaga accatcacaa catgggcatg taccagcagc agtcgggagt tccgccggtg

721 ggtgccccac ctcagggcat gatgcaccag ggccagggtc ctccacagat gcaccaggga

781 catcctggcc aacacacgcc tccttcccaa aacccgaact cgcagtcctc ggggatgccg

841 tctccactgt atccctggat gcgaagtcag tttggtaagt gtcaaggaaa gtga

There are only four different bases and thus only four different nucleotides. The four bases are adenine (A), thymine (T), cytosine (C) and guanine (G). Genes are sections of DNA, in which the neucleotides are viewed in groups of three called "triplets" or "codons". Each codon "codes" for a particular amino acid (amino acids are glued together to make proteins.)

Antenappedia protein sequence:

MTMSTNNCESMTSYFTNSYMGADMHHGHYPGNGVTDLDAQQMHHYSQNANHQGNMP
YPRFPPYDRMP

YYNGQGMDQQQQHQVYSRPDSPSSQVGGVMPQAQTNGQLGVPQQQQQQQQPSQN
QQQQQAQQAPQQL

QQQLPQVTQQVTHPQQQQQPVVYASCKLQAAVGGLGMVPEGGSPPLVDQMSGHHMN
AQMTLPHHMGHP

QAQLGYTDVGVPDVTEVHQNHHNMGMYQQQSGVPPVGAPPQGMMHQGQGPPQMHQ
GHPGQHTPPSQNPNS

QSSGMPSPLYPWMRSQFGKCQGK

Foreground synthesis

Music is derived from the thermal scanning of the performance space *(a FLIR thermal camera was used for this reason, connected to a computer running MAX-MSP)* while the protein sequence rows through real time music transcription:

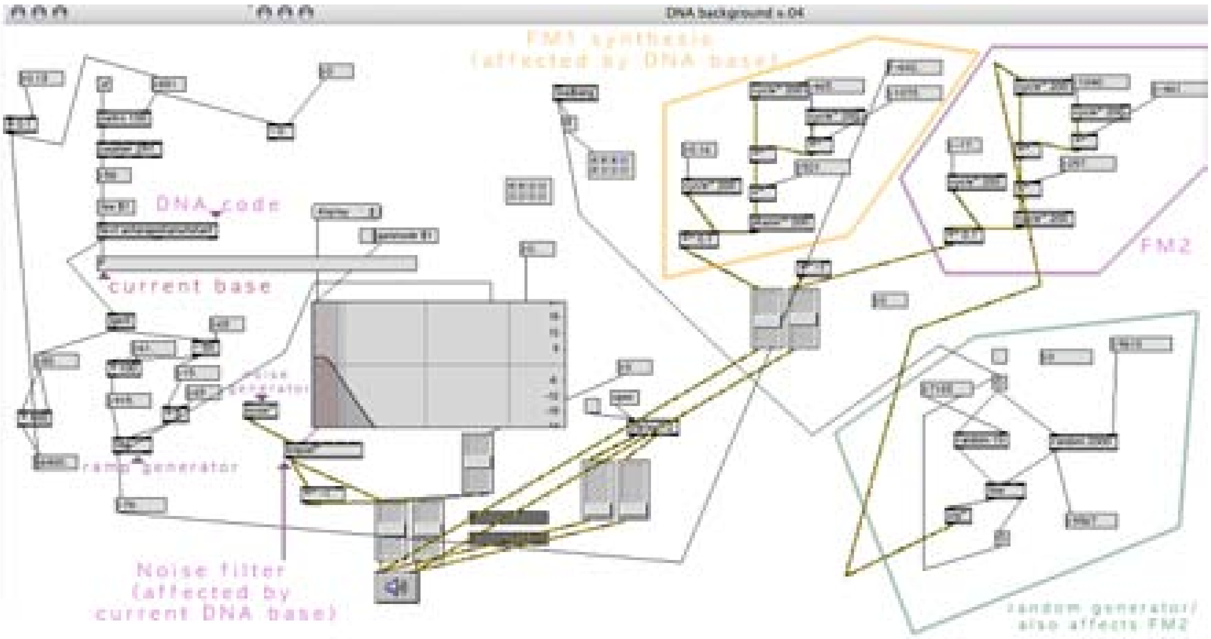


Fig. 9.Thyrsus-Cyclops diagram (assembled in collaboration with composer V. Kokkas): DNA is used to shape noise waves thus creating the acoustic environment.The current DNA base creates a ramp which drives the parameters of FM1 and FM2.

Nine triangle wave generators which are controlled by the chromatic codes of the thermal image captured by the camera. The main performer was appearing in my first sketches as bird-like mutant,[fig. 10] so the parameters of this system are adjusted to yield timbral (in greek=ixoxromatiki) texture which is a synthetic model of the birds' voice. [see natural birds' voice in diagram, fig. 11]

Fig.10. Drawing by Yiannis Melanitis, first thoughts on the male performers’ image, ballpoint pen on paper, 2004

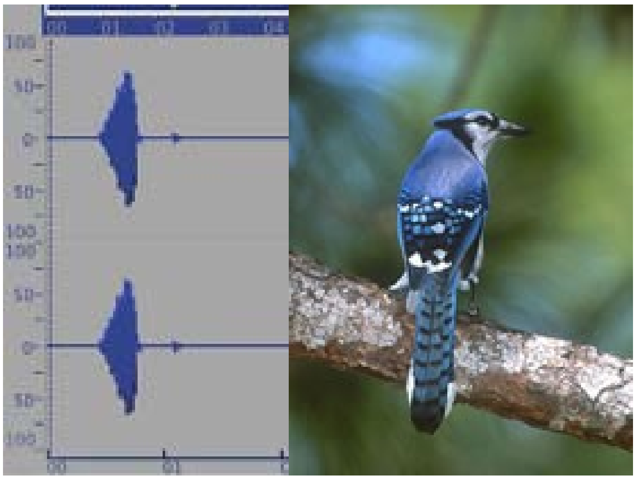


Fig.11. sound wave diagram of the Blue Jay

_the music of the thyrsus is based on the song of the bird Blue Jay [Thyrsus20050528takeB.aif]

_the sound wave diagram of the Blue Jay is also triangle shaped

_sound sample of Blue Jay: [blueJaySound.mp3]

<http://www.geocities.com/melanitis2004/Garden5.html>

'The Garden' is an interactive environment for 4 performers and a three-member female chorus

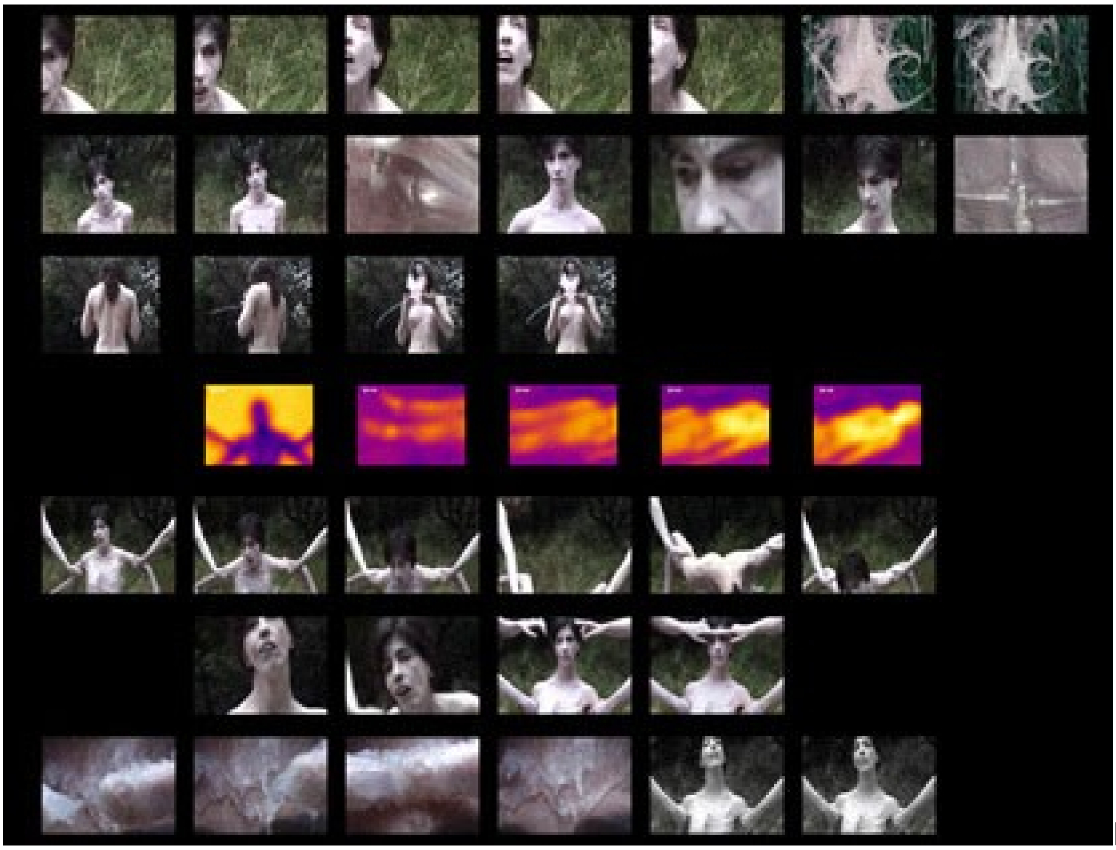


Fig. 11.'The Garden', *Image stills and video:*

http://www.geocities.com/melanitis2004/Gardenvideo.html>

Forthcoming steps

In the ensuing evolutionary steps of the work ‘The Garden’, a work partially performed, being under a transformative process itself, genetic algorithms will define its basic parameters (from agents trajectories till bodily prosthetic forms.) Genetic algorithms are not merely guidelines for formalistic interpretations; more essentially, they should function as a ‘source of metaphors to remodel life, aiming, in partial, to reveal the area that comprises the ‘parental scheme’, the initial philosophical idea concealed under the external schemes, before the metaphors, still before the first, the inceptive transfer…

As Derrida says,[9] in all human words, a .scheme had been parently stamped, a materialized scheme and when they were all new, they represent a certain perceptible image….inevitable materialism of the vocabulary… Whist in ‘The Garden’ the place of vocabulary coincides with the genetic base sequence, our concern are not the coding transformations ; more extensively our aiming is in the approximation of the initial, non-transferable concept…

For the definition of the genetic algoritm through use of simulation computer program for the fruitfly tests Yiannis Melanitis is collaborating with Bouzaklas Ioannis, Geneticist, BSC in enetics MSC Molecular Medicine, Phd Medical School of Athens, ioannis@enternet.gr

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8. Mae-Wan Ho, "The New Age of the Organism", A&D, volume 70, No 3, June 00. page 48, " ...the parts behave as though they are independent of one another. This is the radical nature of the organic whole(as opposed to the mechanical whole), where global cohesion and local freedom are both maximised, and each part is as much in control as it is sensitive and responsive."

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The Characteristic of Professional Higher Education Bachelor Study Programme "Computer Design" in Daugavpils University

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Lecturer **Ilze Volonte**, Mg. Paed;

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Abstract

One of the priorities of the European Union is to lend stability to Latvia (including Latgale as well), which is impossible without the presence of art. Therefore the task of Daugavpils University is to strengthen the development of creative work in the Latgale region, which can be affined by implementing the study programme and training highly qualified specialists.

Currently higher education institutions of Latvia train the specialists in *computer design*, however Daugavpils University is the first university that has started the implementation of this programme by combining the former programmes (art and programming) into one whole.

In this article features of the professional higher education bachelor study programme "Computer Design" directed on the development in trained creative and professional abilities are opened.

Aims and objectives of the study programme

The *aim* of the Professional Higher Education Bachelor Study programme "Computer Design" is training of internationally competitive specialists with versatile knowledge in art, design and computer design. With a further professional training these specialists could become proficient experts able to meet the current and prospective demand for this type of specialists in various branches of Latvia's economy (art, culture, research, production).

The *objectives* set to achieve these aims are as follows:

to foster the perfection of students so that they should become free, responsible and creative personalities;

to promote the acquisition of artistic knowledge, skills and abilities so that the students should be competent in contemporary art, design and computer design and should motivate themselves for further education;

to offer possibilities for preparing to continue there professional education in master study programme.

to introduce the students to the theoretical fundamentals of art and information technologies;

to teach the practical implementation of composition tasks by qualitatively analysing their separate stages;

to develop visual perception by observing objects and phenomena in nature;

to reveal aesthetics values in works of visual art;

to develop visual memory, feeling for colors; to teach to depict the form of an object in space graphic means;

to impart the necessary knowledge and skills of practical work by working in a computer environment and applying different software.

These objectives are to be realized by giving the students theoretical knowledge and professional practices. By during practical tasks, in which the results of systematic training and the obtained skills and abilities in portraying are mirrored, the psychic cognitive processes and creative activities are developed.

The studies take place at the Faculty of Music and Art of Daugavpils University. By acquiring the study programme, the student obtains both the professional *Bachelor's degree in art* and qualification "*Computer designer".*

The acquisition of the programme in full-time studies will take 4 years (160 CP).

Structure of the Study Programme

Structure of the study programme is illustrated in a diagram (see figure1).

General education courses (20 CP or 12% from the study programme in total: General theory of culture; Semiotics; Phenomenology of art; Theory of art; General history of culture; Psychology of art; Technologies of personal growth; Psychology of image; Foreign language studies) are compulsory for all students enrolled and matriculated in the Professional Higher Education Bachelor Study Programme "Computer Design". These studies comprise the basic courses of art theory in the bachelor's standard part, which give versatile knowledge, skills and abilities in principal branches of art. Students work out and defend study papers in history of art.

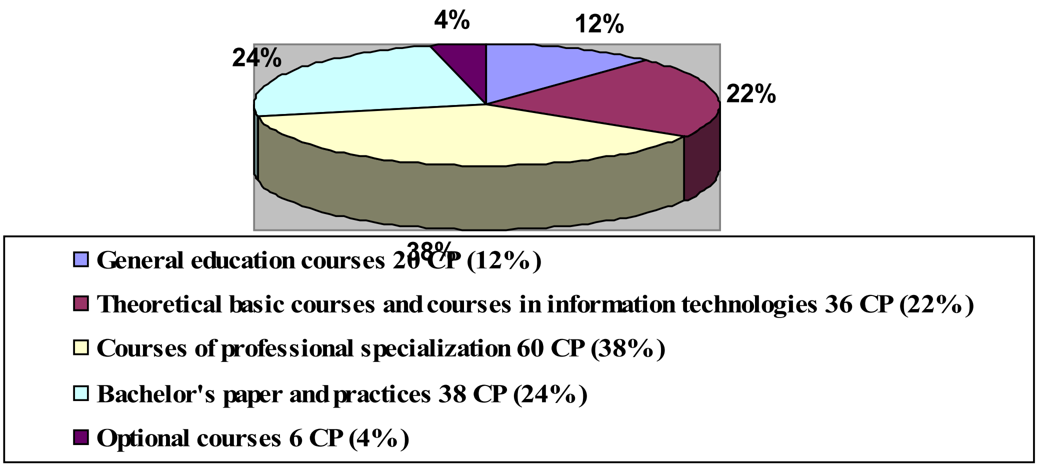


Figure 1*. Structure of the study programme*

Theoretical basic courses and courses in information technologies (36 CP or 22% from the study programme in total: *History of art; Composition; Plastic Anatomy; Chiseling; Studies of letters; Graphic works; Foundations of descriptive geometry and perspective; Study of colour; Theory and history of philosophy and others*) comprise theoretical courses as well as other basic courses in art, culture and information technologies.

Courses of professional specialization (60 CP or 38% from the study programme in total: *Operating System Windows NT and Windows 2000, basic software administrating; General characteristics of new information technologies. Introduction to the theory of colours; Computernets and communications; Mathematical logic; Software of non-linear video montage; Word processors, spreadsheets, data bases (Microsoft Office); Drawing; Painting; Professional composition; Raster graphics, preliminary of print work; Raster graphics, preliminary of print work; Two-dimensional animation (Ulead Gif Animator, Animator Studio); Three-dimensional graphics and animation (MAX); Vector graphics (Corel Draw); Desktop publishing software (Adobe Page Maker) Creating portable files; Creation of home page; Multimedia technologies and project; Sound in multimedia; Theory and practice of modern programming; Technical graphics*). Students have a possibility to acquire the academic foundations of art in practical classes of artistic creativity and creative activities. In this part of the programme, students work out and defend their work in composition.

Optional courses (6 CP or 4%) comprise several optional courses of the bachelor programme. From these students have to choose courses comprising 6 credit points from the study programme in total.

Bachelor's thesis and practices (38 KP or 24% from the study programme in total). During the training students have three professional qualification practices (26 CP), and they have to work out the bachelor's thesis.

To obtain a professional master's degree in art, the graduates can continue their studies in master study programmes higher education institutions both in Latvia and abroad.

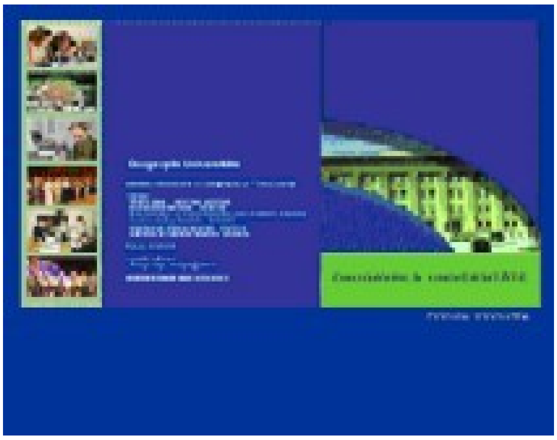
The second, third and forth year students are to have professional qualification practice: 8 weeks long in the second year (8 CP), 8 weeks long – in the third year (8 CP), 10 weeks – in the fourth year (10 CP). The DU regulations on the organization of practices regulate the process of professional qualification practice.

Practice in art – pleinair is organization in open air in Dagda, Kraslava and Daugavpils. According to the study plan it takes place in the first and second year of studies during two weeks of spring semester (4 CP).

During the art-pleinair in the second study year, the students have their training practice (visits to museums in some country; after that 1 week long exhibition of their creative works is organized – see figures 2,3).

Figure 2. Figure 3. *Drawings created by nature*

*Drawings created by nature*The study process envisages 3 study works: one in history of art, the second and the third – according to the qualification chosen (see figures 4,5).



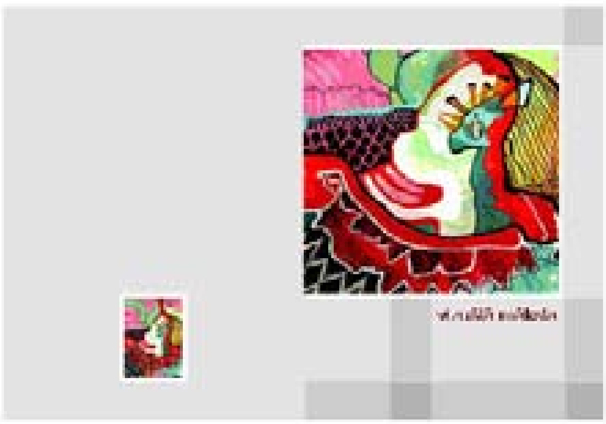


Figure 4. Figure 5. *Fragment of study work*

*Fragment of study work*In the end of training students carry out and defence of the bachelor thesis (see figures 6, 7).

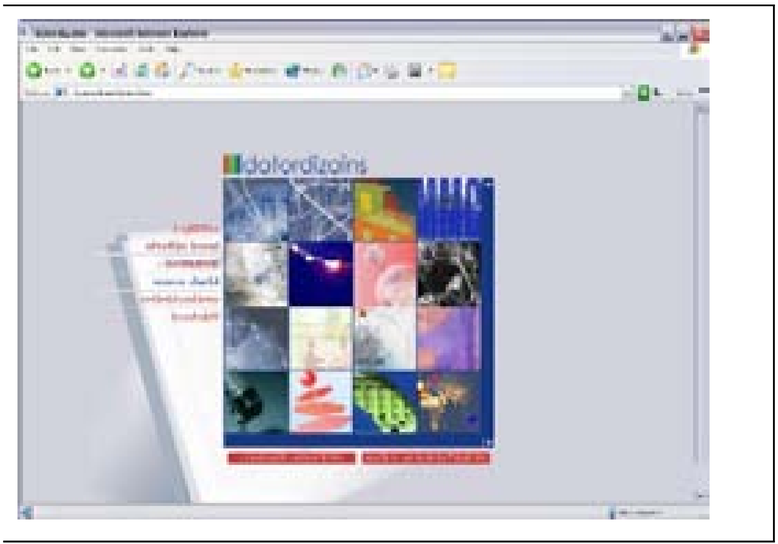


Figure 6.

Fragment of bachelor thesis

Figure 7.

Fragment of bachelor thesis

3. Information about the cooperation with other frameworks, theoretical and applied research

Professional study programme has a successful partnership with other Latvia's and foreign higher education institutions, state organizations and non – governmental organizations. The cooperation with similar programmes of the Liepaja Academy of Pedagogy, Art Academy of Latvia and its branch in Latgale fosters exchange of experience, participation in joint conferences and other projects. As a result of this cooperation the content of the study programmes has been coordinated with the programmes of the Liepaja Academy of Pedagogy, joint research has been organized.

Most significant partners are:

Association of Artists Educators,

Association of Daugavpils regional artists.

Some lecturers are members of international professional organizations.

Academic staff of the Department of Art exchange the information, scientific materials and, on special occasions, carries out common research with the scientists from such countries, as Sweden, Belarus, Lithuania, Finland, Germany, Italy, USA.

Main directions of research work conducted by the Department of Art are a study of ways toward a perception of structure and content of the subjects of the programme, fostering the students' interest in visual art and their creative activities. The results also are approbated through participation in international conferences and seminars (Australia, Belarus, Estonia, Germany, Great Britain, Italy, Lithuania, Mexico, Finland, France, Portugal, Sweden Thailand, USA).

Each year the academic staff of the Department of Art participate in Art exhibitions held in Daugavpils, in other cities and countries: in Belarus, Sweden, in Denmark, Lithuania, Germany, Russia, Italy. Altogether there were 82 exhibitions.

References

Figure 2 - Drawings of student Natalija Maksimcikova.

Figure 3 - Drawings of student Sarmite Logina.

Figure 4 - Fragment of study work of student Danute Janaudite.

Figure 5 - Fragment of study work of student Daina Vilcina.

Figure 6 - Fragment of bachelor thesis of student Ludmila Ekalne.

Figure 7 - Fragment of bachelor thesis of student Jelena Labonarska.

Nature as source of Generative Art

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I intend for Generative Art what results from the activation of a technological device and it is characterized by the following ownerships: itself-operativity of the device, renouncement to the control, flow, indeterminateness, casualness and unpredictabilty of the results.

The application of this concept to the computer programs, also if corrected, it results largely limitative; I speak in this case of Aesthetics of software and not of Generative Art; the aesthetics of software, that can be identified as software art, is only a type or a subspecies of the Generative Art.

I intend to illustrate another field of the Generative art that I valuate particularly meaningful because besides the general aesthetical sense, that is common to all the Generative Art, contains some philosophical implications and specifications that must be analyzed and understood.

I depart from some necessary references:

in the 1951 John Cage performs Imaginary Landscape N. 4 with 24 performers that manipulate at random the tuning and the volume of 12 radio instruments; in the 1963 Nam June Paik introduces 13 Distorteds TV Sets in which a same program transmitted by 13 televisions becomes, in each of them, casually and unpredictably deformed by magnets placed on every single instrument; Alvin Lucier in 1967 composes a piece, Wistlers, tuning low frequency radio receivers to the noise coming from the ionosphere; the project Jardin bio-acustic of Nissim Merkado proposed, in 1978, to reveal the micro-waves of the leaves turning them into a sound laboratory and acoustically following the transformations of the vegetable substance up to its being dry; from the end of the '70th numerous artworks of Érik Samak use and electronically manipulate some animal sounds as the croaking of the frogs, or of the data coming from the physical environment, as in the Autonomous Acoustic Forms that turn into sonorous issues the information furnished by the anemometers by the thermometers and by the hygrometers,; in nearer years Shawn Brixey, with 1987 Photon Voice or Domenico Vicinanza, with Etna's seismographic signals, get sounds still from the action of the photons on the graphite or the vibrations of the Etna.

In all the cases here quoted, and in many others that are skipped, all the necessary and enough conditions are given for being able to speak of Generative Art: the jobs are produced by technologies elettro-electronics, sensory, computers, interfaces, they consists in a flow of acoustic phenomenons or also visual that they manifest out of a whatever control and that they are entirely casual, indefinite, unpredictable and aleatory.

But these jobs, similar from this point of view, also manifests among them a deep difference that must be gathered and interpreted: some play on a casualness drawn by the activation of the only technologies, others instead are realized making to work together technologies and nature.

At this point is necessary to mention a more articulated discourse on the case and the indecision.

L' interest for the "case", its investigation and its activation in aesthetical sense start with the historical avant-garde: memory among the whole case of the 1913/14 Duchamp Stoppages-Étalons where some plates of glass are shaped according to the forms assumed at random by a thread of left cotton fall from a meter high. In this case, and in all the numerous other envoys made by the dadaists, there is a purely and only mechanic casualness , in which the technology neither the nature have still involved.

The 1951 Cage's job marks a turn: here casualness is entirely inside to the technology, the radio, and to it only; the indecision is tied up to the unpredictable and varying nature of the sonorities put in wave from the twelve broadcast broadcasting stations, and from the equally casual formalities in which they is manipulated by the 24 performers. The same, and still more, is the job of Paik that eliminates the same human presence of the performer and, it gives birth more radically to born the case from only the activated technological regulating,: the telecast, the televisions and the magnets deforming the signal.

In comparison to the jobs of Cage and Paik, the Wistlerses of Lucier contain an important element of novelty and mark, for this reason, a further turn: here for the first time casualness is produced making to work together technology and nature: the unpredictable and casual Whistles, in fact, are produced not here by the radios beginning from issuing broadcast and therefore from other technologies but from signals coming from the ionosphere, and therefore from the same nature.

At this point the picture is complete and prefigures with extreme clarity the actual situation that, simply hands to conclusion that preceding,: today casualness is produced by a constant work inside to the new technologies, and the most rigorous case is represented by that we can indifferently call Aesthetics of the programming or Software Art, that of Celestino Soddu or of Casey Reas. Particularly, in Generative Art casualness is aroused using as matrix and as source the same casual and aleatory phenomenons of the nature that are repeated or also technologically transformed : the jobs of Merkado, Samak, Brixey or Vicinanza, above quoted, are some examples that we could do.

Getting an interpretation of all these experiences, the interpretation have to go beyond the limits of the aesthetical approach.

To what answers this obstinate research of "casualness", a research that crosses big part of the history of the art of the '900? To what answers this going ahead and progress from an ingenue mechanical and manual casualness to a technological casualness, until a more complex and hybrid form of casualness that results from the mixture of technology and nature?

The search of casualness is, first, a sign and a symptom of the "de-humanization of art" that appeared, in the first decades of the '900 as an ineluctable result of the whole history of the art.

Duchamp expressly spoken about "de-humanization", but it constitutes equally the horizon toward artists like Mondrian, Gabo or Moholy Nagy went, and the signs of a "de-humanization of art" have been identified, time ago, by Ortega Y Gasset and from Hans Sedlmayr.

The analysis of the to progress of the "de-humanization", following to the increase of the new-technologies, constitutes a remarkable aspect of the research activities that I am developing.

But the concept of "de-humanization of art" limits all events to the aesthetical field and it gathers only one aspect of the matter. To deepen it, therefore, it is necessary some consideration on the techniques.

The requests originated by the techniques is not so much a request considering the reality as "first layer", as identified by Heidegger. This approach to techniques works, at best, for the "technological" epoch but it not suits to the "new-technological" era, in which also the reality as "first layer" is behind in a faded distance.. The injunction that comes from the technique, definitely made clear at the advent of the new-technological era, is instead, as it seems well understood by Günther Anders, the approach to transform everything given. The technique, in short, try to build its own world, to make its world that replaces the other one, that "natural" one, already "given", and that doesn't have anything to exhange with this other.

The "humanization" of the world, identified and described by Leroi-Gourhan, now is replaced by the "Technologyzation", that is when technology take possession of the world.

In this situation, everything that survives still as "given", is worth as an intolerable "rest" , and the nature is the "given" for definition.

Here then the sense, perhaps more depth, of the walk crossed by the research on the "case": it, moving from the ingenue mechanical casualness of the "dadaistic poetry" of Tzara, of the "delicious dead bodies" surrealists, of the "great glass" of Duchamp, held only by him finished when casually broken, and so on, moves and displaces in various way on the technologies to land to a re-writing or technological translation of the nature and to transform it so that something of "given" in something of technologically "done".

The artists, was said, are the "spar" and the "sensory" of the humanity: and therefore, what their job has started to point out and to put already in scene beginning from the years '60, are anything else than the wish of power of the technique, that still and more always pushes her toward the most complete and radical technological appropriation of the nature.

Emergence, Beauty, Software and Kitsch

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Abstract

The discussion about emergence and generative art has been developed mostly around scientific and technological topics, without too much concern on its aesthetic issues. Besides, form and beauty have been replaced, generally speaking, by the idea of sublime, a philosophical streams that follow the growing scientific interest around chaos, dynamic systems and emergence. And indeed the deconstruction of truth left beauty in the realm of taste and in the visual arts conceptual artists have been developing theoretical processes rather than any engagement with visual forms.

Yet beauty, even when speaking about computers and generative art, is not so easily overrun. I'll try to show that if we accept aesthetic relativism and technology without questioning, the sublime, or the aesthetic freedom of emergence, is jeopardized. Thus, generative and software art will be trapped inside a framework already defined as the death of art and a new kind of kitsch appears: say, the spawning of unnoticed forms of simulacra, self-referent individualism and cultural colonization.

In the first part of this paper I'll introduce, very briefly, the context of the sublime (indetermination and emergence) within digital technology. Then I'll try to show that beauty is not out to date, for three (good or bad) reasons: a) an old aesthetics is actually alive within individual taste; b) the existence, inside science, of epistemological problems and new theories that redefine beauty, the sublime and their relationships with method and truth; c) artificial processes that claim for emergence and autopoiesis are not only based upon these same old aesthetic narratives, but also do not always have a clear definition of emergence inside simulation processes and virtual environments.

The dynamic between beauty and the sublime deeply reflect many unsolved problems that I'll try to focus in the second part of the paper: emergence as an open system, the feedback of knowledge, and the game between determination and indetermination (beauty and the sublime, science and humanities). The confusion between complication and the complex and between emergence and its simulacra that can be easily accepted as true generative processes will show the problematic dimension of technological/computational sublime.

In the third and final part of the paper I will defend the quest for a proper aesthetic framework for emergence and interaction: a) because emergence is fuzzy and open, beauty and sublime should be related with hermeneutics and mayeutic processes; b) in order to sustain true indetermination, a re discussion of aura can't be avoided: it switches from technical reproduction to generative irreproductability

As a conclusion, I hope to find some hypothesis and suggestions to develop generative art without its weakening contradictions, in order to fully exploit its creative and pedagogical applications.

1 Introduction

With the development of digital technology and the interdisciplinary debate that appears to its surroundings, the aesthetic questions have returned up to date issues, along with many new interesting topics. The debate reconsiders many well-known ideas of media criticism, such as Baudrillard' simulacra, but it seems to take a special look at the new contributions derived from the sciences that investigate chaos and dynamic systems (particularly A-Life).

All these topics, flowing somehow around emergence, indetermination and creativity, are directly connected with the old philosophic question of beauty and the sublime that now recovers, especially with beauty, some of its old importance.

In fact, beauty and sublime involve the emergent processes that are the cutting edge of computer science and art, but if we consider that the complex nature of the digital tools (computers, software, interfaces) is not always perceived in its full dimension, then the dynamics among beauty and the sublime should be re-discussed over different foundations.

In this paper I will try to avoid the seductions of the techno culture to do a more aesthetic investigation that is to seek, through sublime and beauty, the problematic nature of the artistic generative digital systems. In my opinion, we should consider two important topics: in the first place, the still undefined scientific and artistic structures that we may need to sustain that these new media are not only techno toys, but do have some real social and cultural relevance (for instance, in education and communication); secondly, the consistency of artificial emergence and in general, the aesthetic implications of simulation.

So, if I try to defend beauty, it is mainly to underscore that is its relationship with the sublime that allows the unmasking of some wavering aesthetic problems embedded into software and interfaces that are the most important media or tools of generative art. I will try to show that the lack of critic and aesthetic tools not only weakens the innovative potential of these new technologies and their cultural and social functions, but is also the cause of persistent obsolete forms of beauty or " techno kitsch ", that are the principal limitations of many instances of the digital arts.

2 A short survey on the sublime

Before we begin, it is useful to briefly resume some basic concepts about the sublime, because the sublime is, in many senses, the ancestor of emergence and anticipates its aesthetic questions.

It is well known that the discourse of sublime and its relationship with beauty was developed originally with Kant, but, as Gadamer said [1], Kant is also the starting point of the conflict between beauty and truth, that has produced the numerous failures of contemporary art (including its market system, aesthetics, production and pedagogy). This gives a key to understand why contemporary artists, trying to avoid the Kantian genius framework and because of the decorative and superficial nature of beauty, have directed their experiments towards the sublime.

Later on the sublime has been re-proposed by postmodern philosophers, inside the horizon of nihilism, the end of the great narratives and the uncertainty that characterizes our global and mass mediated world.

Finally the sublime appears as "computational sublime" or "technological sublime", a contemporary shape of sublime that owes to the new spaces, processes and media that technology unleashes. Under this point of view, the sublime resides in the disability of our intellectual tools to understand and control what technology can do. This definition of the sublime fits precisely the chaotic, indeterminate, autonomous and parallel aspects of information society and of digital technology, as James Bailey has deeply investigated [2].

But this shift from beauty to the sublime has a side effect: it makes for the loss of any concrete relationship with reality [3] and with history: for art, this loss designs the territory of the sublime as the place where any type of experimentation that crosses art with technology, pseudo science or science fiction seems to be lawful and possible.

For this reason art is now transformed into techno art and goes ahead without any critical tool to verify its instances, each one incommensurable, on the social, cultural and political plane.

But luckily beauty - as order and measure - doesn't allow itself to be so easily eliminated (both for the good and the bad). In fact, when we are sure that it has been bypassed, beauty comes back following unexpected paths and making the terms of the problem in the need of reexamination.

3 The Persistency of Beauty

Now we will take a closer look upon the process that has gradually emarginated beauty from the current aesthetic discourse, it's quite clear that art has been developing its conceptual framework rather than its sensible, perceptive and formal appeals.

In the first place beauty and "aura" have been considered, by post war culture, as a kind of dangerous screen that hides more urgent and radical social problems, favoring in this way conscience manipulation and forcing the agreement with the mainstream through entertainment and consumerism. So the conceptual and experimental paradigm, now embedded into contemporary art, seems a logical form to approach the sublime, in other words, freedom, chaos and creativity. In this sense emergence and generative processes are interpreted as the latest branch of modernist avant-gardes.

Secondly, and here we find the original problem, beauty has lost its epistemological relationship with reality, because postmodern philosophy, dissolving truth and deconstructing narratives, has created a dust of self sustained instances of individual tastes. Inside this hypothesis, as Vattimo has argued, beauty is easily contaminated by kitsch: this is the form of beauty where its problematic links with truth are not recognized, more precisely, where and when beauty fails to assume that truth doesn't exist in the usual stable and deterministic form (that has embraced the incommensurability of the sublime).

3.1 Postmodern and digital illusions

But the deconstruction of the great narratives does not eliminate the beauty-truth relationship because it is simply fragmented, as said before, into a constellation of individual metaphysics (a kind of fractalization or self similarity).

Here spawns a powder of more dangerous statements, because totally out of control, such as some examples of religious or political fanaticism; similarly, in the art field, we allow everything since it enjoys the freedom of the individual taste (with many good reasons Danto or Vattimo can speak of this context as the death or down of art).

This context is boring and dangerous at he same time, because it refuses (or nobody really cares) any questioning of its statements. As a consequence, self reference (art for the sake of art) overflows and the speech is held up in marginal questions, that, in the case of new media arts, is over coated by the illusion of constituting some kind of innovation[4].

Now, all this is easily misunderstood as sublime, because it is apparently emergent and indeterminate; but without a methodical sustenance these individual statements, for what refers to the arts, still rely on the aesthetics that is traditionally transmitted by the cultural industry and the educational system, namely: the Kantian aesthetics of taste and genius, and by economic and political interests.

This way it is easy to see that many of the experimentations that explore emergent and interactive processes remain caught in this romantic aesthetics and do not develop concretely the full range of possibilities of the sublime that they suggest. In many cases, the contributions of contemporary art are also ignored (many of those who deal with these technologies do not have artistic formation, fact that on one hand is a real bonus, but on the other one leaves these technologies without an adequate aesthetic thought). The inverse equation, say artists playing with science and technology, is also true: the problem is that artists ignore the basic foundations of the scientific processes they are including into their artworks. So in both cases its true that art and science remain actually separated.

For this reason the digital arts are so often sustained only because they include some technological breakthrough or some awesome interface or special effects. These are taken as technologically sublime, but they are actually only makeup, postproduction or entertainment. This makeup is what I consider techno kitsch: old beauty and the sublime reduced to consumer technology.

Because of this, the sublime and beauty should be re instantiated, inside the new opened and indeterminate dimension that beauty assumes after its postmodern deconstruction and inside its relationship with science and technology.

3.2 Beauty, the sublime and computers

On the other hand, beauty, in its kitsch and decorative form, is deeply but elusively embedded inside digital tools, namely software and interfaces. For example, all the 3d modeling and animation applications do is to apply old and academic visual languages (renaissance perspective, Leonardo's atmospherics effects, etc.) or impressionist pictorial techniques (Photoshop's filters).

Inside software this old aesthetic works in a very subtle way, because it is hidden inside algorithms and code, in other words, it triggers deterministic processes interfering with the freedom of the user. He, the user, ends up doing only what software (and its embedded aesthetics) allows him to do [5].

The ancient aesthetics also design the visual metaphors of the interfaces (the virtual architecture of the Renaissance memory's palace) and it is rarely figured out that interfaces are filters that design and shape (before the user) the possible virtual worlds. In this case beauty, as graphic design or as special effects of interfaces, is a true form of kitsch, because it forces the sublime and its chaotic indetermination to develop only within the limits of some arbitrary visual language.

Software and interfaces create a contradictory relationship between beauty and the sublime mostly because they hide information and knowledge: these, embedded into code and algorithms, are only visible to us through these filters. For this reason, know-how is not fully delivered to users and the same user who does something with software ignores how it works and upon which foundations it is constructed. Interfaces, namely created to make computer technology and software user-friendly, are in fact tools to hide information and knowledge. The transparency, then, is the hiding of knowledge. This behavior, sometimes implicit some times explicitly engineered, causes a deep weakening of interactive processes.

The paradox here consists of the fact that the sublime is distorted and its effects are only apparent (easily substituted by kitsch); if we mean by the sublime the complex context of information society, the development of knowledge on a planetary scale (the context of

Vannevar Bush' Memex), well, this is kept carefully out of interactive media and is actually replaced by the Borgesian Babel Tower of interfaces.

Artworks based on interaction and emergence such as software art, A-Life art, generative art etc. are affected in the same way. In these artistic practices, which rely heavily upon interdisciplinary knowledge, information is not fully shared or is shared in a very limited form; so emergent and generative processes do not develop their sublime potential (their emergent qualities) because the elements of the system remain isolated and unlinked. For this reason generative art, in many cases, is just another form of simulacra: beauty is installed dogmatically (even if unconsciously) and the access to the sublime is only virtual (an object never instantiated or a kind of wishful thinking).

3.3 Truth, beauty and science

There is another big question involving sublime that in different ways posits for a revaluation of beauty. This challenge does not come from humanities, but from science. Actually, when art and philosophy have put beauty aside as we have seen, the disciplines that claim objective truth as their field of operations have begun to speak openly on beauty and form.

This aesthetic scientific discourse comes to us in two flavors. The first spawns with the deconstruction of scientific epistemology developed by literary criticism and post structuralism: an intellectual landscape that assimilates science with modern and postmodern art. But this kind of idea does do make justice neither to science nor to beauty; in fact, here it is implicitly assumed that art and beauty stand for epistemological anarchy. Nevertheless, they are useful: we will not go after the deconstruction of science [6] but to the fact that beauty exists (even if in an uncertain and contradictory mode) inside methodic sciences. Secondly, we have the new sciences of dynamic systems, chaos, fractals, artificial life, emergence etc., new branches of science that make intense use of computer simulations, computer visualization and aesthetic order and beauty as a kind of laboratory evidence. Beauty here seems epistemologically significant because dynamic systems reveal its order and organization visually, and this is taken as evidence of the process success (It was the strange beauty of the plotting of Zn+1=Z2+C that started the science of fractals).

Again, I don't want and I can't discuss these topics here. Suffice it to say that the simple existence of this discourse is proof that the problem of beauty is still open and needs further investigations. Moreover, the relationship between science and beauty is tricky and misleading: on the one hand science supports beauty as evidence of some kind of truth and complexity calling for a revaluation of beauty (this is OK), on the other hand the use of science to produce beauty goes against emergence and indetermination, because of the scientific and methodical approach (this is not OK).

What is challenged here is the open dimension of beauty and then, its relationship with the sublime, emergence and creativity: in my opinion, the value of the scientific contributions to aesthetics doesn't fit inside the boundaries of art making (such as in A-Life art, for instance), because it is much like an environment or an epistemological support, what we have described as knowledge, information or know-how.

But this new creative dimension, richly although problematically linked with science, will not go any further if it fails to recognize how the concept of beauty has been changed by postmodern criticism: now beauty stands for the sublime, say, indetermination, openness, freedom; it's a possibility, an emergent behavior, and cannot be used as the original seed (as method) without evident contradictions.

This is precisely what challenges emergent and generative art: maybe this new dimension of beauty could be found looking at emergent and generative processes with more concern.

4 Beauty and the sublime inside generative processes

First of all, we can safely say that formal coherence, order and beauty are the goals of every emergent and generative process; in fact, emergence does make sense only if, commencing with some chaotic initial configuration, generates some kind of harmony and form. This emergent order is taken into existence thanks to the parallel interaction of the elements of the actual process complex system, and this complexity, so difficult to understand and explain (due to its not lineal behavior), is considered a new kind of sublime.

It's like saying that every emergent process starts as sublime and ends up as beauty, but because beauty is an emergent result, it cannot be considered decorative or kitsch: its instances are always different and unpredictable and should be evaluated as a whole. At the same time, this order gains some epistemological value, because emergence and open systems do transform reality and matter, and here lies the importance of scientific knowledge and technology. Yet what is truly significant is the very process of emergence, the motion from sublime to beauty, from chaos to order, not its beautiful instances, even if they are necessary.

But this means that the sublime must be granted as a structure (or method) of the process; let's look at this statement closer, because there are some difficulties. To begin with, we should verify if the sublime really exists inside natural behaviors, then we should also verify if the sublime can be embedded inside artificial simulations, such as artificial life, genetic programming, etc.

What Kant said about this problem is that the sublime doesn't exist as a property of nature, albeit it can be found within natural phenomena. Besides, Kant also said that the sublime is not a property of art, because art is built upon human measure and order: it belongs to human taste, individual experience (Erlebnis), and his science and technology. Then, as Derrida pointed out [7], the sublime is to be found outside both nature and art, and its proper dimension is absence and incommensurability: what is out of limits needs the human presence, so that human beings are the gates that allow the sublime to enter the world.

Now, it makes sense to ask if the sublime can exist within scientific and technological processes: does not this seem to create a conflict between chaos, indetermination and the measurable and deterministic models of science and the numeric language of code? So we should also ask if artificial emergence is entitled to be considered as sublime, say, if technological sublime is a meaningful category.

In my opinion, in these cases it is not possible to speak of pure emergence (true auto poiesis), because this is an option that belongs only to living systems; artificial auto poiesis is just a simulation, it lacks autonomous purpose and can be triggered only by an external interference. What really happens is that we take our weakness of understanding of some complicated iterative result as true emergence. But a misunderstanding doesn't equal emergence, complicated is not the same as complex: a complicated process is a conglomerate of many simple recursive functions that overlap and interfere with each other, but everyone of them is deterministic and includes a pre designed order and beauty, that spreads inevitably along this "wannabe" emergence. So much is it that every artificial simulation must include some random function (that is, a trick) to induce chaos and, in this sense, the sublime.

4.1 Self organization and emergence

These problems have been recently addressed by Mitchell Whitelaw in his deep survey of A-Life art [8]. One of the topics examined in this work that seems relevant to me is self-organization, or the system capability to reach order and form by itself. Self-organization, certainly interesting and weird, is directly related with radical constructivism and with the idea that reality and knowledge are artificial and shaped by the self. But radical constructivism and auto poiesis do not delete reality. On the contrary, they rely heavily on it, even if with the filtering of personal interpretations. In fact, auto poietic systems are open systems, say, they interact with reality, with the outside.

So far, self-organization is of scarce interest to art because, even if we can demonstrate its existence, it delivers nothing to us because it is self referenced. Moreover, we have already seen that the goal is not the instance of emergence, but emergence itself. Since artificial emergence does not exist, what is interesting in A-Life or similar techniques, is their embedded scientific knowledge and technological know-how, because it could be shared with users.

But the relationship between science and art is not so clear and linear as many digital art statements claim it to be. Even if their boundaries seems to be fuzzy, as we have seen in chapter three, art and science are different and when they coexist, such as in simulations or generative processes, it seems to me that something is always lost: if we privilege method, it could be the sublime (emergence or indetermination); if we privilege the sublime we loose the possibility of order and form. Thus, if generative processes can't claim to be a melting pot of art and science, then we need, again, the human being (the user): the fusion of art and science truly happens when the user enters in the generative environment and starts a creative process that uses science through information interchange. Self-organization and scientific simulations are useful only when they communicate their embedded scientific knowledge.

What all this is trying to get into focus is that emergence (the sublime, beauty, science and creativity) is not a mysterious quality of some artificial process, but is a context, an environment. The flourishing of this environment is the true task of interaction.

Above all, the relevance of emergence artificial simulations is yet to be discussed: why do we need these simulations if emergence is actually stronger and deeper in the real world? Whitelaw correctly points out that behind A-Lifer's statements some kind of faith always exist, say, some individual meta-narrative that lays unquestioned and unshared under the process and acts in a way that is, finally closed and unreachable: here self organization stands for self reference and individualism, the same properties of the romantic aesthetics of genius.

But in such a form, artificial emergence or computational sublime grow up with the marks of too many unsolved contradictions, and develop nothing more than expressions of technological power, hi tech interfaces and special effects. In other words, this means that the sublime looses its true creative potential and its full philosophical capability, so that it is made impossible to use it as a foundation of emergent and interactive environments. These fake environments deserve to be negatively considered, as Baudrillard and Virilio among others have pointed out, as simulacra or techno art.

5 The interactive sublime

The inconsistency of artificial emergence doesn't necessarily mean that it can't be proficiently used, but it does make necessary the redefinition of beauty and the sublime foundations. We have seen that: a) beauty is the collection of the individual instances of emergence; b) beauty unfolds through chaos and indetermination; c) beauty, thanks to science and simulation, claims also for a new relationship with truth (even if this process is under deep discussion); d) this complex, free, emergent and open context is the sublime.

So beauty and sublime are part of an open, interactive, hypertextual artwork process; besides, the aesthetic of the open work of Umberto Eco [9] that figured out many statements of interactive and generative art, includes now, thanks to digital technology, an improved interdisciplinary and hypertextual framework. I want to stress again that we need interaction with human beings (artist, users, programmers and combinations of them) to allow the existence of sublime and beauty and scientific knowledge to communicate and gain epistemological value.

We have seen that the sublime and emergence present a difficult approach, because they are not a property but a context that must be carefully protected. This task is what makes the process interesting and much more significant than its results.

But if what is significant is the process itself, then beauty is not only found at its ends, but it needs to be installed inside it, for the simple reason that without beauty (both formal order and scientific evidence) the sublime remains incommensurable. Beauty is the contact point between the process and the sublime. Three questions arise: how is this possible if the sublime is opened and indeterminate? And, if we save this openness, doesn't this mean that beauty is dissolved into the sublime? And scientific evidence, if gives to beauty its truth and epistemological value, will not take away its openness and indetermination?

Well, beauty can take many forms: it will not be a formal beauty, but a kind of experience much more like the one we can find in performance arts like dance, theater, jam sessions, and playing games (as Gadamer had so deeply investigated) say, the pleasure and involvement of pure creativity, empathy and freedom.

5.1 Open beauty

Beauty could be defined as the inner order and design of the structures that allow the free gaming of generative interaction. Built up with form and knowledge and concocted with code and interfaces, this kind of beauty is a sort of architecture that shapes and organizes the space of the sublime but leaves it free and indeterminate. The metaphor of architecture (sublime) and decorative arts (beauty) is very well illustrated by Piranesi and aesthetically developed by Gadamer [1]:

"Architecture is simply and clearly the design of space. Space embraces everything that exists spatially… As art of space it is both art that shapes space and art that makes space."

This design, in our case, needs two elements: an hermeneutic process and a mayeutic process. Hermeneutics is needed because emergence is constitutively open, then every one of its statements or instances must be constantly discussed and verified (may be this could be the true function of method and science inside artistic processes). Mayeutics because the aesthetic goal is the ultimate freedom of the elements of the system and the free organization of the system itself, say, the maximum level of possibilities for every element of the system to be fully developed into individual order and beauty.

We find here, it seems to me, a new form of aura. Aura has been eliminated with much reason by Benjamin' technical reproductability, that deconstructed the romantic definition of the artist as genius and author, but now comes back by hermeneutic and mayeutic forms. With aura, the artist/author is also (even if it matches with the reader or the public) somehow recovered, because the hermeneutic and mayeutic framework needs a design to develop properly (if not, it will be only chaos and emergence will not arise). In fact, inside this architecture, it is possible to find a legitimate place both for the artist and the method, even if it seems that we choke against an hermeneutic self similarity (the hermeneutic circle), because beauty doesn't permit the full deconstruction of the author and science introduces, with scientific knowledge embedded into simulation, a deterministic order.

But this problem can be solved if the process and its tools are always capable to sustain indetermination and freedom of interpretation: it is interaction and its smoothness that allows beauty and order to activate without weakening emergent freedom. It is not by chance that Gadamer [1], speaks of art as an environment that is wider and most important than the artist, the artwork or the public. Thus, inside generative processes, the modalities of interaction become of primary importance because the feedback with the human elements of a generative system is the factor that grants a truly emergent behavior, even if artificial emergence is constitutively limited.

So we need one more thing, that is, to study and verify how interaction develops using digital tools, because if human instances are the necessary condition for emergence to arise, there are mechanisms inside digital technologies that create serious obstacles to true interactive emergence. So let’s go back to the problem of knowledge that we have already approached before.

5.2 Interaction and knowledge

We have seen that software and interfaces procedures hide knowledge, and that this knowledge is shared with the user only in a limited performative way. But the ways by which knowledge is shared and communicated are of great importance for any interactive tool, especially in the case of generative and emergent techniques in art. Why? Because every emergent system is founded over the feedback between its elements and the environment, that is, information and knowledge interchange. Without feedback, the system can't evolve and a generative process becomes predictable and deterministic. In this case we speak of technological or the computational sublime as a kind of fake sublime or techno kitsch, precisely because knowledge is not shared between the participants of the emergent process. Software and interface do operate here in a violent form, and the old aesthetics comes back to take the place of freedom and indetermination. Moreover, what is lost is not just the sublime, but also beauty, because users do not have full access (knowledge is not shared) to its epistemological value.

6 Searching for the total artwork

If emergent and generative capabilities are not enough without full knowledge communication and sharing, we have now to redefine the role that software and interface should play inside interactive processes. Considering what we have found before, digital tools should amplify their framework towards hermeneutic and mayeutic functions; let's see what this could possibly mean.

In the first place, code should become a true communication medium. This is a new dimension of software that overlaps with its performative functions: code is not only the engine of a generative and emergent process, but is also its information system, that creates a bridge between scientific know how, technology and the individuals that are interacting inside it. Code, software and interfaces should always allow the users to begin some kind of backward engineering of the technology in use.

This capability is, actually an hermeneutic process, because it's not just a form of open source software - sharing code between programmers- but a form that does involve end users or other artists without high computational skills. This means that code should evolve into some kind of readable text and that interfaces should be used as hermeneutic tools (not like visual metaphors, but much more like allegories) or disappear. It seems to me that in this way software and interfaces can become an essential part of a generative artwork, not only its computational engine.

In this sense, I'm against the idea of interfaces as a new form of art, because this is how interfaces reintroduce a closed framework, essentially anti generative: visual metaphors (icons, virtual reality, animations, robots…) install inside interactive applications old narratives of beauty, say, makeup and other forms of kitsch. Kitsch disturbs, that's the point, the aesthetic and hermeneutic freedom of users; as I see it, is the main problem of emergent and generative digital art.

What we have just discussed opens a very interesting field of experimentation: how to improve software with new procedures to integrate communication, media and tools and some hypothesis of a generative total artwork. Speaking of open beauty, we have found some kind of new aura. I hope to better explain this idea now.

6.1 Irreproductability

The main quality of a full generative artwork is that it is not, essentially, possible to reproduce. It happens that we think the digital in the context of an improvement of Benjamin' aura theory, in the sense that digital technology introduces the perfect identity between the original artwork and its copies, so that the copy is exactly the same as the original. The aura of a digitalized artwork seems to disappear more radically than within technical reproductability. But, looking at digital media from the point of view of emergent and generative art, what defines the aura is that these processes are not reproducible, because emergence is a unique combination of elements that are always different, both during the process and in its individual instances. So the goal of these systems is to be always unique, always different, because they respect the freedom of their components. From the side of users, this is how mayeutics comes in.

So a true generative artwork is in the first place completely open, deeply interactive, hipertextual, trans and multimedia: open because emergence is indeterminate, interactive because this emergence needs feedback between users, media and tools; hipertextual because entering in the process means to move in and out its different stages and levels; inter and trans disciplinary, because the system uses aesthetic, scientific, historic and technological know how; finally, multi and trans media, because the generative environment is made with different type of languages and texts, say, generative techniques, code, interfaces, scientific simulations, art, and music.

7 Conclusions

All this is, obviously, not easy to concoct and deliver. There are technical difficulties, but, in my opinion, the most challenging problems are theoretical and methodological. The first of them is that work division and specialization reappears, in other words, strategies that heavily count on team work, were different individuals collaborate to develop a specialized part of the project. I like team work very much, but in this case what is lost is the interdisciplinary integration: every specialized individual keeps working on its own and conceptual complexity exists only as a metaphor in the final artwork. But because knowledge is not shared with users, this complexity doesn't truly come to life and becomes useless. As Morin said, "la tete bien faite" or complex thought must be triggered inside the individual, then, first of all, inside the artist (whatever he could be nowadays); this means that deep methodological and pedagogical changes are necessary.

The second problem is the lack of middle level developing tools that permit creative development sharing technology, algorithms and knowledge. This task is the most demanding, and deeply challenges anyone who seriously investigates (without listening to techno kitsch) the new media, because clear social, cultural and pedagogical goals must be established.

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[4] It could be easy to show that the most part of these ideas have ancient historic roots and that many aesthetic problems have been already challenged by Benjamin, Adorno, Hesse, Musil, Joyce, Borges, Italian Futurism, and by musicians like Stockhousen and Berio (see Eco "Opera aperta").

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Mimetic desire and other Symptoms

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Abstract

Mimetically speaking, Piano and Rogers's Beabourg entry was largely due to two examples, Cedric Price's Fan Palace and Jean Prouve's work. Indeed, Jean Prouve was the Chairman of the jury for selecting the winning project for the Beauburg in 1972. He must have been greatly satisfied seeing this entry, it must have pleased him enormously to see a project in which some of his ideas were followed through They learned, no doubt from Ernesto Roger, Richard's uncle, from the Russian Constructivists Archigram etc. They produced a new paradigm of high-tech architecture, which in its turn, will be mimed again and again. Today we are presented with a new paradigm known as biotech or Emergent Architecture, Fractal etc. We have attempted to look at the modality of such development and to the extent to which there could hardly be any development of new ideas totally free from the need to digest and developed a given set of prior assumptions. Some time being conscious of this process is an advantage, sometime on the contrary; certain blindness is conducive to an unprecedented undertaking. Different architects have forged different methods to achieve their objectives, to discover, or invent their individuality. Others have maintained with the classical tradition that it is far better to make a good copy of a masterpiece than to attempt the unknown new, for them the original is the monster.

This article presents the argument that 'mimetic desire' plays an important role in the processes of developing, assimilating and appropriating the elements of architectural design, its grammar and language.

It occurs on the scale of individual oeuvre as much as on the culture collectively. Here we are concern with a few examples in order to pose the issue in the form of a certain interrogative observations and remarks. Originally the term 'mimetic desire' refers to the difficulties human being have in forming their desires. As a result, and quite often they form their desire on a model taken from those happy few who acted upon theirs. Anticipating such a situation affect our modes of response, it require a certain irony, a critical distance from spontaneous belief in the existence of the world in which we live; we simply take it for granted with all it contains. As we suspend our belief we create an instant of contemplation, pure intuition becomes possible.

Mimetic Desire and other symptoms

"Why does almost everything seems to me like its own parody? Why must I think that almost all, no, all the methods and conventions of art today are good for parody only?"

Thomas Mann: Doctor Faustus.

It is as if each and every project registers the all-important fact that architecture, if it is to live up to its own concept, is historically constituted as a convergence of different forms of knowledge and experience, strata of reference, and modes of ideality and reality. It therefore follows that an inner necessity responding to external contingency: a architecture as empirical object, overcoming its empirical tyranny; architecture as thought. Thought which is a relationship with oneself and with the world as well as a relationship with the other: therefore it already has a spatial character at the same time. Architecture for itself and in itself, thus architecture itself.

And yet, appropriating other types of knowledge, knowhow, ways of doing and making, chameleon like adaptation, are an inevitable part of the architect's modus operandi.

Mendelsohn produced one of his least convincing project in the Einstein Tower.

Consider Frank Lloyd Wright in Japan. Virilio and the Atlantic fortifications to mention only a few extreme examples. And then, of course, there are the positivists, who adopted natural science models, mathematical models etc as an ideal type. Buckminster Fuller, Fri Otto, Luigi Nervi et al are among the most admired in this genre. More recently Shigeru Ban in Hanover and Metz, followed the example of Fri Otto with diminishing distance.

Zaha Hadid begun her path by producing drawings close to the Russian Constructivists, until a moment arrived, much later, in which her drawing language took off and became independent of its 'origin', she made it her own.

Imitation is an inevitable part of learning. Cezanne drawings made after Rubens could provide a paradigm for such practice. Indeed, Cezanne was moved to tears reading Balzac's novel Le Chef d'Oeuvre Inconnu, and said he himself was Frenhofer. Balzac imagined a painter who wants to express life itself by color alone, and keep his masterpiece hidden. When Frenhofer dies, his friends find nothing but chaos of colors, of elusive lines, a whole wall of painting. In certain traditional Chinese painting, on the contrary, imitation is an obligatory part of every new painting, which takes sometime the form of a dialogue with the distant predecessor.

In the practice of the Russian Biomechanical Theater around Meyerhold there was much that was borrowed from machine workshops of the time. Technical drawings provided the anti dote against too much 'style' in the production of conventional theater.

A NOX's recent publication by Thames and Hudson presents an odd picture. It is if all that happened in science and technology inevitably lead to only one possible conclusion: NOX's architectural practice. Mark Twain remarked, a propos the theory of evolution, that it was as if a piece of color on the top of Eiffel Tower considered the entire edifice was built in order to support it at the top. We are treated to a summary of the history of architecture from Gottfried Semper to Frederick Kiesler… and NOX. We are introduced to an empirical interpretation of Phenomenology, short version of Klein's history of mathematics and finally history of science as nothing but the an argument which celebrate the inevitability, rationality and complexity of NOX modes of production. The devotees of shape inspired by biomorphic figures and above all by computations are many. But the choice of a project is not an involuntary act. On the contrary it is, inscribed in cultural, economic and symbolic discourse, a project will often embody a desire of a long duration.

As Mayakovsky wrote in his poem Pro Eto (About That), 'we have solved the problem of bread, we have solved the problem of peace, yet this most cardinal problem of love we have not solved.'

The logic of genetic engineering is a fascinating advance in working out the mechanisms of biological production and reproduction. The development of L system provides, no doubt, exciting new instrument for the generation of forms shapes and structures. But, what is it that is imitated, and for what end? It remains to be decided independantly of any scientific claims. For those who are working in the field of biology not even the making of a singular cell is entirely clear let alone multiplication of cells. Or, as Einstein has once remarked, 'as far as the laws of mathematics refer to reality, they are not certain, and as far as they are certain, they do not refer to reality' ('Geometry & Experience' an expanded form of an address to the Prussian Academy of Sciences on Janaury 27 1921). The epistemological difference is just as fundamental in the exact sciences as they are in the humanities. Those who are committed to Convention, Construction, Intuition, or Concept as the principal source of certainty in their field, are bound to act differently. The imagination deforms; it colors our reality. Concerning technology, the need to apply technology to overcome technology is ever more present in our life, if the external life is to remain in equilibrium with the inner life. We have created the possibility of an artificial world to an extent that our human capacity to remain relatively free and deliberate in our choice of action has out striped itself.

Lars Spuybroek (NOX) followed the idea of biotech. The fusion of the body with the synthetic infrastructure. The body as a fluid system of differences. In the context of an exhibition of Frederick Kiesler, we met nearly nine years ago in a conference organized by Witte de With, center for contemporary art, Rotterdam. Lars Spuybroek and Greg Lynn were invited because of certain physiognomic resemblances, biomorphic, between certain projects of theirs and Kiesler's and they spoke eloquently about their affinities and distance. Above all we felt the motivation was different and the technical limitations on the part of Kiesler to realize his new morphology with compatible typology.

Curiously Kiesler made his reputation with an innovative stage set for Karel Capek's R.U.R. (Kurfurstendamm Theatre, Berlin, 1923) in which the term ' Robot' was introduced. Not only was it linguistically close to the Czech word for 'work' but it was also an echo of the ancient myth of the Golem of Prague and Mary Shelley's Frankenstein. Kiesler was inspired by Norman Bell Geddes designs as much as by Patrick Geddes who was a student of Huxley who was able to apply the insights of biology to urban planning. Kiesler modeled some of his charts on Geddes's 'thinking machines' and acknowledged the fundamental concept for him of 'biotechnique'. By now we are all marked by the specter of the machine. Goethe's Elective Affinities was inspired by a chemical process, which he applied to the relationship of two couple. Just as theoretical physics and the physicists, Copenhagen Interpretation, inspired Michel Houellebecq, in particular Niels Bohr, the brilliant Danish physicist who developed the quantum theory followed by the principle of 'correspondence' and 'complementarities' in which the wave and the particle are different aspect of the same reality, have served as a model for his novel: Les Particules Elementaires. In fact OLIPO a group of writers have come to consider numerical systems and Cabalistic Gemetria, the correspondence of letters to numbers, as a profound insight into the nature and character of the literary language. It is inscribed in the Modern and Romantic tradition to imagine a world tragically unknowable in itself and therefore accessible only in terms of our own projections.

The device of taking a natural process as a point of departure is by now a common practice, but the transmutations are subject to the desires and thought processes of the designer. In fact natural mutation is extremely rare; you have to cultivate millions of flies to arrive at a mutation.

Unlike the architecture of the ancient, contemporary architecture ever since the French Revolution have been given to mimetic tendencies hitherto unknown.

The picturesque, the neogothic made constant appeal to existing models, the tree like hut, the ruin etc. In the absence of internal criteria it is inevitable that exterior considerations will become dominant in the conception of a project. Above all there is the desire to respond in visual terms, mimetically, in a very different cultural context, so much more so when the need to bridge the gap between the cultural origin of the work and its destination is larger than usual.

Le Corbusier's Chandigarth (1958) could not have been conceived in the terms in which it was finely cast without being profoundly inspired by the Mogul and earlier cultural monuments of India. Even the Himalaya range in the background must have played its part in the scale and massing of this project. Just as Louis Khan's Dhaka Parliament has much in common with other projects, such as the Exeter library, but it takes its shape and scale in view of the environment in which it was built. At its best, architecture is relatively free of mimetic and metaphoric tendencies. Even when such metaphors may offer an initial impetus and play an important roll in the early stages of inception. The classical orders have become themselves elements in the grammar of architecture not before they where free of their mimetic 'origin', as Semper so beautifully demonstrated.

Rem Koolhaas' CCTV in Beijing and Steven Holl's Architecture Museum in Nanjing (3000 times smaller) do have in common a strategy of assimilation. Koolhaas has adopted sculptural shape, which echo Noguchi efforts. Holl has opted for a study of Chinese spatial effects, in particular, the constantly shifting point of view which determines depth and relationships in space. The search for an image that may correspond with the host culture is guided by a phantasm concerning the 'other'. Peter Eisenman adopted the I Ching as a principal device in designing his Chinese project.

Soon after the XVII Century, the age of the scientific revolution, the Scottish Philosophers, Addison, Shaftsbury, Hume, the French philosophers: Voltaire and Diderot,

paradoxically, have made it impossible to believe in a rational canon of proportions and timeless aesthetic laws. Aesthetic judgment has become problematic. As an a priori synthetic judgment it resists theory, comprehensive understanding, and it is almost impossible to apply. Yet, we do feel some how that symmetrical arrangement is conducive to a desire for a just world, but it appears to have such an effect only on rare individuals.

Following the French Revolution the appeal to 'Nature' has become paramount. Not only in the English gardens and parks but also in searching naturalistic equivalents to architectural elements in the construction of the Neogothic style etc. From then on, thank to mechanical reproduction, the spread of vegetal mimesis to Art Nouveu, Jugendstil and Liberty style, was relatively a short step. Floral, vegetal motifs have inundated all branches of design. In the beginning of last century machine production made it relatively inexpensive and therefore marketable. Industrial design was the new discipline; it demanded the exact opposite of this tendency, the norms and the ideal of the machine inspired P. Behrens and others to come up with the new sobriety of design. Are this generation, thank to new mechanical devices will reintroduce vegetal, floral patterns, in the disguise of 'technical details'?

NOX has produced an admirable body of work, which did make use of certain analogies and similarities between the body movements, the events of perception and the environment. They have been inspired by a new complexity, technical complexity far beyond and ahead of Robert Venturi, which was based on Empson's Seven types of Ambiguity. Lars Spuybroek encourages us to expect a greater determination in exercising his freedom with respect to a given project. Poetics and Physis are interchangeable ever since Aristotle, but it requires imaginative leap in moving from the one to the other. Projects are bound to be futuristic, poised as they are between the realm of nature and the realm of grace, being in the realm of the machine. The science of the machine is capable of fabricating a new power. The technical equipment of the industrial world, our capacity for projecting an artificial environment is vast. Therefore the promise of machine like architecture is so ambiguous and problematic. In their highest form machines are no more than a protocol, the promise of boundless capacity of computation, does have a mechanical dimension but it does not settle any contradictions and inconsistency in our mathematics.

Out of Hours

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Abstract

This paper is a poetic investigation about imaginary time.

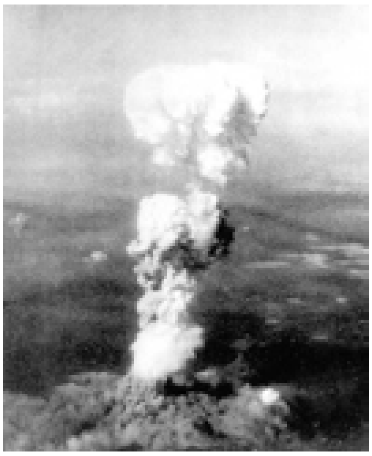
Our linear historical time was broken forever by the atomic bomb. Later everything chanced. An other time was performed: an interrupted time, that is the sound of our today life, a song for human cloning, as aforementioned numbers in alive mirrors. Out of hours visionary people are crossing over a *not linear* line of our time.

0. Timeflow < > *infinite*

LINES
"Written at a Small Distance from my House,
And Sent by my Little Boy to the
Person to Whom They Are
Addressed."

Wordsworth,1798

"Have I not reason to lament
What man has made of man?"
Coleridge, 1798



0. 1 Out of hours

Run, Little Boy, find the river in your mind

Remember, please, Little Boy.
Little boy destroyed Hiroshima;
But a small site of prayer survived.
Only a small site of prayer.
They prayed every day the rosary of Fatima.
Eight priests with their church,
At eight blocks from the bomb center,
Survived with an hopeful tree.
Pray, little girl, pray, with charity.
In the silent site of your mind.
In the light darkness of your heart.
Pray for life surviving in the harmonious Beauty.
Nature is rising on the transparent dawn.
Now and forever. Pray, my darling,
Smiling heart of silence.

Madrigale dedicated to all kids in the world that live without a maternal touch.

1. Our time

Theme: A structure of *imaginary* in our time / Aim: A new identity connected to the past time of cities / Interpretation: Performing codes for a visionary city as a concret tool of our time identity.

1.1 Description *category* - Space >time.

Tools: actual, immanent, eternal

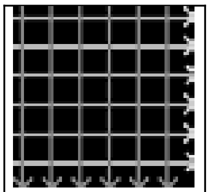
“..she looked over his shoulder.”
W.H.Auden, The shield of Achilles

So Sisifo stopped at hell.
At hell he doesn’t need to cross the stone on his shoulder.
Hell is enough.

 *Boat'people*	 *Tsunami*

2. Immaginary Time

2.1 A representation



In the concept of Stephen Hawking, 1983, immaginary time is another direction of time moving at right angles to ordinary time. In this image the light gray lines represent ordinary time flowing from right to left – past to future. The dark gray lines depict imaginary time, moving at right angles to ordinary time.

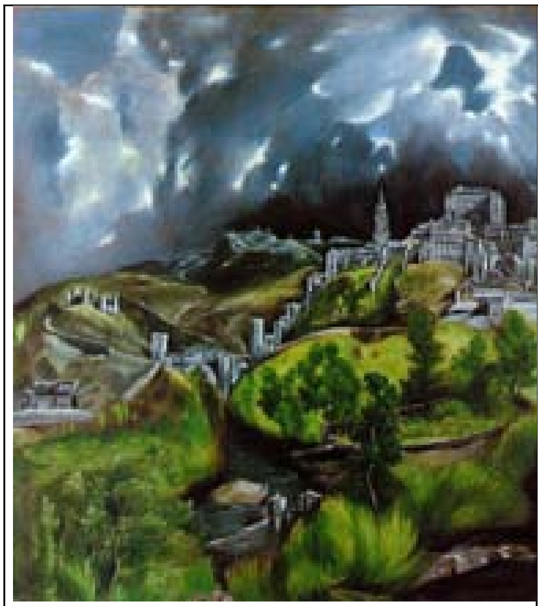
2. 2 Prediction *category* – space + time = 4D

Tools: Performing rules

" and every time that I read, I understand another side."

Goethe

2. 2.1 Gencities, a visionary endless natural site


El Greco, View of Toledo, 1609


C.D.Friedrich, Das Eiseemr, 1823

They flash upon that inward eye
Which is the bliss of solitude;
And then my heart with pleasure fills,
And dances with the daffodils.

W. Wordsworth

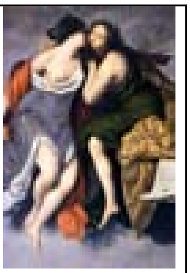
El Greco is one of the most visionary artist that investigated about human ability in representing his own identity as in a curved mirror. His elongated figures, ever straining upward, his intense and unusual colors, that seems to anticipate the Impressionist vision, his passionate involvement in his subject, his ardor and his energy, all combine to create a style that is wholly distinct and individual.

He is the great fuser, and also the transfuser, setting the stamp of his angular intensity upon all that he creates. To the legacies of Venice, Florence, and Siena, he added on the Byzantine tradition, in form and in spirit . El Greco always produces as in icons style, and it is this interior gravity of spirit that gives his odd distortions a sacred rightness.
In View of Toledo the inner landscape of his mind was in the midst of a transformation process in which the stylized landscape departs dramatically from the exacting requirements of realistic depictions of nature, even in the romantic genre of the pastoral. Perhaps this painting with its almost psychedelic hues takes a cue from Michaelangelo's Sistine Chapel ceiling, which, when it was recently restored, used similar and surprisingly vibrant colors.
As in Michelangelo we discover in his work the intention in painting reality as a wonderware in an unique peculiar vision. The same reflection in nature we find in Friederich. A similar process in a different concept. Here an eternal time is performing a metaphor of space of nature as mirror of the whole humanity.

2. 3 Interpretation *category* – imaginary time = a curved space

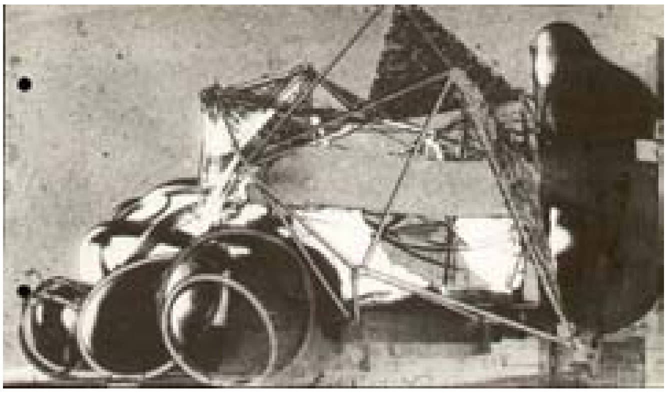
…who'd never heard
Of any world where promises were kept,
Or one could weep because another wept.

W.H. Auden, The shield of Achilles



Picture and Poetry

Interpretative codes are a structure of performing tools. Going ahead between different fields, poetry becomes a tool of punctuation.



PNEUMOASIS

Pneumoasis was the Master thesis degree by *Celestino Soddu* and *Enrica Colabella,*

La Sapienza University, Rome,Faculty of Architecture. It was an imaginary city designed on the imitation of experiences made by Archigram group, called *Istant city*. This was the site of a technological emphasis, used till today.
This was the first important expression of our research about city in line with our time.For a long time I studied the ancient codes starting from Renaissance, in which I focalized my interest, for the strong connection between natural and artificial ware.

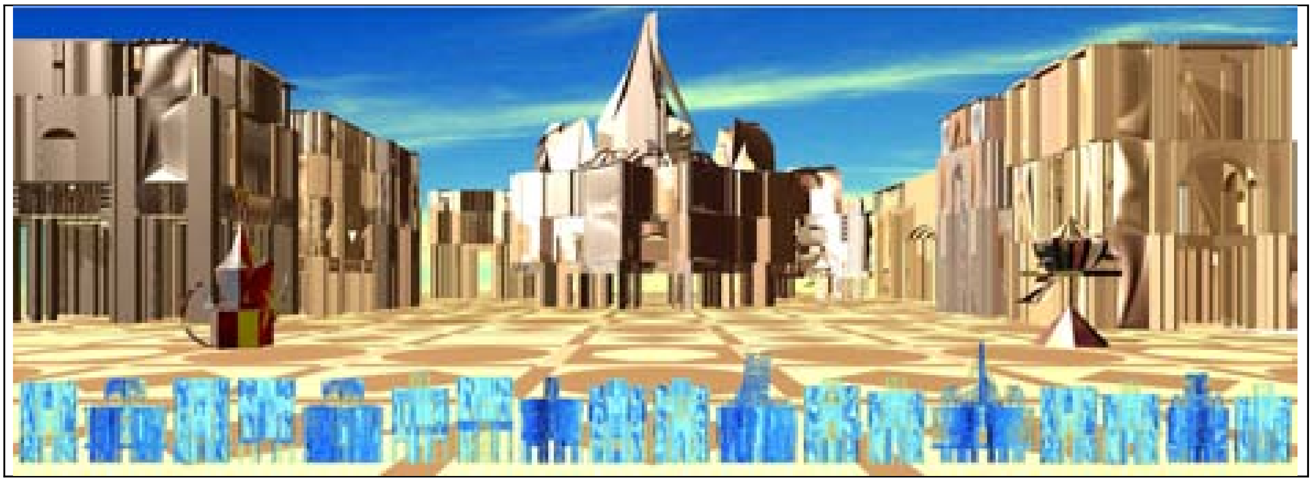
..*every artist creates his own precursors..*
Borges,

The voices of the great past writers interact with the writer's script.

In the natural imitation process we rediscover that:

"…there are not two identical hills"

Borges, El libro d'arena, 1975



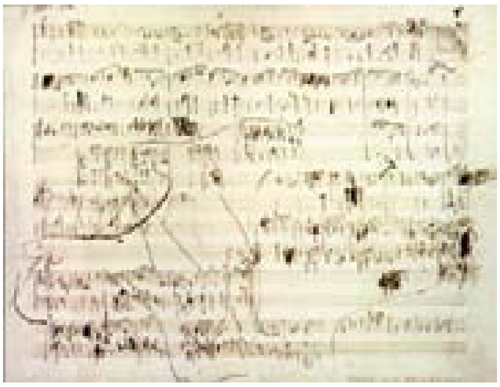
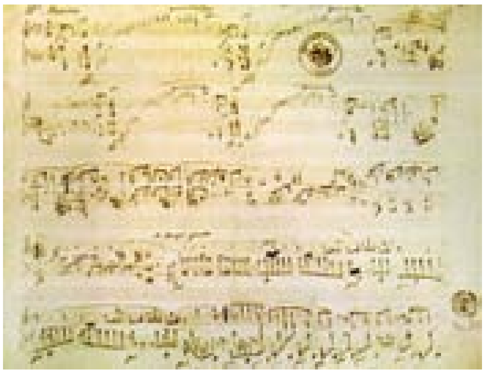
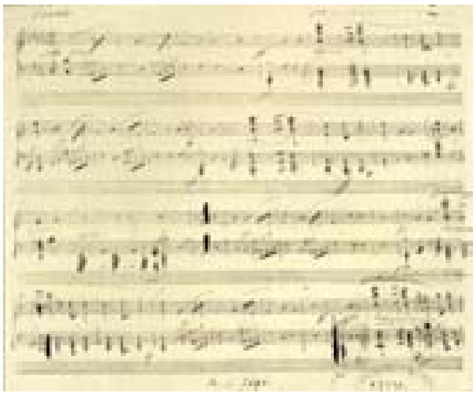
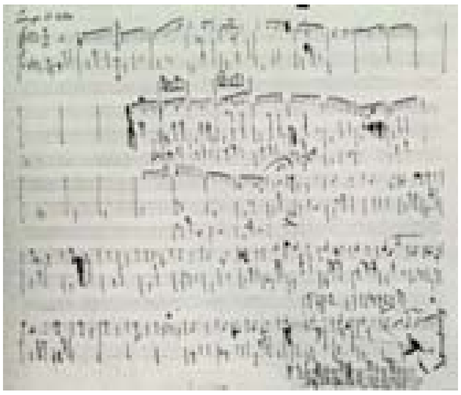
The Ideal city made by Celestino Soddu in 2005 is in a strong assonance with "La Città ideale" by Piero (3 variations, Urbino + 2 Berlino), but in the same time it is total different in results. We recognize the inner codes/structure as a memory of the past discovering a contemporary image of the same concept. The design process follows a dynamic structure of space in a topology that use not linear procedures.
Michelangelo followed the deep basic conviction that ideas as shapes were ***out of time***, hidden as *ule* (Greek, raw material). "..Come io fo in pietra od in un candido foglio.." (as I do using stone or a white paper). The work of artist is in discovering the pre-existent harmony in Nature.

2. 3. 1 A double resonant systems

Two examples of not linear tools: Chopin and Mozart.

2. 3. 2 *Reliance*

Chopin's daring innovation involved him in enclosing almost his entire oeuvre within the sound of the piano, proving that this instrument could transmit musical fantasy, and stir emotion and drama on a par with the symphony orchestra or songs.His inventiveness also encompasses the emotional statement. His compositions broadened the horizons of musical expression by demonstrating profound experience and tragedy, and also new energy, states of heroic euphoria and romantic fantasy, as well as grotesque and humorous features; at the same time, they *disclosed subtle nuances of moods*, going far beyond the expressive conventions of his time.In his compositions, mainly for the piano, Chopin make a remarkable use of the newly developed instrument. His *reliance* on the sustaining pedal was as much a part of his compositional technique as it was a part of his piano playing. He hated large halls, and he wrote to Listz, "The crowd intimidates me and I feel asphyxiated by its eager breath, paralyzed by its inquisitive stare, silenced by its alien faces." And he knew it didn't work for his music: "My playing will be lost in such a large room, and my compositions will be ineffective."

 *Chopin's manuscript of a Mazurka*	 Chopin's manuscript of the Polanaise-Fantasie
 Chopin's manuscript of the Scherzo No. 2	 Chopin's manuscript of the Valzer op. 64 No. 1

2. 3. 3 *Indentation*

Mozart’s invention was also in performing how to play for gaining the harmony of sound written in manuscripts.

“Everyone is amazed that I can keep strict time. What these people cannot grasp is that in tempo rubato, in a slow movement, the left hand follows the right”. (Letter to Mozart’s father October, 24 1777).

"I want her (his sister) to know that in none of the Concertos should an Adagio be played - rather, always Andante". (Letter to Mozart’s father June 9,1784).

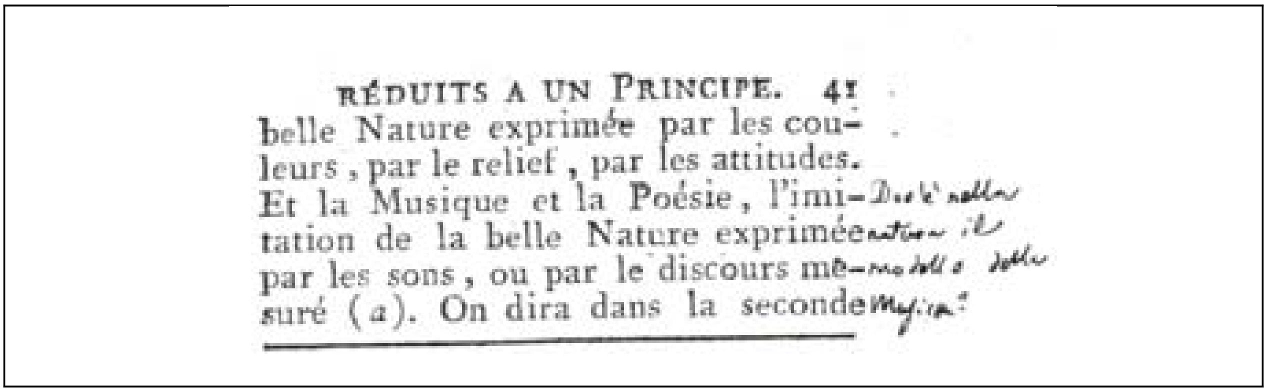
3. Measure

Dynamic relations between *real contest* and *idea* using these 3 operative steps

3.1 Imitation, the model of Nature, process in fieri, variations as a critical constructive step of the genprocess.

…Nature is made better by no mean
But Nature makes that mean; so, over that art
Which you say add to nature, is an art that nature makes

W. Shakespeare


RÉDUITS A UN PRINCIPE. 41
belle Nature exprimée par les couleurs, par le relief, par les attitudes.
Et la Musique et la Poésie, l'imitation de la belle Nature exprimée par les sons, ou par le discours mesuré (a). On dira dans la seconde

The question made by an annotation of Alessandro Manzoni: "Where is in nature the model of Music ?"

"The primary imagination I hold to be the living power and prime agent of all human perception, and as a repetition in the finite of the eternal act of creation of the infinite I am. The secondary I consider as an echo of the former, coexisting with the conscious will, yet still identical with the primary in the kind of its agency, and differing only in degree, and in the mode of its operation". Coleridge, Biographia Literaria

Versus: Emulation
In emulation the dominant approach is "…a simple, universally applicable, one-time fix." The peculiar result to this process is cloning. To repeat the same in an interrupted timeflow.

3. 2 Transition, vection in another system.

We can only
do what it seems to us we were made for,

look at this world with a happy eye but from a sober perspective.

W.H. Auden, a later poem

3. 3 Reflection.

"I never dreamed the way of truth / Was a way of silence."
W.H. Auden, "The Sea and the Mirror"

In Michelangelo the initial agent of a discovering iter is *nous*, intellect. He considered erudite field "pricipium et fons"of art and he called for artist was expert in a lot of disciplines. Art is based on *artes poeticae* and on *to taumaston* (wonderware), the 3° element of Aristotele, that Michelangelo called "*la terribilità*" (terrifying), The formal composition comes from concept: "Alcun concetto/ Ch'un marmo solo in sè non circuisca", (every concept, that an only stone doesn't border) in the plurality of categories that Michelangelo expressed we find a lot of results in the category of original ideas expressed in original way, using mathematical formulas and interior vision.

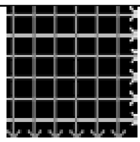
		

An answer to the question of Alessandro Manzoni: Penguins recognize themselves through sound signals. They live in a deep collective structure. Still today.

Dear, I know nothing of
Either, but when I try to imagine a faultless love
Or the life to come, what I hear is the murmur
Of underground streams, what I see is a limestone landscape.

W: H: Auden , a later poem

3. 3.1 A result to open imagination

Smiling heart of silence >		*< Adagio, andante*

As an indication for the playing time of Out of hours Performance

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Out of Hours

Performing voice by ***Josette Martial***
Generative spaces and Music by ***Celestino Soddu***
Idea, text and direction by ***Enrica Colabella***

Run, Little Boy, find the river in your mind

Remember, please, Little Boy.
Little boy destroyed Hiroshima;
But a small site of prayer survived.
Only a small site of prayer.
They prayed every day the rosary of Fatima.
Eight priests with their church,
At eight blocks from the bomb center,
Survived with a hopeful tree.
Pray, little girl, pray, with charity.
In the silent site of your mind.
In the light darkness of your heart.
Pray for life surviving in the harmonious Beauty.
Nature is rising on the transparent dawn.
Now and forever. Pray, my darling,
Smiling heart of silence.

Madrigale dedicated to all kids in the world that live without a maternal touch.

The music is realized with the generative software Musicablu by C. Soddu. This generative software reproduces, in the field of the music, the generative approach of Argenia. The results are virtual jamsessions, endless variations of music scores for a group of instruments that are memorized in a midi file in real time. Particularly the generative structure is:

1.an organizational paradigm building the structure of every single jamsession, defining the various virtual musicians and their identity and character, the used instrument, the type of presence inside the jamsession (accompaniment, solo, controcanto) and the duration.

2.the musical theme, that is turned into structural codes of possible sequences

3.the geometries of the musical sequences, that are abduced by specific musical references.

4.the harmonic structure, first of all the structure of the blues and of the traditional songs.

Every virtual musician has his own interpretative structure realized with:

5.a series of "subjective" interpretative codes of possible themes, defining the identity of the virtual musician, that operate targetted contaminations of the codes abduced by the theme and by the geometries.

6.a structure of progressive interpretation in real time of the pieces just played by the other virtual musicians so that to produce recognizable controcanti.

7.a recognizable identity in the organization of own pieces.

The musical codes of reference adopted in the performance "Out of hours" have been abduced by the Triple Canon of Bach, from the 545 of Mozart, from the variations Goldberg, from some songs of the Beatles and some pieces of Coltrane. Such codes are used both for phrases, both for the "geometry" of the solos.

JOSETTE MARTIAL

In the Basic Canto, the body becomes the harmonious space of creative works. From voice, breathing and colours we may discover new sounds and new dreams. If imagination and improvisation open for us a window on freedom and poetry. For me, this meeting with the Generative Art breaks the walls between us and new dimensions to discover …hope…..Out of Hours…

Presentation

Josette Martial is a French West Indies singer, leaving in Rome. She first prepared a master of expression & comunication technics at the Paris-IV Sorbonne University, then went to Italy, where she found out her passion for singing and voices.

After professional experiences in show business and theater, the singer signed her first Long play with Cam Record. She will stay with this recording company for six years. The Rai TV offered to her a collaboration as show-girl during three years (1985-1987, Rai 2, Cappello sulle 23 and Bella D'estate)

At that time Josette Martial started a personal research on different technics of the use of te voice and the inner-power of self expression of singing and harmonising.

Taking advantage of her traveling childhood in many african, caribean, european and latin american territorys. Where she could observe the effects of singing on people. Josette Martial elaborated il *Basic canto*: innovative method for using the voice and singing based on a chromatic language.

Since 1996, she realizes many ateliers, workshops and teaches in private or in public classes (IALS of Rome – at the Domaine de Birmingham in Guadeloupe).

Cities Mathematical Dances.

C. Farsi, Ph. D.

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Abstract

The aim of this artistic project is to virtually make cities dance. In particular I present three video clips in where famous buildings, monuments, and everyday objects perform mathematical dances to the music of city sounds.

The Project

Normally we think of movement in a city as generated by the city's inhabitants' daily wanderings and routines. In these clips I creatively imagine that landscape features such as (famous) buildings, monuments, and objects can come alive and dance too. This creates a dream-like world of shifting organic forms and perceptions. Moreover, string theory models the matter as made up of tiny strings and thus predicts a world in perpetual motion. Inspired by this viewpoint, in my project everything becomes a vibrating string. Additionally, I emphasized the use of symmetries to reflect symmetries' paramount role in mathematical physics.

The three short video clips I realized for this project are described in detail below.

1.1 The LeaningTowerofPisa Bell Dance. In this clip I describe a left-to-right and right –to-left Tower motion. This work was inspired by the sound of church bells (which are heard daily in all Italian cities) and the realization that, with the help of a modern editing program, the Tower could very well be rendered dancing, in a virtual world, at the tune of those bells. (See Figure 1.)

1.2 The PonteVecchioPouring Dance. In an up-and-down dancing motion, the Old Bridge waves a partnership with the water of the River Arno. The accompanying sounds of rocks and gravel pouring down from a machine were recorded next to a remodeling site in Florence. The gestures of pouring and weaving are seen as creating dual patterns. (See Figure 1.)

1.3 The WomanMan Single Dance. This piece was inspired by today's confusion on men and women's roles in society and by the quick shifting in roles and traditions. This clip also reflects some of my life experiences as a divorced woman. The mannequins in the photographs were in a Florentine shop window under construction. The images are accompanied by the sounds of an ambulance's siren, recorded near the Careggi Hospital in Florence. The siren is meant to emphasize the urgent nature of the problems to be addressed. (See Figure 1.)

2. Technical Background

I edited my video clips with Adobe Premiere 1.5. I used a few selected images and symmetries as the clips' building blocks. (This was inspired by the string-theory view of the world.) I will detail below the generative editing procedures I followed. In all cases, I chose to employ pieces of straight line as opacity functions.

2.1 The LeaningTowerofPisa Bell Dance. The Tower dance was created by the use of one image (together with its mirror image) and of linear functions that change opacity. The functions' extreme values reflect the bells sounds' rhythm, while interpolation is used in between extremes.

2.2 The PonteVecchio Pouring Dance. The Pouring dance is obtained from three different images, and uses linear functions that change opacity in a moderately smooth way, thus reflecting the act of pouring.

2.3 The WomanMan Single Dance. The WomanMan dance was created from two images, each one almost the mirror reflection of the other. The opacity function here is crazily jumping up and down, but I still chose it to be continuous.

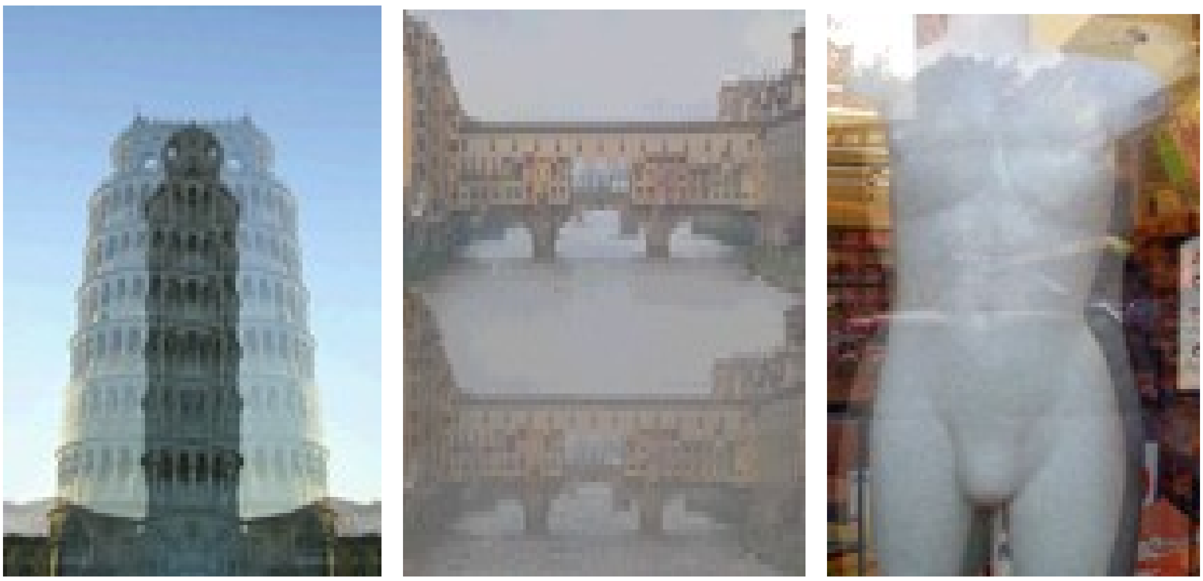

Figure 1. The LeaningTowerofPisa Bell Dance, The PonteVecchio Pouring Dance and The WomanMan Single Dance: Frames

This work was done while visiting the Mathematics Department of the University of Florence in Italy.

Kaleidoscopic Fragrances:
Art, Mathematics, Science and Technology Interactions

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Abstract

Among other things, my artistic research work is connected to different kinds of symmetry (symmetry operations), Penrose tilings, Penrose rhombs, quasicrystals, the golden mean as an element of symmetry, Fibonacci sequences, etc. With the help of reflection, imagination and intuition I try to glean new relationships, new levels of structure, new and different kinds of order in these elements and structures. On the other hand, through some perceptually instable (ambiguous) compositions I wish to emphasize the principles of the way our cognitive system works - not solely our visual apparatus, our brain and mind, but the entire process of perception (as a whole) as well. I find computer graphics as a very useful and attractive medium for creating artworks and technology itself as a link in a braid where science, math and art interact.

Patterns Everywhere

Nature is a veritable treasure house of diverse patterns and humans, as one of its creations, are no exception. It is possible to encounter the same patterns in numerous variants, in different spaces and different periods. Periodic structures in liquid crystals are similar to the wavy sand dunes in deserts; circular shapes of planets are repeated in the shapes of raindrops; spirals can be found in galaxies, in snail houses, plants, etc. Repetition of geometric shapes in Nature makes one think that in the centre of space, time and matter lies mathematics.

Fig.1 M.T. Krasek, Emotions from Arcturus

We may also think, on the other hand, that the whole of mathematics originates within ourselves, within our minds [1]. Whether mathematics has existed forever, or whether it is but a product of man's thoughts and has therefore existed only since the appearance of mankind is a question to which there is no answer yet. Maybe it is not so important whether mathematical principles exist because we search for them, or because we find them [2].

Humans as a biological pattern move within Nature, explore it, learn about it and try to reveal the principles governing it [3].

Perceptions strive to balance and symmetry or, to put it differently, balance and symmetry are both characteristics of perception. They are put into effect whenever external conditions allow for it. Balance and symmetry are also the main characteristics of the principles governing the material world, be it atoms or complex organic compounds. This aspiration for order and balance is therefore a biological and a psychological need of man [4].

Artists and Scientists Walking Hand in Hand

Researchers explain processes in nature, creators either transform Nature or create something new on the basis of their knowledge, feelings, intuition, and imagination. Complex processes of perception, classification, comparison of patterns and their arrangement into new patterns of a higher order take place in our brain's neuronal network. Our brain creates an inner virtual image of the world around us, which enables us to more or less effectively act in all spheres of our lives.

Fig. 2 M.T. Krasek, Double Star GA

> In our brain there is no division into sciences and arts, but a complete image of the way we understand and perceive the world around us. The division is formed as comprehension leaves our brain and is focused on individual aspects of the world within and outside. Most neuronal patterns, which had been formed on the basis of sensory stimulants, are preserved in the form of sensory images, be it visual or otherwise. Re-collection and connection of these images is taking place in a process called imagination. Imagination is an explicit creative ability of our mind and brain, which fundamentally defines every creation, be it artistic or scientific, of new knowledge. [5]

It is therefore a human trait common to both artists and scientists to look for principles, order, beauty and harmony; there are indeed many ways of searching, and especially of presenting that which we have found [6]. In one of his essays late physicist David Bohm wrote that

> … a scientific spirit is necessary, not only in what is commonly called “scientific research”, but also in art and in every phase of life, and that without this spirit, human actions are continually in danger of deteriorating into a mere response to illusion, leading to conflict and destruction. [7]

Therefore an artist needs a scientific attitude to his/her work as the scientist must have an artistic attitude to his/her.

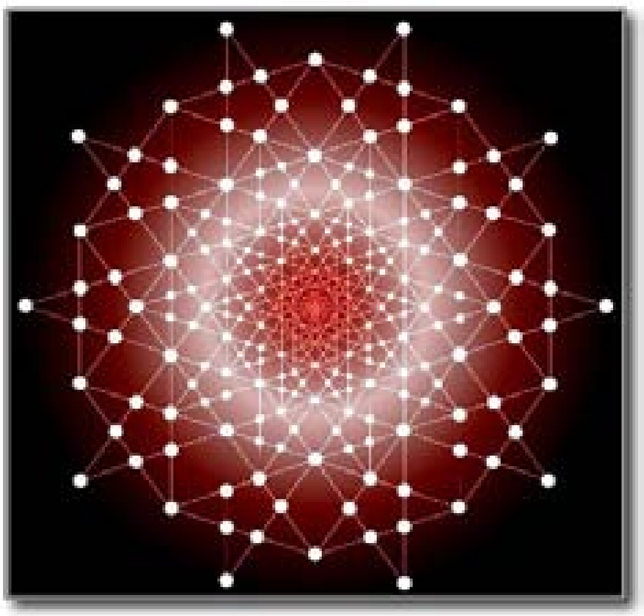

Fig. 3 M.T. Krasek, Stars for Donald

The golden mean, Fibonacci sequences, fivefold symmetry, self-similarity, and inward infinity are just some of the characteristics that are found in nature, art, and science. All these are present in Penrose aperiodic tilings and three-dimensional quasicrystals [8].

They can be explored and presented through artworks as well. With the help of reflection, imagination and intuition we can try to glean new relationships, new levels of structure, new and different kinds of order in these elements and structures [9].

Both artists as well as scientists need to work hard to successfully realize or introduce the concept of symmetry, which can help us analyse, create, classify, recognize and understand.

Fig. 4 M.T. Krasek, Quasicube V

Art has a lot to contribute to help spread the awareness of symmetry in the broader sense of the word - “one that relates to harmony and proportion and ultimately to beauty” [10], individual kinds of symmetry, and symmetry as a connecting link between various disciplines.

Spreading awareness and knowledge about symmetry, of golden mean as one constant which unites the opposites into a new whole on different scales for example through works of art can be very simple and effective, especially when one takes advantages of new technologies.

It is a well-known fact that a text may easily be forgotten, but images persist and are remembered; this is how our brain works. Works of art can therefore help spread the awareness of symmetry [11]. And we can use various tools for that. We can use very simple, classical ways of representations or new sophisticated computer software techniques of today.

Fig. 5 M.T. Krasek, Sunset

Imagining the Future

The symmetry concept should by all means be incorporated into our educational systems. Different generations, and especially those to come, should be exposed to symmetry in its broadest sense of the meaning. It is only in this manner that we can help the young to become creative adults, to perceive more than meets the eye in things and events around them [12]. The task of both artistic and scientific disciplines, as said by the late Slovene artist, art theorist and philosopher Milan Butina, is the same here:

> ...to teach future scientists and artists to observe the world within and outside, and thus to perceive the inner images of both worlds in order to use them to shape man's world. [13]

We can act in this manner now and wish our actions and influence will have an effect on future generations in the way they'll use the technological achievements solely to benefit mankind.

Fig. 6 M.T. Krasek & C.A. Pickover, Infinite Curl 5

> Computers, or computer/human hybrids, will surpass humans in every area, from art to mathematics to music to sheer intellect. I do not know when this will happen, but I think it very likely that it will happen in this century [14].

Is this the future we generate these days? Are we very enthusiastic about it and how much do we look forward to it?

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Physics:exhibitionist by nature

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Abstract

The installation consists of 12 rectangular panels 120 cm (horizontal) X 60 cm (vertical) each devoted to a theme of actual frontier research in physics like unification of the forces, expansion of the universe, entropy, dark matter, Higgs boson, etc. In the panel there is an image evoking the subject, often in a semiserious way, and a very short text (in Italian) giving a key idea. Each panel has an headline, like for instance “fisica disordinata per natura” (“physics messy by nature”) for the entropy theme, “fisica oscura per natura” **(“physics obscure by nature”) for the dark matter theme, etc, always in the form “fisica xxx per natura” (“physics xxx by nature”)**

1. The project

This exhibition is based on the work of the students of the Master in Science Communication (MCS) held at SISSA (International School for Advanced Studies) in the academic year 2004/2005. The International School for Advanced Studies (SISSA), founded in 1978, is a centre for research and postgraduate studies leading to a PhD degree. Initially concentrated around the so-called "hard sciences", SISSA's Sectors have expanded to explore groundbreaking interfaces between science and the humanities. Among the various activities there is a Master in Science Communication (MCS), a two-year part-time course aimed at providing specialized training in different fields of science communication, such as written, television and on-line journalism, institutional and business communication, traditional publishing and multimedia and museology.

Graduates from any discipline can follow the Master, which comprises various courses distributed across three areas: theory and communication techniques, scientific courses and an area more directed towards social studies in science.

One of the scientific courses regards physics communication. The course is held by a scientist and a public science communication expert and is directed at those who have not necessarily followed studies in physics or mathematics, but who are trained to become science communication experts and will therefore deal with these subjects.

The Masters course in physics is subdivided into eight lessons, each one lasting four hours. Every lesson centres on a different theme in physics, dealt with both on a scientific and a communicative level.

The aim of the course was to create a public science communication product which would have the following characteristics:

- to address a general audience
- to put forward an image of physics that is based on knowledge-building processes and on open themes rather than, for example, on iconic-epic representations of scientists
- to give importance to artistic expression
- to promote aspects directed towards dialogue between science and society

The choice of topics was done taking into account the public relevance, the social effects and therefore the communicative ‘spendability’ of the theme in question.

The chosen topics were as follows:

- natural constants
- entropy
- asintotic behaviour
- Higgs’ boson
- geometry, relativity, gravity
- multibodies
- dark matter
- *supernovae*
- strings

It was decided the communicative *output* of the course: to present outcomes on display boards of 60x120cm.

From one month to the next, the students’ task was to produce texts and images inspired by the topics discussed during the lesson, within a homogenous *layout* for all the boards. At the end, twelve boards were created, symbolising the 12 months of the World Year of Physics 2005. The results were supervised by the responsibles of the course.

2. Examples

The following gives two examples of the work produced by the students. One deals with natural constants (panel 1) and the other looks at entropy (panel 2).

The *headline* in each panel (the English text is in the captions) deals with the relationship between physics and nature. It is important to mention that this link is intended in a metaphorical sense: the intention is not to explain or inform. As well as this, where the *body copy* contains information, it is very bare and the combination of text and images has the aim of evoking a sensation through an aesthetic presentation.

In the first example (panel 1) the image is of a metaphorical identity card belonging to the universe, with natural constants as its distinguishing features. Entropy (panel 2) has been represented by an overturned glass of milk. These everyday images were used in a context whose aim is not to simplify, render more trivial or indeed more spectacular. Rather it was hoped to arouse a greater interest in an audience that already had some ideas regarding the topics in question.

Panel 1. Headline: Physics: constant by nature **Body copy**: The building blocks of physics: *h bar*, turnkey of quantum mechanics, *c*, speed of light G, constant of universal gravitation. All the measurable quantities of the Universe, the microcosmos and the macrocosmos, can be expressed by these constants. **Text on the identity card:** *Name:*UNIVERSE; *Born:* 14 BILLION YEARS AGO; *State* IN EXPANSION; *distinguishing features*: h bar c G; *Signature of holder:* infinity

Panel 2. Headline: Physics: messy by nature **Body copy**: Entropy: everything becomes more and more disordered. There is no turning back: time travels one way only. The Universe's entropy continues to grow.

3. Conclusion

The "Physics: exhibitionist by nature" project is an example of how people, motivated in science communication but that do not have a specifically scientific background, can come up with communication products that deal with the more difficult aspects of physics. If the product's aim is not that of explanation, even those people with less technical preparation can be successful in creating communicative and it is possible that images and syntheses are produced, which are closer to the reality than those done by experts. that are interested in physics or would like to know more about it, but who have a kind of reverential fear that prevents them from exploring the subject further. Apart from the aesthetic judgement that one may give to the panels, the project also demonstrates how science can be communicated through research into artistic expression.

INFINITE CEMETERY:
Virtual Reality + Generative Sound *

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Abstract

Infinite Cemetery is a poetic, virtual-sound-generation space, driven by the performer’s interaction data. A dancer’s movement, hand gestures in front of a webcam, or user’s mouse interaction will motivate the events in virtual space and generate the real-time spatial sound, which will explore cognitive aspects of memory and perception in a spatial environment.

Eventually, this project will be incorporated with a dance performance, which will explore the relationship of the physical and mental body in real and virtual space. Infinite Cemetery is a symbolic cemetery exploring new relationships and consciousness between image, sound and the performer. It is a trans-disciplinary collaboration project under the same idea of generation, in both a conceptual and a technical means.

MAX/MSP and VIRTOOLS will receive data from CHAMBRE created by University of Rome, Computer Sceince department, which will allow interesting interaction and cooperation between differnt systems which will constantly generate a new connection between performer, sound and 3D graphics.

Credits:

Original concept & 3D virtual space:

Semi Ryu, Kinetic Imaging, Virginia Commonwealth University, USA

Generative sound composition: Claudio Scozzafava

CHAMBRE: Department of Computer Science, University of Rome “La Sapienza”, Italy

Paolo G. Bottoni, Stefano Faralli, Anna Labella, Claudio Scozzafava
Plug-In to connect VIRTOOLS with CHAMBRE: Stefano Faralli

Ritual: Loveletter readings to objects

Infinite Cemetery illustrates an ironical concept of life, bringing spirit to daily objects represented by virtually-rendered objects. Infinite Cemetery is filled with the voice of love letters written to each writer's favorite object, which should illuminate the personal relationship with and memory of our daily objects. The constant reading of love letters evokes life in objects conventionally known as inanimate, in this symbolic cemetery.

Love letter example:

Dear, dear, Gyroscope,

You, my little master of the forces, are my most favorite object! Many days since your arrival have I spent in admiration of the strange dance that you do on your red pedestal. Your spinning could defy the balance of a thousand drunken sailors! The string that came as companion is now old and tethered, but once tense, springs you back from the inanimate. I am illuminated by the reflected colors as they bounce off your steel shimmer. I feel strange sway as I might swing you from side to side; I am pulled back the opposite way. An even balance is made by your own order, uniquely so. I seek many more years of watching your dance, dear gyroscope, and I hope you shall not tire as the master of the forces…

Sincerely,

Jason

A similar process can be shown in Korean shaman rituals where objects are transformed into a special meaning, acquiring a spiritual power from the ritural process. At the beginning of the ritual, Shaman begins to build her relationship with objects called "Mu-Gu" (shaman's object), in order to obtain her trans-state of shaman. Puppet, fan, knife and bells often appear as Mu-Gu that are usually buried underground and found by the shaman. The Shaman shakes it or dances with it, making Mu-Gu's spirit come alive and activating a trans-state of shaman. Objects appear as mediator between the dead and the spirit in shaman ritual.

In Infinite Cemetery, all the objects in the virtual space could be read as shaman's objects that will act as a transparent membrane between life/death and real/virtual. It raises questions about our notion of "life", focusing on the process of life-giving, rather than the status of life-given. Life is not only the physical status of being, but also something emerging from a relationship and spiritual connection in process. In virtual space, virtual objects are gaining life by being interested or loved by users. Infinite Cemetery is a symbolic space to bring a new romance and life, which plays out an infinite paradox between life/death and real/virtual.

Figure 1: Screenshots from Infinite Cemetery

How VIRTOOLS, MAX-MSP and CHAMBRE can cooperate?

Figure 2 shows the main architecture of our system. Our equipment is a distributed interactive system composed of three subsystems: CHAMBRE [BFLS04], MAX/MSP, VIRTOOLS. CHAMBRE is used to build a system of virtual sensors, (a virtual sensor derives from the transposition of a real stimulus into a virtual environment). All the stimuli carried by the apparatus of virtual sensor, are sent to MAX/MSP and VIRTOOLS in the form of messages. Finally MAX/MSP and VIRTOOLS map this information into multimedia objects.

All the messages are transmitted from CHAMBRE and received by MAX/MSP and VIRTOOLS using two TCP/IP connections. We use the embedded communication sub-system of CHAMBRE, coupled with the MAX/MSP object “netreceive” and with a special plug-in created by Stefano Faralli, for the communication with VIRTOOLS.

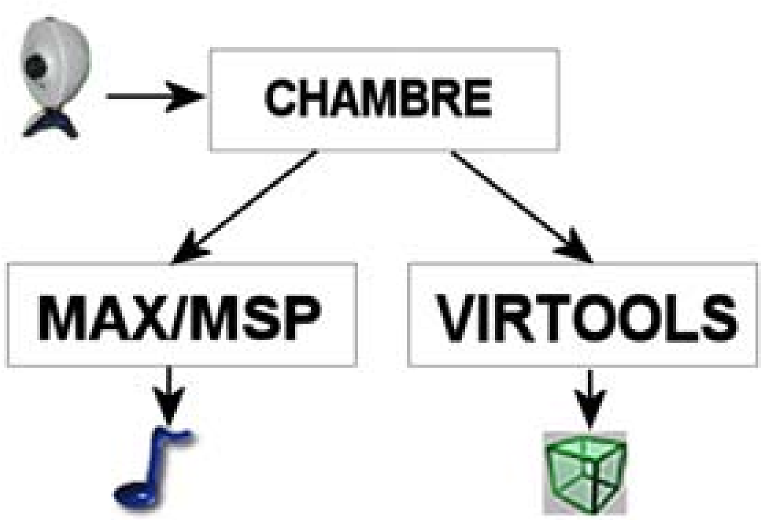

Figure 2: Architecture of Infinite Cemetery

MAX-MSP receives from CHAMBRE a formatted string that is the result of one (or more) user's position in front of the webcam. MAX-MSP translates CHAMBRE's string and uses it to control some audio processing algorithms. The audio samples, containing some "love letters", are subject to various audio processing algorithms in respect to the interaction of the user (proximity, position, etc.). The user chooses an object and, through his or her position in the mapped space, interacts with the multimedia system. More information about CHAMBRE was described in GA 2004 Proceedings.

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Flocking Orchestra - to play a type of generative music by interaction between human and flocking agents

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1. Concept

"Flocking Orchestra" is an interactive installation that employs flocking algorithms to produce music and visuals and thereby creates an interaction between artificial and real life [1]. The artifical life aspect conists of agents which behave basically according to BOID's rules [2] and form complex flocking groups in a virtual 3D space. The users who represent the real life can interact with the agents through their motions, which are tracked by a video camera. Each agent controls a MIDI instrument whose playing style depends on the agent's state. In this system, the user acts as a conductor who influences the flock's musical activity. In addition to gestural interaction, the acoustic properties of the system can be modified on the fly by using an intuitive GUI. The acoustical and visual output of the system results from the combination of the behaviors of both the users and the flock. It therefore creates on the behavioral level a mixing of natural and artificial reality.

The system has been designed to run on a variety of different computational configuration ranging from small laptops to exhibition scale installations. This type of scalability allows people to experience the installation not only at exhibition sites but also at home.

2. Insight

The basic mechanism to realize flocking behavior consists of the calculation of an acceleration vector for each agent during each time step. This vector results from the combination of three types of forces: collision avoidance with other agents and the boundary surfaces, velocity alignment with other agents, and attraction toward the center of gravity of other agents. Each agent perceives the agents of the same species only within a limited perception area. In addition to these three basic flocking forces, there exists a forth force which causes attraction towards the front surface of the virtual space. This force is applied to an agent when it detects motion in the real world. This motion is calculated by calculating the difference in the color values at each pixel location between two successive camera images. By tuning the parameters, such as the balance among the forces and the minimum value of the velocity, it is possible to realize a variety of flocking.

The appearance of the agents can be adjusted by modifying both their shapes and colors. The current version provides six choices of shapes: square, sphere, paper plane, paper crane, ASCII faces, and hexadecimal ID. Two color values can be freely assigned to agents of each species. These two color values are then mixed depending the amount of motion that has been detected by the agent. An alternative way of choosing colors consists ion the assignment of a fixed single color that has originally been sampled from Japanese *Origami* paper.

It is also possible to change the background images covering the bounding planes of the virtual space. Each surface can be filled by either a uniform color, an image retrieved from a file, or an image that has been captured from live video. Finally, it is also possible to cover the entire background by a single image instead of displaying the five textured bounding planes.

The agents are divided into two species: the melodists and the percussionists. As the names indicate, these species play different types of instruments. A melodist plays a tonal instrument by mapping its position to the parameters for a note. It's vertical coordinate is mapped to the note's pitch, it's horizontal coordinate is mapped to the note's pan position, and it's depth is mapped to the note's amplitude. Via the GUI, a variety of musical parameters can be defined: instrument types, rhythm, tempo, scale, pitch range, chord progression, etc. These parameters can be chosen in order to mimic particular musical genres such as classic, rock, jazz, ethnic, and so on.

3. Configuration

This installation requires a Macintosh computer (G4 or G5 CPU) which runs the MacOS X operating system and a web camera. Therefore, this installation runs on any of the currently available Macintosh computers. In order to have the installation respond acceptably quick to interaction, screen resolution should be reduced to 320 x 240 pixels on slower machines (below 600 MHz). Powerful machines such as a 2.5GHz dual G5 machine will easily display more than 512 agents at a resolution of 640 by 480 pixels. Figure 1 shows a typical exhibition configuration such as the one that will be used at the GA conference 2005.

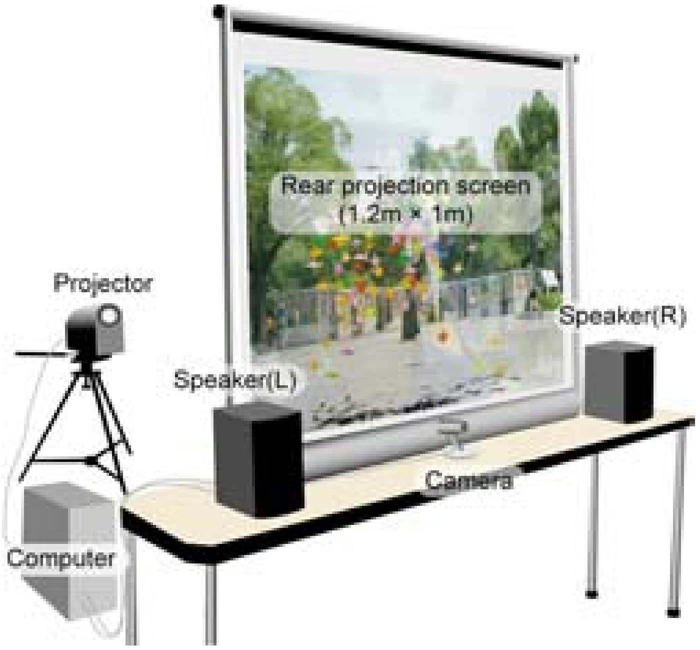

Figure 1. The hardware configuration for an exhibition scale installation.

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Bindu Point: Telecommunication with the Mythic Present

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Abstract

The “Bindu Point” project applies technology in the creation of a hyper-dimensional performance environment. Camera input to motion detection software feeds a generative parenting algorithm which outputs a layered stream of synthesized drones in response to the movement of the performer. Performer, musician and the system itself form an organic feedback loop, both triggering input and responding to the resulting audio and video output.

Performer as Ritual Technician

The format of “Bindu Point” attempts to address the use of technology as a mediator of experience, in that it exists within non-virtual space where the technology is augmenting human reality. The performer encounters the system in physical, human space, rather than entering their consciousness into virtual, machine space.

The motion detection hot spots set by the camera input, create the potential to activate a sonic environment. The presence of “Bindu Point” in the performance space allowing the manifestation of an invisible dimension which can be explored intuitively rather than by learned technical knowledge.

The resulting performances use trance-state improvisational movement to set in motion generative audio and chaos driven video feedback, creating a constantly evolving immersive environment of electronic drones and images.

Bindu Point was performed at the Out There Festival in July 2004, the Sonorities Festival at Sonic Arts Research Centre, Belfast 2005 and Generative Art 2005 in Milan, Italy. Video documentation from the first performance of *Bindu Point* has been screened at the ePerformance & Plugins Festival, Sydney, Australia and Inport 2005, Talinn, Estonia.

Background Information

This performance piece comes out of research and development begun during my Computer Arts MA and a subsequently funded collaboration with Lee Adams by Arts Council England South East and South Hill Park.

The initial design of the system used the Big Eye application from STEIM, feeding midi information into another application created using Macromedia Director. The processing then uses a parenting system to splice the binary equivalents of each two note values together to create a child value that is mutated and sent to the output. The current system incorporates motion triggering, midi processing and audio into a single new application written using Max/MSP.

With the creation of this new instrument, the challenge lies in learning how to creatively pilot it. By augmenting the audio output with additional synthesiser voices and audio processing, I am able to manipulate the output and create a spontaneous, improvised audio response to the movement of the performer.

Biographies

Lee Adams

Lee's recent performance, installation and video work has begun to explore the limits and boundaries of his physical control and endurance. His melancholic, often visceral performances range from the intimate to the epic and often examine the positioning and relationship between performer and audience, questioning notions of true/fictional and performed self, otherness, difference, gender, sex, love, pain, suffering, transcendence and the politics of the body in relation to culture and power.

In 2001 Lee began to devise a series of solo performances starting with *The Bachelor Stripped Bare* selected for the NRLA Platform at the New Territories Festival 2002, and described by Robert Ayers in Live Art Magazine as *'… a wonderfully old-fashioned and self conscious Genetesque apparition … violently transgendering …'* this was followed by *Cruising*, commissioned by the LIFT Festival Club and broadcast on BBC2 television as part of the cultural history series *Taboo – 50 Years of Censorship*. Later in 1992 Lee developed and performed *Valentine* for The Centre of Attention and collaborated with Ernst Fischer and Helen Spackman on *Fallout* at the Riverside Studios.

In 2003 Lee performed at Tate Modern with Guillermo Gomez-Pena in *Ex Centris: The Museum of Fetishized Identities,* described by realtimearts.net as *'A bit like partying your way through the Apocalypse';* with Oreet Ashery in *Central Location* for *Wonderyears* at the NGBK Gallery, Berlin and at *Visions of Excess* an ' … eighteen hour voyage into the heart of darkness …' staged in the Demon lap dancing club and curated by Ron Athey and Vaginal Davis for the Fierce! Festival. In 2004 Lee performed at the ICA with the International Necronautical Society (INS) in *Calling All Agents*.

2004 also saw Lee produce a second collaboration with Ernst Fischer and Helen Spackman; *Iconostasis*, a multi-media performance for Act 02 at the 291 Gallery, London; *Porca Miseria*, commissioned by Duckie for Gay Shame at the Coronet. Later that year he performed a live art intervention for Insight Arts Trust at the Royal Opera House, Covent Garden.

In May 2005 Lee co-produced the London performances of Ron Athey's experimental opera *The Judas Cradle*, at 291 Gallery, part of a national tour commissioned by Fierce! and funded by The Arts Council of England. Most recently Lee was commissioned to create a new work 'The Mark of Cain' for Club Underworld in Athens.

Martin Franklin

Martin's career as a recording musician began with his Ambient trio TUU whose music has been released internationally on labels including Island Records, Beyond, Planet Dog, Hearts Of Space and Waveform.

His music is often commissioned for performance, recently being used in Momix Dance Theatre Company's world tour of "Opus Cactus", "Six Feet Under" (HBO TV) and commissions for Kadam Asian Dance & Music Co., Sujata Banerjee, animation company D Fie Foe a.o.

His interactive audio piece "_Clear" was featured in the Soundtoys "Convergence" exhibition presented during Cybersonica 2002 at the ICA in London and his is currently included in the Soundtoys touring exhibition "Transigence"

During 2005, he worked with Youth Dance England on video and performance soundtracks, a collaborative commission with writer Jane Draycott to create a hybrid poetry/digital media artwork and at Henley River & Rowing Museum, creating experimental video pieces based on their collection.

ArTbitrating: an evolutionary arbitrary mapping from visual to sound domain

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Abstract

Here, we present ArTbitrating, and evolutionary computational system for visual and sound composition. ArTbitrating emerged from attempts of modelling some kind of creativity in visual and sound domains. Two previous interactive evolutionary systems were developed in visual and sound domain. In ArTbitrating, abstract visual compositions, as well as image files, are transformed in trajectories for production in sound domain.

1. Introduction

Kandinsky is painting music. That is to say, he has broken down the barrier between music and painting, and has isolated the pure emotion which, for want a better name, we call the artistic emotion. The effect of music is too subtle for words, and the same with Kandinsky´s paintings. Presumably the lines and colors have the same effect as harmony and rhythm in music have on the truly musical.

Color-music is no new idea [1], attempts have been made to play compositions in color, by flashes and harmonies; also music has been interpreted in color. Kandinsky refers to attempts to paint in color-counterpoint. Picasso admirers hailed him as a visual musician.

Nowadays, some visual artists are using evolutionary programs to help them produce images that they could not have imagined otherwise. Work on genetic algorithms suggests that unconscious, nondeliberative psychological processes might enable largely random (but useful) combinations and sensible selections to be made in human minds [2]. Karl Sims´s computer graphics program, for instance, uses genetic algorithms to generate new images from preexisting images [3, 4]. These systems typically operate by presenting the user with a collection of images (initially random), shown next to each other simultaneously on-screen, from which the user chooses the parent or parents of the next generation of images. The new generation is created by some set of genetic operators, the corresponding new images are computed, and then these images are again displayed for further choice. With only a few such generations of viewing and selection, users can follow promising visual avenues to create quite striking final images.

Moreover, in sound domain, a new generation of composition researchers is discovering that by using simulated evolution techniques it is relatively easy to obtain novelty – often complex novelty – despite of it is correspondingly difficult to rein in the direction that novelty takes [5 - 7].

And since we have evolutionary systems for image generation and sound generation, why not to devise a system applied to composition in visual and sound domains? This is what is being proposed next.

2. ArTbitrating: an evolutionary environment for visual and sound composition

ArTbitrating environment emerged from two other evolutionary environments, VOX POPULI, an interactive environment for sound production, and Art Lab, applied to visual domain. VOX POPULI can be described as an interactive evolutionary system that can be used as a new form of musical instrument [6, 7].

At Art Lab, an interactive genetic algorithm (IGA) is used for the generation and evolution of geometric abstract compostions [16]. Art Lab´s interface permitts the user to generate sets of four frames, each time, of the most common graphic primitives available in any programming environment: lines, boxes, arc, circles, ellipses, miscellaneous. Art Lab´s interface promotes the presentation of the generated abstract compositions for a "human mentor" to evaluate them.

At ArTbitrating environment such compositions result in sound trajectories, or curves that guide the sound production. Thus, each visual composition is the matrix of a sound production. And since that we are using visual compositions to generate sound trajectories, why not to use image files?

Be the visual composition a rendered composition or a file image, both are treated as attractors in a dynamic system, which results in the sound composition. The problem is the same: how to map visual attributes in sound attributes. Very simple mappings were applied and even with those very simple mappings some interesting material was produced. Figure 1 presents the evolutionary environment ArTbitrating while realizing a sound performance using Kandinsky´s composition On White II (1929).

To define a mapping from visual to sound domain is not a simple problem. In both domains, there is a lot of controversy about “values”. Kandinsky offers some clues in his book Concerning the Spiritual in Art, which we intend to apply to this work [8]. According to him, “keen colors are well suited by sharp forms (e.g, a yellow triangle), and soft, deep colors by round forms (e.g., a blue circle). But it must be remembered that an unsuitable combination of form and color is not necessary discordant, but may, with manipulation, show the way to fresh possibilities of harmony.” Further, Kandinsky places: “In music a light blue is like a flute, a darker blue a cello; a still darker a thunderous double bass; and the darkest of all – an organ.”

All these problems are congregated in arTbitrariness, which refers to the initiative of upgrading the aesthetical judgment through evolutionary computation and others population based techniques for exploratory search, and is interpreted as an iterative interactive optimization process [9]. The main goal of arTbitrariness is to avoid to leave to the artist what can (already) be optimized and to avoid to leave to the machine what can’t be optimized (yet), looking for an arbitrary point among subjectivity and objectivity, with its associated automation capability.

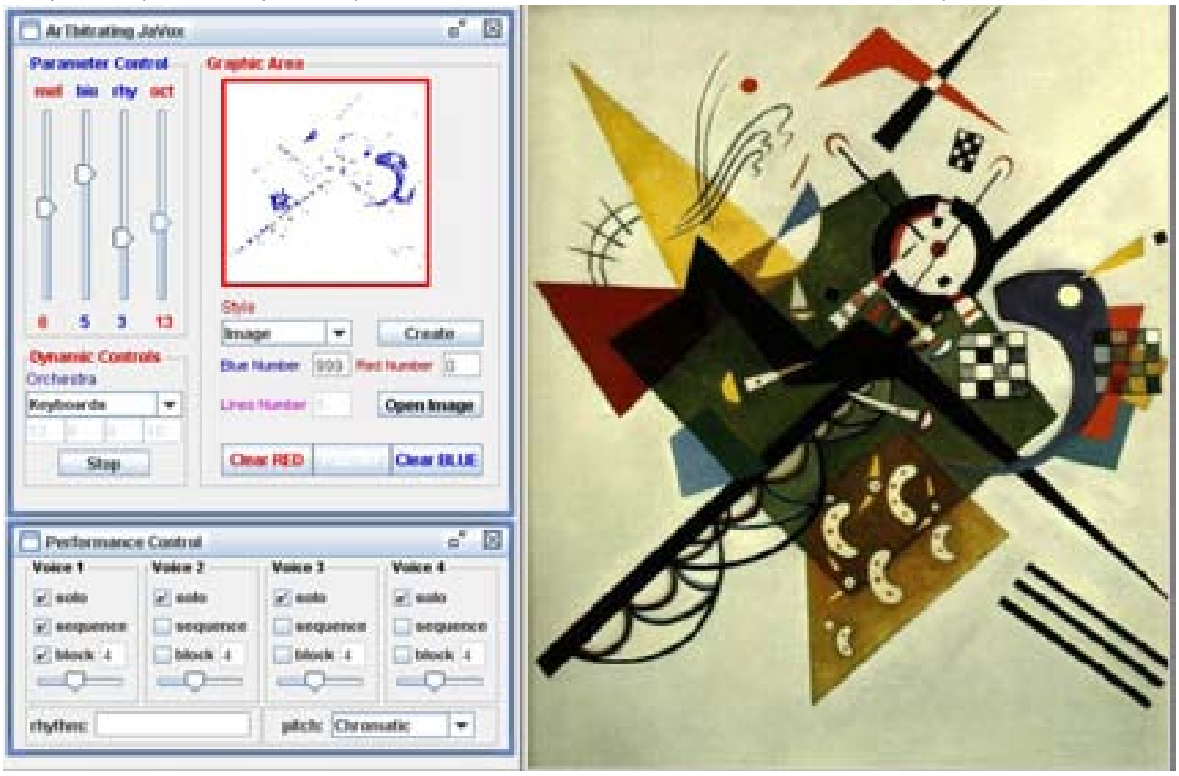

Figure 1. On the left, the ArTbitrating environment is showed presenting a performance using a mapping for sound generation that was created from Kandinsky ´s visual composition On White II, on the right.

3. Conclusion

At ArTbitrating, the user can experience to create an abstract visual composition and “hear” it. He can also generate a sound production from a image file. If there is a lot to do with relation to the mapping of the attributes of the visual domain to the sound domain, each domain, by itself, already contains a universe of challenges.

Two main challenges are foreseen in ArTbitrating environment: the first is relative to the visual domain. It is necessary to add more sophisticated graphical resources, as well as criteria for the generation of visual compositions. The other is relative to the mapping itself of the attributes of the objects of the visual domain to the sound domain. Both refer to the question of the subjectivity, running into the context of the arTbitrariness. If computational creativity is still in its early days, the attempts to emulate some kind of creativity on computers already present impressive results.

4. Acknowledgements

I am very thankful to the students Rafael Boccaletto Maiolla, Leonardo Laface de

Almeida and Daniel Gurian Domingues for their Java support. I am also thankful to Dr. Fernando Von Zuben, who stimulated who stimulated me in theis work. I am much obliged to my co-advisor, Dr. Jônatas Manzolli, co-author of VOX POPULI, for all his strong support in music computing and to NICS/Unicamp for allowing me to use the tools developed there. Finally, I would like to thank to PIBIC/CNPq program and to CenPRA, for the possibility of developing this work.

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_grau

Robert Seidel

experimental film, 10:01min, Germany 2004

_grau is a personal reflection on memories coming up during a car accident, where past events emerge, fuse, erode and finally vanish ethereally. Various real sources were distorted, filtered and fitted into a sculptural structure to create not a plain abstract, but a very private snapshot of a whole life within its last seconds.

The cinematic structure of _grau is based on a personal discussion, in which I formulated my standpoint that no events falls into pure black/white or bad/good. The shade changes by factors like time, space and personal relations to it. As a result I came up with the name _grau for the movie, which is the german word for gray, containing everything inbetween the extremes. Also the length of 10:01 minutes is related to this and refers to the binary system by Gottfried Wilhelm Leibniz, where he ascribes 1 to god and 0 to the devil. And finally the colors of the movie itself never reach pure black or white respectively. These structural ideas build the foundation of _grau and haven't changed from the beginning. Just the underscore was added to the name, as it allowed me to find my working directories on my hard drive more easily, as this name always gets shown in first place.

My original plan was it to create a purely abstract movie, exploring these concepts and freeing my mind from some very depressing commercial work I had to do over years. I wanted to create a textural deep, inspired by the complexity of nature without willing to copy it. So I did a lot of research of different ways to generate three-dimensional geometry without the cumbersome tools available. More spontaneous explorations of the space came for example from 3d scans, MRT data of my brain or captured motions of myself. While travelling to one of the technical institutes helping me out with technology I almost had an accident, which shifted the planned abstract structure into a more "personal history" narration. This made me think less of primal notion itself, but how I would perceive my whole life compressed into some seconds rushing through my brain. A kind of unweighted chaos, where small events become more important than a couple of years and everything transforms in a very fluid way. It also incorporates my visual development from the beginning, not only using the computer or doing paintings, but ranging from toy shapes, ice crystal fractals or plant growth. Layering all these different spatial concepts organically, created a slowly evolving and almost breathing complexity out of very basic ideas, a kind of a emotional distillate.

Every sculptural moment has a meaning that originates from real experiences and is adapted from my sketches, my own body fragments or filtered through scientific visualization methods. For example the first, still colored seconds are the prismatic halos of the collision fading into gray. From there on the temporal structure develops backwards, bringing up current and past memories and finally resulting into the "decision fur". Here every hair strand is representing one decision I made in my life, altogether resulting in the accident. The musical framework supports these ideas and connects my memories born out of the dramatic moments to clusters. These are unleashed from the image flux partially - to ease the desired, free associations of the beholder.

Even though _grau is a movie technically, I think it is more a hybrid form: a living painting (Tableaux Vivants) of branching memory structures. It was my diploma work at the Bauhaus University Weimar and is the third work (Lightmare, 2001 and E3, 2002), that tries to explore the relationship between digital imagery and the real world. Technology allows to layer, re-structure and compress memories and importantly put them into motion in very unique ways, thereby allowing the procedural exploration of coherences in a way never possible before in history. All my works can be downloaded at www.2minds.de and please feel free to contact me under info@grau1001.de.

A Study in Synchresis

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0) Abstract

The ability to record and replay images and sound is quite new, and the combining of the two is even more recent - with cinema spending its first 35 years separated from any synchronized sound. However, sound attracts slight notice outside of the realm of music - becoming quickly overlooked as soon as it is combined with image. Our aim is to separate and recombine the visual and auditory elements as a means of examining sound's influence on the cumulative message that we receive from an audio/visual source - also known as synchresis.

1) Introduction

The French avant-garde composer, author and theoretician, Michel Chion, has been a pioneer in the new field of audio-visual relationships, developing a theory he calls synchresis (derived from synchronism and synthesis), which he defines as:

"The spontaneous and irresistible mental fusion, completely free of any logic, that happens between a sound and a visual when these occur at exactly the same time" [chion:1994:1].

Our aim is to explore this concept; the idea that there is an emergent property which is revealed in the union of sound and image.

Historically, in the early days of sound films, it was common practice to record a different actor's voice from the one that actually appeared on screen. This separation of the actual sound and the presented sound has continued - and become increasingly sophisticated. Today, the audio for sound film is largely created - and totally created in the case of animation - in the post-production studio. The audio in any given scene can range from a partial to total construct of sounds that were either recorded after the fact, by Foley artists, or drawn from massive high-quality sound libraries.

Through this process of sound design we are able to both conceal and emphasize - as well as create reassociations in the fabrication of a dual modality reality. This is done through the use of sound that is often more real than the real. What we hear is not simply a replacement of the sounds from the original scene, but the construction of a soundscape that is deemed most conducive to eliciting the desired psychological response. This more real than real sound is what Chion calls rendered sound [chion:1994:2].

Chion sees this as a means of adding value to the image. In other words, as the nature of synchronous sound is one that induces the audience to construe the image, and hence event, differently, we can view the relationship of sound and image in film, as well as visual media in general - as John Cage and Merce Cunningham explored in their collaborations - as one that is not merely associationist, but synergetic.

This synergetic emergent property has been explored in numerous scientific studies, where it has been found that "Spatially and temporally coincident acoustic and visual information are often bound together to form multisensory percepts" [anderson:2004]. This, in turn, can give rise to illusory percepts, when incongruent information is presented through these two modalities. The McGurk effect is an example of this, using speech, where a spoken sound and a video of a person articulating an unmatched sound gives rise to a third, imaginary sound; or BA + GA = DA [mcgurk:1976].

Along these lines Chion had an exercise he called Forced Marriage which involved replaying the same film segment with different soundtracks in order to examine the relationships that are altered and created [chion:1994:3]. Our project is an extension of this concept in which we examine the power and effects of synchresis by means of an interactive installation that allows the audience to immediately and dynamically see, hear and feel the effects of this phenomenon.

2) The Installation The basic element of our study on synchresis is a short video - created with the goal of audio dynamism - shown on a screen in stereo sound. The audio for this film is recorded and mastered in a way that every single sound source has it's own audio track. This allows each sound to be altered, swapped or replaced independently.

2.0) Sound Templates In order to maintain a relation with the initial sound elements, each original track will leave it's template behind when a new track comes in to replace it. In other words, it's volume, timing, and positioning in the audio environment will remain associated with the track, and will then be applied to the new sound (for example, a car approaching and passing from left to right would be replaced by the sound of a train which would have it's volume and pan matched to this movement).

2.1) Sound Manipulation The second dynamic and independent variable will affect the actual sound elements, such as pitch, timbre and harmonics.

3) Conclusion

Through this exercise the audience will develop both appreciation for the synergetic properties of sound and image as well as an awareness of the ability of the sound designer to manipulate and re-associate through careful selection.

It will provide some insight into how we hear - and how characteristics of visual elements may be rendered in sound, such as "movement, weight, size, solidity, resistance, contact, texture, temperature, impact, release, ..." [sonnenshein:2001].

Synchresis is an often-overlooked element of life - with sound generally getting overshadowed due to the primacy of image. Here we venture to pull audio back to the forefront through interactive and generative methods that aim to show both the malleability of the message we receive from visual information, and the power of creation and association that is the property of the union of auditory and the visual stimuli.

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Music to Colors

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ABSTRACT

The final outcome of early 20th Century thought was to make pure cinema as visual music and express oneself through a rhythm that stood for nothing but itself. But as Antonin Artaud wrote in 1927, “The idea of a pure cinema is wrong, as it is wrong in any art form to enforce a principle upon it.” Music to Colors takes it a step further. It is concentrated on life energy, the consciousness of living, not objective art. Rhythm is only important as it involves a natural process of creation and destruction of life energy. Music to Color is only one “instrument” that allows us to realize the creation and destruction cycle.

Keywords

Eye, images, Ear, sounds.

THE IMAGES HIT THE EYE LIKE THE SOUNDS REACH THE EAR.

Plato believed that the world was made according to musical principles and harmony and rhythm ruled man’s inner self.

Aristotle wrote: “Given that some re-create the world through figures and colors, and others through sound, in the arts as well, all of us re-create by means of rhythm, dialogue, and harmony, and these or those separately or mingled.”

Since its origins, Occidental Europe has been teeming with theories that link aural sensation to visual sensation, music to painting. Music theorists were the first to approach the idea. They tried to create a “fusion” of music and color by creating an instrument that could produce different colors for different musical notes.

The first attempt at “painted music” was in 1725 and 1735, when the Jesuit Louis-Bertrand Castel introduced the *clavecin oculaire* (ocular clavichord). The instrument was meant to paint sounds with corresponding colors in such a way, claimed Castel, that a deaf person could enjoy and judge the beauty of a musical piece through the colors it created, and a blind person could judge colors through the sound. The instrument functioned like a traditional clavichord, excepting that each note was associated, in accordance with Castel’s own exhaustive studies, with a particular color that would be displayed upon the playing of each note.

On the 16th of January 1877 Bainbridge Bishop patented a coloring organ that simultaneously played music and projected colored lights through illuminated windows.

In 1895 the Englishman Wallace Rimington conceived of a small music box that contained many apertures with colored glass and an electric wire. The apertures could open and close – projecting colors on a white screen – by playing a soundless keyboard.

The construction of such instruments continued throughout the 19th Century in the attempt to discover the “scientific” link between sound and color, but the period that saw the greatest experimentation was the first three decades of the 20th Century. In that period, everything was tried: organs that produced music or color, or keyboards that created colors without making a sound. Nevertheless, the marriage between music and color could also be made by endowing the picture with a temporal dimension like that of music. This concept saw a flowering of experimentation and theoretical hypotheses in Europe in the 10 years preceding the Great War.

The futurist brothers Ginanni-Corradini, better known as Arnaldo Gina and Bruno Corra, conceived of chromatic music while they were studying Byzantine mosaics in Ravenna. They declared their idea in the manifesto Arte in 1910, claiming that colors create both a harmonious music and a sonorous one. They could, they exclaimed, express feeling and states of being with notes and equally compose harmonies, motifs and symphonies. “You can create a new and more rudimentary form of pictorial art by using a mass of color harmoniously mingled, one on top of the other, in such a way as to please the eye without representing a figure. This would correspond to what in music is called harmony; we can therefore call it chromatic harmony. Like music (a series of notes over time), color can give shape to a temporal art that is an assortment of chromatic tones successively hitting the eye, a movement of color, a chromatic thread.” Corra sought to put the idea of music to color into practice; he built a piano with 28 keys that correspond to 8 differently colored electric lamps. By pushing one key, a color would be projected over a background. By pushing many keys, the colors would form a harmonious light.

One of the few to see things clearly was the french director Henri Fescourt. “Visual music,” he said, “is a possibility and manner for the cinema of tomorrow. To what should it apply?”

MUSIC TO COLORS.

The avant-garde sought to form, and develop to its fullest, experimentation in a wrong way.

Music to Color takes it a step further. It is concentrated on life energy, the consciousness of living, not objective art. Rhythm is only important as it involves a natural process of creation and destruction of life energy. Music to Colors is only one “instrument” that allows us to realize the creation and destruction cycle.

It involves a system of mixed technologies (analogical – digital) that allow us to realize and adapt the ideas of the first experimenters in a live music performance.

The first part of the system is an interface Pitch to Midi converter that transforms an audio analogue sign that can come from any sound source into Midi digital messages.

The Pitch to Midi interface converter is connected to a simple Midi interface that receives and transmits signals to and from a computer’s serial or USB port.

It should be made clear that the Midi protocol does not transmit sound, but information relative to the process. This information is played by one or more instruments hooked up to the system and transmitted to a computer.

The Midi messages are digital signals made up of numerical sequences in binary form that then travel in serial form. The amount of information the Midi program can carry depends on the instruments being used and the manner in which they are being used. Music to Colors creates a literal communication line between the musician’s sound and the computer’s image.

There is nothing hyper high tech or avant-garde about the system because it has been created with computers and instruments by now in disuse, with a completely different approach from the technology of VJs that has been in fashion for some years now.

In fact, with Music to Colors, you can use any kind of video material. This means that the usual feedback will not be the result of automatic computerized processes. Instead, the “automatism” factor will prime the visual rhythm of the images recorded during the acts (photographs, video takes).

The flow and rhythm of the visual will avoid narration and instead look to dismantle the “record of the experience” and thus constructing a natural platform of Music to Colors.

ACKNOWLEDGMENTS

I would like to tank to the Situationists International.

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Big Questions about The Big Easy

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Abstract

My *Big Questions about The Big Easy* is a traditional black and white photograph that documents a blackboard drawing and installation. It was created in response to the devastation and flooding caused by Hurricane Katrina.

Introduction

The Big Easy, The Crescent City, both New Orleans nicknames that describe America's unique Gulf Coast city. It is the birthplace of Jazz, a city of celebration, "let the good times roll" and a rich diaspora of Creole/Cajun dialects, Zydeco dance music and legendary cuisine. Her diverse roots include Choctaw, French, Spanish, African, German Latin, Sephardic, Italian, and Irish to name a few [1] Located between Lake Ponchatrain and the Mississippi River New Orleans is a curious mix of voudun myth, alligators and gumbo, where red beans and rice are always served on Monday. Legend has it that NOLA is so charming to vacationing tourists that many never leave.

Tourists flock to Mardi Gras celebrations partying with great excess in the old French Quarter. But the real NOLA, mostly African American, is very poor with poor public schools and high unemployment and scars of Jim Crow segregation remain. Where oil rigs and legendary corrupt politics coexist with elegant antebellum steamboat houses and vernacular 3 room shotgun houses.[2] New Orleans is a hand built city made of wood and plaster surrounded by water, a bowl that was created by a long slow process. Her demise has been very slow, slowly the city has been sinking. Nothing happens quickly in New Orleans, the hot humid temperatures slow everything down. Each Autumn brings Hurricane season, most often the city is spared unfortunately this year it was not.

On August 29, 2005 Hurricane Katrina changed the city of New Orleans. The flooding that followed and the destruction that it caused have made a profound impact on the world. The news media broadcast and published images that resonate. Katrina showed America and the world that America is vulnerable, that she was/is not prepared to take care of her own.

In an era of terrorism, the devastation of Post Katrina New Orleans is very different from Post 9/11 New York. The two disasters were horrific but the victims of the World Trade Center bombings were killed at work. Recovery workers slept in their own beds each night after work. The entire city of New York was not threatened. Alas, New Orleans will never be the same. Her map will be different. Is it possible that New Orleans population could possibly decrease by as much as 50 percent? Her city and state services will never be the same. There are, as I discovered no answers only questions. Questions that generate only more questions.

The Installation

The installation *Big Questions about The Big Easy* contains a recreation of an early map of New Orleans, circa 1768. .[3] This French project plan depicts a mirrored grid with a parade route dividing it. It is located on high ground where the Mississippi River is spoon or crescent shaped.

This is the area where Mardi Gras parades flood the street each Fat Tuesday before Lent and tourists party in excess. This area is home to many successful businesses and this original French Quarter was damaged very little by hurricane winds or flooding.

The drawing itself is site specific, a dusty white chalk drawing on an old fashioned blackboard (before whiteboards). It is a work in progress, a system that can be easily changed, a plan with order and boundaries. And it is hand drawn, not computer generated as a reminder that New Orleans is hand crafted and maybe some answers need to be generated by the needs of the local residents, not outsiders.

Why the map ?

My use of the 1768 map was prompted by the New York Times publication of a series of maps illustrating the effects of Katrina and the extensive flooding of New Orleans and the Gulf Coast. [4] Initially, I started working with the maps and numeric systems as well as the “X” shaped code used by the search and rescue teams going door to door evacuating the survivors and counting the dead, with the goal of predicting what was going to happen to the poor low lying neighborhoods. Layers and layers of orange spray painted codes and graffiti sprayed by survivors blanket everything from discarded refrigerators ”Deliver directly to George W. Bush”, to shops windows ”Do Not Enter, I am inside”. And on a fallen levee “Katrina, you bitch” [5]

Visual overload and questions

Photographs and news reports graphically documented the massive flooding and the human suffering and evacuation incurred by thousands of residents, tourists and those who could not or would not leave their homes. The photographs and stories coming out of the overcrowded Superdome and the New Orleans Convention Center where visually shocking and heartbreaking.

Many of the rumors and stories including inflated statistics were spread via the Internet and news media alike. Big wild stories mostly were false, some smaller ones proved to be sad and true. “Here lies Vera. God help us.” “Dying patients, with directional arrow.”

One of my sources of anecdotal stories is my brother that evacuated early and returned to help with recovery. According to him, one of the difficulties is that information and services are scattered. No one source has all of the needed information or paperwork to help. Monies are being distributed and contracts for trash removal are being awarded. But one fact became very clear, the US Government did not communicate with the local and state governments and the world witnessed the event.

Again and again, I returned to the question “What will New Orleans look like in the future?” My initial gut feeling and now greatest fear is that when all the debris has been removed and the low lying areas have been cleared that New Orleans will be devoid of her unique diverse culture and that all that will remain will be a Disney-like diluted historic cartoon reproduction for tourists, a sanitized French Quarter.

Ten weeks after Katrina there appears to be no concrete answers or solutions for New Orleans. Each questions generates scores of other questions. From “Why did the levee system fail?” “What will the population be in one year, three years, etc.?” “Where will the displaced poor of the Lower Ninth Ward relocate?” “Will the historic vernacular architecture be recreated?” “How high should the houses be to protect inhabitants from flooding?” “How can New Orleans be rebuilt from “the bottom up” if the funding comes from “the top down?”

Updating the conceptual map

My hand drawn blackboard map of New Orleans contains only questions, 60 rolls of questions all recorded by hand, generated randomly and added to daily. The rolls and rolls of paper coil tightly like a Category 4 storm that came to visit and stayed, leaving behind only Big Questions about The Big Easy

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Evol, Punani Series Live

Roc Jimenez de Cisneros

Anna Ramos

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Evol is a computer music unit formed in 1996 by Roc Jimenez de Cisneros and Anna Ramos in Barcelona. Their recordings and performances explore the many sides of digital noise and algorithmic composition. Harsh and bloody trips along the most extreme path of computer music, putting together sonic brutality, crazy algebra, fractal structures and a slight ironic touch.

Evol's musical outcome has been featured in top record labels such as Mego (Austria), Fals.ch (Austria), Scarcelight Recordings (USA), Diskono (UK), Antifrost (Greece), Lucky Kitchen (USA-Spain) and their own home label, Alku. The Barcelona duo has played in festivals, museums, galleries and club events all over Europe and the United States.

"Magia Potagia", their latest record for the Vienna-based label Mego, is a document of the work Evol have been doing within the field of algorithmic composition for the past three years. It features three tracks from two different periods, all of them 100% computer- generated and almost no edited at all, to preserve their fractal nature. The first track, "Punani Potagia", is part of their acclaimed Punani series, which is now the central part of their work. The next chapter of this series (to be published in US label Scarcelight) will feature a rendering from Casey Reas "Hairy Red" in the cover.

"Punani Series Live" is a series of live performances of generative audio (using Pure Data, Max/MSP and custom software) for two computers, where Evol experiment even further in their self-similar generative Punani pieces. The results of these unpredictable performances is usually recorded to eventually become part of the Punani CDs.

Synchronized Swamp: Uncanny Expressive Mathematics

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Abstract
Synchronised Swamp is an artistic audio installation that simulates synthetic frog and insect-like choruses both audibly and spatially using a computer, multi-channel sound output and distributed speaker system. The software plays back several samples of a synthetic chorusing swamp creature per audio channel, while a mathematical model is then used to bring the collectively sounding samples in and out of synchrony.

1. Introduction

Ever noticed on a hot summer's day that the crickets seem to be singing *in time with each other*? Or perhaps you might have walked through a park or swamp and semi-consciously perceived a lurching rhythm in the sound of the nearby calling frogs. These two groups of creatures, when singing in large enough numbers, have a tendency to collectively organise their sound in a way that reveals the initial cacophony to be driven by an underlying dynamic. A large noisy group of frogs or insects is typically referred to as a 'chorus' (something performed, sung, or uttered simultaneously or unanimously by a number of animals), and at particular intervals such choruses exhibit a tendency to undergo synchronisation, such that the calling voices fall into step and hence unison.

Biologists have attributed the synchronisation of frog and insect calls as the result of a vocal race between males competing for the attention of females. Dominant males in these communities tend to be the first and loudest to call. Females will eventually respond to the most raucous prominent males with an invitation to mate.

This may happen because it's easier for a female to locate the source of a signal if she tunes out any subsequent, competing calls. From the male perspective, of course, this means that every male in the crowd wants to be first [1].

This motivates male frogs to vie for the lead calling spot, sexually favoured, as it were. One suggestion offered by biologists is that synchronisation of groups of these calling creatures initially appears to be the side-effect of some kind of sex inspired vocal race. Males fall into a coincidental sync as a result of listening to their neighbours and competing for the lead spot in the calling period, much like athlete sprinters tend to bunch up towards the end of a race.

The Puerto Rican white-lipped frog employs vibrations in the earth created through its vocal pouch as another form of communication with its neighbours:

When the frog croaks, its vocal pouch expands explosively, striking the ground. The impact generates a Rayleigh wave of vertical vibrations that travels along the ground's surface at roughly 100 meters per second (and with a peak acceleration of 0.002 g at a distance of one meter) [2].

Narins and colleague then constructed a device using the solenoid from a typewriter to simulate the seismic "thump" generated by the white-lipped frog. They insulated their device to prevent airborne sounds being heard by the frogs, and discovered a

remarkable thing, that males within three meters of their artificial “frog” consistently entrained their calls to it, producing a chorus [2]. While seismic communication among frogs is perhaps not always present, it does provide a clear mechanism for synchronisation.
What makes sync interesting is that it is not simply phenomenological – there appears to be common underlying principles driving this complex system. Periodicity, timbre, displacement and position of callers, sex, race, size and number are some of the factors that could be attributing to the synchronisation. Is it possibly to describe the overall dynamics of a field of frogs or insects simply through sexual selection?
Enter a relatively new sub-branch of mathematics - the theory of *coupled oscillators*. The emergence of synchronised behaviour across different fields of research has been revealed through the study of *coupled oscillators*, as has been described by Steven Strogatz [5]. The discovery of coupled oscillators begins with the famous observation of the Dutch physicist Huygens, who noticed that two pendulum clocks when placed side by side displayed the uncanny tendency to synchronise their swinging. This phenomenon is not simply confined to clocks but is also expressed throughout the natural world, occurring in the synchronisation of the pace-maker cells in the heart that generate the heart-beat, the periodic flashing of swarms of fire-flies, the synchronised propagation of waves in the intestine and nervous system, and the synchronised chirping of certain frogs and insects [5]. It is therefore from this phenomenon that the S*ynchronised Swamp* is inspired. In order to generate the timing for the play back of its sounds, the *Synchronised Swamp* generative installation exploits a mathematical equation derived through *coupled oscillators*.

2. Frogs as Oscillators

When frogs and insects begin to call, they do so repeatedly. It is a constant sound, with a measurable period – a sound repeated at interval. An oscillator can be defined as something that repeats a regular pattern, something which exhibits cyclical behaviour. The most fundamental type of oscillator is one that undergoes simple harmonic motion, in other words, has sinusoidal properties. If we treat each frog or insect (henceforth only referred to as ‘frog’ for simplicity) as behaving like an oscillator, this opens up the possibly for modelling their interaction in large numbers.
To better visualise the concept of frogs as oscillators, imagine a ball travelling clockwise around a circle. This ball represents a frog’s calling cycle:

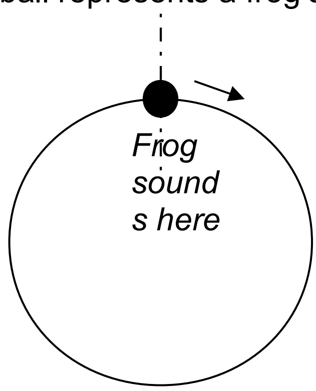

Figure 1 – Cyclical frog chirping

Whenever the ball reaches the apex of the circle, i.e. 12 o’clock, the frog croaks. The speed of the ball travelling around the circle affects the frequency of the frog call. Now, imagine two frogs in this way:

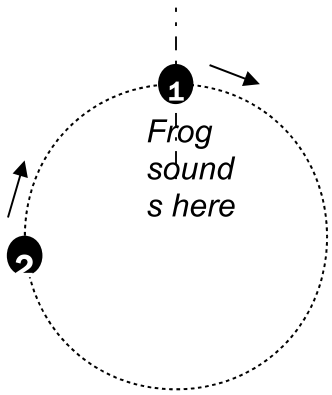

Figure 2 – Two frogs calling

From this diagram we can see that frog 2 will sound a little after frog 1, a delay dependent on their respective speeds (frequency) of cycling (oscillation). If frog 2 is actually faster than frog 1, it will eventually overtake it and take the lead. Extend this example to many more frogs, and the possibility for synchrony or chaos arises:

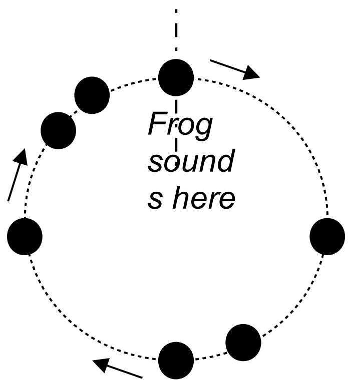

Figure 3 – Many frogs calling

The closer the frog calls are spaced together, the stronger they are synchronised with one another. If the frogs call at the exact same moment – they are completely synchronised. This is the basis for the conceptual model that *Synchronous Swamp* uses in its generation of sound.

3. The Path to Synchrony - Coupling

How is synchrony achieved in the frog calling model? The answer is coupling, hence the term *coupled oscillators*. Take the example of the two frogs calling in *Figure 1* – in order to sync the two together, the distance between the two must be reduced. Consider that each frog is listening to the other, and that each time it hears its partner call, it speeds up or slows down to compensate, such that the next time it croaks the time delay between the two calls is reduced. In the prior example, frog 1 would slow down and call later than it previously had, while frog 2 would attempt to call earlier, and shorten its period of calling. These two imaginary frogs can then be said to be *coupled*. Exactly how much and how quickly each frog changes its period of calling to compensate for the distance between them is referred to as the *coupling* *strength*. The coupling strength is an important parameter of the *Synchronised Swamp* installation as it is one of the major factors driving the synchronisation that is seen and heard.

4. The Sync Equation

The playback of sounds in *Synchronised Swamp*, with a couple of exceptions, is entirely driven by one mathematical relation. At times this equation cannot be heard, or could be mistaken for a random probability distribution, where each sound emitted appears to have been randomly generated over time. The frog sounds are short in duration, so that in large numbers they can form clouds of sound not unlike the experiments of Xenakis [3] who employed Gaussian and Poisson distributions as compositional tools. Xenakis realised that the aggregate of a large number of events can be perceived as an event in its own right. This is where the mass synchronisation generated in *Synchronised Swamp* comes into play - pockets of synchronised frogs emerge from the soup of particles, as if an invisible attractor were drawing clusters together. Complex rhythms that previously escaped the casual listener begin to emerge. Finally, the avalanche of accumulated synchronisation lashes out in a wave of distributed sound, much like the noise made by the sea rapidly ebbing from a beach carpeted with loose shingles.
The sync equation used is one that was initially formulated by mathematician Yoshiki Kuramoto, based in work done by Art Winfree [4]. It describes a system of *n* different oscillators. The oscillators have initial starting frequencies that are described by a Gaussian distribution, such that most of the frequencies are clustered together. The equation models a system where every oscillator is coupled to each other. What this means in terms of the frog paradigm, is that every frog is listening to every other frog in the group, and adjusting the timing of its call according to the timing of every other frog, as described above in the section on *coupling*. In practical terms, this paves the way for a very strong form of sync, given that the frogs in the metaphorical swamp are *all* seeking to arrive at a common period of calling.

5. The Prototype

The development of *Synchronised Swamp* began with a prototype of the sync model. It was necessary to establish the correct timing of ‘frog’ calls using the coupled oscillator equation before any aesthetic modifications and experimentation could come into play. Timing, after all, is the cornerstone of this artwork. Should the timing not be accurate, the finer details of the synchronisation process would be lost, or not function at all. The frogs were initially represented as sonic clicks – short clips of sine wave material, and particular attention had to be made towards overlapping sounds which typically occurred as the system slid towards complete synchrony. Detail at the sync point had to be sharp – any sloppy form of synchronisation would dilute the impact and the otherwise strong conceptual grounding. Synchronisation is an important and mysterious phenomenon of nature, and any artistic examination of the process would have to hint at its silent, inexorable background mechanism.
Development began with assigning sound to the “frogs”. The PortAudio library (http://www.portaudio.com), an open source sound API written in C was used to communicate with the computer sound-card hardware. PortAudio is a library that provides streaming audio input and output. It is a cross-platform API that works on

Windows, Macintosh, Linux and UNIX running OSS, SGI, and BeOS. PortAudio was chosen for its robustness, obvious portability, availability and ability to manipulate digital sound on a sample-by-sample basis. The portability of PortAudio proved to be invaluable as the application was initially built on an IBM T40 laptop running Linux, then tested on a windows partition using the Windows MME sound driver, and then ported to a desktop PC using the Steinberg ASIO driver, which was necessary to achieve multi-channel output.

The process of playing back sound using PortAudio is initiated through a callback function that is called by PortAudio when audio processing is needed. Once the audio stream is started, the callback function will be called repeatedly by PortAudio in the background. In the callback function audio data is written to the output buffer. Sample playback and DSP manipulation take place in the callback function. While calculations for the sync timing occur elsewhere, the PortAudio callback deals with the overlapping of samples, and implements any additional audio processing before the samples are shunted to the various multiple outputs.

For sound sample loading the open source library Libsndfile (http://www.mega-nerd.com/libsndfile/) was used. Libsndfile is a C library for reading and writing files containing sampled sound of various formats (such as Microsoft Windows .wav format) through one standard library interface. It is released as source code and must be compiled to produce a binary. Libsndfile was chosen for its ability to read and write a large number of file formats and reusability on Linux, UNIX, Windows, MacOS and other platforms.

From the initial sine wave clicks that were used as output, with the introduction of Libsndfile it was straightforward to move forward to using digitally recorded samples. The first sound sample employed was still a very short, high resonance ‘puck’ sound, with an emphasis again on its short duration to enable good perception of the temporal structure of the installation.

Using a Pulsar Scope card and Scope Fusion DSP/routing software, 8 channels of audio output were eventually established. Communicating with the card meant sending interleaved frames of audio to the output buffer, with the number of samples per frame being equal to the number of channels used. In order to evenly distribute the frogs and ensure complete frames of 8 channel audio, the total number of frogs was required to be a multiple of 8. Frogs were therefore cyclically assigned to channels in groups of eight.

6. System Mechanics

It should be noted that the absolute time of the sample-synchronisation process was not calculated, but that instead relative time within the framework of the synchronising system was considered important. In other words, there was no attempt to generate the actual frequencies (e.g. in Hz) of the oscillators, only the relative differences between their phases.

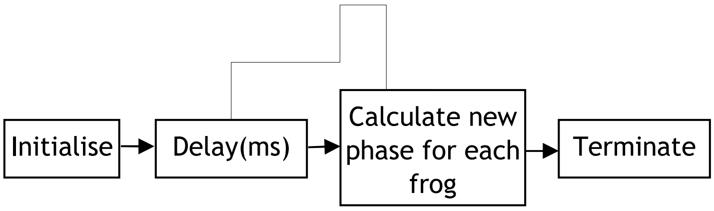

Figure 4 – System Process

From the above diagram it can be seen that the software, after being initialised, remains in an infinite loop until terminated, within which two steps take place. First, the system undergoes a delay (which can be varied over time), and then each frog in the group has its new phase calculated. During the initialisation, each frog is assigned a random phase, as well as an intrinsic frequency, the latter indicating of how often the frog would call if it weren't under the influence of the sync. This intrinsic frequency is determined using a Gaussian distribution, and the spread of this distribution is also variable.

The formula for calculating the new frog phase is based on the following pseudo code, an implementation of the sync equation as detailed by Strogatz (2000):

```
theta = coupling_strength * sin((diff/MAX_DEGREES)*2*PI)
new_phase = old_phase + theta;
```

The variable *diff* is the phase difference between the current frog and one of the other frogs in the system. In the global approach where there are no constraints, the current frog is compared with all the other frogs in the system, leaving *theta* to be calculated that many times. The result of the *theta* equation is to minimise the gap between the current frog and the frog it is being compared with. As a result of this minimisation being employed throughout the entire group of sounding creatures, the system moves towards synchronisation.

7. Unravelling Sync

Experiments with the prototype proved that synchronization did indeed take place. In fact, it proved a little too effective. The global approach where every frog is listening to every other frog, and changing its phase accordingly, resulted in a fast, binding sync. The system synchronized too quickly, even with the most disorganized mob. While the process of sync is a fascinating phenomenon, much of the actual thrill is derived from witnessing a chaotic mess achieve order. Once order has been attained, the system becomes repetitive and less interesting. Oddly enough, after having initially desired to attain sync, it then became imperative to unravel and delay the sync.

Essentially three techniques were used to delay or counter synchronization. Firstly, the most obvious candidate was the *coupling strength*. The strength of the coupling between elements in the group had a remarkable effect on the speed of synchronization. However, using the initial model, the *coupling strength* remained too sensitive. Only within a fraction of its range would the system achieve a slow sync. Below this range was chaos, and above, iron clad order. This sensitivity was further reduced by widening the spread of intrinsic frog frequencies. With staggered, widely varying speeds within the group, sync was harder to achieve. Again, though, this suffered the same sensitivity issues as before, albeit abated. Turning back to the literature for inspiration, Kuramoto [5], whose mathematical model this project is based on, had tried to achieve sync using a ring of connectivity with oscillators arranged in a circle. He and his colleagues found that a ring of dissimilar oscillators could not easily achieve widespread synchrony – small groups of neighbours only would tend to cycle together. Implementing this into the *Synchronised Swamp* was straightforward and quickly accomplished, with a successful outcome. The “frogs” now settled into a shifting sound-scape of lopsided rhythms, with small pockets of repetition. It was as if several groups were simultaneously vying for sync, destabilising the system into a never ending contest for supremacy.

8. Synthetic Sync

Satisfied with the timing, the aesthetics of the swamp were now ready to be developed. After much experimentation, five samples made up the bank of sounds used in the swamp. These were both synthetic and recorded samples of frog and insect-like sounds, edited and drawn from two main sources – sample CDs and the internet. To provide sonic variation, samples were incrementally pitched shifted, beginning from below the root sample to several octaves up (the range being dependent on the total number of frogs). The already fairly short recording now degenerated into rasping and popping twittering – perfect for the swamp.
For additional variation, an oscillating and panning grain based effect developed through experimentation was arbitrarily applied to the first 16 frogs. The result was to produce an uncanny cricket-like sound that hopped in a lively fashion from speaker to speaker. Further trial and error lead to two favoured frog populations, one of 32 frogs and one of 256. The former offered good resolution and clarity, with simple, crisp rhythms, while the larger group demonstrated an animated alternative – a bubbling soup of particles, swirling and giddy under the influence of the power of sync, producing an odd but hypnotic sensation of an organic system moving inexorably forward towards some infinite point, driven by an inexhaustible kinetic dynamic.

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Density flow of a vector field along the roman surface of Steiner

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Abstract

In this paper we consider the density flow of a vector field along the Steiner's Roman surface. The components of the vector field are Wierstrass's elliptic functions. Symbolic and numerical computations, as well the visualization, are performed with the software Mathematica 5.1.

Denisity flow of a vector field along the roman surface of Steiner

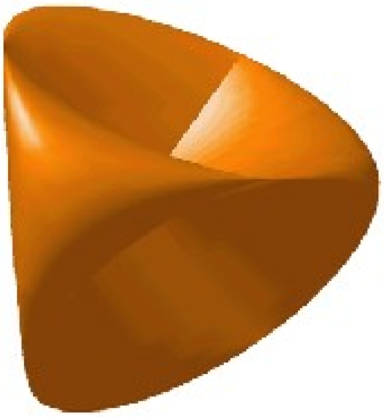

Fig. 1 : the roman surface of Steiner.

The roman surface is defined by the parametric equations

(1) $x(u,v)=\cos(u)^2\cos(v)\sin(v),$

(2) $y(u,v)=\cos(u)\sin(u)\cos(v),$

(3) $z(u,v)=\cos(u)\sin(u)\sin(v).$

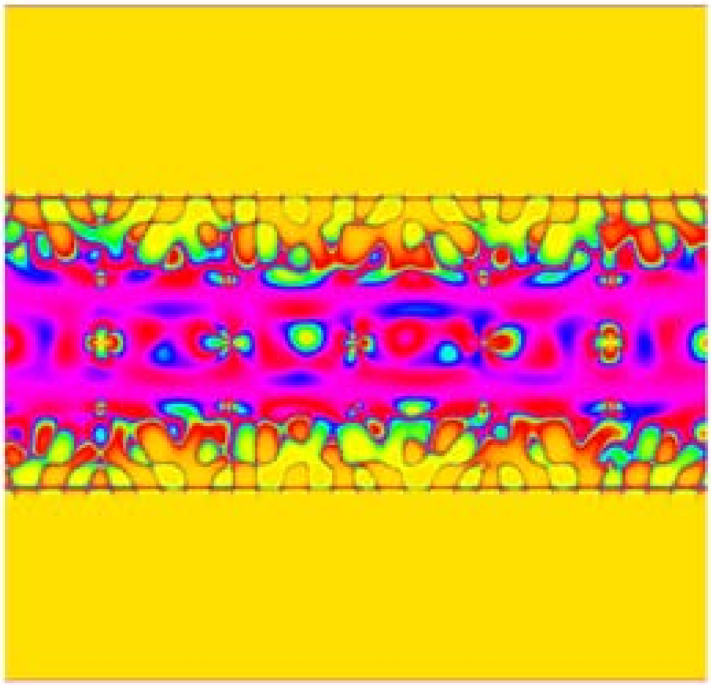

Fig. 2 : densità del flusso del campo vettoriale W

This picture represents the density of the flow of the vector field W with components

(4) $W^1(u,v) = \mathrm{Re}[\sigma(u+iv, \omega_1 + i\omega_2)]$,

(5) $W^2(u,v) = \mathrm{Im}[P(u+iv, \omega_1 + i\omega_2)]$,

(6) $W^3(u,v) = \mathrm{Im}[\sigma(u+iv, \omega_1 + i\omega_2)]$,

where P and σ denote the Weierstrass elliptic functions with fundamental periods $\omega_1=1$ and $\omega_2=2$. The density through the surface is given by

(7) $\rho = N\cdot W\ (g_{11}\, g_{22} - g_{12}^2)^{1/2}$,

where the functions g_{ij} , i,j=1,2, are the coefficients of the first fundamental form of the surface and N denotes the Gauss map. The visualization of the density is obtained by the means of the following “color function”

(8) $CF(u,v) = \mathrm{Hue}(-1/2(1+(1+ \rho)(1+ \rho^2)^{-1}),1,1)$

The program

The program has been written with the software Matematica 5.1.

```
In[16]:= << Graphics`Colors`;
x[u_, v_] := Cos[u]^2 * Cos[v] Sin[v];
y[u_, v_] := Cos[u] Sin[u] Cos[v];
z[u_, v_] := Cos[u] Sin[u] Sin[v];
a := -(7/2) Pi; b := (7/2) Pi; c := -(7/2) Pi; d := (7/2) Pi;
W := {Re[WeierstrassSigma[u + v * ⅈ, WeierstrassInvariants[{1, 2 * ⅈ}]]],
   Im[WeierstrassP[u + v * ⅈ, WeierstrassInvariants[{1, ⅈ * 2}]]],
   Im[WeierstrassSigma[u + v * ⅈ, WeierstrassInvariants[{1, ⅈ * 2}]]]};
Punti := 600
F[u_, v_] := {x[u, v], y[u, v], z[u, v]};
υ[u_, v_] := D[F[u, v], u] × D[F[u, v], v];
Gauss[u_, v_] := 1/√Expand[υ[u, v].υ[u, v]] D[F[u, v], u] × D[F[u, v], v];
g[11][u_, v_] := D[F[u, v], u].D[F[u, v], u];
g[12][u_, v_] := D[F[u, v], u].D[F[u, v], v];
g[22][u_, v_] := D[F[u, v], v].D[F[u, v], v];
Flusso := Evaluate[Gauss[u, v].W (√g[11][u, v] * g[22][u, v] - g[12][u, v]^2)];
CF[2][w_] := Evaluate[Re[1- (1/2) (1 + ((w - 1) / (1 + w^2)))]];
FIG = DensityPlot[CF[2][Flusso], {u, a, b}, {v, c, d}, ColorFunction → Hue, PlotPoints → Punti,
   Mesh → False, Axes → False, Frame → False];
```

Fig. 4: the program

Orme.04 a jam session featuring a computer as an improvising musician

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Abstract

Orme.04 is a musical performance featuring the computer as a percussionist and as an organist. For this purpose a set of intelligent agents have been implemented to interact realtime with human musicians in the context of an improvisation.

1.The musical set

The virtual band is composed of two percussionists (one human and one virtual), an organist (virtual) and a saxophone player (human). The virtual musicians listen to the rhythms and melodies played by human musicians through microphones and the human musicians listen to the rhythms proposed by the virtual percussionist and see the chords sequences decided by the virtual organist on a computer monitor.

The improvisation has no limited duration neither has predetermined musical patterns (rhythms, melodies, chords sequences, global form).

2. The intelligent system

The virtual musicians are part of a larger project developed by Davide Morelli [1] and David Plans Casal [2] : "Frank: an Open Source framework for evolutionary music composition", a set of puredata [3-4] externals initially implementing Todd & Werner's co-evolutionary methods [5] using Genetic Algorithms and at the moment exploring the possibilities given by the usage of graphs to represent musical patterns.

2.1 The virtual organist

This agent is capable of learning which chords sequences I played most fo the times and which I played rarely. After a long enough training session I can ask the agent to build chords sequences in the same style I previously played. It is capable of answering to questions like: "we are in C major tonality, D minor chord, where did I usually go from here?" or even "build a chord sequence of 4 steps starting from G major 7th in C major tonality going to A minor using rarely used chords transitions".

Using an oriented graph in which each node is a chord and each arc is a transition between two chords we can express the probability of each chord transition in a given style. Moreover, choosing relative chord names instead of absolute names (relative to a main tone), we can apply the same rules to each tonality we may want to modulate to.

2.2 The virtual percussionist

This agent listens to the rhythms played by the human percussionist, parse them performing a quantization (reducing it to 32th and 16th triplet notes), group them in family recognizing similar rhythms. The agent is also capable of proposing variations of previously listened rhythms evolving them without losing the connection with the original rhythm.

This agent, like the previous, has been implemented through a graph dynamically built in realtime representing both the memory of played rhythms and a tool to build new ones.

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Generation of Ego Dynamics

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Abstract

In the performance “The Strange AttrACTOR” chaotic dynamics create the suggestion to investigate deeply what happens inside man. The main aim of the performance is to use the stage (and not only the stage) like another possibility to research, experiment and think about man, identity, infinity, art. In this way man introduces the actor, who in turn introduces the Strange AttrACTOR, who revolves and moves in the atmosphere created by particular music (composed starting from dynamic systems – Cellular Automata and Chua’s System -) and figurative representations (Strange Attractors, which emerge from Chua’s Oscillator).

Starting from fixed rules, the performance is “generated” by using the feedback coming from the audience. The metaphor foresees that psychological dynamics are chaotic: sometimes these dynamics are on a steady state, sometimes they are disordered and/or disorganized, influencing behavioural expressions. Music and video dynamics, coming from strange attractors, are present in the performance as well.

1. Introduction

Scientific disciplines are based on the experimental method, which specifies constant laws and mathematical formulas. In the evolution of a physical system it is impossible to determine exactly its future status without precise information about its initial one [1]. In fact any infinitesimal difference in the initial positions between two systems create a wide variance in their development: such kinds of systems are scientifically labelled as “chaotic”.

A “strange attractor” is a particular solution of a chaotic dynamical system, while *The Strange AttrACTOR* (by A. Adamo) is a theatrical performance in which the main character uses the stage like “another dimension” to think about the relationship between man and science and about himself [2]: each man’s daily life can be considered like a dynamical system with two entries [3]: inter-individual (the world) ↔ intra-individual (psychological dynamics).

2. “The Strange AttrACTOR”

Theatre is, among the arts, the closest to life. Some art forms use inanimate materials (colours, stones, and so on), while theatrical art uses the best living material: man with his/her physique, gestures and personality. Thus the performance *The Strange AttrACTOR* introduces a dialectic between cause and chaos, order and disorder, organization and self-organization, becoming a continuous “laboratory of research and experimentation”. In fact the performance was produced in scientific settings (University of Calabria, thanks to professor Eleonora Bilotta, Pier Augusto Bertacchini, Mauro Francaviglia and Pietro Pantano) and was on stage in scientific conferences (for example, “Mathematics, Art and Industrial Culture” Conference, Cetraro – Cosenza - Italy, 19 May 2005), while the conventional theatrical stage was far away.

The scenography of *The Strange AttrACTOR* is a mixture of elements used in scientific laboratories: music is composed starting from discrete (Cellular Automata) and continuous (Chua’s System) dynamical systems and there are videos which show figurative representations emerging from Chua’s Oscillator (Figure 1).

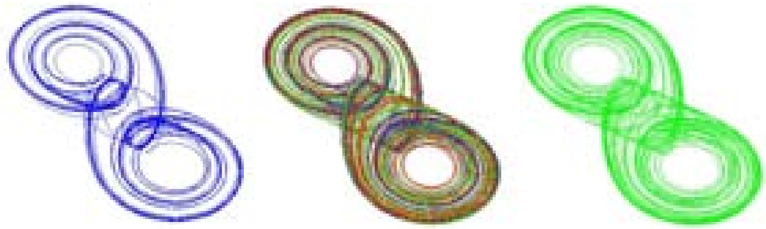

Figure 1. Some strange attractors which emerge from Chua’s System.

In “Mathematics, Art and Industrial Culture” Conference the stage was casually “built” by the audience through “strings” [4, 5], that seemed to outline a precise differentiation between the stage and the audience (Figure 2), but there was no separation. The stage can be generated in infinite possible ways.

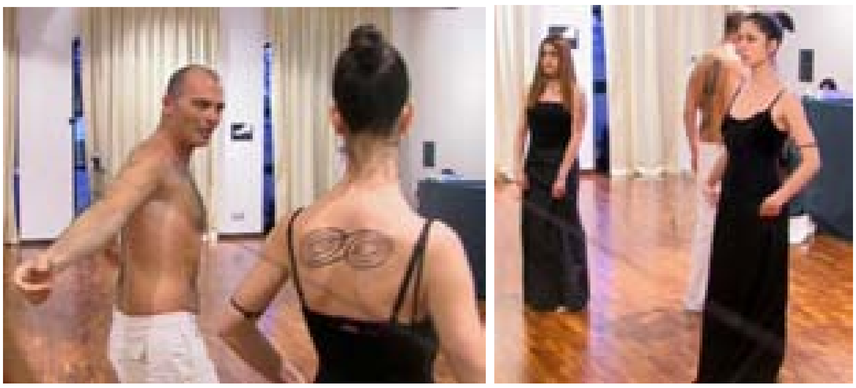

Figure 2. The main characters (A. Adamo, F. Bertacchini, C. Senatore) and the “strings”.

In this way there is not “the fourth walls” and the actor can talk to the audience (Figure 3), inviting it to an active participation in the show.

Figure 3. The "Strange AttrACTOR" (A. Adamo) and the audience.

The audience becomes a key part of the performance, or rather a "part of the observed system" in the oscillation author-actor-character. Thus the performance refers to Pirandello's theatrical works (in particular to *Ciascuno a suo modo*), Von Triar's "invisibile walls" in the movie *Dogville*, and Matte Blanco's "spider web of psychological relationships". According to Blanco [6] every knowledge of the world is a knowledge of relationships: an event is a relationship between two events and a relationship itself, so what we know are only relationships, relationships among relationships, relationships among relationships among relationships and so on.

Scientific elements are also used in the script of *The Strange AttrACTOR* (laws, butterfly effects, initial conditions, strange attractors, and so on). The fragmented and numerous Ego dynamics [7] are generated on the screen (Figure 4) following the splitting and multiplication of different personalities. Reciprocity, exchange and conflict are on stage in a "chaotic order".

Figure 4. AttrACTOR's multiplications (Videomaking by M.G.Lorenzi).

The AttrACTOR invites the audience to change the common way to consider the world, showing himself like a group of parts, like "Uno, Nessuno, Centomila" [8]: Luigi Pirandello wrote that a person chooses a form to look at himself in a coherent way, a single personality, but the others look at him from different perspectives; so he believes to be one for himself and for the others, but paradoxically he is many persons.

3. Conclusions

Thanks to *The Strange AttrACTOR,* science does not look like an austere and unyielding dimension, playing instead with the innovative theatrical language and acquiring the possibility to reach a wide audience. Even if the performance refers to scientific subjects, it is a theatrical performance which derives from the movements of the XX century: its main legacy is an attention to the psychological dynamics [9] and their expression through verbal communication. The recovery of dramatical writing runs in parellel with the link between science and body, gestures as well as man in his totality, for a new “REALTIFICIAL” theatrical art.

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