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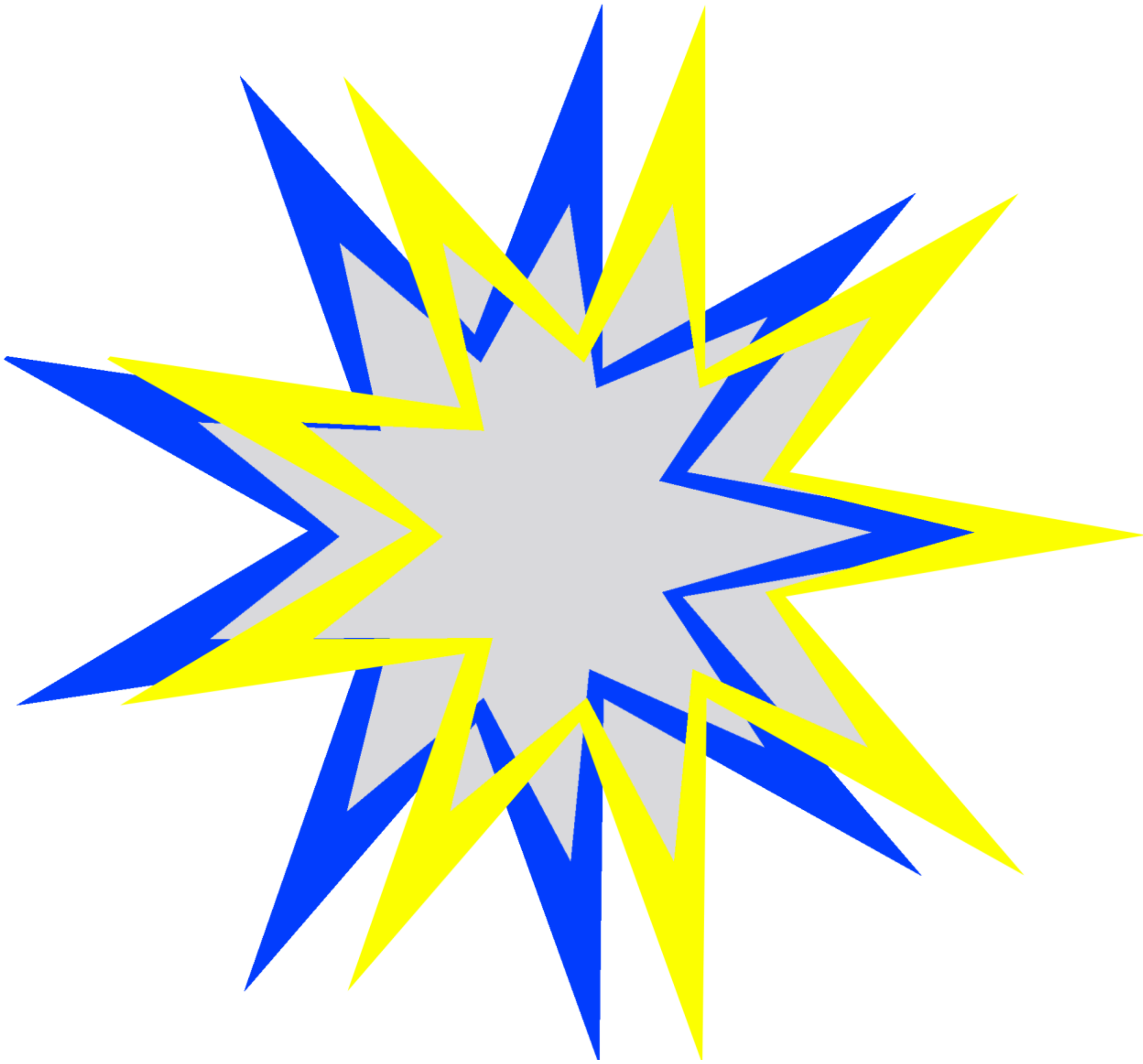

GENERATIVE ART 2009

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Edited by Celestino Soddu
Generative Design Lab
Department of Architecture and Planning
Politecnico di Milano University, Italy

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"...Ars sine scientia nihil est", Jean Vignot, 1392

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„Atalanta Fugiens"
Poland, INIRE

Contributions in the proceedings DVD:

Lello Masucci
Poetry / Final cut
Atelier Multimediale, Italy
Caterina Davinio
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Francesco Martin
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Gordon Monro
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We founded, 12 years ago, Generative Art conference, defining a unique international role for opening a new meeting, able to focus the state of art of advanced approaches to creativeness.
Generative Art is open to all new fields of Art research. The main character of our conference not belongs to pre-defined categories, disciplines and other attempts to build boundaries for limiting exchange experiences. It works, on contrary, for opening dynamically doors in the wall of a fixed scientific power of all the times.
Generative Art is a philosophy, imprinted by the vision of art in imitation of Nature, as mirror of our uniqueness. Unique ad continuum.
Following our tradition of Renassaince, of Baroc and of Futurism, this generative approach is able to create logical processes and not only single results. The focus is that the Idea, structured like an organic code, works by involving logics and technologies and not only is focused for single results. Using advanced and scientific approaches Generative Art really links Science and Art: in each Generative Artworks. It is really difficult to understand where creativeness was applied to Science or to Art. As Leonardo in Renaissance.
The generative processes, as in natural life, need a precedent. So the crisis, developed in the last century from the past to a totally new time, is completely behind.
We are sure that each generative engine defined and developed by an artist is really an artwork. It is not only a technology performing users and not artists. GA engines work generating a lot of possible variations of an artist vision. Variations increase more the performed artist Idea than single possible events. Generative artworks are systems able to run and produce unpredictable and unique events fitting the artist's desires: music, images, 3D models, poetry, literature, movies.
So, Generative Art is the wandering field of creativeness that works for Idea first than event, vision first than object, harmony first than sounds.

Celestino Soddu
Enrica Colabella

(this introduction collects our mixed sentences for the perfectible 12th dimension of GA conference)

PAPERS

Energy consumption as design principle

Aant van der Zee.
Department of Architecture, Building and Planning
Eindhoven University of Technology
e-mail: a.v.d.zee@tue.nl

Bauke de Vries.
Department of Architecture, Building and Planning
Eindhoven University of Technology.

Abstract

In this paper we will outline the development of a design tool, for the early design phase, based on an integral design strategy, with respect to energy-performance and spatial layout. The proposed tool will help the designer to generate a draft that fulfills both criteria and analyze their mutual effect.

Energy consumption reduction is implemented by the government in the Netherlands and many other countries by gradually reducing the energy performance coefficient over the past years. Designers and engineers have adjusted their design and materials such that could meet the new standard. However, up to now this has not lead to dramatic changes in the architectural layout of buildings. We anticipate that at some point substantial changes in design and material use are needed. Our aim is to find this point through the generation of design alternatives for housing as a function of decreasing energy consumption

1. Introduction

After WO-II in the Netherland the "Leitmotiv" in Dutch building industry was mass housing production. There were after the war far too few houses for the Dutch population, so the building industry sought ways to build houses in less time mass production of dwellings. This resulted in the development of the so-called

“doorzonwoning” (see figure 1). It was an easy and fast to build dwellings type, till to today this is still the most build housing type. To reduce the heat loss the cavity layer was partial filled with an insulation material.
Because of the changing climate, energy consumption reduction has now become a hot topic in building industry. Early in the 1994 the Dutch government made a new building code to reduce the energy transmission for buildings and dwellings. The total energy performance of a building is expressed in the energy-performance-coefficient. This coefficient has to be less then 1.0 (for dwellings), the lower the better the energy performance will be. During the following years this index is decreased till 0.75 nowadays. It is our expectation that in the following years the Dutch government will decreased this index further. The building industry will first increase the insulation (more insulation or newly development insulation materials) in the building envelope as an easy way to fulfill the energy reduction constraint. There will come a point at which further increasing of the insulation layer will gain less reduction against substantial extra costs. It is our belief that increasing the reduction energy reduction of buildings cannot continue without changing the layout of the building.

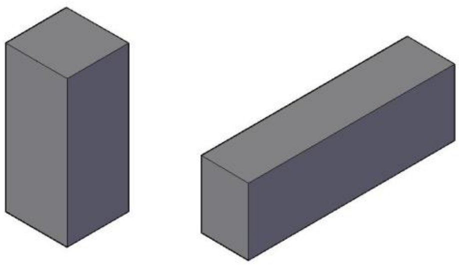


Figure 1.1 Extreme solutions

In this paper we explore the possibilities to use a genetic algorithm in search of new dwelling types which are better suited for low energy housing. This will be done for building blocks, which has as two extreme solutions namely: “row houses” and “high-rise apartments building” (see figure 1.1).

Our approach to Generative Design takes the Dutch building codes and regulations as a starting point. In the following section we will apply our GD system and imply current codes with respect to lighting, energy consumption and minimal requirements for furnishing [4].

2. First experiment

In order to validate the application we use a simple test design project, consisting of 8 rooms, each with a minimum and maximum area. This simple client’s brief is a typical requirement for a Dutch one-family house. The relations and areas of the rooms are presented Table 2.1.

Rooms	Relationship between rooms											
Name	**Min.**	**Max.**		**V1**	**V2**	**V3**	**V4**	**V5**	**V6**	**V7**	**V8**	**B**
Circ.room space	2	10	**V1**									
Entree	2	10	**V2**									
Living	15	40	**V3**									
Kitchen	10	15	**V4**									
Bedroom 1	20	25	**V5**									
Bedroom 2	12	15	**V6**									
Bedroom 3	12	15	**V7**									
Bathroom	5	10	**V8**									
Environment	-	-	**B**									
Total area	78	140										

Table 2.1 Client's brief

The goal of this experiment was to see if it is possible to generate existing housing types [3]. In this experiment we used the above mentioned client's brief as starting point. We used some typical constrains:

1) Relationship between the rooms (see table 1.1);
2) Maximum and minimum area of the rooms (see table 1.1);
3) Maximum number of floor levels (max 3 floor levels);
4) Energy performance (EPC < 1.0)
5) Construction (there have to be sufficient load bearing walls).

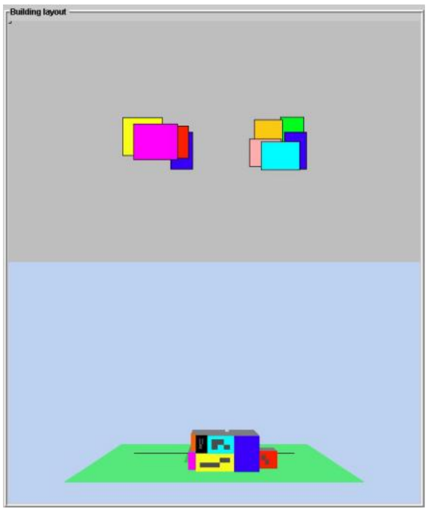


Figure 2.2 A typical solution

Overall the results of the system were not as neatly and smoothly as the examples from practice (figure 2.2). But the Dutch dwellings experiment demonstrates that dwellings can be reproduced from implying building codes.

3. New experiment

Energy consumption reduction is implemented by the government in the Netherlands and many other countries by gradually reducing the energy performance coefficient over the past years. Designers and engineers have adjusted their design and materials such that could meet the new standard. However, up to now this has not lead to dramatic changes in the architectural layout of buildings. Our aim in this experiment is to find this point through the generation of design alternatives for housing as a function of decreasing energy consumption. We start with a normal heat resistance (= 2.5 W/k) for the envelope and let the GA generate shapes that meet the energy performance coefficient given the spatial conditions. Subsequently, the energy performance coefficient will be reduced to study the changes in spatial layout.

In order to generate alternatives, which can be tested against the energy performance constraint and spatial conformances, the design is parameterized. Each dwelling is considered as a volume with a constant volume but different measurements. The overall shape of the building is a summation of volumes (= dwelling). We depict housing, as parameterized apartments, corridors and envelopes. Each of the parameters represents physical, geometrical and topological properties. By systematically changing these variables, the GA [1, 2] is able to generate alternative spatial configurations and envelope sections [5].

In our next experiment we use the same application with a few minor adaptations to the new problem. First of all we will have to adjust the genotype and will use less constrains. For this experiment we will use only a few basic parameters concerning:

1) Shape of the building;
2) Heat resistance of the walls;
3) Number of floor levels;
4) Area of windows in walls;
5) Energy performance of the building (EPC).

In the next paragraph we will briefly discuss the parameters.

3.1 Building shape

The overall shape for the building will be parameterized, into 3 variables namely the width, length, and number of floors. These properties will affect all other constrains.

3.2 Walls

In our model we use calculated mean heat resistance. This needs a translating from out-come to realistic construction.

In the Dutch building regulation the minimum heat resistance for outside walls is 2.5 K/W. If the wall consists of 40 cm fiber wool with a lambda of 0.025 W/(m.K) the heat resistance would be 16 W/k, so if we choose a maximum value 20 instead of ∞ we get a bandwidth for the solution will be is $2.5 < R_c <= 20$.

3.3 Floor levels

Because of the nature of the phenotype it is possible that some floor/floor-spaces do not exists, say, we have spaces on the ground floor, second, third, sixth and eight layer (see figure 3.1 a). In the data model we reorganize the data that need re-ordering to get a consistent model. In that case layers on which the spaces are located are renumbered to become consecutive (see figure 3.1 b).

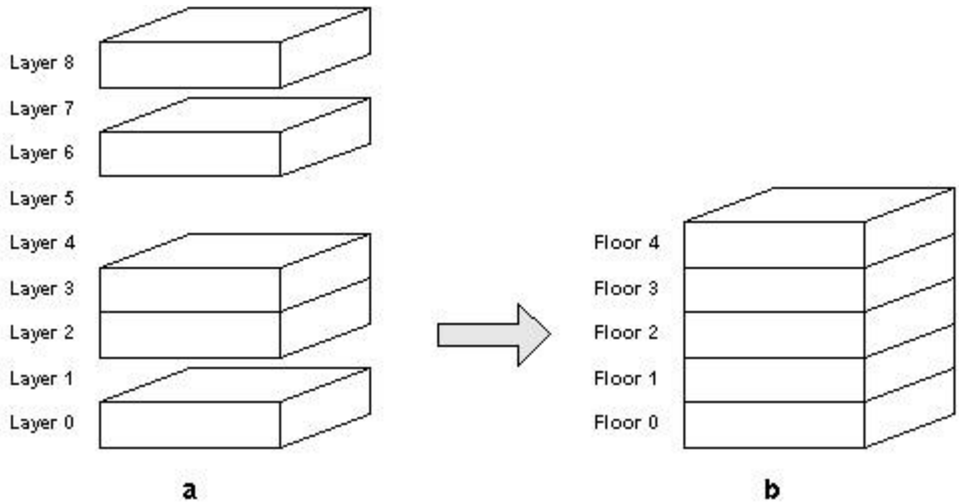


Figure 3.1 Floor layers

In our new experiment we will constrain the number of floor levels to 5.
The solution bandwidth will be 1 <= Fl <= 5.

3.4 Windows

In order to translate a grid from the genotype we translate the genotype-number back into ‘1’ and ‘0’. A ‘0’ corresponds to a closed wall and a ‘1’ correspond to a window. This array is a 1 dimensional representation of a 2 dimension grid, see figure 3.4. In this way there is flexibility in window size, shape and location. Some restrictions are made by

1) A minimum offset from the wall perimeter, so there can’t be a window place at the edge of a wall;
2) A window must be built up from a minimum number of grid cells, this is necessary so there will be no windows with the area of 1 grid cell.

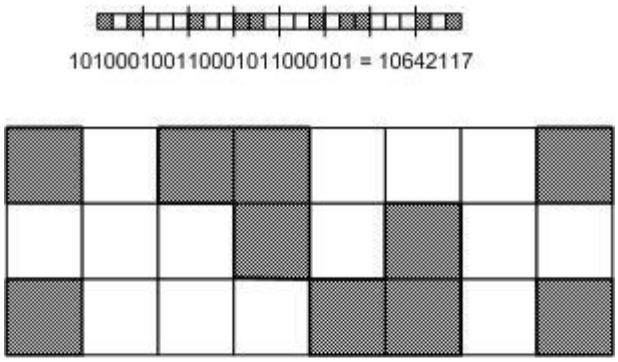


Figure 3.2 Window grid

The number of possible windows solutions is controlled by the grid dimensions. For a draft design a grid of 3 x 8 is adequate. Each grid size has it own maximum number, 2(i+j) + 1, where I en j are the grid dimensions. The maximum number corresponds with a wall made entirely out of glass.

According Dutch regulation every room need to have at least 0.5 m^2 window, and the window area can't be larger then the containing wall. Because of the way we designed the window this is impossible.
The bandwidth of the solution will be: $0.5 <= A_{win} <= A_{wall}$

3.5 Energy performance objective

In the Netherlands the energy performance of a building is calculated according to a national norm [3]. This norm provides the terminology and calculation methods of the energy performance of dwellings. The energy performance (Q_{pres_tot}) is a function of the total outside area of the enclosures, the heat resistance of the used material, window orientation and area, used heating installation etc. The total energy performance of a building is expressed in the energy-performance-coefficient. The objective is that this coefficient (EPC) is less then 1.0, the smaller the better the energy performance will be. It is our understanding that this objective will (indirectly) decrease the total area of the outside enclosure.

$$EPC = Q_{pres\_tot} / (330.0 * A_{g\_verw} + 65.0 * A_{verlies}) \qquad \text{eq. 1}$$

Where:

Q_{pres_tot}	Characteristic energy consumption of a building	A_{g_verw}	Total 'living' area
EPC	Energy performance coefficient	$A_{verlies}$	Total heat loss area of a building

The solution bandwidth will be $0 < EPC <= 1.0$

3.6

The experiment will consist of several runs of the application. For each run the EPC value will be decreased by 0.25. The application has to find values for the other parameters, as there are: building shape, heat resistance of the walls, number of floor levels, windows area in the walls, to fulfil the EPC constrain, each of this set values can be decode into a building shape. In this way we can see what typical solutions are for a specific EPC value

4. What can expect

We hope to establish prove that by decreasing the EPC-constrain there will a turning point in the layout development of low energy housing.
We hope to see that the shape will slowly grow into a cube. However it won't be a perfect cube because of the fact that the ground floor has a better heat resistance then walls. To gain as much as possible positive influence of the sunlight, the windows will be located mainly in the south façade.

But what ever the result will be the GA has proven to be a valuable tool in building research.

5. Further experiments

After this experiment we will investigate what the influence will be of the spatial layout of the city on the energy reduction of dwellings.

Therefore the genotype must be extended to "hold" more buildings then the one in our former experiments. And there has to implemented a new constrain which deals with the influence of the shadows casting on dwellings by nearby buildings.

References

1. Goldberg, D.E. (1989) Genetic Algorithms in Search, Optimisation and Machine Learning, Addison Wesley, 1989.
2. Holland, J, "Genetic Algorithms", Scientific American, Where, 1992
3. NEN, Nederlands Normalisatie Instituut: 1998, NEN 5128, Energy performance of dwellings and residential buildings - Determination method pub; Nederlands Normalisatie Instituut.
4. Vries, de B. , Zee van der A., Carp, J. () Dutch Dwellings, in Celestino Soddu(ed.): Proceedings of the 7th International Conference on Generative Art 2004. Milaan. pp. 50-58.
5. Zee, van der A and Vries, de B (2003) Evolutionary development of early stage design alternatives for buildings, in B.Tunçer, S.Özsariyildiz and S. Sariyildiz (eds), E-activities in design and design education, Europia Productions, 2003, Istanbul. pp. 211-220

A Window to the Emotions

A. Echeverría Rey, PhD
Universidad Autónoma de Madrid, Department of Computer Science, Spain
www.ii.uam.es
e-mail: alejandro.e.rey@gmail.com

R. Rojas Bello, MCS
Universidad Autónoma de Madrid, Department of Computer Science, Spain
www.ii.uam.es
e-mail: rrojas7@gmail.com

Abstract

Nowadays, psychologists classify the emotions into discrete categories in a common and universal language. The simplest category is composed of six basic emotions resulting from cross-cultural studies: happiness, sadness, fear, anger, disgust / displeasure and surprise. This work presents a new paint generator which uses facial feature extraction and analyzes most important face's contours to infer expressions with different degrades of intensity. These measurements conform the basis to create personalized (both in colour and design) generative paintings from the emotions detected earlier. Each emotion is reflected in a set of colours and shapes applied to a group of points drawn in a canvas using RGB colour palette. The resulting paint represents the user's facial emotion along a temporal axis. It is generated from a non-repeatable seed by means of complex transformations producing unique results. All of them have its own identity and are recognizable by the creative concept introduced in this work.

1. Introduction

A generative art algorithm could be divided in three parts:

The first one is the *generative seed* of the algorithm which could be random, pseudo-random or a natural observation. In this case, we will use the user's face expressions to feed the algorithm. The relation between vision and forms is introduced in section 2. Section 3 is devoted to the representation of emotions and expressions and the complete extraction process is detailed in section 4.

The second one is the *transformation engine* which makes complex changes over the initial values. In this case, we will use a set of rules which is described in section 5.

The last one is the *generative product* which could be paintings, music, sculptures, etc. Since our approach generates paintings, this is why section 6 contains some representative painting examples of canonical expressions.

One of the most important tasks for a generative algorithm is to maintain its identity, which could be generated in the main parts of the algorithm: the *generative seed* and the *transformation engine*. In the case of our algorithm, its identity comes from both parts.

In section 7 we describe the application created to test the algorithm. And in section 8 we can find the conclusions and the future work of this paper.

2. Vision and forms

Obtaining forms can be approached as a way to establish a relationship between an image in a 2D coordinate system and an object in a 3D system. To solve the problem computationally there are two directions: top-down, bottom-up [1].

The top-down strategy starts of a set of assumptions and expected properties based on expert knowledge [2], these properties are checked successively in each stage of processing up to the image data. Moreover, the bottom-up strategy is the proposal made by David Marr [2] [3]. Marr defined the process of object detection using a computational approach, in which the visual system is like a computer programmed to receive objects; their operation diagram is as follows:

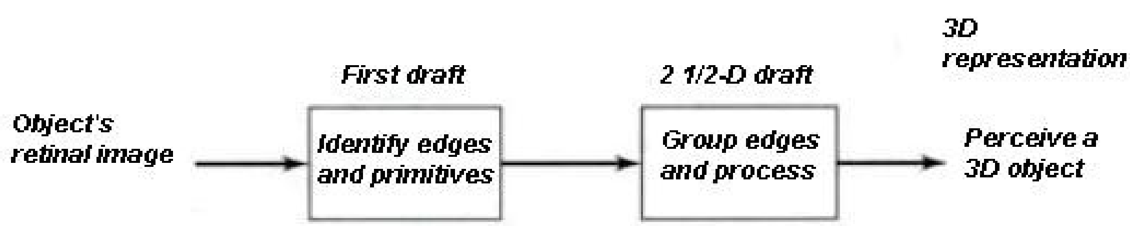


Figure 2.1: *David Marr's computational approach [2].*

In Figure 2.1, the starting point is the image of the object on the retina, the image is analyzed to identify areas of light and darkness and the parts that the intensity changes. The analysis result is a series of basic characteristics (closed areas, segments of lines, ends of lines and lines that define edges) called first draft. Then the contents of the first sketch is grouped according to size and features of similar guidelines, the result is processed again, and a new sketch - called 2½D - that ends in a three-dimensional perception is achieved.

3. Emotions and expressions

Information extracted from the facial features is regularly geometric character (associated with forms of eyes, nose, mouth, and location corners of the mouth or eyes) and related to the appearance or texture (wrinkles, furrows and protuberances). These are the bases of emotion recognition, which has grown particularly in the field of HCII (Intelligent Human Computer Interaction) [4] [5] [6] [7] [8], and it's focus of interest in the support of psychiatric and psychological diagnoses [9] [10] [11] [12].

Nowadays, psychologists classify the emotions into discrete categories in a common and universal language. As we can see in Figure 3.1, the simplest category is composed of six basic emotions resulting from crosscultural studies [14] [13]: happiness, sadness, fear, anger, disgust/displeasure and surprise.

To quantify and classify these basic emotions FACS model - proposed by Ekman and Friesen (1978) [15] - attempts to address the lack of metrics for classification of basic emotions with a series of points to note in the face. It is almost a standard when it comes to classification of facial expression and is present in the research area of psychology and in the area of 3D animation [16] [17].

Figure 3.1: *Faces expressive of the emotions anger (A), surprise (B), disgust (C), sadness (D), happiness (E) and fear (F) from the collection made by Ekman and Friesen [Ekman00].*

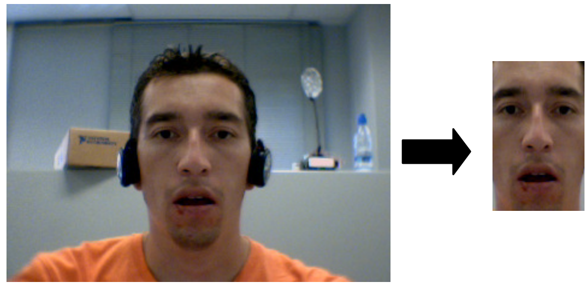
FACS describes all visual activities based on only 46 action units (AUs), moreover several categories of head and eye positions and movements. Importantly, although FACS arises in anatomy there is no 1:1 correspondence between muscle groups and the AUs, this is due to the fact that a muscle can act in different ways - or contract in different regions - to produce different visible actions. A clear example of this are the frontal muscles, the contraction of the middle of them only raises the inner corners of eyebrows (producing AU1) while contraction of the lateral frontal raises the eyebrows from their side outer (producing AU2).

4. Extracting features

Our algorithm to extract the characteristics of a facial expression is based on contour extraction and morphological operators. This approach was presented in a Master Thesis Project [18] and is defined - in general - on the following stages:

• Capture a frame from a video or camera.

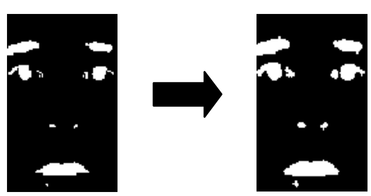
• Locate and remove a sub image from the frame and get only the face to be analyzed1.



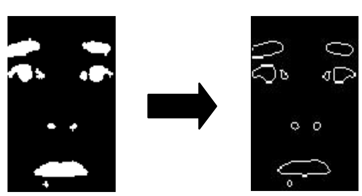
• Convert the facial image to greyscale.

• Binarize the sub image by setting a threshold over which the pixels grey level exceeded X are all black and all white under the threshold.

• Apply the morphological filter dilate on the binarized image. Then, we get an image with accentuates eyebrows, eyes and mouth.



• Apply *Canny edge detection algorithm* [19].



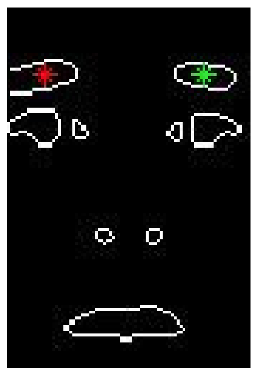
[1] This task is performed by the AdaBoost classifier over Haar features. This is part of the public distribution OpenCV libraries and a compiled version for use in Matlab. http://www.mathworks.com/matlabcentral/fileexchange/19912

• Delete smaller objects that do not exceed a threshold number of pixels that may define the objects.

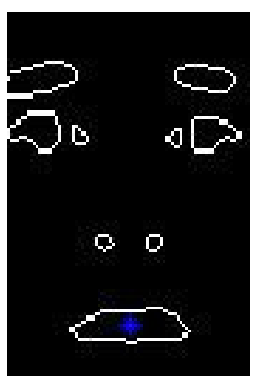
• Joining line segments broken by bridge operator.

• Label the remaining objects individually and calculate their centroids.

• Locate the two less distant objects to the X-axis (according to coordinates of the picture) and identify them as eyebrows. The coordinate axis will always have its origin at the upper-left pixel of the image.



• Locate the object with the largest area in the bottom of the picture and identify it as the object that represents the mouth.



To measure the expressions we focus the attention on AU1, AU4, AU26 and AU27 of FACS, as we can see in Figure 4.1

***Figure 4.1:** AU1, AU4, AU26 and U27 respectively.*

And we classified the expression using this criterion:

	>=4 objects	2 objects	Opened mouth	Closed mouth	Center of eyebrows up	Center of eyebrows down
Anger			X			X
Surprise	X		X			
Disgust		X		X		
Sadness				X	X	
Happiness		X	X			
Fear	X			X		

***Table 4.2:** The image has divide in two equal parts, upper and bottom.*

In order to measure the intensity of the expression we analyze degrees of inclination on eyebrows, mouth aperture and number of objects detected in the face.

5. The painting process

The system makes use of existing associations made between groups of colours and expressions [20] using the Colour Image Scale, developed by Shigenobu Kobayashi in 1981 [21]. In figure XXX we can see some representative examples of colour combinations which will be used by the algorithm to paint the user's emotions

***Figure 5.1:** Representative examples of the three-colour combinations for emotions with the images associated with similar colour co*mbinations in Kobayashi's Colour Image Scale

The painting process is inspired by the so called *Blind Paintbrush* [22], using a group of points which move along a 2D canvas changing its colour and position depending mostly on face measures obtained from the user as explained earlier. The intensity of the colours will change linearly during the process, starting from dark and finishing with light colours. These changes create cloud-like results recognizable in all paintings generated by this algorithm.

Those points change it position by means of jumps. Intense emotions, such as anger and disgust, make small jumps and smooth ones, such as happiness and sadness, make greater changes in their position. After a number of iterations, this will lead to sparse results for smooth emotions, and dense paintings for intense ones.

The direction of each point will be determined by the input too, allowing free changes of direction when negative emotions, and minimizing it with positive ones. It will produce more cloud-like forms in the first case, and sharpened forms in the second case.

The binary information contained in the contour matrix obtained in the extraction process will be used as a mask (adding or subtracting a small constant to both colour and jump size values) in order to add some extra user identity to the painting.

Mouth aperture determines de number of points which will draw during the painting process, and the main initial position and direction will be determined by the information obtained from the eyebrows inclination.

Small random values are added to all parameters in order to increment the number of iterations for the whole process (initially fixed).

The identity of the generative algorithm comes from three sources: first of all, the contour binary matrix. Second, the colours and shapes generated by means of the user emotions. Lastly, the linear colour intensity change (from dark to light).

6. Some examples

This section contains some representative painting examples of canonical expressions. Figure 6.1 shows the resulting painting from a happiness face, in which we can see green colour (one of its representatives), and big jumps with small changes of directions in some points. Figure 6.2 shows sadness expression by means of sparse structure with grey-blue colours. Figure 6.3 shows the resulting painting from a surprise face, in which we can see pink colour and big jumps with small changes of directions in some points.

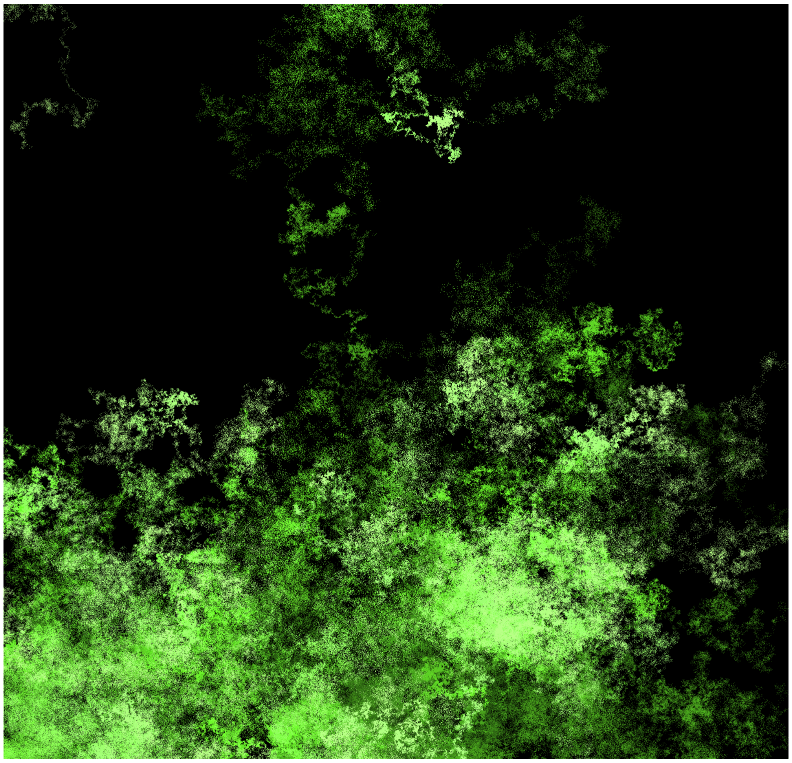


Figure 6.1: *Example of a painting generated by a happiness expression.*

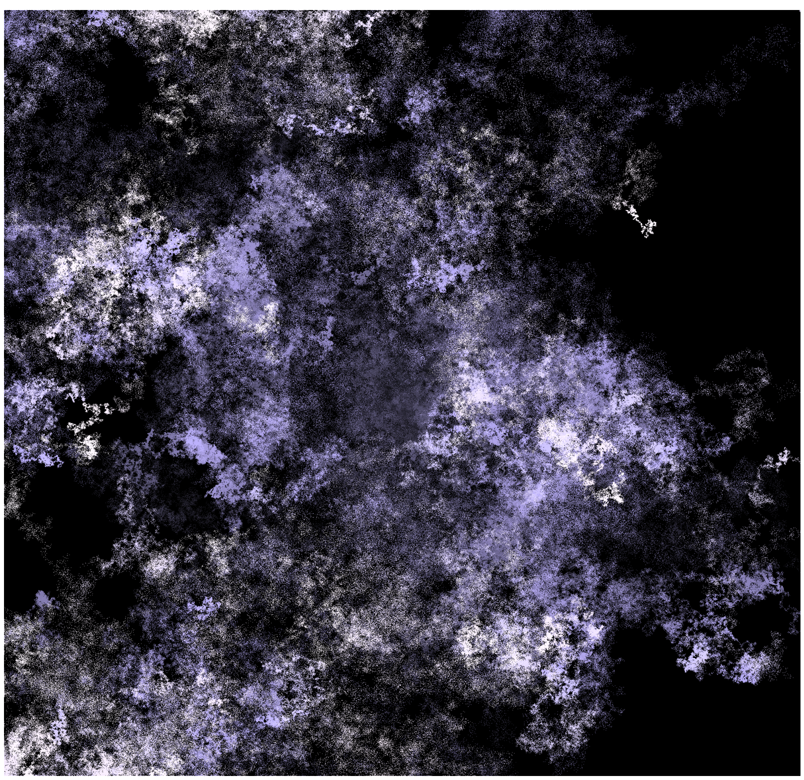


Figure 6.2: *Example of a painting generated by a sadness expression.*

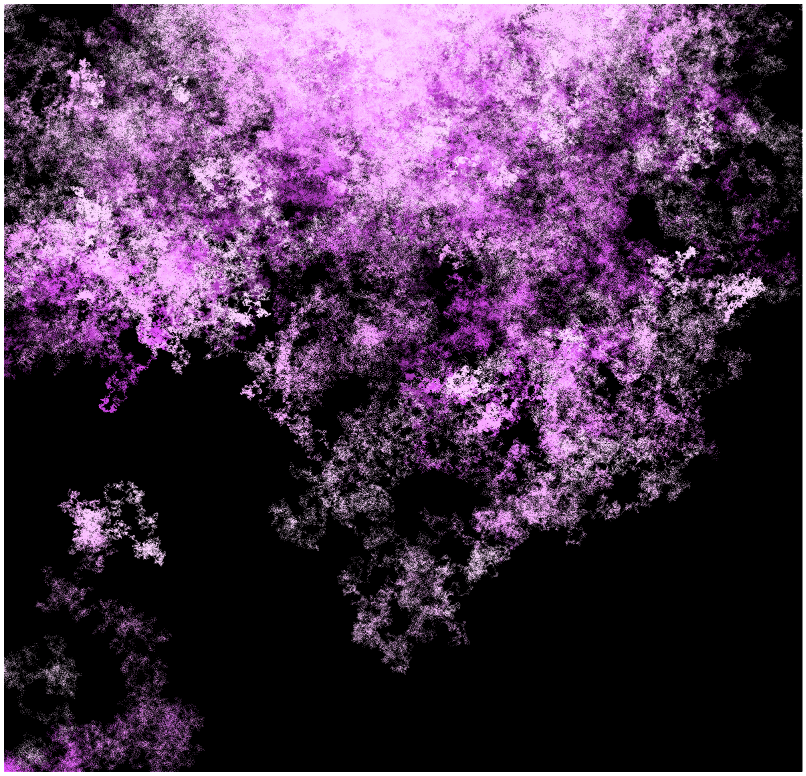


Figure 6.3: *Example of a painting generated by a surprise expression.*

7. The application

The application to test the algorithm consists of a window with two panels, as we can see in Figure 7.1. The upper one shows the video capture during the recording process. And the lower panel is used to show the resulting painting when the generative algorithm ends. It needs an initial recording to capture a neutral expression in order to compute measure differences during the process using those base values. It's a two step algorithm: firstly it extracts the expressions, and later it generates the final painting.

8. Conclusions and future work

This paper proposes a generative algorithm to generate paintings starting from facial feature values representing degrades of expressions intensity by means of contours matrices. These measurements conform the basis to create personalized generative paintings from the detected emotions, each one reflected in a set of colours and shapes applied to a group of points drawn in a canvas using RGB colour palette. The resulting painting represents the user's facial emotion along a temporal axis. It is generated from a personal and non-repeatable seed by means of complex transformations producing unique results, but with an identity.

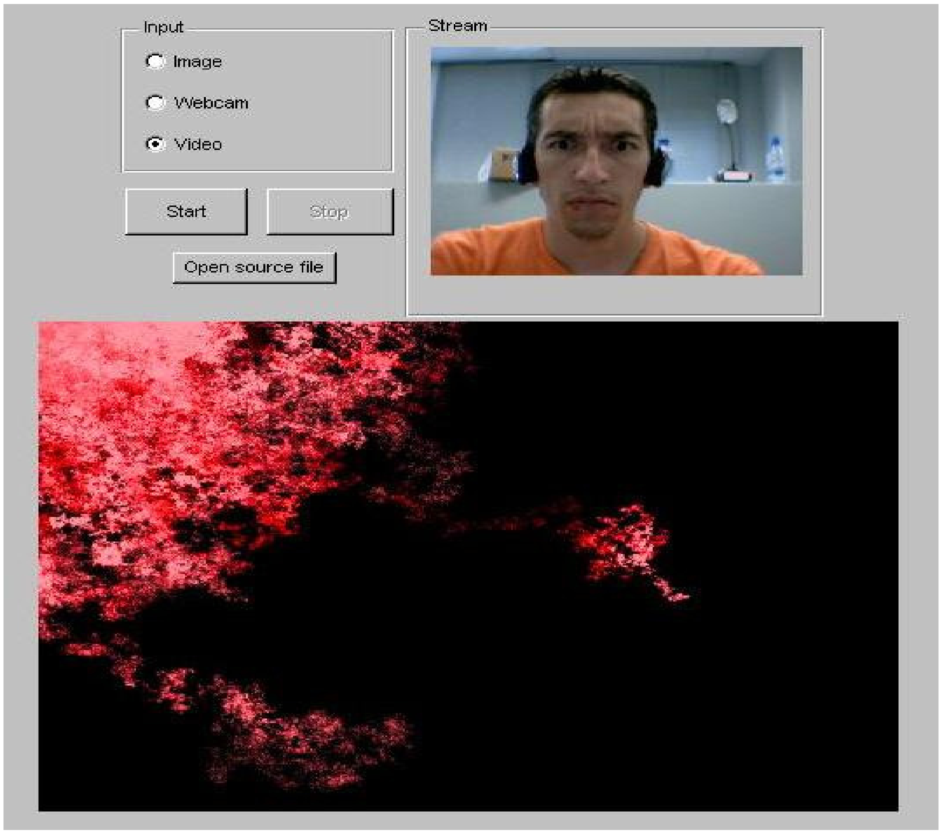


Figure 7.1: *Example of a painting generated by an anger expression.*

One possible future work is to incorporate the identification of micro-expressions which bring us closer to the detail of the expression by monitoring muscle movement. In this case it could apply an AAM (Active Appearance Model) or an ASM (Active Shape Model) to obtain more detail of what the eyes, eyebrows, cheeks, mouth and forehead are expressing. Thus the parameters and the paint generated from the face would be more accurate.

The painting process could be improved too creating a more complex set of transformation rules and changing the way of obtaining the identity of the algorithm. Other *generative products* could be investigated, such as music or text.

References

[1] Pajares, G.; de la Cruz, J., Visión por computador, Ed. Ra-Ma, 2ª Edición 2007.

[2] Marr, D., Visión Una investigación basada en el cálculo acerca de la representación y el procesamiento humano de la información visual, Ed. Alianza, 1985.

[3] Goldstein, B., Sensación y percepción, Ed. Paraninfo, 6ª Edición 2006.

[4] Sun, Y.; Sebe, N.; Lew, M.; Gevers, T., Authentic Emotion Detection in Real-Time Video [Online], Procs. of the Computer Vision in Human-Computer Interaction, pp.94-104 Vol.3058 2004.

[5] Jaimes, A., The Face in Activity Analysis and Gesture Interfaces [Online], Procs. Computer Human Interfaces 2006, 2006.

[6] Branco, P., Usability Indicators - In Your Face [Online], Procs. Computer Human Interaction, 2006.

[7] Chatting, D.; Thorne, J., Faces as Content [Online], Procs. Human Computer Interaction, 2006.

[8] Lyons, M., HCI and the FACE [Online], Procs. of CHI 2006, April 22–27, 2006, Montreal, Canada. pp.1671-1674 , 2006.

[9] Machado, P.; Beutler, L.; Greenberg, L., Emotion Recognition in Psychotherapy: Impact of Therapist Level of Experience and Emotional Awareness [Online], Journal of Clinical Psychology pp.39-57 Vol.55, 1999.

[10] Martínez, F.; Montero, J.; De la Cerra, J., Sesgos cognitivos en el reconocimiento de expresiones emocionales de voz sintética en la alexitimia [Online], Psicothema 2002

[11] Browndyke, J., Neuropsychosocial factors in emotion recognition: Facial expressions [Online], Telepsychology Solutions, 2002.

[12] Pal, P.; Iyer, A.; Yantorno, R., Emotion Detection from Infant Facial Expressions and Cries [Online], Procs. IEEE International Conference Acoustics, Speech and Signal processing, pp.721-724 Vol.2 2006.

[13] Ekman, Paul., Universals and cultural differences in facial expressions of emotion, Journal of Personality and Social Psychology Vol.4 Nº53 pp.712-717, 1972.

[14] Zhihong, Z.; Maja, P.; Roisman, G.; Huang, T. S., A Survey of Affect Recognition Methods: Audio, Visual and Spontaneous Expressions [Online], Procs. of the 9th international conference on Multimodal interfaces, pp.126-133 2007.

[15] Ekman, P.; Friesen, W., Facial Action Coding System, Ed. Consulting Psychologists Press, 1978.

[16] Curio, C.; Breidt, M; Kleiner, M.; Vuong, Q.; Giese, M.; Bülthoff, H., Semantic 3D Motion Retargeting for Facial Animation [Online], Procs. 3th Symposium on Applied perception in graphics and visualization, pp.77-84 2006.

[17] Wojdel, A.; Rothkrantz, L., Intelligent system for semiautomatic facial animation [Online], Proceedings of Euromedia'2000, 2000.

[18] Rojas Bello, R. “Identificación de características relevantes para reconocimiento de emociones en el rostro”, Escuela Politécnica Superior, Universidad Autónoma de Madrid, 2009.

[19] Canny, J.F., A computational approach to edge detection [Online], IEEE Transactions on Pattern Analysis and Machine Intelligence Vol.8 Nº6 pp.679-698, 1986.

[20] Da Pos, O. and Green-Armytage P., Facial expressions, colours and basic emotions, Colour: Design and Creativity, 2007.

[21] Kobayashi, S., The aim and method of the Color Image Scale, Color Research and Application, 6, 93-107, 1981.

[22] Echeverría Rey, A., Blind Paintbrush, ArtEscapes’07 - Variations of life in the media arts. Exhibition. Universidad Politécnica de Valencia, 2007.

"VR"_the simulacrum of a personal Imaginary

Anabela Costa
Visual Artist, Independent Filmmaker
www.anabelacosta.com
translation to english by: Francisca Salgueiro
e-mail: anabelacosta@msn.com

"VIRTUAL WORLDS"

Imaginary Worlds – Imaginary Realities

Imagination is an essential human characteristic which has been expressed through many different forms. We have seen it applied in all cultures over the centuries, through visual or literary forms. Related to religion, fiction or mythology it is definitely present in our daily lives, since the beginning.

We have many examples of artwork that put on view the ability that people have to create virtual worlds that distance themselves from the reality of the time in which they were created. Those pieces launch us to parallel and alternative realities: virtual realities which, somehow, we share with its author. Such as in science fiction, since the genre is defined by the projection of the narrative in the future. The fictitious reality of the piece remains a personal conjecture of the author, considered an unthinkable realty of implementation. Its contemporaries perceive this reality as a creative delusion, impossible to attest.

Virtual worlds, whatever the creative form may be (text, painting, sculpture, drama, cinema etc…), have always existed. They can be shared or individual and they have always put together a brief imaginary universe that communicates with our own personal or collective reality. Creating foreign worlds gives us the opportunity to be transported and freed, in some way, we are offered a chance to learn and recreate ourselves.

Imagination is an open process, a work in progress, constant and dynamic. It turns reality into something imaginary but more real all together 1 (pp.29). This new reality is where all sorts of trades may come about, allowing new alternatives in a featured and boundless space. **It is a place of "becoming", where yesterday leaves a mark of a past which leaves knowledge for the present, while this learning process shapes the future which belongs to tomorrow that turns into today, it is no longer the same as yesterday's today.**

The human kind has this ability to adapt, lead, and to transcend through the acquisition of knowledge of multiple order. The area of the imaginary is a place of latency. In this process, this space with which we live on a daily basis performs an overlap of different levels and types of realities, which inter-communicate and inter-depend.

We are used to relate the term "virtual" to the absence of existence, precluding the veracity of it because it is not part of the tangible world. The same connotation is given to “virtual worlds”, considered unrealistic and therefore lacking of existence; they are usually exclusively connected to technology. For my part, I find it an erroneous conclusion. In this case, the definition of a virtual world, as opposed to an actual world, would be the most proper one, seeing that the virtual character comes from its fictitious nature. However, the propriety of a virtual unit is precisely its propensity to be updated, which brings on a shift to the actual present even if only by a few minimum elements.

Instead of opposing the two notions, we should add to the concept of “real world” the idea of “possible worlds” where, unlike in those virtual worlds, **experience can be possible**. Therefore, its contribution to our- personal or collective – knowledge is also real and it is assimilated and integrated to our daily lives, since they allow the establishment of **psychological experiences** which cannot be eluded by the human conscience.

Image, Imagination, Experimentation, Interaction

A virtual world ends up being a world of “imagining”, allowing a "possible world" that gives us some sort of freedom. A **world of “imagining”, a**"possible world" **is a freedom place** and **imagining** is a **measure of freedom**. Films are one of the many means of representing virtual worlds: they tell us stories, imagined realities like any other literary or pictorial support; they create imaginary worlds where they cross imageries, worlds that stand as places of unlimited possibilities. We notice that the development of *virtuality*, nowadays goes together with technical development. Cinema provides a realistic quality to the representation because it employs movement or time, taking on a more organic representation of concrete elements like people, animals or objects which move through the projection of light on the surface of the screen. Its moving image has a crucial importance in the development of what we call today *Virtual Reality*. The scientific and technological developments allowed the creation of images that flood our daily lives, and systems that lead us to the illusion of movement, by taking advantage of scientific data. Thus, the moving image culture can be regarded as essential to the contemporary expression.

In this day and age, we have pictures everywhere to the point that it has become a common place; the ordinary man sees himself surrounded by images which he can easily use and produce. We have it continuously on our computer screens, on our television, pictures overrun the commercial items from the bags given to us in shops to the yogurt packages in the supermarket. Nevertheless, despite the several calls for attention, as in the famous –almost *cliché*- painting of Magritte ***Ceci n'est pas une Pipe***, we still take the image for the object itself. This is a notion which has been the center of discussion since the time of ancient Greece in Plato’s philosophy, in particular. The representation has yet again obtained this dimension of a real element; it has once more been reified. We notice that if often people instinctively deem that the representation is the real object, the fact that we add motion to it only emphasizes that illusion, though usually the purpose of the utilization of images today, and particularly the image in motion, seems precisely to be deceiving the viewer and leading him to believe in the actual veracity of the representation. This concerns mostly the contemporary television programs where the success of a show can significantly depend on a true involvement of the viewer with the reality of it.

The worlds of technological expression, called *virtual worlds*, rely on image and imagination which allow and implicate experimentation and interaction. The need for the visual component in our worlds, including the virtual ones, has given rise to different and increasingly complex environments. These environments are only possible with the development of *softwares*, the 3D representation for example, which are very much necessary. This turns the virtual environment into a world whose representation acquires a realistic character, where concrete details of the physical world may be integrated such as mass, acceleration, friction, light or time.

New fields of investigation have emerged, saving the same image support, which may be used by artist as well: *augmented Reality* or *immersive Virtual Reality*, where the user gets immersed in a visual environment totally generated by the computer which may be a complete sham, a fantastic world. The environment will always be artificially generated by the machine, and you will feel as a component of the universe of immersion, where you can interact. The interaction may be an action as common as clicking the mouse or the keyboard of our computer, giving instructions to which the machine responds.

Interaction is a flow; therefore it can be used in the most diverse forms as means of artistic expression. In the artistic field, the main function of interactivity is the relation between the public and the artwork whose content they should be able to transform; hence, the public contributes to the construction of the art piece. This is made possible and easier, with the introduction of **new technologies** that will ultimately lead to the raising of new issues such as the participation of each individual in the work in question. In short, there will ultimately be a need to **reposition the artist, the work and the public**, giving the work a more dramatic side, risking in some cases the reduction of the piece to just that- a show, empty of substance. In Immersive Virtual Reality, interaction is an essential feature to the concept of immersion, achieved by projecting the 3D image inducting the space-time unit such as the surround system. The experience is visual and sonorous; real / imaginary and objective / subjective, physical and mental. Immersive reality makes the imaginary even more real by adding a sensory perception. Within these new contexts, the notions of public and private space, interior space, and outer space comes eventually to a significant change.

ANIMATION CINEMA_ MY APPROACH

Interior space, Experimentalism

Thoughts are full with movement since dynamism makes an essential part of life we always live between the expected and the uncertain. It is natural that the creative process will take place in that dynamism since it consists on a mental process: a swing that connects experience and conscience and, also because the dynamic nature of the construction of a mental image, like plastic expression of language itself, necessarily triggers a kind of movement of the spirit. If "To look is to seize myriad movements at once." 2 (pp 53), then the fruition of the artistic object is also movement when it opens a space of "multiple possibility" " 3 (pp. 299). In a work said of experimental artistic research, the purpose of the creative course resides in the definition of the concept -giving shape to it- as well as in the construction path itself via the absence of a pre-determined. That creative process is only possible inside each creator's interior space. It is a space of high energetic potential; it is a site of more or less conscious dreaming, of intuition and emotion: an area of an inner being dimension- vast and mysterious. It is consequently a place of interaction where everything is at stake. That is the place where all thoughts and dreams are born and where they see themselves convert into imaged, virtual ideas. Logically, their origin is located in the inner and psychic reality, and they are developed by dint of a mental desire of creating those imaged ideas. That same desire allows us to navigate between our interior space and the world around us, operating the symbolic that the image reflects and suggest itself. On the way of creation, we are given a succession on multiple chances and choices that eventually will turn into final goals. The key is then to recognize and transform them; transformation is the raw material. It is as if somehow the product under construction would grow through the gain of its independence, growing in self-construction.

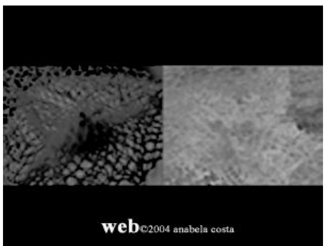
Art, Science and Technology

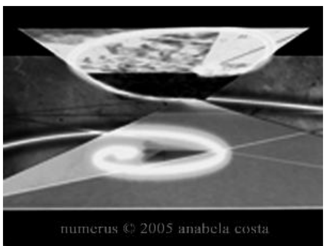
If the artist dwells integrated in society, in constant observation, he ultimately ends up being a reflection of it. We live in a moment of human evolution where mobility is of crucial importance in the context of a globalized world. It determines the human survival today; this is a fact that has been made evident by the global financial crisis. This mobility and an irreversible adaptability permit individual and social changes, letting us see the singularity of what is created during the process of transformation: a new possible .

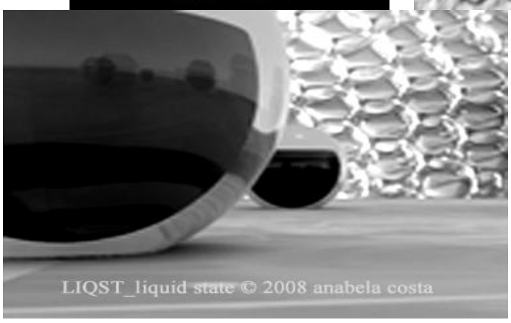
The effervescence of the mental process often leads to a crossing of information from different areas. If we instinctively perform a crossing of information and knowledge from several areas, within the contemporary context of the understanding of the world and its evolution, the isolation of the arts and sciences, knowledge in general, would be a considerable loss. More willingly will this fusion of knowledge lead to new discoveries and other understandings. Transdisciplinarity is an old necessity of the human kind, seen on Leonardo DA VINCI for instance. It requires a fusion of knowledge but also of content. It is necessarily a creative practice itself, and naturally rich in these areas of expression, where we use a lot of information, from a technological background to a conceptual one. In my practice, science and plastic expression are closely linked, in various ways and for many reasons. The creative process- fluid, flexible and random- and irreversibility are central and crucial factors for its development; including change, which is the engine of the creative process, while the connection between consciousness and experience, between the conscious and unconscious, and awareness of the creative process give articulation that leads to cohesion of expression.

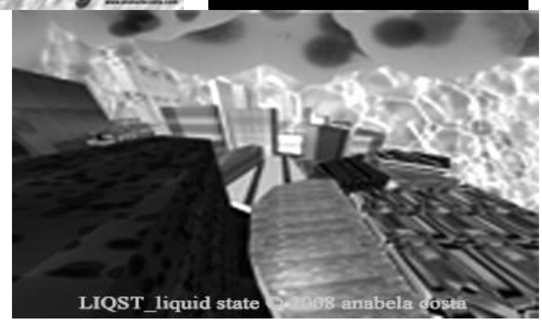
A few years ago I felt the need to add motion to my practice; it led me directly to film animation. However, my expression is not figurative, and the construction of movement through the systematic repetition of previously made designs, such as in classical animation, seemed quite limiting and not very interesting to me. In an attempt to resolve this restriction, I was drawn to the new technologies related to digital animation: 3D representation, special effects and editing. At this time of my artistic journey I am, almost exclusively, linked to the use of digital technologies to give shape to my thoughts. I rarely use the manual gesture for my plastic creations. Representation in 3D has always been familiar to me as I had an academic sculpture education. I have always thought it obvious to see it evolve along with new technologies. Today it is a scantling tool of unlimited possibility. The times of Fine Arts, where many sketches were needed to define the 360 degrees of the object we had imagined, seem very distant now.

From that necessity, I sensed right ahead, in my first work, the power of the relation between space, movement and time that had not been tried out until then. I was immediately captivated by the prospect of working the different changes of space-time scale.









Time-Movement

Scientific research has significantly contributed to the systematic redefinition of what is REAL and what is not, with the discovery of new adjusting and constructing REALs. The “scientific real”, which is constantly changed by the succession of scientific discoveries, brings in new concepts of several areas. It is the process of adjustment that is carried out through the construction of new realities, ranging from the infinitely large to the infinitely small. The great questioning of “time” has been at the heart of the scientific thinking since Newton. We see it all over, from the illusory nature of time suggested by Einstein with the theory of relativity, to quantum physics in the Theory of Chaos, where concepts like time, substance and energy are analyzed. To science, some philosophical thinking can be summed up; such as KANT’s idea of time like an inner/outer space or BERGSON’s where we have"(...) the difference between the duration of the mental phenomenon and/or the time of the projection of this duration in space (...)"4. Or even as recently as António DAMÂSIO’s study of the brain, of conscience, emotion (“which is related to movement”5(pp. 93). and of how we understand Time. Time has been, since antiquity, a recurring theme in several areas of knowledge.

When changing our notion of space we are also altering our conception of time. Speaking of Time, of its irreversibility, is to talk about existence and change: about becoming. The time we feel and conceive, as a result of this physic relation we have with space, is very individual and has a lot of biological features- the time of existence between life and death, the time of memory, of perception and the time of expectation (cf. ST.AGUSTIN). It also has an emotional dimension, subjective and psychological. The moving image that represents time reflects the space, the light, the color, and the soul. Images of Time, as false movement, because we have an aberrant illusion, are pure optical and sound situations that use and take advantage of our psychological memory for their own production.

Once again, we come into contact with an extraordinarily complex system, which adds sensations, emotions, perceptions, etc. in brief, a psychological whole. As in any work of art, its communication and perception is possible in a system procedure of forces between conscious and unconscious: a threshold phenomenon. 6

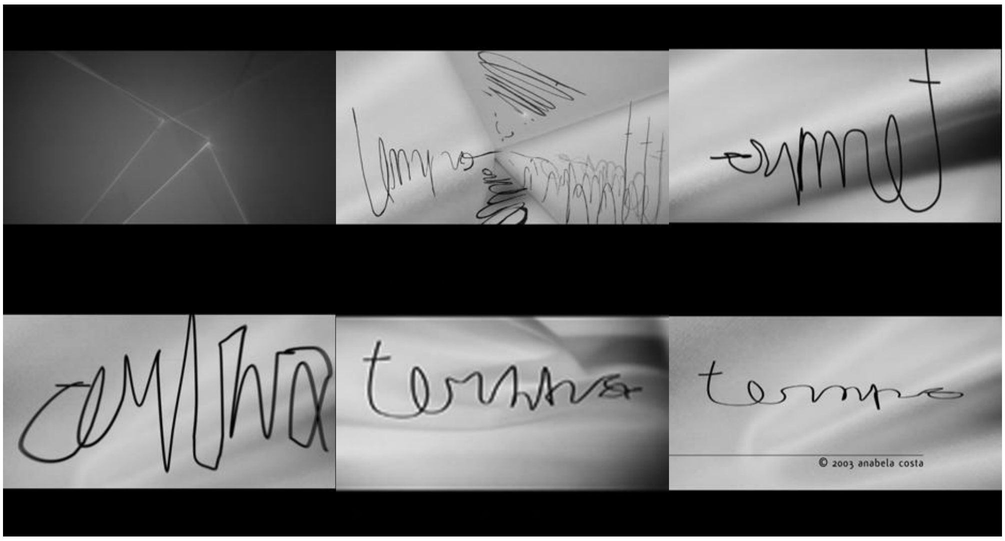
Therefore, what should we have when “the illusory motion ceases to match the laws of natural motion, and it purely destroys the illusion of prosaic imitative movement concepts?” 7 If “to conceive poetically is to feel by thinking" 8 and "the process of thinking is the mechanism of cinema” 9, only the personal interpretation of the unreality of motion, as construction of poetic representation of time, can make sense. The use of the quantity of movement, of the fullness and emptiness, of the continuity and discontinuity of rhythm, make possible the visualization of time on the screen, which is the structure of cinema. Today, due to the electronic construction instruments of image and sound, cinema can do with no use of images of the past, even the "design after design" of the traditional animation cinema had a prior body. The electronic procedures have also democratized the technical access “making it accessible to the great majority of people, which allows the creation of new records, part of other technical, formal and conceptual universes. Today, cinema may not even be considered as cinema as it does not necessarily have to make use of cameras, nor film, not even a screen. The distinctions and borders between genres are blurring and disciplines are starting to merge but they have also been recreated.

The electronic media have given other chances to editing and dubbing. From the need of the film industry to create simulated realities, increasingly relevant to the collective imagination, we have seen the surfacing of tools such as special effects, which may be used for artistic purposes. Personally, entertainment as a show, does not interest me at all. I do not entertain. However I use the same tools that are proven to be very powerful, equally intense as a white canvas and paint brushes or a block of stone. They bring us to new other possibilities in representation, either for the montage or in the construction and enrichment of the environments where simulated fantastic settings can be fully built, mixed with real images, with time and motion manipulations. There are many variants and their combinations create a difficult world, impossible to cover.

The new possibilities of tools to create and view images, “without employing images from the past” (cf. Manuel DE OLIVEIRA), without employing previously made representations , develop a whole lot more possibilities that are multiplied when we cross softwares. Also, the interaction of the various artistic disciplines (plastic, visual and sound) allows and promotes, on the one hand, the formation of increasingly complex structures, but also of structures of great subtlety, if that is the artist’s motivation. In my case, it has provided many playful interactions only made possible thanks to electronics. The Imaging, Modeling, Visualization of the new media is essential. They represent the imperative necessity of enlargement, and store a great potential, an energy that could give soul and shape to the needs of the contemporary mental universe, allowing artists to go on with their work, reflecting the mystery of spirit.

Human beings, in their fundamental characteristics, which are the transforming dimension and their ability to renew, invent and make an extension of themselves through electronic processors, which ultimately do what the mind considers fastidious. As a result of technological changes, the contemporary world is a place of multiple relationships and interactions. Photography, cinema, recording, all began as mere technical resorts, made possible by considerable advances in science and technology, which have ended up exceeding this first nature, earning an Art status. It is undeniable that this same thing is happening with technological expression that we find today, and that could naturally lead us to another new artistic expression.

In general, the use of the moving image by the artists requires a manipulation that in some way reflects and questions existence, as in any other artistic expression. New artists, with new techniques, have to perform the transformation of the image giving it the necessary autonomy to the fruition experience. Its transcendence makes us question the “existing” and the “being”. This new sign uses non static image and sound as a reflection of our contemporaneity, these are the expressions of the new temporalities, the expression of flow. Our machines are felt as extensions of man, they have made possible the extension of our horizon and therefore I believe that human kind is not at stake, as some may fear. I also believe that if that would come to be the case, societies as living networks have the ability to self-regulate and to reorganize themselves. We should not forget that desire, poetry and pleasure are very difficult to synthesize and so they will always set us apart from the machines.



Imagery and Poetic

The representative power of images, as a symbol of knowledge and identity, resides in the ability to describe "actuality". Art is the expression of a virtual world, which should question actuality’s complexity in its essence. Today, it has gained new meanings since it is built-in within this process of change, in which we live, the culture of the moving image which, as a mass culture, has trivialized art. I personally think that this transforming dimension can only been attained through metaphor.

We have seen that virtual reality is a sort of space, a territory of new posts. The abstract form, open the mystery of the intimate observation of things, it is the place of the spirit’s thinking where it is forced to self-reflect and to try to make the synthesis of the world in human creation. By using pure visual images, not figurative, and adding the descriptive power of color, we manage to capture the attention of the spirit.

The creation of an imagery involves the guided use of imagination. This is the method to transform dreamed-thoughts into imaged-objects which go beyond reality, which are as personal and as poetic as its creator’s imagination.

The poetic imagination, since it is dynamic, open, inventive and creative, is an opportunity to have the freedom to create fantastic worlds for an experience of discovery. Therefore the poetic potency resides in metamorphosis.

The poetic creation gives expression to a multitude of equally complex spaces and of multiple dimensions. Thoughts become ideas, which acquire expression of emotion, displayed in a game of rhythms. From thought to thought, idea to idea, emotion to emotion we witness poetic and subtle movement, a game between idea and emotion. It is a movement which extends on itself, giving rise to the poetic emotion: the expression of the movement of life. My dreamed thoughts, imaged-thoughts, are converted into images by a direct consequence of the machine's mathematical calculations and its processing.

Imagery cannot be said true or false, it simply is. My imagery is my reference, my REAL, which allows the restructuring of the imaged-thought into visual form and noise, which falls within the continuity of illusion even when it becomes real, it stands as reality, if we see it as "the product of the universal process of entropy" 10 (cf. BAUDRILLARD). My imaginary reality or the simulation of it, which is not material, since it has never belonged to some point of a past time, is let to be part of Time when it poetically flows through the screen's area. The sound, whether or not it has a structure in common with the image, whether it is musical or not, defines and depicts emotions, draws the area and interacts with the image, reinforcing the poetic space. The sound punctuates the rhythms, conferring cohesion and unity to the movement / time, transformed into an altogether. Through the change, the becoming and the moment where time is enhanced, we try to get a perception from the timing to the dream.

But, if before it was said that the cinema gave the illusion of the world: this new cinema, which kind of illusion does it handle?

CONCLUSION

Until a few centuries ago Beauty and Knowledge were immutable concepts, we do not live in that time anymore; today "the world is made of change." Without any doubt, we live in a time where the notion of space has changed, where real, actual, material and virtual inter-depend. Therefore new forms, new behaviors and new cultural values are offered to us.

I am lucky to live in a technological world which, for the first time in the history of cinema, allows us not to make use of images of the past, but lets it to be built using exclusively the imagery of our non figurative imaginary, that thereby leaves the virtual-latent nature to enroll in actuality. This transformation, surprising and unique, is as important as it is revolutionary and I honestly think that it may end up creating significant changes, new readings and new interpretations in the relations between space, time and image. My imaginary reality gains body, it becomes concrete and material. In the particular case I wanted to show, this latent-virtual becomes concrete through electronic technologies, which in turn become powerful tools, allowing giving shape to my thoughts. Artists have tried precisely over the centuries and through several techniques, to give shape to their imaginary reality. This technologic performance as a simulation, like we know it in disciplines as diverse as cosmology, bio-sciences or meteorology for instance, let me create simulacra from my own fantasy and reality, with a range of endless possibilities and variations, and subsequently to create images for my thoughts, from my own imagistic universe, with all the richness inherent to the limitless possibilities that are allowed now for the same "virtual object", trough a mixture of several disciplines: photography, drawing, painting, movement, sound, music etc.., resulting in very subtle changes, which were impossible to achieve until today.

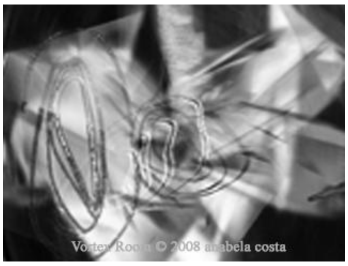
If you define the concept of virtual (such as BERGSON and DELEUZE) in the sense of the concept of a non-sensitive world that, in a complex dynamic process becomes reality and is a part of the phenomenally world given by infinite multiple sensitive things; or (like LEVY) as a virtual set of pre-determined options, which lack of existence; then when we speak of virtual, we talk about latency, of becoming, that is to say of motion. If we think of the virtual as the immaterial and unexpressed speed of time or, if we consider virtual reality as a technologic performance of speed of the digital multi-linear flows; what we have left, in both conceptions, is the flow/movement as an expression of time. I obviously work with the representation of movement, we are not before the movement in real time, and I am not concerned by the force of gravity. I also do not extend to the perception of movement by the binomial eye/brain issues or to the reading of motion - in its illusion - the same as we do when we watch TV or go to the movies. The suggestion of movement depends on our imperfect perception of speed which confuses the object and trajectory.

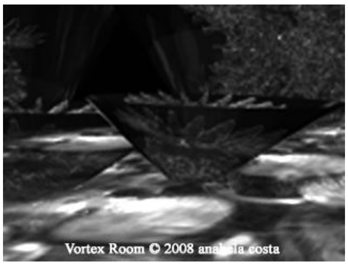
There is a feature that seems crucial and transversal to the overall staff of the universe, the virtual the imaginary - the inconstancy. This observation leads me always the same question: What is reality? Means, like the extension of a desire for representing thoughts, imaginary reality, representation of feeling or emotion for the abstract reality, end up intersecting; the imaginary and virtual realities become closer. Transience remains a constant feature.

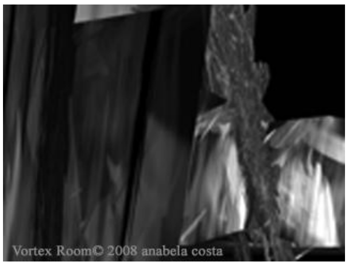
Life exists as a movement with rhythms and cadences. Movement is the nature of life in its non-linearity and poetic emergence. In a universe as unique and singular as the one I have been offered to live in, I always work to understand what the key should be. Imagery-dream, poetry and movement/time are without doubt the three points of my vision. The generic quality of poetry is at the heart of what art is. Because, if "Poetry is an imaginative awareness of experience expressed through meaning, sound, and rhythmic language choices so as to evoke an emotional response.[and]The main ingredients are movement and sound.[if] Poetry is about movement and expression. Poetry expressed the way we feel about a certain subject through imagery and other senses. ", as can be read in a dictionary, then 'the essence of art is poetry'' as stated Heidegger.

My last film, Vortex Room (2008), is an essay, an exercise on such complex issues as these ones, and it does not intend to be more than a trial as I state in its

synopsis: "Vortex is an essay on movement. What's left from movement in animation? Is it illusion? The animated movement of all is its poetry. Vortex Room is a journey towards an aesthetic and Poetic vertigo. "
In those fields of illusion, imaginary, dream poetry and all these elements in co-relation in a continuous motion, I do not entail myself any barriers.







REFERENCES

[1] Deleuze, Gilles (2006). Para além da imagem-movimento, Imagem –Tempo cinema 2, Assírio e Alvim, Lisboa

[2] Gil, José (1996). Preface, A Imagem-Nua e as pequenas percepções, estética e fenomenologia, Relógio D'Água Editores

[3] idem:

[4] Debono, Marc-Williams. Penser le Temps

[5] Damásio, António R. (2000). Emoção e Sentimento, O sentimento de si. O corpo,a emoção e a neurobiologia da consciência, Edições Europa-América, Lisboa.

[6] Gil, José (1996). A Imagem-Nua e as pequenas percepções, estética e fenomenologia, Relógio D'Água Editores, Lisboa

[7] Xavier, José-Manuel (2007). A fabricação de ilusões, Poética do movimento, Edições da Monstra, Lisboa.

[8] Gil, José (1994). A onda, o Ritmo, o contágio, o Espaço Interior Editorial Presença, Lisboa

[9] Deleuze, Gilles (2006).Para além da imagem-movimento, Imagem –Tempo cinema 2, Assírio e Alvim, Lisboa.

[10] Baudrillard, Jean , Integral Reality http://www.egs.edu/faculty/baudrillard/baudrillard-integral-reality.html

BIBBLIOGRAPHY

Baudrillard, Jean http://www.egs.edu/faculty/baudrillard/baudrillard-integral-reality.html

Baudrillard, Jean (1991), Simulacros e Simulação, Relógio d'Àgua, Lisboa

Bittarello, Maria Beatrice (2008). Another Time, Another Space: Virtual Worlds, Myths and Imagination. http://journals.tdl.org/jvwr/article/view/282/236

Camões, Luís Vaz de, Mudam-se os tempos, Poesia Completa, Editora Nova Aguilar

Damásio, António R.(2000). Emoção e Sentimento,(pp93), O sentimento de si. O corpo, a emoção e a neurobiologia da consciência, Edições Europa-América, Lisboa.

Debono,Marc-Williams.Penser leTemps http://plasticites-sciences-arts.org/PLASTIR/Debono%20P9.pdf

Debono, Marc-Williams, Introduction à la Metaplasticité. http://plasticites-sciences-arts.org/metaplasticite.pdf

Brenner, Joseph E. The Dialectics of Plasticity: a Lupascian Analysis. http://plasticites-sciences-arts.org/PLASTIR/Brenner%20P14.pdf

Combet, Eric. Du concept de la plasticité à la plasticité du concept. http://plasticites-sciences-arts.org/PLASTIR/Combet%20P14.pdf

Deleuze, Gilles (2006). Imagem –Tempo cinema 2, Assírio e Alvim, Lisboa.

Gil, José (1996). A Imagem-Nua e as pequenas percepções, estética e fenomenologia, Relógio D'Água Editores, Lisboa

Heidegger, Martin.(2000) A origem da obra de arte. Edições 70, Lisboa

Lioret, ALain, (2004). Émergence de nouvelles esthétiques du mouvement, L'Harmattan, Paris.

Lévy, Pierre (2001). O que é o Virtual ? Quarteto Editora

Merleau-Ponty, Maurice (2002). O olho e o espirito, Vega edições, Lsboa.

Prigogine, Ilya (1988). O Nascimento do Tempo, Edições 70, Lisboa.

Xavier, José-Manuel (2007). A fabricação de ilusões, Poética do movimento, Edições da Monstra, Lisboa.

The music of paintings: a rhythmic perspective

André Gonçalves, MSc.
GAIPS, Inesc-Id, Instituto Superior Técnico, Universidade Técnica de Lisboa, Lisboa, Portugal
e-mail: andre.pintado@ist.utl.pt

Eduardo Lopes, PhD.
Departamento de Música, Universidade de Évora, Évora, Portugal
http://home.uevora.pt/~el
e-mail: el@uevora.pt

Ana Paiva, PhD.
GAIPS, Inesc-Id, Instituto Superior Técnico, Universidade Técnica de Lisboa, Lisboa, Portugal
e-mail: ana.paiva@inesc-id.pt

Abstract

Olivier Messiaen once mentioned: "I am affected by a kind of synopsia which allows me, when I hear music, and equally when I read it, to see inwardly, in the mind's eye, colours which move with the music". It is now known that a number of artists have a condition called synesthesia. Synesthesia is a neurological phenomenon where the stimulus of a sense induces the stimulus of another sense. For instance, there are people who see colours when looking at some specific numbers, or when hearing some specific music. Since it enables the association of typically non-associated concepts, it is believed that this phenomenon is the key to creativity.

It is easily perceivable that some rhythms convey a more relaxed experience than others. This also applies to shapes. We can call this the instability/stability of a rhythm or shape. Using a mathematical model created by us, we quantify the instability of a shape present in a painting and then, using the theory of Pulse Salience, generate a rhythm with a similar instability value.

We present a computational system which is able to play the music/rhythms of paintings. The system is organized in three layers, and there are two key modules: an image analyzer tool and a rhythm generator tool. The former extracts the image

characteristics and assigns an instability/stability value to a shape, while the latter generates and plays rhythms according to the instability/stability values.

The aim of the system is to provide a multi-sensorial experience similar to synesthesia, using the cognitive and perceptual influence of rhythm in humans. We believe that if people can be exposed to a similar experience, this will improve their overall perception of a work of art as well as enhance their own creativity.

1. Introduction

”If there is no shape, there is no flavor” [1]. This quote could be thought as a comedy quote, but it is not. The man who tasted shapes is a famous example of a person who experienced a condition called synesthesia, a condition in which people mix senses. His mind works like a house with no walls, where the senses do not have their ‘privacy’ and finish melting with each other. In his case, he mixes taste and touch, but there are many more variants of this condition, some more common than others [2,3].

Transposing this inter-sensorial experiences to art, it is known that artists are often appealed to dig new ground into other areas. Painters like Paul Klee or Wassily Kandinsky often created paintings based on musical rhythms, harmonies or melodies [4,5]. It is also known that musicians often compose or improvise inspired by other media. Whether it’s painting, architecture [6], poetry or dance, these composers find a mapping between both fields, so they can cause an effect with music similar to the effect caused by the other media. The concepts mapped can vary from abstract ones (emotions, memories, etc.) through more concrete ones (textures, form/geometry, movement, etc.). Film score and cartoon music composers are experts in translating the real ambiance and feelings of the characters into the music. More generally, there have been art movements, like Fluxus in the 60’s, which were entirely dedicated to projects blending different artistic media and disciplines, also called intermedia [7].

So, how can we provide a synesthetic experience to people? More specifically, how can we make the computer generate music based on drawings or images so that the music generated transmits the same feelings as the drawing?

We named our system Sense², which reads 'sense square' and has itself multiple interpretations: the multiplication of senses; the reference to two senses; the reference to the 'square' as a geometry figure; and 'sense the square' in a reference to the imperative mood of the verb 'to sense', as if we were strongly suggesting the user to feel the geometry.

Our fields of action are paintings or drawings, and music. We must then map this multi-disciplinarity by finding a common feature in both fields. First, we focus ourselves on the shapes present in the images and on musical rhythms. Second, the bridge between shapes and rhythms is made with a feature we call instability. Instability is the power of something to be or not to be smooth to the perception of a person. In short, an unstable shape is not smooth and has sharp edges, whereas an unstable rhythm has an unexpected variation/surprise on the perception of the people who are listening to it, and depending on its value can even cause confusion.

This document is organized in four chapters. In the first chapter we describe the background concepts introduced previously: music, rhythm, pulse salience and computer music. In the second chapter we present the details behind the implementation of Sense². In here, we explain all the details about the mathematical formulas that constitute both models of instability, and also some system programming details. In the third chapter we present the evaluation of our system. Finally, in the fourth chapter we conclude on the results of all our work, and on the results of the evaluation. We finish by proposing future work that could not only improve Sense² but also make use of the models in other scenarios.

2. Background

2.1 Music and Rhythm

Music has plenty of characteristics and from the point of view of automatic music generation, one can think of lower level characteristics that would be proper to map: harmony, melody, timbre, etc. Or higher level ones: multiple instruments, patterns, musical styles, etc. For cultural reasons well beyond the scope of this document, in western music theory, pitch has been preferred over rhythm, and the proof is that in today's music education, pitch is more widely spread, and quite more valorized than rhythm. This happens because of the rhythm naturalness in human perception, with humans tending to ignore or underestimate what is natural to them.

In musical terms, rhythm (from the Greek ‘rhythmos’ meaning “flow” or “movement”) is the arrangement of sounds in time. By arrangement we mean the organization of musical notes or events in an interval of time, which can include the duration of notes (and silences), the accentuation of notes, meter and tempo. If one takes rhythm out of a music piece, one is not able to recognize it anymore. But if one takes the pitch out of a piece, one still gets something musically rich (and perhaps sometimes similar to popular dance music). These crucial perceptual qualities cause rhythm to be the most important music characteristic and yet it has not been fully recognized by Musicology and music theory, at least in the shape of rhythm treatises.

2.2 Pulse Salience

The Just in Time theory introduces Pulse Salience. Pulse salience is a rhythm characteristic that characterizes the salience of a given rhythmic event [8,9]. A salient pulse is like the black sheep that stands out in a flock, except that non-experienced listeners internalize it without noticing it. It can be measured through three factors: the duration of a pulse (also called agogic accentuation), the accentuation effect due to the action of rhythm cells or rhythm motifs, and the accentuation resulting from the placing of a pulse over a strong metrical point which is perceived as stable.

2.2 Computer Music

When computers were invented in the 40’s, musicians and researchers were interested in using them to assist humans with music tasks such as performing or composing [10,11]. The Computer Music area can be divided into four categories: synthesis, composition, performance and analysis. We focus ourselves in composition.

Computer music composition is all about algorithms. There are literally hundreds of methods and hybrids of methods, created since the beginning of the computer music era, and some of them were even created longtime before computers were born [12,13]. Classification of computer music composition methods often divide these in the following groups: Mathematical Models, Knowledge Based Systems, Grammars, Evolutionary Methods, Learning Systems, Distributed Systems, ‘Sonification’ and Hybrid Systems. This categorization is quite empirical as, for example, we can consider almost all of them to be mathematical models or knowledge based systems. Each one of these groups differentiates from the others not only by their computational features but also by their different use. For a complete and detailed reference on these methods please refer to [10,14,15].

3. Sense^2

Sense^2 is a system which generates music following paintings. For this reason, one must create a direct or indirect mapping between paintings characteristics and music characteristics. Rather than to map concrete painting characteristics into concrete music ones, which could lead us to non-creative results, we have chosen to take a step towards human consciousness and decided to use human feelings as the bridge between both media. We use the fact that some paintings or some music convey a more relaxed experience than others. We focus ourselves on shapes and rhythms, and we call this the instability/stability of a shape or rhythm.

3.1 Measuring Instability

3.1.1 Instability of shapes

The calculation of the instability of a shape depends on whether the shape is a line, a circle or a polygon.

We define the line instability as its inclination, or the angle formed by it and an imaginary horizontal line, where a vertical line (90º) has 0% instability and a horizontal line (0º) has also 0%. The 100% instability is reached when the line forms a 45º angle with the imaginary horizontal line (Figure 1).

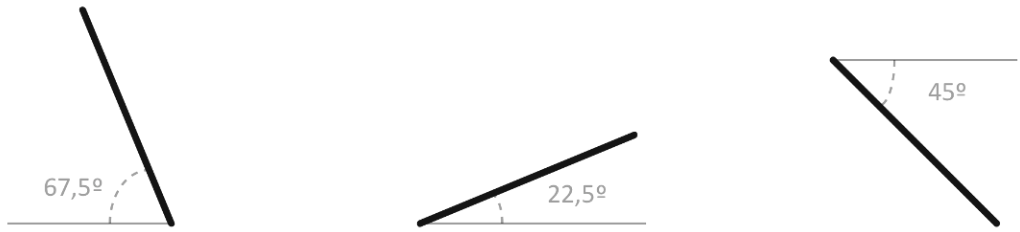


Figure 1a: 67,5º = 50% unstable *Figure 1b: 22,5º = 50% unstable* *Figure 1c: 45º = 100% unstable*

Figure 1: Example of line stabilities

These angles are calculated using the mathematical operation dot product (where a and b are vectors):

$$\theta = \arccos\left(\frac{a \cdot b}{|a||b|}\right) \tag{1.1}$$

Which, applied to the line points p2, p3 and the imaginary p1:

$$\theta = \arccos\left(\frac{(x_1 - x_2)\times(x_3 - x_2) + (y_1 - y_2)\times(y_3 - y_2)}{\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \times \sqrt{(x_3 - x_2)^2 + (y_3 - y_2)^2}}\right)$$

Then, to obtain the percentage (all the angles are previously normalized from 0º to 90º):

$$instability_l = \begin{cases} \theta \times \dfrac{100}{45} & \text{if } \theta \leq 45^{o} \\ (90 - \theta) \times \dfrac{100}{45} & \text{if } \theta > 45^{o} \end{cases} \tag{1.2}$$

The circle shape is always considered to be a stable shape. For this reason its instability is always 0%.

$$instability_c = 0\% \tag{2}$$

The calculation of the stability of a polygon is the most complex of the three. One can easily see that the smoothness of a polygon depends on angles and on the presence of those angles in the shape. More precisely, here we say that it depends on the number of acute and obtuse angles and on the size of the rays that create those angles. We should add that all the angles are normalized between 0º and 180º, and 90º is considered to be an obtuse angle. Let's look at the method in detail.

Let $\hat{a}_{a1} \ldots \hat{a}_{an}$ be the acute angles of a polygon, and $l_{a1} \ldots l_{an}$ the length of the two rays that form that angle. In the same way, let $\hat{a}_{o1} \ldots \hat{a}_{on}$ be the obtuse angles of a polygon, and $l_{o1} \ldots l_{on}$ the length of the two rays that form that angle (Figure 2).

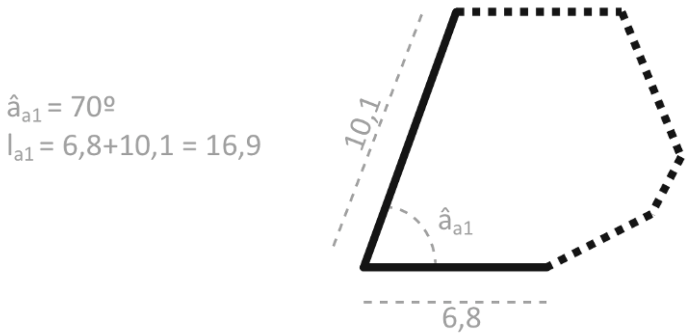


Figure 2: Example of acute angle in a polygon and the calculation of the length of its two rays

n_a and n_o are respectively the number of acute and obtuse angles of a shape. We define the "Acute Perimeter" of a shape as the sum of the lengths of the two rays that form an acute angle multiplied by that angle. The multiplication is used as a way to weigh the angle. An angle formed by two small rays must have a smaller value than the same angle formed by two large rays. All angles are previously normalized from 0º to 180º. Thus, we have:

$$AcutePerimeter = \sum_{k=0}^{n_a} l_{ak} \times (90 - \hat{a}_{ak}) \tag{3.1}$$

$$ObtusePerimeter = \sum_{k=0}^{n_o} l_{ok} \times (180 - \hat{a}_{ok}) \tag{3.2}$$

We then defined the Acute Value and Obtuse Value as:

$$AcuteValue = \frac{AcutePerimeter}{n_a} \tag{3.3}$$

$$ObtuseValue = \frac{ObtusePerimeter}{n_o} \tag{3.4}$$

This operation is a way to weigh the perimeter value which can be quite big. If there are no acute angles the “Acute Value” is obviously 0, and the same occurs with the “Obtuse Value”.

Finally, Instability or “Acute Percentage” is a percentage of the “Acute Value” in the total value composed by Acute and Obtuse Value:

$$instability_p = AcuteValue \times \left(\frac{100}{AcuteValue + ObtuseValue} \right) \tag{3.5}$$

To exemplify our polygon instability model, we present two examples of instability quantification for two different polygons. Let us calculate the Acute and Obtuse Values for the first polygon example (Figure 3):

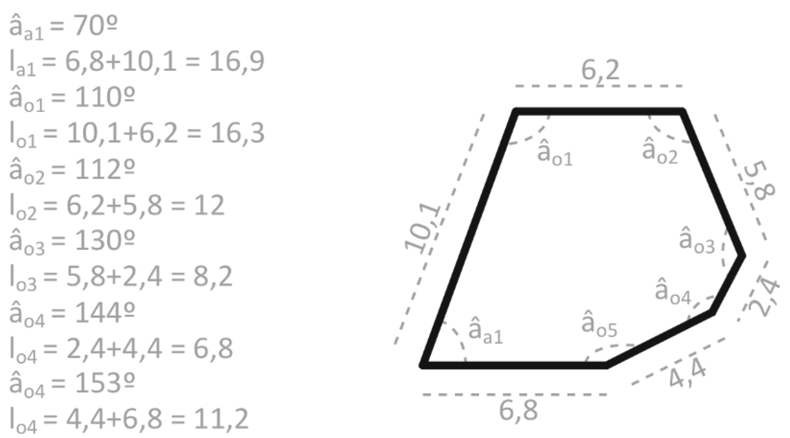


Figure 3: A detailed view of a quite stable shape

$$AcuteValue = \frac{20 \times 19{,}9}{1} = 338$$

$$ObtuseValue = \frac{(80 \times 16{,}3) + (78 \times 12) + (50 \times 8{,}2) + (36 \times 6{,}8) + (27 \times 11{,}2)}{5} = \frac{3197{,}2}{5} = 639{,}44$$

Then, using formula 3.5, the instability percentage:

$$instability_{p} = 338 \times \left(\frac{100}{338 + 639,44} \right) = 34,58\,\%$$

Let us do the same process for a more complex shape (Figure 4):

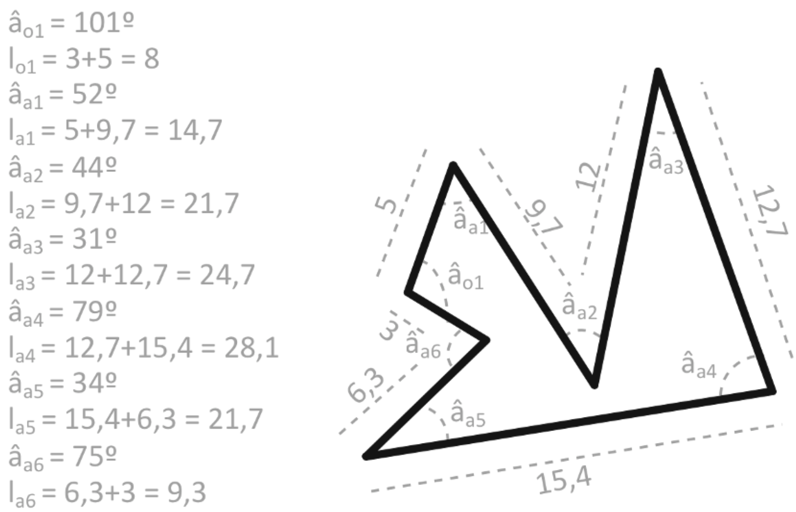


Figure 4: A detailed view of an unstable shape

$$AcuteValue = \frac{(38 \times 14,7) + (46 \times 21,7) + (59 \times 24,7) + (11 \times 28,1) + (56 \times 21,7) + (15 \times 9,3)}{6} = \frac{4677,9}{6} = 779,65$$

$$ObtuseValue = \frac{79 \times 8}{1} = 632$$

Then, using formula 3.5, the instability percentage:

$$instability_{p} = 779,65 \times \left(\frac{100}{779,65 + 632} \right) = 55,22\,\%$$

One can see that a polygon with no acute angles has 0% instability, and a polygon with no obtuse angles has 100% instability. This is quite arguable, as an equilateral triangle, for example, can be seen as being a stable and unstable shape. This model sees it as being all unstable. Yet, The main goal when making this model was to mathematically reflect the smoothness of the shape, and the two previous examples show that the model is quite accurate.

3.1.2 Instability of rhythms

Our instability quantification method is based on Pulse Salience, a rhythm characteristic which associates values to notes following their salience. Let us first introduce the Pulse Salience method, which is essential to the comprehension of our theory. Then, we will detail our rhythm Instability Quantification method, which is used in the Rhythm Generator and Rhythm Chooser modules.

Pulse Salience

As said before, pulse salience is a rhythm characteristic which characterizes the salience of a given rhythmic event. In Ricardo Cruz's thesis [16,17], the author identified a way to quantify the salience of every note in set of measures, or a score. Like in Lopes' theory, the salience value of a pulse depends on three factors:

- The pulse position in the measure, also called "metric position";
- The pulse duration, also called "agogic accentuation";
- The rhythmic events that precede the pulse which can accentuate the pulse, also called "rhythm cell accentuation".

Recalling the mathematical functions from (Cruz 2008):

Metric Position Value:

$$O(\omega) = BU - M(\omega - 1)$$

Agogic Accentuation Value:

$$P(\eta) = \eta$$

Rhythm Cell Accentuation Value:

$$Q(\eta) = \sum_{(\zeta,\sigma)\in C} \left(\left\lceil R\left(\frac{\eta}{\zeta}\right) M \sigma \right\rceil \right)$$

From which the author derived the Pulse salience general formula:

$$S(\eta,\omega) = BU - M(\omega - 1) + \eta + \sum_{(\zeta,\sigma)\in C} \left(\left\lceil R\left(\frac{\eta}{\zeta}\right) M \sigma \right\rceil \right) \tag{4}$$

Where:

η is the pulse's type

ω is the pulse's metric position

B the number of beats in each measure

U the value filling a beat

M the value of the shortest pulse present in the rhythmic segment.

C a set of tuples (ζ , σ) representing the preceding rhythm cell - that can be in fact a group of equal homogeneous cells. For each tuple, ζ is the value of a pulse type and σ the number of pulses of that type in the rhythm cell.

R a function given by:

$$R(x) = \begin{cases} x & \text{if } x > 1 \\ 0 & \text{if } x \leq 1 \end{cases}$$

Figure 5 represents all the possible metric positions of a pulse in a measure, and table 1 represents the different pulse types used in our system, and their possible values.

Figure 5: The sixteenth metric positions in a quaternary meter following 'Just in Time'

Pulse	**Notation**	**Value**
Quarter Note	♩	1000
Dotted Eighth Note	♪.	750
Eighth Note	♪	500

Sixteenth Note	𝅘𝅥𝅯	250
Sixteenth Silence	𝄿	0

Table 1: Pulse types and their possible values

Here are the pulse salience values for the different pulses for the rhythm in figure 6. For more detailed examples, please refer to (Cruz 2008).

Figure 6: Pulse salience values for a random rhythm

$$S(1000,1) = 4\times 1000 - 250\times(1-1) + 1000 + 0 = 5000$$

$$S(500,3) = 4\times 1000 - 250\times(3-1) + 500 + 0 = 4000$$

$$S(0,7) = 0$$

$$S(0,15) = 0$$

$$S(250,2) = 4\times 1000 - 250\times(2-1) + 250 + 0 = 4000$$

$$S(250,10) = 4\times 1000 - 250\times(10-1) + 250 + 0 = 2000$$

$$S(250,6) = 4\times 1000 - 250\times(6-1) + 250 + 0 = 3000$$

$$S(250,13) = 4\times 1000 - 250\times(13-1) + 250 + 0 = 1250$$

$$S(1000,4) = 4\times 1000 - 250\times(4-1) + 1000 + 4000 = 8250$$

As one can see, the quarter note in metric position 4 has a salience value of 8250 especially because it is located straightly after a rhythm cell of four sixteenth notes.

Instability of Rhythms

Our model divides rhythm instability into two mathematical measurements: Pulse Instability and Rhythm Instability. Rhythm Instability may only be calculated if Pulse Instability was calculated previously for all the notes in the measure.

Let us start with Pulse Instability. We say that a note is unstable if it has a high salience value and is positioned in a weak metric position (such as 10 or 16). The Pulse Instability value must mirror this in perfection, so we define it as:

$$instability_{pulse}(\eta,\omega) = S(\eta,\omega) \times \omega$$

This will cause the Pulse Instability value to increase proportionally with metric position. There is however one special case, which is the silence case. Silences haven't got salience value because they do not sound, but the fact is that their presence can cause instability/stability. For this purpose, we have contemplated silences in our formula:

$$instability_{pulse}(0,\omega) = \frac{\sum_{\omega \in s} O(\omega)}{n_s^2} = \frac{\sum_{\omega \in s} BU - M(\omega - 1)}{n_s^2}$$

Where:

s is the group of silences where the given silence is present

n_s is the number of silences that form the group of silences where the given silence is present

The division by n_s^2 works as a weighting to reduce the importance of instability of many silences put next to each other, and to spread the value over all the silences that belong to the group.

The general formula for Pulse Instability is then given by:

$$instability_{pulse}(\eta,\omega) = \begin{cases} \dfrac{\sum_{\omega \in s} BU - M(\omega - 1)}{n_s^2} & \text{if } \eta = 0 \\ S(\eta,\omega) \times \omega & \text{if } \eta > 0 \end{cases} \qquad (5)$$

The Pulse Instability formulas are able to associate an instability value to each rhythm pulse, but there is still a problem concerning the quantification of the overall rhythm instability. This is why we created Rhythm Instability. We cannot just sum the Pulse Instability for each pulse in a rhythm, because this would result in a higher Rhythm Instability value for rhythms with many pulses, and a lower one for rhythms with a few pulses. The solution was to weight the overall Pulse Instability value by the number of pulses in the rhythm:

$$instability_{rhythm} = \frac{\sum_{\omega=1}^{16} instability_{pulse}(\eta,\omega)}{n_{pulses}} \quad (6)$$

As the instability of a shape is defined as a percentage, the rhythm instability must also be defined as such, for coherence reasons. We did so, by dividing the Rhythm Instability values in 10 intervals so that this conversion from an instability value to a percentage could be done. For the definition of the interval endpoints we produced some studies where we generated large quantities of rhythms and noticed that the Rhythm Instability values oscillated in between 6000 and 32600, and most of them between 11320 and 21960. As a result we defined the Instability intervals as such:

0% to 10% : $[6000, 11320[$

10% to 20% : $[11320, 12650[$

20% to 30% : $[12650, 13980[$

30% to 40% : $[13980, 15310[$

40% to 50% : $[15310, 16640[$

50% to 60% : $[16640, 17970[$

60% to 70% : $[17970, 19300[$

70% to 80% : $[19300, 20630[$

$$80\% \text{ to } 90\% : [20630\ ,21960\ [$$

$$90\% \text{ to } 100\% : [21960\ ,32600\ [$$

Here is the detailed calculation of the Rhythm Instability for the rhythm present in figure 6:

$$instability_{pulse}(1000\ ,1) = (4 \times 1000\ - 250\ \times (1-1) + 1000\ + 0) \times 1 = 5000$$

$$instability_{pulse}(500\ ,3) = (4000\ - 250\ \times 2 + 500\ ) \times 3 = 4000\ \times 3 = 12000$$

$$instability_{pulse}(0,7) = \frac{(4000\ - 250\ \times 6) + (4000\ - 250\ \times 14\ )}{2^2} = \frac{3000}{4} = 750$$

$$instability_{pulse}(0,15\ ) = instability_{pulse}(0,7) = 750$$

$$instability_{pulse}(250\ ,2) = (4000\ - 250\ + 250\ ) \times 2 = 8000$$

$$instability_{pulse}(250\ ,10\ ) = (4000\ - 250\ \times 9 + 250\ ) \times 10\ = 20000$$

$$instability_{pulse}(250\ ,6) = (4000\ - 250\ \times 5 + 250\ ) \times 6 = 18000$$

$$instability_{pulse}(250\ ,14\ ) = (4000\ - 250\ \times 13\ + 250\ ) \times 14\ = 14000$$

$$instability_{pulse}(1000\ ,4) = (4000\ - 250\ \times 3 + 1000\ + 4000\ ) \times 4 = 330000$$

$$instability_{rhythm} = \frac{instability_{pulse}(1000\ ,1) + \ldots + instability_{pulse}(1000\ ,4)}{7} = \frac{111500}{7} = 15928\ ,57$$

And then, following the intervals defined previously, we can see that 15928,57 fits in the instability interval 40% to 50%. So we say that the rhythm in figure 6 has an instability value between 40% and 50%. The reader may have noticed that one cannot say precisely what is the instability percentage of the rhythm, as it is defined by an interval and not by a unique value. Briefly, there is no need to computationally distinguish between a rhythm 41% and 42% unstable, because most human ears would not be capable to do it either. This will be detailed in the next section [18].

3.2 The System

The System Driver is the first module to be executed upon the running of Sense2. He is the responsible for calling the interface system, the picture analyzer module and the synesthetic layer. He guarantees that all these modules are executed in this order. The interface is composed by a "file selection window", followed by a window where the selected image is loaded. After this file selection, its absolute path is sent to the Picture Analyzer.

The Picture Analyzer was implemented using the openCV library, and it is responsible for extracting lines, circles and polygons from pictures. Lines and circles are extracted using the Hough transform and the polygons are extracted using Canny or Threshold algorithms. All this information is then written to a XML file for later use.

The Synesthetic Layer is responsible for converting image characteristics into instability values. It uses the concepts and model explained in section 3.1.1 (instability of shapes). The instability values calculated by this layer are then sent to the Composition Layer.

The composition process is composed of two main tasks: generation and choice. The Rhythm Instability Function defined previously is not a bijective function, which means that there are numerous rhythms with the same Instability value and that given an Instability Value we cannot get one rhythm. Following this thought we created the Rhythm Generator, a module which generates rhythms.

To simplify the generation and hearing we have introduced some constraints and yet there were still more than 3.000.000 rhythms. A search in this set would reveal itself to be exhaustive and uninteresting, because even a trained listener wouldn't notice the difference between most of them. We decided then to generate 100 new rhythms every time the program was run. To guarantee that the Rhythm Instability value for these rhythms was spread all over the possible Rhythm Instability values, we divided the Rhythm Instability values in 10 intervals so that each one of the intervals would contain 10 rhythms.

The Rhythm Chooser will choose the right rhythm in this list, following the instability value sent by the Synesthetic Layer. The rhythms are taken from the rhythm list quite directly. For example, if the shape instability percentage is 31%, the rhythms will be randomly taken from the fourth interval (30% to 40%), and if the shape instability percentage is 9%, the rhythms will be taken from the first interval (0% to 10%).

Figures 7, 8 and 9 present some possible rhythms for the shapes on the left.

Figure 7: One possible rhythm for the line on the left

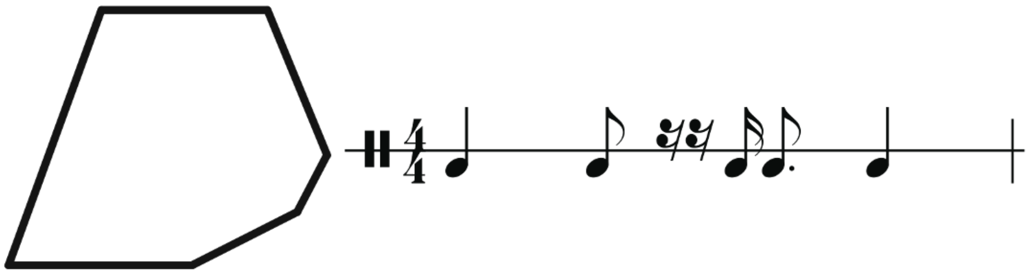


Figure 8: One possible rhythm for the polygon on the left

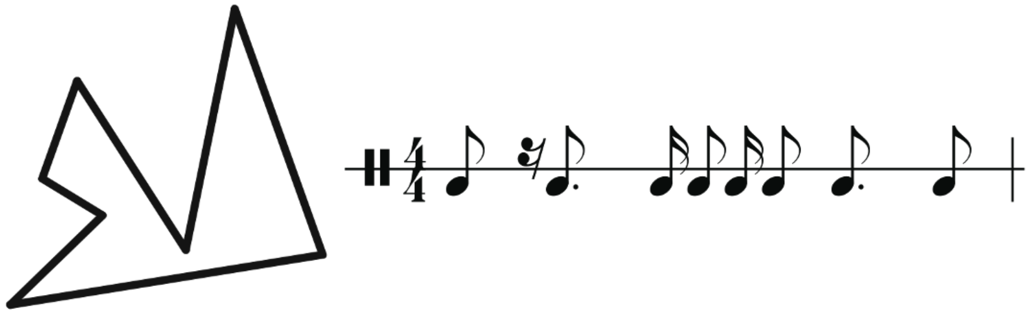


Figure 9: One possible rhythm for the shape on the left

The Output Layer outputs the rhythms generated and chosen by the Composition Layer.

4. Evaluation

4.1 Characterization

For the evaluation of our methods we created two web questionnaires. Both were composed by personal questions (user age, music skills, music instrument skills, painting interest and painting knowledge) and by 8 questions. In each of the questions, we asked the users to evaluate a music track, in a 0 to 6 scale, following a painting. In the first questionnaire, the music was generated by our system, and in the second one, the music was generated randomly.

The questionnaires were distributed electronically by email and social networks. The targeted users belonged to no special music or computer research groups, and there were a total of 47 participants in the first questionnaire and 35 in the second one.

The questions we were trying to answer with this test were:

- Is the music generated by Sense2 appropriate to the paintings?
- Does music knowledge and skills influence the participants' opinion on the music's appropriateness?
- Does painting interest and knowledge influence the participants' opinion on the music's appropriateness?

4.2 Music Appropriateness

Figure 10 presents a comparison between the average appropriateness from both tests: normal and random.

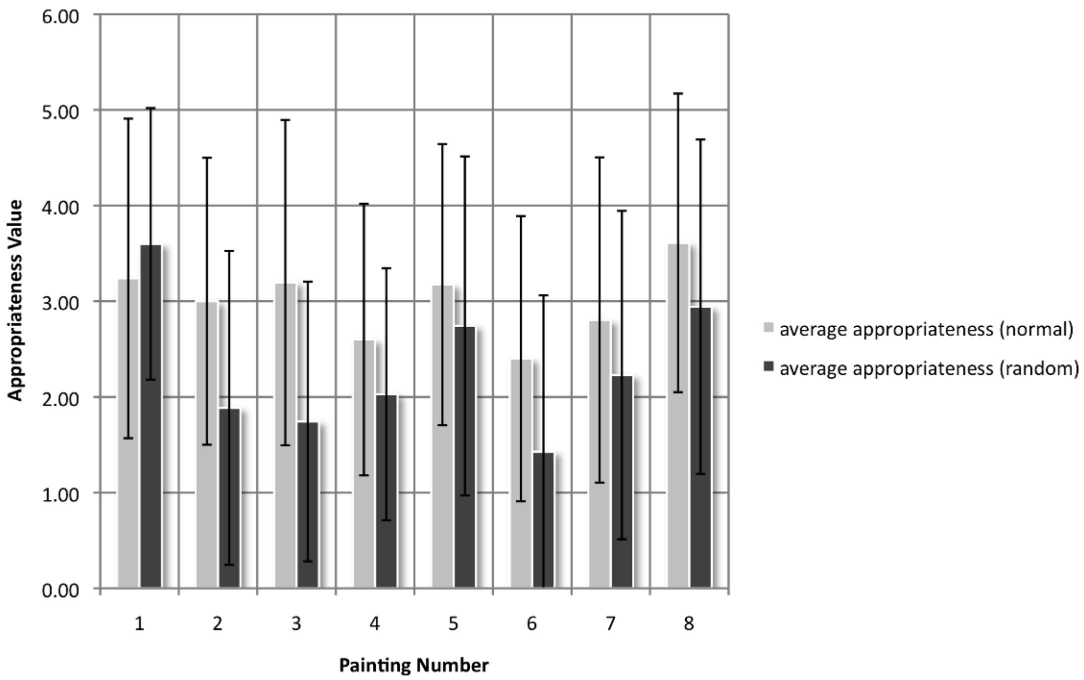


Figure 10: Comparison of average appropriateness value per painting in the normal test and random test

The correlation factors between the average appropriateness from normal generated music and all the personal characteristics can be seen in table 2.

	average appropriateness
music knowledge	-0,15
music skills	-0,24
painting interest	0.29
painting knowledge	0.15
global painting (mean between painting interest and knowledge)	0.33

Table 2: Correlation factor (ρ) between the average appropriateness from normal generated music and personal characteristics

To identify significant differences between both average appropriateness measures (from music generated normally and randomly) we performed the Mann-Whitney U tests. These results are presented in table 3.

	average appropriateness
Mann-Whitney U	425,500
Asymp. Sig. (2 tailed)	0,000

Table 3: Mann-Whitney U differences test

In the first test, it appears that people saw some similarity between the painting and its music. The standard deviation values are close to 2, which is very high and means that the appropriateness varied quite a lot between users and that there is no consensus between users in their opinion. The value 3 is typically a value used by subjects who are undecided, so having an average of 3 shows perhaps that the participants did not know what to answer, so they answered in the middle of the scale.

However, the correlation factor between the painting characteristics and the average appropriateness is moderate and not insignificant, specially the global painting one, meaning that the higher the painting knowledge and interest people have, the higher relation between the painting and its music they see. The correlation factor between the music knowledge and the average appropriateness is negative but too weak to conclude about its influence on appropriateness. We should be careful when talking about the correlation factor between music instrument skills and average appropriateness because we only have two percussion player responses to our forms, and the correlation does not mirror that.

The comparison between the values of music appropriateness of both tests shows that there is a clear difference between the appropriateness of both tests. The Mann-Whitney U test confirms this, as the 2-tailed value is much lower than the p-value of 0.0.5. This means that there is not enough confidence to accept the null hypothesis, i.e. the results obtained in the randomly generated music test are significantly worse than the results obtained in the normally generated music test.

Form 2 always 'looses' to form 1 except in the first painting, but the average difference is d = 0.68, which shows that appropriateness from form 2 is a bit lower than the appropriateness from form 1. The average difference for standard deviation for appropriateness of both forms is d = -0.024, which means that the results from form 2 are insignificantly more disperse than the results from form 1.

5. Conclusions & Future Work

5.1 Conclusions

At this time, the questions which emerge are: did we manage to create a system which provides a synesthetic experience? And did the generated music transmit the same feeling as the painting? The answers to these questions are not straight and the coin is always two-sided.

The results from the evaluation show that the system had some impact, but that this one varied from person to person. Some users admitted that most of the music tracks did not make sense to them, whereas others said that the system really made sense to them. First, we think that the fact that the domain is too abstract, too vast and the possibilities too many, may have contributed to some wrong choices. And second, we think that the users' bar was too high, and that the users were expecting a perfect system, because they do not have a notion of the difficulty of the area.

5.2 Future Work

Given the evaluation results, we propose future work to improve our model. Some users referred colors as being important to their perception of the painting. Even if colors do not have a direct influence on instability or stability perception by the user, they could be present in the ambient or the melody of the music. Dark colors mixed with few shapes transmit a dark and slow ambience and maybe a more frighten or suspense feeling. Whereas dark colors mixed with lots of confusing shapes transmit a dark but fast ambience, maybe like an anguish feeling. Light colors transmit a more happy and agitated ambience. Music can easily transmit that. Color interpretation mixed with shapes interpretation is a whole new field and could be a good improvement to our matter.

Also, these models could be used in other intermedia projects. We believe that instead of shapes, we could use the shape instability model in dance movements, in a dance-music relation, resulting in the 'sonification' of live dance pieces.

References

[1] Richard Cytowic. The Man Who Tasted Shapes. MIT Press, 2003.

[2] Edward Hubbard and Vilayanur Ramachandran. "Hearing Colors, Tasting Shapes." Scientific American, April 2003.

[3] Daniel Smilek, Kelly Malcolmson, Jonathan Carriere, Meghan Eller, Donna Kwan, and Michael Reynold. "When "32" is a Jerk and "E" is a King: Personifying Inanimate Objects in Synesthesia." Journal of Cognitive Neuroscience 19, no. 6 (June 2007): 981-992.

[4] Hajo Duchting. Paul Klee: Painting Music. Prestel Verlag, 1997.

[5] Wassily Kandinsky. Concerning the Spiritual in Art. Dover Publications, 1977.

[6] Myra Melford. "Aural Architecture." In Arcana: Musicians on Music, by John Zorn, 119-135. New York: Granary Books, 1999.

[7] Hannah Higgins. Fluxus experience. University of California Press, 2002.

[8] Eduardo Lopes. "Just in Time: Towards a theory of rhythm and metre." Phd Thesis, Department of Music, University of Southampton, Southampton, 2003.

[9] Eduardo Lopes. "From Blues To Latin Just In Time: A rhythmic analysis of 'Unit Seven'." Jazz Research Journal 2, no. 1 (2008): 55-82.

[10] David Cope. Computer Models of Musical Creativity. The MIT Press, 2005.

[11] Stephan Schwanauer. “A learning machine for tonal composition.” In Machine models of music, 511-532. Cambridge: MIT Press, 1992.

[12] David Cope. The Algorithmic Composer. A-R Editions, 2000.

[13] Peter Copley and Andrew Gartland-Jones. “Musical form and algorithmic solutions.” C&C '05: Proceedings of the 5th conference on Creativity & cognition. London, 2005. 226-231.

[14] George Papadopoulos and Geraint Wiggins. “AI Methods for Algorithmic Composition: A Survey, A Critical View, and Future Prospects.” Proceedings of the AISB'99 Symposium on Musical Creativity. AISB, 1999. 110-117.

[15] Stephen Pope. “Fifteen Years of Computer-assisted Composition.” Proceedings of the 2nd Brazilian Symposium on Computer Music. 1995.

[16] Ricardo Cruz. “I-Sounds: Emotion-based Music Composition for Virtual Environments.” Msc Thesis, Instituto Superior Técnico, Lisbon, 2008.

[17] Ricardo Cruz and Eduardo Lopes. “Pulse Salience Quantification Method.” Document obtained from the authors, 2008.

[18] André Gonçalves. Pulse Salience and Instability calculation. 08 May 2009. http://web.ist.utl.pt/andre.pintado/salience (accessed November 01, 2009).

A Realtime Generative Music System using Autonomous Melody, Harmony, and Rhythm Agents

Arne Eigenfeldt
School for the Contemporary Arts, Simon Fraser University, Burnaby, Canada
www.sfu.ca/~eigenfel
e-mail: arne_e@sfu.ca

Philippe Pasquier
School of Interactive Arts and Technology, Simon Fraser University, Burnaby, Canada
www.sfu.ca/pasquier/
email: pasquier@sfu.ca

Abstract

Kinetic Engine is a realtime generative music system that has been in development since 2005. It has been used as an extended instrument within an improvising ensemble, as a networked performance ensemble, as an interactive installation, and as an independent performance system under the composer's control. The first two versions were solely concerned with polyphonic rhythmic organisation using multi-agents. Version 3 introduced a genetic algorithm for the evolution of a population of rhythms, in realtime, based upon the analysis of music provided. Version 4 explored melodic organisation, again using multi-agents, while the most recent version adds a third order Markov model for harmonic generation.

This paper gives an overview of the different versions of the system. Furthermore, the system's use as a performance instrument, as opposed to an independent installation, will also be discussed, describing the necessary shifts in conception regarding generative algorithms. Finally, an attempt to evaluate the entire system from an artistic, rather than scientific, perspective will be undertaken.

1. Introduction

Kinetic Engine is a interactive generative music system designed and created by a composer, exploring new methods for the generation of musically interesting gestures in realtime. Generative music systems have been used in live performance for decades [1]. The principle organising method for controlling complexity in these systems has been constrained randomness, the limits of which are discussed in detail elsewhere [2, 3]. Simply put, while constrained randomness provides a convenient and adequate solution for generating music gestures in realtime, it cannot come close to the organised complexity of intelligent improvising musicians (the model for most interactive computer music).

Thus, *Kinetic Engine* has been developed, not as a singular approach to employing intelligence in realtime musical organisation, but instead as a series of alternative strategies which explore different aspects, and provide divergent solutions. As new versions appear, older versions continue to exist, fulfilling their specific purposes.

The system has been implemented by the first author, a composer; the second author, a specialist in multi-agent systems and artificial intelligence, has provided much needed advice, direction, and support during the last year.

Section 2 provides some background information, describing the paradigm within which *Kinetic Engine* exists and its basic goals; Section 3 briefly describes the different versions to date; Section 4 gives an artistic evaluation of each system; Section 5 posits some conclusions, while Section 6 suggests our future directions.

2. Background

2.1 Interactive computer music

Realtime computer music, in which the computer makes compositional decisions in performance and reacts to composer/performer interactions, has tended to fall within the domain of improvisatory systems. In an effort to model the “unpredictability” of improvisation, constrained random procedures have been incorporated so that the musical surface - its detail - can be both varied, yet easily controlled [4]. Formal cohesion, or large-scale structural logic offered by recapitulation and restatement, have tended to remain under direct composer/performer control.

2.2 Computational models of musical creativity

Many models exist for generative music systems, including rule-based methods [5], stochastic methods [6], data-driven methods [7], and artificial life models [8, 9, 10]. The use of any given model is perhaps more dependent upon the aesthetic choice of the artist, rather than the success of the model, which in itself may be subjective. Chadabe, for example, views his interactions with his system to be “like sailing a boat on windy seas, interacting with the wind and the waves to keep the boat on course” [11]; within such an paradigm, stochastic generation is entirely viable.

Rowe, however, suggests that “interactive (music) software simulates intelligent behaviour by modelling human hearing, understanding, and response” [12]. Not coincidentally, all these processes are also inherent in musical improvisation. The difficulty in achieving Rowe’s precept is in implementing musical understanding, which implies some type of intelligence: the necessitated requirements for this software would include an instantaneous evaluation of the musical environment, an evaluation of the current environment in comparison to the past environment, as well as an evaluation of the evolution toward the desired future environment, which in itself may be constantly changing. One can understand why this integral aspect of spontaneous musical generation has been left to composer/performers, who have themselves spent years acquiring just such skills.

3. Description

Kinetic Engine began as an effort to place more high-level compositional responsibility within software, using aspects of artificial intelligence. Recognising the complexity of accomplishing this task in a comprehensive manner, the decision was made to limit the exploration in initial versions to rhythmic development and interaction. Other musical aspects - melodic, harmonic, timbral control - have gradually been added.

3.1 Kinetic Engine v.1

Kinetic Engine derives its name from the conception of its first system: software that could generate perpetual high-level musical variations on its own; as such, it was presented as a continuously running installation. This initial version focused on the interrelationship of simple parts that would create a varying rhythmic interplay between four virtual players.

The system was based upon a hierarchical model, with four “dumb” players executing commands sent to them from an intelligent virtual conductor. Each player generated a random rhythmic pattern, of which the number of notes was determined by the conductor based upon an overall density rating that cyclically increased over time. Players performed their patterns, which were in sync to a common tempo and time signature, with their output being sent to a multi-timbral virtual synthesiser, playing percussion samples.

While the notion of repetition is integral to *Kinetic Engine*, continual variation is equally important. As such, each player was required to generate a certain degree of variations on their material, the actual amount of which would have to meet an aggregate level set by the conductor. Each player used a stochastic generator to calculate its own degree of internal variation - which including both pattern and timbral variations - and sent this amount to the conductor. The conductor would accumulate the total amount of variation that was carried out during the previous pattern, and compare it to the variation metre’s level. If the actual variation score was more than the required amount, the variation metre would decrease; if the score was less than the required amount, the variation metre would increase.

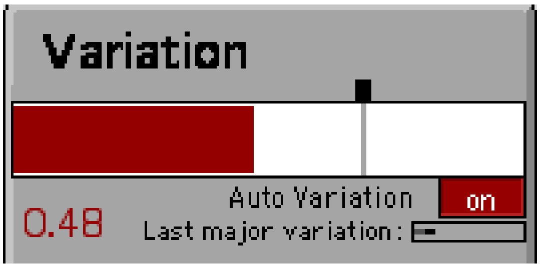


Figure 1. Variation metre, showing the actual variation (red) and required variation (grey line)

The conductor would require more and more variation as time went on, thereby slowly increasing the variation metre; players would thus be required to increase their internal variations. When the individual players could not produce enough variations, the conductor would force a new composition to begin, thus triggering a final, conclusive, variation which would entail a new tempo, time signature, a low density, and instrument changes. Each composition would have a similar overall form of gradual increase in complexity through an accumulation in density and variation.

During a composition, the conductor would monitor the variations of the individual players over the previous few measures, and determine which player had consistently increasing or decreasing variation amounts: these would be displayed in the Evaluation monitor (see Fig. 2, left). If a player was determined to have several successive levels of increasing magnitude, the player would be highlighted by having its volume increased.

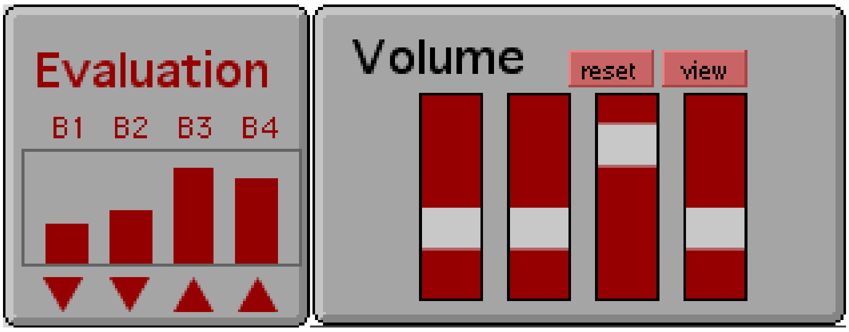


Figure 2. Evaluation of player variations, resulting in a "solo" for player 3

Lastly, specific parameters for each composition (tempo, time signature, length, and ranges for density and variation amounts) would be stored, and a fuzzy logic algorithm was used to construct predicates that ensured subsequent compositions were not "too similar" to previous ones.

Version 1 is the only version that has been retired, since the hierarchical model proved too difficult to expand and update. It's limitations will be discussed in Section 4.

A more detailed, albeit incomplete, description of version 1 is available elsewhere [2].

3.2 Kinetic Engine v.2

Version 2, like its predecessor, is restricted to rhythmic interaction between individual players; it introduces performative control over density, as well as the potential to influence the ensemble through global parameters. Version 2 introduced the notion of intelligent interaction between individual players through the use of autonomous multi-agents. Agents generate their own rhythms in response to a changing environment - primarily based upon overall density - using individual parameters that are considered the agent's personality, as well as their perceived role within the ensemble. Personality attributes include, for example, the agent's amount of social interaction, responsiveness, confidence, mischievousness, and propensity to play on the beat (vs. off the beat) and syncopate.

Once individual rhythms have been generated, agents "listen" to one another, and alter their patterns based upon these relationships. Agents determine when to begin playing (they are autonomous), as well as what to play (they are proactive); they interact with one another (they are social), as well as with their environment (they are reactive).

A great deal of an agent's actions are determined by its perceived role in the ensemble, which, in turn, is determined by the instrument it has decided to play. Agents know that a shaker is performed differently than a bass drum, for example, and thus will not attempt to create a shaker-like pattern for it. The intelligent method for individual and overall timbral organisation is described elsewhere [13].

Version 2 is a rule-based system whose complex interactions result from multiple probability tables. Most of these tables are pre-determined; however, many are influenced by the agent's personality and the changing environment.

Version 2 is discussed in detail elsewhere [14].

3.3 Kinetic Engine v.3

Version 3 of *Kinetic Engine* attempts to balance spontaneous change with the ability to alter and adapt its rule-set. As such, version 3 offers the potential for both realtime composition through recombinance [7] as well as improvisation through generative means.

Desired tendencies for musical generation can be given to the system through specially composed MIDI files. These files are analysed - prior to performance - for patterns and tendencies (i.e. pattern, repetition, variation, and pitch content); this information is saved as an individual XML file for each input file. During performance, agents read the XML files and produce initial material that is closely related to the analysed music.

A genetic algorithm is used to generate a larger population of rhythms based upon the initial material; individuals from the population are chosen by the agent that best match the current state of the environment. Environmental variables, set by the performer, include density (number of notes per pattern) and complexity (relative amount of syncopation). Agents keep track of those individuals selected for performance: those individuals that have been heard become more likely to be culled prior to the next population generation.

The user can decide when to initiate a new generation, or the software can decide this itself. Successive populations include those individuals from the previous population that were not heard (although, due to a Gaussian selection process, there is a chance that heard individuals might live into the next population), as well as new individuals that are variations of the current population. The amount of variation between generations is constrained; for this reason, the potential for mutation, or more dramatic variation, exists.

A unique level of interaction occurs between agents during performance. Since their populations are evolved in isolation, dynamic rhythmic interaction is much more limited than in previous versions. For this reason, an attempt is made to have agents anticipate and predict other agent behaviours, and interact at the phrase, rather than pattern, level. Agents generate a future event-list, which amounts to their "intentions". The points at which they will switch individuals (patterns), and the amount of change that occurs at these points, is broadcast to the community. Agents will then attempt to alter their own intentions, so that they line up with other agents, in order to create larger cadencial phrase structures.

Version 3 is discussed in detail elsewhere [15].

3.4 Later versions

Version 4 of *Kinetic Engine* is software dedicated to a single composition: *In Equilibrio*, and introduces melodic organisation. Events are generated using a module based entirely upon the multi-agent structure of version 2: these events are then sent to six melodic agents which generate melodic phrases. The pitch and dynamic shapes of these phrases are determined by the individual agent's unique characteristics, similar to version 2's personality attributes.

Each melodic agent attempts to create organic pitch shapes, while at the same time, searching for a harmonic balance between itself and other agents: balance, in this case, is achieved when each agent has its initial phrase point at equidistant intervals from every other. However, this goal is complicated by a constantly changing pitch set, in which each pitch has a differing weight, which exerts its own "pull" on the agent.

Version 5 introduces a single agent dedicated to harmonic generation based upon a modified Markov analysis of a given musical corpus. However, unlike traditional Markov-based generation, a method is employed in which user determined feature vectors (bass line, harmonic tension, harmonic complexity) are defined, and a resultant progression is created that balances user-requested material with coherence with the database. This is an attempt to overcome the perceived weakness of Markov models at handling deeper musical structures [5].

Version 4 is discussed in detail elsewhere [16]; version 5 is discussed in detail elsewhere [17].

4. Artistic Evaluation

The initial goal of *Kinetic Engine*, and reflected in the original version, was for software to make decisions at a level higher than the musical surface. In order to accomplish this, the software had to determine a goal, and monitor the progress towards this goal. In this sense, the first version of *Kinetic Engine* was successful. The musical surface was unpredictable in its detail, due to its use of constrained randomness (through its choice of specific rhythms, timbres, and variations); however, sectional change and evolution was ensured through the gradual increases in both density and variation. The end result was a series of compositions that ranged in duration from 3 to 15 minutes: this variation in duration was due to the fuzzy logic algorithm that determined duration, as well as tempo, time signature, and timbral groupings.

Listeners who spent longer periods with version 1 would have heard several compositions of a contrasting nature; however, the overall formal structure was limited, specifically in its ability to generate unexpected formal constructions. This resulted from a trade-off that ensued from limiting the ranges in the formal scheme; in order to guarantee a certain degree of formal success, limits had to be placed on potential choices. In the short term, this guaranteed a favourable outcome, but excluded completely novel combinations.

Version 2 explores more evolutionary approaches to form through its multi-agent design: form would develop through the interaction of the agents themselves. This proved to be a very flexible design, as different situations can use different numbers of agents. Direct performance control allows for extremely fast changes to the system in response to a live musical situation; therefore, the composer is once again making structural decisions. This is deemed an acceptable trade-off, since the complexity of the system's output requires very little realtime supervision, and is analogous to a conductor guiding a group of creative musicians (as opposed to controlling a group of dumb software players).

While the rule-set for generating rhythmic patterns is greatly improved from version 1, it remains static. This results in musical generation that, while initially engaging, remains essentially homogeneous over longer periods of time. Similar to its older brother, version 2 is designed in such a way that successful musical output is favoured over completely novel results.

Lastly, when using the system as an intelligent instrument within an improvising ensemble, a situation often arises in which the human musicians request specific output from *Kinetic Engine*, usually in the form of a specific beat. Since the system is entirely generative, this is not possible: any patterns that emerge are the result of the spontaneous reaction to the current environment, and a complex interaction between the agents themselves. As such, version 2 could be considered an improvisational system, without compositional control over its output.

Version 3 was created in an effort to include just such compositional control over pattern generation, while maintaining the complexity of multi-agent interaction. This version was extremely ambitious, particularly since it was coded in MaxMSP, a visual data-flow language not known for its programming structure or ability to handle very large programs. After the initial generation of material based upon analysis, the system was, essentially, generative; however, the use of the generative material was overseen by an algorithm that required a complete understanding of its resources (through an analysis of all generated material) via its requirement to select individuals based upon the immediate, though continually transforming, environment. As such, every agent was spending a great deal of time generating new populations, and then analysing these populations, all in realtime: the system lacked the immediate responsiveness of version 2.

These setbacks could, presumably, be overcome through standard methods of code efficiency testing. However, after over three years of being limited to rhythmic interaction, it was felt that the next version of *Kinetic Engine* should incorporate melodic organisation.

Two compositions were created using version 3 in a studio environment. The first, *Armar*, is a percussion quartet using Cuban music as a corpus. The system was run in realtime, and its output was recorded into a MIDI sequencer. Several "performances" were recorded, the best selected, and then transcribed into a notation program. *Other, Previously*, composed for guitar and cello, used a Javanese ensemble composition, *Ladrang Wilugeng*, as its corpus. *Kinetic Engine* discriminates 12 different pitches during analysis; as such, it was possible to generate pitch-based output that had less than 12 discrete pitches (which is the case with the gamelan source material).

Melodic generation is more fully explored in version 4, albeit in ways that are not intelligent. As this system is a realtime system under performer control, all structural decisions, including harmonic change, are left to the performer. Melodic agents, while social, reactive, and pro-active, are not autonomous. From an artistic viewpoint, this system is successful, although limited; in other words, it can generate one piece, although many different versions of this piece.

An independent system exists that generates harmonic progressions based upon the analysis of a given musical corpus. Work is underway to combine this system with the performance engine of version 4; however, at this time it is unfinished.

5. Conclusions

Constrained random systems allow for the effortless generation of horizontal gestures; however, these gestures will have little interaction between them. Kinetic Engine *is based on complex interactions between its parts through the use of multi-agents. These agents explore a musical space, which can be either constrained (v.2, v.4) or more open (v.1, v.3).*

A trade-off has existed in every version between a successful artistic result and novel, unexpected outcomes. McCormack [18] discusses this problem in relation to evolutionary art in its search for interesting phenotypes within the constraints of aesthetic selection. One can view generative systems, such as Kinetic Engine*, as systems that make similar aesthetic selections, albeit within parameterised processes, rather than from a population. McCormack goes on to identify the need for artificial creativity to exist within systems, so that the system can not only generate novelty, but recognise when it has done so.*

The limitations placed upon Kinetic Engine*'s output can be considered an aesthetic decision, specifically a rejection of disorganised complexity. Complexity has been, and remains, a goal of artistic creation; interactive generative systems can therefore be seen as complex systems. Weaver [19] suggests that the complexity of a system, whether it is a piece of music or a living organism, is the degree of difficulty in predicting the properties of the system; however, he differentiates between* disorganised complexity - *which can be analysed and produced using statistical methods - from* organised complexity - *which results from the interaction of its parts, and has the potential for emergent properties.*

Kinetic Engine *has explored organised complexity in its various incarnations; however, a successful, intelligent, and autonomous method of formal control has yet to be found.*

6. Future Directions

Current work includes adding a third software control layer to version 4, subsuming the performer's control in a way that resembles the conductor in version 1. This would return to the installation/non-performative model, but would add a layer of intelligent formal control to the software. Harmonic control would be assigned to the harmonic agent, and additional agents would be designed to monitor overall form and evolution, thus combining a top-down analysis with a bottom-up generation.

Lastly, Kinetic Engine *various versions were engendered by artistic desires. The success of each system was, for the most part, determined by its creator on rather subjective grounds. More extensive, and objective, methods of validation are currently being planned in regards to both* Kinetic Engine *and more general generative systems.*

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6. References

[1] Chadabe, J. (1977) "Some Reflections on the Nature of the Landscape within Which Computer Music Systems are Designed." *Computer Music Journal*, 1(3):5-11

[2] Eigenfeldt, A. (2006) "Kinetic Engine: Toward an Intelligent Improvising Instrument" *Proceedings of the Sound and Music Computing Conference*, Marseille pp. 97-100

[3] Eigenfeldt, A. (2007) "Computer Improvisation or Real-time Composition: A Composer's Search for Intelligent Tools" *Electroacoustic Music Studies Conference 2007*, http://www.ems-network.org/spip.php?rubrique49 Accessed 22 October 2009

[4] Chadabe, J. (1984) “Interactive Composing.” *Computer Music Journal*, 8(1):22-27

[5] Ames, C. (1989) “The Markov Process as a Compositional Model: A Survey and Tutorial” *Leonardo*, 22(2):175-187

[6] Lewis, G. (2000) “Too Many Notes: Computers, Complexity and Culture in Voyager”, *Leonardo Music Journal*, vol. 10, pp. 33-39

[7] Cope, D. (1996) *Experiments in Musical Intelligence*. Middleton, A-R Editions

[8] Miranda, E. (2003) “On the Music of Emergent Behaviour. What can Evolutionary Computation bring to the Musician?” *Leonardo*, 36(1):55-59

[9] Biles, J. (1994) “GenJam: A Genetic Algorithm for Generating Jazz Solos”, *Proceedings of the 1994 International Computer Music Conference*, Aarhus pp.131-137

[10] Blackwell, T., Bentley, P.J. (2002) “Improvised Music with Swarms”, *Proceedings of the Congress On Evolutionary Computation*, Honolulu pp. 1462-1468

[11] Chadabe, J. (2009) *Electronic Music: Unsung Revolutions of the 20th Century*. http://www.percontra.net/6music2.htm Accessed 22 October 2009

[12] Rowe, R. (1993) Interactive Music Systems, Cambridge, Mass., MIT Press

[13] Eigenfeldt, A., Pasquier, P. (2009) “Realtime Selection of Percussion Samples Through Timbral Similarity in Max/MSP”, *Proceedings of the International Computer Music Conference*, Montreal pp. 77-80

[14] Eigenfeldt, A. (2007) “Drum Circle: Intelligent Agents in Max/MSP.” *Proceedings of the International Computer Music Conference*, Copenhagen pp. 9-12

[15] Eigenfeldt, A. (2009) “The Evolution of Evolutionary Software: Intelligent Rhythm Generation in Kinetic Engine.” *Applications of Evolutionary Computing, EvoWorkshops 2009 Proceedings*, LNCS 5484 Springer, Berlin pp. 498-507

[16] Eigenfeldt, A. (2009) “Multiagency and Realtime Composition: *In Equilibrio*”, http://cec.concordia.ca/econtact/11_4 Accessed 22 October 2009

[17] Eigenfeldt, A., Pasquier, P. (2010) “Realtime Generation of Harmonic Progressions Using Controlled Markov Selection.” *Proceedings of ICCC-X - Computational Creativity Conference*, Lisbon

[18] McCormack, J. (2005) “Open Problems in Evolutionary Music and Art.” *EvoWorkshops 2005 Proceedings*, LNCS 3449 Springer, Berlin pp. 428-436

[19] Weaver, W. (1948) “Science and Complexity.” *American Scientist,* 36 pp. 536-544

Musical Data Surrounding Two Iconic Churches

Brigid Burke

clarinettist, composer, visual and media artist

email: brigid@alphalink.com.au
web site: http:www.brigid.com.au

Abstract

An artist talk about "An Enchanted Aisle" a 14 minute work combining clarinet, live interactive audio interfaces and synchronized video for live performance and a visual and audio Installation. It explores the sonic vocabularies of liturgical and social interactions due to digital mediums been transmitted in the air and the effect this change that has had on the life around and in the Cathedral. (St Patrick's Cathedral Melbourne Victoria Australia and Piazza del Duomo, Milan Italy)

The Cathedral is surrounded by people that inhabit, visit and at times formulate their own identities and communities when occupying Cathedrals. These interactions have not changed over the centuries except for the last fifty years with the introduction of digital data been transmitted everywhere in the environment. Cathedrals can talk to each other from one side of the world to the other, through digital media cameras and live air broadcasts. A comparison was made of both sites through audio means. New forms of communications have effected the forms of interaction and importance of the place of the Cathedral in society. The out come is the creation of a work that gives realism and breath to this digital world. The end result is at times abstract, random and ambiguous. I have explored these meanings by creating a work that gives moments of the past and present as equal identities in "An Enchanted Aisle"

"An Enchanted Aisle" was created in three stages with the forth stage been a Performance, presentation and installation.

Introduction

The aim in 'An Enchanted Aisle' was to make sound and image cohesive through digital means and examine the aesthetics of two iconic church's on either sides of the world. To achieve this integration the audio is analyzed and used directly to control the manipulation of specific aspects guided by the moving images. The structure and the real energy of this idea comes from combining the strength of the interaction, real-time processing, sound/image linking and mapping into the singular work that explores all forms of expression. When linking the music and visuals I question the unity and the relationship between the computer process and performance outcome.

A relevant quote from Pierre Proske's Synchronized Swamp project.:

"The emergence of identical or "same" behaviour across different fields of biological research is aptly demonstrated in the domain of coupled oscillators. The study of coupled oscillators, a more recent sub-branch of mathematics, can be traced back to this facility is available the Dutch physicist Huygens, who noticed that two pendulum clocks when placed side by side display the uncanny tendency to synchronise their swinging. This phenomenon is one that is expressed throughout the natural world, occurring in the synchronisation of the cells of a body that generate the heart-beat, the periodic flashing of swarms of fire flies, the synchronised propagation of waves in the heart intestine and nervous system, and the synchronised chirping of certain frogs and insects."

I see the correspondence here in the two Cathedrals. How they work like a pendulum on either sides of the world. Communicating to each other and working apart but in synchronisation with each other. The people around them working, living in similar ways as in the natural world. In mapping audio to create this synchronisation I am using various programs which have given me endless possibilities. I am using the live interactive audio program AudioMulch developed by Ross Bercinni from Melbourne Australia that allows me to facilitate this flexibility and address mapping in a modular way that is easy to reconfigure throughout performance and in recreation of the samples.

2. Process

An Enchanted Aisle is 14 minute sound work combining clarinet, live interactive electronics, a cappella (SSA)and visual and audio Installation. The sound work was then divided into four audio-visual stand alone video works entitled.

1. As it is
2. Through the Red Glow
3. The River Never Lies
4. A Fast Interaction

As a whole the composition explores liturgical and social interactions due to digital mediums been transmitted in the air and the effect this change that has had on the life around and in the Cathedral. (St Patrick's Cathedral Melbourne Victoria Australia and Piazza del Duomo, Milan Italy)

An "An Enchanted Aisle" explores the tempo both audibly and visually while creating abstract, floating image impressions of movement. The research took place in both Melbourne Australia and Milan Italy collecting audio and visual samples and observing both Cathedrals and surrounding areas.

Both Cathedral's are surrounded by people that inhabit, visit and at times formulate their own individual identities. These interactions have not changed over the centuries except for the last fifty years with the introduction of digital data been transmitted everywhere in the environment. Cathedrals can talk to each other from one side of the world to the other, through digital media cameras and live air broadcasts.

The visual samples are of the two Cathedrals, pope's heads and figurines. Both sites are under constant restoration and I have documented them with line drawings, photos and video footage. The contrasts that float in the atmosphere surrounding the Cathedrals are of tone, pulse, melody, detail, verbal history, chants, solemn silence and wind. A series of visuals start out the raw state and then become heavily modified with text floating combined with the drawings and pope's heads appearing throughout each of the four films. When creating An Enchanted Aisle I examine the media I am going to use in the composition/improvisational elements**.** Generative art is often understood exclusively as software generated abstractions. I personally understand the term as a much broader range of strategies involving both digital and non-digital systems and processes bridging specific art traditions and media. I think about basic audio elements: sonic realm,

amplitude (volume),
pitch, timbre (tone quality),
duration,
tempo,
rhythm
density.

I then take these forms and add extended Voice and woodwind techniques:

screams,
pure tones,
throat sounds/hums
tongue clicking,
kissing sounds,
micro-tonality,
key clicks,
multiphonics,
monophonics,
quarter tones,
over-blowing
interrupted tones

Electronic filters:

pitch shifters, reverbs,
flangers,
room placements,
harmonics,
sine waves,
ring modulators,
delays, phases,
granulation
EQ.

The process continues with manipulation of files into different layers and multi channels, concentrating on microtonal interaction between the samples. A similar process is applied to the visual materials including analysis of brightness, colour, contrast, duration, speed and complexity. The images have two categories: graphic based images and film/still images. The sound and image influences the shape and analysis of each of the movements. The audio in the compositions uses a real-time environment of acoustic sound and generative mapping structures. The other added facet is to combine live acoustic clarinet. Audio Mulch (live interactive Mapping Audio program) controls the modulating parameters (for example pitch shifters, granulators, phases, loops, switches) Controlling the amount of dynamics, on and off switches and loops during performance on the clarinet.

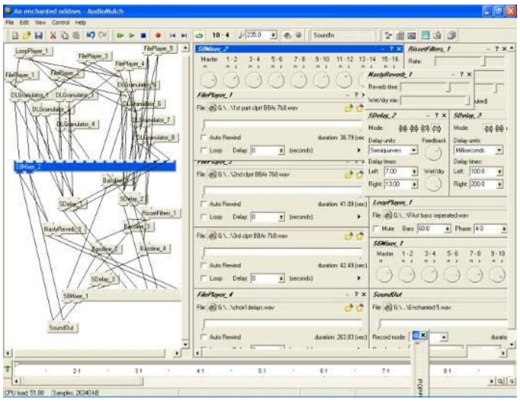
A comparison of both sites was made through audio means. New forms of communications have affected the forms of interaction and importance of the place of the Cathedral in society. The atmosphere and the breath this digital world has created are abstract, random and ambiguous messages around the cathedrals. “An Enchanted Aisle” explores these meanings by creating a work that gives moments of the past and present as equal identities. In the making of “An Enchanted Aisle” I collected 16th and 17th century liturgical excerpts by Palastrina, Bach, Viadana, Tallis and Byrd from choirs housed at St Patrick’s Cathedral Melbourne and Piazza del Duomo in Milan Italy.

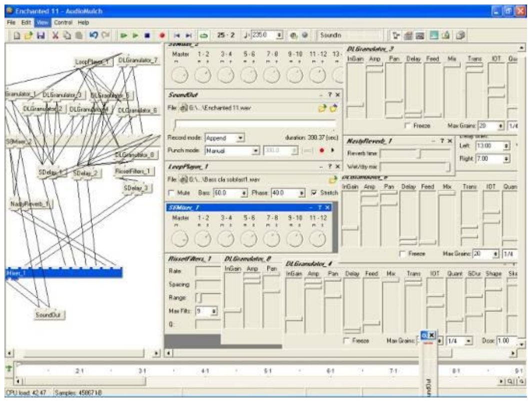
These composers inspired me to create “Inside an Enchanted Aisle” a three part female choir a cappella work.

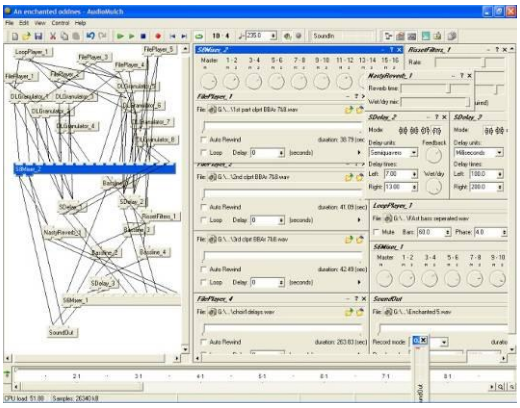
I have collected audio samples of conversations, environmental city sounds, digital devices and analog sounds surrounding the two cathedrals. These audio samples were then transformed in the studio with intricate processing through Audio computer mapping soft ware packages. The sound files went through different processes such as Granulation, pulse manipulation, Sound shaper, Pitch Shifters, Reverbs, Flanger’s, room placements, Phases and EQ. The process continued with manipulation of files into different layers and multi channels, concentrating on microtonal interaction between the samples.

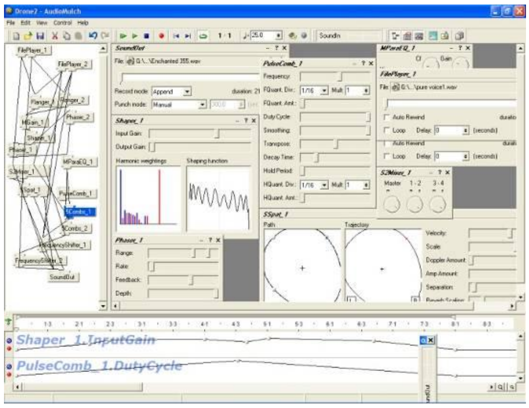
The woodwind files were then replicated from the voice samples and in some cases the liturgical music. The files were then processed in the same manner concentrating on microtonal tonality and granulation. The short video excerpts of drawings, photographs and manipulated art work have been processed in a similar process as the audio through multi-channelling. The last stage was the combination all the processed and unprocessed audio samples for live performance in Audio Mulch (a live interactive computer music program).

Examples of patches from Audio Mulch









Examples of processors I have used:

S Delay - This effect is useful for filling out or widening the instruments sound Particularly the live clarinet or looped sound the delays are between 50 - 100ms , it is also possible to create at time a doubling effect.

DL Granulator - is implementation of a delay live granulator

A delay line granulator samples small Sonic fragments from a delay line and resembles them into a stream of enveloped grains of sound.

IOT - The Interonset time parameter determines the time between the start of one grain and the start of the next in the output stream.

TRANS - Transposition factor- the slider has the range of 1-2 octaves.

GDur - Grain Duration from 10-500 milliseconds

Parameters - are controlled by sliders

In Grain - specifies amount of input signal

PAN - grain pans from right to left channels

DELAY - the ranges are 0-9.5 seconds

FREEZE - will freeze input to the delay line

FEED - Controls how much the granulated output is fed back into the delayed input

Quant -Quantization is only activated when the clock is running and allows the onset times of all grains to be quantazed.

Dcor – Decorrelation –when set too 1 it is totally uncorrelated (random)
, when set to 0 pitches are correlated e.g. high pitch to the right.

Photographs

Piazza del Duomo, Milan Italy

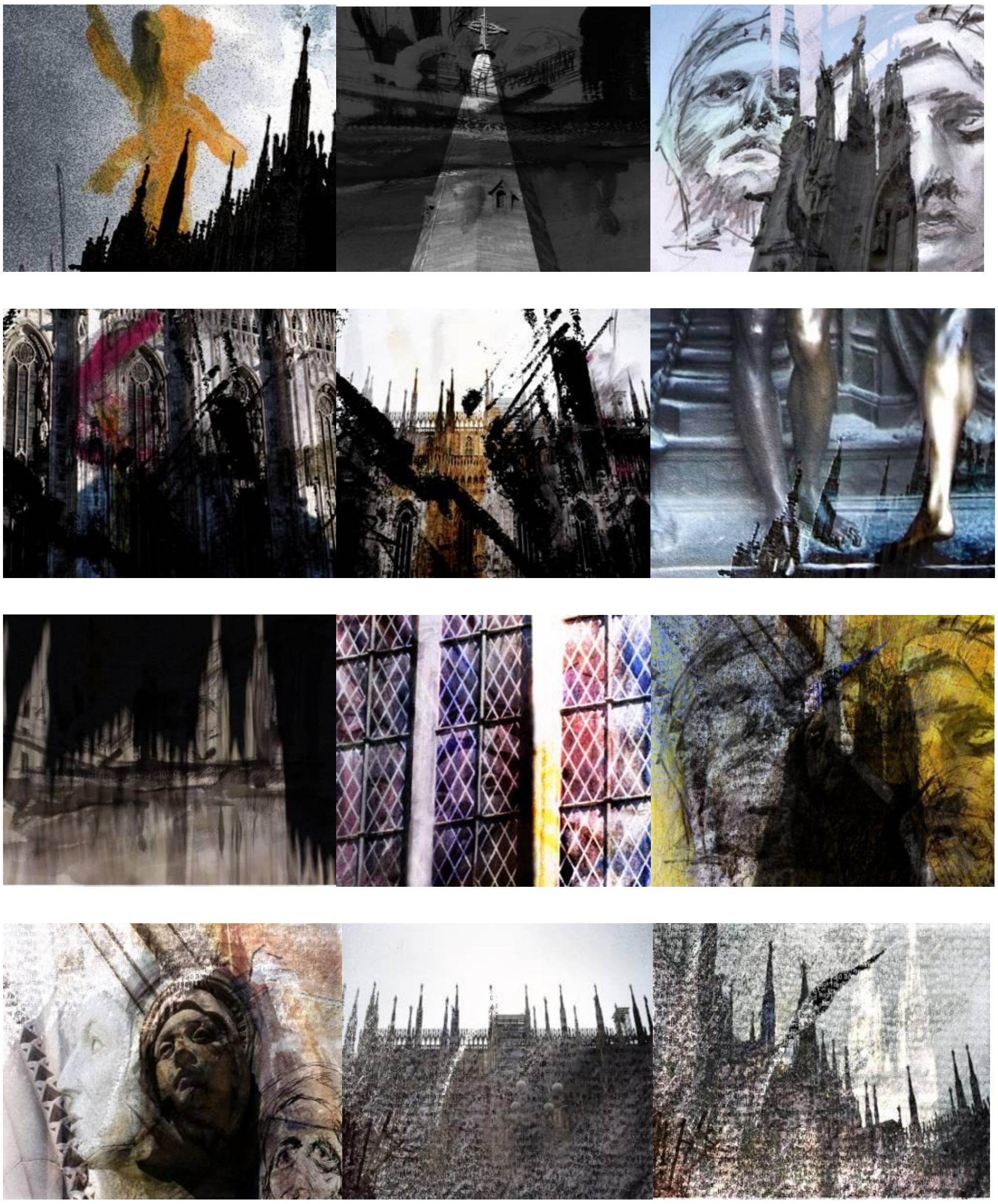
St Patrick’s Cathedral Melbourne Victoria Australia

Drawings

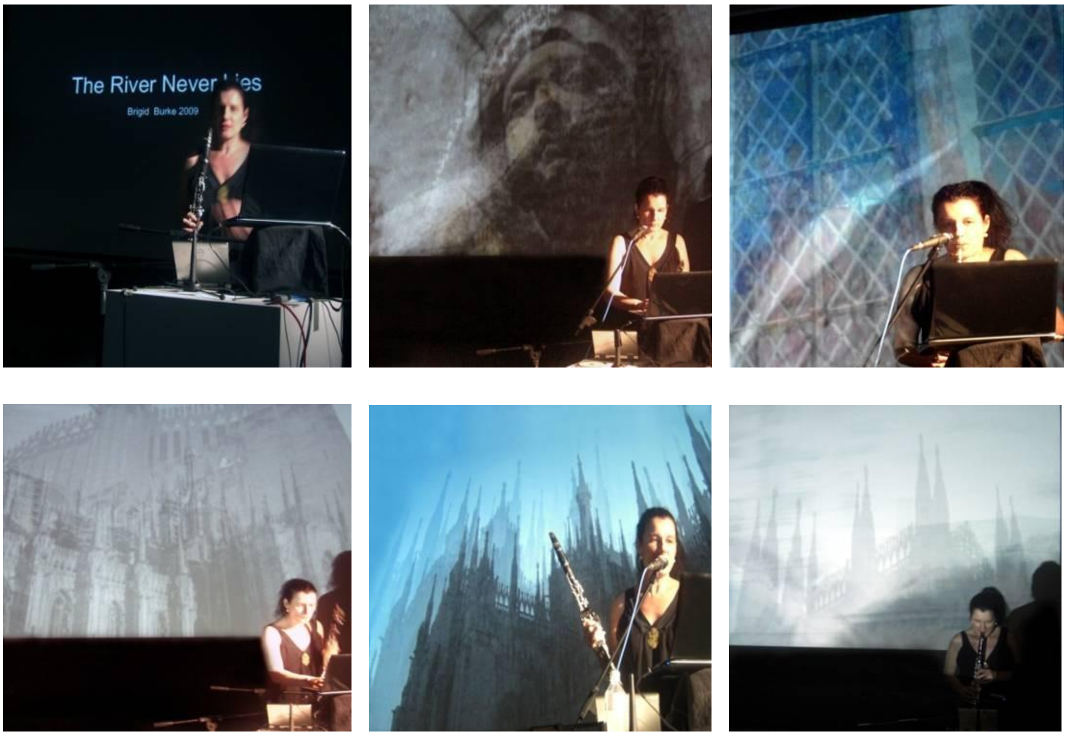
Piazza del Duomo, Milan Italy
(mainly from a distance)

St Patrick's Cathedral Melbourne Victoria Australia
(Popes heads and figure)

Computerized photographs, drawings and text of both sites



The performance atmosphere, acoustics, audience reaction and ambience though out the theatre helps me perform and react to activate the real time audio mapping devices with my immediate reactions to the visuals and acoustics of the environment. Examples of performance



The live audio is generated through computer synthesis which is used to control the modulating parameters controlling the amount of dynamics, on and off switches and loops during performance on the clarinet/voice. The end result was a performance of clarinet, voice, live electronics, synchronized video and A Cappella Choir. In conjunction an installation that includes an exhibition of photographs and finished art works printed on silk, limited edition silk-screens , 5.1audio surround sound and video projection. The aim was to use both old and new of technologies for the outcome, to recreate an environmental situation as presented today so they are remixed and realized in an interactive multi agent performance platform

4. Conclusion

Interaction with the visuals and sound through analysis and mapping offers new opportunities and challenges that deserve original and creative application. Through the use of the uncanny, the video aims to blur boundaries between fact and fiction, data and realism, myth and reality, investigating ideas around superstition, rituals and histories. Through the juxtaposition and comparisons between the two cathedrals one can only be drawn out of the apparent unspoken and the redefining of social, political, historic spatial narratives.

5. Biography

Brigid is an Australian composer, performance artist, clarinet soloist, visual artist, film maker and educator. She has performed and toured extensively internationally. Highlights have been The International Video Dance Festival of Le Breuil France, 2008 21th Instants Video Festival in France, Music Marathon Boston USA, Futura Festival Paris, ABC Saturday Afternoon Sessions Australia, The International Clarinet Festival in Vancouver Canada and Tokyo Japan, 2007 Melbourne International Arts Festival and performances in and ICA London. Other ensembles who Brigid performs with are Tri Duo, Carte Blanche, Australian Chamber Enssemble, David McNicol and Ollie Bown

Her main focus is integrating musical ideas with a combination of different media. Each component of media is a tool in the exploration of her artistic process: sound (acoustic, laptop, clarinets and electronics), composition, improvisation, installation, video, collaboration (with dancers, acoustic performers and new media performers), print making, pen and ink drawings, painting and animation (digital).

In 2008 she was a recipient of an Australia Council Project Fellowship. She has a Master of Music in Composition from Melbourne University Australia.

References:

Cope, D. (1991*) Computers and Musical Style*, Winsconsin, Madison.

Cage, J. (1961) *Silence*, Middletown, Connecticut, Wesleyan University Press

Rush, Michael. *Video Art* Thames & Hudson

Pierre Proske, Synchronised Swamp : Uncanny Expressive Mathematics http://www.hz-journal.org/n7/proske.html

Ross Bencina 2006 AudioMulch software, documentation and web site. http://www.audiomulch.com/ email: rossb@audiomulch.com

Schafer, R. M. 1977. The Tuning of the World, Alfred A. Knopf, New York.

20 years ARGENIA evolution

Prof. Arch. Celestino Soddu
Director of Generative Design Lab
Department of Architecture and Planning, DiAP
Politecnico di Milano University
www.generativeart.com - *www.generativedesign.com* – *www.generativism.com*
www.argenia.it – *www.domus.argenia.it*
e-mail: celestino.soddu@polimi.it

Abstract

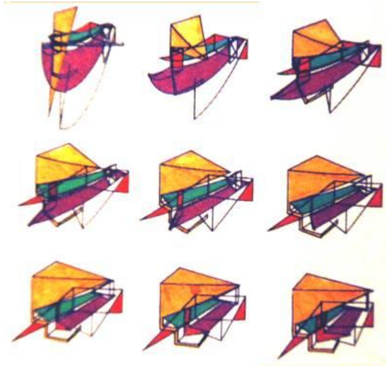
Starting from 1986, I developed my generative approach by identifying, from Basilica generative software to the last Argenia "open" version, the challenges linked to my own creative Vision:

1. The cultural references to Italian Heritage, from Renaissance to Futurism, particularly Leonardo, Borromini, Palladio, Piranesi and Depero, and the reference to Gaudi' and Kandinskij, following my subjective approach to complexity.
2. Subjectivity as the main way to reach the complexity
3. Moving through multiple dimensions as the main engine for generating identifiable series of events,
4. Variations as the main expression of a Vision, following Bach approach.
5. Recognizability of each possible unpredictable result as confirmation of the quality of a generative process.
6. Identity, architectural, environmental identity, following own cultural and creative Identity as the main topic to manage with Generative approach.

Moving from subjectivity to multi-subjectivity, the new challenge is the possibility to extend Argenia to different users with the possibility to involve each user in constructing, in a while, the artificial DNA of his own creativity. This new software will be used, together I hope with other tools made by the friends of Generative Art, for starting new research and teaching activities also inside Domus Argenia, the international centre on Identities and Generative Art just now established in Sardinia.

1.Premise

When, in 1986, I designed Basilica, my first generative software in the field of Architecture, I had the experience of seven years of experimental software. Starting from 1979 I had designed software in the field of perspective representation of architecture, of reverse perspective for generating 3D models from 2D images, of the total 360 degree perspective and about the use of fractal geometry for generating natural environments. These first software were made together with experimental representations of complex not-linear systems with the aim to manage in a morphogenetical way multiple bifurcations and variations. My first reference, but also the friend for discussing these advanced approaches to Art and Science was C.L.Ragghianti, which published several times my researches in his magazine "Critica d'Arte".



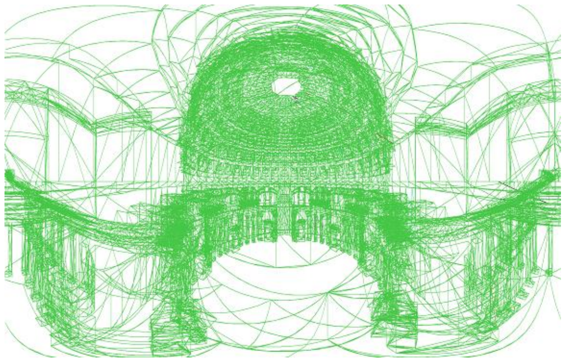


Fig. 1, Cover of "The not-Euclidean Image" C.Soddu, 1986
Fig. 2, From the article on "Critica d'Arte", the magazine of C.L.Ragghianti, n. 18, 1988, about dynamic multi-dimensional and not-Euclidean interpretation of "futuristic" Balla.
Fig. 3. Use of Total Perspective for representing the Pantheon. Made with the "Total Perspective" software designed by C. Soddu in 1985. The software was explained in "Not-Euclidean image" book, 1986.

The aim of designing generative software was born from my passion for the architectural composition and design and from a consideration: in architectural design processes, each following step toward the final result forces us to choose among different possibilities/bifurcations. We need to choose what seems acceptable and what seems to fit our aims. But we are not able to valuate, also *a posteriori*, if the choice has been happy. Certainly, the custom in designing and the acquired experience allows us to knowingly make such choices, as when we make a movement to chess and we pre-view the possible future scenerios. But always the doubt that the lost road would have been able of fitting unpredictable qualities remains. We know very well that alternatives that seem to be not practicable are only hypothesis not yet arrived to an acceptable maturation. But alternatives are innumerable and each one multiplies the possible incoming scenarios until infinite.

The matter is that we are aware that architectural idea/vision can be only represented with the endless possible choices that we valuated as fine. All they are part of our Vision, not only those that we have made for finishing a project. Idea is a Poetic of a world of possible. Poetics cannot find its full expression through only one final result.

It's possible to write this Idea as chaotic dynamic not-linear system? Were each bifurcation/alternative could be represented and variations can be generated by changing the starting point?

This consideration is at the base of my generative approach. <u>Idea is not only the result but the logics able to develop the design processes</u>. Idea as genetic code in imitation of Nature. Idea is the system of transformation-logics to move from a scribble (or other unpredictable starting point, not necessary fitting the idea) to an architectural project. And the idea belongs to subjective poetic. (C.Soddu, "Alive Codeness", GA2008 proceedings, DomusArgenia Publisher). This is the engine of Basilica, my generative software able to represent my Generative Vision in Architecture.

2.My first experimentations: generative engines from moving through different dimensions

Therefore, using my acquired experience in nrealizing software based on mathematical / geometrical approach, I decided to design generative software with the aim to write something like progressive Logics of Transformation from an existing environment into a possible one that had to be, more than only a tool, the expression of an Architectural Vision.

I have immediately realized that this approach would have sense only by stratifying a lot of possible "choices", therefore this approach would have asked a lot of time for reaching the necessary complexity. My idea was, and it remains, to stratify, to put into the interconnected system and recording them as operative logics, as algorithms, the "thoughts of design transformation" able to reflect particular design moments and different environmental situations. Design processes are not only dialectical games. They need creative vision and experience. Algorithms come accordingly

I had learned from my previous professional design activities that, very often, the only possibility to overcome a moment of stalemate in the development of a project, that is the moment in which we don't succeed in identifying possible alternatives and the design evolution seems linear, axiomatic and boring, is waiting for a change of humor or, if we are in a hurry, is artificially changing the point of view. We can do that, for instance, by turning upside-down the sketch that we are working to, or tracing a new perspective view from another point of observation. The new point of view is able to be a catalyst for seeing in different way the relationships among the existing structures so that it helps us to identify, immediately, a set of alternatives among which to choose.

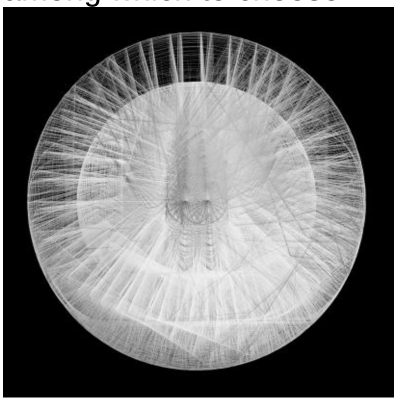
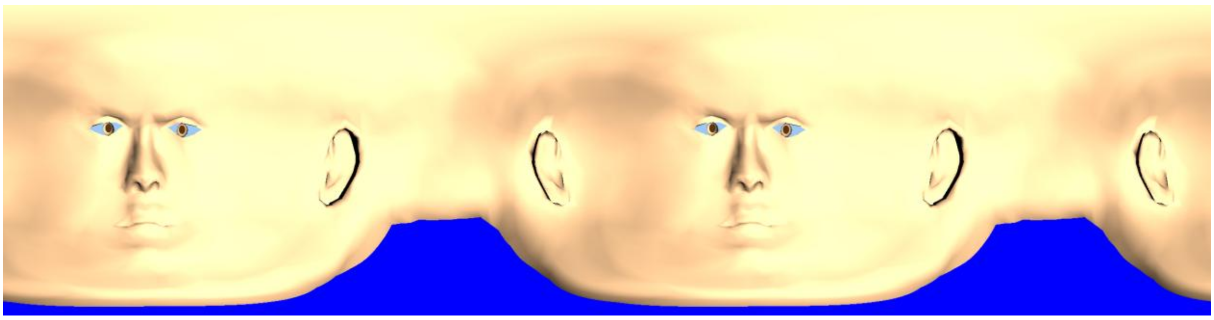


Fig. 4 Studies on multiple dimensions: a 9 dimension sphere. C.Soddu 2004

Fig. 5 Using reverse perspective of Florenskji in the 360 degree view of a face seen by inside the same face. (C.Soddu, "Perspective, a visionary process, the main generative road for crossing dimensions", NNJ journal, incoming publishing.



Therefore, the progressive creation of "logics of transformation" was immediately based on the manifold passages through different points of view, in practice on the passage from two to three dimensions, and vice versa using perspective representations and reconstructions 2D-3D and on different passages from a dimension to another not limited to 3 dimensions. (C.Soddu, “Endless interpretations, infinite in the mirror” GA2007).

Also my studies on the representations of medieval cities by Giotto and Simone Martini, developed in my book " Not Euclidean Image" (C.Soddu, L'immagine non-euclidea, Gangemi Publ. 1986) identified, in the medieval images of cities and architectures, the dynamic progression of the "perspective" point as able to define a multiplicity of "reasonable" spatial orders that, all together, can better represent the idea of "medieval city". This particular "ideal city" is in the mind of these medieval artists and architects but, as happens also today, they cannot succeed in representing their Vision with only a static image but with dynamic images based on sliding points of view. These medieval city images seems to be not in “correct” perspective but they are only constructed stratifying different views with different points of view.

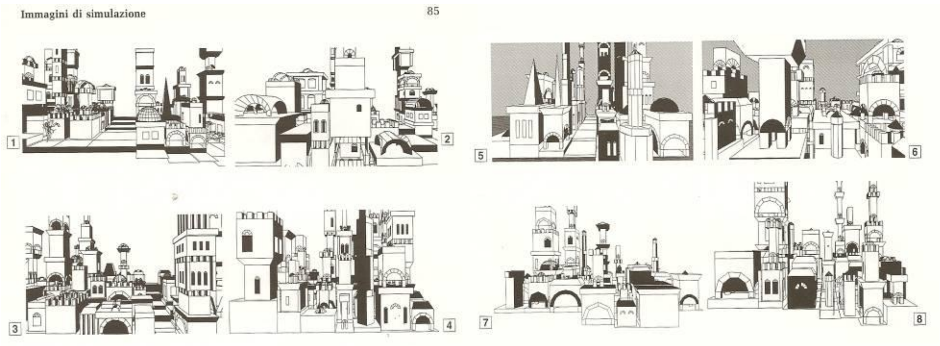


Fig. 6, 7 Starting from the studies on Simone Martini dynamic representation of medieval cities (“Not-Euclidean Image” book 1986) to the medieval town generated 3d models (from “Aleatory Cities” book by C.Soddu, 1989)

I have begun my generative experimentations by writing the first version of Basilica on Apple II with pen plotter. All was focused to generate events belonging to an urban "medieval" environment, or better an urban environment whose characters were my interpretation of Giotto and Simone Martini. The dynamic sliding of the point of view into only one image, peculiar character of the historical representations of medieval cities, but also used later by Piranesi (C.Soddu GA2008), became, in my generative program, the engine of possible transformations and multiple variations, operating "subjective" transformations among two and three dimensions. The main difficulty of these first experimentations of the middle of Eighties was the time due to verify the system. Because the screens with green or yellow phosphoruses were at low resolution, the only possibility was to directly trace a representation through the pen plotter. I launched in the evenings the program and the subsequent mornings I got up for seeing the result. Updated the program I had to wait a lot for verifying it again.

Soon, however, an aspect became more and more clear: Approaching the project through repeated progressions of transformations had two important results: the complexity and the strong identity; every result, although unpredictable, gained the possibility of being recognizable as belonging to a Medieval Vision.

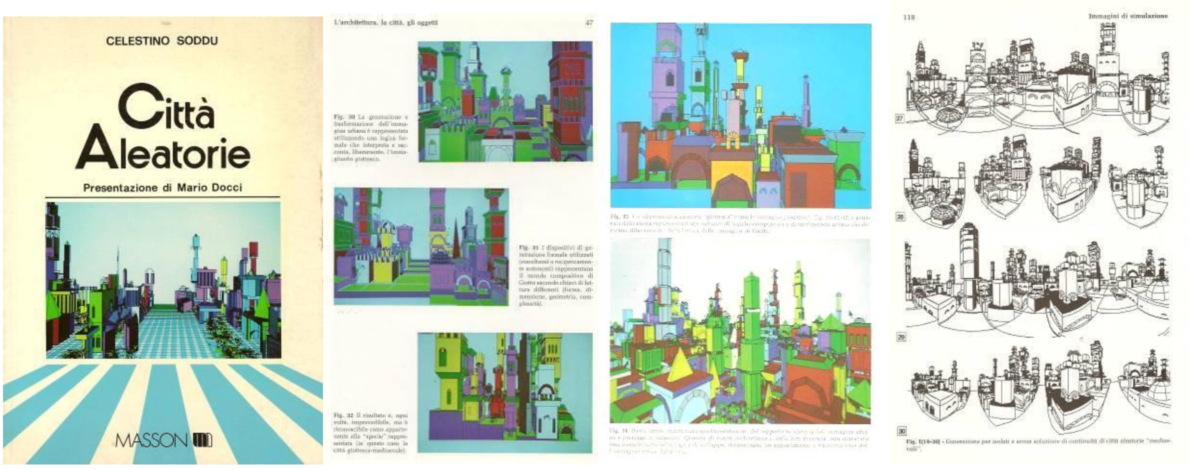


Fig. 8 Cover and 3 pages of "Aleatory Cities", Masson Publ. 1989. The first book of Celestino Soddu explaining his Generative approach to Architecture and urban design and his software Basilica. In the images the generation of "Medieval Cities" as interpretation of Giotto and Simone Martini artworks.

First Basilica, toward the complexity.

The primitive structure of my generative software Basilica was therefore very simple: 1) Identifying organizational paradigms of architecture able to define events, relationships and interferences, 2) Tracing initial events that define, in first approximation, the dimensions and the orientation. 3) Managing ranges of geometric transformations, each one able to increase one of the functional / aesthetical / symbolic aspects and to push the events toward my architectural Vision. Each aspect answers to one of the functional, static and constructive architectural requests and, parallelly, to one of the characters identifying my Vision of architecture. I.E. "how I can apply a character of my Vision for transforming my beam in a way that it can reach the static needs?".

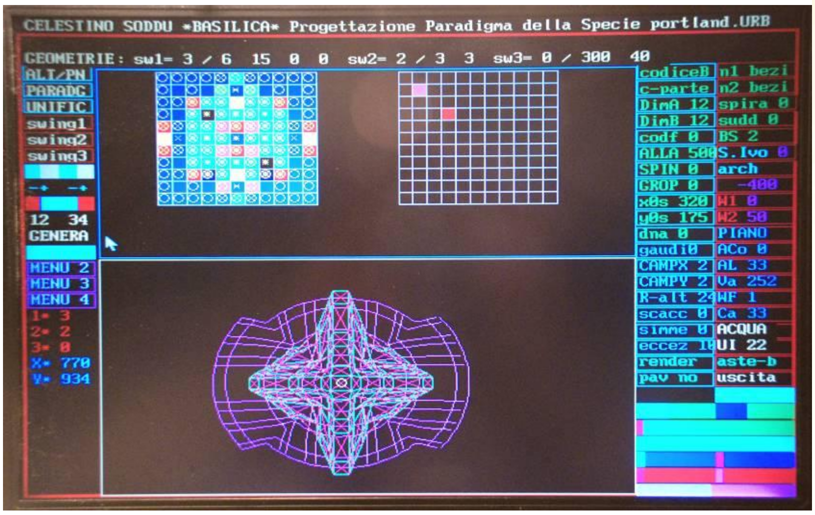


Fig.9, 10 Basilica Generative software (1987, it works only on Dos, also the last version 2009), Screendump of the paradigm and global geometrical transformations design interface. On the right a page from the book "Aleatory Cities" (1989) with 8 screen dumps of medieval town generation using Basilica.

The transformations run in parallel and also in series, belonging to single events and to the whole system; therefore transformations are repeated several times by using manifold "logics of transformation. If a series of transformations refers to the same logic in a way that we could define "fractal", the related functional / aesthetics / symbolic character is strengthened.

I designed these logics of transformation, these algorithms, in different moments and in different situations. Actually they reached a critical mass whose potentiality is to represent, even if still partially, my architectural idea in its evolutions and mutations. Reaching a critical mass of algorithms is fundamental for overcoming the simplification and for working on complexity. Today my generative software Basilica, in its last version, generates complex architectural scenarios because, stratifying from more than twenty years, I used every occasion for increasing the number of possible points of view and possible logics of transformation. It is evident that my generative approach founds on Poetic, therefore on the subjectivity, the possibility to reach the complexity and the production of variations. But does exists an "objective" way for reaching generative complexity?

In Basilica the choice of *when* and *how* these logics of transformation are activated, of what algorithm the program have to choose in each particular situation, is done by managing the progressive evolution of the system. All possible "transformations" that are able to fit the Vision could happen; but some were more probable than the others because they reflected a specific way to compare the transforming event to the already existing events. Like a Cellular Automata program mixed with something like Fuzzy Logic. This "management of the tones" also answered to the peculiarity of architectural characters able of reflecting the peculiarity of each single design occasion, the environment and urban identity in which the incoming architecture will live, in other words, the live-complexity of cities.

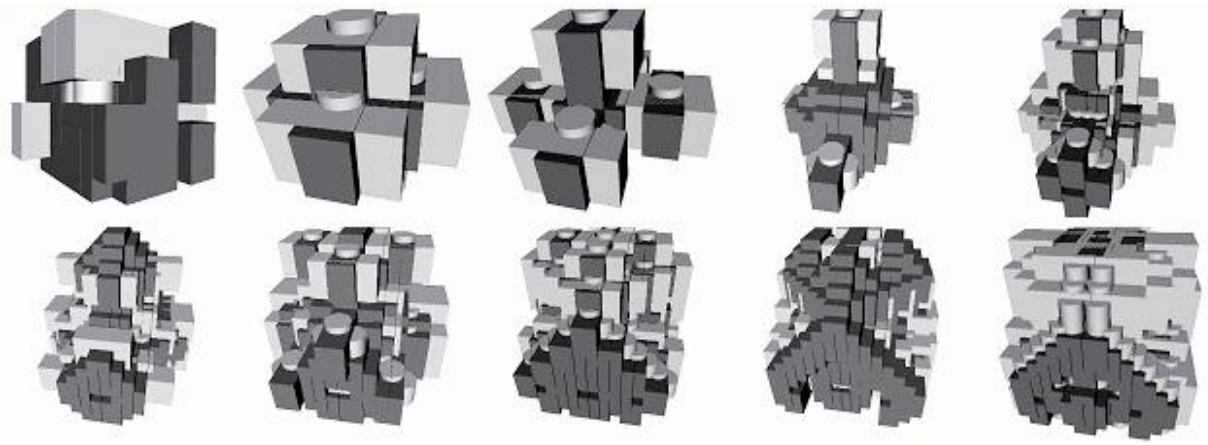


Fig. 11, 3d Cellular Automata software designed by C.Soddu for Generating 3D topologic paradigms, and now integrated in Argenia software.

The different starting point and the numerical not-precision of parameters used in these logics of transformation guaranteed the unpredictabilty and uniqueness of each results together with the recognizability of outputs as belonging to the same idea. (Marie-Pascale Corcuff , Chance and Generativity, in GA2008 proceedings)

The characteristic of the generative approach is generating unpredictable results belonging to the same idea, as happens in all not-linear complex systems. In my approach each result is also recognizable as "figure" (Enrica Colabella, figura, aura uniqueness, in GA2006 proceedings). This is the realization of a feasible architecture and not only the realization of an abstract three-dimensional image. In other terms my approach can be called "figurative", as for instance the approach of H.Cohen and of H.Dehlinger (GA1998 and subsequents) in the generative visual art, the experiments of P. van Looke in Mathematics that have the aim to reach the figuration (Philip Van Loocke, Symbolic organic design, GA2006 proceedings), and the generative architectures of Renato Saleri Lunazzi ("GRUE: Génération régulée pour un urbanisme environmental", GA2008 proceedings). Figure is defined as dynamic event in which abstract is hidden inside. Similar to figurative is the representation of Nature

The "figurative" approach needs the use of a "control paradigm". It addresses the generative progression toward the "figuration", a functionally and constructively correct architecture, a recognizable event as possible variation of a known species, a human figure, a tree, a house, a city.

Another question is the difference among subjective and objective approaches. The aim of constructing a tool for everybody, an aid for generative design that, as the experiences of John Frazer J.Frazer, An evolutionary Architecture, Architectural Association Publications, 1995), Aant van der Zee and Bauke de Vries (Aant van der Zee, Bauke de Vries, Design by computation, GA2008 proceedings) try to refer mainly to "objective" functional aspects is different from my "subjective" approach that tries to increase and communicate an Idea by tracing a software as artificial Dna able to generate events belonging to a subjective Vision.

Results based on "objectivity" are very interesting. They identify a set of alternatives but they don't easily succeed in reaching complexity; and when it happens it is by introducing "subjective" choices as "objective" choices. For instance each house is different; each bridge is different even if it was built following the same scientifically correct choices based on the objectivity of statics. These "subjective" differences are really important in architecture and design. The difference among objective and subjective approaches could be identified, for instance, as the difference among axonometric and perspective views. The axonometric view, objective, cannot reach the representation of Infinite despite its strong communication and measurability. The perspective view, instead, can reach the representation of Infinite because it was born from the subjectivity of a point of view.

Based on subjectivity, for the reason that poetics is subjective and can be, obviously, not shared by everyone but only sometimes appreciable as subjective representation of the complexity of our life, this approach is more difficult to use as conceptual and operational reference in front of the "objective" approaches that can reflect in each results the direct relationship between algorithm and formal / functional needs. Knowing and exchanging "basic" algorithms is useful for basic needs, creating own algorithms is essential in performing creative results. Quoting Focillon, each visionary people must create his own tools.

The question that many people often asked me: "which algorithm do you use for Basilica?" hides the question: which category do you belong to? This question is misleading because my approach is based on the multiplicity and on the progressive

increasing of algorithms able to fit my own Vision. This increasing number of logics is the attempt to produce "variations" as progressive increase of recognizability of the idea. (C.Soddu, "Recognizability of the idea: the evolutionary process of Argenia", in "Creative Evolutionary Systems" edited by P.Bentley & D. Corne, Morgan Kaufmann Publisher, San Francisco US, 2001)
In Basilica I used specific geometric parametric algorithms, algorithms managing the transformation of event's figure by moving from a dimension to another, Cellular Automata and parallel progressions of transformations of single events that dynamically interact with others, as flocking of birds, and structures of repetition of the same algorithm applied to the same event, as fractal approach. But none of these methods is primary. The peculiarity of my approach is "how" I use them all together. It is the expression of how it's possible to effort single, unexpected and unpredictable requests with the aim to fit my Vision of Architecture. The main question is not only the tools but the right aim. I teach that to my students too, bringing them to consider their Vision overcoming the tools. (See the interactive website www.generativism.com with the teaching experience on Generative Art and Generative Architectural Design by Enrica Colabella and me)

Putting aside the difference based on categories of tools, we can identify two topics that make the difference among generative approaches and that can be reported to all involved fields, from Music to Visual art, from Architecture to Mathematics: ***Figurative*** versus ***Abstract*** and ***Subjective*** versus ***Objective***.

3.Progressive paradigmatic development

I had to wait until 1988, this time with a PC 086, to find the time for subsequently developing the idea of generative software Basilica. And the possibility to use screen dumps for recording the sequence of results and to publish them together with the description of my software in the book C.Soddu, Città Aleatorie, "Aleatory City", Masson Publ. 1989.

Setting up a more rich paradigmatic structure of architecture was the following step. It allowed me to better direct and characterize single events and to generate more believable architectures. Moving from the previous simplified paradigm, now the architectural events were controlled by a paradigm constructed around a void space surrounded by 26 events: In total 27 events, number also identified by Borromini as the main reference for architectural systems. Figuratively: an empty space, four pillars, four vertical frames, two horizontal frames, eight knots / interfaces / capitals, eight beams. Obviously every space had in common with the nearby space, or with external space, 9 events that could be generated following this double influence in the progressive process of transformation. Possible evolutions could be managed, based on such relationships, through 3D Cellular Automata.

At superficial approach this paradigmatic structure could be valuated as too much axiomatic because it is easily representable as a cube. Instead the paradigm was shaped in a way that the geometric transformations could easily modify the architeture varying from a triangular based prism to pentagonal or octagonal based prism or to cylinder.

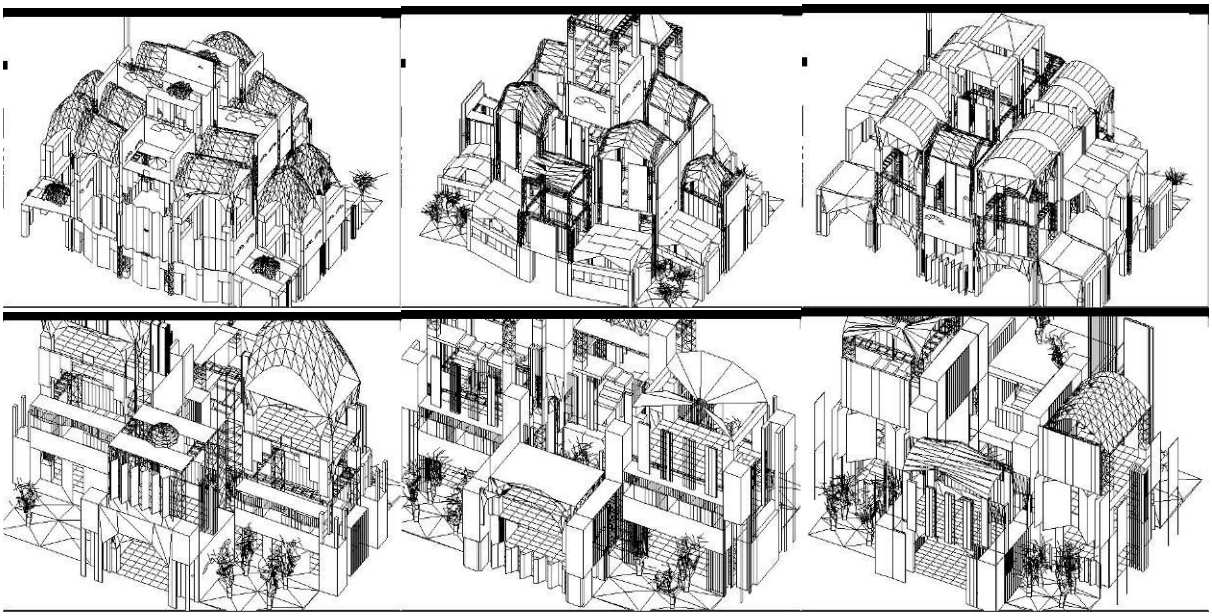


Fig. 12 screen dumps of Basilica using the new paradigm. 1990

Transformations can also involve the verticality of the architectural order, moving from inverted to truncated pyramid and managing, with an explicit reference to Borromini, the possible helical torsion of architectural structures. These trasnforming codes were in Basilica starting from 1992, soon after the publishing of the book “the environment design of morphogenesis”.

In any case Basilica keeps, as main aim, the feasibility of the architectural system because beams and pillars varied, melting, or dividing themselves, becoming more thick or more thin, folding up themselves or fragmenting themselves but always doing that in relationship to the static and constructive congruences requested by the feasibility. The “new” concept of material could be a false problem. I.e. every architect has his proper way for transforming a "beam": He do that by following the variation of the length. From a wood beam of few meters, moving toward a steel beam until a long suspended bridge, each possible transformation follows both the constructive needs and architectural character. Every designer has his own subjective way to manage these transformations also if each different result maintains, in the progression of transformations, its static, constructive and functional credibility and clarity.

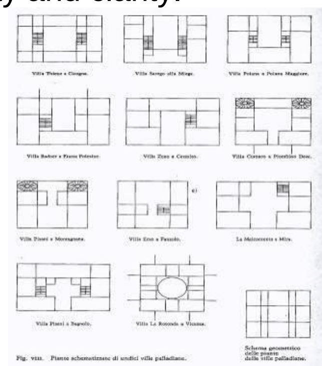


Fig. 13. the book by C.Soddu and E.Colabella “The environmental design of Morphogenesis”, Progetto Leonardo Publ., 1992

Fig. 14. All Palladio villas have different geometrical organization but all belong to the same paradigm, as Wittkower shown in this drawing in “Architectural Principles in the Age of Humanism”. (The paradigm is down on the right).

The reached results made by using this “architectural paradigm” drawn by Borromini were immediately enthusiastic: this further complexity of the paradigm produced fields of further recognizability of the idea.

In the meantime I have identified in the history of architecture, the organizational paradigm used by Palladio and drawn by Wittkover. This is able, through specific logics of geometric transformation, to splendidly suit manifold organizational possibilities strongly maintaining the architectural harmony in "innovative" geometrical orders. Approaching the transformig logics for creating “innovative” architectural systems, my first reference was Borromini: he made his wonderful architectural orders by using geometrical transformations on classical paradigms.

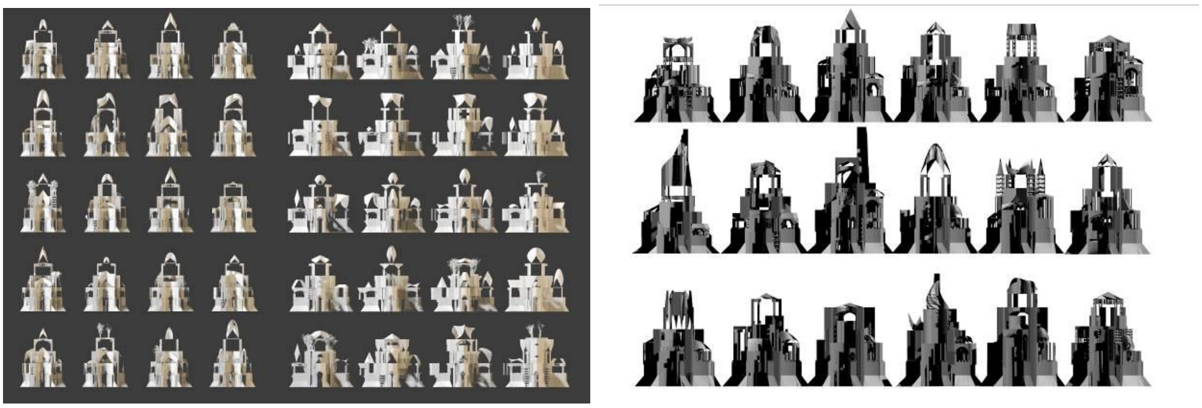


Fig. 15. Castles using the paradigm belonging to "La Rotonda" by Palladio. These two different variations of Castles were made In two different moments (with different codes). 1995, 2004

4.Variations, Design and Generative Art

Following Italian experience of Gio Ponti: not only architecture. At the beginning of Nineties, I was wondering if this generative approach could also be used in other fields like Design, Art and Music. In the book "The environmental project of morphogenesis, Dna of the artificial ware” (C.Soddu, E.Colabella, Il progetto ambientale di morfogenesi. Codici genetici dell'artificiale, Progetto Leonardo Publisher, 1992) I shown the first results made by approaching what has been for a long time the theme at the center of the design discussions: the chair. I used a paradigm really simple: the support to earth, the support-seat interface, the seat, the back, the interface seat-back. Looking at the results I identified a very interesting possibility in Design, industrial production and market: the industrial production of unique and not-repeatable objects. And we, Enrica Colabella and me, named this approach and the related software with the neologism Argenia. In the subsequent years, following this possibility, I designed Argenia for Jewels, Coffee pots, Lamps and other objects.

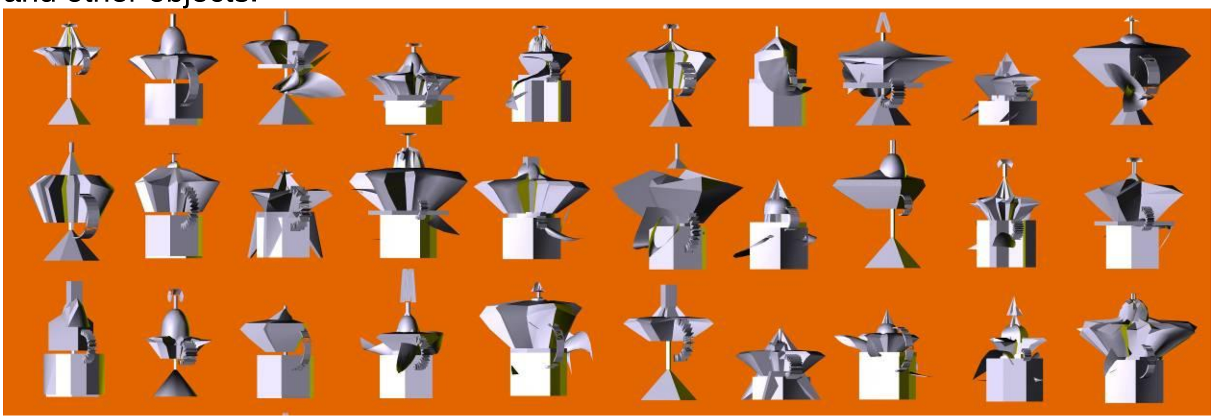


Fig. 16. Generation of coffee pots, 1995

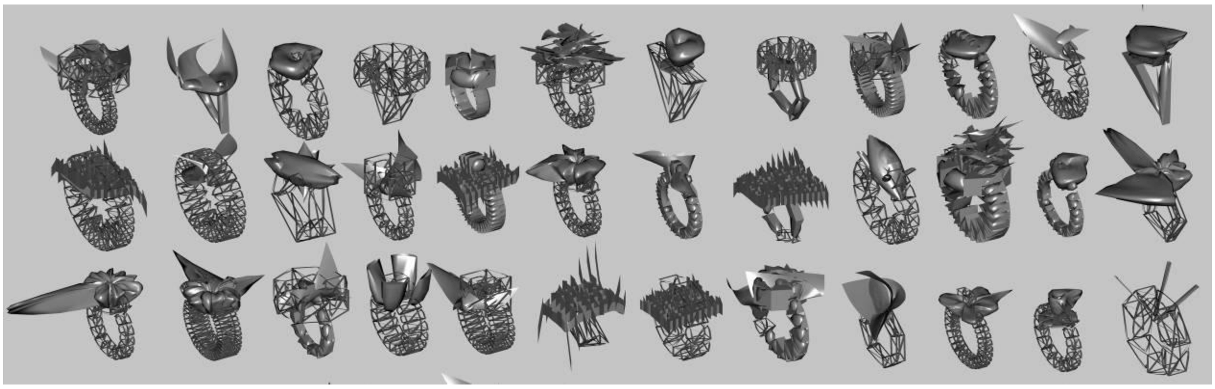


Fig. 17.Generation of "warrior's" rings, 2002

From these experiments a new generative field of interest was born too: to work on Visual Art by following the Renaissance tradition to look at the Past for tracing the innovation. As Picasso re-painted Velasquez and the African art, naturally by stratifying over the identity of the references his own identity of artist, his own poetic, so I tried to re-paint Picasso by designing a dedicated generative software. A generative artwork was born: "d'apres Picasso", an Argenia program able to generate a multiplicity of 3D models of women that, all together, can represent my interpretation of the women of Picasso, and printing them (in 2D but also, starting from 2001 with 3D printers) in real time, one after the other, until infinite.

Fig.18, 19. "D'apres Picasso", endless generation of woman's portrait (1997) and the phisical rapid prototyping results directly constructed by "d'apres Picasso Argenia software", 2002

With Enrica Colabella we have, in 1995, founded the Generative Design Lab of Politecnico di Milano University and the relative website. We have named this creative field Generative Art. The first personal exhibition of this kind of new "figurative/abstract" generative art was "d'apres Picasso" in a gallery in Milan in 1996. This personal exhibition has been the occasion to meet J.Frazer that, in 1998, participated to the first Generative Art Conference and invited me to the HKPolyU for make experiment related to my research. The first international conference GA'98, organized by my Generative Design Lab, has been the true first great experience of exchanging advanced approaches to creativeness and design. The presence of J.Frazer for architecture and design, of Hans Dehlinger for visual art, of Mauro Annunziato for artificial life, of Philip van Looke for generative mathematics and of other enthusiastic researchers, has been the occasion to define Generative Art as a multi-disciplinary field where the more advanced experiences in dynamically managing creative fields could usefully be discussed, exchanged and developed. Enrica Colabella and I named "Generative Art" this conference because we didn't intend to propose a limited conference to specific categories (cellular automata, sworm, artificial life, shape grammar etc.) or to single disciplines (Architecture, Music, Design, Visual Art, etc.) but to look at a wide context linked to Science / Art. I have to say that this denomination, Generative Art, has been successful. Already from the following year, with the presence at GA'99 of P.S.Coates, J. J. Romero Cardalda, Adrian Ward and Gabriel Maldonado this multi-disciplinary approach was definitely established. (GA1998, 1st Generative Art conference proceedings, 2nd e-book edition in English and Italian, Domus Argenia Publ. 2009, in the attached DVD)

During my staying at Hong Kong Polytechnic University in 2001, I developed and experimented the feasibility of a direct interaction between my generative software Argenia and rapid prototyping devices, and therefore with industrial devices at numerical control. I successfully managed the possibility to directly produce unique objects by using these devices. Argenia opens this possibility by generating in real time unique STL files usable for producing a sequence of unique objects. The possibility of industrial production of unique objects belonging to a recognizable species, as in Nature, through generative software Argenia and existing industrial devices was confirmed.

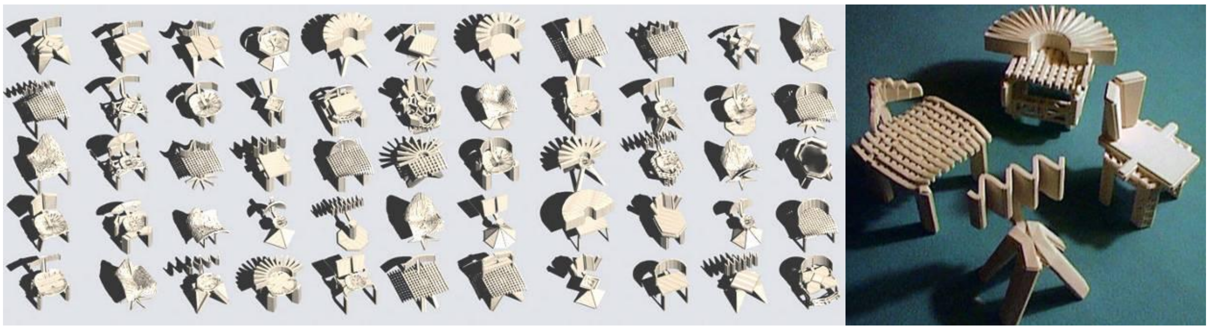


Fig. 20.Chairs generated by Argenia, starting from 1990. On the right chairs generated by using Argenia and directly produced with rapid prototyping device

Unfortunately the unique object didn't fit the market of those years, completely dominated by the repetition of all equal "fashion" objects. The market didn't accept the concept that idea comes before object. Idea as Product was, ans is, our flag. The subjective Vision able to generate, as in Nature, multiple different unique objects that people can choose because the Idea is recognizable was, and still now is, not accepted by the market.

5.Artificial Dna. Recognizable City Identity.

Beginning from 2001 I have developed a research field on Generative Architecture and Town Design fitting an essential need of contemporary environment: how managing in progress the urban and environmental identities and their clarity and recognizability.

I have discovered that, with minimal variations inside single algorithms managing the "logics of transformation" and their hierarchy, it was possible to reach aesthetical and symbolic tuning with the environmental characters of different urban identities.

Fig. 21, 22, 23. Ideal Cities, from the Cultural Heritage (Renaissance, Piero della Francesca 1480) to incoming City Identities.

I worked on generative projects focused on specific urban identities. The first experience has been Hong Kong, with the occasion of my personal exhibition at the HK Visual Art Museum in 2002. The aim has been to exhibit visionary scenarios of HK generated with Basilica and Argenia, unpredictable scenarios but where an increasing HK identity could be found. And I tried to ask to the visitors: “in which scenario do you see HK-City more HK then before? Clearly referring to a HK-Ideal-City that is in the mind of each inhabitant. Answers gave me the possibility to select the "logics of transformation" used for generating the "approved" scenarios and to reconstruct an artificial Dna of HK, its genetic code able to represent the HK-Ideal-City.

Fig. 24. Hong Kong City Identity in progress. Generative projects shown in the personal exhibition of C.Soddu at Visual Art Museum, 2002

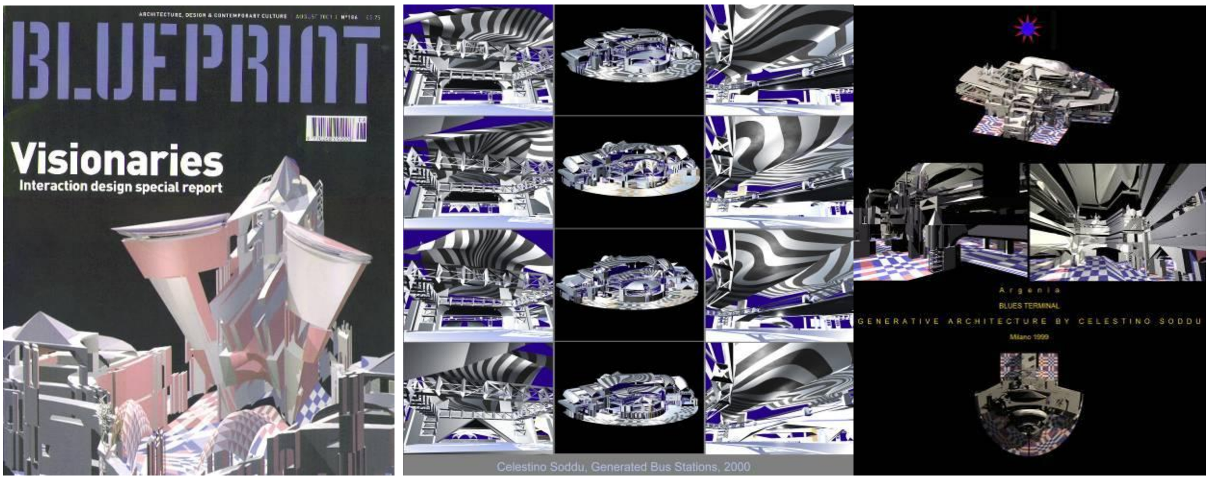


Fig. 25, 26, 27. Generative Visionary Architecture, The cover of Blueprint magazine 2001 with generative visionary architectures by C.Soddu, and other projects of C.Soddu published in the same magazine.

The following years, with my personal exhibitions in Los Angeles (Pacific Design Centre, 2002), in Washington D.C. (IDB Cultural Center, 2003), another in HK (International Financial Center, 2004) and in Milan (Palace of Giureconsulti, 2005) I have developed the creation of artificial DNA of these urban Identities and of others as NYCity, Chicago, Shanghai, Beijing, Macau, Dehli.

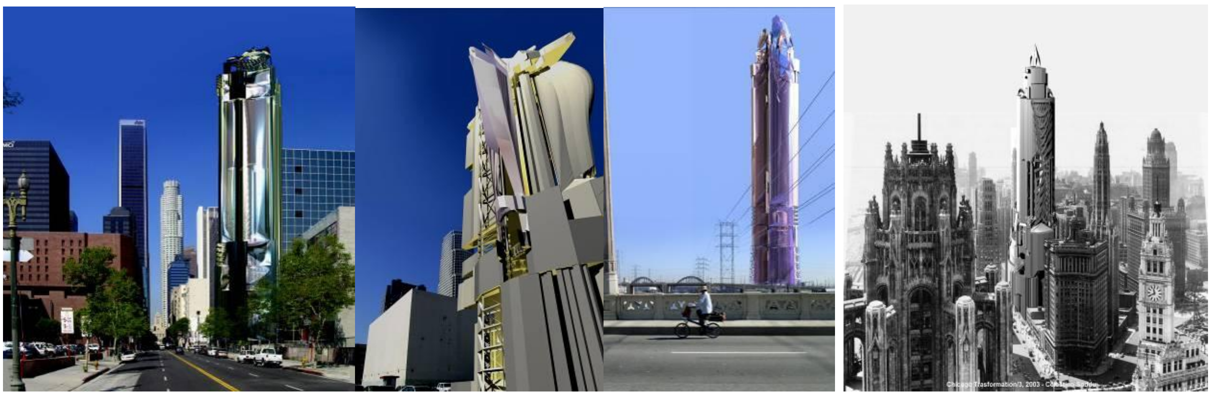


Fig. 28. Los Angeles: a office building, the broadcasting tower and IRTAL, shown at the personal exhibition of C.Soddu at Pacific Design Centre, L.A., and a new tower in "old" Chicago, 2002

Fig. 29. Variations of the new Cultural centre of World Bank in Washington D.C. presented in the personal exhibition at IDB Center, Washington D.C. 2003.

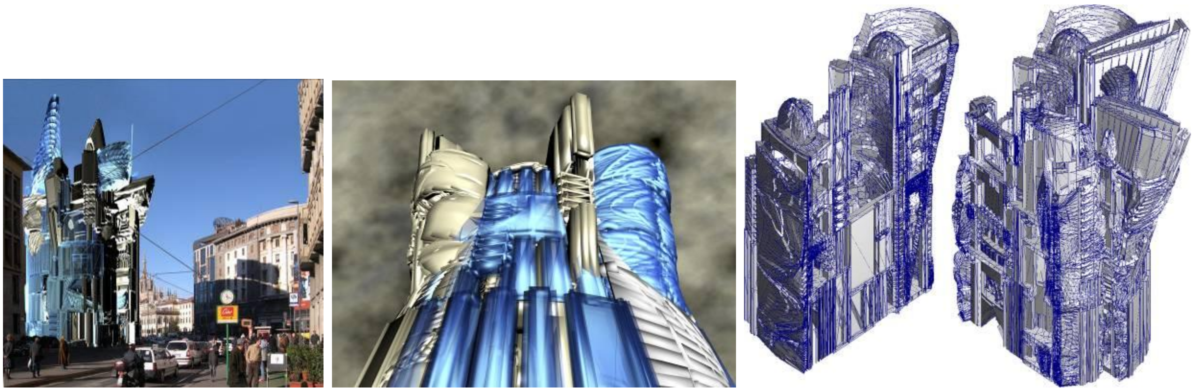


Fig. 30. C.Soddu Personal Exhibition in HK International Financial Center, Futurism Museum in Milan, 2004

In the same years, developing in my GenLab a research/exchange Asia-link program founded by European Commission, program of which I was coordinator, I succeed in establishing a Generative Design Labs network involving T.U.Eindhoven with Bauke de Vries and Aant van der Zee, Kassel University with Hans Dehlinger, China with Tongji University in Shanghai and Tianjin University, and enlarging the network to other Universities. This program, implemented with meetings, workshops, seminars and exhibitions was great and very useful for disseminating the Generative approach in several countries.

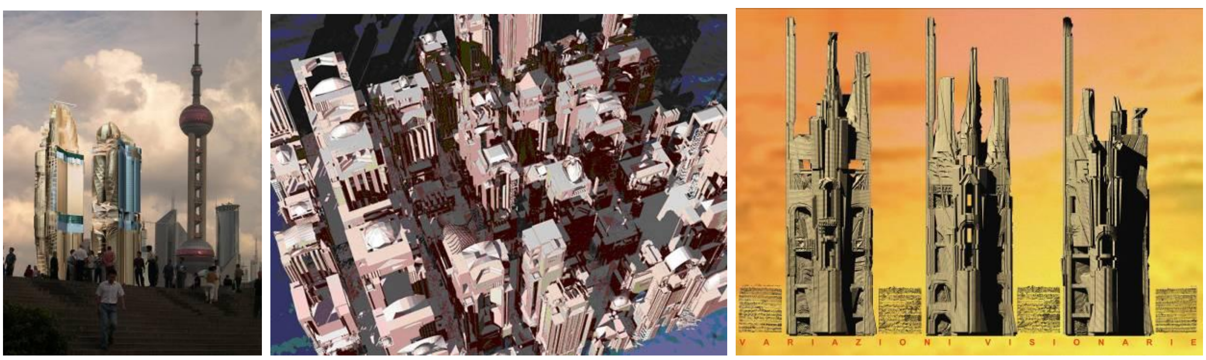


Fig. 31. Shanghai Generative projects, a generated town environment belonging to the reconstruction of New York City artificial DNA and 3 tower "homage to Gaudi"", using Basilica 2003

Fig. 32. Milano, Variations of Futuristic imprinting on Piazza Cordusio, The starting point of Milan Identity in 1915. (2005)

Fig.33. Dehli, finding city identity, 2006

Fig. 34, 35. Generating over the drawings of my main masters, Leonardo and Piranesi, and learning from them (2008,2009)

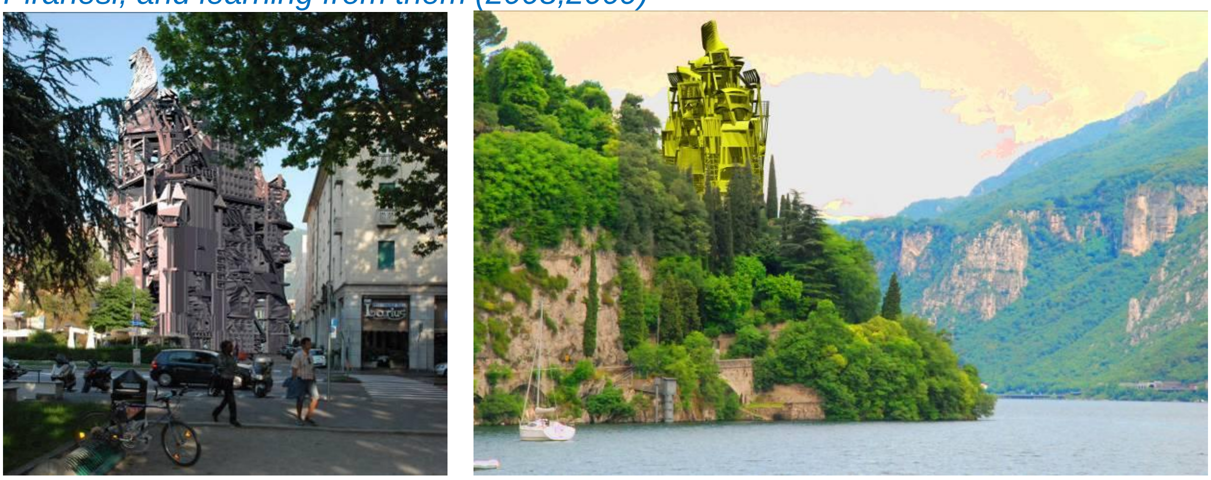


Fig. 36. Generative scenarios of Lecco presented during the Futuristic Visionary Evening, 21 June 2009, at Lecco. Architectures generated using Basilica.

Fig. 37. Generated (with Basilica) scenarios at Serramanna, Barumini and Poetto for the last personal exhibition at the gallery of Domus Argenia Center regarding ancient Sardinian Identity following Nature (Sardinia 2009)

6. How to gain multi-subjectivity from singular subjectivity?

How to overcome the problem of disseminating a subjective generative approach that works very well in creative design, as I verified with my student of Politecnico di Milano? How to design generative software usable by different people for increasing and managing their own design Identity?

I decided, until now, not to sell Argenia because it was not usable by other people: it directly reflects too much my subjective Vision. This new hypothesis for which I have worked is a generative software able "to learn" from the architects, artists and designers. The aim is that the software becomes, after the first experiences, a rich and vivacious expression of each own creative and professional identity. In practice generative software that builds, step-by-step, the creative subjective artificial “Dna” of whom uses it.

Argenia, in the last beta-version, performs a “Dna” that can be managed for representing different subjective creative identities through integrations and stratifications that each artist / designer can operate. This happens because Argenia is open to change by following new logics of transformation and new paradigms. It has the possibility to work defining paradigms, transforming logics, codes, cellular Automata rules and fractal repetitions. In the core of Argenia there are:

1. a series of logics based on geometric transformations. Each geometric transformation is structured by using modifiable parameters able to manage the character and "how" the algorithm will run.

2. The functional character defining the incoming event in relation with the nearby events is defined by the user choosing among different logics of transformation belonging to "how the event will end", "how is folded", "how is divided", and so on.

3. Each one of these characters is defined with an increasable set of "logics of transformation" that operate this "How". The user can make new hierarchies among

these logics, can modify, can upgrade, can develop new ones and can select which will run in the generation process..

4. The organizational system of three-dimensional events doesn't work only in one "structural direction", as Basilica that was constructed with the distinction among vertical and horizontal structures in base to the architectural feasibility, but work through "directions" that the user can point out as character of every incoming event.

5. The user can build the organizational paradigm of each 3D event by modifying or generating a new one. It’s possible to use 3D Cellular Automata and choosing the association of each character and each transforming rule to the structure of Cellular Automata. Cellular Automata logics are, in Argenia, different and selectable by the user.

7. The generation of events can be performed also by choosing or mixing diversified tools of construction of surfaces (Bezier, T-Spline, and so on.) able to reach different character of 3D results.

8. The progressive increase of complexity can also be reached by using parallel fractal transformations and by managing the relative parameters.

Besides, there are optional outputs for generated 3Dmodels directly usable withrrapid prototyping devices, render and common commercial 3D tools.

Argenia is now opened to all artists, architects and designers because Argenia will be used in the activities of the new center "Domus Argenia", just now established in Sardinia. The opening was made with an exhibition about the Sardinian DNA done by interpreting the megalithic cultural references of this wonderful country. Domus Argenia has the aim to develop exchange among different creativeness and different disciplines in a cultural approach focusing on Identities, the subjective creativeness and different cultural heritages.   And will be open also to not-lucky young people of the entire world for increasing their own possibility to creatively work with their own cultural reference.

This is my generative challenge of next years.   .

References

Celestino Soddu, “L’immagine non Euclidea” (not-euclidean image), Gangemi Publ. 1986

Celestino Soddu, “Città Aleatorie” (Aleatory Cities), Masson Publ. 1989

Celestino Soddu, Enrica Colabella, “Il progetto ambientale di morfogenesi. Codici genetici dell’artificiale” (Environmental design of morphogenesis, Genetic codes of artificial ware), Progetto Leonardo Publ. 1992

Celestino Soddu, “Milan, Visionary Variations”, Gangemi Publ. 2005

C.Soddu, “Recognizability of the idea: the evolutionary process of Argenia” in P.Bentley & D. Corne (edited by), "Creative Evolutionary Systems", Morgan Kaufmann Publisher, San Francisco US, 2001

Rudolf Wittkower, Architectural Principles in the Age of Humanism, Academy Editions, London 1962

Enrica Colabella, Categorema, GA2007 proceedings

Enrica Colabella, Generative Art, GA2008 proceedings

Marie-Pascale Corcuff , Chance and Generativity, GA2008 proceedings

Celestino Soddu, “Endless interpretations, infinite in the mirror”, GA2007 proceedings

J.Frazer, An evolutionary Architecture, Architectural Association Publications, 1995

Aant van der Zee - Bauke de Vries, “Design by computation, Chance and Generativity”, GA2008 proceedings.

Renato Saleri Lunazzi - Marian Janda, “GRUE: Génération régulée pour un urbanisme environmental”, GA2008 proceedings.

Celestino Soddu, Alive Codeness, GA2008 proceedings, Domus Argenia publ.

C. Soddu, "Generative Design / Visionary Variations - Morphogenetic processes for Complex Future Identities" in the book Organic Aesthetics and generative methods in Architectural design" edited by P. Van Looke & Y. Joye in Communication & Cognition, Vol 36, Number 3/4, Ghent, Belgium 2004

C. Soddu, "变化多端的建筑生成设计法" (Generative Design), article in the magazine "Architect", December 2004, China

C.Soddu, E.Colabella, “A Universal Mother Tongue”, Leonardo Electronic Almanac Volume 13, Number 8, August 2005

Philip Van Loocke, Symbolic organic design, GA2006 proceedings

C.Soddu, GENCITIES AND VISIONARY WORLDS, GA2005 proceedings

Robert J. Krawczyk , Architectural Interpretation of Cellular Automata, GA2002

Gabriel Maldonado, Sound and Graphics in CsoundAV, GA2001 proceedings

www.generativism.com The interactive website with the teaching experience on Generative Design by Enrica Colabella and Celestino Soddu.

www.domus.argenia.it The site of just established “Domus Argenia Center on Identities and Generative Art”.

Swarms on Stage

Swarm Simulations for Dance Performance

Daniel Bisig

Institute for Computer Music and Sound Technology

Zurich University of the Arts

e-mail: daniel.bisig@zhdk.ch

Tatsuo Unemi

Department of Information Systems Science

Soka University

e-mail: unemi@iss.soka.ac.jp

Abstract

Simulations of swarm behavior have been employed as a generative processes in many musical and artistic realizations. Despite this popularity, the application of swarm simulations as a visual and interactive component for stage performances seems to be very rare. This paper tries to show that swarm simulations can be employed as flexible and fascinating choreographic elements for dance performance. In particular, a swarm's strong spatial presence and it's behavioral flexibility provide a wide range of choreographic possibilities that accentuate or complement the human dancers' activities. This paper places a particular focus on the presentation of several examples of swarm based stage effects that have been realized as collaboration between the authors and choreographers.

1. Introduction

Dance as an art form relies on the expressive qualities of the human body. The body's physical immediacy, it's spatial movement and it's participation and synchronization within groups form the constituents of choreographic design. Dance draws much of its fascination and aesthetics from the creation of antagonisms between naturalness and artificiality. The body's gestural capabilities and social phenomena of body language and group formation form the source material from which basic behavioral elements are extracted via a process of abstraction and formalization. A dance piece then constitutes an artificial re-synthesis of human behavior that results from a modification, exaggeration and recombination of these basic elements. Thus, on a very general level, choreography and the sciences of Artificial Life and Artificial Intelligence share a similar synthetic approach of recreating an artificial system as an abstraction of a natural system. But there exists a much more striking and profound similarity between choreography and a particular type of simulation. Swarm simulations constitute multi-agent systems that model group formation and spatial movement. These simulations directly deal with some of the very fundamental constituents of dance. Both swarm simulations and choreography deal with relationship between local and global patterns. Both deal with the occupation of space via clustering and dispersion. Both deal with the synchronization of behaviors. And both blur the distinction between individuals and groups in that individuality appears both on the level of the single dancer/agent and on the level of the entire group.

On the other hand, dance choreography and swarm simulations differ with regard to several fundamental aspect. The most obvious and important distinction concerns the manifestation of the presence of the actors. Human dancers naturally possess a very strong and immediate presence in the physical space whereas a simulated entity is inherently dissociated from the physical world. This dissociation can be partially overcome by rendering the virtual entity perceivable via one or several feedback modalities, but a certain level of in-corporality always remains. A further distinction concerns the differences in complexity on the level of the individual and the group. Each single dancer possesses an intricate and highly individual body that always stands out as a strong visual element. This complexity of the individual dancer contrasts with the comparatively simple patterns that groups of dancers can form. Any emphasis on group patterns in choreography are therefore hampered by the dancers own idiosyncrasies. The simulated entities in a virtual swarm on the other hand are usually rendered as simplistic and totally uniform shapes. In these simulations, the complexity clearly manifests on the level of the group and the appearance of the individual agents hardly distracts from these group phenomena. It is therefore relatively simple to perceive a simulated swarm as a sort of meta-individual whose morphological diversity far exceeds those of the human dancers. Furthermore, the relationship between space and actors differs considerably between human dancers and virtual agents. The spatial scale of the dancers and the stage is immutable. The movement and distribution of dancers is mostly restricted to the two dimensional plane of the stage surface. In a simulation on the other hand, the mapping of the topology and scale of the virtual world into the physical stage is very flexible and can change throughout a performance. This mapping creates a correspondence between the visual and physical properties of the swarm, the stage and the dancers. Any physical surface on the stage can serve as a window into the virtual world and / or represent physical barriers within the virtual world. Depending on the scale and continuity of this mapping, the stage can appear as a narrow cage for the simulated swarm or open up into a seemingly endless universe. Finally, the choreographic process usually represents a top-down approach of designing the local and global structures and dynamics of the performance. A swarm simulation on the other hand represents a complex system whose global properties emerge via bottom-up processes of self-organization. For this reason, swarm simulations can introduce elements of unpredictability and surprise into an otherwise entirely pre-specified choreography. For all of these reasons, swarm simulations represent an attractive and alternative choreographic element that both supports and complements the presence and activity of human dancers. The swarm allows to transform a stage into a responsive environment and at the same time it can act as an artificial dancer whose movements and morphological changes are unlike anything a human dancer would be capable of.

Throughout the remainder of this paper, the authors present four exemplary applications of interactive swarm visualizations for dance performance. These works have been realized in collaboration with the two choreographers Jiri Kylian and Pablo Ventura and where shown in a variety of venues.

2. Dance Performances

2.1 Vanishing Twins

The dance performance "Vanishing Twins" was choreographed by Jiri Kylián and premiered at the Lucent Dance Theatre in The Hague, Holland in 2008. In this performance, two swarm simulations were projected into the left and right half of the stage background. Each simulation consisted of 5000 agents that where depicted as triangles and that densely populated the entire two dimensional simulation space. The agents' exhibited the classical Boid's type of behaviors [1] as well as additional interaction dependent reactions [2]. These reactions were triggered via a camera based tracking system that captured the dancer's image from an inclined frontal position. The reactions included an evasion behavior away from the position of a dancer's movements and a color change behavior from white to black that was proportional to the amount of movement. The swarm simulation was running and projected throughout the entire performance but the interactive behaviors became active only at the very end of the piece. During the non-interactive part of the simulation, the agents would engage into a constant circular motion that was constrained by the outer boundaries of the stage background. The simulation switched to the interactive mode when only two dancers were left on the stage. Each of the dancers was positioned at the center of the left and right swarm projection, respectively. The dancers' behaviors alternated between stationary phases and short bursts of very active movements. During these short bursts, the dancers ripped a large black region in the shape of their bodies into the projected visualization that was otherwise densely covered by white triangles (Figure 1). As soon as the dancers stopped their movements, the agents reclaimed these black regions and the uniform coverage of the circularly moving white triangles was recreated.

In "Vanishing Twins", the manifestation of the swarm simulation was dislocated from the physical position of the dancers. The dancers moved in the two-dimensional space of the stage surface, whereas the swarm visualization covered the vertical stage background. But at the same time, the dancers possessed a virtual presence within this vertical agent world. The horizontal position of the dancers on stage was mapped into a vertical position within the visualization of the simulation. Contrary to the dancers physical presence, their virtual presence in the simulation was constantly compromised by the swarm. The swarm assumed the role of a hostile environment that constantly threatened the existence of its inhabitants. Only via highly exaggerated movements could the dancers maintain their unharmed virtual presence as a black silhouette that was devoid of any white triangles. As soon as the dancers' movements slowed down, their silhouettes started to distort due to the agent's circular movements and was soon swallowed by the crowd of white triangles. The dissolution of the dancers' virtual existence by the swarm's activity is a metaphorical reenactment of the biological phenomena that an unborn child fails to compete with its twin's need for resources and disappears within the mother's womb. This phenomena forms the inspiration for the piece "Vanishing Twins".

Figure 1: Swarm projection for the choreography “Vanishing Twins” by Jiri Kylián.

2.2 Swarms

The dance performance "Swarms" was choreographed by Pablo Ventura and premiered at the Schauspielhaus in Zürich, Switzerland in 2008. The performance comprised three scenes for each of which a specific swarm simulation had been created. Both the swarm simulation and the tracking system were based on libraries that had been developed as part of the “interactive swarm orchestra” project [3][4]. In each scene, the visualization of the agents consisted of black lines that traced the agents' movement trajectories and whose opacity gradually decreased to zero towards the older sections of the trajectories. The agents themselves possessed no visual shape. The visualization was projected on a vertical screen in the background of the stage. Throughout the first two scenes, the dancers were tracked via a camera that was positioned at the front of the audience on ground level. No camera tracking was required for the last scene since the corresponding swarm simulation didn't respond to interaction. During the interactive scenes, the dancers' bodies and movements generated several force fields within the two dimensional swarm simulation. Each of these fields consisted of two a dimensional grid of two dimensional vectors. A distance force field comprised vectors that point from each grid point towards the closest point on the dancers' body contours. A tangential force field comprised vectors that point from each grid point along the tangent of the dancers body contours. A motion force field comprised vectors that pointed along the gradient of a motion history image of the dancers' movements. All these force fields were continuously updated based on tracking information. The simulated agents engaged not only into Boids type of activities but also possessed a set of behaviors that caused them to move along these force vectors. For this reason, the swarm simulation combined biological aspects of collective movement with purely physical phenomena of passive propulsion within force fields (Figure 2 left side). For the non-interactive scene, the swarm existed in a three-dimensional simulation space. The agents were subjected two distance and tangential force fields that had been pre-calculated based on a polygon model of a human figure. Accordingly, the agents trajectories extended from an initially random distribution towards and along the figure's surface, which thereby became increasingly recognizable (Figure 2 right side).

The ambiguous connotations of the human body form an underlying topic in all of Pablo Ventura's choreographies. The human body forms an integral part of our subjectivity, at the same time, its functioning resembles that of a very intricate machinery, and finally, the human body constitutes a very iconic element in our culture. In his choreographies, Pablo Ventura experiments with these connotations by alternating the dancers' appearance and behaviors between biological and artificial, aestheticized and natural, human-like and robot-like. The behaviors and interactive reactions of the simulated swarms have been specifically adapted to this concept. The dancers' natural bodies act as a machinery for the generation of physical forces in space. The artificial swarms respond to these forces via behaviors that blend seemingly natural biological and physical phenomena. Accordingly, both the dancers and the simulation mix machinic and natural qualities. During the last scene, the dancers movements slow down until they finally lay down on the hardly illuminated stage. In this moment, when the dancers human shape is no longer perceivable, the swarm reforms into a depiction of a single large human body. By doing this, the swarm shifts from a simulated complex entity towards a mediation of the human body as a visual icon.

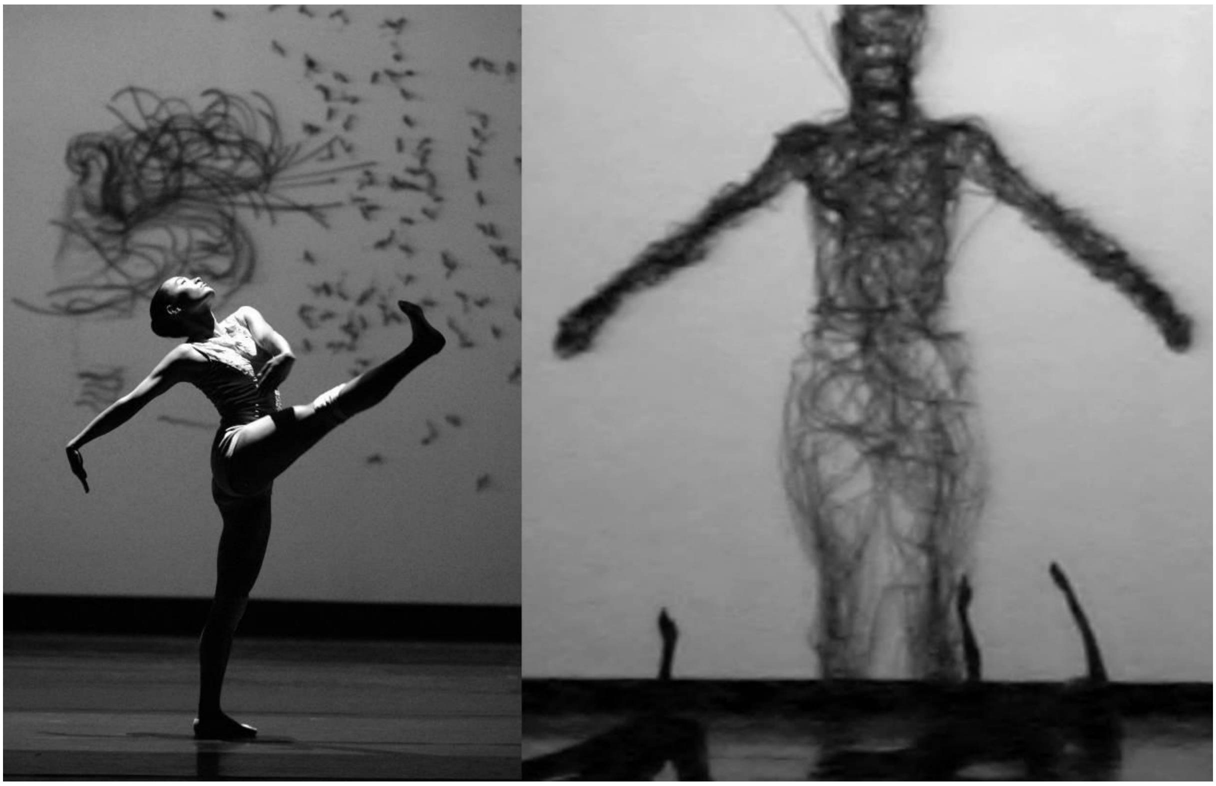


Figure 2: Two scenes from the choreography “Swarms” by Pablo Venura.

2.3 Gods and Dogs

The dance performance "Gods and Dogs" was choreographed by Jiri Kylián and premiered at the Lucent Dance Theatre in The Hague, Holland in 2008. For this performance, a visualization of a two dimensional swarm simulation was projected directly on a single dancer's body (Figure 3). The dancer was tracked from a frontal and elevated camera. The tracking system extracted the dancers' body as a foreground object that formed a zone of attraction within the simulation world. The size of the simulated world was only slightly larger than the dancer's body size and its position with respect to the stage changed in correlation with the dancer's movements. The agents themselves became visible as short trails once the entered the zone of attraction. Accordingly, whenever the dancer moved quickly across the stage, the zone of attraction would shift away from the agents and the agents would fade away. Once the dancer stopped his fast movements, the agents would quickly move into the zone of attraction and thereby became once again visible on the dancer's body. This fast alternation between disappearance and reappearance of the agents was facilitated by the moving simulation world that forced the agents to stay in the vicinity of the attractive zone.

In "Gods and Dogs", the swarm visualization is no longer dislocated from the physical position of the dancer. Accordingly, the dancer no longer appears to assume a remote presence within the virtual world of the swarm. Rather, the swarm manifests itself on the physical surface of the dancer's body and thereby partially looses its incorporal qualities. The dancer's body and the swarm visualization blend into a form a shared existence. The underlying subject of this choreography is the ill-defined and shifting distinction between what is considered normal and non-normal by a society. The swarm that gradually covers the body surface changes the dancers appearance from a normal to a non-normal state. The swarm behaves like a parasite that cannot exist without its host, the dancer's body. Once the swarm has caught up with the dancer, it spreads like a disease from the dancer's body outline until it covers the entire body surface. The dancer can try to escape this threat to his normality but will eventually succumb to the swarm's parasitic behavior. In this situation, the swarm is in position of power and dominance and partially supersedes the physical reality of the dancer's body.

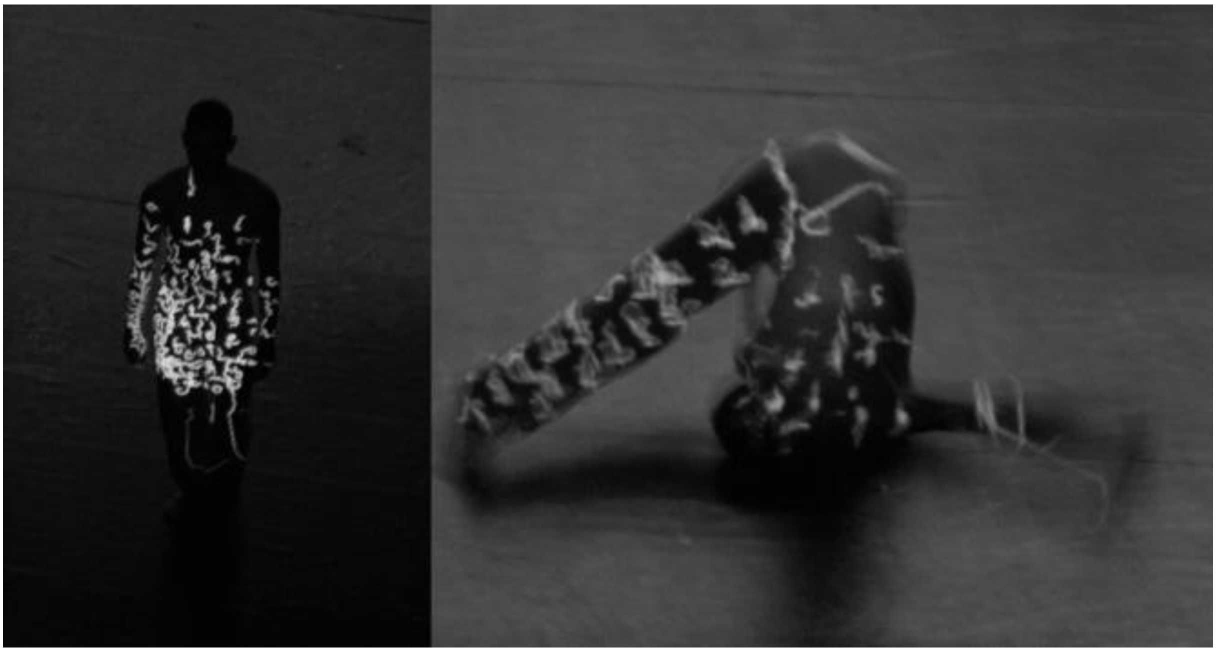


Figure 3: Swarm projection on the dancer's body in the choreography “Gods and Dogs” by Jiri Kylián.

2.4 2047

The dance performance "2047" was choreographed by Pablo Ventura and premiered at the Tanzhaus Wasserwerk in Zürich, Switzerland in 2009. The most prominent element of the stage design for this performance consisted of a white surface that covered the back half of stage surface and the sloped upwards to the ceiling along the rear wall of the stage. This surface served as a screen for a frontal projection via two video beamers. The interaction between a single dancer and a swarm simulation played a prominent role in a particular scene. As for the “Swarms” choreography, the swarm simulation and the tracking system were based on libraries that had been developed as part of the “interactive swarm orchestra” project [3][4]. During this scene, the dancer was performing in the middle of the horizontal section of the surface. The dancer was tracked via two cameras, one positioned above the dancer and pointing straight down, the other was placed in a frontal position and horizontal orientation. Similar to the setup for the "Swarms" piece, the dancer's body contour and motion created virtual force fields to which the swarm responded. The force fields from the frontal tracking were mapped to a position on the vertical surface behind the dancer and the force fields from the vertical tracking were mapped to a position exactly underneath the dancer. The swarm was projected as a single continuous visualization on the surface and the dancer's body (Figure 4). The swarm was continuously moving from the top of the vertical surface towards the front of the horizontal surface. When the swarm crossed the two force fields, the tangential and attractive forces of the dancer's contour narrowed it down to a very dense streak that followed the dancers silhouette whereas the motion field countered this vertical movement and caused the swarm to spread horizontally.

The title of the performance refers to a subplot in the film 2047 by director Wong Kar-wai. In this subplot, two men traveling in a train are served by android waitresses. The notion of travel and the mixture of natural and artificial traits of the androids form the underlying conceptual and aesthetic aspects of the dance performance. The virtual swarm embodied the natural and artificial duality of the android. The unnatural beauty of the female androids was represented by combining the swarm visualization with its own horizontal mirror image and thereby creating a highly symmetrical appearance. The projection of the constantly moving swarm on both the white surface and the dancer's body blurred the visual difference between the stage environment and the dancer. This blurring accentuated the fact that the androids and the moving train form part of the same artificial system.

At the end of the dance performance, the audience was allowed to enter the stage and interact with the swarm simulation. Through this participatory element, the swarm that had been an aspect of an entirely pre-specified choreography transformed the stage into an environment for explorative improvisation. This opportunity allowed the audience to gain an intuitive understanding for the connection between the dancer's choreographed activities and the spontaneous behavior of the swarm. It is via the interactive capabilities of the swarm that certain aspects of an otherwise highly abstract choreography became accessible to the subjective curiosity of the audience.

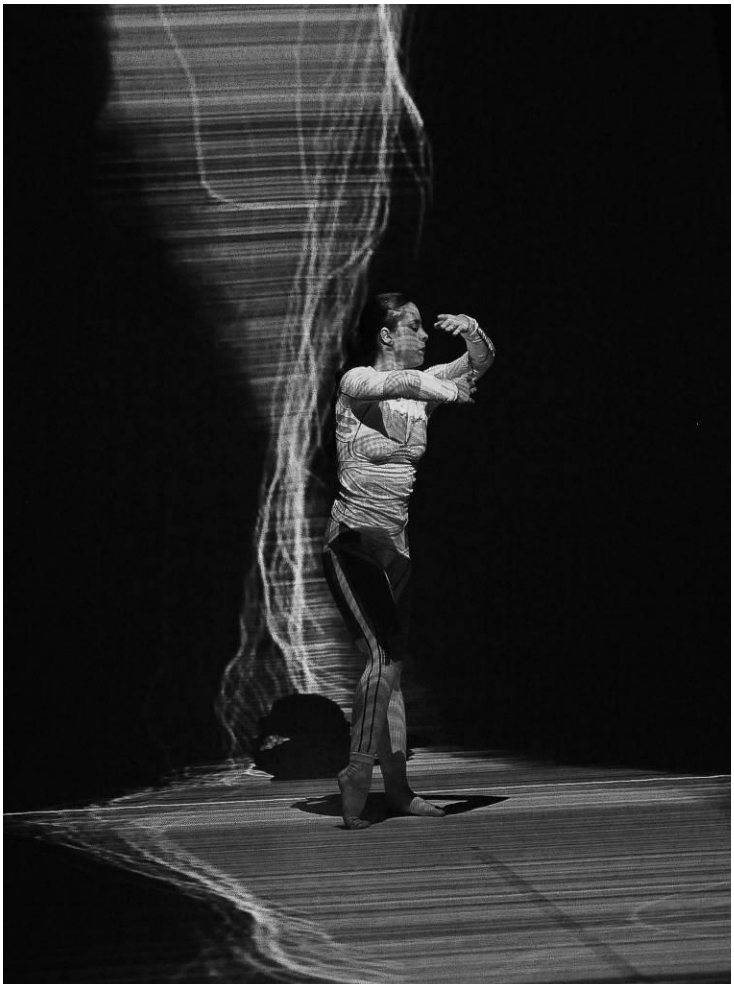


Figure 4: Swarm projection for the choreography “2047” by Pablo Venura.

3. Conclusions and Outlook

The preceding description of four dance performances that employed swarm simulations as an important choreographic element hopefully illustrates some of the potential capabilities that these systems offer for contemporary dance. In all these examples, the experimentation and adaptation of the swarm simulations and their visualizations formed an important aspect of the rehearsal process. But in front of the audience, these performances followed an entirely pre-specified structure. The choreography "2047" is the only example that breached this choreographic tradition but merely as part of an installative situation that took place after the performance had finished. The authors believe that the audience could witness the swarms spontaneous and autonomous qualities in a more substantial way if the interaction between the dancers and the swarm comprised elements of improvisation. The authors look forward to expand their work into this direction.

4. References

[1] Craig W. R. (1987). Flocks, herds, and schools: A distributed behavioral model, Computer Graphics, Vol. 21, No. 4, pp. 25-34, (SIGGRAPH '87 Conference Proceedings).

[2] Unemi T. and Bisig D. (2007). Identity SA - an interactive swarm-based animation with a deformed reflection, Proceedings of the Generative Art Conference. Milano, Italy.

[3] Bisig D., Neukom M., and Flury J. (2007) Interactive Swarm Orchestra. Proceedings of the Generative Art Conference. Milano, Italy.

[4] Bisig D., Neukom M., and Flury J. (2008) Interactive Swarm Orchestra - A Generic Programming Environment for Swarm Based Computer Music. Proceedings of the International Computer Music Conference. Belfast, Ireland.

Viva Naturalia ad Artem

Prof. Enrica Colabella, architect
Generative Design Lab, DiAP, Politecnico di Milano University, Milano, Italy
www.generativeart.com
e-mail: enrica.colabella@polimi.it

"…Doom is dark and deeper than any sea-dingle…"
W. H. Auden, The Wanderer

Abstract:

This investigation about Nature is not only for discovering rules and harmonious structures in an organic process of creativity, but also for focusing mainly impressions of our times connected to a wildness concept of Nature.
Viva Naturalia can trace a wandering locum of Art evocations, following our impressions. Evocations of sites in mother tongue, the first sounds of our life. In our time familiar sounds of childhood may be only an artificial-set of a constant open all day TV sound. But *how* we memorize these sounds is very different for each person. This ability is strong deeply connected to our singular wildness that represents our uniqueness. This is a *viva naturalia* process. So our voice is the most natural expression of our own code.
Hypothesis: wildness is connected to our male part as belonging to our original matrix.
The image by G. Dorè in an our time contest: the rider Don Chisciotte, with matt dark gray dress, alone on the mountains, walking toward suburb until downtown. His walking is a metaphor of a generative process for a possible raider.
The garden of God. Stones and leaves. The ginestra of Etna.
Cantores in chorus. Popular sentences. Dimensions. Characters.
Joseph, the father of alphabet.
Correspondences by Baudelaire. *Voyelles* by Rimbaud.
Pascal, *the inner rhyme*. Junger, *Eulogy of vowels*.
Sounds of visual mind. Algorithms for performing codes.
An evolutionary path: from romanticism toward modernism.
Key interpretations: blue, yellow, red.
Measure: *grosso modo/singulari modo*; *tempo rubato.*
Exempla: Baudelaire – Cezanne – Ledoux – Chopin; *blue*
Dickens - Turner – Paxton – Scriabin; *yellow*
Dostoevskij – Kandinsky – Gaudì – Rimsky-Korsacov; *red*.
Walking & Jumping

1. Aim of investigation

"…O where are you going said reader to rider?…."
W. H. Auden, O where are you going?

A generative process needs first of all a well defined aim, able to performing ideas.
Now this is how to discover wild uniqueness of human beings as a mirror of live Nature in a conscious Art process.

2. Mother tongue, starting point for endless variations

Are not, perhaps, the biggest part of words colored
with the idea of what they represent outside?"
Balzac, 1852

We discover since our infancy in wandering Nature a mirror of our singular identity, that artists try from ever and ever to translate in their works.
These are great catalyses for Art, as poetry, music, pictures, architectures, objects design For translating from *reality* to art we need not only a grammar, a syntax, logics, ideas, codes, we need also impressive impressions. How to collect them it is not script in any scientific book. We can only try to be simple, sure, sincere, that means wild, as the main expression of our uniqueness in our childhood.
By gaining this fields may be we arrive to a good expression of our own impressions. Obviously a scientific generative approach is the basic process for this creative experimental work.(see my paper Generative Art, GA 2008).
It is necessary condition, but it is not enough.
Investigation about words as expression of our ancestral wildness.

2.1 Joseph, the father of alphabethe

F. Crombette, bringing the Greek explanation of the magic origin of the writing, hypothesizes that the Hebrews for religious motives, for their depth God's respect , they heard the necessity of a writing of communication with the Egyptians, but that it had lost its magic character. On the base of the multiplicities of meaning of the hieroglyphs and the assonances, made easy by the extreme mobility of the vocal part of the names, they discovered that in the different pronunciations a thing stays unchanged: it is what they send forth the lips but that it is not pronunciabile without the aid of the vowels. The consonants are the skeleton, the vowels the meat. Crombette identifies in Joseph, the person that had the great idea to separate in a word the part of the consonants from the vowels . Here is the deep reason for which the Jew writing didn't have vowels. Joseph was the inventor of alphabethe.

3. Vowels.

A noir, E blanc, I rouge, U vert, O bleu; voyelles,
Je dirai quelque jour vos naissances latentes:
A, noir corset velu des mouches éclatantes
Qui bombinent autour des puanteurs cruell
Golfes d'ombre; E, candeurs des vapeurs et des tentes,
Lances des glaciers fiers, rois blancs, frissons d'ombelles;
I, pourpres, sang craché, rire des lèvres belles
Dans la colère ou les ivresses pénitente
U, cycles, vibrements divins des mers virides,
Paix des pâtis semés d'animaux, paix des rides
Que l'alchimie imprime aux grands fronts studieux
O, supreme Clairion plein des strideurs étranges,
Silences traversés des Mondes et des Anges;
- O l'Oméga, rayon violet de Ses Yeux
Rimbaud, Voyelles, 1872

Rimbaud in « Alchimie du verb » writes »J’inventai la couleur des voyelles ! », *but the invention rises always from a impressive impression. So walks the hyphotesis that E. Gaubert made on the Mercury de France on reminding to the colored* ABC *learning that Rimbaud would have used in his childhood. Gaubert had in fact roused an ‘800 illustrated alphabet in which the agreements with the vowel cromatismis of the poet are notable: the letter Á. is black, the E is yellow, the I is red, the U green, theO blue. If it is excluded E (but it is been objected that the yellow can discolor itself up to seem white) the correlation is perfect. But iy is not enogh. We need* the corrispondence *with the childhood impressions, these walk for evocative definition of colors.*

3.1 Vowels complexity: *Vocal Variations, tecnical tools in the art of talking*

Delivery of a message is a complex issue. Delivery consists of three elements – the verbal , words used,, the visual , body language, and ***the vocal, use of the voice****.*

Vocal variation through pitch. *We each have an upper limit and a lower limit to the range of notes we can hit with our voice. Some of us can’t “hit” any note in particular, but we all have a range of possibilities! By default we will usually fall into a limited range of pitch. It takes effort to break out of that range and add variation to the voice. Naturally, when excited, our pitch will rise. It takes effort to learn to sometimes drop the pitch for the sake of emphasis. This is worth doing to avoid screeching your way through an exciting talking like a shrill dog whistle!*

Vocal variation through pace. *All of us can speak faster and slower. Most listeners can cope with both faster and slower (as long as volume is appropriate). However, listeners will struggle with monotonous pace. It’s hard to listen to a 100mph preacher. It’s hard to listen to a 1mph preacher. Be sure to vary the pace . . . which takes effort to learn. Just like with pitch, we have a default when excited – we go faster.. Emphasis can be achieved by slowing the pace at the key moment, but it takes effort to learn this.*

Vocal variation through power / punch*. You can speak louder and softer. We tend to fall into a certain level, it takes effort to add variation. Again, for emphasis we naturally go louder. But going softer can really be effective too, with some practice. Here’s a post that addresses this specific issue -When Less is More*

Vocal variation through pause. *Basic truths – speakers feel that any pause is really, really long, and they think that listeners think they've forgotten what they'll say next. In reality a pause is never perceived to be as long as it feels to the speaker. Pauses really help. They add emphasis. They allow seconds for soaking in a truth. They allow people to breathe. So don't undermine every possible pause with verbal filler, you know, umm, like, just really, you know, like, that.*

3.1.2 The eulogy of vowels

Junger wrote some wanderful pages as eulogy of vewels. He tells about Pascal that called "the inner rhyme" the chord that gives to verses their more evocative attractive vibrations. Rhythm has a consonant nature, chord a vocal nature. The vowels are the pulp of the words, while the consonants are the bony structure. That's why the changes of the language, its migrations and its decadence strike more the vowels. He quotes Jacob Grimm: "*To the vowels in their whole a female character to the consonants a masculine character must be attributed".* The vowel represents the short-lived element of the word, in it the color resides, while in the consonant there is the drowing. The feelings are deeply connected with vowels. The Á. means verticality and ampleness, the O height and depth, the E the void and the sublime, the I the life and the putrefaction, the U the generation and the death. Few keys are enough for therefore disclosing the fullness of the world in the measure in which it reveals him to the ear in the language,

4. Correspondence, similitude, performing

« La Nature est un temple où de vivants piliers
Laissent parfois sortir de confuses paroles;
L'homme y passe à travers des forêts de symboles
Qui l'observent avec des regards familiars.
Comme de long échos qui de loin se confondent
Dans une ténébreuse et profonde unité,
Vaste comme la nuit et comme la clarté,
Les pafums, les couleurs et les sons se répondent.
Il est des parfums frais comme des chairs d'enfants,
Doux comme del hautbois, verts comme les prairies,
- Et d'autres, corrompus, riches et triomphants,
Ayant l'expansion des choses infinies,
Comme l'ambre, le musc, le benjoin et l'encens,
Qui chantent les transports de l'esprit et des sens »
Charles Baudelaire, Correspondences from Les Fleurs Du Mal, 1857

Baudelaire can recover on this poetic the plan dimension of nature that the western intellectual for a long time has lost. A dimension that is not "naturalistic" only for the reference to perfumes colors sounds of the nature, but also in relationship to the "baby's meats", the lost innocence, irrecoverable in the reality in how much prevented by other perfumes "corrupt, rich and triumphant."
The poet stands himself in opposite feelings of life, where those prosaic of the daily life become sublimed, in deceptive form, from all internal feelings.

Quartina al tramonto del 15.02.'08

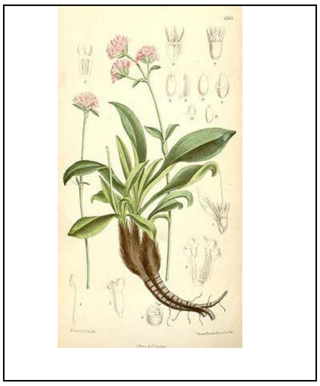
La gentilezza è un passo veloce flebile tra la polvere.
Segno invisibile di racconti trattenuti di memoria infantile.
Curvati nell'angolo con lieve statico furore di voce popolare;
Il tempo trascende solo gli inoperosi, distandoli d'inedia.

Una punteggiatura lunga, sospesa
Quel pensare che sia il tempo
Ad accarezzare l'amore.

Due pagine bianche
Improvvise
Scoperte tra l'affollata
Propaggine della terra
Svelata.
Terra, terra agognata
Con delicata armonia
Riempirò il tuo vuoto
Inaspettato spazio.
Non Ti deluderò
Musa attenta
Inquieto è il canto:
Ciò che verrà
E' già dato.

This paper tries to outline *how Natura walks* for artist of our time. This represent the most adaptable tool for our eyes, used in all culture.In our time we are over the Hegel dialectical vision of the world. After last studies about, we can affirm that the opposites black/white, far/near etc. are not in one dimension system, but they generate a dynamical asymmetry. So this explained generative process is not necessary for activating a creative process, but it is a good methodology that works in experimental way by gaining complex results, the main question of our time.

4.1. Characters, interpretation keys, Maestri



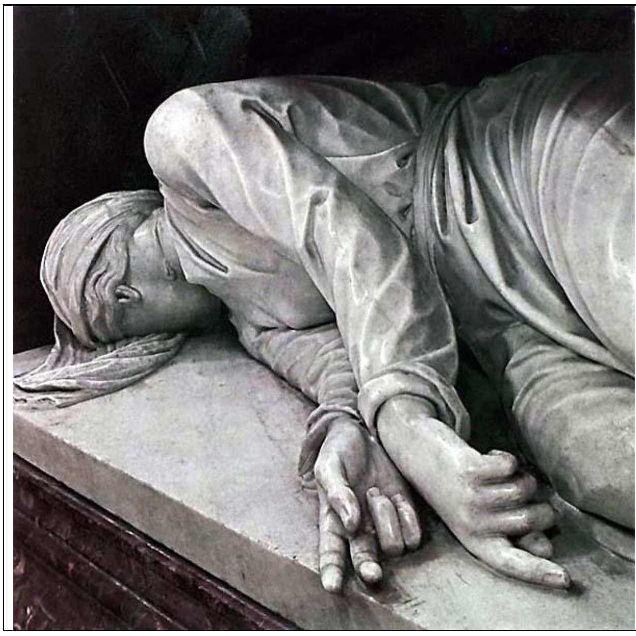
Nardostachys_grandiflora

Apophasie
Naturalia character: *neutral* colors on the table, when wind is flatting

Wild *as the sun that shines dawn on mountains*
Clear *as water that flows slowly between the folds of stones*
Strong *as the proud running of a young horse on the path of home*
Fragrant *as nardo that represents the humility of Mary*
Lucent *as the looking of a mother that caresses her son*
Winding *as the curve of a shell spiral in the sea*
Pure *as the call sound of a turtle dove*
Ethereal *as the wing flight of a white butterfly.*

4.1.2 The sound of the heart voice

"Bellezza delle prime foglie/Beauty of the first leaves
bagnate dai raggi del sole/watered by sun rays
colla loro ombra appena nata!/ with their shadow just born!
Fedor Tjutcev, The first leaf, 1851

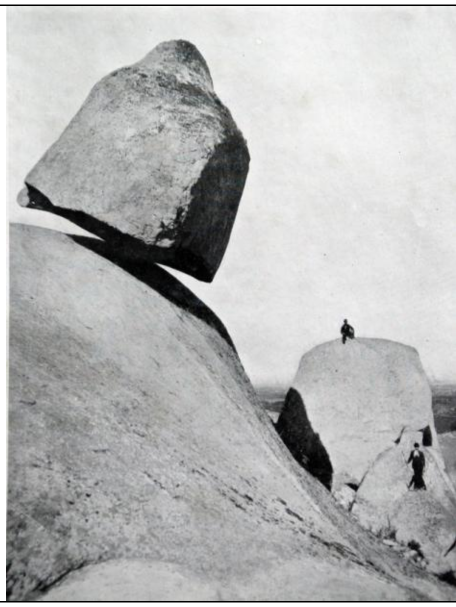


Antiveduto Grammatica, Santa Cecilia e due angeli musicanti, 1613 ca., Musei Civici, Treviso

The statue of S.Cecilia carved by Stephen Maderno in 1599. *TALKING Hands*
Gramatica, S. Cecilia e two angels musician – *The sonorous backdrop*

Cecilia, holy, martyr of Rome, doesn't exactly know the date of the martyrdom. The church in Trastevere of S. Cecilia was founded, in 230 from pope Urbano I, on the house of a pious homonym woman of the holy martyr. The Title Caeciliae goes up again to the V century. In the 821 Pasquale I it makes to rebuild the church transferring there the body of the holy from her crypt, in the Cemetery of Callisto, on the Street Appia .Pope Pasquale put back the body in a box of cypress that was contained in a sarcophagus and secret in the confession under the greater altar. The pope before interring Cecilia put the head in a silver casket that was given subsequently by Pope S. Leo IV to the church of the Sses. Four CrownedS. On 19 October of 1589 there was the recognition of the relics and the body, deprived of the head, of Cecilia was found uncorrupted.

Leaves and stones



The ginestra of Etna-
Pietra Movediza of Tandil, Argentinian

…
"Sta natura ognor verde, anzi procede
Per sì lungo cammino
Che sembra star. Caggiono i regni intanto,

Passan genti e linguaggi: ella nol vede:
E l'uom d'eternità s'arroga il vanto.
E tu, lenta ginestra,
Che di selve odorate
Queste campagne dispogliate adorni,
Anche tu presto alla crudel possanza
Soccomberai del sotterraneo foco,
Che ritornando al loco
Già noto, stenderà l'avaro lembo
Su tue molli foreste. E piegherai
Sotto il fascio mortal non renitente
Il tuo capo innocente"…
Giacomo Leopardi, La ginestra

The Piedra Movediza fell down in 1912 and split in two below. Although it is impossible after the fact to ascertain the reason it fell, it is very possible that the delicately balanced rock was thrown off balance by the common practice of placing glass bottles under it and watching them explode. This was the way the locals would prove to visitors that the rock, in fact, moved, since the movement was too subtle to be detected by the naked eye. There have been projects to restore the rock, and a replica stone was placed where the original used to be. Other similar stones like El Centinela are also attractions, but none has the truly astonishing quality of teetering ever so slowly like the "moving rock" once did.

Stones talk us about life and death, and how the transforming walks and the going down of the earth's forms. They are the diary of the land that had a long lively past, before the birth of human beings, curious able readers of the stones pages.

"Invano tendi in ascolto l'orecchio/ In vain you prick up your ears.Una sola cosa sento nel mormorio delle sfere:/Only one thing I hear in the spheres murmuring:
La voce tonante del tutto:Infinito"./ The voice of the whole tone: Infinite"

Goethe .

4. Oral tradition – cantores in chorus

Cantoria, Luca della Robbia e Donatello

Vowels in chorus

I set a imaginary site, like a virtual chorus with 12 players, following the Eschilo tradition of Greek chorus, playing, dancing and singing.
They are connected by the colors yellow, blue, red.
The choice of Cantoria people follows my impressions of artists that were important in my life, improving my ability in discovering feelings of art.
During my investigation I was in a deep attention that my hypothesis that the selected artists were really mainly connected to colors key. This for the plausibility of my investigation system.

3 *A collective code,* toward avanguarde

"Oh don't believe in the unity of man"
Dostojevskij

For trying to understand some starting points of the deformed relationship between Nature and Art in the reality of our time , characterized by a total absence of poetic and a big power of technology, I focused some roots of investigation at the beginning of the last century. This time was characterized by a double direction: one strongly connected to the 800 Romanticism, the other one in a total new relationship between Art and Nature .a revolutionary vision figurative and abstract, this incredible passage performs the new *homo faber*, as strong expressions of the machines power.
Balzac, was a prophet of the avant--garde But the avant-garde term starts to have sense beginning from the letter that the young Rimbaud writes May 15 th 1871 to Paul Demeny, the famous Letter of the clairvoyant, in which the illusion is advanced, that will be proper of all the avant-garde of the XX century, of an art outpost of a real change of the reality. Illusion, certain. But the center of the letter is another. Rimbaud launches an extreme provocation: "Me it is another." Quoting Monteigne "My I of today and my I of tomorrow are surely two."
Only in this way it will be possible to gain, beyond the forms already deposited in the language, the other forms that are excluded, or even what has considered shapeless, destined to sink in the nothing without salvation. What this extreme action had to not only have an artistic effect, not only cognitive, but to be a move of the general axle, and therefore also ethical, of the human life. Rimbaud confirmsto reach a new sensibility, but also in new opinions, to a different staircase of values that puts us in relationship with the world.
A performed friendly site of artists works by defining interpretative relationships between them, as a common denominator: the connections in their artworks to a same dominant impressive color. The colors, used as a key interpretations, are: *yellow, blue, red.*
These tools were used as a water diviners.

The fatherly sounds of love replay in the time bottoms

As fragments of revealed attentions.

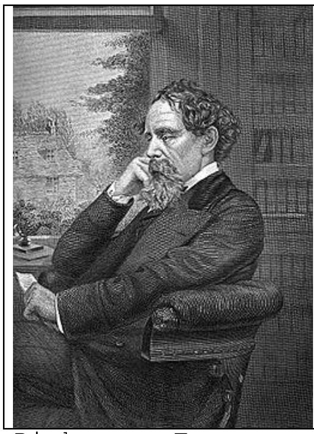
The theme of this investigation is the relationship between nature and art.
Following Stefan Zweig Dickens, Balzac and Dostojevskij are the most expressive novelist of XIX century. In the meaning of novelist as genius able to generate a new cosmos with his own rules. The novelist is able in giving his own nature to the artificial ware that he invented. This is deeply recognizable not only for the author, but for all people. Poetry in prose.
Each one works in his identity spheres:

Dickens in the family sphere

Balzac in the society sphere

Dostojevskij in the singular person sphere
Literature is, in this *iter*, not only the starting point of investigation, but also the double vortex, that working as an attractor is able to outline connecting also the other arts, painting, architecture and music, following the tradition that literature is the most important art.
Cantores data:
Dickens, Landport, 7 febbraio 1812 – Gadshill, 9 giugno 1870
William Turner Londra, 23 aprile 1775 – Chelsea, 19 dicembre 1851il
Joeph Paxton was born August 3, 1803, in Milton Bryan 1858?
A. N. Scriabin, Mosca, 6 gennaio 1872 – Mosca, 27 aprile 1915
Balzac, Tours, 20 maggio 1799 – Parigi, 18 agosto 1850
Paul Cezanne, 19 Gennaio del 1839 ad Aix-en-Provenc muore ad Aix il 22 ottobre del 1906
Ledoux, Dormans, 21 marzo 1736 – Parigi, 18 novembre 1806
CHOPIN, Zelazowa Wola, 1º marzo 1810[3] – Parigi, 17 ottobre 1849
Dostojevskij, Mosca, 11 novembre 1821 – San Pietroburgo, 9 febbraio 1881
Vasilij Kandinskij, Mosca il 4 dicembre 1866 - il 13 dicembre 1944
Antoni GAUDi', Riudoms, 25 giugno 1852 – Barcellona, 10 giugno 1926
N. A. Rimsky Korsakov, Tichvin, 18 marzo 1844 – Ljubensk, 21 giugno 1908

1 –*yellow*
Nature in the mirror – The art of memory – *the looking* – lighting and technique




Dickens – Turner - Joseph Paxton - Scriabin

Charles Dickens
He is the unique exemplum of deeply loved author from his first work until the last moment of his life. He was friendly called “Boz”. His glory remained fixed lighting as a sun over the world. The first framgment part of the book Pickquick had 400 copies, the fifteen one 40.000 copies!

For hearing his voice people made crazy things.
His tomb still now is always covered by flowers.
His poetic identity is strongly connected with tradition. He is the unique great poet of his century, whose intent is totally connected to the intellectual needs of his time. His great worth was to discover the poetic site of the prosaic life. Dickens made come the sun into the grayness of his land.
He is the golden circle in the daily English life. He wanted help aged people and children, using words performed in bivocal art, poetry in prose. A dynamic evocative picture in our mind is the result of this generating impression process.
His eye outlines a richness of characters with infallible precision. No one is equal to an other, until in any little detail is sculpted their personality. In his work is not present any approximate simplification. All is real and alive, described by his deeply careful looking. This is a wandering infallible tool. Dickens is a visual genius. His eye is an English eye, cold, gray, lucent as steel. In his memory no one impressions of his life were lost, every thing was collected, his eye was more strong than time. Nothing was forgot, all the impression were alive, full of smell and read for every possible evocations. His visual memory was not comparable. He used a special arteficium, reflecting the characters in a concave mirror, for increasing their grotesque aspect. By this unique vision he performed evident the whole character. Dickens works with the real eye of the body. His characters remind to pictures. Real images invented by a strange angular eye position reflect every life phenomena. His humour is like a warm sun ray, able to transform landscape in a wandering site.
Dickens is winner for his smiling.

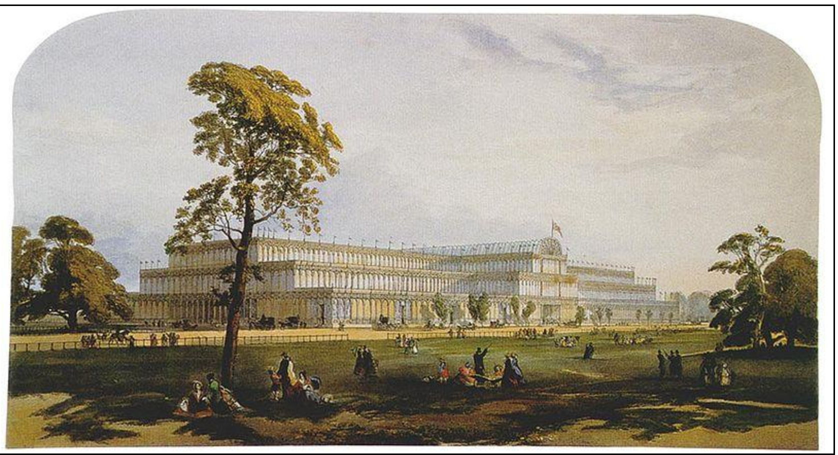
Turner, John Mallord William. One of the finest landscape artists. His work was exhibited when he was still a teenager. His entire life was devoted to his art. Unlike many artists of his era, he was successful throughout his career. His father was a barber. His mother died when he was very young. The boy received little schooling. His father taught him how to read, but this was the extent of his education except for the study of art. By the age of 13 he was making drawings at home and exhibiting them in his father's shop window for sale. Turner was 15 years old when he received a rare honor--one of his paintings was exhibited at the Royal Academy. By the time he was 18 he had his own studio. Before he was 20 print sellers were eagerly buying his drawings for reproduction. He quickly achieved a fine reputation and was elected an associate of the Royal Academy. In 1802, when he was only 27, Turner became a full member. He then began traveling widely in Europe. Venice was the inspiration of some of Turner's finest work. Wherever he visited he studied the effects of sea and sky in every kind of weather. His early training had been as a topographic draftsman. With the years, however, he developed a ***painting technique*** all his own. Instead of merely recording factually what he saw, Turner translated scenes into a ***light-filled expression*** of his own romantic feelings. As he grew older Turner became an eccentric. Except for his father, with whom he lived for 30 years, he had no close friends. He allowed no one to watch him while he painted. He gave up attending the meetings of the academy. None of his acquaintances saw him for months at a time. Turner continued to travel but always alone. He still held exhibitions, but he usually refused to sell his paintings. When he was persuaded to sell one, he was dejected for days. In 1850 he exhibited for the last time. One day Turner disappeared from his house. His housekeeper, after a search of many months, found him hiding in a house in Chelsea. He had been ill for a long time. He died the following day--Dec. 19, 1851. Turner left a large fortune that he hoped would be used to support what he called "decaying artists." He is called in England the painter of light.

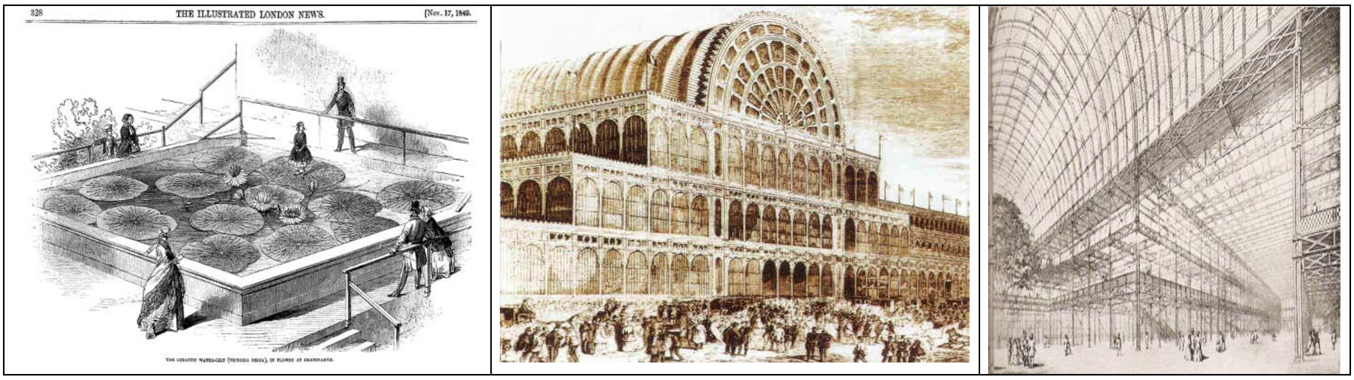
    

1- *Colour Beginning* 1819; Watercolor, 22.5 x 28.6 cm; Tate Gallery, London
2- *S. Giorgio Maggiore: Early Morning* 1819; Watercolor, 22.4 x 28.7 cm; Tate Gallery, London
3- *Slavers throwing overboard the Dead and Dying - Typhon coming on ("The Slave Ship")* 1840; Oil on canvas, 90.8 x 122.6 cm; Museum of Fine Arts, Boston
4- *Norham Castle, Sunrise* c. 1835-40; Oil on canvas, 78 x 122 cm; Clore Gallery for the Turner Collection, London
5- *The Fighting "Temeraire" tugged to her last berth to be broken up* 1838; Oil on canvas, 91 x 122 cm; National Gallery, London

Joseph Paxton

Paxton was a remarkable designer of "natural engineering" He designed the Crystal Palace in Hyde Park, London, the building that would house the "Great Exhibition of the Works of All Nations" in 1851. Over 233 designs were submitted for the building. The catalyst of his design was a wonderful flower: Victoria Regia.(Expanded_flower) Paxton produced his design on a piece of blotting paper and submitted the final design *in less than nine days*. The building itself was erected in just six months, with 293,655 panes of glass, 330 huge iron columns and 24 miles of gutters.
In 1854 the building was moved to Sydenham where, until it was damaged by fire in 1936, it housed a museum of sculpture, pictures, and architecture and was used for concerts. In 1941 its demolition was completed because it served as a guide to enemy planes. The building was constructed of iron, glass, and laminated wood. One of the most significant examples of 19th-century, proto-modern architecture, it was *widely* imitated in Europe and America.





Victoria Regia.(Expanded_flower) - the Crystal Palace

Alexander Scriabin

Light **key board**

The musical language of Alexander Scriabin was unique and exotic from the outset, and over the course of his career became even more so influenced by the spiritual mysticism of his day, and explored an other world through his music.
Compositions such as his Third Symphony, The Divine Poem deal with subjects like pantheism vs. monotheism, and late in life his intentions were to create holistic religious events, not unlike ancient Mediterranean pagan rites, infused with music, dancing, colors, and smells. Scriabin's theory was that each note in the octave could be associated with a specific color, and in *Prometheus, the Poem of Fire*, he wrote the colours and music to match. His arrangement was:

C	Db	D	Eb	E	F	F#	G	Ab	A	Bb	B
Red	Violet	Yellow	Steel	Pale Blue	Dark Red	Bright Blue	Orange	Purple	Green	Steel	Pale Blue

Part of his eccentricity was his claim to experience synesthesia, the bleeding of one sensory experience into another; thus he equated colors, as in red, blue, or yellow, with certain tones and key relationships. F sharp, for example, he experienced as blue, and C major as red. This experience inspired the creation of a color organ, a *keyboard type* device that projected colors upon a screen, depending upon the chords played. However, it wasn't until the 1970s that a similar device actually succeeded at a performance, due to the necessary technology involved. His influence upon the Western tradition is perhaps felt mostly in spirit, rather than in his unique and fascinating harmonic language. *Yellow* for him was an high test of intellect.

2 - *blue*

Nature inside Nature – The art of dreaming – *the mind tenderness* – the night

Balzac – Cezanne – Ledoux - Chopin

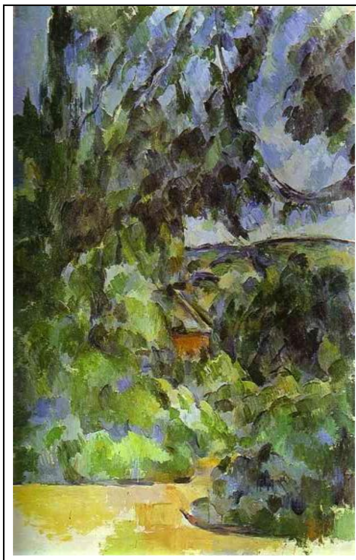
Balzac

Balzac is the *magister* of the pure precious form. Synthesis *"en raccourci".* His methodology is in compressing and in *compendium..* He arrives to define the characters of the human comedy. His world is poor, without contrast, interferences; it is also simple, he enlightens with its flame every hidden corner of life. He chooses each prototype of human beings and moulds with his hands his character color. In *blue.*
His own code is mirrored on the collective codes of his time and beyond his time, arriving to outline the eternal codes of human beings life. Together to his 80 works on Human Comedy, there are too 40 *unfinished* artworks: *Mosca, Wagram, The existence of passion…*
If Balzac finished the his whole opera, closing his human passions circle, his work should become not understood. For the reason that his art should be too much perfect, terrific for all posterity.
For this simple feeling that deeply respects the human *temporary* status his color is *blue*. This is a great art of telling, connected to the *oral tradition* in imitation of Nature. He a great performer of the bivocal art of poetry in prose. His characters remind to us a tender music.
The unfinished Human comedy , as a wonderful unfinished statue, is a greatest exemplum, a wandering song toward the human un reaching perfection.

Cezanne

Cézanne, at the beginning of his activity, ideclares that the fantastic character and the historical character that more have influenced him iis Frenhofer, the protagonist of the story The unknown masterpiece of Balzac. According to Bonnard, at the end of his life, with the tears to the eyes, Cézanne declares that this story is his history. Does he speak this story of what? Balzac in the Unknown Masterpiece prophesies the inaugural crisis of a new language. The young Poussin meets, bringing himselff in the study of Porbus to show him his sketches, an old man, that entered hardly immediately not, inveighs against that painting - that of Porbus and of Pussin - that he deludes, to have represented the nature to have of it also torn the secret,. But if the hand stretches him on the cloth, on the body that is represented there, on that breast that appears so "solid and round", the cold of a statue meets him the dead rigidity of a dead body. The painting, the art, doesn't have to copy the nature, but they has to look for of "to gather the spirit, the soul". Only so it is possible to reach the beauty that is "severe and difficult thing", that can be cultured only tightening her/it in a form, that is it same plural, multiform, as the reality that surrounds us, as the life that "it overflows" and that "it fluctuates around nebulously."
Porbus and Poussin finally reach to see her Belle Noiseuse, the picture from to which the old Frenhofer is working more than one decade. And they don't see anything. They examine the painting, "putting to the right themselves to the left, of forehead, lowering themselvesf" in a sort of desperate clown mimic and they don't see anything else other than "colors confusedly and contained in a crowd of eccentric lines". And finally, as "escaped an unbelievable destruction", they perceive, petrified by the admiration, in an angle of the picture, a foot that emerges from the shapeless chaos of the colors from the dense fog of those lines.
That fragment, to which they devote a sort of dark admiration, is for them the residue of the only language that they succeed in considering such. And the last rest of the representative language, that seems, in it complex, hold backin the slow obstinate, stubborn breakup of the folly. And therefore they

communicate to the old man their disappointment: on the painting, they says, nothing is not seen, the painting represents the nothing. It begins indeed here, "the legend of the modern art", not so much for the artists and the poets that have meditated on this story as on a prophecy, but because Balzac gathers the cognitive change that emerges from a new reality: from the "magnificent chaos of the roads", from the crowd, from the mutable one, from the buzz, from the noise leading of the metropolitan condition. It gathers that is the salt of this reality, that overflows from the usual linguistic codes, elusive inside a pure representation.
Cezanne always suffered the terror of the black
"I have to always work, but not for reaching the ended one, that arouses the admiration of the imbeciles. What the common people mostly appreciates is not but the result of the work of an artisan, that makes every l work not artistic and banal": This is the objective of a young Cézanne trentacinquenne, that holds to have reached at the end of the nineties, when he writes to Gasquet: "… I have come too soon perhaps. I was the painter of your generation more than of mine."



Landscape in blue – Woman in blue – The bathers

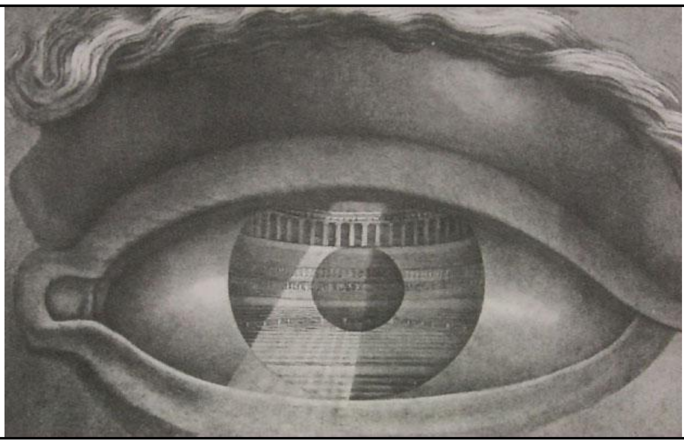
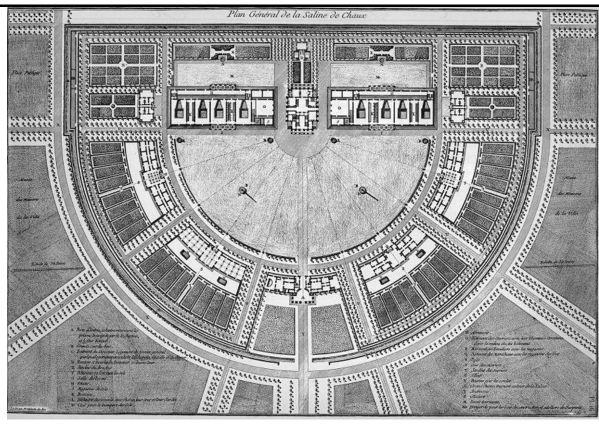
LEDOUX

He said that the shape must be "*pure as the one of the Sun during its journey*" Its harmony lies firstly in the air and the sun. The cosmic vision is provided by the shape of the
Salt works, which looks like a sundial.But the radiant organization allows also the functional distribution, each building trade owning a building in an equal part of the sun and of the public and private space (especially the gardens).
The obsession for meaning characterizing Ledoux' work determines him to explain even that the building situated at the most western point will be appointed to the clerk who will be the last ones to work every day, writing down in the books the daily production… At midday, the Sun is of course at its height on the top of the director's house, which also stands for the justice palace and the church… In one of Ledoux' engravings we can even see the sun crossing over the building and illuminating the priest, who is on the top of the stairs, where everything converges.
We obviously think of Tommaso Campanella's Cité du Soleil (La città del sole)
The feeling that the Royal Salt works have a secret connection with the outer space is still present nowadays: the strength and the balance which come out of this architectural composition determine a feeling in between trouble and fullness: there are some who leave it serene, there are others who leave it panicked. Conductor Emmanuel Krivine, who would spend many summers at the Royal Salt works with the French Youth Orchestra, used to say that inside the salt works one has to face oneself… Those who have spent some time there know at what extent this could be a good or a bad experience.
II. The architect's eye
The second compositional element is the reference which Ledoux explicitly makes to the ancient

theatre. In the opinion of Anthony Vidler (1987, p. 49)4, "we literarily have to interpret the Salt works as a theatre, since it follows the lines of the ancient amphitheatre as described by Vitruve and illustrated by Perrault" (in the work published in 1673, that Ledoux thoroughly examined).
Just like the theatre of Besançon, whose revolutionary auditorium breaks with the Italian model of theatre and becomes the prototype of the "modern" auditorium, the shape of the Salt works represents the social and political ideal of the City of Chaux.
We can also call theatrical in the Salt works the combination of abstract elements and dramatic motifs, whether we refer to the colonnade of the director's house, which has to play with the sun, or to the salt urns, or to the imitating rustic roofing. It is the "talking architecture", with its production and strength symbolism.
Finally, the third approach to the plan of the Salt works is that of the eye. We have insisted a lot in our comments on the ideology of social control exercised by the Salt works, where, Ledoux says, "nothing escapes the supervision". Michel Foucault (1975) has even compared it to a "watching machine" which announces the concentration universes.

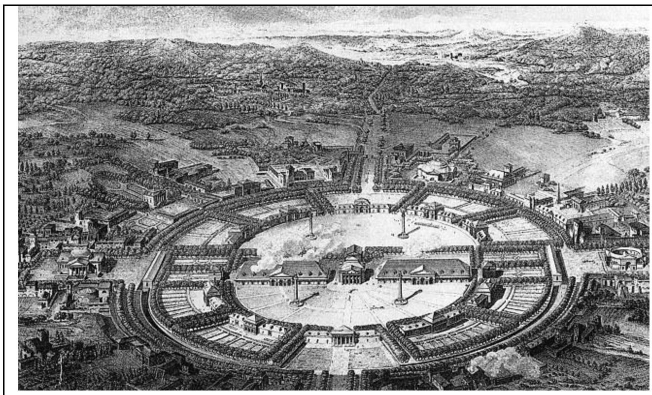
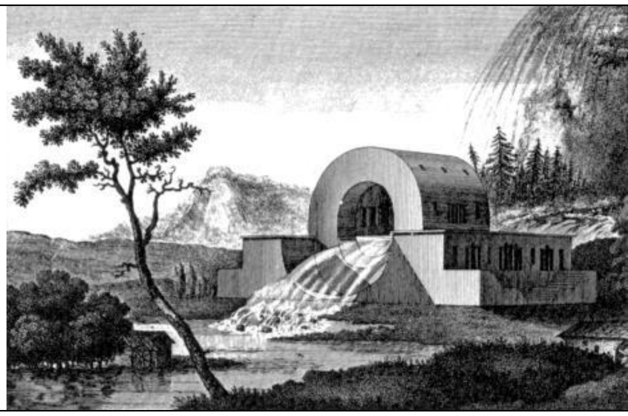
III. The Salt works, real building and embryo of utopia

The royal Salt works built between 1775 and 1779, 20 years before the French Revolution, does not represent a utopia in itself, but rather a vision of the future. Maybe we should not forget to mention that two centuries later some intellectuals had the idea of setting up there a "foundation", in charge with creating an international centre of reflection upon the future. Nevertheless, Ledoux' utopia is "The city of Chaux", an ideal city whose plans he will constantly improve, especially after the Revolution…In this way, until the 1980s, the tourist guides mentioned the Salt works as an old country house or an unfinished ideal city. These rough guesses spread by a popular mythology are very far from the historical reality. Ledoux has really built a salt manufacture at the king's request. This salt works has been desired and built in semi- circle.
It is only during the Revolution and particularly during his imprisonment that Ledoux will conceive the work of his life: the plans of an ideal city which he will describe in his treaty of architecture. But contrary to what some people have written, Ledoux' ideal city is not the result of an opportunist appropriation by the former king's architect of his work in a revolutionary light. It is likely that Ledoux had from the very beginning in his mind this project of an ideal city, the public order giving him the opportunity to test some ideas before their development in his writings.
The ideal City is hence conceived twenty years after the building of the Salt works, in a totally different political context. It is the result of both social and architectural utopia... Ledoux extends there the theories which explained the choices made for the Royal Salt works. But what is intriguing is that this utopia is not one without a site, since it is situated exactly on the place of he Salt works, the latter being its centre. In the famous engraving of the ideal City of Chaux ,we clearly recognize the Salt works, but also Loue's valley, in the place where it meets the Jura Bresse, having in the background the Chaux forest Massif, which names the imaginary city.
We are now aware that there was no clear-cut distinction between the Salt works project and that of the city of Chaux, it is even likely that Ledoux has thought from the very beginning to set up a new industrial City in Franche-Comté. Vidler reminds in this way that at that age the region constituted the object of many projects of economical development. In particular, there was built the channel from the Rhone to the Rhine, which still exists nowadays. It is likely, as this author believed, that Ledoux had tried
to convince Turgot's entourage to build at the borders of the kingdom a city in a new style, for which he made several successive plans.
In these "urban fictions" Ledoux closes the Salt works' circle and he makes the centre of an imaginary city out of it. We encounter there the idea of a community life following J. J. Rousseau's model, but also the idea of a new industrial urbanism. Ledoux enhances gradually his great urban project through other buildings, explaining their functioning, designing their catalogue, and setting up their plan. To his mind, these ones should be engraved by better artists and afterwards published in his treaty of architecture,which will partially be made in 1804.

The eye of the member of the audience reflecting the theatre of Besançon, Inner view of the theatre, drawing by Ledoux

The Royal Saltworks at Arc-et-Senans, plan view of facilities

General view over the city of Chaux
Project for the ideal city of Chaux: House of supervisors of the source of the Loue. Published in 1804.

Chopin

Chopin was a great performer in his art of tempo rubato, as a blue tone of the night able to hold every different interpretation.
"Tempo Rubato"is the freedom of movement tuned to the performer in certain passages for emphasizing the expression. Without any doubt the rubato is born from "Il canto Gregoriano". Cantors had some notes following their will, crossing suddenly on others, certainly for preserving the tradition of declamation used by the Greek rhapsodes. It is met in Italian recitativo and later in Frescobaldi, Bach(Fantasia cromatica),Mozart and Beethoven.
This, in Chopin, is considered as a sign of Italianism. There is inside most of all the direct influence of the folkloristic Slavic folklore music, where the rubato exists in a natural status.
Lizt called it “the rule of the irregularity"
It belongs to the peculiar movement of the fraseggio and to its tonality.
The rubato is a flexible measure able to give to the melodic phrase a characteristic tone of each mother tongue. Chopin asked always that the song part, often that on the right hand, had freedom of expression, involving the alteration of tempo.
Chopin used to say: *"That your left hand be your Maestro and preserve always the measure*" And still "There are done some balances for restoring the whole".
The rubato is one of the topic mysteries of the Chopin opera.
Lizt tried to explain it with a verbal simile: "Just suppose a tree that the wind makes fold. Among its leaves cross the sun rays and the flickered generated light is the rubato".
To the art of suggestion Chopin adds an indefinable nuance that expresses together an interior tension and a species of anxious aspiration.

3 – *red*
Nature from Nature – The art of telling – *the heart passion* – hope in dawn

Dostojevskij – Kandisky – Antoni Gaudì – Rimsky-Korsakov

Dostojevskij

…
"Non vi si pensa quanto sangue costa"../"There is no thought on how much blood it costs"..
Dante, Paradiso», XXIX

Omage to Dostojevskij

The mute crowd steals the flowers on your corpse,

In the house of smiths, at the fourth floor.
Relic in death of what in life was ignored.
Russia was united in the moment of your death:
The rich and the poor together in the goodbye.
3 weeks later, the Tsar was killed.
You died, as Beethoven, just a frame before the storm.

Fedor Michailovic Dostojevskij represents a total new vision of art. He performed a new infinite spiritual measure. His spiritual dimension is his greatness. In the attempt of following Hegel dialectic between good and bad, he perforated inside them a deep singular hope fragment.
His visionary feelings are evocative of the harmonic sound of fable, told with a deep slow maternal voice, that is trying to go beyond the child pain. In his work we discover the trouble of all possible human wildness, performed in a aesthetical process of consciousness. Only in the eternal immutable of our beings, we can connect with his art. Only if we connect to our true deep nature we arrive in understanding his poetic. Instead of a warm sun, in his literature the land burns on the sky a blood dawn. But over the *red* there is too an immense goodness on the sky more high toward infinite. Over the face of all his characters we discover the eternal darkness and the eternal light.
His world is between the site of death and the site of madness, between dream and terrific truth. He didn't give us any information for helping us about how to arrive to him. During all his life he was solitary and surly, starting from an infancy full of shadows. He was born in a asylium of poor people. The sad absence of love is the embryo of literature. The infancy idea is for ever exiled from his life. But he invented the young Kolja, full of fantasy and of good human feelings. The doom of Dostojevskij was so dark for almost his whole life. A frame of his life was really marvelous. ***For the commemoration of Puschkin his bass and veiled voice is like a red flame of ecstasy producing with his oration on the people imagination, as a suddenly harricane***. Panic, tears, a young student faints, women

kissed his hands. An endless enthusiasm as a big red fire grows on his head crowned by spines. After a short time he died. His immense love finished. He gave back his own doom to the same doom, following its absolute aware reality.

Kandisky

Kandinsky thought that the art had to communicate spirituality ` and to do well it owed us to be an absence of the realistic representation of the reality `.
The color is a mean to practice on the soul a direct influence. The color is a key, the eye the hammer that strikes him/it, the soul the tool from the thousand ropes. For Kandisky the meanings of some colors are: Yellow - is ` full of energy but deprived of deep emotions Blue - is` depth and nostagico and he/she remembers the sky Green is` equal to the yellow conbinato with the blue one and from an idea of calm that is able' easily to bring to the boredom or to the indifference.
***Red - is ` energetic but it depends on the tonalities `: clear is ` warm and strong middle - and ` sure is firm but if it is ` dark is' cold but with a lot of passion*** White points out absolute silence Black means last silence without exceptions Grey is an intersection between white and black and then it means silence and immobility ` without hope of a change. Kandinsky also identified every color with the sound of a musical instrument. Kandinsky has studied the impressions that gave certain colors with certain figures so that to express the spiritual contents and to transmit feelings between the artist and the observer without including the reality `Kandinsky thought that painting was an art very similar to the music: able to transmit emotions without representing the reality `. As the musicians you/they can compose the music, the artists can compose colors and forms to give an effect to the observer similar to that that from' the music. Kandinsky believed that the forms were a way of expressing the calm ` inside, he wants to observe objects to learn their inside meaning. The beauty of the drawn object should be only a way of attracting the attention of the observer with the purpose to directly communicate with the soul. When Kandinsky paints abstracted pictures the first inspiration, of base it comes from the nature but then it gradually minimizes the natural forms in essential figures thin to arrive together to a dynamic of colored shapes `.Kandinsky divides the phases toward the abstractivism in three parts: "Impressions" (perception sensoriale) the first impression that is directly born from the nature. "Improvisations" (emotions at the first instinct) they are sudden expressions of emotions and feelings. "Compositions" (synthesis of emotions and feelings): expressions that slowly come from the inside and external emotions that are elaborated by Kandinsky. Kandinsky delines a method to teach the Abstractivism. It tries to identify the basic figures of reality ` (triangle, square, circle) that are the expressions of the "power, weight and movement" and their relationship on the picture, with lines, stains and colors "pure". Kandinsky believed that combinations, type a yellow triangle or a red square, or a blue circle, are best ways to communicate. Kandinsky teaches his more ` tall abstractivism through the color. He gradually estranges from the materialistic elements (out of the reality `) and he is able to perform objects that are dissolved in a simplification of stains from which Kandinsky creates harmonic combinations. The color 'gives to the painting strong deep emotions revealing an internal world, for this the choice of the color cannot be casual as it is too the choice of the figure. They are expressions of a "inside need" and then, making the correct combination, he succeeds indeed in communicating with the human soul. As if, wanting to transmit to the observer excites deep, you are enough to draw a blue circle.




Couple on the horse - Yellow, red and blue - Color studie,2- Succession 1935

Gaudì

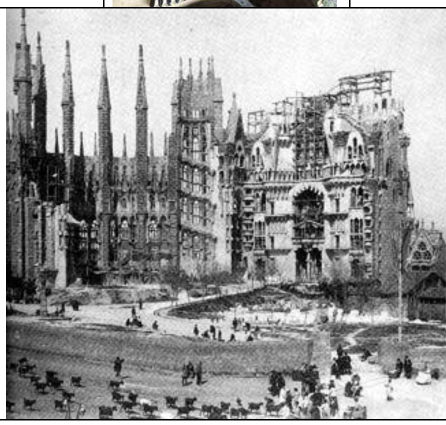
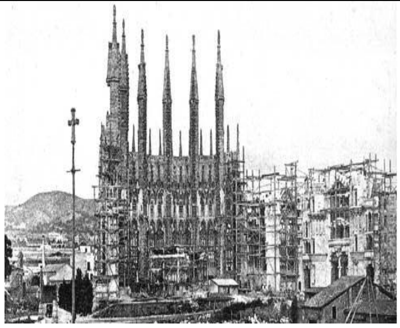
La ciudad està en mi cosmo un poema
Que no he lo grado detener en palabras..
…yo sento la fatiga del espejro
que no descansa en una imagen sola
J. L. Borges, Vanilocuencia

As a child and throughout his life, Gaudi suffered from arthritis. Because of this, Gaudi had difficulty keeping his attendance up at school. Instead, he spent much of his time walking and observing animals, plants and forms in nature. Later, Gaudi attended the Escola Pia in Reus. Here, he achieved very good grades in geometry, poetry and Greek. Also, his religious nature probably came from his school.
Gaudí's oeuvre is considered to be the finest exemplar of Catalan Modernisme: a cultural movement roughly dated between 1896-1911 that embraced more ornate and decorate forms of design. It is characterized by the predominance of the curve over the straight line, by rich decoration and detail, by the frequent use of vegetal and other organic motifs, the taste for asymmetry, a refined aestheticism, and the dynamic shapes. Interestingly, Gaudí believed that differences in architecture were caused more by culture, society, politics and religion than aesthetics per se.Gaudí was also deeply fascinated by nature, creatively capturing both environmental and human forms within his designs. In his own words ..."*Originality consists of returning to the origin. Thus, originality means returning, through one's resources, to the simplicity of the early solutions*." And again ...*"Everything comes from the great book of nature*."Gaudí was also an innovator par excellence, incorporating ground-breaking ventilation systems within his designs a good thirty years before they gained mainstream acceptance. Further buttressing his nature-loving credentials, Gaudí was even an early precursor to the recent wave of eco-architects—using and reusing local materials wherever possible. On 7 June of 1926 he was run over by a streetcar. Hismiserable aspect deceived the rescuers, which thought of him a vagabond poor man and they transported him to the hospital of the Saint Cross, a hospice for the mendicant founded by the rich bourgeoises of the Catalogna. He was recognized only the following day by the chaplain of the Sagrada Familia, but Gaudì firmly asked not to be brought away from the hospital for staying with his poor friends He died on June 10. Despite this almost miserable end, to his funeral participated thousand of people. The Barcellonesis nicknamed him from that moment "God's architect". He is buried in the crypt of the Sagrada Familia.

The chimneys to Palau Güell





Casa Batlò –
Sagrada Familia in 1889 and in 1907 The "Templo Expiatorio de la Sagrada Familia" (Expiatory Temple of the Holy Family) was the idea of a bookseller, Josep María Bocabella, literate and devoted man who in 1866 founded the Asociación Espiritual de Devotos de San José (Spiritual Association of Devotees of St. Joseph), whose objective was to achieve, through the protection of St. Joseph, the triumph of the Catholic Church in a time in which the phenomenon of dechristianization was impulsed by the Industrial Revolution and the accompanying social changes.

Rimsky Korsakov

His own words:

about the first sifony``In one way or another, towards May 1862, the first movement, the Scherzo, and the Finale of the symphony had been composed and somehow orchestrated by me. The Finale in particular won general approval at the time. My attempts to write an Adagio met with no success, and it was useless to hope for any: in those days one was somehow ashamed to write a cantabile melody; the fear of dropping into the commonplace precluded any kind of sincerity. ...I succeeded in composing the Andante while we lay at anchor in England, and sent the score to Balakirev by mail. I wrote it without a piano (we had none); perhaps once or twice I managed to play the entire composition at a restaurant on shore.''
About "Bird's song in snow Maiden"``Some songlets of birds were borrowed for the dance of the birds... One of the motives of Spring (in the Prologue and Act IV) is the altogether accurately reproduced song of a bullfinch which had lived rather long in our cage; only that our dear little bullfinch sang it in F-sharp major, while I took it a tone lower for the convenience of the violin harmonics.''
About Mussorgsk's unfinished music``If Moussorgsky's compositions are destined to live unfaded for fifty years after their author's death (when all his works will became the property of any and every publisher), such an archeologically accurate edition will always be possible, as the manuscripts went to the Public Library on leaving me. For the present, though, there was need of an edition for performances, for practical artistic purposes, for making his colossal talent known, and not for the mere studying of his personality and artistic sins

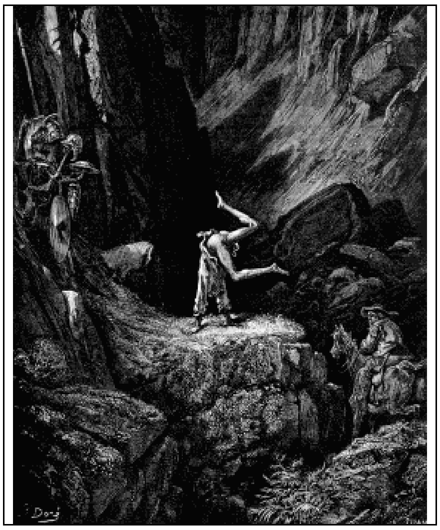
5. Walking & Jumping, back from the dead

"Sunt, o fortissime, quorum forma
semel mota est et in hoc renovamine mansit;
sunt, qiubus in plures lus est transige figuras,
ut complexi terram maris incola, Proteu.
Ovidio, Metamorphosis; 728-731

Endosymbiosis

UCLA molecular biologist James A. Lake reports important new insights about prokaryotes and the evolution of life. This work is a major advance in our understanding of how a group of organisms came to be that learned to harness the sun and then effected the greatest environmental change the Earth has ever seen, in this case with beneficial results.
Endosymbiosis refers to a cell living within another cell. If the cells live together long enough, they will exchange genes; they merge but often keep their own cell membranes and sometimes their own genomes.
"Higher life would not have happened without this event," Lake said. "These are very important organisms. At the time these two early prokaryotes were evolving, there was no oxygen in the Earth's atmosphere. Humans could not live. No oxygen-breathing organisms could live.
"We have a flow of genes from two different organisms, clostridia and actinobacteria, together," he said. "Because the group into which they are flowing has two membranes, we hypothesize that that was an endosymbiosis that resulted in a double membrane. It looks as if a single-membrane organism has engulfed another. The genomes are telling us that the double-membrane prokaryotes combine sets of genes from the two different organisms."
For this study, Lake has looked back more than 2.5 billion years. He conducted an analysis of the genomics of the five groups of prokaryotes

Lake is interested in learning how every organism is related.
"We all are interested in our ancestors," he said. "A friend at UC Berkeley, Alan Wilson, was the first person to collect DNA from large numbers of people around the world. He showed that we are all related to a woman who lived in Africa 200,000 years ago. Some in the media called her Eve. He called her the Lucky Mother, the mother of us all.
We have no voices of ancestors. We have not yet news about our ancestral mother tongue, for identify a morphogenesis process of our species. May be we discover a way of hearing the voices of stones. But this is not only a technology, it is too the poetical voice of the wild nature translated in Art. Lovely from men crossing generations.



Don Chisciotte by G. Dorè

In the new reality of walking and jumping process of genetic laboratories, are the jumping of Don Chischiotte yet able of performing a while space of impressions memories, generating dreams in our minds? Just like a contemporary Ulisse, can Don Chisciotte yet catalyze our research toward infinite? May be, but in my simple opinion, it is necessary to abandon the rich certainty of the exactness for the visionary measure of *grosso modo/singolari modo*, as a great useful tool for imagination**.**

A popular sentence in art: *All that glisters is not gold"*

The phrase "All that glisters is not gold" comes from Shakespeare's The Merchant of Venice, Act II, Scene VII.
In a sub-plot of the play, Portia's dead father has decreed in his will that she is to marry whichever of her suitors correctly picks one of three caskets that contain her portrait. The choices are gold, silver and lead caskets. The Prince of Morocco chooses gold, and when the casket is unlocked finds not her portrait, but a picture of Death with this message in its hollow eye:
"All that glisters is not gold;
Often have you heard that told.
Many a man his life hath sold
But my outside to behold.
Gilded tombs do worms enfold."
The phrase (also written as "All that glitters is not gold") means that a shiny, attractive bauble is not necessarily valuable.
"Glisters" was also used by Thomas Gray more than 100 years after Shakespeare. He refers to the death of a favorite cat which was drowned in a goldfish bowl.
"Not all that tempts your wand'ring eyes
And heedless hearts, is lawful prize;

Nor all that glisters, gold."

Figurative & abstract of Death

Transformed in ash,
Ash of dead are wherever,
In the room, in the garden;
On the lake, on the sea,
Under a tree of forest:
For a frame.
On the tomb of Dickens in London,
On the tomb of Raffaello in Rome,
On the tomb of Pope Giovanni Paolo II in the Vatican,
A while longer, people put a flower, for love.

Crypt of Capuchin Monks

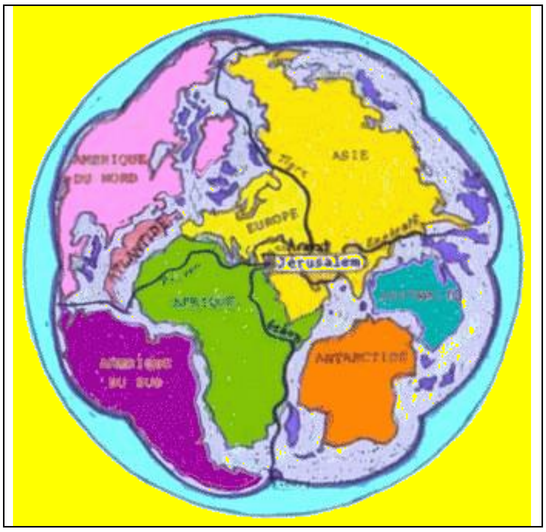
Santa Maria della Concezione dei Cappuccini, or Nostra Signora della Concezione dei Cappuccini, is a church in Rome at via Veneto, 27, built by the pope Urbano VII. The main interest is the crypt decorated by the bones of perhaps 4000 Capuchin monks, collected from 1528 until 1870 from the old capuchin cemetery. The crypt is divided in 5 small chapels where are some mummies with the typical dresses of Capuchin monks.
On the entrance it is written:
" We were what you are, and what we are you will be"
This choice of decorating the crypt with bones should seem macabre, but in reality it is a way of exorcizing death and of remarking that body is only a container of soul and for this reason once she leaved from the container, this is possible to use in another way:

Bologna, The church of Corpus Domini, St. Caterina body

Caterina, (Bologna, 08- 09 -1413/ 09 – 03 – 1463) studied music and painting, and poetry, also in Latin. She composed texts of formation and devotion, and then a story in Latin of the Passion 5.000 verses, a bilingual breviary. People said that she had apparitions and revelations, and around her started to form continuously a climate miracle. But also staying with the feet for earth, the gift it is extraordinary: to turn the penitence into joy, the obedience in choice. There is in her an ability of enormous belief. She guarantees that the perfection is for everybody: of course to whoever desires it indeed.
Already in her life people called her holy. And this voice spreads more and more after its death, among a lot of people that have seen never her, and they know only her from the stories of her prodigies in life and in death. To four months from the death, it is said in a relationship of the epoch, during an exhumation, on her face the natural colors.reappeared for a short time. Saint from immediately for everybody, therefore, even if the canonization will happen only in 1712, with Clemente XI. Her body is not buried. It is still found situated above a seat as that of alive person, in a cell close at the church that has called today still in Bologna "of the holy Caterina."

A new ***bio*** machine for cremation

Lost land for *evohumanity*


Fernand Crombette, His Geographical MAP, The lost land, before Noè

Fernand Crombette lets think about a researcher of another epoch. Autodidactic, solitary researcher, confined between his study and the libraries, not working that for the posterity, without care to make to be known and to recognize, early, studying without truce, he seems to want him to entirely hide behind his work. Wanting to stay unknown, it signed his works: "a French Catholic". That beautiful lesson of humility!

References

Stefan Zweig, "*Tre Maestri Balzac, Dickens, Dostojvskij"; Sperlig & Kupferl*;Milano,1945.
Bruno H. Burg, "*Nel giardino di Dio"*, *Bompiani*;Milano, 1943.
Publio Ovidio Nasone,*"Metamorfosi", Einaudi;*Torino, 1979.
Jorge Luis Borges, *"Carme presunto"*, *Einaudi;*Torino, 1969.
Fedor Tjutcev,*"Poesie"*, *Einaudi;*Torino, 1964.
Iosif Brodskij*, "Lettera ad Orazio" in Dolore e ragione; Adelphi, Milano,1998.*
Ernst Junger,"*Foglie e pietre"; Adelphi,*Milano *1997.*
W.H.*Auden,"The Voice of the Poet"*; *Audio book by Random House*, Canada.
Sir Harry Johnston, Alan H. Burgohne, Perceval Landon, J. Thomson, "*Le meraviglie del mondo",Soc. edi. Libraria, Milano 1914*
V. Kandisky," *Dello sprituale nell'arte: L'effetto del colore" - Tutti gli scritti vol.2 ed.Feltrinelli* Milano*1973*
Camille Bourniquel, "*Chopin", EPM, Milano,1960*
http://digilander.libero.it/crombette
www.generativeart.com
www.generativism.com

The Impure And Unpredictable Lines Of Flight

James Swinson

Central Saint Martins College of Art and Design

University of the Art London UK

j.swinson@csm.arts.ac.uk

Abstract

In all processes: scientific, creative or social; change and insight emerges from dissidence, flaws or mistakes. These anomalies are generated in the virtual, the present where past and future eternally meet offering the potential for creative lines of flight.

The technologies that emerged in the second industrial revolution underpinned the machine aesthetics of the historic avant-garde movements of early 20th century. Any illusion that this phase of technological and artistic advance would automatically lead to mass emancipation was crushed by Stalinism and the destructive force of the Nazi war machine.

Mass culture and production attracted authoritarian notions of order and conformity that chimed with intellectual frameworks obsessed with fixed and timeless structures, typological thinking, purity and certainty. As Primo Levy eloquently argued change emerges from the impure and unpredictable, a notion that is anathema to all repressive, authoritarian, regimes. While Manuel DeLanda contrasts the rigid Euclidian mechanics of assembly line production with the adaptive, organic, biological processes of tissue generation.

In the aftermath of WW2 like a phoenix rising from the ashes, dynamic generative code placed an emphasis on process over structure with the potential to re-define disciplines and social fields. Alan Turing's universal machine, anticipating the infinitely adaptable, programmable computer, emerged from the convergence of mathematical problem solving, wartime code breaking, and speculations on the human mind. Watson and Crick's double helix as the configuration for the production of life was derived from photographic interpretation and tinkering with Heath Robinson-like models.

Paradigm shifts in mathematics and molecular biology were matched by the insights of artists coming to terms with the de-locating force of machine warfare and mass production driven consumerism. Avant-garde filmmakers and writers challenged the fixed codes of mainstream narrative literature and action cinema. Andy Warhol's silkscreens and films messed with the repetitive codes of mechanical reproduction and Gerhard Richter manipulated the 'virtual smudge' of the photographic event.

1 Primo Levy – In Praise of Impurity

Primo Levy's *Periodic Table* brings together his passion for chemistry and his personal tales of defiance in the face of Fascism and anti-Semitism. The Periodic Table originally charted the basic elements from which the known world was composed. The paradigm shift in atomic physics at the turn of the 19th century introduced a new level of mutability and dynamism into the table, extending its members through fission, fusion and radioactive decay. Levy's own Jewish community in the Piedmont region of Italy were a product of migration and only partial integration into Italian society over five centuries reflected in their distinctive argot, a hybrid of Hebrew and Piedmontese. He designates his community to the relatively immutable element of Argon, 'a so called inert gas'. Although not materially inert having to strive to earn a living he describes his Piedmont community as spiritually inert:

their deeds…having in common a touch of the static, an attitude of dignified abstention, or voluntary (or accepted) relegation to the margins of the great river of life. *[1]*

The relative stability of this community was to be shattered by the rise of Fascism. Firstly, by the introduction of anti-Semitic laws by Mussolini's government in 1938 and then more profoundly by the German invasion of northern Italy in 1943. Before joining the partisans and his eventually capture and deportation to Auschwitz, he completed his chemistry degree in Turin. The University laboratory is the site of his encounter with elemental zinc providing an allegory of purity and impurity intertwining questions of race and chemical reactions. His failure to get pure zinc to react with sulphuric acid raises two conflicting philosophical conclusions:

the praise of purity, which protects like a coat of mail; the praise of impurity, which gives rise to changes, in other words to life. *[2]*

He discards the first proposition associating it with the authoritarian and "disgustingly moralistic" propositions of fascism, which promotes uniformity and crushes dissent and diversity. Levy embraces impurity, the grain of mustard that leads to desire and the emergence of the new.

So take the solution of copper sulphate which is in the shelf of reagents, add a drop of it to your sulphuric acid, and you'll see the reaction begin: the zinc wakes up, it is covered with a white fur of hydrogen bubbles, and there we are the enchantment has taken place. *[3]*

Having left his experiment to cook, Levy wanders off around the lab to see what's new and what his colleagues are doing. He encounters Rita and for that moment realises that the zinc provides a fragile but negotiable bridge between them.

2 Alan Turing – A life Incompleted

Primo Levy's insights flowed from his move to contaminate literature with chemistry. The English mathematician Alan Turing was also driven to transverse disciplinary boundaries. As a schoolboy in an English boarding school Turing encountered a system that could certainly be described as 'disgustingly moralistic' in its intolerance of difference. Turing found a close friend, Christopher Morcom who shared his many intellectual interests, only to be deprived of his companionship by his early death a year before he went up to Cambridge. Turing operated outside of the approved curriculum familiarising himself with the great paradigm shifts in modern science, Darwin's theories of evolution, Einstein's theory of relativity and the emerging quantum theory. Despite his inability to conform to the strictures of his early education he succeeded in gaining a scholarship to study Mathematics at Kings College Cambridge.

At Cambridge in the 1930s Turing gained the reputation of an eccentric loner probably accentuated by his homosexuality. He engaged with the question posed by Hilbert of the provability of mathematics and Gödel's response, whose incompleteness theorem offered proof that mathematics was neither consistent nor complete. Turing's contribution to these arguments was set in motion by a leading Cambridge mathematician, Newman who speculated on the possibility of a mechanical process being applied to mathematical statement designed to come up with an answer to its provability. Turing imagined a machine like a typewriter, that is a machine that could generate symbols that could be adapted to this task. The machine would be automatic, hence able to work without human intervention on a mathematical statement, writing its way towards a conclusion about its provability. This line of enquiry lead Turing towards a computational machine he called the *universal machine*, which could be designed to read description numbers from a tape decode them into tables and execute them. In his search he found an unsolvable mathematical problem contrary to Hilbert's assertion.

There was more to what he had done than a mathematical trick or logical ingenuity. He had created something new – the idea of his machines. [4]

The idea of the Turing machine as a model was based on thinking through what people did in the physical world –offering a bridge, a connection between abstract symbols and the physical worlds.

It was not an exact science, in the sense of making observations and predictions. All he had done was set up a new model, a new framework. It was a play of imagination like that of Einstein or von Neumann, doubting the axioms rather than measuring the effects. [5]

Turing's imaginings included a comparison between the computational potential of machines and the human brain. These theoretical speculations were put to practical use when Turing was recruited to the team at Bletchley Park at the outbreak of WW2 to work on deciphering the complex codes generated by the German Enigma machines. The building of large computational machines at Bletchley designed to process numbers on an enormous scale, had stretched the available technology to the limits. These machines were dedicated to a particular task and the Universal Machine Turing had in mind would be adaptable to a number of tasks anticipating the programmable computer. This still turned on his original notion that two parallel ideas were in play one the mechanical processing and the other the instructional note.

In the aftermath of the war Turing dedicated his time to experimenting with early prototypes of the computer such as the ACE. But privately he was not allowed to enjoy peacetime, when his homosexuality put him on the wrong side of the law. Turing had broken the moral code by failing to be apologetic about his sexuality and maintain an appropriate level of secrecy about his liaisons. Homosexuality was illegal in the UK in the 1950s and his honesty nearly landed him in jail. To avoid a custodial sentence he agreed to chemical castration, which consisted of regular oestrogen injection to quell his libido. His intellectual achievements and contribution to the war effort did nothing to temper the harassment to which he was subjected leading to his suicide in 1954; a similar and controversial fate to that suffered by Primo Levy in 1987. Turing whose intellect and imagination had enabled him to be a major contributor to the development of the digital age was victimised by a legal system that outlawed him as indecent and impure. His creative line of flight was crushed by a moral panic that saw homosexual men as potential traitors.

3 Watson and Crick – Breaking the Code of Life

Alongside the early development of digital code to which Turing was contributing before his death, a major leap in understanding genetic code was taking place. The process of research that lead to James D. Watson and Francis Crick's elucidation of the structure of DNA in 1953 destroys the myths of the rational and sophisticated process of scientific discovery. From the start their collaboration cut across disciplines, Watson originally studied Zoology and Crick came from a Physics background. Despite the fact that Nucleic Acids had been known for some time it wasn't until 1952 that Hershey and Chase conducted their experiments on the T2 phage virus that conclusively confirmed DNA as the genetic material.

At the time, biochemists that focused their work on DNA had little or no interest in genetics and conversely few geneticists were interested in biochemistry. Watson and Cricks' first insight was to realise that the determination of the structure of DNA was crucial to understanding the coding of genetic inheritance. Their second insight was to gather already existing data from a number of sources.

Watson and Crick's method towards determining the structure of DNA was the interpretation of X-ray crystallographic photographs and their translation of their data into three-dimensional models. The account of the trial and error process of their research leading to the double-helix structure is reminiscent of studio based art practice.

To our annoyance, there seemed every reason to believe that the phosphodiester bonds, which bound together the successive nucleotides in the DNA, might exist in a variety of shapes. At least with our level of chemical intuition, there was unlikely to be any single conformation much prettier than the rest.

After tea however a shape began to emerge which brought back our spirits….admittedly a few of our atomic contacts were too close for comfort, but, after all the fiddling had just begun. [6}

Considerable controversy surrounded Watson and Cricks' reliance on the expertise of Maurice Wilkins and Rosalind Franklin crystallographers in the Biophysics Unit at King's College London to produce the images that confirmed the structure. Wilkins did eventually share the Nobel Prize but Franklin who had almost certainly produced the decisive images, lost out on the recognition having died of cancer in 1958. For many the question remains, in cracking the code of DNA did they also break a code of ethics, did ambition provide their line of flight?

Elucidation of the structure of DNA established the field of molecular biology providing an understanding of the processes that drive evolutionary change and the ability of organisms to adapt to changing environments. DeLanda has pointed out the contrast between the dynamism and flexibility of biological assemblage and the rigid inadaptable structures produced by assembly line production; two forms of reproduction one aiming at conformity and repetition the other at generating difference.

4 Warhol – Embracing the mistakes

There has been much speculation by critics and biographers on the influences on the emergence of Andy Warhol as a key figure in American Pop Art in the early 1960's. The cultural cross infection at the time between London and New York is well established and undoubtedly Warhol would have been aware of the work of the London-based Independent Group and their appropriation of the alluring images of American consumer products, largely unavailable in the gloomy and impoverished post-war cities of Europe. Lawrence Alloway a member of the group is credited with first coining the term Pop Art. The irony that Pop Art as a product of consumer culture first surfaced outside America, would not have been lost on Warhol. It is one of the paradoxes of Warhol's practice that he injected irony into a culture where irony is largely absent.

Central to Warhol's appropriation of mass culture is an engagement with the technologies integral to the post war culture of consumption: print, photography, film and audio. His strategy in the Factory was to set in motion creative production that paralleled the industrial production and marketing of the new consumer goods. The purchase of a Model T Ford or a refrigerator guaranteed a new level of consistency, reliability and uniformity of product at a budget price.

Warhol frequently expressed his admiration of brand consistency in apparently throwaway comments such as, what's so great about Coca Cola is that it doesn't matter whether you are a bum in the gutter or the US president you can only buy the same Coke. What at first appears a celebration of democracy could equally be taken as an ironic echo of the US cold war view of the grey conformity of a Stalinist State in Eastern Europe. Elsewhere Warhol had also more directly identified with the machine age claiming:

I think everybody should be a machine
I think everybody should like everybody [7]

He alluded to the methods of the assembly line based on the principles of Henry Ford and Taylor's scientific management but his deployment of mechanical means of production was aimed at maximising accidents and flaws in the production process, which led to the most valued and retained outcomes. Gerald Malanga, Warhol's silkscreen assistant and collaborator recalls:

Sometimes, when making a painting we'd go off register when making a painting and there'd be a flaw. Andy accepted all that. I think it can all be boiled down to one statement "Embracing the mistakes" – accepting that which occurs spontaneously………The flaws were part of the art. It was as if he possessed an almost Zen-like sensibility. *[8]*

The silkscreen printing process in an industrial context is aimed at perfect reproduction but Warhol 1960's silkscreen work is dominated by miss-registered images, over- or under-inked layers, moire interference patterns and poor reproduction of images re-scaled from the newspapers. These added textures not only create new meaning they highlight the mechanism of change through a break in the chain of perfect reproduction, a break in the code of repetition highlighting difference and multiplicity, through the 'flaws' sullying the surface. Warhol's appropriation of images was influenced by Marcel Duchamp's notion of the modified readymade or found object. He adds a twist to this using the term 'leftovers' to describe the raw materials of his practice, adding the connotation of the impure, discarded or waste product of an urban, industrialised society from which his ideas take flight.

I am not saying that popular taste is bad so that what's left-over from bad taste is good: I'm saying that what's left over is probably bad, but if you can take it and make it good or at least interesting, then you're not wasting as much as you would otherwise. *[9]*

The prints of the early 1960's included not only the reworked images of everyday mass consumption such as the Campbell's soup tins and coca cola cans but also the images of death and disaster from suicide, car crashes to the electric chair. Death as a part of everyday reality clipped from the newspapers offers a content that is determined by chance and accident. The falling body in Suicide (1962), the suspended moment before death captured by the camera retains a paradoxically eternal sense of the virtual intensified by Warhol's enlarged silkscreen copy of the printed image in a newspaper, thus twice removed from the original photograph. In the series of car crashes the sudden arrested momentum of the car on impact and the destruction of its occupants as the frozen aftermath of the event still delivers a strong sense of chance and temporality captured in the fragile surface of the hit and miss reproduction of the twice printed image. The unpredictable timing and circumstance of death encapsulates the indeterminacy of life.

In 1963 the success of his printmaking allowed Warhol to diversify into film. His approach was deceptively naïve in filmmaking terms with the expressed intention of making paintings that move. He made use of a basic 16mm electric Bolex camera capable of approximately 3 minutes of continuous shooting and deploying a minimal set up of lighting and a fixed camera position. The postproduction on his early films was equally minimal, the editing process involving a simple non-selective process of assemblage with a near 1:1 shooting ratio.

One of Warhol's earliest films Sleep *(1963), was an attempt to make an eight hour film of a man asleep, eschewing any cinematic compression of time in delivering the average, conventional duration of a night's sleep. His performer for the film was the poet John Giorna who allowed Warhol to enter his flat and shoot roll after roll of film while he slept. He was equipped with a camera only capable of shooting a100 feet of film at a time. The final print fell short of the original intention with a running time of 5 and a half hours, this length only achieved by slow motion and the repeated use of the same footage. The finished film utilises these limitations coming close to Warhol's intention to produce a painting that moves, simulating a 'real time' aesthetic that prefigured the video camera and electronic surveillance. A similar treatment was given to a portrait of the Empire State building in* Empire *(1964), which through the use of a more sophisticated camera shooting 1.200 foot rolls had a running time of eight hours. The minimalism and repetitive structure of these films emphasised the audience as a dramatic and spontaneous element in their often restless and noisy responses to the film. In this way Warhol provided an ironic reversal of mainstream cinema, avoiding its predictable narrative structure and performance consumed by a passive and mesmerised audience.*

Michel Foucault recognised in Warhol's prints a sublime stupidity in the repetition of images. His comments seem even more appropriate to his films:

But in concentration on this boundless monotony, we find the sudden illumination of multiplicity itself – with nothing at its centre, at its highest point, or beyond it – a flickering of light that travels even faster than the eyes and successively lights up the moving labels and the snapshots that refer to each other to eternity, without ever saying anything: suddenly, arising from the background of the old inertia of equivalences, the striped form of the event tears through the darkness, and the eternal phantasm informs that soup can that singular and depthless face. *[10]*

Visitors to the Factory had routinely been photographed in a simple booth lit by a single photoflood lamp. This basic set up was subsequently used to film over 400 people in an archive of film portraits, which became known as Screen Tests. *Some of these portraits were compiled into several films including:* 13 Most Beautiful Boys, 12 Most Beautiful Women and 50 Fantastics [i] *When projected in an auditorium the close up of the subjects' faces are enormous. Every tic and twitch of the subject trying to stare without moving or blinking at the camera is amplified into a major event in the minimal 'real-time' framework of the piece. Tears gathering on the lower eyelids in the harsh lighting become as dramatic as any sequence from a mainstream action movie as they finally tumble down the face. These involuntary filmic 'accidents' and 'flaws' engender an intense experience of temporality and the virtual. They also follow the creative logic of change in the flaws generated in Warhol's silkscreen prints.*

Warhol's in his obsessive assemblage of Factory 'stars' in the early 1960's openly embraced the deviant and bohemian culture of lower Manhattan from drag queens to junkies, the human leftovers from which the imagination can take flight. The films, performances and photographs, parodied the Hollywood star system and complimented his silkscreen images of mainstream celebrities such as Elvis, Marilyn Munroe, Liz Taylor and Jackie Kennedy all subjected to the same improvised, and error-prone process as his car crashes and soup cans. This drive to subvert the codes of consumer culture while apparently appearing to celebrate and propagate them connects with Warhol's embrace of impurity and open transgression of the moral codes of the time, prefiguring the dynamic cultural shifts and celebration of difference that characterised the late 60's, after a decade of change in attitudes to empire, race, class, sexuality and gender. Ironically the success of his creative practice by the late 1960's had turned Warhol into a global celebrity and his creative production lost much of its subversive edge of improvisation and accident as he rubbed shoulders with the stars he once parodied from a distance. Yet a surprising departure shown in Documenta 7 in 1982 was a series of abstract pieces titled Oxidation Paintings. *These copper-surfaced panels were corroded by drips and splashes of urine, which could very well stand as homage to Primo Levy's chemically inspired and subversive embrace of the productive forces of impurity.*

5 Gerhard Richter and the Virtual Smudge

Richter trained as an artist in the GDR in the 1950's at the Kunstakademie in Dresden where the dominant style of painting was Social Realism. He crossed the border to West Germany in 1961 to study at the Kunstakademie in Dusselldorf. .

Exposure to the complexities of contemporary art practices in the West created a crisis for Richter's own practice as a painter. Richter's response was to turn to photography as a source of images for his paintings, like many Pop artists in the US and the UK, but his deployment of photography was not directly concerned with the icons of consumerism but was driven by a more directly philosophical conundrum. justifying the use of a potentially redundant image making technology; in 1960 the future of painting seemed at best uncertain or at worse doomed. Richter was also caught in an ideological impasse between the poles of the cold war the authoritarian communist state and market driven consumer culture.

For Richter the photographic image had achieved a state of pictorial perfection and a credibility that painting lacked because it was able to see 'objectively' it tells 'the absolute truth'.

Photography altered ways of seeing and thinking. Photographs were regarded as true, paintings as artificial. The painted picture was no longer credible; its representation froze into immobility, because it was not authentic but invented. *[11]*

Richter has amassed a large archive of photographic images compiled into a book titled Atlas*. Some of the images are found or acquired; the artist has taken most. Atlas has been exhibited in galleries around the world independent of the paintings for which they are the source material. [12]*

The translation of the photographic image into a painting by Richter is not an attempt to faithfully copy the image as in Photorealist painting. His strategy is to use the photographic image to create a painting that stands as a distinct autonomous object.
The techniques he employs suppress the fine detail of the photo and usually its specificity but retain its generic quality: a family portrait, a landscape, an aircraft etc.
The subject of the photograph is affectively de-located. When the subject is a portrait, identification and subjective qualities are suppressed by the translation into paint. In his early paintings Richter sometimes used photos of celebrities such as Jackie Kennedy *(1962) and* Queen Elizabeth *(1967) but these portraits tell you little 'about' the subject.*

In a portrait painted by me, the likeness to the model is apparent, unintentional and also entirely useless. *[13]*

His painterly process suppresses any feeling of inner life or as Richter puts it 'Soul', retaining only the superficial surface appearance of the subject.

Appearance, semblance is the theme of my life. All that is, seems and is visible to us because we perceive it by the reflected light of semblance. Nothing else is visible. *[14]*

The process emptying the image from obvious meanings such as points of potential emotional or ideological identifications paradoxically opens up the image to multiple interpretations throwing the struggle for significance back onto the spectator.

Pictures which are interpretable, and which contain a meaning are bad pictures. A picture presents itself as the Unmanageable, the Illogical, the Meaningless. It demonstrates the endless multiplicity of aspects; it takes away our certainty because it deprives a thing of its meaning and its name. *[15]*

Deleuze has argued that the delocating experience of war torn European cities in the wake of WW2 created the condition for the avant-garde strategies in the cinema and the emergence of the time image where time could be experienced directly through the image. These strategies in the work of filmmakers such as Alan Resnais and Margarite Duras re-coded the relationship between sound and image calling into question subjective memory tied to a specific individual through conventional flashback sequences. Thus challenging the audience to find their own meanings in the film.

Richter's manipulation of the painted surface deploys a smeared or blurring effect or a softening of focus that suppresses detail. This is achieved by dragging a dry brush or rag across the surface of the image. This fulfils the function for Richter of levelling the significance of elements of the image placing an emphasis on the quotidian and ordinariness.

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I blur things to make everything equally important and unimportant. I blur things so that they do not look artistic or craftsmanlike but technological, smooth and perfect. *[16]*

In doing so Richter also emulates and amplifies in paint key characteristics of the technology of photography: the blurring of the moving object or moving camera travelling faster than the shutter speed, optical focus and depth of field inscribing time and space into the photographic image, angle of vision and framing providing a distinctive photographic composition in contrast with the pictorial painterly composition that pre-dates the emergence of photography. These technological gestures are gestures of potential, suggesting movement and change, a spark of hope, a virtual smudge from which the imagination can take flight. They work against Richter's declared intention to hover in an un-shifting state of uncertainty; rather they offer the spectator a potential line of flight, the possibility to use their imagination to *create meaning and perhaps generate a gesture of impurity breaking the autonomous coding of the painting.*

6 Impure Conclusion

Primo Levy's embrace of impurity and change was a powerful stand against authoritarianism and prejudice. But in the chemistry he created between art and science in his writing, he also affirmed the creative potential of the cross contamination of ideas from one discipline to another.

References

[1-3] Primo Levy *The Periodic Table* London Penguin 1984

[4-5] Andrew Hodges *Alan Turing: The Enigma* London Burnett Books 1983

[6] James D. Watson *The Double Helix* London Penguin 1968

[7] Andy Warhol interviewed in *Pop Art Redefined* John Russell and Suzi Gablik Thames and Hudson 1969

[8] Gerald Malanga *Archiving Warhol* Creation Books 2002

[9] Andy Warhol *From A to Z and back again – the philosophy of Andy Warhol* Picador 1975

[10] Michel Foucault *language counter-memory, practice* Cornell University 1977

[11, 13-16] Gerhard Richter *The Daily Practice of Painting Wriitngs and Interviews* 1962-93 London Thames and Hudson

[12] Gerhard Richter *Atlas of photographs collages and sketches* London Thames and Hudson 1997

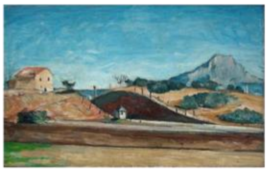
Cezanne and the Mount Sainte-Victoire: A neuroesthetic approach

Courchia Jean Paul, MD
Saint Joseph's Hospital, Dpt of Ophthalmology. Marseille. France
e-mail : courchia@numericable.fr

Guigui Sarah, B.A
Ben Gurion Univ. of the Negev, Medical school for internat Health Israel.
Righini Maud, MD
Saint Joseph's Hospital, Dpt of Ophthalmology. Marseille. France
Courchia Benjamin, B.A
Ben Gurion Univ. of the Negev, Medical school for internat Health Israel
Dr Cwilich Gabriel, Ph.D
Yeshiva University Faculty. New York. USA
Kaminetzky Elliot
Yeshiva University. New York. NY USA
Bomstein-Erb Erwan
Canal Educatif à la Demande. Paris. France
Fabre Come
Canal Educatif à la Demande. Paris.

Is there a Cezanne's theory?

Cézanne dies in 1906 after making one last attempt at capturing the beauty of the Sainte-Victoire. He said about the subject of his last painting, *Le jardinier Vallier* (1906): "If I succeed in drawing this guy, it means the theory is true." What theory was he referring to? In an attempt to answer this question, four of his works are studied: *La tranchée* (Munich), *La Montagne Sainte-Victoire au Grand pin* (London), *La Montagne Sainte-Victoire* (Paris), and *La Montagne Sainte-Victoire from the Lauves* (Basel).



La tranchée

La MSV au grand pin

La MSV

La MSV vue des Lauves

1. Cezanne and the mount Sainte Victoire:

The mountain with an altogether geographical, emotional, educational, and symbolic value will ultimately become the laboratory of Cubism. Cézanne said: “Observe and learn how to see and treat nature as if it were composed of basic shapes such as cylinders, spheres, and cones.”

2. Analysis of the paintings: loosing the visual strategy, mixing the colours, a taste of unfinished.

The regular visual strategy in front of a painting would be to search for an anchor point. However, in these four paintings, such anchor points cannot be found. We are lost in the Basel’s painting; there only the shape and the color stimulate the eyes. In the London and Paris paintings, Cézanne uses a personal process. He puts down colors where they should not be (green and ocher in the sky), hatched brushstrokes to represent pine needles that are not even connected to the branches. Cézanne also shows a pronounced taste for the unfinished. In the Basel’s work, the painting doesn’t fully cover the white canvas.

2.1 What does Cezanne want?

Cézanne is a link between various artistic movements: Impressionism, Cubism, Fauvism, perhaps Expressionism, and certainly Abstract Art. The art of painting changes at that time for two reasons: the advent of photography (1839), and the invention of the tube paint (1840) -- artists leave their studio and paint outside. Pissarro told Cezanne: "The eye must absorb everything…do not follow rules and principles, but paint what you see and feel, and do not be inhibited by nature.” From then on (1879), he became himself. “Cézanne interprets what he sees: Cezanne exceeds Impressionism. His vision is more focused on his brain than his eyes”. Cézanne’s hatched lines are in opposition to the pointillism of Seurat. He starts with his painting a “conversation” with the visitor’s brain.

2.2 Conversation with the brain:

These colored lines stimulate the brain (Hubel-Wiesel, Nobel Prize in Physiology 1981). Brain cells respond not to points of light, but to angles, to contrast rather than brightness and to borders rather than curves. Cézanne offers a true deconstruction to the brain. He takes advantage of the fact that our visual system is sensitive to edges. The visitor’s brain is the painter’s partner; the brain will complete the eye’s work.

2.3 The process of vision:

Cézanne is interested in the first visual step -- the image is focused and decomposed. The retina encodes the basic features of the scene (shape and color) and sends them to the visual cortex. A few milliseconds later, this information becomes a form in our visual brain (top-down processing).

3. Cézanne, “Father of Modern Art”:

Cézanne said he tried to “copy nature but failed.” This is probably because, instead of merely copying reality, he revealed the psychological process that creates it. This innovative theory would be followed by many of Cézanne’s successors (Braque, Picasso, Leger, Gris and Mondrian).
Cézanne showed us what we are unable to see; that is to say: how we see. After all, doesn’t "painting mean to think with the brush?”

ARTPLANKTOS, THE TRAVELING NET-ART PROJECT

Konstantina (Dida) Papalexandrou
Artist, didapapalexandrou@hotmail.com

"***As you set out for Ithaca***
hope your journey is long,
full of adventure, full of
discovery…"

K. Kavafis

Inspired by Sherry Levine's statement that "a painting's meaning lies not in its origin but in its destination", Artplanktos' project was created to explore the artwork's search for a new meaning via the search for a destination. Artplanktos is an ongoing travelling net-art, fully autonomous as it transforms through its journey.

The word "artplanktos" comes from the word "art" and the Greek word "plankton". The latter is derived from the ancient Greek "plagtos" which means "the wanderer," the "one that travels around". Artplanktos consists of 27 artworks created on paper that include small relief dots used in Braille. The repetition of these dots, and the empty spaces around them, creates a unique canvas which helps the artist to overcome the primary artistic rules of form and composition. As conceptual art has suggested, these traditional artistic rules are not compulsory or even necessary to support a work of art. Other characteristics are required which can be derived from self-defined and autonomous systems.

Each Artplanktos artwork begins its lonely journey from different starting points (e.g. Greece, Italy, France, Belgium, Germany, Serbia, England, Russia, Spain, Portugal, US, etc.). The artwork is left "out in the streets" waiting for someone to pick it up. On the reverse of each artwork, written instructions in 27 languages explain the concept of the project. The instructions refer to the artwork's essence; it is not a lost piece of art but rather a traveler, asking for help in order to continue its journey. The founders can take it with them and keep it as long as they want, but it is very important to let it go when they wish, to allow it to continue its journey.

It is also crucial for the project that the traveling procedure is monitored. For this reason a supporting site exists where the founder responds to particular questions that form the artwork's CV. Every time there is an input, the artwork is taking something from the participant, who is now becoming a co-creator.

Every little trip reforms the artwork's journey. Each journey is unique and continuous. Every artwork's CV is enriched with the journey's information. This information restates the artwork and transforms it from the "it" to the "he" and/or "she" state; thus establishing a new identity. Finally, the artwork emerges as a unique, independent and self-managed unity which is defined by human designated characteristics.

The developmental stages of the project lasted 4 years and were monitored step by step because they were considered to be very important. The first Artplanktos artwork started its journey in 2007. Computer technology was not only used as a tool for the construction of the project but was also a vital part of it, as it supports its existence.

So far, Artplanktos has traveled in three continents and the journey continues…

Cityscope – The Concept of an Urban Kaleidoscope

Prof. Dipl.-Ing. Marco Hemmerling MA
Detmolder Schule für Architektur und Innenarchitektur
Hochschule Ostwestfalen-Lippe, University of Applied Sciences
Emilienstrasse 45, D-32756 Detmold, Germany
www.hs-owl.de/fb1
e-mail: marco.hemmerling@hs-owl.de

Abstract

The paper discusses the relation of movement and space against the background of human perception. Next to a theoretical approach the experimental installation Cityscope tries to explore the phenomenon of spatial perception within an urban context. Methods of reflection, distortion and fragmentation alter the usual visual experience of the beholder and generate a reinforced perception of the spatial object and its surroundings. The effects of perception were tested in a digital mock-up first using 3D-Modeling and Visualisation-Software. The final shape of the installation was then generated from the point of view and movement of the beholder in relation to the specific context. Using CAD-CAM technology the digital model data was transmitted to the production process in order to ensure the congruency between the digital model and the final installation.

Introduction

Visual experiences are gained in the dimensions of our physical world. The abilities, that are acquired in that context form – beside the genetically determined visual experience – the phenomenon of spatial perception. Spatial perception as one of the basic achievements for orientation can be differentiated into two principles of perception:

- The perception of the position of objects in space (height, width, depth, distance of the object to the point of view)
- The perception of movement (change of the position of an object or the point of view in time)

The perception of movement and space is obviously linked to each other and implies the interaction of human being and space or spatial objects. The space changes in relation to the point of view and the position of the beholder and generates diverse perceptions. The relation of both - subject and object - as described in the following quotation formed the basis for the experimental installation Cityscope, that tries to explore the limits of perception by reinforcing the relation of beholder and space using illusionary elements of alienation:

"Perception will no longer reside in the relation between a subject and an object, but rather in the movement serving as the limit of that relation, in the period associated with the subject and object. Perception will confront its own limit; it will be in the midst of things, throughout its own proximity, as the presence of one haecceity in another, the prehension of one by the other or the passage from one to the other." (Deleuze, Guattari, A Thousand Plateaus, p. 282)

Case study - Cityscope

Staring point for the concept of Cityscope was the kaleidoscope (from grecian.: kalo = beautiful, eidos = form, skopeo = I see). The instrument was already known to ancient Greek and reinvented by Sir David Brewster in 1816, while conducting experiments on light polarization. It's visual performance is based on a tube of symmetric organized mirrors, that reflect small coloured objects.

Next to the inspiration of the kaleidoscope as an instrument to extend perception, Bruno Tauts Glass Pavilion for the "Deutscher Werkbund" Exhibition in Cologne from 1914 served as an inspiration for Cityscope. The prismatic glass dome, which was commissioned from the association of the German glass industry, was a colourful landmark with reflective glass plates in between the concrete beams of the structure. Bruno Taut himself described the appearance of his Glass Pavilion as follows:

"...reflections of light whose colours began at the base with a dark blue and rose up through moss green and golden yellow to culminate at the top in a luminous pale yellow." (Richards, New Glass Architecture, p. 16)

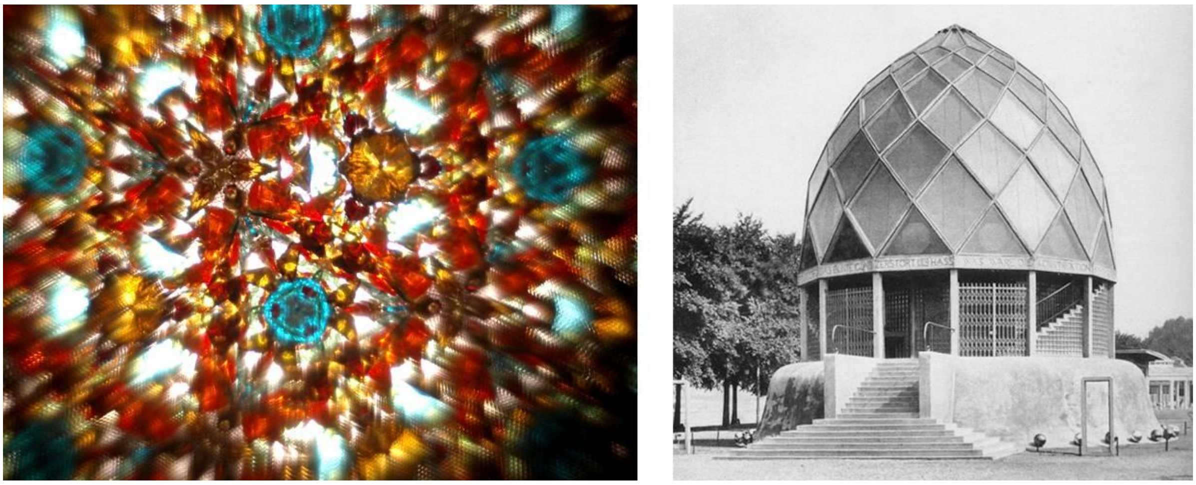


Figure 1: Interior View of a Kaleidoscope (left) and Glass Pavilion by Bruno Taut at the "Deutscher Werkbund" Exhibition in Cologne, 1914 (right).

The spatial installation Cityscope deals with the fragmented perception of urban spaces. The bevelling structure can be seen as an urban kaleidoscope, which reflects fragmented views on the city and composes at the same time a three-dimensional image of the surrounding facades. While moving around the sculpture the images, which reflect on the triangulated envelope, continuously change. In that way the beholder becomes an integral part of the installation and its complex reflections. Like in a kaleidoscope, the scattered fragments are guided to harmonious whole.

A sophisticated perception of urbanity is often limited to the ground floor level. Cityscope tries to open the perspective by concentrating different and unusual views of the urban surroundings. The crystal-like installation is positioned in front of the main station in Cologne, a highly frequented urban square, which allows different angles of vision and supports at the same time the interaction of the beholder with the installation.

The radiant foil, that is applied to the outer skin of the sculpture reflects, dependent on the daylight situation and the point of view of the beholder, the light in different colours. The colour-transformation generates an intentional alienation, which reinforces the idea of a fragmented perception. Through the movement around the installation the dichroitic colours of the foil change continuously.

Like the facades of a city, the specular envelope becomes transparent in the night, when the installation is illuminated from the inside. The appearance changes in another transformation-process into complementary colours and the inside of the installation can be experienced. The light installation was programmed with different sequences in order to support a dynamic perception of the sculpture by night.

Design Process

Cityscope was designed using parametric Software in order to create relational connections within the bevelling surfaces. While changing the position of the sculpture in relation to the surrounding facades the triangulated shape transforms continuously. Next to the parametric 3D-Model for the generation of the shape, visualization software was used to display the visual reflections in relation to the position of the beholder.

Figure 2: Concept image (left) and Digital Design Model within the urban context (right).

While moving around the sculpture - using a virtual camera - the dependency of the surroundings to the angle of inclination of the triangles became visible. Working with this technique the aim to capture different fragments of the city in to several adjacent surfaces could finally be reached. As a consequence the final shape of the sculpture is very much related to the site and reacts to the heights and proportions of its surroundings (station, church, dome...).

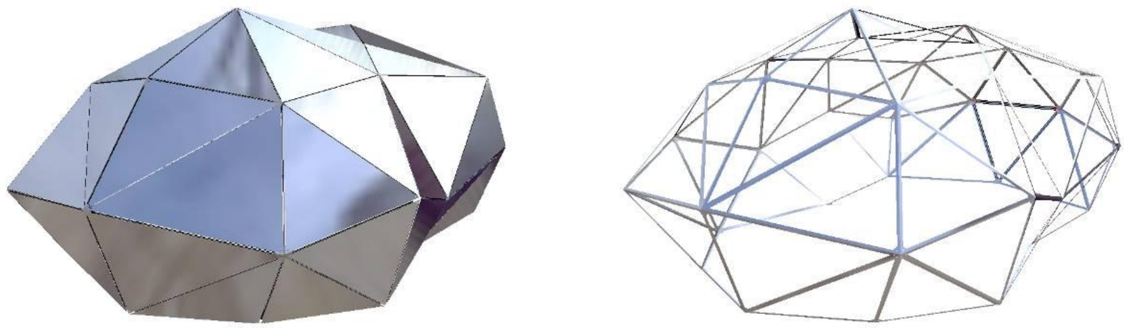


Figure 3: 3D-Model of the reflective skin (left) and framework of the installation (right).

Fabrication and Construction Process

After defining the shape of the outer skin the details for the construction and fixtures were developed. Based on an aluminium framework the acrylic glass panels were mounted with hidden fixtures on the knots where the bars meet. In that way every triangle was fixed in each the corner of the panel. Since all knots, bars and the synthetic panels where different in size and angle, CAD-CAM technology was the logic consequence for the production process of these elements. The material property and the thickness of all parts were transferred into the digital model resulting in a detailed construction model, which allowed it to minimize the joints between the different elements.

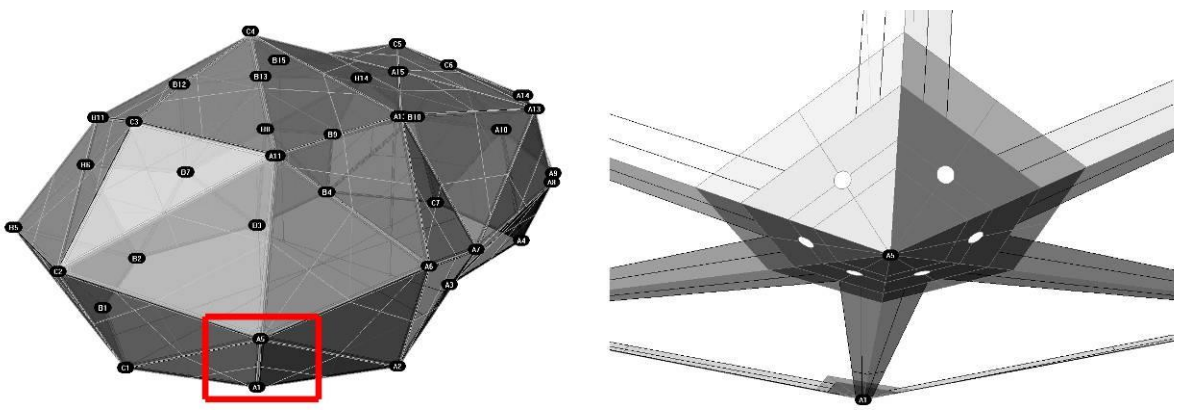


Figure 4: Digital model for CAD-CAM (left) and aluminium knot (right).

Another important aspect involved the assembly process. The structure had to be erected and dismounted in only a few hours, including the base-plate and the light installation. After testing various construction-principles for the knots the solution of a folded aluminium plate came up, that allows a fast and precise assembly and constitutes at the same time only a minimum of construction space. After including all the relevant information into the digital model the files were sent to the CNC-machines for the production of the different elements – both synthetic panels and aluminium parts (bars and knots).

Figure 5: Appearance of Cityscope by day (left) and reflection of the skin (right).

Conclusion

A digital design model, which relates to the perception of space through movement enables the designer to investigate the complexity of spatial perception in an extended way. In this respect the simulation of a time-based and beholder-related vision of space delivers a comprehensive design tool.

The approach to focus within the design process on the relation of space and movement involves two major aspects: The visual perception of space and the interaction between object (space) and subject (beholder). The installation Cityscope was meant to reinforce the visual perception of an urban space. Next to the amplification of perception by distorting and fragmenting the usual vision, the level of interaction between beholder and space increased significantly.

Outlook

Taking into account the visual perception of space in time results consequently into a more human-related design approach. Since human perception is based on manifold phenomenological experiences, the extension of the design approach to other levels of perception – like audition, olfaction or haptics – will be subject for future projects. The simulation of physical experiences with the help of virtual scenarios involves as well a critical attitude towards the significance and assignability of these methods.

Figure 6: Kaleidoscopic effect by night.

Acknowledgements

Cityscope was conducted with the support of Hans H. Löhr, Jens Böke and David Lemberski during the architectural festival plan08 in Cologne in September 2008. The installation could not have been realized without the support of Deutsche Bahn, Ebener Fassadentechnik, 3M, Bayer and Remagen Licht.

References

Deleuze, G., Guattari, F., A Thousand Plateaus, Capitalism and Schizophrenia (trans. Brian Massumi), University of Minnesota Press, 7th ed.., 1998

Giedion, S., Space, Time & Architecture, Havard University Press, 1967

Merlau-Ponty, M., Phenomenology of Perception, (trans. Colin Smith), Routledge & Kegan Paul Ltd.., London, 1962

Richards, B., New Glass Architecture, Yale University Press, 2006

Taut, B., Whyhe, I .B., Chrystal Chain Letters: Architetcural Fanatsies by Bruno Taut and His Circle, MIT Press, 1985

FROM PHYSICAL AND MENTAL OPERATIONS TO GENERATIVE PROCESSES

Marie-Pascale Corcuff
Architecte DPLG, Docteur en géographie
GRIEF
École Nationale Supérieure d'Architecture de Bretagne, Rennes, France
e-mail: m-p.c@wanadoo.fr

Abstract:
Architecture deals with matter, and, from the first attempts to make shelters to the most sophisticated techniques of our time, a number of physical operations and transformations are carried out in order to transform materials into forms able to accommodate human life.
Progressively, architecture has become a more intellectual activity implying mental, or conceptual, operations, in great part because the scale of buildings implied drawing a project before it was built. Without ignoring the necessities of construction, those operations and transformations have acquired their autonomy, have sometimes become a game, or an art, for itself.
These physical and mental operations resort mainly to topology and geometry, or one could say that they contributed to develop those sciences that constitute our essential knowledge on space and forms.
Generative processes differ from the other ways man has had to fabricate and even conceive forms : they work generally in the digital world (even if the forms obtained may be built), which differs from the physical world, and they function more like the ways nature itself makes forms (growth, recursivity, etc.). But generative processes that tend to generate forms use, as traditional ways man has had to make forms, topological and geometrical operations/transformations ; some processes (IFS) even allow us to define a form *only* by a set of geometrical transformations, which are iterated. That must lead us to question our understanding of space and forms.
This paper focuses on some topographical and geometrical operations, and their physical and conceptual manifestations in the history of architecture and more generally of man-made forms. It discusses their use in generative processes, illustrated through works by the author.

In his paper titled « Gencities and and visionary Worlds » [1], Celestino Soddu invited us to consider a pyramid as an example of an investigation on species, in order to explain the logical structure of creation. Pursuing this lead, we'll explore the physical and mental operations involved in making forms, and the generative approach to forms, through the same example of the pyramid.
This paper also attempts to make a link between different concerns, issues and experiments exposed in previous papers.

Making forms

To fulfill their various needs, human beings resort to forms as they encounter them, or transform matter to make forms. There are no pyramids (to my knowing) in the natural world of forms. Some shells are in the shape of cones, some stones may be in the shape of regular or semi-regular polyhedra, but we don't encounter pyramids as such.

The way in which we are able to make a pyramid depends first upon the type, or state, of matter we use. With some solid matter like stone we may, as Celestino Soddu suggests, « cut a series of pieces from a cube » (supposing that this matter presents itself initially as a cube) « through plain cuts », though that technique would better fit a semi-solid matter like clay. If a sculptor hasn't got a saw able to cut stone, he would rather cut chips out of a block of stone until he gets the rough shape of a pyramid

(having probably drawn some lines to guide its work), and then sand and polish it to get plane surfaces.
With clay or some other malleable matter, one can model a pyramid by pressing with his hands on the mass, and continuously transforming the shape of the volume of clay into a pyramid.
But one can also find a mould in the shape of a pyramid, pack the clay (or even better pour plaster, which will become solid) in it, and remove the mould to get a pyramid. It's the technique of the mud pie, and supposing some child has got a bucket in such a shape, and wet sand, he can mimic his own surroundings of Cairo on the beach.
A lot of solid forms that we use begin with a semi-solid, or even fluid, matter, easily transformed into the wanted shape, and then processed in order to become solid (or processed to become fluid, and then restored to its solid state) : adobe, mud, is easily modelled and then either cooked or let to dessicate in the sun ; glass, or metal, is heated up to fluidify it, modelled, and then returns to its solid state when cooled.
By the way many solid forms that constitute our geological environment have acquired their form in fluid or semi-fluid state. Mountains are generally the result of such deformations. Though mountains are not pyramids (as Benoît Mandelbrot is fond to say), the pyramid is nevertheless a common abstraction of such shapes.

The mould that can be used to make a pyramid introduces the issue of what we attempt in making a pyramid : a filled volume, or an hollow one ; the volume, or the surface (or pseudo-surface) of a pyramid. All techniques above stay in 3D : volumes are cut, or transformed ; but usually to make a mould, one takes and cuts some pseudo-surface (a metal sheet, for instance) and folds it.
Such a hollow pyramid can also be easily made by sticking four poles in the ground, linking them at the top, and putting cloth, or any other sheet on them.
Pyramids are not all filled, like those of the Pharaohs, which where not destined to living human beings and, for that reason, may be discussed as actually belonging to architecture. Louvre Pei's Pyramid is only the quasi-surface of a pyramid made of sheets of glass (and without a base, even). Living human beings need holed volumes to inhabit.

An important issue in considering how to build a pyramid is its size. Egyptians, even if they had the idea of making a pyramid by cutting a great stone or moulding clay, couldn't have built their huge pyramids that way, because of the size they wanted to give them. Architecture leads often to assemble small parts to do a big form. So the great pyramids were built by stacking stones (there is a theory that pretends that those « stones » were themselves moulded), which was a difficult task enough (but possible). The pyramid is the sublime abstraction of the heap.
A young French artist, Simon Boudvin [2], has explored the concept of the heap, especially remarking that any architecture is in a way a heap of matter, and that this matter has had to be taken somewhere, leaving a hole. One might also remember that general Napoléon Bonaparte (not yet just « Napoléon »), reflecting upon the Egyptian Pyramids, not only famously said : « Soldiers, from the top of those Pyramids, forty centuries are looking at you !» (or something like that), but estimated that the stones present in one of those Pyramids would be enough to build a wall all around the borders of France...

Thinking forms

Through making forms, man has discovered laws of space and forms, which are expressed in those branches of mathematics that are geometry and topology.

It is maybe extreme to say that geometry derives from human actions (some scientists or philosophers may disagree), but it is nevertheless an opinion that may be sustained. Artists, and especially architects, had to abstract his making of forms because of the size of the forms they intended to make, and also because of the necessity to explain their design to other people who would actually build it.
Representing forms has been an important step towards thinking forms, because it generally implies, at least, a scaling of forms, either by drawing them on a sheet of paper, or by making models : in both cases, those representations need be not too large to be handled. Drawings go further into abstraction, because they not only scale forms, but they imply projections, i. e., reducing from 3D to 2D, either by orthogonal and other parallel projections, or by perspective.
Geometry sees figures as sets of points, those points being linked by straight lines, those lines being again linked by straight planes. For example, geometry considers the pyramid essentially as a set of five points, the vertices of the pyramid : four points in a plane that are the vertices, or corners, of a

square, and a fifth vertex, which is the centre of the square, lifted up at some level. What we call « square » is indifferently its set of vertices, its perimeter or its interior, though those three instances are dimensionally distinct, because once you get the four points, there is no ambiguity about what you can do with them in the context of geometry. So geometry can say that the square is defined by its type of symmetry (four axes of symmetry, its bisectors and diagonals), and even that this type of symmetry leads only to the square ; or that the pyramid is defined by its type of symmetry (four planes of symmetry defined by those of the square), and even that this type of symmetry leads only to the pyramid.

There are many ways of exploring forms, of *thinking* forms, one of which is to wonder about folding patterns. Paper or cardboard is a good instance of pseudo-surface, and by cutting, folding, and pasting it, we can imagine abstract operations on surfaces. One can obtain a pyramid by drawing four equal (isosceles, or even equilateral) triangles linked to each other by their side, cutting the pattern, folding it in order to link and glue the two free sides, and by putting it on a plane surface :

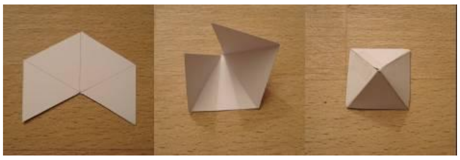


Fig. 1 Folding a pyramid (var. 1)

Or one can obtain a pyramid by drawing equal triangles on the sides of a square, folding and glueing the pattern accordingly :

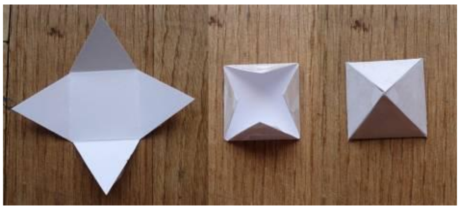


Fig. 2 Folding a pyramid (var. 2)

This operation, which links 2D (the surface symbolized by the paper) to 3D (the volume bounded by the surface), lets us think what could be a 4D-pyramid. Actually this is a very simple polytope : as a pyramid is constituted by a square and four triangles, a hyper-pyramid is constituted by a cube and six pyramids, one has only to imagine linking the 6 faces of a cube to a 9^{th} vertex (in the fourth dimension). A 3D projection of that is a cube with 6 adjacent pyramids inside ;other projections (or if the hyper-pyramid rotates in the fourth dimension) would show the 9^{th} vertex going our of the cube.

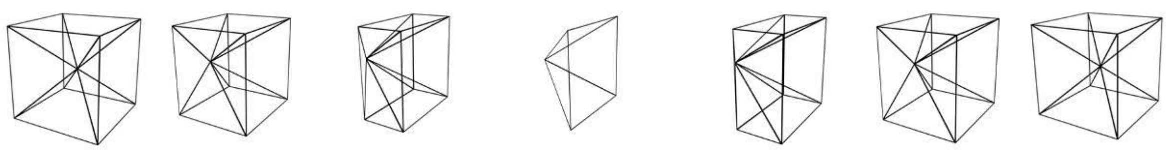


Fig. 3 Rotation in 4D-space of a 4D-pyramid

That reminds us that a cube may be built with 6 pyramids, each one with its height being half the side of its base :

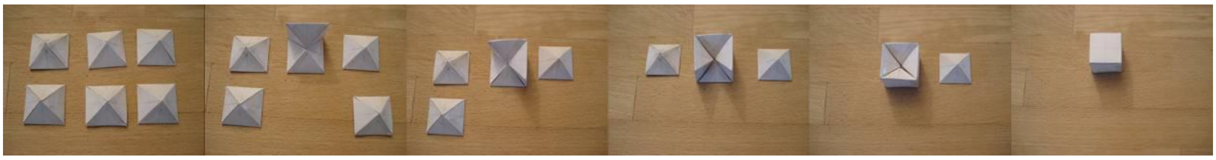


Fig. 4 Six pyramids filling a cube

But we can also put the pyramids outside a cube, rather than inside. We know that by surrounding a square with the four triangles that are defined by its diagonals, we get a square, the area of which is twice the area of the initial square. Sadly, and because the laws of 3D space are not the same than those of the plane, we don't get a cube by surrounding a cube with the pyramids defined by its diagonals. But we obtain an interesting polyhedron known as a rhombic dodecahedron (and its volume is twice the volume of the cube) :

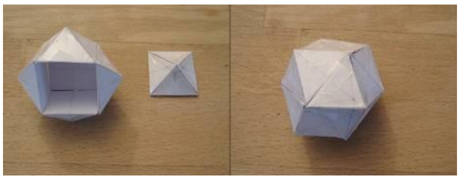


Fig. 5 Pyramids around a cube make a rhombic dodecahedron

Then one can wonder how to fill a pyramid with pyramids. A pyramid contains five pyramids half its size, but there remains four holes ; if the triangles of the pyramid are equilateral, those holes are regular tetrahedra :

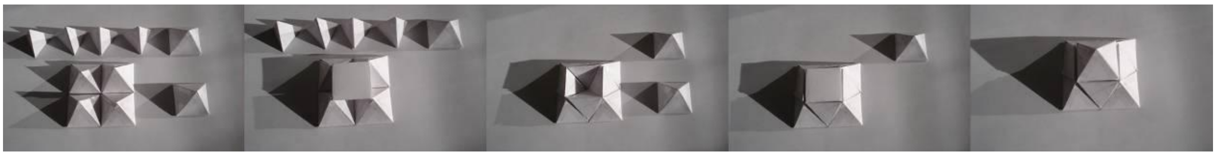


Fig. 5 Making a pyramid with 6 pyramids and 4 tetrahedra

This reminds us that a regular pyramid is half an octahedron :

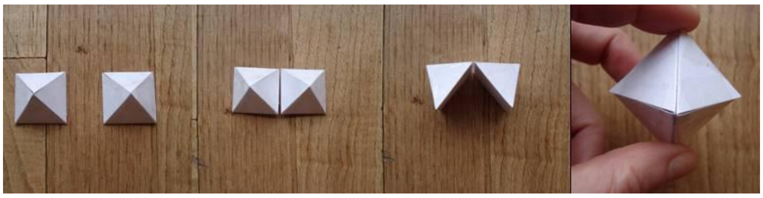


Fig. 6 Making an octahedron with two pyramids

To finish this exploration of folding paper, let's mention the art of origami. There are many ways to obtain a pyramid through origami, which let you get something like that :

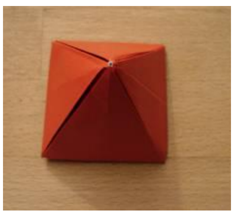


Fig.7 A pyramid in origami

Generating forms

Generating forms means considering forms in some different way, not by describing them by all their geometrical characteristics, but as the result of applying rules : there is a shift in the attitude of the designer, who doesn't (and doesn't want to) know exactly what he will obtain, though he has total freedom to elaborate rules of his choice.
That links generative art to how natural forms are made : no superior intelligence has decided the exact form of such or such mountain, or of such or such tree, or even of such or such animal. Natural forms are the (always provisional) result of processes, applying rules related to physical forces, and/or biological patterns. We can describe, analyse, and measure them at some given time, but they cannot be really understood without the fact that they develop themselves in time.

Physical and spatial laws

How can a pyramid appear « by itself », applying only physical laws ?
José Bico and colleagues of the research laboratory Physique et Mécanique des Milieux Hétérogènes (MPPH) at the Ecole Supérieure de Physique et de Chimie Industrielles de la Ville de Paris (ESCPI) have developed amazing experiments they call « capillary origami ». It consists in putting a water drop on a flexible sheet, previously cut along a pattern. Pictures and videos on his website [3] show how a tetrahedron or a cube appears miraculously only through laws of capillarity. No doubt that a pyramid could also be obtained this way.
A way to obtain a pyramid by applying only laws of gravity is to pour sand onto a square, permitting sand to freely fall from the edges. You may obtain a rough pyramid depending on the quality of the sand and the size of the square :

Fig. 8 A pyramid obtained by pouring sand on a square

The slope of the pyramidal heap depends on the sand (around 30°).
I developed the idea of distance maps in a previous paper [4], and linked it to sand heaps. A pyramid appears when the centres of the distance map form the perimeter of a square. The slope of the pyramid depends on the ratio you decide to affect to the level of grey in relation to the distance.

Fig. 9 Distance map of a square and its translation into a mesh

Cellular automata

Pyramids occur with 3D CA with the following rules : starting with one cell, a cell appears if it has neighbours on one of its sides or corners or just below (a 3D cell has 26 neighbours). That rule mimics one way of physically building a pyramid :

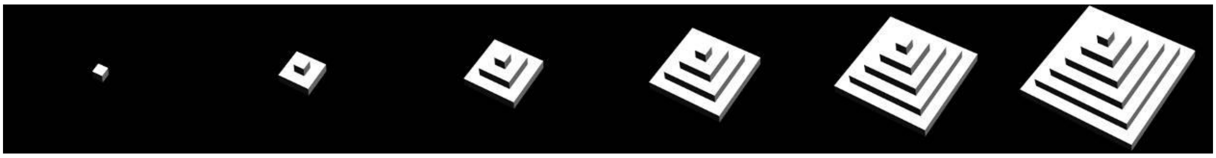


Fig. 10 A very simple 3D cellular automaton

When we work with 2D cellular automata (on orthogonal grids, with a neighbourhood of 8 neighbours, and rules concern the sum of neighbours (totalistic CA)) and when we display the results of the succeeding generations of the CA as layers, beginning with one cell, and going down, we also obtain pyramids. If we use only growing CA (no cell disappears), we can show the results by considering the « age » of each cell and translating that age either into a level of grey (from white for the oldest cells to black for the youngest) for each pixel in a bitmap (which is a kind of map) or into a height for each vertex of a mesh. Those are not true 3D forms, but only the surface of a 3D form. But it does not matter, as in a growing CA, no cell disappears, so there are no holes inside the 3D form obtained, and representing the surface of it is the same as trying to represent the whole form.
The CA that provides an actual, straight, pyramid is the most simple : no cell disappears, a cell appears if it has any number of neighbours (1 to 8)[1]. This CA shows growing squares, but with levels of grey, the picture is roughly the same as the previous distance map :

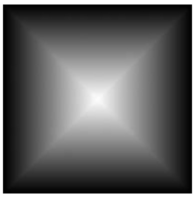


Fig. 11 Code 131071 cellular automaton (age of cell = level of grey)

With a mesh, we obtain a true pyramid :

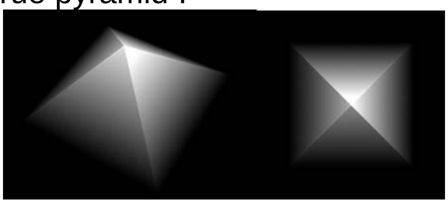


Fig. 12 Code 131071 cellular automaton (age of cell = height of mesh vertex)

Other rules yield more complex pyramids :

1 The decimal code of such cellular automata is obtained by writing the rules of the CA to form a binary number, then translating this number into a decimal number.

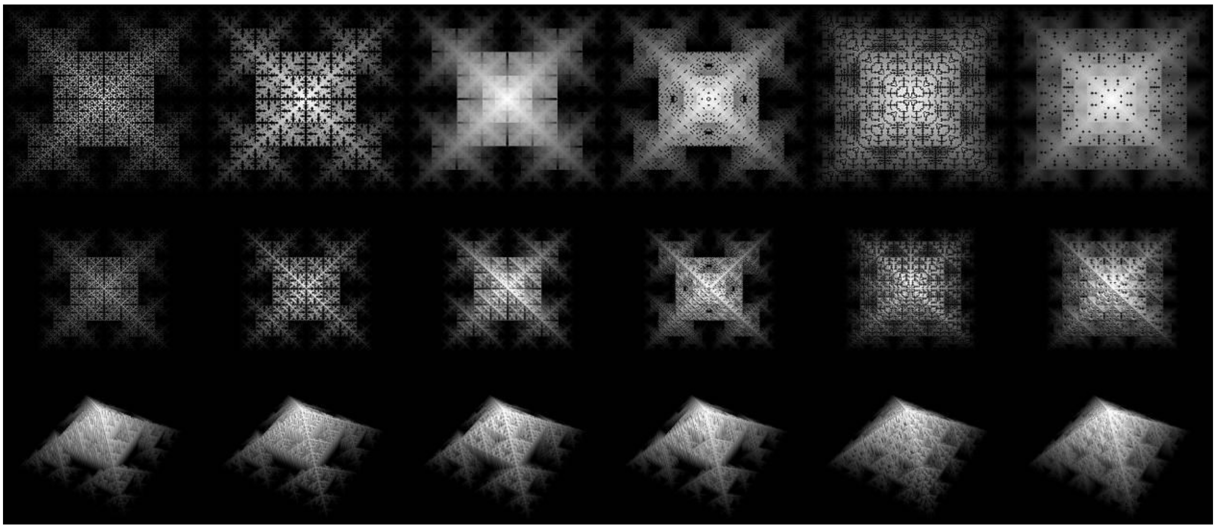


Fig. 13 Code 66047, 68095, 73727, 75775, 83967, 86015 cellular automata

Even with CA rules that are more complex than the one that yields the true pyramid, results show the same symmetries, as there is, first, the symmetry of the square in a 2D CA, and then the piling of generations and their regular growing that leads to a pyramidal configuration.

Fractals

Fractal geometry does not only let us generate forms that are not possible to make otherwise, but it makes us see forms in a different way. A cube is not only, as in traditional geometry, a figure with a particular set of symmetries but is the result, the *attractor*, of a particular set of contracting transformations (iteratively or recursively applied), and is (which is even more important) the only one. This set of transformation then characterizes better the cube than its set of symmetries. This way of seeing forms lets us recognize forms that are such attractors (they are self-similar) and forms that are not. In two dimensions, if we consider regular polygons, we can consider the equilateral triangle and the square as such attractors, but other regular polygons are not attractors of IFS. That has to do, obviously, with their capacity to tile that particular space. In 3D, only the cube (among regular polyhedra) both tiles the space and is the limit of an IFS.

This way of seeing forms induces us to look into forms to see how they are made with similar figures. When we deal with forms that are not self-similar, this generates incomplete, holed (and fractal) forms.

Looking into the pyramid (the one which is the half of an octahedron) we discovered that it can be partly filled with similar (half-size) pyramids but that there remained four holes : those holes are tetrahedra. There is a fractal form that is the result of an IFS constituted of 6 transformations, and that we can approach by iteratively (or recursively) applying this set :

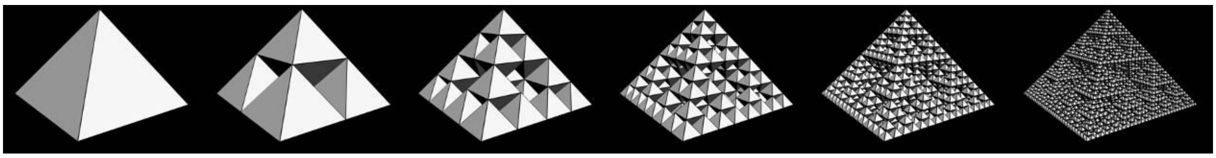


Fig. 14 Fractal based upon the filling of the pyramid with half-size pyramids

This construction is actually the half of the one based upon the octahedron.
We can also consider another IFS (pyr-1) constituted by 5 transformations which scale the form by ½, and translate the forms towards the corners of the whole form :

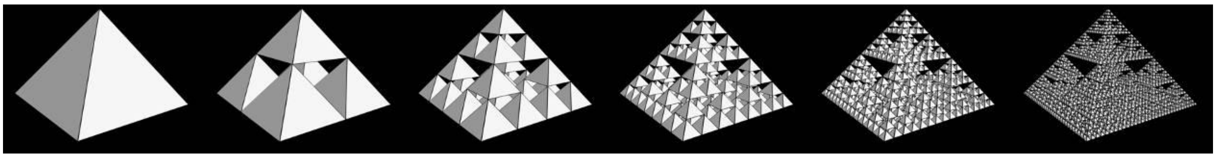


Fig. 15 Fractal based upon pyr-1 IFS

In a way similar to the one exposed in a previous paper [5], we can hybridize this IFS with another (pyr-2), defined by 5 transformations, with the same scaling, and which translates 4 forms towards the sides of the square base, and the 5th upon them, with a 45° rotation :

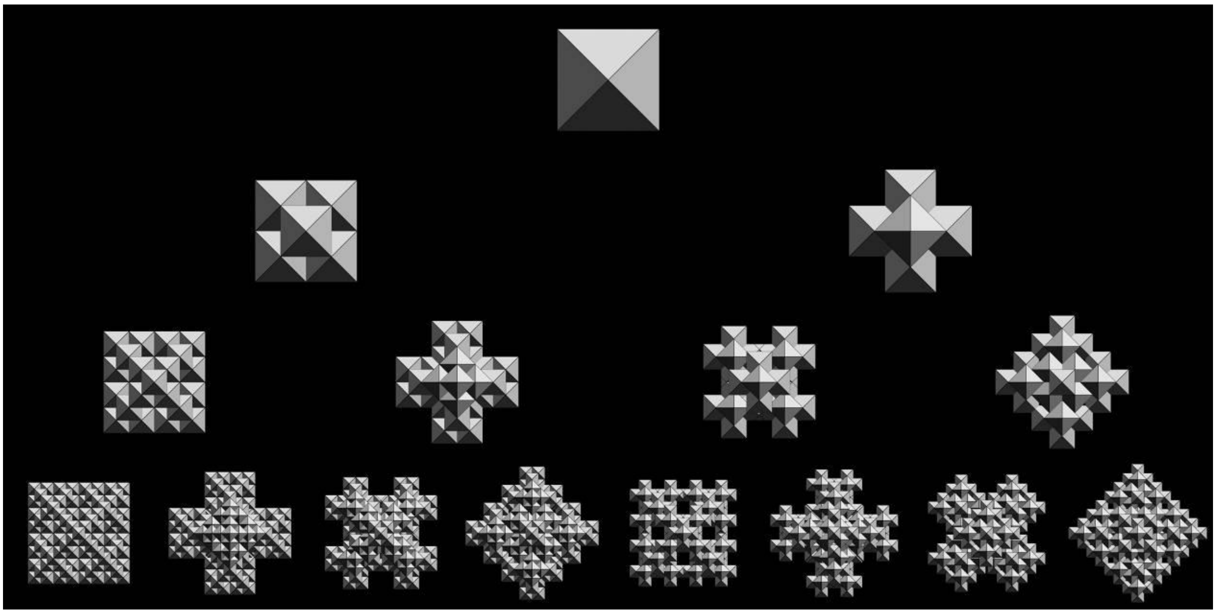


Fig. 16 Hybridization of pyr-1 and pyr-2 IFS (seen from above)

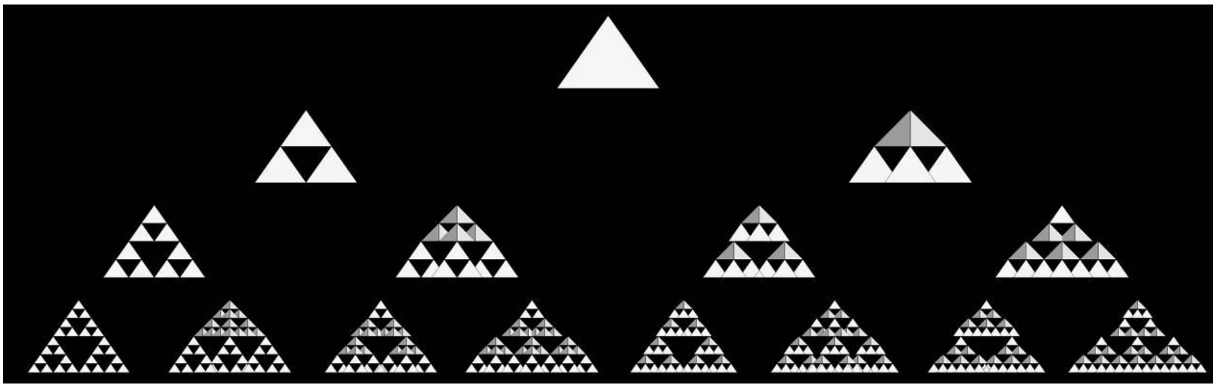


Fig. 17 Hybridization of pyr-1 and pyr-2 IFS (seen from forward)

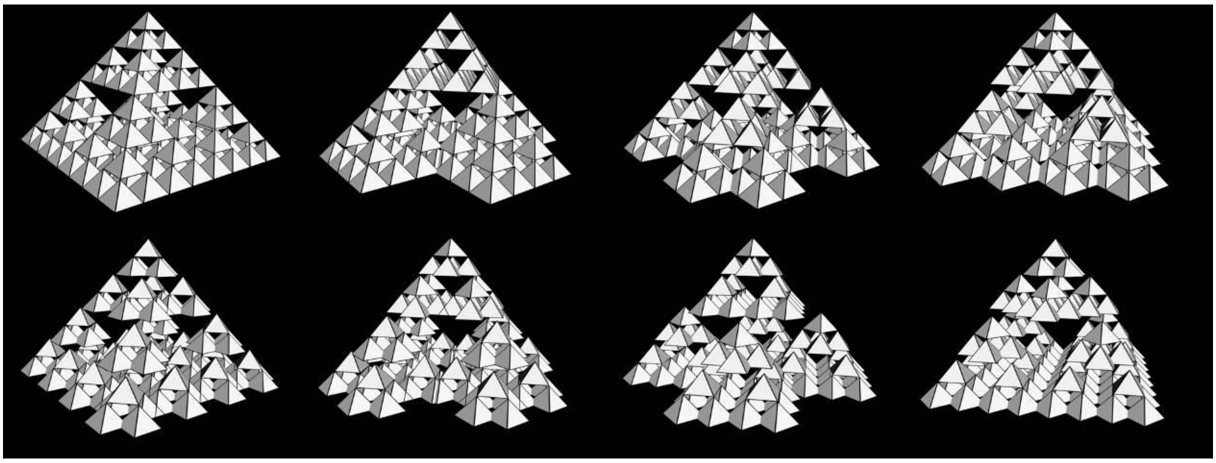


Fig. 18 Hybridization of pyr-1 and pyr-2 IFS (perspective)

A further step would be to find a way of playing with counter-forms as in 2D.

This little travel in the world of pyramids did not pretend to be exhaustive. Its only aim was to let us see pyramids in some different ways.

References

[1] Soddu, Celestino, « Gencities and visionary Worlds », in proceedings of the International Conference GA2005, Aleadesign Editor, 2005
[2] http://boudvin.free.fr/
[3] http://www.pmmh.espci.fr/~jbico/Research_fr.html
[4] Corcuff, Marie-Pascale, « Generativity and the Question of Space » in proceedings of the International Conference GA2005, Aleadesign Editor, 2005
[5] Corcuff, Marie-Pascale, « Chance and Generativity » in proceedings of the International Conference GA2008, Aleadesign Editor, 2008

Structural Synthesis using a Context Free Design Grammar Approach

Mikael Hvidtfeldt Christensen, MSc.
Aarhus, Denmark.
structuresynth.sf.net
e-mail: mikael@hvidtfeldts.net

Abstract

This paper introduces Structure Synth, a 3D structure generator based on design grammar specifications.
Noam Chomsky pioneered the use of formal grammars to describe the structure and syntax of language. These formal grammars were classified according to their expressive power. Of special importance here is the class of Context Free Grammars, originally believed to be powerful enough to model natural languages. While Chomsky's formal grammars describe structure in one-dimensional strings (symbolic sequences), Chris Coyne created the Context Free Design Grammar, an extension of the formal grammars modeling two-dimensional structures using a simple set of primitives (e.g. squares and circles).
Structure Synth is the natural extension of these ideas into three dimensions. The user specifies a grammar, and the program generates one of the many possible structures adhering to the syntax of the grammar. Compared to general-purpose programming, the restrictions of context-free systems encourage the user to discover and explore the systems. And even though the syntax limits the complexity of the rules, the resulting structures are often highly complex and nearly always unpredictable and surprising.

Introduction

Structure Synth is a software system for creating and exploring structures defined by a set of transformation rules. This paper describes the ideas behind Structure Synth together with an introduction to the methods it is inspired by.
The paper is organized as follows: First, formal grammars are introduced and it is discussed how they can be used for generating content. This is followed by a description of how Context Free Design Grammars can be used to generate two-dimensional graphical content.
The second part describes how Structure Synth extends these ideas into three dimensions. The purpose is not to give a complete reference to all aspects of the application, but to illustrate the syntax and provide examples of the different types of structure that can be generated.
The paper concludes with a discussion of why context-free grammars are interesting in relation to generative art, and presents some possible future directions for Structure Synth.

Formal Grammars

A formal language is a set of strings, where each string is a finite sequence of symbols. Formal languages can be specified in different ways: for languages with a finite number of strings, it would be possible to list all strings, but a more convenient way is to describe a formal language by a set of rules, which may generate the strings in the vocabulary. It is important to note that formal languages have no direct connection to the natural languages. Formal languages are mathematical, formalized concepts. They may be used when trying to describe or model the structure of natural languages, but bear in mind that the entities in a formal language (the strings and the symbols) may represent structure at many different levels. For instance, the strings in a formal language could represent words, sentences, or paragraphs of text in a natural language depending on the level of structure being modeled.

Noam Chomsky studied the structure of formal languages and created a hierarchy that classified the languages according to the generative power of their formal grammar [1]. A formal grammar is one way to describe or generate a formal language. A formal grammar is a set of rules (sometimes called production rules) which operates on two kinds of symbols: the terminal symbols, which are the symbols that the strings in the formal language are composed of, and the non-terminals, which are intermediate symbols used during the derivation. By applying the production rules to a start symbol in the formal grammar, all the possible strings in the formal language are created. For instance, consider the following toy-example for describing a small subset of the English language:

S → NP VP
VP → V NP
NP → DET N
DET → the | a | an | ...
N → dog | boy | cat | ....

Here the start symbol is a sentence (S), which is composed of a noun phrase (NP) and a verb phrase (VP). The verb phrase again consists of a verb (V) and a noun phrase, and the noun phrase consists of a determiner (DET) and a noun (N). These are the non-terminals of this toy grammar. Finally, there are a few production rules for substituting the noun and determiner with terminals, which here are actual English words. An example of a sentence analyzed (or constructed) using this grammar is shown in Figure 11.

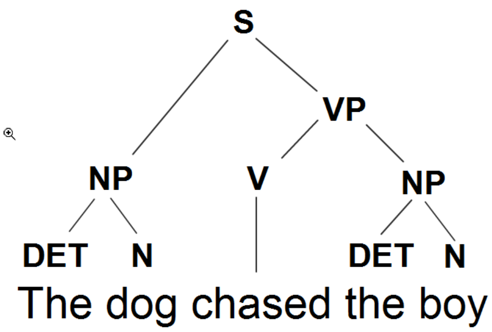


Figure 11: An example of using a formal grammar to describe the structure in an English sentence. Here the strings in the grammar correspond to complete sentences, and the terminal symbols are English words. The structure is shown in a hierarchical tree, corresponding to the production rules listed above.

The production rules above all share a specific simple form: they consist of a single symbol, which transforms into one or more new symbols. Thus, when deriving strings using the grammar, it is not necessary to take the context (the surrounding symbols) into account, which is referred to as a context-free transformation. It is also possible to construct production rules which are context-sensitive. For instance, a transformation rule of the form: $\alpha A\beta \rightarrow \alpha X\beta$ would imply that A could be substituted by X, but only if the A was surrounded by α and β. This is an example of a context-sensitive transformation.

The hierarchy Chomsky created for the formal grammars contains the following classes:

Type 0	All formal grammars. Here there are no restrictions on the production rules.
Type 1	Context-sensitive grammars. These are grammars that can be expressed using context-sensitive production rules, such as the one mentioned above: $\alpha A\beta \rightarrow \alpha X\beta$ where α and β are arbitrary symbols, and A is a non-terminal and X a non-empty symbol.
Type 2	Context-free grammars. Here the left side of the production rules consists of single non-terminal. This class of grammars has been used to study the structure of several natural languages [19]. In addition, the syntax of many computer languages (such as Java and C#) belongs to this class[2].
Type 3	Regular expressions. This class puts additional constraints on the right side of the production rule. It will not be discussed here, since it is not relevant for following discussion.

[2] The Backus-Naur notation [19], which is often used to describe the format of computer languages, is a notation for context-free grammars.

Formal grammars are often used to analyze and identify structure in linguistics and computer science. But instead of starting with a string in a formal language and tracing it back to the start symbol in the grammar, the reverse process is also possible. That is, given the production rules for a formal language, we can generate arbitrary strings in the vocabulary of that language. This is easy since we can just apply randomly chosen production rules to the start symbol until only terminal symbols are left. For instance, given a grammar as shown in Figure 11, we could generate syntactically correct English sentences.

SCIgen [2] is an example of a generator, which builds random computer science papers using a context-free grammar. Several examples exist where papers created by SCIgen have been accepted by editors that were not aware that the content was computer generated. The most notable example is a paper by SCIgen, which was accepted in the Elsevier journal ‘Applied Mathematics and Computation’ in 2007 (a placeholder page for the now removed article can be found at [3]).

Here is an example of its output:

> ....In our research, we use pseudorandom methodologies to show that the transistor and the transistor are regularly incompatible. On a similar note, we emphasize that PloySerfism manages compilers. Indeed, DHTs and voice-over-IP have a long history of interfering in this manner. However, model checking might not be the panacea that theorists expected.
>
> In this position paper we explore the following contributions in detail. For starters, we prove that gigabit switches can be made unstable, cooperative, and adaptive. We demonstrate not only that the infamous stable algorithm for the construction of randomized algorithms by Kobayashi et al. is in Co-NP, but that the same is true for massive multiplayer online role-playing games.
>
> We proceed as follows. We motivate the need for extreme programming. Second, we place our work in context with the prior work in this area. Ultimately, we conclude......

And here is a fragment of the hand-made context-free grammar SCIgen use:

> EVAL_ANALYZE_ONE → note the heavy tail on the CDF in EXP_FIG, exhibiting DIFFERENT EVAL_MEASUREMENT
>
> EVAL_ANALYZE_ONE → the many discontinuities in the graphs point to DIFFERENT EVAL_MEASUREMENT introduced with our hardware upgrades
>
> EVAL_ANALYZE_ONE → bugs in our system caused the unstable behavior throughout the experiments
>
> EVAL_ANALYZE_ONE → Gaussian electromagnetic disturbances in our EXP_WHERE caused unstable experimental results
>
> EVAL_ANALYZE_ONE → operator error alone cannot account for these results

Here the upper cased words are the non-terminals, which are to be substituted. This is only a small subset - the complete grammar contained approximately 3000 production rules. As is evident the grammar contains large contiguous fragments of text. Still the resulting output shows a great deal of variation.

Context Free Design Grammar

Formal grammars produce strings, that is, one-dimensional sequences of symbols. But for graphical content, we usually need two or three dimensions. One way to achieve this would be by interpreting the one-dimensional sequence as an encoding that produces a two- or three-dimensional result. For instance, each symbol in the sequence could be interpreted as an action such as 'move forward one unit', 'turn left 90 degrees', etc. This is the approach Lindenmayer systems [4] use to produce graphical output. However, Lindenmayer systems require two decoupled steps: the generation of a 1-dimensional sequence, and the subsequent transformation into a 2D or 3D illustration.

A more direct approach was suggested by Chris Coyne in his Context Free Design Grammar (CFDG) [5][3]. Similar to formal grammars a Context Free Design Grammar has production rules and non-

[3] Chris Coyne had previously experimented with using grammars for producing text. The SCIGen project mentioned in the

terminal and terminal symbols. The terminal symbols are now geometrical primitives - in Chris Coyne's original implementation circles and squares were used as the basic primitives.
The Context Free Design Grammar extends the syntax of the formal grammars by including transformation operators[4]. These transformation operators modify the current rendering state. Possible transformations include the rotation and scaling of the current coordinate system and modifications of the hue or saturation of the current drawing color. Notice that while rendering states have been introduced in the CFDG, the actual expansion of the non-terminal symbols is still context-free - it does not depend on the history or rendering state of the system. As is the case for formal grammars, one non-terminal symbol may have several different possible substitutions. The CFDG makes it possible to assign different weights to the different production rules for a given symbol.
The following is an example of a Context Free Design Grammar:

```
startshape SEED

rule SEED {
  SQUARE {}
  SEED { y 1.2 size 0.99 rotate 2.5 brightness 0.0015 }
}

rule SEED 0.04 {
  SQUARE {}
  SEED { y 1.2 s 0.9 r 1.5 flip 90 }
  SEED { y 1.2 x 1.2 s 0.8 r -60 }
  SEED { y 1.2 x -1.2 s 0.6 r 60  flip 90 }
}
```

Now by applying the transformation rules to the start rule, outputs such as the ones in Figure 12 can be created. These images were created using Context Free Art [6], an implementation of a Context Free Design Grammar created by Mark Lentczner and John Horigan.

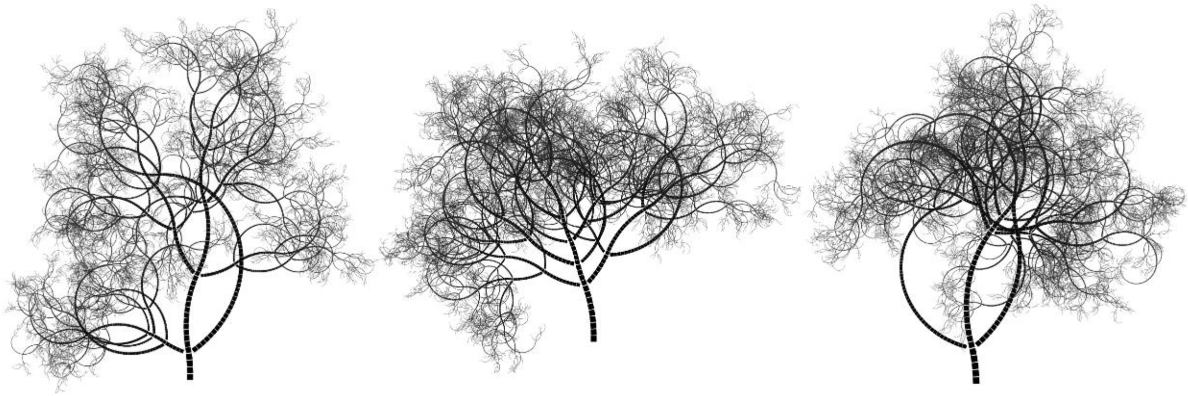


Figure 12: An example of a Context Free Art system. The three structures are instances of the same system, but with different random seeds.

Chomsky's formal languages consist of *finite* strings. In contrast, systems specified by a context-free design grammar often emit an infinite number of terminals. In practice, this is overcome by applying some kind of termination rule, such as stopping the production if the primitives become too small to be visible. Also, whereas the natural representation of a string in a formal language is a sequence of symbols, Context Free Design Grammars produce rule expansions which are naturally represented in abstract, hierarchical trees (a rule may spawn one or more rule calls, corresponding to new branches in these hierarchical trees).

previous section was inspired by a high school paper generator created by Chris Coyne.

[4] The Context Free Art developers use a different terminology - their *adjustment rules* correspond to the *transformation operators* in this paper.

Similar to Context Free Design Grammars, most Lindenmayer systems also grow potentially unlimited strings. Lindenmayer also introduced a notation for representing hierarchical trees in his Lindenmayer systems [4]. By interpreting brackets in the output as creating new branches, it becomes possible to create tree-like hierarchical structures. An output such as A[B][C] would be interpreted as A being the root of the tree with two branches, B and C[5]. Similar to Context Free Design Grammars, Lindenmayer also described the use of multiple production rules with different weights - something he referred to as Stochastic Lindenmayer systems. This means the Context Free Design Grammars are very close in expressive power to what Lindenmayer would have classified as a Stochastic Context-Free Bracketed L-system. CFDG systems offer a couple of advantages, though. The CFDG unites the substitution rules and the geometrical operators. This makes the representation slightly more intuitive and it makes it possible to implement more flexible termination rules. For instance, the rule expansion can be terminated, whenever the geometrical primitives become too small to be visible. A similar termination rule would be difficult to implement in a Lindenmayer system, since the rule expansion is separated from the geometric representation.

Structure Synth

Structure Synth extends Context Free Art into three dimensions. Its syntax is derived from the original Context Free Design Grammar but with a few key differences.

Termination criteria: In Context Free Art the recursion automatically terminates when the objects produced are too small to be visible. This is a very elegant solution, but it is not possible to extend to a dynamic 3D world, where the user can move and zoom with the camera. Instead, several options exist in Structure Synth for terminating the rendering, such as specifying a maximum recursion level, or a maximum number of objects, or setting a fixed minimum size.

Transformations and primitives: Since Structure Synth operates in three-dimensional space, a new set of transformations and primitives was necessary. The transformations include translations, flipping and rotations about the three Cartesian axes, and the new set of primitives include volumetric objects such as spheres, boxes and lower dimensional objects such as triangles, lines and dots.

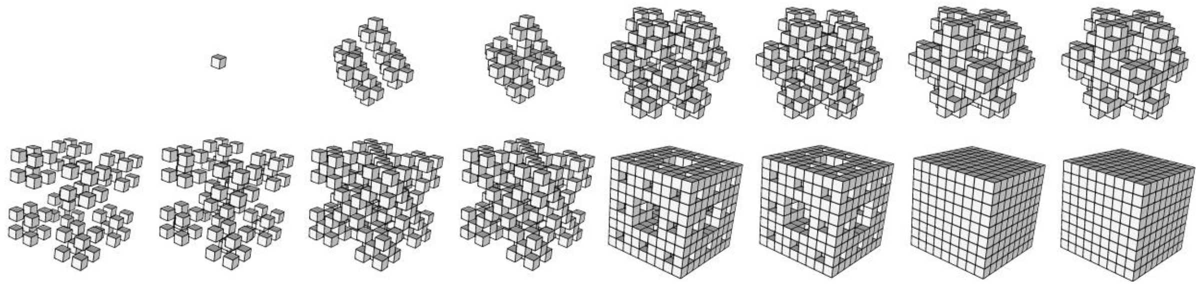


Figure 13: Rule retirement and substitution. An extension allows rules to be changed after a number of iterations. In this case, a rule makes spatial subdivisions until a specified recursion depth is reached - this makes it possible to create Menger fractal variations such as these [7].

Language extensions: A few new features were added to Structure Synth. A rule retirement system makes it possible to substitute one rule for another after a specified maximum recursion level. Even though this is a slight violation of the context-freeness, this was included in order to make it possible to create objects such as those in Figure 13. A new coloring system was also introduced making it possible to use random colors from different color pools, including sampling colors from a bitmap file. Random Seed Synchronization (See Figure 19) makes it possible to synchronize the random number streams whenever a rule branches (calls two or more new rules).

Language reductions: The start shape is no longer explicitly declared. Instead, all commands at top-level scope are implicitly converted into an anonymous start rule. In addition, Context Free Art defines two different forms of modifiers, which are placed after the rule designator: square brackets and curly brackets, where the modifier order is not significant for the square brackets. Structure Synth, on the

[5] Implementation-wise, the left bracket would push the current state, and the right bracket would pop the current system state.

other hand, only uses curly brackets placed before the rule designator, and the transformation order is always significant.
The following Structure Synth system creates the output shown in Figure 14:

```
set background white

{ h 30 sat 0.7 } seed
{ ry 180 h 30 sat 0.7 } seed

rule seed weight 100 {
  box
  { y 0.4 rx 1 s 0.995 b 0.995 } seed
}

rule seed weight 100 {
  box
  { y 0.4 rx 1 ry 1 s 0.995 b 0.995 } seed
}

rule seed weight 100 {
  box
  { y 0.4 rx 1 rz -1 s 0.995 b 0.995 } seed
}

rule seed weight 6 {
  { rx 15 }  seed
  { ry 180 h 3  }  seed
}
```

Figure 14: Three-dimensional version of Figure 12 created in Structure Synth.

Differences to procedural programming

A Structure Synth grammar like the one above may look similar to a normal computer program – the syntax is quite close to the syntax of procedural programming languages like C, Java, Pascal, or Basic. And instead of thinking of the system as a grammar and its output as strings in the language specified by this grammar, it is perhaps easier to think of the grammar as a restricted subset of an ordinary computer language, just without parameter passing and conditional logic.
The similarities may be a bit deceptive though, since there are two major differences: functions (which are the rules in the CFDG terminology) may have multiple definitions each with an arbitrary weight. Moreover, recursion is handled *breadth first*.
The last point requires further explanation: Whenever a procedural programming language executes a function or procedure, it does so in sequential order – the individual statements in the function are executed in the order of appearance[6]. If one of the statements is a procedure call, this procedure is executed and must complete before the next statement is executed. The state of the currently executing function (the return address pointer, local variables, etc.) is typically stored in stack frames on a call stack, in order to be able to return after executing a function. Put differently, this means the function call tree for the program is traversed *depth-first*. Recursion in Structure Synth is handled differently. Instead of a call stack, there is generational queue system: whenever a rule is encountered, all sub rule calls and primitives in the rule definition are pushed onto a new queue that will be evaluated at the next generation. This means the rules are traversed *breadth first* – all calls at the same recursive depth are processed at the same time. Consider the following example:

Procedure recurse() {
  recurse();
  drawBox();
}
	Rule recurse {
	  recurse
	  box
	}

Example of recursion in a traditional computer language to the left and in Structure Synth to the right.

A traditional programming language would never reach the ‘drawBox()’ function call. It would recurse until the call stack overflowed. In contrast, in Structure Synth the first generation would process both the ‘recurse’ and 'box' statement. (The ‘recurse’ statement would be expanded into new 'recurse' and 'box' statements and scheduled for execution on the next generation queue).

Technical implementation notes

Structure Synth provides a graphical environment with a multiple tab editor, syntax highlighting, and OpenGL preview. Besides the integrated OpenGL view, it is possible to export structures to third-party software (such as Sunflow [8] and POV-Ray [9]) using an extensible template based export system.
Structure Synth is written in C++ using the Nokia Qt framework [10]. It uses the OpenGL API [11] for visualization and the Mersenne Twister RNG [12] for random numbers (the C standard library random number generator is insufficient, since two independent random number streams are used: one for geometry and one for colors). It uses a hand-written recursive descent parser to parse the grammar, from which a binary representation of the transformation rules is created. All geometrical transformations (translation, rotation, and scaling) are stored in 4x4 (homogeneous) matrices.
Structure Synth is open source (dual licensed under the GPL and LGPL [13]) and cross-platform (including Windows XP and Vista, Mac OS X, Linux, and FreeBSD). The source and binary files are hosted at SourceForge and can be downloaded from [14].

[6] The compiler may have some liberty to reorder the instruction order between the defined sequence points in the language, but this is not relevant for our discussion.

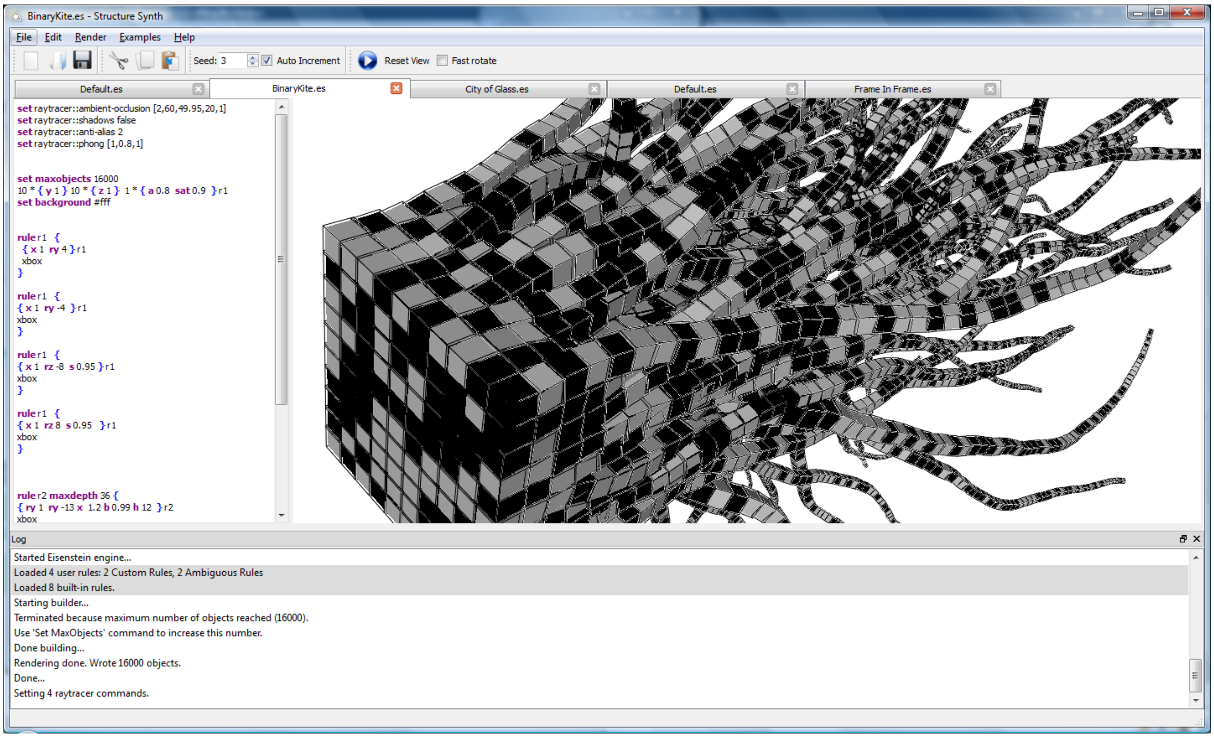


Figure 15: Structure Synth graphical user interface showing a tabbed interface, with a syntax-highlighting editor and an integrated OpenGL preview.

Examples of systems

The purpose of this section is to illustrate some typical aspects of Structure Synth.
Structure Synth makes it possible to formulate systems, which are deterministic (reproducible) each time the system is instantiated, but also makes it possible to create stochastic systems with inherent random behavior (see Figure 17). Yet, the recursive nature of both types of systems often results in very complex images. Many of the stochastic Structure Synth systems also display a lot of diversity. Some examples of different instances with the same system are shown in Figure 16. Stochastic systems with near-continuous transformations (meaning the state is changed slowly) often look organic or biological. (See Figure 18)
While some deterministic systems (such as the Menger fractal in Figure 13) may exhibit self-similarity, it is also possible to create stochastic systems which are self-similar in Structure Synth. This may be done by using the random seed synchronization, which makes it possible to spawn branches that will be governed by identical random number sequences[7].

[7] Normally ambiguous rule substitutions are resolved using a random number generator. This means that two different branches, each starting with identical symbols, may end up with different expansions. The random seed synchronization is a special command for synchronizing two different branches - ensuring their expansion will be identical.

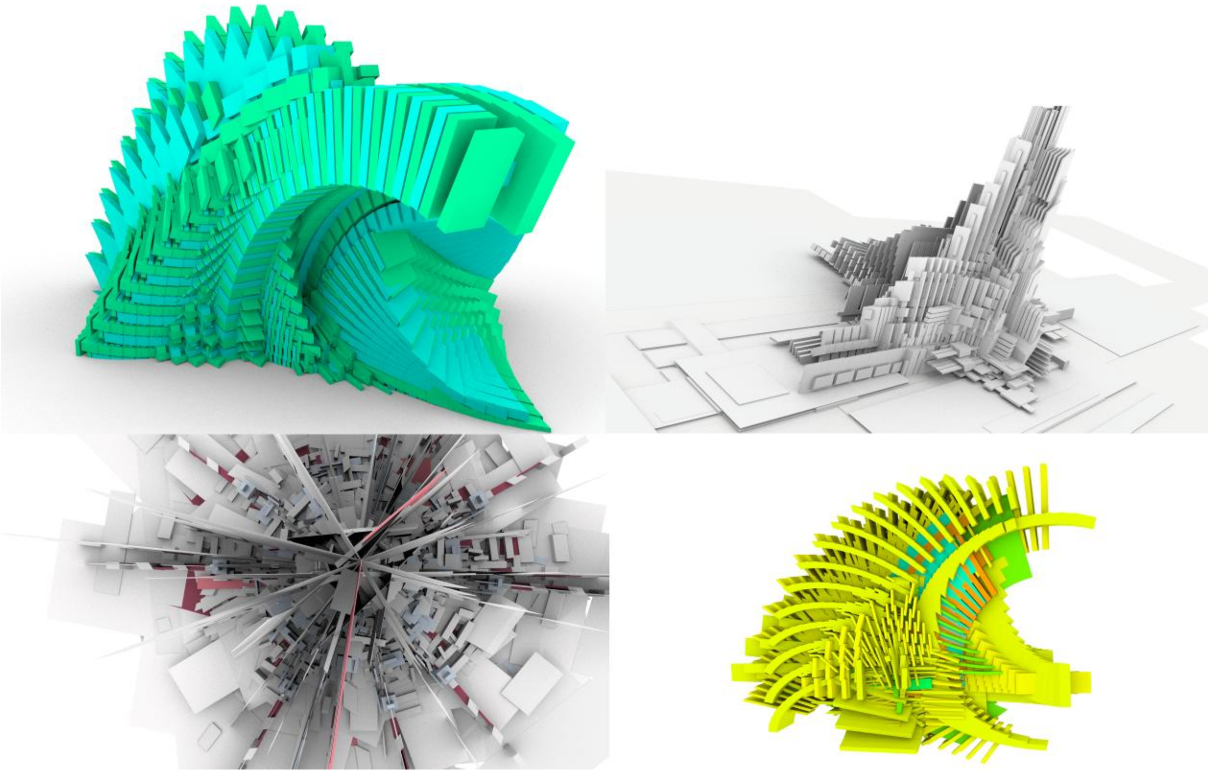


Figure 16: Diversity. All of the images above are instances of the same grammar but with different random seed. Images: The Nabla System [15], with seeds 29, 338, 7 (radial), 201.

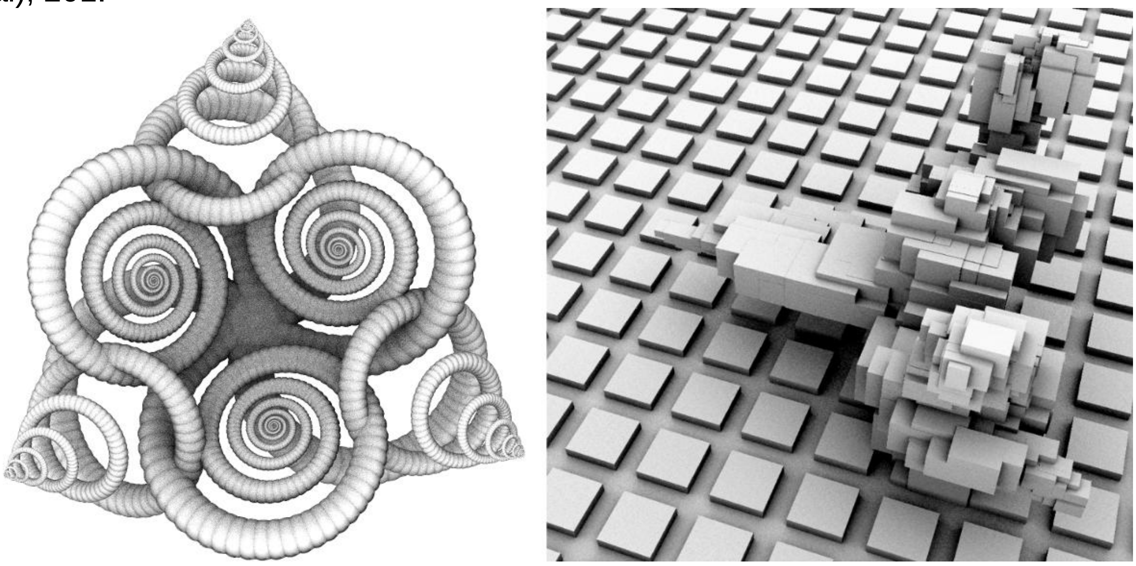


Figure 17: Deterministic versus stochastic systems. The picture on the left has no ambiguous rules. In contrast, the structure on the right will be different every time the system is instantiated. [16]

Figure 18: Organic. These two images are variants of the Nouveau system [17] - a system based on random continuous transformations. Such images often have an organic appearance.

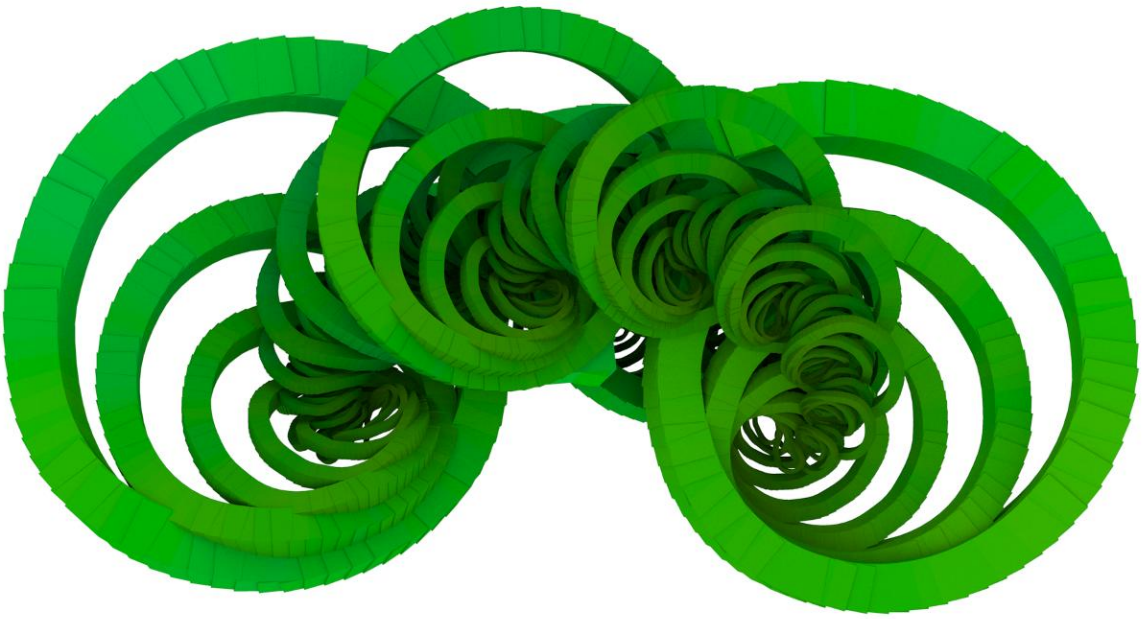


Figure 19: Stochastic self-similarity. The principal form of the ring system above is stochastic, yet the system above copies itself on many scales [18].

Constrained systems and Generative Art

The first part of this paper discussed how systems of various complexity (expressive power) can be generated using formal grammars, and how this led to design grammars and Structure Synth.

So why restrict Context Free Art and Structure Synth to context-free systems? It is well known that it can be computationally hard [19] to *analyze* the structure of context-sensitive systems, but it is not much harder to *generate* structures based on a more powerful grammar. The grammar in Structure Synth could easily be extended to context-sensitive systems. However, context-free systems have the nice property of being complex enough to be interesting, while not being omnipotent (in the general-purpose programming languages sense), making them very suitable for *generative art*:

Even though no definitive definition of 'generative art' exists, it has been suggested that generative art is about creating and exploring systems, without being too much in control (see e.g. [20]). When generating structures, it should not be possible to anticipate how a given structure turns out by looking at the rules. There should be a sense of non-determinism and surprise in the result. The system needs not to necessarily be driven by random choices in order to achieve this – the Mandelbrot set is a good example of this: nobody would have been able to imagine how complex images a simple system like "$z \rightarrow z^2+c$" could create, yet there is nothing stochastic in the generation of Mandelbrot sets. Choosing

to work within a restricted rule system is a way to give up some control and to be forced to think differently. It becomes necessary to explore and work within the limitations of the system, which may lead to interesting and unexpected results.
More generic languages, for instance the popular Java-based Processing environment [21], have no limitations in expressiveness[8]. Does this mean that Processing is not suitable for generative art, because of its universal expressive power? Well, the answer is of course that Processing is very suitable and is widely used by the generative art community. In fact, any Structure Synth or Context Free Art system could be created in Processing/Java because of this universal power. However, Processing is also suitable for many other applications, such as Data Visualization and other non-generative tasks. Context Free Art and Structure Synth on the other hand force you to explore generative systems.

Conclusions and future work

This paper introduced Structure Synth and described its heritage from Chomsky's grammars and the Context Free Design Grammar by Chris Coyne. It has been argued (but not formally proved) that these systems are closely related to stochastic context-free bracketed Lindenmayer-systems, but different from procedural programming languages. Finally, the potential benefits from working with constrained systems have been discussed.
The next version of Structure Synth will focus on two new features: a new internal raytracer for creating high-resolution output directly in Structure Synth, without having to use external third-party software. It will also include automation and scripting of the structure creation using a built-in JavaScript interpreter: this will make it possible to vary internal grammar parameters and create animations. Integration with other programs (such as VVVV [22] and Blender [23]) is in progress and there will likely be better integration with other software systems as well.
On a longer time frame, there are several ideas that might be pursued. One possibility is to extend Structure Synth to make it suitable for live performances - by making it possible to interact with and control the model building in real-time. Another idea is to implement topological operations on grid meshes (using operations such as those used by TopMod [24]) instead of working with fixed primitives. Finally, several people have suggested a user interface for automatically creating a set of 'mutated' systems, making it possible to evolve the systems in a direction supervised by the user (evolutionary art / design).

Acknowledgements

I would like to thank René Thomsen and Kamma O. Hansen for commenting on and proofreading this paper. I would also like to thank the users of Structure Synth who have provided valuable and encouraging feedback. In particular, I would like to thank the Structure Synth Flickr community for many interesting discussions and suggestions.

References

[1] N. Chomsky (1956): Three models for the description of language. IRE Transactions on Information Theory (2): 113–124
[2] J. Stribling, M. Krohn, D. Aguayo (2005): SCIgen - an automatic cs paper generator, pdos.lcs.mit.edu.
[3] R. Mosallahnezhad (2007): Cooperative, Compact Algorithms for Randomized Algorithms. Applied Mathematics and Computation, Elsevier.
[4] P. Prusinkiewicz, A. Lindenmayer (1990): "The Algorithmic Beauty of Plants."
[5] Chris Coyne's CFDG description: http://www.chriscoyne.com/cfdg/.

[8] Java, like all other general-purpose programming languages, is Turing complete - meaning they can express arbitrary computations. This places their output in the most powerful 'Type 0' category of the Chomsky Hierarchy [19].

[6] C. Coyne, M. Lentczner, J. Horigan: Context Free Art. http://www.contextfreeart.org/
[7] Menger variations at Flickr: http://www.flickr.com/photos/syntopia/3199111727/
[8] Sunflow. http://sunflow.sourceforge.net/
[9] POV-Ray - The Persistence of Vision Raytracer. http://www.povray.org/
[10] Nokia Qt. http://qt.nokia.com/
[11] OpenGL. http://www.opengl.org/
[12] Mersenne Twister. http://www.math.sci.hiroshima-u.ac.jp/~m-mat/MT/emt.html
[13] GPL and LGPL. http://www.gnu.org/licenses/gpl.html
[14] Structure Synth at SourceForge: http://structuresynth.sourceforge.net/
[15] Nabla System at Flickr: http://www.flickr.com/photos/syntopia/3401189363/
[16] Deterministic versus Stochastic system: http://www.flickr.com/photos/syntopia/3909688627/ and http://www.flickr.com/photos/syntopia/2244330735/
[17] Nouveau System. http://www.flickr.com/photos/syntopia/3571168238/
[18] Synctor. http://www.flickr.com/photos/syntopia/3272377029/
[19] J. C. Martin (1991): Introduction to Languages and the Theory of Computation. McGraw-Hill.
[20] P. Galanter (2003): What is Generative Art? Complexity Theory as a Context for Art Theory. Generative Art 2003 Conference.
[21] Processing 1.0. http://processing.org/
[22] VVVV: a multipurpose toolkit. http://vvvv.org
[23] Blender - open source 3D content creation suite. http://www.blender.org/
[24] TopMod3D - topological mesh modeler. http://www.topmod3d.org/

Les Folies Cellulaires – An Exploration in Architectural Design Using Cellular Automata

Mirjana Devetakovic, PhD., Ljiljana Petrusevski, PhD., Milana Dabic, Bojan Mitrovic
Faculty of Architecture, University of Belgrade, Serbia
http://genericexplorations.blogspot.com
e-mail: eaoyu@sezampro.rs

Abstract

Inspired by Tschumi's famous realization in the Parc de la Villette, the Authors explore the concept of cellular automata (CA), applied in architectural and urban design. The theoretical approach to the problem of cellular automata considers works of Krawczyk, Coates and other authors proposing various ways of using cellular automata in the design process, particularly in architectural design. The experimental activity is realized by the CA module of the software Fun3D which has been created to support generative processes in architectural design. The CA module of the software allows certain level of redesign of a basically cubic cell and other elements of a CA system, as well as combination of multiple cellular systems. A series of "follies" has been created in a design experiment with senior architecture students. The resulting designs retain some features of Tschumi's follies (scale, type of context, coloristic approach, spatial interpretation) introducing and examining cellularity as a main creative idea. This paper is part of a continued research activity titled Generic Explorations, within the Faculty of Architecture, University of Belgrade.

Keywords: cellular automata, cellularity, architecture, generic, experimental

Introduction

The concept of cellular automata (CA), introduced by Von Neumann [1] and later explored and popularized by Wolfram [2], has extensively been examined in various fields, including architectural design. Early experiments realized by Coates [3] indicated a significant potential of the CA in the process of spatial form generation, while Krawczyk [4] proposed architectural interpretations of a form based on the CA concept. One of the typical interpretations of a CA based form is certainly in domain of high-density buildings, as propose Herr and Kwan [5].

In their previous research in the field of CA, the Authors of this paper examine the design potential of the concept [6] and possible architectural interpretations of generated spatial form in a given context [7]. The research realised under the title Generic Explorations [8], included several design experiments with senior architecture students at the University of Belgrade. In these studies, a methodological approach based on the research by design with a critical number of participants, combined with certain additional analysis and systematizations of results, has been developed and tested. The studies were supported by CA module of the Fun3D software, created to respond to the specific needs of architectural design.

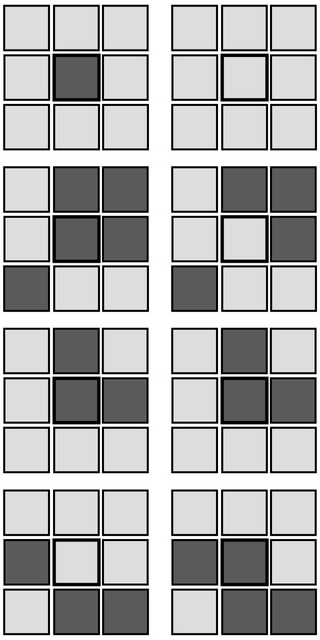
This study is focused on examining the CA generic concept inspired by a well known architectural realisation of a significant cellularity. Tschumi's famous "Les follies" realised in mid 80-es in the Parc de La Villette in Paris [9], consist of 26 spatial points materialised on a 3x3x3 system of cubic cells [10]. The characteristic cellularity of Tschumi's follies was a starting point for this exploration of the CA concept in architectural design.

Cellular Automata

A cellular automaton (CA) is a discrete dynamical system. Space, time, and the states of the system are discrete. Each point in a regular spatial lattice, called a cell, can have any one of a finite number of states. The states of the cells in the lattice are updated according to a local rule. That is, the state of a cell at a given time depends only on its own state one time step previously, and the states of its nearby neighbors at the previous time step. All cells on the lattice are updated synchronously. Thus the state of the entire lattice advances in discrete time steps.

Conway's Game of Life - The GAME OF LIFE is a CELLULAR AUTOMATON [11] devised by the British mathematician John Horton Conway in 1970. It is the best-known example of a cellular automaton. The universe of the Game of Life is an infinite two-dimensional grid of cells, each of which is either ALIVE (populated) or DEAD (unpopulated or empty). Cells interact with their eight NEIGHBORS, the cells that are directly horizontally, vertically, or diagonally adjacent.

At each step in time, the following effects occur:



LONELINESS: any live cell with fewer than two neighbors dies.

OVERCROWDING: any live cell with more than three neighbors dies.

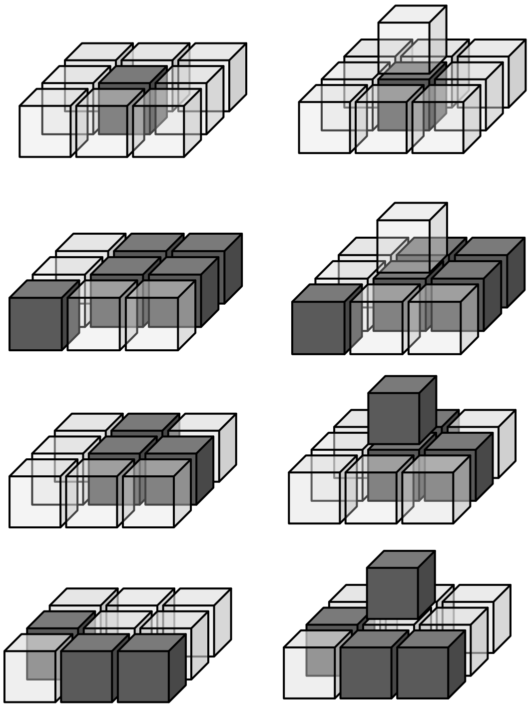
STASIS: any live cell with two or three neighbors lives, unchanged, to the next generation.

REPRODUCTION: any dead cell with exactly three neighbors comes to life.

Figure 20 – The rules of the Game of Life, 2D

The "game" is actually a zero-player game, meaning that its EVOLUTION is determined by its INITIAL STATE, needing no input from human players. One interacts with the Game of Life by creating an initial configuration and observing how it evolves.
The INITIAL PATTERN constitutes the first generation of the system. The second generation is created by applying the above rules simultaneously to every cell in the first generation -- births and deaths happen simultaneously, and the discrete moment at which this happens is called a TICK. The rules continue to be applied repeatedly to create further generations.

3D Layers Evolution View of the Game of Life - Considering a generative process as a set of layers instead of a change of a system single state, the flat cellular automata context becomes a spatial one, with a significant third dimension. The simple rectangular cell becomes a cubic block, reproducing itself in every following generation according to spatially interpreted rules of the Game of Life:



LONELINESS: any live cell with fewer than two neighbors dies.

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STASIS : any live cell with two or three neighbors lives, unchanged, to the next generation

REPRODUCTION: any dead cell with exactly three neighbors comes to life.

Figure 21 The rules of the Game of Life, 3D Layers

The layers of a single CA system, as shown on the Figure 22, define a spatial form that could be interpreted in different ways, depending of its own geometric characteristics and on a wider context.

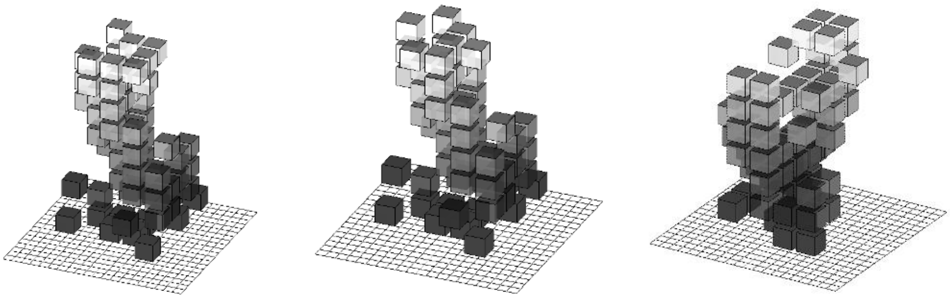


Figure 22 Typical CA spatial forms based on the rules of the Game of Life

The software

Fun3D (the name derived from “Function 3D”) is a software developed by B. Mitrovic, within the “Generic Explorations” project. Its development begun with a module supporting creation of parametric curves and surfaces, continuing with another module aimed at creation of 3D L-systems.

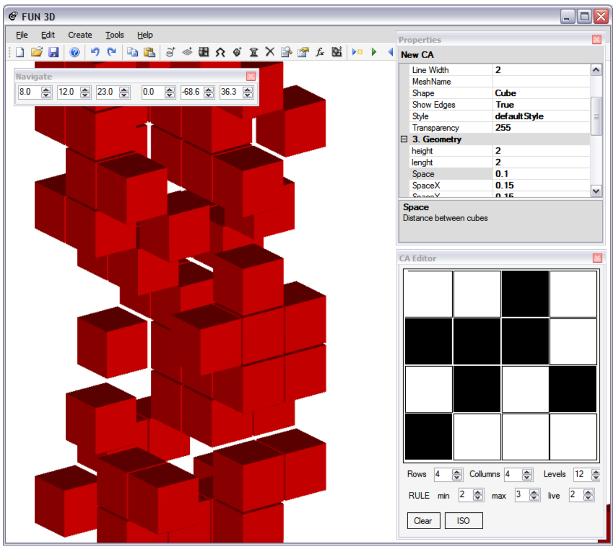


Figure 23 Fun3D (created by B. Mitrovic, within the “Generic Explorations” project)

The CA module of the software (Figure 23) allows creation of CA based spatial form, as well as control of the following CA elements:

- Initial configuration (controlled by a graphic interface)
- Rule definition (totalistic)
- Total number of layers
- Position of a system (x, y and z coordinates)
- Rotation of the system (along x, y and z axes)
- Proportion of the cell (height, width and length)
- Color range of the cell layers
- Transparency
- Gap between cells of the system
- Lighting
- Shadows

Variation of mentioned parameters, especially the ones affecting geometry, results in a range of spatial forms. A sequence on the Figure 24 represents variations of the CA system based on the same generative rule. As resulted forms have surprisingly different spatial characteristics, the Authors suggest a need for deep exploration in the field of geometry of 3D cellular automata.

The presented module can generate and visualize several CA systems within the same scene, each with different geometric parameters, and based on different rules. It also permits copying of an entire system and pasting it within the same scene. Combination of various CA systems within the same scene, results in a spatial form of a significant complexity that needs to be additionally examined and interpreted.
One of the most important features of the CA module is export of .dxf file formats that makes the software fully compatible with a range of CAD programs.

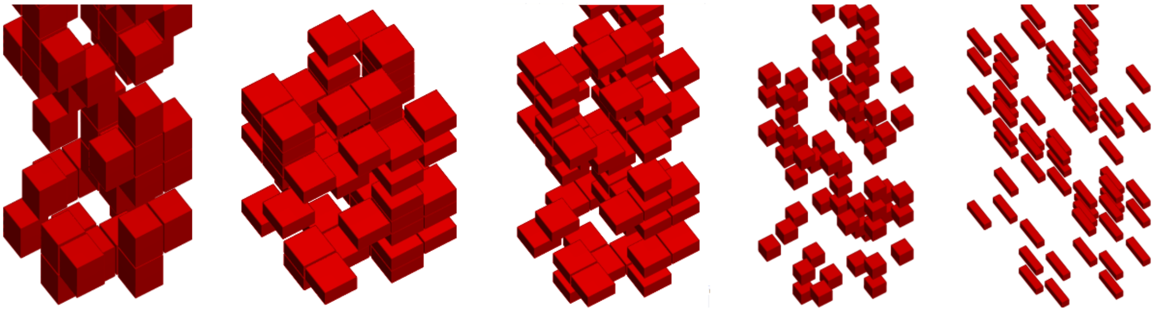


Figure 24 Variations of a single CA system based on the same rule (2,3,2)

Further developments of the CA module of the Fun3D software include some additional features both geometric and explorative. The improved geometric features associated to this research are related to definition of a basic cell, as well as to control of the gap between cells in x, y and z directions. The additional explorative features that need to be enhanced, presume a possibility to chose particular segments of a CA space (universe), both vertically (along generations) and horizontally (in the initial cell layout).

Fun3D software is protected by the Creative Commons license [13], which means that it could be freely used and redistributed, with mentioning its author (B. Mitrovic) and the context in which it has been developed (Generic Explorations project, Faculty of Architecture, University of Belgrade).

The experimental part of the study

In the experimental part of the study the two stages were completed:

- the computing stage (*in silico*) in which the reinterpretation possibilities have been examined by the CA module of the Fun3D software
- and the design stage in which a group of senior students has been asked to reinterpret Les Follies using the CA concept in general.

Computing experiments

In the initial stage of the experiment, the Tschumi's characteristic 3x3x3 grid has been examined using the basic functionalities of Fun3D software. A relatively simple initial configuration of 3x3 cells that has never been considered in our previous explorations, resulted in an unexpected variety of spatial forms, produced by applying different rules.

Figure 25 represents an explorative set of nine various initial configurations of CA systems, each of which has been a base for a spatial form generated by rules 2,3,2; 3,4,3; 1,3,1 and 2,4,2. An analysis of the results indicated that could be possible to combine multiple rules on the same initial configuration, if we manage to introduce different geometry to the initial cell of the system. This required an additional functionality to be included in the Fun3D CA module – possibility to choose geometry other than solid cubic.

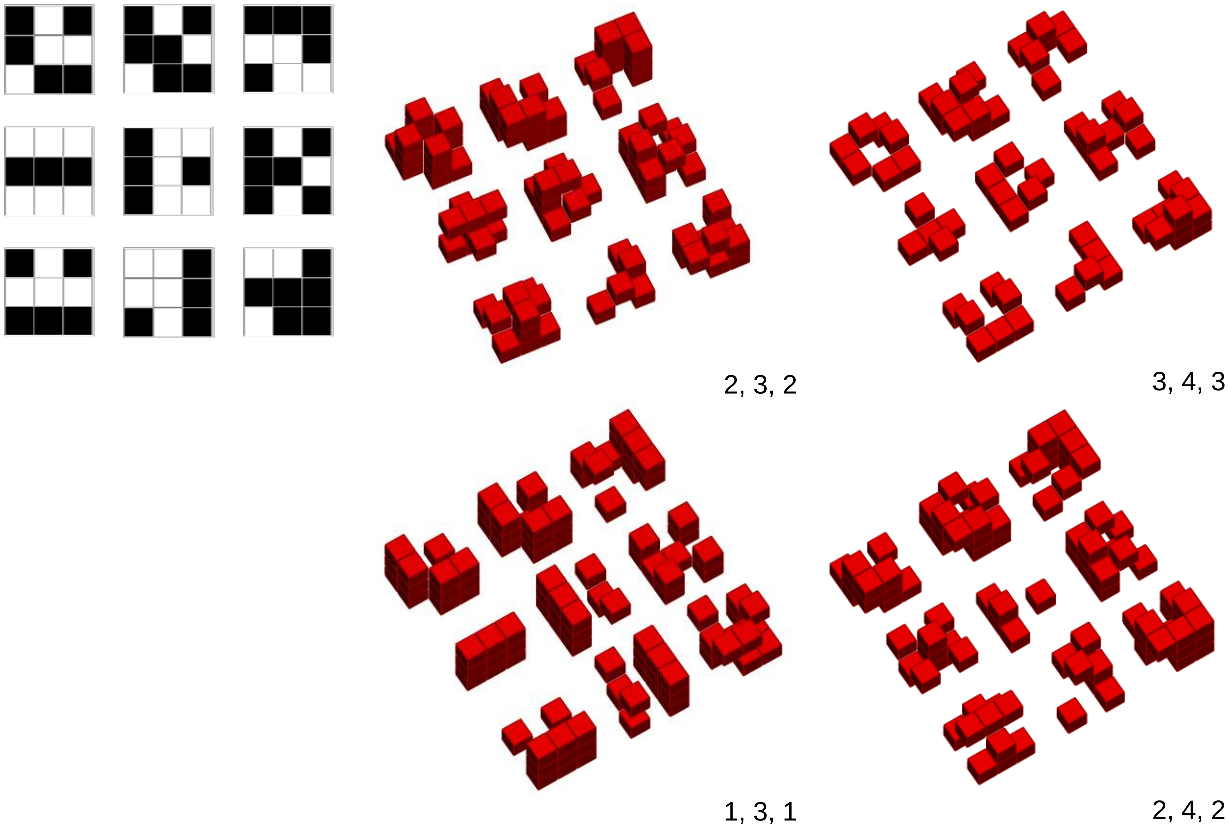


Figure 25 Application of various rules on a series of initial configurations

Figure 26 shows a combination of two CA systems: the first based on 1,3,1 rule (solid cells) and the second, consisting of wire frame cells, based on various other rules. In this stage we have shown that a combination of several CA systems results in spatial forms that might be considered as a generic reinterpretation of Tschumi's follies.

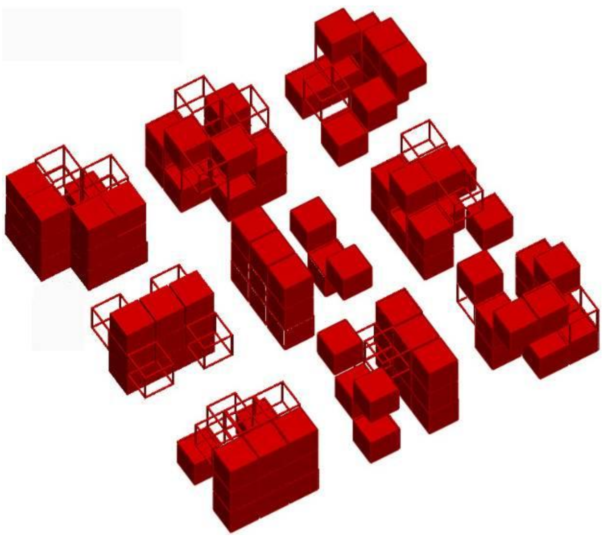


Figure 26 Combination of two cellular systems - a generic reinterpretation of Tschumi's follies

Experimental design

In this part of the study, a group of senior architecture students was asked to reinterpret the famous Tschumi's work, after an exploration of its geometry, and particularly its cellularity, that has been done in previous step.

The results from this part of the study, realised with students as a research by design, could be systematized in three groups:

- Variations of a single 3x3x3 CA system
- Multiplication of a CA system
- Changing the inner structure of a CA system

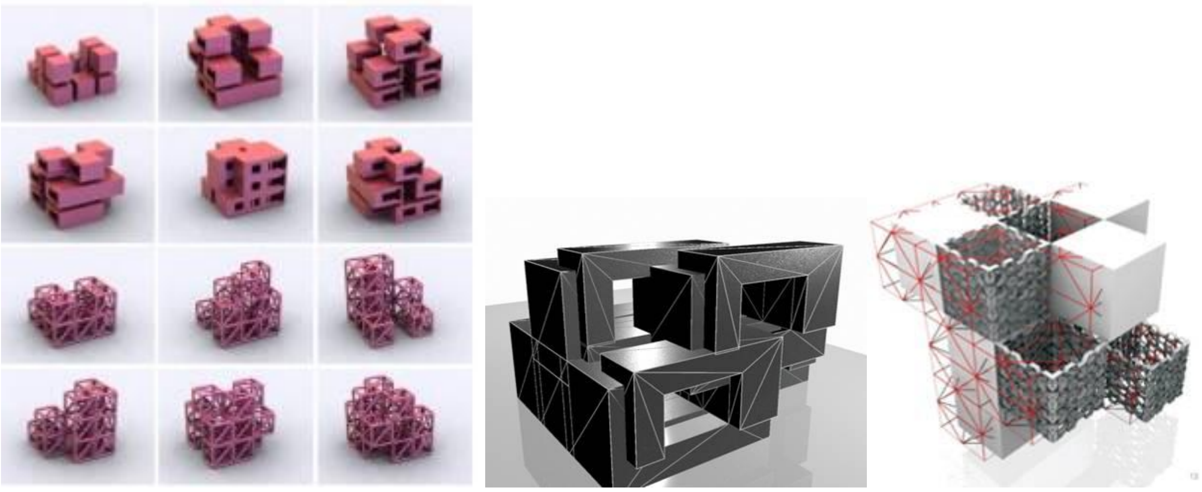


Figure 27 Variations of a 3x3x3 system

The first group of designs (Figure 27) represent relatively simple 3x3x3 systems consisting of one or several CA. Main characteristics of reinterpretation is change of initial cell, either its entire geometry or its proportion and texture.

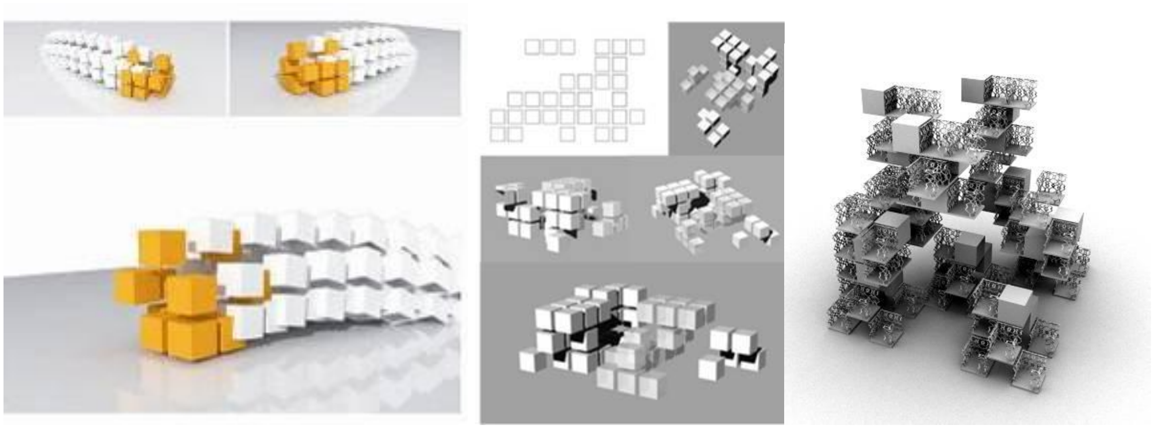


Figure 28 Multiplications of a CA system

Figure 28 shows the second group of results which main characteristics is a multiplication of the initial 3x3x3 CA system. While some designers retained Tschumi's orthogonal layout of objects, the others introduced alternative concepts like affine transformations, fragmentation, fractalization, etc.

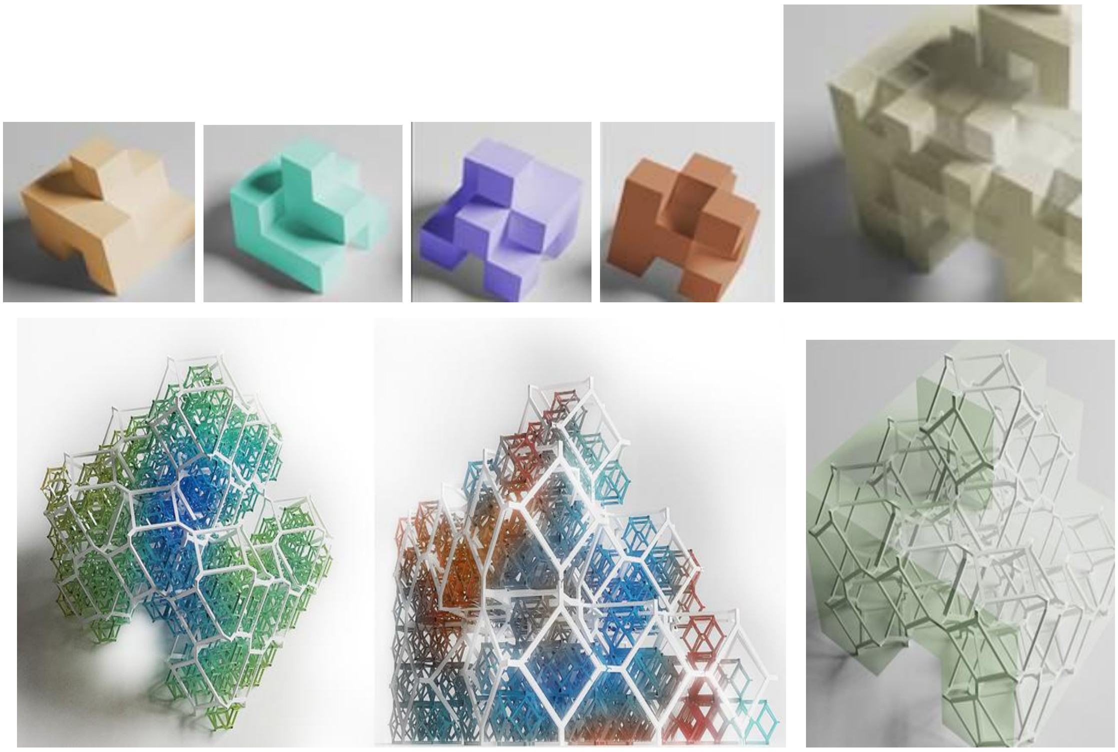


Figure 29 Changing of the inner structure of a CA system

In the last group of results (Figure 29) the 3x3x3 CA system changes its inner structure. This change is based on the fractalization mentioned in the previous group, but it is used just as a step towards introduction of more complex geometry within each cell of the system.

The resulted reinterpretations indicate that there's a significant potential in the simplest 3x3x3 cellular system. They require an additional architectural interpretation, as in many aspects the resulting designs lose an initial sculptural signification.

Fragmentation, compatibility, fractalization and hidden geometric potential of cellular automata

As a result of the exploration inspired by Tschumi's work, after the experimental stage, a range of issues on CA applied in architectural design, have been identified. The following four issues are highlighted:

- Fragmentation
- Compatibility
- Fractalization
- Hidden geometric potential

Fragmentation of CA systems

Tschumi's differentiation of basic structural elements required fragmentation of a CA system, i.e. decomposition of one CA system into combination of several systems. Consequently the ratio of x, y and z dimensions of initial cubic cell, has to be changed, and the cell becomes one of the elements forming the structure.

This fragmentation becomes possible by introducing various sizes of gaps between elements in x, y and z directions. This functionality has been included in the CA module of Fun3D software in the final stage of this study, and represents the latest improvement of the software. Some of the results are shown on Figure 30.

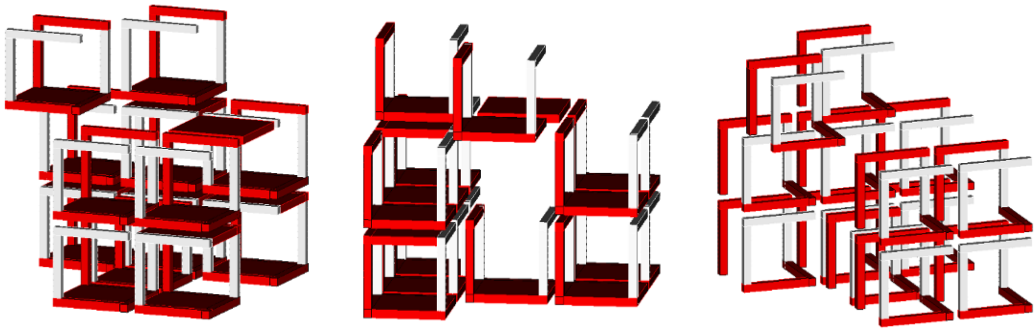


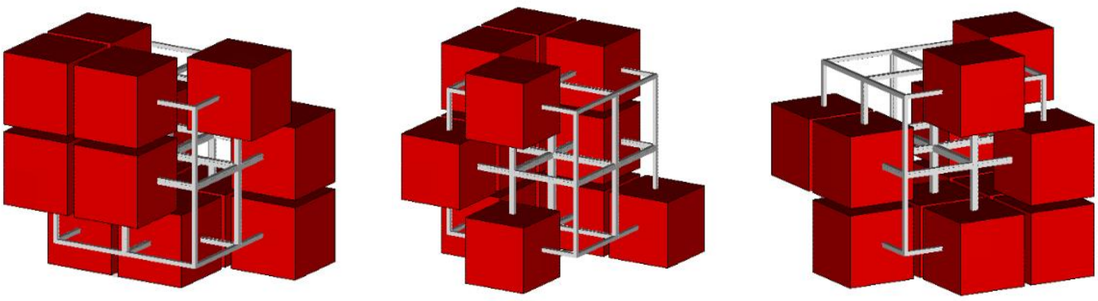
Figure 30 Fragmentation of a 3x3x3 CA system

Compatible CA systems

The issue of compatibility of CA systems came from combination of multiple CA systems. Combining a single 3x3x3 CA system with other systems could occur:

- On the same level, i.e. with one or more 3x3x3 CA systems (as shown on Figure 26 and Figure 30)
- With a 2x2x2 CA sub-system (□□□□□□31)
- With a 4x4x4 or higher CA super-system (Figure 32)

The sub and super CA systems are the systems one level lower/higher than the observed 3x3x3 system. The corners of both systems are placed in centres of the cubic elements of the 3x3x3 system.



□□□□□□31□□□□□□□□□□□□□□□□□□□□□

A sub-system of 2x2x2 cells can be treated as a special case of CA because of limited number of cells and therefore limited number of combinations of final 2x2x2 spatial forms. But, it seems to have a powerful structural potential (□□□□□□31), so it requires some further examinations.

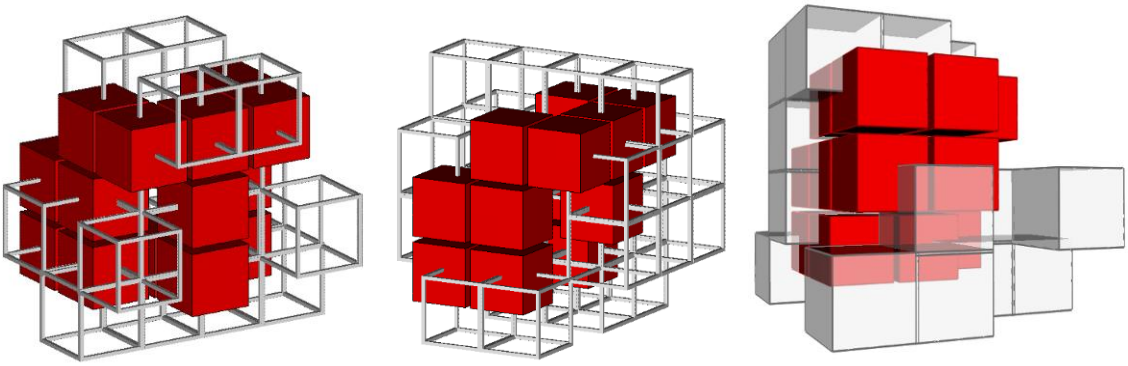


Figure 32 A CA super-system 4x4x4

The 4x4x4 super-system (Figure 32) is based on an altered initial CA configuration and could be generated according to a rule different than the one of main 3x3x3 system. Introduction of such super-system requires an architectural (instead of sculptural) interpretation of the resulted spatial form.

Fractalization

The fractalization of the 3x3x3 CA on Figure 33 has been realized by replacing the initial cell with the entire system, introducing thus the principle of self-similarity.

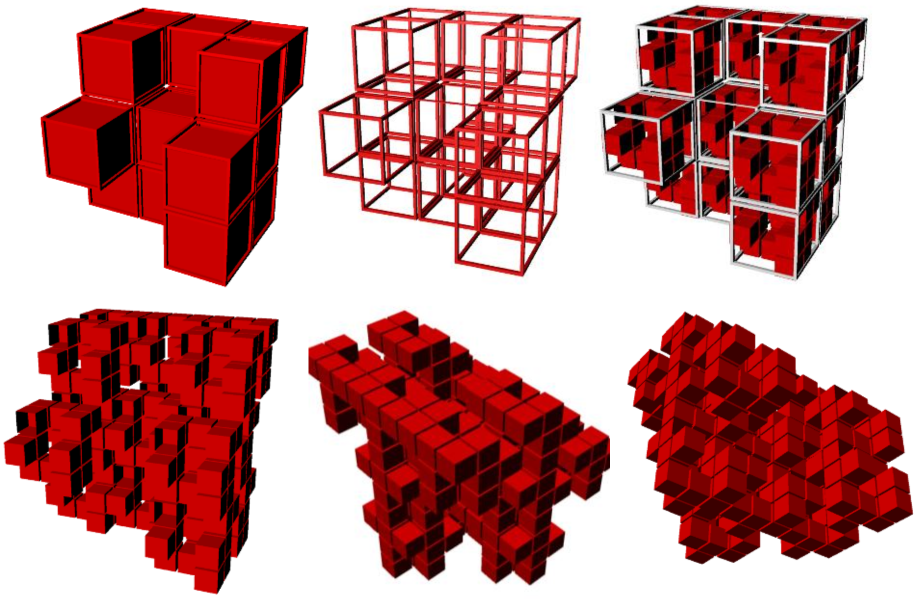


Figure 33 Fractalization of a 3x3x3 form

The spatial form resulted from the fractalization of an initial 3x3x3 CA, also requires an additional architectural interpretation, since its fractal nature suggests a mega-structure instead of a small-size sculptural object.

A hidden geometric potential

Finally, a single 3x3x3 CA system has been explored as a generator of a complex inner surface. In the example on the Figure 34, the system of cubic cell diagonals has been used as an input for a loft surface.

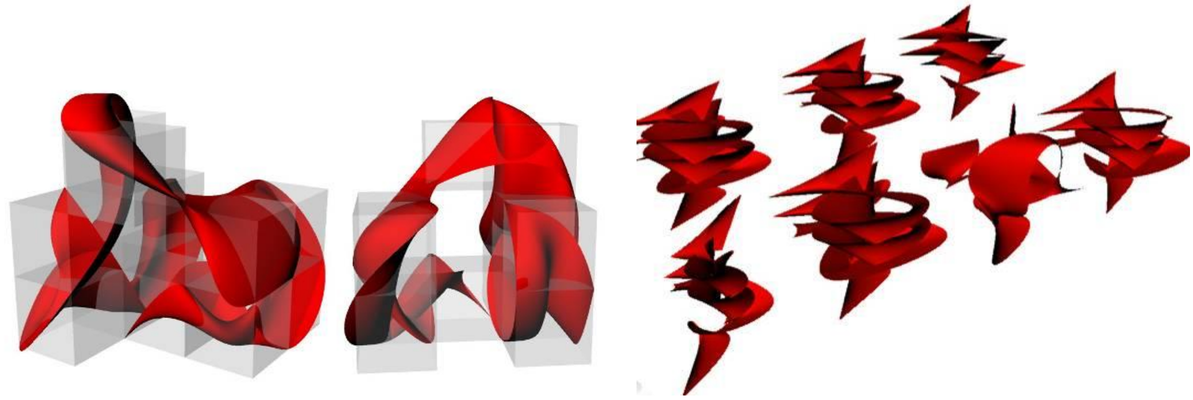


Figure 34 A CA as a generator of a complex surface

In this stage, it was necessary to use a NURBS modeling software (Rhino 3D), with a certain scripting support that permitted generation of a series of complex surfaces based on variations of 3x3x3 CA.

Conclusion

Focused on simple 3x3x3 grids, inspired by Tschumi's follies, this study demonstrates a considerable design variety resulting from application of well-known CA generative concepts. Variations of a single 3x3x3 CA system by introducing initial cell different than solid box, as well as multiplication of the system and change of its inner structure, call for new architectural reading of resulting spatial forms.

Reinterpretation of Tschumi's work, derived from an experimental activity, requires additional functionalities to be included in the CA module of the Fun3D software. Some of these functionalities have already been developed and applied (variations of initial cell, fragmentation), while some need to be further elaborated (advanced compatibility, fractalization, etc.).

Finally, this study indicates that there's also a geometric potential hidden within the simple CA systems, which could result in complex geometries. This requires either NURBS modelling to be integrated in the existing explorative tools, or the future explorations to be performed in NURBS modelling environments with flexible scripting solutions.

References

[1] von Neumann, John [1966]. **The Theory of Self-Reproducing Automata**. Arthur Burks (Ed.) University of Illinois Press.

[2] Wolfram, S.: **A New Kind of Science**, Wolfram Media, Inc., 2002.; The book is available online at: http://www.wolframscience.com/ (November 2009)

[3] Coates, P.; Healy, N.; Lamb, C.; Voon, W.L.: **The use of Cellular Automata to explore bottom up architectonic rules**, Eurographics UK Chapter, 14th Annual Conference, Imperial College, London UK, 1996 http://uelceca.net/research/other/eurographics1996.pdf (November 2009)

[4] Krawczyk, R. J.: **Architectural Interpretation of Cellular Automata**, Generative Art Conference, Milano, 2002, http://www.iit.edu/~krawczyk/rjkga02.pdf (November 2009)

[5] Herr, C.; Kvan, T.: **Using Cellular Automata to Generate High-Density Building Form**, Computer Aided Architectural Design Futures 2005 [Proceedings of the 11th International Conference on Computer Aided Architectural Design Futures / ISBN 1-4020-3460-1] Vienna (Austria) 20–22 June 2005, pp. 249-258 http://cumincad.scix.net/cgi-bin/works/Show?cf2005_1_53_133 (November 2009)

[6] Petrusevski, Lj.; Devetakovic, M.; Mitrovic, B.: **Self-Replicating Systems in Spatial Form Generation – The Concept of Cellular Automata**, Spatium journal, No. 19, Belgrade 2009, http://elearning.amres.ac.rs/journals/index.php/spatium/article/view/7/6 (November 2009)

[7] Petrusevski, Lj.; Devetakovic, M.; Mitrovic, B.: **Architectural interpretations of spatial form based on cellular automata** (in Serbian language), Architecture and Urbanism, IAUS, Belgrade, 2009

[8] For some more info on an ongoing research and teaching activity of the Generic Explorations group, please refer to: http://genericexplorations.blogspot.com (November 2009)

[9] Tschumi, B.: **Event Cities 2**, MIT Press, 2001
Derrida, J. : **Point de folie - Maintenant l'architecture**, *La Case Vide: La Villete* (1985). Ed. Bernard Tschumi.

[10] La villette, plan of the park with a disposition of 26 folies

http://www.villette.com/ressources/documents/1/847,plan.pdf (November 2009)

[11] A widely spread definition, according to: Fornes, M.: Game of life; THEVERYMANY, 2006, http://www.theverymany.net/labels/CA.html (November 2009)

[12] The Fun3D software is freely available at http://code.google.com/p/fun3d/ (November 2009)

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Generative Improvising in Shur: an approach to generative Persian traditional music

Morteza Kasravi, Author, MS
Department of Electrical Engineering, Shahrood University of technology, Shahrood, Iran
E-mail: Kasravi@gmail.com

Sadjad Moxtari, Contributer, Ms
Science and Technology University of Tehran
Tehran, Iran

Abstract:

Our goal is to aesthetically analysis Persian traditional music which is been generated by genetic algorithm technique. A survey on general music philosophy, in this special case, Persian traditional music philosophy and regarding to its unique rules such as micro tones , improvisations ,semi-atonality and etc, shows that traditional optimization algorithms are not appropriate for generating Persian traditional music. Therefore through an investigation in evolutionary algorithms, we considered using genetic algorithm as our music generator system. In order to produce Fitness Function of Genetic Algorithm we utilize Persian traditional music concepts such as ***Dastgậh, Gushe, Shahed tone*** *and etc****,*** *and Persian traditional music unique rules. Due to the extent of Radif which is the base of Persian traditional music, Shur, as one of its twelve Dastgậhs (mode) is chosen as genetic algorithm state space. We choose Shur for its capability to mark Persian traditional music tone through its unique scale and its significant role in Radif as omm'ol alhan (= mother of tones).Having Fitness Function and initializing the first generation of genetic algorithm which is derived from a transformed accidental event in real world as our system input, we move toward finding an optimum tone by reproduction of generations. In this paper the genetic algorithm system output is analyzed in presence of Persian traditional music aesthetics.*

Introduction:

The dependency of traditional Persian music composition on motifs and melodic particles derived from Radif, was the origin of our idea for composing a piece of music using these motifs through a computer program.To reach to a pure traditional music we tried to realize our idea respecting the traditional methodes of music teaching in Iran. Infact, composing in these methodes happens after many years of learning Radif. So, firstly, we had to make a Radif database to teach computer the motifs. Then, using a sentence by sentence analyzing of Radif, we derived rules that were supposed to be learned by practising it. In order to get even closer to a biological approach of learning, we set up a genetic alogorithm procedure to start the composing. While, Radif database is its musical motif knowlage, fitness function made by the mentioned derived rules is its composing technic and an accidental input is its motivator.

Persian traditional music philosophy:

The structure of the Radif is complex and its history can in part be uncovered by a comparison of its versions and components.But listening to the Radif in its various versions, one may be struck by the degree to which different gushes and Dastgahs present themselves in a variety of scalar patterns, motifs, and rhythmic types while at the same time providing a sense of strong stylistic unity. Dastgahs and Gushes differ, but the radif sounds very much like a single unified work, in a style not easily confused with Arabic or Turkish classical music, or with the folk and tribal traditions of the Middle East—to say nothing of the musics of South Asia (Nettl, 1992: 63).

If there is a general stylistic unity in the Radif overriding the diversity of rhythms and modes, it is in good measure based on ornamentation and phrasing, areas that we can only touch upon in this group of studies. Even more specific to the Radif is a group of techniques of treatment of motifs and gestures. In contrast to at least some non-metric music in Arabic traditions, the radif as a whole is perhaps best characterized by its dependence on a set of short melodic particles, which may (but not always quite accurately) also be called gestures or motifs. The composition techniques are quite unified. Typically, one short motif is presented and briefly developed in some way, sometimes separated from others by non-motivic and musically more generalized materials, followed by new motifs similarly treated or by the reappearances of motifs presented earlier. The techniques by which these motifs are developed include repetition, melodic sequence, extension, augmentation, and contraction. And there are also characteristic combinations of these techniques, such as repetition followed by upward transposition further followed by a second transposed version given in extended form. These techniques appear distributed throughout the Radif and are equally present in all of the dastgahs. Most important, they play a significant role in the performance of improvised avaz and in composed works based on the radif. It is to a substantial extent the dependence on motifs and their brief development that give the radif, and the Iranian classical tradition, its unique character (Nettl, 1992: 63-64).

Persian traditional music concepts:

Radif: The combination of pieces that form the whole Persian traditional music, are called Radif. However Radif is not a complete defined set of pieces, but it is an ideal melodic idea for improvisation (Farhat, 2007: 45). This melodic idea has not been learnt or used directly. In fact, during many years of its practicing and through an applied experience, a performer will be able to learn how to use them. On the other hand, just an experienced listener will be able to distinguish them (Farhat, 2007: 45). There are several Radif versions in Persian traditional music, which are classified into two major groups:

One group is written for the vocalists which is called vocal Radif (Radif-e-Avazi) and the second group is written for instruments that is called Instrumental Radif (Radif-e-Sazi).

In another classification each version is distinguished by the name of its assembler. Some notable versions of this classification are: Mirza Abdollah's Instrumental Radif, Ostad Davami's Vocal Radif, and etc.

Dastgah: Dastgah is usually translated into "mode" while this term can not properly define Dastgah's concepts. Dastgah is a set of pieces which are traditionally collected under a unique name (Dastgah's name) (Farhat, 2007: 41). These pieces, which are called Gushehs, have some similar properties but are in different modes. In another words, Radif contains a variety of modes grouped under 12 names. Among them, seven groups are called Dastgahs, for their independent spirit and five groups are called Avaz. Each avaz is assossiated with one Dastgah. The 7 dastgahs are: Shur, Segah, Chahargah, Rast panjgah, Homayun, Nava, and Mahur.

There are 4 avaz assossiated with Shur, the most important Dastgah in Persian traditional music, Dashti, Bayat-e-tork, Abu ata, and Afshari. The last one belongs to Homayun.

A group of musicians believe that this kind of classification is not correct. They claim that if we consider a relationship between Afshari and Shur, then using the same reasons we can relate Nava and Shur too (khaleghi, 1999: 252-253).

However most of musicians have come to an agreement over this kind of classification and therefore we use it in this paper too.

Gusheh: is a general name for each piece of Dastgah's reparatory. Each Dastgah has a different number of Gusheh. Gushehs have different lengths, different weights, and different roles. Some of them offer melodic ideas for improvisation beginning and some for its end. There are some Gushehs that are not mentioned in any Radif versions but are used widely in folklore performances. Some Gushehs are used in some regional parts of Iran and have been unknown for the other parts. Some Gushehs are created during the composing process.

Daramad: Daramad is a Gusheh by which a Dastgah begins. Daramad is the most important Gusheh in every Dastgah and presents the main idea of that Dastgah. Proceeding Gushehs have different modes from Daramad (Farhat, 2007: 46). For the finishing piece (Forud) we have to return back to this idea.

Tetra-chord: Persian traditional music despite its western form is not based on firm scales. In order to show Dastgah characteristics, we make use of concepts like tetra-chords and in some cases penta-chord.

Final: Final's role is like tonic note in western music definition. A Piece ends in Final. Final doesn't appear necessarily in the beginning, it indicates the place where a piece character is going to be introduced or recalled. All the other tones in a mode are described in relation with Final.

Aqaz (begin): aqaz is a note where improvisation starts. (Farhat, 2007: 49).

Ist (stop): In some special cases instead of ending in Final the tune pauses on Ist. This ending is temporary and at last the tune returns to its Final (Farhat, 2007: 49).

Shahed: In most of the Persian modes this note has a different more important role than he other notes. It can be the same as Final or not. We call it Shahed (Farhat, 2007: 49).

Moteqaier (variant): There is a varying note in some modes. For example in some modes Eb and Ep appear alternatively. These notes should not be mixed up with third degree below the Final which it's pitch rises less than a semi-tone when it's going to resolve on second degree below the Final and then on Final (Farhat, 2007: 49).

Forud: Forud is a melodic cadence with a constant pattern which varies in each improvisation. In a Dastgah, Forud plays an important role (it can have numerous patterns). Forud is the joint element of different Gushehs, while most of them have independent modes. In some cases Forud is the unique methode for relating *Gusheh*s in a *Dastgah.* This is why Gushehs are gathered under a unique name. Foruds can be as short as several notes or as long as an independent Gusheh (Farhat, 2007: 50).

Oj: The traditional method of using Gushehs in Dastgah is from low-pitched to high-pitched. Therefore Daramad is in first tetra-chord. When pitch rises gradually to its highest range it is Called Oj. Oj literally means the maximum point.

Microtone: when an interval is less than a semitone it is called microtone. This kind of interval is not used in Persian traditional music alone but an interval may rise or lower by a microtone (Farhat, 2007: 51).

Coron: a symbol that lowers the pitch of a note by a microtone. We show it by "p" like Ep as Mi coron.[9]

Sharp and **Flat**: these terms are similar to western music we show them by "#" and "b".

Pish-dang: is a tetra-chord which is preceding the first tetra-chord.

Pas-dang: is a tetra-chord which is preceding the second tetra-chord.

Naghme: literally means a musical piece, we use it to indicate our generated music.

Choosing state space:

In order to have a smaller state space which leads in to a more rapid analysis and a faster procedure, though Avazes have too short lengths, we had to select a Dastgah in Radif.This Dastgah must contain all the characteristics of the traditional Persian music spirit and accent, in this way, Mahur and Homayun with their similarities to the western major and minor scales are ignored (khaleghi, 1999: 305). Rast-panjgah is more appropriate for modulation and doesn't have a unique spirit (khaleghi, 1999: 303). Therefore we selected Shur, Segah, and Chahargah.

Among these three Dastgah, Shur is the most important and the most expended Dastgah which reflects the best the Persian music spirit. It is said that Iranians who are not familiar with any kind of traditional music, murmur in Shur either.Shur is known as the mother of tunes in Persian traditional music.

So, we selected Shur as our state space. Shur divides into two ranges itself: low-pitched and high-

[9] Also we have Sori, which is a symbol that raises the pitch of a note by a microtone. We show it by ">" like E> as Mi Sori. this accidental is not used in this paper

pitched. Low-pictched part and high-pitched part are very similar in movement so we decided to choose low-pitched which is more expended already. Also Shur has rhythmic Gushes, however these are pieces that are generated just using ideas and concept which are shown in non-rhytmic parts.

So we ignore all rhythmic parts and concentrate over none-rhytmic, low-pitched parts of Shur.

G Shur tone range and role:

Pish-dang= Bp C D Ep F G

First tetra-chord=F G Ap Bb C Dp

Second tetra-chord=C Dp Eb F G Ab (Ap)

Pas-dang=G Ab (Ap) Bb C Dp

Daramad to Rahab are in first tetra chord in these range Ap is Shahed and F is the Ist.

In Salmak and Oj shahed changes to C.

Shahed in Gharache range is Eb and C is the Ist.

Shahed in Razavi range is F and C is the Ist.

Shahed in Hoseini range is G and C is the Ist.

F is the Aqaz note.

Dp is the Motaqier note.

Building fitness function by finding Radif rules:

Sentence analysis:

Daramad:

Daramad is the first Gusheh of Shur and it reveals the spirit of Dastgah and introduces new notes to the listeners.

1. Plays on Final and Shahed, uses a passage from first degree below Final to third degree above the Final to stabilize[10] Shur spirit. This passage or similar passages are essential to make listeners' ears familiar with the accent of Shur.
2. As completing first sentence it shows the third degree[11] tone.
3. Shows last note of first tetra-chord, hesitates a bit more on second degree, and come back to Final by a melodic form which is shown in the next step.
4. Completes third sentence, with a bit more emphasize on 4th degree.
5. It's like third and 4th sentence, but emphasize goes to all degrees of first tetra-chord.
6. Emphasizing on all degrees of first tetra-chord, and sounds Shahed and in this case the leading-tone for Final.

[10] When we say a tone or a spirit is stabilized we mean that it is familiar to listener's ear

[11] When not mentioned above the final or below the final we mean above the final.

7. Preparing for a Forud by emphasizing on F (the aqaz that shows Shur spirit) and G (Final) return to G by a perfect fourth jump. This kind of returning to Final is common in Persian traditional music and is called “bird wing”.

Panje-she’ri:

Panje-she’ri is in fact a second Daramad for Shur

1. It’s like first sentence of Daramad and the difference is about its emphasize on third degree tone of first tetra-chord, since in the following sentence third degree is the note which the most emphasize will be over it.

2. For the first time hesitation goes on third degree of first tetra-chord. This is done by using a pattern similar to previous sentence (like a serial counterpoint).

3. Hesitates on Final to bring back the previous spirit, which is going to be forgotten when the new tone is heard. A rapid return to a stabilized spirit after using none stabilized tone is a normal form in Persian traditional music.

4. Sentence 4 is just the same as what is heard in Daramad until the end of Gusheh.

Kereshme:

Generally Kereshme is a type of Gusheh which is much more free and it uses some ranges that are not familiarized yet.

1. Up to here, Shur spirit and important tones like Shahed and Final are introduced. In the following part the rest of notes will be shown.

So a melodic pattern begins with these tones and spirits, in second sentence this pattern continues to third sentence where a short emphasize goes on 4th degree of first tetra-chord, which returns rapidly in third sentence to the start pattern. Now listener’s ears are ready for emphasizing on 4th degree.

2. Sentences 5, 6, and 7 follow preceding patterns.

3. In sentences 8 and 9 emphasizing on 4th degree completes.

4. After making a so called Oj in previous sentences with a known pattern, it returns to third and second degree and at last with a continuous movement which breaks rhythmic spirit of Gusheh to the Final.

5. Sentences 11, 12, and 13 are exactly like sentences 5, 6, and 7 to fade away Oj spirit.

6. Sentences 14 to 16 are melodic movements to show some available intervals.

7. The last two sentences are exactly like Daramad.

Rahab:

Rahab is the 4th and the last Daramad for Shur. It doesn’t introduce new things; it just indicates new patterns to be used in what is shown in the preceding Gushehs,

1. First and second sentences show two melodic ideas which can be used to go from Shahed to Final.

2. Third sentence is a melodic pattern which is repeated to make it familiar, since this pattern would be used in the following sentences.

3. Using the introduced pattern in the third sentence from 4th sentence to the end of Gusheh, we make use of other tones of tetra-chord: first on second degree, then 4th, then third, and after all on Final.

Oj:

Second tetra-chord is heard in Oj for the first time. Please note that it is a type of Gusheh and should not be confused with the concept of Oj in Persian traditional music.

In Oj, Ap is still the leading-tone but Shahed changes to C. Also, in Oj, Bb introduce as an “rest point” for Forud.

1. Introduces C and immediately returns to F for preserving the spirit.

2. After introducing C, with a similar pattern, goes to C and doesn’t return. This movement stabilizes

the C tone.

3. Returns to Final with a melodic pattern in which the most emphasize is on C. Now, we return back to our previous spirit, knowing that a new note is also added to what we had before.

4. Now, in sentences 4 and 5 we introduce C as a Shahed of Gusheh .

5. Introduces Bb, the third degree, as a rest point for Forud.

6. Again, goes to C, Gusheh's Shahed, not for an introduction purpose, but for a commonly usage of this tone. In another words, after introducing all essential notes, from this point we can start using them to show the melodic idea.

7. In sentences 9, 10, and 11, it shows a melodic idea for Forud.

8. In sentences 12 and 13, it returns to the leading-tone and then to the Final.

Mollanaazi:

Mollanazi is a melodic Gusheh which uses the introduced idea to form a piece.

1. Emphasizing on C, Bb, and A, it shows an idea which is similar to what we have in Daramad. It is used for utilizing tetra-chord range in a downward movement.

2. Second and third sentences suggest a melodic idea for Final in which F and C are heard more. F is for preserving Shur's spirit and C is Gusheh's Shahed.

3. Sentences 4, 5, and 6, start a Forud by emphasizing on Bb and moving toward Ap and C.

Naghme-ie-avval and **naghme-ie-dovvom**:

These two Gushehs are only melodic. They only use introduced items to suggest ideas that can be used in improvisation

Zirkesh-e-salmak:

Zirkesh-e-salmak is used for Forud,

1. First three sentences present a pattern in which the pitch of third degree below the Final rises by a microtone to make a better Forud on Final.

2. Second three sentences are just like the first three sentences, except that the second group is a bit different in the number of notes and the way they are used.

3. Sentences 7 to 11 are like the first three sentences. Their movement through Final is straighter and its elements are longer.

4. Also sentences 12 to 15 are used for Forud, their difference is in using F in Forud procedure.

5. The 16th sentence's form is like its previous 3 sentences and together with the last three sentences it forms a complete Forud.

Salmak:

Salmak is more like an Oj and introduces a few more new concepts.

1. The first three sentences are used to reach C, in this way F, the third degree of the second tetra-chord, and Eb, the second degree of the second tetra-chord is shown, but this does not make them familiar.

2. Sentences 4 to 8 suggest two melodic ideas for Forud.

Golriz:

Golriz is a Gusheh for entering into Hoseini from Daramad range. In Hoseini Ap lowers using Microtone and Shahed and Ist changes.

1. Sentences 1 to 5 are a simple Forud to Final.

2. Sentences 6 and 7 are a passage for entering into Hoseini tone. This is done by lowering Ap with the help of a microtone, and stopping on Hoseini's Shahed.

3. 8th sentence stabilized the Shahed.

4. Sentences 9 and 10 prepare the mode for the last Forud.

5. The 11th sentence using a prepared passage in the two latest sentences goes toward C which is Hoseini's Ist

6. Then it moves toward Hoseini's Shahed.

Majles-Afruz:

Majles-Afruz is a rhythmic Gusheh to stabilize Hoseini and to return to Daramad range.

1. The First five notes use a rhythmic pattern and emphasize on stabilization of Hoseini.
2. Sentences 4, 5, and 6 Introduce F and stop on G, which is Hoseini's Shahed.
3. Sentence 7 is an important passage to return back from Hoseini to Daramad range.

Ozzal:

Ozzal is for introducing Pish-dang.

1. In the first sentence, it introduces pish-dang.
2. But in the rest of Gusheh, it doesn't have anything new and just repeats the previous patterns.

Safa:

Safa is for entering to Hoseini's Oj from Daramad.

1. The first two sentences just remind the Pish-dang spirit.
2. Emphasizing on Eb and F together with rising Ab by a microtone, it moves toward Hoseini's oj.

Bozorg:

Bozorg is for entering Razavi. From this Gusheh, movement toward Final Forud begins.

1. Using F, Razavi's Shahed, exactly after G which is Hoseini's Shahed, in the first 6 sentences, it prepares the spirit for entering into Razavi.
2. Making use of a passage it completely enters into Razavi and stops on C to make a cadence-like for Kuchak.

Kuchak:

Kuchak goes from Razavi to Hoseini.

1. The first two sentences emphasize on F to stabilize Razavi's spirit.
2. The third and the forth sentences prepare the spirit for entering into Hoseini.
3. Last sentence is the common way for moving toward Hoseini.

Do-beyti:

Do-beyti is a melodic Gusheh in Hoseini:

1. The First sentence emphasize on Hoseini's G, also on F to form an accent.
2. From the second sentence up to the end, it moves toward C to make a cadence-like for the beginning of Khara.

Khara:

Khara is just like Do-beyti but in Razavi.

Qajar:

1. In the first sentence it moves toward C which is Oj's Shahed.
2. The next two sentences are similar, but they do this from G despite the first sentence which moves from F.
3. Moves toward G to complete Forud in Hazin

Hazin:

1. The first four sentences stabilized Oj's Shahed.
2. In the next two sentences it pauses on Bb to prepare Forud.

3. In the last sentences it completes Forud by rising Dp using a microtone.

Rules derived from sentence analyzing:

1. For introducing Shur's spirit to the listener's ears, we should use a passage containing F and Bb.
2. We can only use a note after familiarizing and stabilizing it.
3. We can only stabilize a note after shortly intrducing it.
4. If we pauses and/or emphasize on a non-stabilized note, we should rapidly show the last familiar spirit again.
5. To stabilize a newly used note we can use sentences with the same melodic patterns, like the ones that are before the sentence which contains this note.
6. Pausing on a previously introduced note stabilizes it.
7. For performing the last Forud we have two basic methods: firstly, to raise the pitch of a third degree down of Final using a Microtone or secondly, to use a descending jump from Bb to G. Using Final as the last note will have the same result but not as impressing as these two methods.
8. For preparing a better Forud, sometimes the melody has to pause on Bb.
9. A Dorrab[12] in a sentence or a passage beginning gives a more emphasized sentence or passage. It is used in the passages that are designed to introduce or recall the accent or spirit of Dastgah.

Functions derived from the obtained rules:

Shownfirmsearch (generated naghme, population index, desired note):

This function searches throughout the entire generated naghme and locates the places where each note is introduced, stabilized, and/or used. It uses rule 6 to find out these terms

This function is used to simulate rules 2, 3, 6, 7, and 8.

Passagesearch (generated naghme, population index, desired notes, passage range):

This function searches throughout the entire generated naghme, and finds passages containing given notes. It also gives ascending or descending order of passage and indicates the first note's plucking method.

This function is used to simulate rules 1, 7, and 9.

Melodyformsearch (generated naghme, population index, desired sentence, beginning, and end index of desired passage in sentence):

This function searches throughout the entire generated naghme, and finds the passages which are similar to the given passage.

This function is used in shownfirmsearch () function to simulate rules 4 and 5. Due to the limited processing power of the PC in which the program runs, and a need for a higher processing power, this function is omitted and rules 4 and 5 are ignored.

Ojforudsearch (accidental input):

This function analyzes accidental input and output where a forud is likely to happen.

This function is used to simulate rules 7, and 8.

Other functions:

RDBbuilder (input radif data file):

[12] A plucking technic in which a note's length is divided into three parts and played together, the three particle durations are ¼, ¼, and ½ of its original length.

Because of the Persian music special notation, a coding char was written to encode Radif's note to codes that is possible for a machin to compile. This function builds Radif database from radif data file.

RDBsearch (desired note, radif database, note length)

This function searches throughout the Radif database and outputs Dastgahs, Gushes, and sentences in which a note with a desired note length exists. By considering zero as the desired note length, this function ignores note length filter for founded items.

Sequence (generated naghme, population, tempo), playit (note value, tempo), and FC (note value):

These functions are written for sampling an approximate audible output for the best fitted generation. This output is just for estimating the real output. The actual outputs of this program are notes that should be played by a Setar player.

Reproducing functions:

Elit (generated naghme, elite factor):

This function copies the best fitted members of the current generation to next generation.

Crossover (generated naghme, elite factor, crossover factor)

This function crosses over the best members of the current generation to reproduce the next generation. These are the members that are not as proper as the other members which have been copied in to the next generation,

Mutate (generated naghme, elite factor, crossover factor, radif database, accidental input length)

This function mutates remaining members and copies mutated members in to the next generation.

Correctfitness (generated naghme, radif data base, accidental input) and Fitnesscheck (generated naghme)

These functions are written for generating fitness report of the current generation to work with a genetic algorithm.

Making an accidental input from a real world:

In order to provide an accidental input firstly, we take a wave sound and import its frequencies (for making a suitable pattern for our special case we make use of the absolute values of the frequencies):

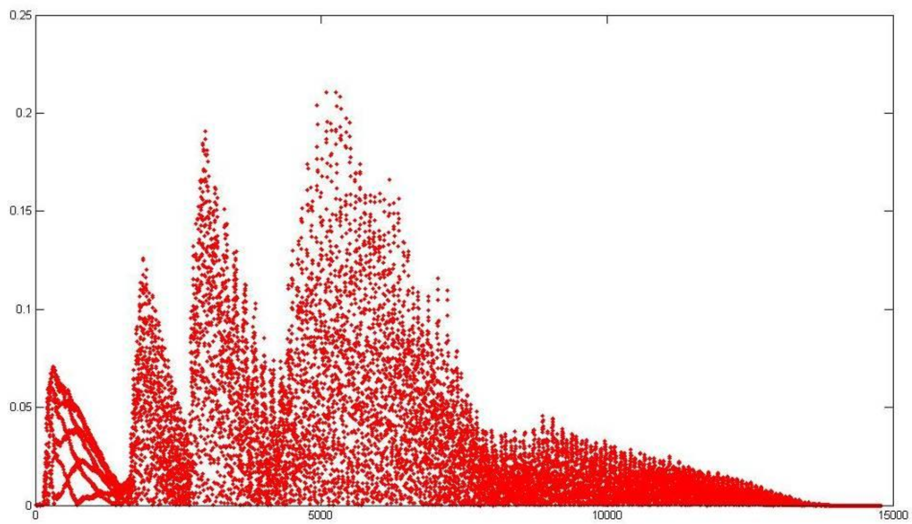

Figure 35

Then in an assumed range of frequencies we fit the values to the maximum points.

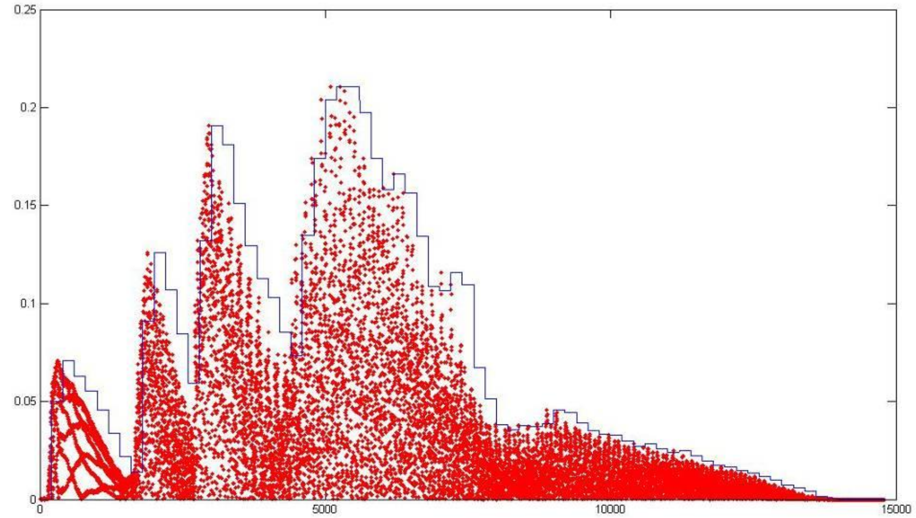

Figure 36

Then we use an algorithm which is similar to the first-order hold algorithm, in order to calculate the plotted values in figure 3 and 4.

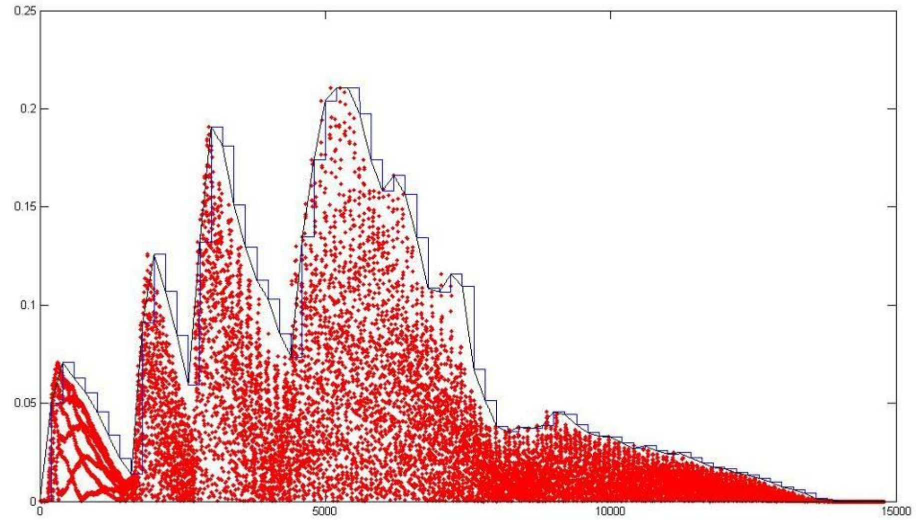

Figure 37

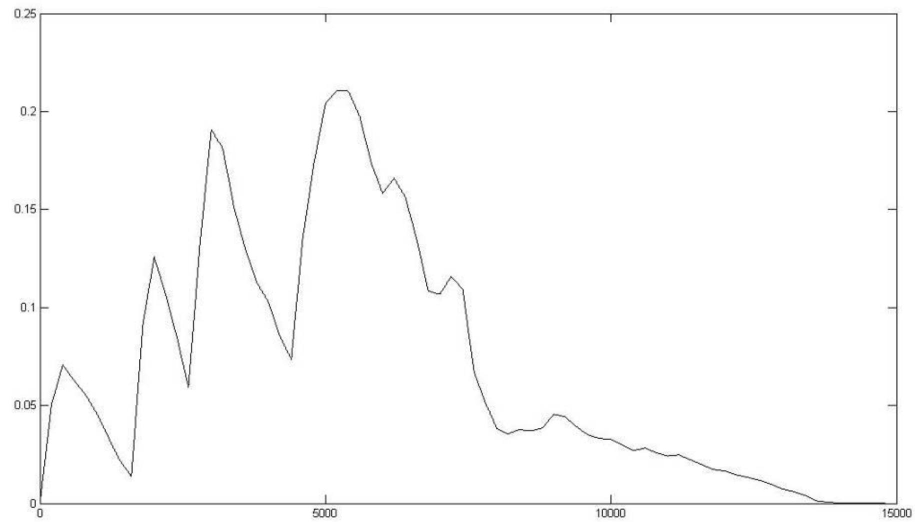

Figure 38

These values make our input pattern. In order to produce the first generation, we scaled these values to a special range of frequencies that our available notes which are founded in Radif database were able to support them.

Then, through determining the length of our output, we scale the accidental input length. Now each produced value indicates the note that must be picked up at each moment. For having a more effective randomize selection of an assumed note we can choose it from a range of determined notes in which there are two more notes with higher and lower pitches. Now, we randomly select a note out of these three notes.

In the next step, we looked for sentences inside our database that were containing this note. At last we accidently selected a sentence and added it to our generated input.

Aesthetics:

Since, there is not a defined term for aesthetic analysis in traditional Persian music, to analyise a piece of music, it is common that somone with a trained ear listens to the composed piece and judges it is how far or how near to the traditional persian music. As well we had followed a same method here and asked a proffesionall Setar (an Iranian instrument) player to hear generated pieces. As a result, it was said that generated pieces are similar to improvisitions which were heard before. And also some kinds of movements are found in generated pieces that were not heard before.

Unfortunately, due to the low proccessing speed of the computer used for running the program, none of the generated pieces reached to the global optimum state.

References:

1. Tala'i, Dariush (2000), ***The Radif of Persian Traditional Music: Radif of Mirza Abdollah., Pedagogical and Analytical Notation***, third edition, mahur institute of culture and art, Tehran.
2. Farhat, Hormoz (2007), ***The Dastgah Concept in Persian Music***, third edition, Part publication, Tehran.
3. Khaleghi, Ruhollah (1999), ***An approach to music*****,** fifth edition, mehvar publications, Tehran.

4. Nettl, Bruno and Carol M. Babiracki (1992), ***The Radif of Persian Music: Studies of Structure and Cultural Context***, revised edition, Elephant & Cats, Indiana University.

Appendix a: Note coding

1.**Length**	#	2.**note**	#	3.**accidental**	#	4.**octave**	#
Whole tone	1	A	1	Natural	1	1 (A=55Hz)	1
half note	2	B	2	Flat	2	2 (A=110Hz)	2
quarter note	3	C	3	Sharp	3	3 (A=220Hz)	3
eighth note	4	D	4	Coron	4	4 (A=440Hz)	4
sixteenth note	5	E	5	Sori	5	5 (A=880Hz)	5
thirty-second note	6	F	6	Double bemol	6	6 (A=1760Hz)	6
sixty-fourth note	7	G	7	Double sori	7	7 (A=3520Hz)	7

5.**Plucking**	#	6.**Articulation**	#	7.**Articulation**	#	8.**First articulation accidental**	#	9.**Second articulation accidental**	#
....	1	>	1	>>	1	Natural	1	Natural	1
...	2	Tr	2	<<	2	Flat	2	Flat	2
..	3	.	3	Π	3	Sharp	3	Sharp	3
				U	4	Coron	4	Coron	4
				>>.	5	Sori	5	Sori	5
				.>	6	Double bemol	6	Double bemol	6
						Double sori	7	Double sori	7

Etc.	#
Dastgah	$
Gushe	+
Sentence (begining and end)	/
Note (begining and end	-
Repeat beginning	*2
Repeat end	*

Example: first sentence of Daramad of Shur:

$1+1.1/-461330000-471300000-414400000-422400000-*2-414400120-471300000-*-414400210-514400000-414400210-271310000-/

Appendix b: A sample output

541400000-552400000-541400000-552400000-541400000-552400000-541400000-552400000-
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Fractal house and heritage

Mounjia Abdeltif

Laboratory VUDD
National Superior School of Architecture of Algiers, Algeria

Abstract:

Twentieth century was a failure in matter of architecture and urban design in Algeria and particularly in Algiers, the capital. “Modernist” principles were experienced by French colonizers everywhere. Unfortunately, they are revealing many problems caused by disconnection, simplification, reduction and lack of complexity. Sprawled urban territory has made neighbourhoods non liveable spaces: quality of life disappeared completely. Now very serious social problems are emerging and development cannot take place.

Scientists are changing their ways of thinking and many new methods are being tested. All fields are working as teams and trying to share new ideas about managing cities and use sustainable development principles.

In our thesis, while observing heritage architecture (a restored eighteenth century house), we found out that it was designed with a strong analogy to laws of nature and cosmology. Magic square, peer and odd numbers, golden number, golden proportions, connections to cosmos and relation to human body structure characterize this architecture. Body and spirit, it is actually alive and durable. Three century old, it is still comfortable. Spaces are in right measure, optimizing and allow many different uses over time. Mathematical beauty and fractal geometry could be demonstrated. Symmetry of scale, iterations, high level of complexity and harmony between parts (holistic method) appear through observation. Finding the whole in a part (the city in the house) is not a common thing today. This house is typical and unique: it **belongs** to this particular city. Like a living cell or a galaxy, it looks like a sponge, a lung or a bone. It is part of universe; it is understandable through new sciences that are emerging in this starting century.

While talking about natural organisms, we found out that columns in the heart of the house have screwed forms. They recall DNA molecule. Rooms around centre have a spiral arrangement. Tiles also show spiral forms, etc. We find also numbers of Fibonacci (series) that are present in many flowers or fruits and DNA. Our house is mathematically definitely alive and sustainable.

Keywords: Complexity, fractals, belonging, geometry, sustainability, heritage, emergence.

Theoretical framework

In order to be able to understand the complexity of heritage architecture, we had to look for modern sciences that are helpful and efficient. Among them, fractal theory (Benoit Mandelbrot, 1980) or fractal geometry has the advantage to correspond totally to our objectives. This new vision of the world makes us put aside Euclidian geometry which is limitative and insufficient. Instead of dimensions 1, 2 and 3 only, fractals use fractions. Objects could have dimensions between 1 and 2, or between 2 and 3. Benoit Mandelbrot, in the eighties, wrote a book where he explained complexity of natural forms and using computer science, he could modelize them and talk about particular kind of dimensions (Sierpinsky carpet, “flocon de Koch”, etc). The mathematician Karl Menger has invented the model called “Menger’s sponge” (dimension, 2, 7). This model is a process of infinite iterations of centers (fig. 1). Volume tends to zero and surface tends to infinite (fig. 3). Cube is the most stable form of all (fig. 2). In this paper we will be working with this object in order to demonstrate numerous properties of traditional house in Algiers.

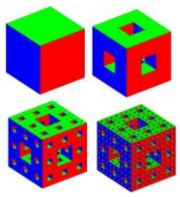


Fig. 1

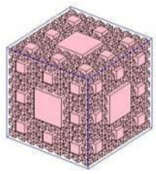


Fig. 2

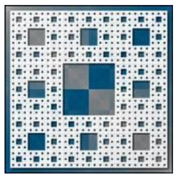


Fig. 3

Problematic

Today, throughout the scientific world, researchers are strongly concerned with urban renewal related to sustainable development. They are trying to find new strategies and new methodologies in order to solve crisis at several levels. Cities are growing in all directions without any limit and quality of life is decreasing fast. Urban landscape is no longer manageable and its development can’t be predictable. Hopefully, people have understood, now, that cities, as complex systems, have to be organized through complexity. “New” sciences have emerged since the birth of computer science. Scientists are convinced that all fields of knowledge have to be connected and have to work together, aiming to solve problems. Mathematics and philosophy are coming back and helping in this quest. In Algeria, one hundred and thirty two years of colonization have destroyed a whole society. Algerian people have lost identity and culture. Today, they lack references when they try to build cities and architecture. They borrow occidental models and think that they represent modernity. Unfortunately, they are wrong models, completely inadequate and based on simplified patterns which don’t have any qualities for the future. Urgency for housing is a pretext. People have been building huge sets of buildings that are destroying natural landscape and causing an ecological disaster. Units are very expensive and are not sustainable. At the beginning, when a family finds a housing unit to live in (fig. 4), every body is happy. A few years later, family members are separated, every day life is unbearable, elevators are always broken and socio-psychological diseases

appear slowly. Actually, we don't know how to build habitable neighbourhoods. New landscapes are composed of collective housing (fig. 5) or individual houses that are expensive but without any convenience or architectural quality. Old city is no longer habitable and French city is so expensive that offices and shopping activities are concentrated there. We call it: "city centre" because it is the only part that have urban wholeness, architectural significance and intelligible language. There is a positive feeling there. It is the only urban qualitative place today for public life.
In the universities, scientists are thinking about new strategies but there is a big gap between theory and practice. Politics and inhabitants are disconnected. It is very difficult to build ethical laws in these conditions. Hopefully, researchers are mobilizing energies and research teams are working hard to make sustainable solutions emerge progressively.
The only place where it is possible to find complex, ecological, ethical, aesthetical, optimized architecture is heritage. Many properties are not revealed yet but a lot of architects are searching. Until now, astonishing qualities are showing that cities of the past are the best lesson of architecture and excellent resources for learning about sustainability, efficiency, optimized systems, high environmental qualities, cultural balance, spirituality, durable patterns, social timeless rules and beauty. We decided to penetrate that period of history where society was civilized and knew how to dwell, to build and to be. Through valuable traces, we tried to dig deeply looking for the essential which is not visible with the eyes. Treasures for the future are certainly in timeless lost pattern languages rooted in eternal tradition and wise modernity.

Fig. 4

Fig. 5

In order to expose the most important properties of Algerian heritage, we will choose Algiers, the capital in the Ottoman era (18° century). After a big earthquake, in 1715, the destroyed city was rebuilt almost entirely. The whole city grew on the base of specific rules that generated a particular architectural language. All houses followed the same rules but took local forms according to the site place. At that time the large system of Algiers was composed of two sub systems: The compact mineral city and the spread out vegetal city (network of gardens), both visually connected (fig. 6).

Fig. 6

Fig. 7

The two systems were so connected that it was impossible to separate them. Very often, the owner of a house in mineral city (winter house) had a second (summer house) inside a garden (fig. 7). The house that we are presenting is in this case: “Dar” Abdeltif. “Dar” in Arabic means large house. This word comes from the verb: “daara” which means “to turn”. “Daira” means circle. Therefore, each house is based on a “movement” around a centre.

Conceptual study through eleven properties:

Remark: we will be noticing that these eleven properties are strongly linked inside a set of systems. No separateness makes this house more complex than others.

3. 1. **The turning house:**

Several aspects show the spiral or helix movement. T-shaped rooms are arranged in spiral form around a courtyard. Between the court yard and rooms, there is a gallery with arcades. Arcades are punctuated with twisted columns (fig.8). On the top of the capital of each column, there are eight spirals (fig. 8). Spirals are sculpted on doors and recall the form of the plan (fig. 9). Some of the ceramic tiles have a spiral design on them. Spiral is a very old famous form chosen to express beauty. It comes from natural forms (snails, galaxies, sun flower (fig. 11), pine apple) and could be constructed with golden number (1, 618) and “suite” of Fibonacci (mathematician). Twisted columns are analogous to DNA molecule (fig. 10). This remarks show the high level of aesthetical value of people at that time. They used to use science of nature at all scales in the way of building. Also, Muslims during the pilgrimage turn seven times around the “Kaaba” (tawaf, fig. 40). From macro to micro scale, the spiral has been structuring the dynamical aliveness. Ethics and aesthetics meet.

Fig. 8

Fig. 9

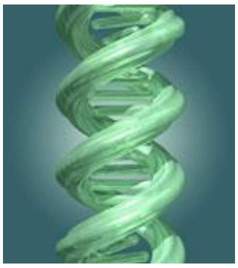


Fig. 10

Fig. 11

3. 2. **The house “cube”:**

All houses at that time are designed basically as cubes. This form is symbolic. The “Kaaba” (fig. 12) in the “haram” of Mecca is a cube and the centre of all Dar el Islam. The cube is a non separable form. The center of islamic houses in North Africa is an empty cube. The void IS the most important part of the house and the center of interest.

3. 3. **The courtyard house:**

All houses have a heart (fig. 13) or center called “west ed dar”. It is analogous to spiritual place in Mecca. In nature (micro scale) we find centralized forms (algae (fig. 14), digit (fig. 15)). Architecture is inspiring. Builders were observing nature. This courtyard is the most important connector in this highly complex architecture. Galleries connect all the spaces of the house to the courtyard. This element doesn’t exist systematically in houses of Islamic territory elsewhere (Tunisia and Morocco, sometimes there are no galleries around the courtyard).

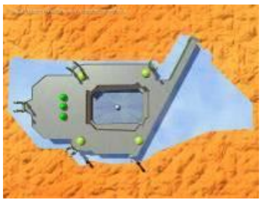



Fig. 12 Fig. 13 Fig. 14 Fig. 15

3. 4. **The house "sponge":**

The natural sponge (fig. 16) is a soft "body" full of voids. With this kind of structure, it attracts water and absorbs it. Interior surface is infinite even if the volume is small. The model of Karl Menger describes the natural organism. This traditional house has the properties of this model. It is organized on the basis of interrelated cavities (fig. 17).




Fig. 16 Fig. 17 Fig. 18 Fig. 19

In summer, when temperature is very high, this house, with such an interior complex form, makes air circulate efficiently, get hot while rising towards curved ceilings (fig. 18) and finally gets out from small openings (fig. 18 and 19). Water works in natural sponge, air works in house. No need for air conditioning here. When it is 40° C outside, inside it is around 18° C. Energy is saved and space is well arranged.

3. 5. **The house "bone":**

Bone is spongious (fig. 20) even if it looks tough. Inside it is full of voids (fig. 21) while rather strong. The structure is highly complex. Our house has also a strong thick wall as a protective skin and is full of compartments or cavities. It looks like an interior sculpture.

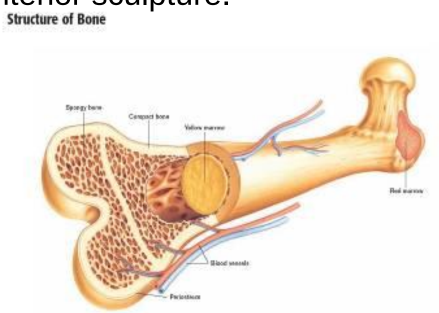


Fig. 20

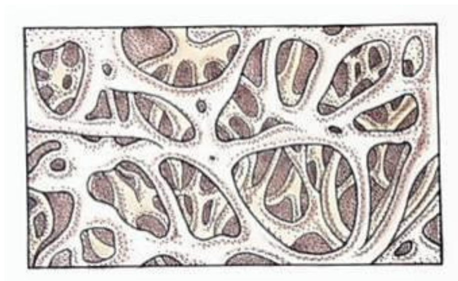


Fig. 21

"In all things, perfection is finally attained not when there is nothing to add, but when there is nothing to take away." Antoine de St Exupery.

3. 6. **The cosmic house:**

Keith Critchlow, in "Islamic Patterns", explains all the cosmological approach of islamic philosophy that generated arts. In Islam, art and architecture are not separable. He shows magic squares (fig. 22) of all orders. Our house is conceived on order 3. Magic square and Menger's sponge are related. The form has a center and numbers. On the cross, numbers are odd and on the four angles they are even. In sacred book (Qur'an) odd numbers are magics. Five is very special: Five pilars of islam, five daily prayers, five fingers in members, five openings in face, five senses, etc. Five is in the center. We have found (in our Phd research) that all courtyards measure 1/5° of the surface of the house. It is a specific rule. 1, 3, 7 and 9 turn around five. Each number has a historical and cosmical meaning. Magic squares are very old (India, China, thousands years old). Islamic civilization took a lot from what existed before (mesopotamian, Indian, Greek) and added its own amount of science and knowledge (El Khawarizmi invented algorithms that are used to generate fractals figures today, fractions, and algebra). When genius people were building such houses, they had a high level of spirituality and some of them were practicing 'tassawouf" which is a mystical attitude. Twentieth century has eradicated this religious behaviour especially in colonized countries. In all fields, a tendancy to simplification arouse. Today, people are becoming aware of the lack of spirituality. We notice that it is emerging again everywhere in the world.

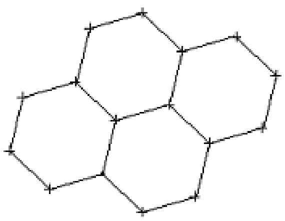
2	7	6	→ 15
9	5	1	→ 15
4	3	8	→ 15

15 ↙ ↓ 15 ↓ 15 ↓ 15 ↘ 15

Fig. 22

3. 7**. The natural house:**

In this house, the floor of the courtyard is built with hexagonal marble pieces. It is an analogy to honey bee design (fig. 23). Buiders name it "periodic" pavage. It is an optimization of the use of the material. It is interesting to think about: "why bees construct hexagonal cavities for honey (fig. 24), eggs or pollen storage" (fig. 25)? For sure it has a very smart explanation.(In Qur'an there is a whole sourate about bees.) This truth was noticed by mathematician Pappus in the antiquity. Ethics and aesthetics meet.



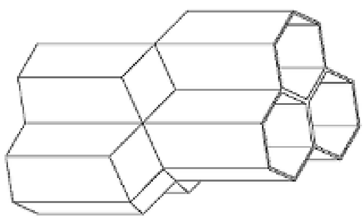


Fig. 23 Fig. 24 Fig. 25

3. 8. **The optimized house:**

In the whole house, we could not find a millimeter of unuseful or negative space. Three- dimensional design makes this house intelligent. Every thing is at the right place. Complexity makes all places connected and intelligible. Remarkable strengh is in all connectors: galleries, entrance room, stair cases, porch, and centers at all levels. These "in between" makes the inner quality of such a design. A huge energy goes from the courtyard towards all rooms. These rooms are complex: they can allow a family to inhabit. They are kinds of small appartments (T shaped in order to design a center that is connected to the courtyard). Storage spaces are inside walls or in stairs volume. The amount of variable daylight is regulated with the center. Rooms are not too deep. They receive sunlight from all sides. Christopher Alexander (1979) talks about the quality without a name, in his book, “The Timeless Way of Building” (1979). Actually, every property added to the other one makes a very strong system of interrelated phenomenons. It is this situation that gives us the sensation of beauty.

3. 9. **The spacious house:**

Since surface tends to infinite whatever the volume could be, it is a sensation of unfolding inside each space (fig. 27, 28, 29, 30). We could imagine a mental morphogenesis where the whole precedes parts like in the embryo. Inside the body, after the enveloppe, heart is the first important step. Then each part, autonomous and also a whole itself, will grow depending to the whole and other parts. DNA gives all informations. Every thing is registered there. In one special house, all parts are special but they use laws of all houses in this city. The part is inside the whole and the whole is inside the part (fig. 26).


Fig. 26


Fig. 27


Fig. 28


Fig. 29


Fig. 30

A famous saying of the prophet Muhammed (PBUH) states: “Four secrets of happiness: A good wife, a good neighbour, a spacious house and a good mount”. Besim Hakim (1986, architect and historian) said that spaciousness is a matter of design morphology. In a house where surface grows infinitely, we perceive spaciousness, we feel it. Feeling is essential inside a building. When we talk about a generous person, we say she has a big heart.

3. 10. **The house of interiorities:**

This house system is made only of interiorities. The vegetal city is inside the large city. The garden is inside the vegetal city. The house is inside the garden. The courtyard is inside the house. All parts of the house are ordered according to the symmetry of scales. The concept of belonging is very important in such society. French colonizer destroyed interiority (fig. 31 and 32) as a need and a value. They introduced the occidental concept of exteriority (fig. 33) which did not exist at that time. They broke thick walls to put openings (violation of intimacy). They built new models of architecture and urban organization. After independence (1962), people forgot how to build in adequation with their actual values and needs. They have been valuing intimacy but they continue to copy exteriority (fig. 34) of the colonizer, even if they still inhabit the interior of the house. In traditional houses, the façade is inside. Four walls are richly decorated with ceramic tiles and galleries are limited with elegant columns. Arches are typical to Algiers. Interior life in comfortable interior spaces made houses contain thousands of activities. The volume evolves inwardly with the family. It is powerful and efficient. It has all qualities of adaptability. It could last three centuries and continue to prove its potency.


Fig. 31


Fig. 32


Fig. 33


Fig. 34

3. 11. **The house lung:**

The lung is a fractal structure (fig. 35). It looks like a complex tree. But it has a remarkable ability: it contracts and expands. Our house, when it is built in compact mineral city where pieces of land are small, keeps its whole language but it contracts. Instead of four galleries we can find three or two or one. The same is for rooms. It is important to mention that a 40m 2 house has the same language as a 600m 2 house in a large property: entrance transition, courtyard, T shaped rooms, galleries, niches and terrace with its room. In a large house, spaces expand, surface increases but principles are kept.

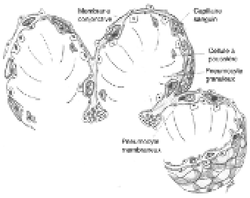


Fig. 35


Fig. 36


Fig. 37


Fig. 38

On the right drawings, one shows contraction and the two others show expansion.
Remark: the universe has been in constant expansion (fig. 39) (Edwin Hubble, 1929) and rotative move (fig. 40).


Fig. 39


Fig 40

Conclusion:

This house symbolizes constant move and it breathes. Air is circulating with convenience. It is sane. People inside are in good health because exchanges can occur in good conditions. The analogy with lung, bone and sponge helps us understand the sustainability in such a complex system. Optimization is one of the most important qualities. Since we can understand this living organism through modern sciences, we have all the tools for the elaboration of future rules in modern architecture. Heritage helps us recover identity and appreciate the work of our ancestors and build our own local building laws. They have to be evolving with expected needs. New technology is not in contradiction with all our reasoning. If we work hard to establish strong ethical specific principles in our territory, we could allow future promises of new aesthetics to emerge. People would not copy randomly other models. They would help appropriate solutions to emerge locally. Globalization would not be frightening anymore. Cultural values have a big impact on architectural forms.

References:

Akbar, J. (1988). Crisis in the Built Environment. New York: A Mimar Book.

Alexander, C. (1978). The Timeless Way of Building. New York: Oxford University Press.

Alexander, C. (1979). A Pattern Language. New York: Oxford University Press.

Burckhard, T. (1985). L'art de l'Islam. Paris: Sindbad.

Chevallier, D. (1979). L'espace Social de la Ville Arabe. Paris : Maisonneuve et Larose.

Critchlow, K. (1976). Islamic Patterns. New York : Thames and Hudson.

Devoux, A. (1988). El-Djezaïr, Histoire d'une Cité, d'Icosium à Alger. Alger: Enag Editions.

Golvin, L. (1988). Palais et Demeures d'Alger à la Periode Ottomane. Alger : Office des Publications Universitaires.

Hakim, B, S. (1986). Arabic-Islamic cities. London: Routledge and Kegan Paul.

Le Corbusier. (1957). La Charte d'Athènes. Poitiers : Editions de Minuit.

Mandelbrot, B. (1999). Les Objets Fractals. Paris : Flammarion.

Missoum, S. (2003). Alger à l'Epoque Ottomane. Alger : INAS.

Morin, E. (2000). Comprendre la Complexité. Paris : Flammarion.

Quillien, J. (2007). Nature of Order, a Personal Interpretation. Santa Fe: Culicidae Architectural Press.

Salingaros, N. (2006). A theory of Architecture. Soligen: Umbau- Verlag.

Shih, G. (1982). Living Images. Boston: Science Book International.

Truth to Process – Evolutionary Art and the Aesthetics of Dynamism

Philip Galanter, BA, MFA
Department of Visualization, Texas A&M University, College Station, Texas, USA
e-mail: galanter@viz.tamu.edu

Abstract

After a great deal of initial promise and enthusiasm, evolutionary art seems to have hit a premature and disappointing plateau. This paper proposes a difficult but necessary program for the advancement of evolutionary art.

First two significant problems are discussed. The first is the problem of creating aesthetic fitness functions that would allow evolutionary art systems to execute unattended with industrial sized populations and generations. In this context a quick survey of computational aesthetic evaluation is offered. Then it is suggested that progress in perceptual psychology and neuroaesthetics, coupled with advancements in connectionist computing, may provides new techniques for scoring aesthetic fitness.

The second problem is the sense of "sameness" and lack of innovation exhibited by typical evolutionary art systems. In this regard the related technical problem of genetic representation is noted, various types of genetic representation are reviewed, and a critique is offered relative to evolution in nature. It is noted that evolution in exercises multiple levels of complexification and emergence.

Finally an implication for generative art aesthetics and theory is discussed. It is suggested that current evolutionary art systems and projects are incoherent in so far as they don't focus on the essential virtue of generative art, i.e. a focus on process rather than final form. It is suggested that the general shift from nouns to verbs that is essential to generative art should be pushed to the fore. An aesthetic of truth to process and dynamism is proposed as foundational for evolutionary art.

1. Introduction

Although computational evolutionary art has been an active practice for at least 20 years [1] there is a vague feeling of disappointment with the present state of the art. Industrial applications of evolutionary methods such as genetic algorithms have tracked the general progress seen in other sectors of computation and technology. But evolutionary art seems to have reached a premature plateau. Improvements in the aesthetics of evolutionary art have been slow, and any headway has frequently been by way of narrow techniques that are not generalizable or extensible.

In terms of technology there are two significant challenges, the problem of aesthetic fitness functions and the problem of genetic representation. But there are also related aesthetic and art-theoretical issues that must be faced as well.

2. Fitness Functions for Art

In industrial applications such as automotive design, electronics, routing optimization, investment, chemical process engineering and so on evolutionary techniques have yielded significant value. A common element is that an a priori fitness function can be defined and applied as part of the iterative algorithm. And so fitness scores can be automatically calculated for each candidate solution. [2]

This allows evolutionary systems to run hundreds or thousands of generations with very large populations. And once the system begins it can run for as long as necessary without human intervention.

Artists face a difficult problem in this regard. How does one define and implement an aesthetic fitness function? Various theories proposing a formulaic approach to aesthetic evaluation have come and gone over the years without much success. Some are skeptical as to whether aesthetics can ever be systematized for human understanding let alone computer implementation.

The typical response is to keep the artist “in the loop.” The artist manually assigns fitness scores as each new generation is created. This approach is usually called “interactive evolutionary computing” or IEC.

Lewis has cataloged a large number of evolutionary art projects with nearly 200 citations. Most of those systems by far are interactive and use some form of case-by-case human judgment to provide fitness scores. [3] This is sometimes called “the fitness bottleneck” because the artist, usually by orders of magnitude, cannot evaluate populations as quickly as the computer can generate them. An additional problem is that the artist’s judgment will become inconsistent due to fatigue and boredom. The result is that compared to industrial applications evolutionary art systems typically suffer from small populations and few generations.

To overcome these fatigue and bottleneck problems Drave’s Electric Sheep system accepts evaluation information from the users of the thousands of computers displaying the results as a screen saver. [4] Earlier Sim’s Galapagos system used the amount of time an observer would spend looking at a given image as a fitness function. While such systems overcome the fitness bottleneck to some extent, the long term aesthetic utility of this approach is open to question. As both demonstrated and satirized by Komar and Melamid, aesthetics derived from polling leads to the unremarkable and mediocre. [5]

2.1 Computational Aesthetic Evaluation

When it comes to IEC one is reminded of the Mechanical Turk. In the 18th century this was described as a machine that could play chess. [6] In reality the Mechanical

Turk was more like stage magic than computation. Despite making a great show of revealing the see-thru machinery supposedly involved, in reality a human operator was hidden inside the cabinet. This operator made all the decisions and won or lost the game. And in an interactive evolutionary computing system there is a hidden artist making all the decisions and winning or losing the aesthetic game.

From one point of view the challenge of computational aesthetic evaluation (CAE) is to create aesthetic fitness functions that can solve the problems presented by IEC. If human evaluation could be eliminated evolutionary art could benefit from the large populations and multiplicity of generations enjoyed by industrial applications.

So far though, computational aesthetic evaluation remains a grand challenge-level problem. For example, attempts to partially solve this problem have been made by Sanders and Gero [7] and Greenfield [8] using agent-based systems; Jaskowski et al [9], Fornari et al [10], and Ciesielski et al [11] using error measurement relative to an exemplar; McDermott et al [12] similarly using perceptual measures, spectral analysis, and low-level comparison to sound targets; and Khalifa and Foster [13] using music theory-based rules.

Various numeric measures as aesthetic indicators have been explored such as Zipf's law (Manaris et al [14]), fractal dimension (Mori et al [15] and Taylor [16]), and various complexity measures (Birkhoff [17], Machado and Cardoso [18]).

Attempts to use connectionist models such as neural networks in computational aesthetic evaluation include Machado et al [19], Phon-Amnuaisuk et al [20], and Gedeon [21].

Some researchers have tried to deal with the fatigue problem by only using human evaluation for a subset of the population. The scores are then leveraged across the entire population based on similarities in the population. Takagi offers a broad overview of attempts to fuse evolutionary computing and interactive evolution computing. He includes both art systems as well as other applications up to 2001 with over 250 citations. [22] More recent reports on hybrid systems for evolutionary art include Yuan and Gong [23], Pallez, Machado et al [24], and Machwe and Parmee [25].

2.2 Connectionism and the Psychology and Neurology of Aesthetics

Despite the above efforts computational aesthetic evaluation remains an unsolved problem. This shouldn't be terribly surprising because we don't know much about how human aesthetic evaluation works either. And this may be a hint as to where future progress will be found.

Significant research is underway by experimental psychologists as reported in journals such as Psychology of Aesthetics, Creativity, and the Arts, Empirical Studies of the Arts, and the Journal of Consciousness Studies. A picture of how human aesthetics works is being assembled piece by piece from the point of view of experimental psychology.

A new addition to such research is the nascent field of neuroaesthetics. Neuroaesthetics is the scientific study of the neurological bases for the creation, experience, and contemplation of works of art. An example of such work is a recent chapter by Martindale where he proposes a general neural network model of aesthetic perception. In support of this model he cites the compatible results of 25 empirical studies of aesthetic perception. [26]

It's important to note that Martindale's model is theoretical and has not been implemented as a computational neural network. But this kind of work may give others ideas and incentive for doing so. As an example of connectionist computing inspired by neurological theory, Hawkins has introduced a new connectionist design he calls "hierarchical temporal memory" (HTM) based on a theory of the neocortex. [27]

The human brain has about 100 billion (10^{11}) neurons each with about 10 thousand (10^4) synaptic connections. In addition there are about 900 billion glial cells in the brain. At one time these cells were thought to be relatively passive. Current thinking, however, is that glial cells also actively process information. Given there are upwards of 10^{15} connections it seems unlikely digital technology will be able to duplicate the mechanics of the brain any time soon.

In this regard it's worth noting that some evolutionary psychologists have hypothesized that our aesthetic capabilities arise from adaptations related to mate selection. In addition, animals with much simpler neurology seem to select mates based on a simple kind of aesthetic evaluation. It may be that computation orders of magnitude less than that exhibited by the human brain will be up to the task.

So perhaps breakthroughs in both the neurology of aesthetics and connectionist computing will synergistically lead to breakthroughs in computational aesthetic evaluation.

3. Aesthetic Sameness and Genetic Representation

The second major technical problem is that of genetic representation. This problem exhibits two related symptoms in evolutionary art. Frequently work from a given evolutionary systems displays a certain sameness or cast that many find disappointing. And as a corollary a given evolutionary system typically will not shift paradigms or otherwise innovate in significant ways.

To be sure such systems can assist in the discovery of surprises, but crossing genres rarely happens if at all. Innovation at the level of a Picasso transitioning from his Blue Period through the Rose, African, and then Cubist periods is not something we see given the current state of evolutionary art technology. Note that this is <u>not</u> an observation about a lack of quality, although there is that as well, but rather a statement about the inability of evolutionary art systems to significantly break aesthetic paradigms at <u>any</u> level of quality.

In nature complexity at higher scales is an emergent property of self-organization at lower scales. This process has been called by some “complexification.” [28] The problem of aesthetic sameness and lack of innovation is due, at least in part, to the lack of complexification capacity found in most evolutionary art systems.

Artists typically have a vague to specific notion of what the desired result is, and then designs an evolutionary system to explore that aesthetic space. In doing so the design of the genetic representation is of meta-significance because it will constrain the space of *all possible* evolutionary paths.

There are at least four kinds of genetic representation and each allows for a greater or lesser degree of complexification.

Fixed parameters offer the simplest kind of genetic representation. For example, in a system for creating drawings of insects there would be a gene for head size, another for body color, another for leg length, and so on. Such a system will always draw six legs, and so it will never draw a spider. A fixed parametric evolutionary system is highly constrained.

Extensible parameters offer a slightly more complicated representation. In an insect drawing system an arbitrary number of leg genes would be allowed, and so spiders and even centipedes could be drawn. But without wing or fin genes the system will never draw birds or fish. And so an extensible parametric system is still tightly constrained.

Direct mechanical representations are more complicated, but allow for a significant increase in complexification. A version for drawing insects would include genes that construct a (typically virtual) drawing machine as well as genes that instruct the drawing machine as to what marks to make. In theory this kind of genetic representation can allow most any picture to be drawn. And mutations in the genes that construct the drawing machine might, for example, turn pencil-like marks into brushed ink-like marks. But the complexification such a system affords is still limited because the genetically constructed machines only exhibit a single level of emergence.

Reproductive mechanical representations are those most like DNA as found in nature. In such a system genes can construct machines that can go on to construct other machines and so on. And indeed such machines may create copies of themselves, i.e. reproduce. Such a system can induce an arbitrary number of levels of emergence across multiple scales. This kind of genetic representation has the potential to provide complexification as found in nature.

A quick review of complexification in nature is useful at this point. (See figure 3.) According to current theories, shortly after the big bang matter self-organized as it settled into lower energy states resulting first in subatomic particles and then atoms. Hydrogen and helium atoms, in turn, diversified and gained mass through fusion within stars. Self-organization then transitioned from the atomic level to the chemical level with the formation of molecules. Some molecules increased their numbers more rapidly than others due to the appearance of yet other molecules acting as catalysts. This process intensified when feedback loops of reactions that produced their own catalysts appeared. Some of these reactions complexified into networks of self-reinforcing catalytic reactions called “autocatalytic sets.” [29]

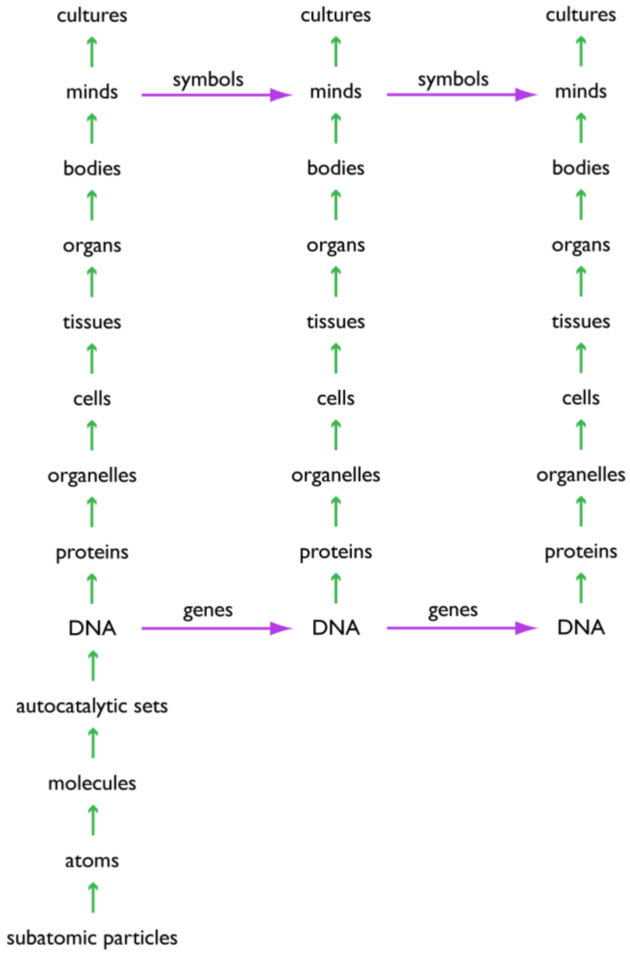


Figure 3

It is hypothesized that out of this sea of autocatalysis arose a primordial form of DNA that had the unique ability to reproduce itself in a way similar to autocatalysis despite the fact that its chemical structure wasn’t fixed. As is now well-known DNA is, in part, made up of sequences of nucleotides that can vary in quantity and order. This created the basis for an extremely robust system of complexification spanning many scales and requiring a number of levels of emergence.

And so there is an upward increase of complexity as DNA creates proteins, proteins organize to create organelles, organelles organize to create cells, cells organize to create tissues, tissues organize to create organs, and organs organize resulting in creatures.

At the level of DNA there is the unique ability to reproduce genes and then kick off a nearly identical sequence of emergence. This results in new living individuals inheriting, with perhaps a little variation, the complexity slowly built up over millions of years.

(It is beyond the scope of this paper to discuss, but it's not until minds capable of symbolic understanding emerge that another mode of inheritance from individual to individual becomes possible. This has suggested to some that evolutionary art systems should generate emergent individuals capable of further information exchange at a higher level).

Like DNA, an evolutionary art system using reproductive mechanical genetic representations would allow for greater complexity because it would allow multiple levels of emergence across multiple scales. And perhaps then evolutionary art systems could then exhibit the wished for variety and innovation we find in nature.

Unfortunately most evolutionary art systems currently utilize fixed or extensible parametric genetic representations, and a few arguably use direct mechanical representations. The creation of evolutionary art systems that use reproductive mechanical representations remains an unsolved problem as a matter of technology. It also presents an interesting art theoretical problem.

4. Dynamism and Truth to Process

As should be clear from the previous section, evolution in nature is a bottom up process. There are multiple levels of emergence at increasing scales. And this has happened over millions of years due to iterative and immediate competition and survival and not long term planning.

In short evolution is not teleological. It does not set out to create an advanced creature and then project downward to determine what is needed at lower levels.
For all their complexity creatures in the natural world are unplanned and unanticipated emergent properties resulting from many levels of bottom up complexification.

This is the opposite of how evolutionary art is typically created. Generally the artist has some idea of approximately what the end product should be, and then he designs a system and genetic representation that will lead to the anticipated result. This usually involves at most a single level of emergence. Simply as a practical matter this dooms the work to the sameness and systemic lack of innovation noted earlier.

Perhaps this is acceptable and even desired for certain kinds of generative art and design. For example, if one is designing tables its not useful if the system suddenly starts offering lampshades, however surprising and innovative that may be.

But in the realm of fine art where innovation and conceptual focus are the hallmarks of truly great work, one has to ask whether the typical approach is not only practically insufficient but also art-theoretically incoherent.

In previous writing I've discussed generative art, and especially complexity-based generative art, as a move from art objects to art processes. What is essential to generative art is not the final object. There are many non-generative ways to create objects too. The defining aspect of generative art is the way the artist cedes control to an autonomous system. [30, 31]

Previous art movements have promoted the notion of “truth to materials.” In the context of formalism it was thought that the most powerful aesthetic would be the presentation of the essential nature of the medium. That would deliver the purest distillation of significant form. Applied to architecture this meant that concrete was presented as concrete, and steel beams were shown as steel beams. For Clement Greenberg paintings as simulated windows into illusory space presented a weak formal aesthetic. Only when the canvas was literally considered as a flat support for paint presented as paint could painting harness its true form and essential power.

In taking a top down rather than bottom up approach, current evolutionary art has turned the process of evolution upside down. And the teleology that doesn’t exist in nature has been introduced in art that is supposed to be inspired by nature. This is part of theoretical incoherence referred to previously.

What is essential to generative art is not any particular material but rather the harnessing of process. At this point in art history a powerful aesthetic for generative art could be called “truth to process.”

Evolutionary art created in the context of truth to process should be created from the bottom up. It should start with reproductive mechanical genetic representations. Gene expression should not directly create the object, but rather should kick off a process of complexification that crosses multiple scales and levels of emergence. This is currently a yet to be implemented lesson from nature.

Most importantly generative art in the spirit of “truth to process” should not obsess on formal issues surrounding the final object. Formal aspects of the final object are important only in so far as they lead back to the processes that created them. Evolutionary art, and generative art in general, should give the audience a sense of dynamism and offer the generative system itself. In the move from nouns to verbs generative art should embrace dynamism, the aesthetic of creation as an activity, and truth to process as intrinsically beautiful.

References

[1] Todd, S. and W. Latham, *Evolutionary art and computers*. 1992, London ; San Diego: Academic Press. 224 p., 32 p. of plates.

[2] Fogel, L.J., *Intelligence through simulated evolution : forty years of evolutionary programming*. Wiley series on intelligent systems. 1999, New York: Wiley. xiii, 162.

[3] Lewis, M., *Evolutionary Visual Art and Design*, in *The art of artificial evolution : a handbook on evolutionary art and music*, J. Romero and P. Machado, Editors. 2008, Springer: Berlin. p. 3-37.

[4] Draves, S., *The electric sheep screen-saver: A case study in aesthetic evolution.* Applications of Evolutionary Computing, Proceedings, 2005. **3449**: p. 458-467.

[5] Ross, A., *Poll stars.* Artforum International, 1995. **33**(5).

[6] Aldiss, B., *The mechanical Turk - The true story of the chess-playing machine that changed the world.* Tls-the Times Literary Supplement, 2002(5170): p. 33-33.

[7] Saunders, R. and J.S. Gero, *Curious agents and situated design evaluations.* Ai Edam-Artificial Intelligence for Engineering Design Analysis and Manufacturing, 2004. **18**(2): p. 153-161.

[8] Greenfield, G., *Robot paintings evolved using simulated robots.* Applications of Evolutionary Computing, Proceedings, 2006. **3907**: p. 611-621.

[9] Jaskowski, W., *Learning and recognition of hand-drawn shapes using generative genetic programming.* Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2007. **4448 LNCS**: p. 281-290.

[10] Fornari, J., *Creating soundscapes using evolutionary spatial control.* Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2007. **4448 LNCS**: p. 517-526.

[11] Ciesielski, V., *Evolution of animated photomosaics.* Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2007. **4448 LNCS**: p. 498-507.

[12] McDermott, J., N.J.L. Griffith, and M. O'Neill, *Toward user-directed evolution of sound synthesis parameters.* Applications of Evolutionary Computing, Proceedings, 2005. **3449**: p. 517-526.

[13] Khalifa, Y. and R. Foster, *A two-stage autonomous evolutionary music composer.* Applications of Evolutionary Computing, Proceedings, 2006. **3907**: p. 717-721.

[14] Manaris, B., et al., *Developing fitness functions for pleasant music: Zipf's law*

and interactive evolution systems. Applications of Evolutionary Computing, Proceedings, 2005. **3449**: p. 498-507.

[15] Mori, T., Y. Endou, and A. Nakayama, *Fractal analysis and aesthetic evaluation of geometrically overlapping patterns.* Textile Research Journal, 1996. **66**(9): p. 581-586.

[16] Taylor, R.P., *Chaos, Fractals, Nature: a new look at Jackson Pollock*. 2006, Eugene, USA: Fractals Research.

[17] Birkhoff, G.D., *Aesthetic measure*. 1933, Cambridge, Mass.,: Harvard University Press. xii, 1 p., 2 l., 3-225, 1 p.

[18] Machado, P., *Computing aesthetics.* Lecture Notes in Artificial Intelligence (Subseries of Lecture Notes in Computer Science), 1998. **1515**.

[19] Machado, P., J. Romero, and B. Manaris, *Experiments in Computational Aesthetics*, in *The art of artificial evolution : a handbook on evolutionary art and music*, J. Romero and P. Machado, Editors. 2008, Springer: Berlin. p. 417-451.

[20] Phon-Amnuaisuk, S., *Evolving music generation with SOM-fitness genetic programming.* Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2007. **4448 LNCS**: p. 557-566.

[21] Gedeon, T. and D. s, *Neural network for modeling esthetic selection.* Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2008. **4985 LNCS**(PART 2): p. 666-674.

[22] Takagi, H., *Interactive evolutionary computation: Fusion of the capabilities of EC optimization and human evaluation.* Proceedings of the Ieee, 2001. **89**(9): p. 1275-1296.

[23] Yuan, J., *Large population size IGAs with individuals' fitness not assigned by user.* Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2008. **5227 LNAI**: p. 267-274.

[24] Machado, P., et al., *Partially Interactive Evolutionary Artists.* New Generation Computing, 2005. **23**(2): p. 143-155.

[25] Machwe, A.T., *Towards an interactive, generative design system: Integrating a 'build and evolve' approach with machine learning for complex freeform design.* Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2007. **4448 LNCS**: p. 449-458.

[26] Martindale, C., *A Neural-Network Theory of Beauty*, in *Evolutionary and neurocognitive approaches to aesthetics, creativity, and the arts*, C. Martindale, P. Locher, and V.M. Petrov, Editors. 2007, Baywood Pub.: Amityville, N.Y. p. 181-194.

[27] Hawkins, J. and S. Blakeslee, *On intelligence*. 1st ed. 2004, New York: Times Books. 261 p.

[28] Casti, J.L., *Complexification : explaining a paradoxical world through the science of surprise*. 1st ed. 1994, New York, NY: HarperCollins. xiv, 320 p.

[29] Kauffman, S.A., *At home in the universe : the search for laws of self-organization and complexity*. 1995, New York: Oxford University Press. viii, 321.

[30] Galanter, P., *What is Generative Art? Complexity theory as a context for art theory*, in *International Conference on Generative Art*. 2003, Generative Design Lab, Milan Polytechnic: Milan, Italy.

[31] Galanter, P., *Complexism and the role of evolutionary art*, in *The art of artificial evolution : a handbook on evolutionary art and music*, J. Romero and P. Machado, Editors. 2008, Springer: Berlin. p. 311-332.

Accessible art creation tools, a generative arts application.

R. Clair, MEng, MSc, PhD Student.
Université François Rabelais Tours, Laboratoire d'informatique, Tours, France.
www.li.univ-tours.com
e-mail: romain.clair@univ-tours.fr

Dr N. Monmarché, PhD.
Université François Rabelais Tours, Laboratoire d'informatique, Tours, France.

Pr M. Slimane, PhD.
Université François Rabelais Tours, Laboratoire d'informatique, Tours, France.

Premise

Art is an important activity for human beings and the apparition of computers revolutionized our practice. Some tried to use them to generate art, providing a lot of methods to produce graphic art or music automatically. We are working on accessible art creation programs and we propose to use these methods as interactive powerful tools to assist people who cannot practice regular art creation in a new form of art creation experience.

Designing accessible software means to follow conception guidelines in three main areas to ensure that most people will be able to :

- Get information from the program, by designing accessible interfaces, usually adopting multi-modality.
- Control the program. We provide some different way of commanding the application and make sure that they can be substituted by adapted devices.
- Understand the program. The program concepts should adapt to the user, or at least it will be simple and limit the required specific knowledge.

We give detail about two of our projects setting up these ideas. The first one is a virtual music instrument. It offers the opportunity to play music in real time using only a keyboard or a mouse. It integrate an automatic accompaniment engine playing variations on the user's themes.

The second one is an accessible drawing workshop. It constituted a simple tool to create pictures. It provide the regular drawing tools like pencils and brushes but also more advanced ones based on generative arts.

1 The project context

When taking an interest in art, we are forced to admit that it is a very large, and not so well defined domain. In our research, and in this paper as well, we are interested only in graphic art and music. This two particular fields of art creation have bounded close links with computers as soon as they appeared.

Automatic or semi-automatic art creation, generative arts in a way can be a main interest for computer researchers because it involves most of the existing metaheuristics. Studying the methods used to generate arts, we have encounter Markov chains [1], generative grammars [2], artificial neural networks [3], constraint programming [4], genetic algorithms [5], artificial ant colonies algorithms [6] *etc.* It is a very special kind of problem on which this generic methods can be applied. Thus it constitute an amazing and excellent way of testing and sometime improving this techinques.

Our research team works on using computers to help disabled people. Obviously we are working on improving the basics of their everyday life: for using the web [7], helping therapists [8], or for video games [9]. But the idea of accessible arts seems also important for us. Thus we worked on the idea of accessible art creation tools, using generative art as an art creation assistance for disabled people.

After the definition of the notion of accessibility and its impact on the design of programs, we'll describe two of our projects associating generative arts and accessibility: a virtual music instrument and a drawing workshop.

2 General consideration on accessibility

2.1 Definition

Accessibility covers a lot of different notions. To define it, we can refer to its application on the world wide web. The World Wide Web Consortium (W3C) with the Web Accessibility Initiative (WAI) provides advices and guidelines to make the web more accessible. They define accessibility like this:

“Web accessibility means that people with disabilities can use the Web. More specifically, Web accessibility means that people with disabilities can perceive, understand, navigate, and interact with the Web, and that they can contribute to the Web. Web accessibility also benefits others, including older people with changing abilities due to aging.”[10]

This definition can easily be extended to every computer software. Thus we have to deal, since the beginning of application design, with three main problems:

- Perception. We should by-pass sensory disabilities and make sure our interfaces provides information for each and every user.

- Comprehension. Cognitive deficiencies as well as cultural or knowledge differences must not be an obstacle to understand our softwares.
- Control. Mainly linked with motor disabilities, we should ensure that everyone can control our applications.

Obviously, dealing with handicap is one of the main issue designing accessible programs, but it can also involve cultural habits and economical problems. It follow the ideal and may be utopian goal of universal access.

2.2 Interfaces

The application interface, the more often a Graphical User Interface (GUI) is the medium used to communicate information to the user. We have all get used to the standard application window, with its “file – edition ...” scrolling menu. This kind of interface is not accessible to everyone and specially not for blind or visually impaired.

Multi-modality is way to avoid this problem. The idea is simple: if everyone cannot access to the information on the firstly planned way, alternative ways should be proposed in addition. For example if using a classical GUI, a vocal or a Braille display should be also provided, or a text-only, that can more easily be magnified. Indeed, accessibility can rely on external tools, provided by the operating system for example. Most of the present operating systems offers a zoom to enlarge a part of the screen, or a speech synthesis to pronounce the textual elements. But the program conception must assure that this external tool can be efficient. For example, the graphical structure of information, like columns, giving a meaning to the position of elements can disable a speech synthesizer which reads the screen line to line.

2.3 Controllers

In the other direction, controllers are the way an application can get information from the user. There is a wide range of devices for this purpose, from the most standard ones, like keyboards and mice, to the most specific, like motion detectors, breath captors, joysticks *etc.*

In this domain, the mouse – keyboard couple is the most commonly used. Sometimes, they set up two different ways of controlling the application, but they are also often combined to form a two handed complex controller. Of course it offers powerful command abilities, but it is reserved for able people. In the area of accessibility, it cannot be a satisfying solution.

As for interfaces, controllers should also be multiple and distinct. Multi-modality applies for input devices too. There should always be two or more different way of making each of a program expected action.

Assistive technologies are various here, adapted devices exists for a lot of disabilities. Most of them are substitute for keyboards and mice, but they do not produce exactly the same behaviour and offer the same opportunities. This differences have to be taken into account when designing accessible controllers. For example, using a virtual keyboard cannot be as fast as a trained user on a regular one.

2.4 Concepts

The third and may be the most difficult goal is to ensure that what we propose can be understood by everyone. It covers the technical aspects, the way the programmer have encoded the software. As it seems obvious for anyone that this technical considerations should not appear to the user, we just are forced to admit that it is usually not the case, and that most of the programs required few knowledge in using computers. It is particularly the case with computer graphics or music. Many specific notions associated with the way the computer deals with images or music have to be understood by a user willing to use a software. With computer graphics, the comprehension of image resolutions, compression algorithms, *etc.* are required, and for examples in music: sample rates for digitalized music or the midi standard.

The specificities associated with the activity proposed by the program should also be taken into account. For example, do I have to know the music theory to play music with a computer program ? We suggest that being accessible also means that the required specific knowledge should be at least limited.

All this constraints can be beneficial during the conception of the program, but it should constitute a limitation to the capacities offered. The more a software can do, the more complex it is. But this consideration is not a fate. An ideal accessible software is capable to adapt to the user needs, which means not only that it will not overwhelmed a user facing difficulties. It also means that it should get richer when its user learn to use it. The assistance provided is important, but may be not in every case.

3 The virtual music instrument

3.1 Goals

This first project focus on music. The founding idea is that computers can be a way to access a form of musical expression for those who cannot use traditional instrument, for example. It leads us to the concept of a virtual music instrument.

The targeted audience tends of course to be as vast as possible. But to be more specific, in the field of handicap, we aimed more at motor and cognitive disabilities than at sensory ones. The reason is simple, blind and visually impaired are able to practice music, and there are some famous examples. On the contrary, music for deaf people needs to be very specific, based on the few frequencies they are able to perceive. We also want to provide a creation tool for the people who do not play music because they do not know music.

Therefore, we developed a computer program for playing music in real-time and of course, it should be as accessible as possible. It obeys the following rules:

- Integrating several controllers
- A maximum of build in music knowledge
- No visible technical information
- As easy to use as possible
- Assisting the use with an automatic accompaniment

3.2 Accessibility considerations

As it is a musical tool, we limit the visual information to the minimum. In facts, there was no need for displaying anything, so the software interface is only a blank window where the mouse can move. This limitation to produce only sound and no graphics is also for testing purpose, because we do not want to have visual “interferences“ to the feeling users can have about the produced music.

There are, for now, two possible controller for this instrument. The keyboard is the first one. It imitate the behaviour of a classic piano keyboard. Pressing a key triggers a sound which stops when the key is released. Each note appears more than once on the keyboard, the idea is that we do not offers to many possible notes, but each note can be played using different keys. This way, we offer the opportunity to play major triads using adjacent keys. From left to right we mount over the scale and on top of each of the bottom note, there is its third, followed by its fifth. Of course, the user is not supposed to know these harmonic notions. He or she will just feel that going to a key to the upper one will produce a pleasant result, actually a rather consonant one.

The second is based on the mouse. Of course, it can be substituted by an adapted device, so the mouse controller is only base on the mouse movement. The buttons are only used to toggle on or off the mouse controller. The functioning is based on the distance crossed by the pointer since the last note played. When the pointer moves away from its last origin, nothing is done, but when this distance reduces, a note is played and the origin is reset to the current position. The pitch of the note played is proportional to the percentage of the global window crossed; the higher the percentage, the deepest the note. It must be a new and original approach of producing music, at least we hope so.

To limit the music knowledge required for using the software, we have adopted two measures. Firstly, we have limited the available notes to a two octave major scale. The underlying idea is to ensure a more pleasant results by limiting the dissonances. Thus, the instrument has a 15 note range. Secondly, we chose to mask the notions of tempo. The ideal case is to detect automatically the tempo in what the user plays. The detection is not yet implemented, the program works at a fixed tempo.

3.3 Automatic accompaniment

To assist the user in his or her musical experience, the virtual music instrument has a built in automatic accompaniment. It starts when the user plays, and the result depends on what he or she plays.

It is based on an interactive artificial ant colony algorithm. Additional bass notes will be played according to what the user plays, as soon as he or she begins. We ensure that this accompaniment is consistent with the user's playing by using his or her played notes pitches and rhythms as the basis for our generator. The engine is only able to produced variations of the user's playing by combining the already played notes with the already played rhythmic patterns. The behaviour of the engine when let on his own his to create and repeat a cycle of notes. But the user influence it when he or she plays and the automatic accompaniment tends to follow the user.

For more detail about the functioning of the algorithm, see [11]

3.4 First results

We have started a test phase where we have presented the program to its presumed audience. We have met therapists, musician, children, able and disabled people and we have collected their returns.

Some found an interest in using this software. The obvious first reason for it is fun. As it is an uncommon and surprising tool, people and specially children find it entertaining. From the therapist's point of view, it seems that the program can be used for relaxation. All the sighted people feels like the program should also provide a visual feedback, specially when using the mouse.

Of course, the program do not pleased everybody and the main reason seems to be that when explaining what the software is supposed to do, people preconceived an idea of what they will get and it can be quite far from what the program really propose.

4 The accessible drawing workshop

4.1 Goals

The second project carrying out these ideas of accessible art creation tools is graphic oriented. It consists in an accessible drawing workshop, with the usual tools like pencils and brushes but also integrating most advanced tools based on generative methods.

Once again, we wanted this program to be accessible to the largest possible audience. Of course, it is not planed to compete with existing art creation tools. This tools are much more mature but above all, they are not designed in the same purpose. These are tools for artists and in fact for artists able to learn the use of complex computer programs. See [12] for more detail about existing art creation tools.

We aimed more at motor and cognitive handicaps here, for similar reasons. Our workshop should also be easily used even by young children. Thus it was designed following this guidelines:

- Integrating several controllers
- No complex settings
- No visible technical information
- As easy and pleasant to use as possible
- Assisting the user with semi-autonomous generative tools

4.2 Interface

Obviously, a drawing workshop offers a Graphical User Interface (GUI). According to the previous rules, we have chosen not to match with the standard of GUI design. The program do not integrate the usual scrolling menu bar. It is commanded by graphic bubble shaped buttons. They are grouped in a tool bar bringing together the drawing tools, a circular flower shaped group with the general purpose command buttons and a rosette for colour choices. We wanted the GUI to be adapted for each user so each user has his own profile where he can choose the position of each buttons group. Figure 1 shows an example of the position of the GUI elements.

Figure 39: Drawing workshop GUI

There is another pop-up menu which appears near the actual position of the mouse pointer when it is not moving. Indeed, some people can get easily tired of crossing long distance with a mouse pointer so we wanted to always offer a close access to their usual tools.

As everyone have already guessed, the program can be controller with a mouse. We have taken a particular attention to this controller to limit tiredness. With the pop-up menu of course, but the maintaining of a pressed mouse button has been reduced to the minimum and every tool works with a toggle. The mouse button activate the pencil which draws until the button is pressed again.

Keyboard can also be used with a single key short-cut to select each tool and the opportunity to draw using the keyboard arrows.

4.3 Advanced tools

In addition to the standard tools which for now are a pen, a line, we added more advanced ones. The first included tool is also based on artificial ant colonies.

Pressing the button when one of the ant tool is selected will drop ants on the picture. They will move on it laying down a colour behind them. Their movement imitate the collective behaviour of real ants. In fact, each ant is looking for a specific colour. It will explore the picture randomly but tends to be attracted to the area containing its seeked colour. The Figure 2 is a picture produced using this tool with one single click on the centre of the image.

Figure 40: Example of ants drawings

We planed to have more advanced tools, based on fractals, L-systems or genetic algorithms for example, but as the project is still under development, they are not yet implemented. For the same simple reason, we do not have now enough evaluation to produce real results, but the very first test are encouraging.

5 Conclusion

Generative arts can also be used to help disabled people access a form of art creation. We have designed accessible art creation tools, adapting automatic art generation tools as an assistance for people which encounter difficulties in accessing regular art creation. Following accessibility guidelines and making this automatic art generators interact with the user, we have conceived two programs: A virtual music instrument to play real-time music accompanied automatically by the software and a accessible drawing workshop with which one can create digital pictures using art generating tools.

As an objective evaluation of an art production is inappropriate, we have proceeded to a test phase where we have gathered the comments of real users while they experience the software. The first results of the subjective evaluation of one of this tools seems to be promising.

Bibliography

1: Iannis Xenakis, Formalized Music, University Press, New York, USA, 1971.
2: Jon McCormack, Grammar Based Music Composition. In Complex Systems 96, ISO Press, 1996.
3: Michael C. Mozer, Neural network music composition by prediction, Connection Science, 1994.

4: Martin Henz, Stefan Lauer and Detlev Zimmerman, COMPOzE - Intention-based Music Composition through Constraint Programming, 1996
5: John Al Biles, GenJam: A genetic algorithm for generating jazz solos, 1994
6: Nicolas Monmarché, Isabelle Mahnich and Mohamed Slimane, Artificial Art made by Artificial Ants. In The Art of Artificial Evolution, Springer, 2007.
7: Sonia Colas, Nicolas Monmarché and Mohamed Slimane, Reaching Web accessibility compliance with to an automatic correction tool, Special issue of the AMSE journal, 2008.
8: A. Puret et al., A robot-toy to incite the communication from a child with autism, Special issue of the AMSE journal, 2008.
9: Alexis Sepchat, Romain Clair, Nicolas Monmarché & Mohamed Slimane, Using ants' task division for better game engines, 2008
10: Education and Outreach Working Group (EOWG), Web Accessibility Initiative (WAI), 2005, http://www.w3.org/WAI/
11: Romain Clair, Nicolas Monmarché and Mohamed Slimane, An interactive ant algorithm for real-time music accompaniment. In Evolution artificielle, 9th international conference, Strasbourg, october 2009.
12: Romain Clair, Nicolas Monmarché and Mohamed Slimane, Art, an accessibility issue. In Accessible Design in a Digital World (ADDW), York, 2008.

Dynamics of the Unseen: Surfaces and Their Environments as Dynamic Landscapes

S. Franceschelli, PhD
Ecole Normale Supérieure Lettres et sciences Humaines & IXXI, Rhônalpin Institute of Complex Systems, *Lyon, France*
&
Ecole Nationale Supérieure des Arts Décoratifs, Paris, France
e-mail: Sara.Franceschelli@ens-lsh.fr

Abstract

This paper presents a structural interpretation of the figure of epigenetic landscape in theoretical biology, introduced since the end of the 1930s by the embryologist and theoretical biologist Conrad Hal Waddington, in order to comprehend developmental morphogenesis. On the basis of this interpretation, a research and innovation program on morphogenesis and morphodynamics, DYNLAN, is run at ENSAD, Ecole Nationale Supérieure des Arts Décoratifs, Paris.

Introduction

In every day language the term “landscape” has several acceptations. The most obvious are perhaps the ones referring to landscape as an expanse of scenery that can be seen in a single view: a desert landscape, for example, or a picture, or an artistic representation depicting this expanse of scenery. One also speaks, in this sense, of landscape architecture, of landscape ecology, and so on.

In this paper, however, I’m using another acceptation of landscape, emerging from theoretical biology. It is not a material landscape, but an abstract one; nevertheless it also concerns vision: it is a mental picture offering a theoretical view on developmental morphogenesis. The expression “theoretical view” is a pleonasm, in the light of the etymology of “theory” [13]. I would like indeed to stress that the figure of epigenetic landscape conveys the attention of the mind’s eye on sophisticated relational aspects of morphogenesis - as comprehended by Conrad Hal Waddington – which would perhaps not so clearly emerge if expressed by natural language, without the help of images.

Before considering these images in section 2, I first discuss some aspects of morphogenesis between natural sciences and arts.

[13] From *Theoria* "contemplation, speculation, a looking at, things looked at," from *theorein* "to consider, speculate, look at," from *theoros* "spectator," from *thea* "a view" + *horan* "to see."

1. Morphogenesis between natural sciences and arts

The variety of natural forms is a recurrent source of inspiration in urbanism and architectural conception and, more extensively, in art. Far from being a purely formal research, this attention to natural forms is often accompanied by a quest for the construction principles that regulate the genesis of these forms. Morphogenesis seems *d'emblée* committed to structural aspects.

This is an essential assumption in the fascinating work on morphogenesis, both in the animated and unanimated world, of the well known Scottish morphologist D'Arcy Wentworth Thompson.

His book, *On Growth and Form,* first published in 1917 [19], has influenced generations of researchers from the most various fields: biologists, architects, artists, mathematicians, and human scientists [1]. Thompson, without advocating an abandon of Darwinism, suggests in his book that evolution has been overemphasized by biologists as the determinant of the form of living organisms, and the roles of mechanics and physics have been underestimated. Structural transformations, determined by forces, are advocated instead of natural selection, in order to explain these forms.

Martin Kemp [7,8] has extensively studied the influences on the arts of Thompson and thompsonisms (carried by other morphologists belonging to the same tradition, for example Peter Medawar and Conrad Hal Waddington). Beside the intrinsic interest of appreciating the impact of scientific imagery in art, Kemp indicates another main interest of his research perspective: the discerning of fundamental qualities of structure and process in nature as shared enterprises of art and science, as witnessed, for example, by the words of the sculptor Peter Randall-Page, whose stone sculptures are evocative of the organic geometries expounded by students of phyllotaxis, without representing specific botanical forms "Altough my work is firmly rooted in observation, I try to achieve… rightness of form through a kinship with, rather than a facsimile of nature" [11].

In this paper I will consider the work of Conrad Hall Waddington (1905-1975) on morphogenesis, in particular his notion of "epigenetic landscape". Extremely known in the world of biology as the eclectic embryologist and promoter of theoretical biology who introduced in the 1942 the term "epigenetics", Conrad Hal Waddington has been an extremely curious academic, with a particularly wide range of interests. Theoretically influenced by Alfred North Whitehead's process philosophy, he also was found of art and he was acquainted with a significant number of artists and creators of his time, for example John and Mary Myfawny Piper, Henry Moore, Ben Nicholson, Alexander Calder, Laslo Moholy-Nagy, and Walter Gropius.

Witnessing his exceptional investment in "boundary investigations", his 1969 book *Behind Appearance: A Study of the relations between Painting and the Natural Sciences in this Century*. As the title explicitly indicates, Waddington analyses the reciprocal exchanges between sciences and painting in the twentieth century. Curiously, among the variety of possible objects at the interface between science and art, he does not consider in his book his own figure of epigenetic landscape.

Nevertheless, something in the appearance of this powerful figure calls for an excursion behind appearance. It is what I'm trying and showing in next sections.

2. Things You Can Tell Just by Looking at Landscapes

Images of landscapes played and play an important role in the development of biology, in very diverse fields, from population genetics and evolutionary theory to embryology and epigenetics.

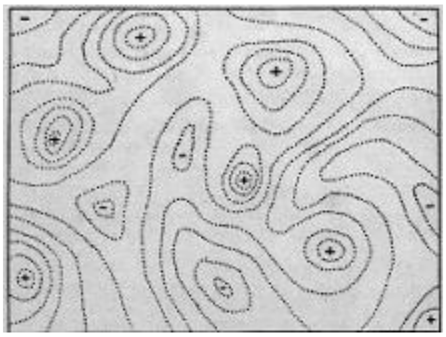


Fig. 1. Sewall Wright's 1932 adaptive landscape [25]

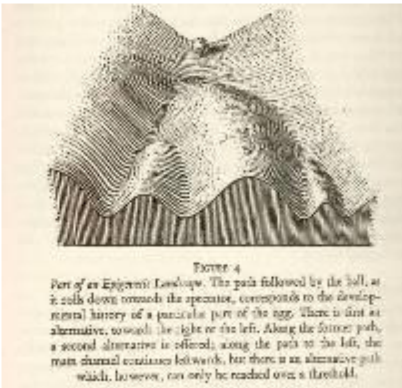


Fig. 2. C.H. Waddington's 1957 epigenetic landscape [23 p.29]

Fig. 1 represents Sewall Wright's first explicit illustration of the idea of an adaptive surface, or adaptive landscape [25] : "Diagrammatic representation of the field of gene combinations in two dimensions instead of many thousands. Dotted lines represent contours with respect adaptiveness" (from the original caption). In the framework of the modern synthesis, which found in Sewall Wright one of its founders, the dynamics of mendelian populations on this surface is expected to go towards local maxima of fitness.

Conrad Hall Waddington introduced the first image of an "epigenetic landscape" in

1940, in the frontespiece of his *Organisers and Genes* [21]. He invented himself the neologism “epigenetics” in 1942 [22], as the “the interactions of genes with their environment that bring the phenotype into being.”

Waddington’s epigenetic landscape is a metaphor for how gene interactions modulate cellular differentiation during development. One is asked to imagine a number of marbles rolling down a hill towards a wall that come to rest at the lowest points. These points represent the eventual cell fates, that is, tissue types. This idea was actually based on experiments: Waddington found that one effect of mutation (which could modulate the epigenetic landscape) was to affect how cells differentiated. Some of these experiments are discussed in *Organisers and Genes*. Notions introduced by Conrad Hal Waddington in the 1940s and 1950s, such as canalisation and genetic assimilation, have been recently reconsidered in a molecular framework, for example within the work by Rutherford and Lindquist on the Drosophila heatshock protein HSP90 [13,10]. Without contesting the importance of Waddington’s experimental activities, I do not think of them as the unique source in Waddington’s work leading to the genesis of landscape images. Another important source of inspiration comes from his theoretical interest in a possible mathematization of biological processes in terms of non-linear equations.

Questions about the status of landscapes in theoretical biology, their heuristic role, historical and conceptual relationships between fitness, adaptive, and epigenetic landscapes are debated in philosophical literature (for example [9], [12], [6]).

Despite the different acceptations of the images of landscape following the different subfields of biology, their characteristic shape defined by peaks, pits, and cols, seems to present an evocative analogy with the images of potential or energy landscapes for dissipative systems in mathematical and physical literature.

If in the case of Waddington's epigenetic landscape, especially in its 1957s' version (cf. Fig.2), the visual analogy with potential or energy landscape is evident, in the sense that the motion is meant to develop in the sense of a – local- minimisation of the potential, for fitness and adaptive landscapes one needs to take into account an inversion of polarity in the motion of the individuals or of the mendelian populations: moving, in this case, from a certain region towards a fitness maximum – local, again.

This visual analogy could encourage the mathematical minded reader towards a mathematical interpretation of landscapes in theoretical biology in terms of potential landscapes. However this clearcut interpretation seems to be absent in the establishment of this image in the history of twenty century evolutionary theory, at least in Sewall Wright's seminal papers of the 30's on population genetics, where he introduces his adaptive landscape.

The philosopher of science Jean Gayon, in his beautiful study on the figures of landscapes in biology [6], argues that it seems pertinent to think that Sewall Wright was aware of this possible interpretation, at least that he could not ignore it, in the light of his correspondence with Ronald Fisher. However, points Jean Gayon, Wright himself affirmed years later that he did not meant to give this mathematical interpretation. He was indeed interested in suggesting a visual metaphor and in using its rhetorical power in order to make his theory more understandable by non mathematics trained biologists.

Waddington himself, in his 1957 book *The Strategy of the genes* [23], qualifies his epigenetic landscape as a mental image, a representation by a diagram of the developmental system of an embryo:

"Although the epigenetic landscape only provides a rough and ready picture of the developing embryo, and cannot be interpreted rigorously, it has certain merits for those who, like myself, find it comforting to have some mental picture, however vague, for what they are trying to think about" [23, p.30].

Let us consider the 1957 version of the epigenetic landscape again (cf. Fig. 2). A ball, lying on the top of an undulating landscape, is ready to move along one of the paths opened in front of it. The undulated surface represents the fertilized egg. The path followed by the ball represents the developmental history of a particular part of the egg. As Waddington emphasizes it in the original caption, there is first an alternative, towards the right or the left. Along the former path, a second alternative is offered; along the path to the left, the main channel continues leftwards, but there is an alternative path which, however, can only be reached over a threshold.

This image is completed by a “hidden” part, underlying the epigenetic surface, and giving an explicit and mysterious at a time interpretation of the constitution of the surface itself (Fig. 3): “the complex system of interaction underlying the epigenetic landscape. The pegs in the ground of the figure represent genes; the strings leading from them the chemical tendencies which the genes produce. The modelling of the epigenetic landscape […] is controlled by the pull of these numerous guy-rops which are ultimately anchored to the genes” (from the original caption).

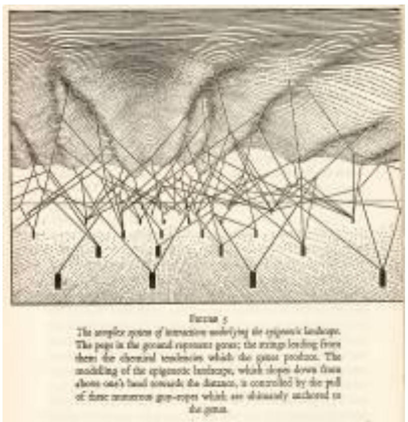


Fig. 3 The underlying part of the epigenetics landscape [23]

Insofar, if seriously taken, this “mental picture”, says quite clearly at least two things:

- the development of the embryo is canalized along defined pathways
- the undulating surface on which pathways, or channels, are defined, is moulded by the underlying network of genes interactions.

It thus conveys a non reductionist position *vis-à-vis* single gene action. Waddington writes “it is not necessary, in fact, to await a full understanding of the chemistry of single genes before trying to form some theoretical picture of how gene-systems produce integrated patterns of developmental change”. [23, p. 9]

I will leave the reader forge his own opinion from literature (for example [3], [2]) of the innovative and iconoclastic character of Waddington’s vision, namely with regard to his integrated representation of (epi)genetic actions and of embryological development, in the context of epistemological cultures dominating biological research of his time.

Here I rather wish to shed light on structural thinking inscribed in Waddington’s images. Since the first occurrence and illustration of the notion of epigenetic landscape, as the frontispiece of his 1940 *Organisers and genes* [Fig. 4], Waddington presents the landscape from a holistic point of view, even if not yet so explicitly as in the 1957 representations.

Fig. 4. from a drawing by the painter John Piper. Original caption: “Looking down the main valley toward the sea. As the river flows away into the mountains it passes a hanging valley, and then the two branch valleys, on its left bank”. [21]

The following passage form a book of 1939, *An introduction to modern genetics* [20, pp.180-4] seems to indicate that Waddington had already a structural image of the process of constitution of the landscape:

“If we want to consider the whole set of reactions concerned in a developmental process such as pigment formation, we therefore have to replace the single time-effect curve by a branching system of lines which symbolizes all the possible ways of development controlled by different genes. Moreover we have to remember that each branch curve is affected not only by the gene whose branch it is but by the whole genotype. We can include this point if we symbolize the developmental reactions not by branching lines on a plane but by branching valleys on a surface. The line followed by the process, *i.e.* the actual time-effect curve, is now the bottom of the valley, and we can think of the sides of the valley as symbolizing all the other genes which co-operate to fix the course of the time-effect curve; some of these genes will belong to one side of the valley, tending to push the curve in one direction, while others will belong to the other side and will have an antagonistic effect. One might roughly say that all these genes correspond to the geological structure which moulds the form of the valley.”

Waddington’s comparison of the of genetic actions on the whole to the geological structure moulding the valleys of the landscape leads us to think to the epigenetic surface as a generic emergent process.

The question of a possible interpretation of the epigenetic landscape in terms of a dynamical systems approach is not only based on historiographical considerations on its genesis, in the context of the use of non-linear equations, and the study of attractors in phase-space, in other fields of theoretical biology (such as epidemiology and population dynamics: Waddington knows and quote the work of Lotka and Kostizin).

In fact, several authors have theoretically interpreted Waddington images from this perspective (for example Jonathan Slack [17] and Peter Saunders [14], [15]).

Perhaps the first has been the mathematician René Thom, who in the 1960's elaborated his catastrophe theory, as a mathematical theory of morphogenesis, inspired, as he wrote himself, by embryology and in particular by Waddington's notions.

The possible interpretation of the epigenetic landscape in terms of catastrophe theory has animated a famous correspondence between Conrad Hal Waddington and René Thom in the late 1960's and in the 1970's [18]. I've already written on this correspondence, showing their misunderstandings on the notions of stability that can be associated to the figure of the epigenetic landscape [4], [5].

Here I just remind an aspect of their misunderstandings, in order to show that their partial mutual incomprehension is interesting, since it gives an example of the power of images to catch theoretical questions, difficult to express in mathematical terms.

3. A "generative" misunderstanding? Towards an image of dynamic landscapes

Waddington speaks of two kinds of stability: on one hand homeostasis, that means stability towards a final steady state (different tissues, different organs); on the other hand, homeorhesis, one of his neologisms, as the stability of the process of development itself. This second acceptation of stability is a dynamical one, the stability of a pathway, not of a final state. This is important to Waddington, since it explains why development stays on track, despite external aggressions. On the model of epigenetic landscape, this is represented by the slope of the valleys -or channels-, avoiding that a perturbed trajectory of the ball escapes the valley itself, unless the perturbation is important enough. In this case, the ball would jump in another valley, *i.e.* in another canalized path.

Thom bases his catastrophe theory on structural stability, as a property of observable objects (living or not). In his opinion homeorhesis should be implied as a property of a structurally stable process.

One can ask the question: what is the reason of the misunderstanding between the two savants?

A first interpretation of this lack of agreement between the two scientists can be based on taking into account of their cultural differences. To use the expression introduced by Evelyn Fox Keller in *Making Sense of Life* [3], they do not share the same "epistemological culture" and they do not have the same explanatory needs.
René Thom himself introduces this correspondence as an example of the difficulties in communication between a mathematician and a biologist because of the differences in their exigencies of mathematical rigour. However, following some of Waddington's remarks on the peculiarity of the variable "time" in biology, I suggest another interpretation of their disagreement, based on Waddington's unsatisfied need of representing, thanks to the metaphor of epigenetic landscape, different spatio-temporal scales in the process of the organism development.

Waddington's landscape implies different variables and parameters depending on the spatio-temporal scale (morphogenesis of tissues/organs; morphogenesis of the landscape itself).
Thom's catastrophe theory gives a general description of the variations of the form, but it does not consider a temporal dynamics.

I called this misunderstanding "generative", since it puts on the table a set of desiderata defining epigenetic landscape as a dynamical landscape that synthetically captures several essential questions for the modelling of complex systems.

What are the nature and the evolution of equilibria that characterise the landscape? How is their stability characterised? And their robustness? What is the effect on a landscape of different kinds of disturbances or interactions with the environment? At what spatio-temporal scale is it suitable to situate such analyses and investigations? What are the variables that are represented by the landscape? In what space do they live?

We took this set of questions as an agenda four our research program DYNLAN, on the conception and realization of dynamic landscapes, that begun in October 2009, in collaboration with my colleague at ENSAD Yves Mahieu, architect. The program implies two students/researchers: Chengliang Wang, artist and Jonas Ranft, PhD student in theoretical biophysics.

In the following section, I will shortly present a first pedagogical experience based on this approach to landscapes that took place in May 2008 at ENSAD. It deals with the conception and realization of a dynamic surface in relation with its environment.

4. « Paysages sensibles et dynamiques »: an experience

The framework of the experience has been a month of interdisciplinary work for 1st year students[14]. During the month of may, 16 students have worked on the project "Paysages sensibles et dynamiques", proposed by Yves Mahieu and myself. Three more ENSAD teachers joined us: Sophie Larger, designer; René Lesné, art historian and Xavier Miclet, set decorateur. Our already interdisciplinary team has been completed by two technical assistants: Michel Davidov and Xavier Tiret, both engineers. Moreover Carole Knibbe and Guillaume Beslon, bioinformaticians of IXXI, Rhonalpin Institute of Complex Systems, working on synthetic evolution, visited us twice, at the beginning and at the end of the experience, in the framework of a IXXI project ("Morphostructural and semantics properties of landscapes in theoretical biology").

The first day a workshop took place, in which each teacher introduced his own vision of the landscape:

[14] The 16 following ENSAD students participated to the project: Sarah Escamilla, Julien Cédolin, Victor Alvar de Biaudos de Casteja, Camille Pajot, Marie Riegert, Juliette Mallet, Anaïs Mathieu, Jennifer Pineau, Kevin Garcia, Laura Martinez, Hélène-Mahi Fofana, Nils Lacroix, Marion De Villechabrolle, Sophie Dang Vu, Matthieu Rocolle, Sarah Théron.

-my self on the epigenetic landscape and on the Thom-Waddington correspondence
-Yves Mahieu, on architecture of tensed membranes
-Carole Knibbe, on the image of fitness landscape
-Sophie Larger, on some contemporary artists that could be inspiring for the work (Ernesto Neto, Fischli & Weiss).
-René Lesné, on the figure of landscape in the history of art
-Xavier Miclet, on several materials and cloth.

Eventually Xavier Tiret presented a variety of mechanisms that could be conceived to move the landscape. Michel Davidov introduced the notion of interactivity and some electronic devices in order to realize it.

We asked students to conceive and construct a structure underlying a surface whose form can change under the variation of the parameters controlling the structure and in relation with environmental stimuli. Here you can find some pictures of the dynamic surface, generated by the interplay of motor actions on the cables and the bars connected to the composite tensed membranes.



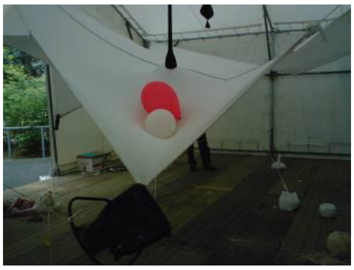


Fig. 5-6-7 First experimentations on tensed membranes. In the middle: one of the motors.

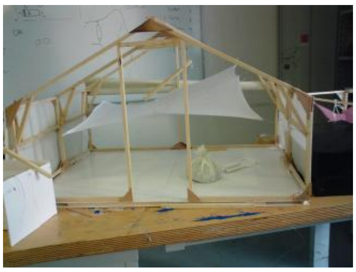


Fig. 8-9-10 On the left: a reduced 1 :10 model of the external tent. Various morphologies of the final dynamic landscape.

Fig. 11-12-13 Various morphologies of the final dynamic landscape.

By way of conclusion

The figure of epigenetic landscape conveys properties of complex dynamical systems that put on the table a new aspect with respect to the traditional problem of morphogenesis, *i.e.* the one of considering the action of forces on the morphogenetic process. This new aspect concerns the cartography of these possible actions - defined by the valleys of the landscape's surface. It also concerns the generation of the surface itself, as the result of its underlying tectonics, or of its epigenetics. These underlying processes, whatever their nature, may run at different spatio-temporal scales with respect to the morphogenetic events that the landscape should comprehend in its space of possibilities. In other terms, the constitution and dynamics of the landscape themselves can be seen, in a more abstract way, as a morphogenetic problem.

In the first experience of 3D realization, described here above, we concentrated on this last aspect: to generate a landscape of possibilities as emerging by an underlying tectonics. In this sense, our dynamic composite surface, moving in relation to its environment, under the integrated effect of motors and of human decisions, is intended to share some of the emerging character of other unknown dynamic landscapes.

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Bibliography

1. Beesley P., Bonnemaison S. (2008). On Growth and Form. Organic Architecture and Beyond. Tuns.
2. Hall B.K., Laubichler M. (eds.). Biological theory, Volume 3, Issue 3 - Summer

2008 - Conrad Hal Waddington, Theoretical Biology, and EvoDevo Thematic Issue

3. Fox-Keller E. (2002). Making Sense of Life. Explaining Biological Development with Models, Metphors and Machines. Harvard University Press.
4. Franceschelli S. (2006). "Morphogenèse, stabilité structurelle et paysage épigénétique". In A. Lesne, P.Bourgine (éds.). Morphogenèse. L'origine des formes. Belin, Echelles, 298-308.
5. Franceschelli S. (2007b). "Epigenetic landscape and catastrophe theory: commentary on a correspondence ". In Bouchaud J.-P., Mézard M., Complex Systems, LXXXV. Les Houches Summer School Proceedings. Elsevier 483-89.
6. Gayon J. (1998). "La marginalisation de la forme dans la biologie de l'évolution". Bull. Hist. Epistém. Sci. Vie 5(2), 133-66.
7. Kemp M. (1996). "Doing What Comes Naturally. Morphogenesis and the limits of the genetic code". Art Journal 55, 1, 27-32.
8. Kemp M. (2006). "Growth and form". In Seen/Unseen. Art, Science, and Intuition from Leonardo to the Hubble Telescope. Oxford University Press.
9. Provine W.B. (1986). Sewall Wright and Evolutionary Biology. Chicago, The University of Chicago Press.
10. Queitsch Ch., Sangster T.A., Lindquist S. (2002).)."Hsp90 as a capacitor of phenotypic variation". Nature, 417, 618-24.
11. Randall-Page P., in Hamilton and Warner, Peter Randall-Page, 18-19, quoted in [7].
12. Ruse M. (1990). "Are Pictures Really Necessary? The Case of Sewall Wright's Adaptive Landscape". PSA, 2, 63-77.
13. Rutherford S., Lindquist S. (1998)."Hsp90 as a capacitor for morphological evolution". Nature, 396, 336-42.
14. Saunders P.T. (1993). "The organism as a Dynamical System". In Varela F., Stein W. (eds.) SFI Studies in the Science of Complexity. Lecture Notes Vol. III, Addison Wesley, Reading, 41-63.
15. Saunders PT. (1989). "The Evolution of Form and Pattern". Leonardo, Art and the New Biology. Biological Forms and Patterns, 22, 1, 33-38.
16. Skipper Jr R.A. (2004). "The Heuristic Role of Sewall Wright's Adaptive Landscape Diagram". Philosophy of Science, 71, 1176-1188.
17. Slack J.M.W. (2002). "Conrad Hal Waddington: the last renaissance biologist?". Nature 3, 889-95.
18. Thom R. (1966). Une théorie dynamique de la morphogenèse. In Modèles mathématiques de la morphogenèse, Christian Bourgeois Editeur.
19. Thompson D.W. (1917). On growth and Form.
20. Waddington C.H. (1939). An introduction to modern genetics. Macmillan Company, NY.
21. Waddington C.H. (1940). Organisers and genes. Cambridge University Press.
22. Waddington C.A. (1942). The epigenotype. Endeavour 1, 18-20.
23. Waddington C.H. (1957). The strategy of the genes. London, Allen and Unwin.
24. Waddington C.H. (1968). Behind appearance. A study of the relations between painting and the natural sciences in this century. MIT.
25. Wright S. (1932). "the Role of Mutation, Inbreeding, Crossbreeding, and Selection in Evolution", Proceedings of the Sixth International Congress of genetics, t. 1, 352-66.

SHORT PAPERS

Towards a Material Architecture: The Aesthetics of Generative Materiality

Dina Krunic, BArch, MArch, PhD in progress
Department of Architecture and Urban Design, University of California, Los Angeles
www.aud.ucla.edu, www.studiodina.com
e-mail: dkrunic@ucla.edu, dina@studiodina.com

Abstract

The language of generative architecture inherently focuses on typologies of processes which are non-material. Algorithmic language assumes virtual materiality and relies on computerized images. Generative design processes therefore present unique aesthetics that carry within themselves traces of materiality, which architects such as Oosterhuis, MatSys, ChrisBosse, Morphosis Architects, Zaha Hadid, Biothing, Material Ecology, Gregg Lynn and Evan Douglis explore in the physical world.
This research examines aesthetics of Parametric design, Cellular automata, Flocking of birds, Genetic algorithms, and Shape grammars to define framework for evaluating material applicability to generative design processes.
In this paper, I put the Aesthetics of Generative Design in a historical context. I define aesthetic implications of algorithmic systems with regard to shape generation and systemize generative design according to essential and accidental aesthetic qualities. Finally, I link Materiality and Performance to aesthetic variations within Generative Design.

Keywords:
Generative design processes, Essential and Accidental aesthetics, generative materiality, material variability, emergent materiality, performance

1. Introduction

Could we define something called generative architecture and if so, how would we construct the definition and characterize architecture which merges physicality with generative design processes? At the moment, generative design in architecture is exploring how to integrate computation with the process of design. With algorithmic languages, these processes assume virtual materiality and indefinite attachment to what Delanda calls the accumulation of materials throughout history or the presence of structures that surround us (i.e. architecture). [1] Therefore, if we follow Delanda's logic that everything is material, generative design processes must also contain traces of materiality which, while unconventional, must be understand in order to define the relationship of generative design to architecture. What is clearly defined in generative design are aesthetic qualities, which are of matter. In order to define relationship between generative processes and the material world, we need to look to aesthetics to understand what kind of materiality and performative qualities of substance it suggests.

2. Aesthetics of Generative Design

2.1 Aesthetics

Greek philosophers dealt with the question of 'objecthood' and the aesthetics of objects. The concept of "the essence" originated with Aristotle who used the Greek expression to *ti ên einai*, literally meaning 'the what it was to be', or sometimes the shorter phrase *to ti esti*, literally 'the what it is,' to construct the idea of essence and accident. Essence is the attribute or set of attributes that make an object or substance what it fundamentally is, which it has by necessity, without which it loses its identity. Essence is contrasted with accident: a property that the object or the substance has contingently, without which the substance can still retain its identity, which could also be referred to as an ornament.

Greek philosophers initially felt that objects were beautiful in and of themselves. Plato, in trying to understand this beauty described objects as beautiful when incorporating proportion, harmony, and unity among their parts; Aristotle found that the universal elements of beauty were order, symmetry, and definiteness. The object's material essence was closely related to beauty. According to their understanding of the world, Beautiful is a quality of the object, or the substance. But this quality, since it is a quality of the object, can also be essential or accidental. [6]
The essential quality of a substance is unchanged in the process of state transition, it is topological. For example, a chair being wood, metal or plastic; its colour, texture, size and shape is an accident, as it is still a chair regardless of those accidental qualities. Therefore, there is an essential aesthetic of the object, Beautiful that is maintained from an initial state throughout the process of generation and does not change with the change of state or with the change of its accidental qualities.
Accidental quality of a substance, on the other hand, is what depends on accidental qualities of matter. In the same example, material, colour, texture, size and shape are all accidental qualities whose variations and combinations have their separate aesthetic, the accidental aesthetic. Therefore, Beautiful can be constructed with variations and combinations of initial accidental qualities in the process of generation.
Typology of design processes, which in themselves are inherently non-material, can still be evaluated based on essential or accidental aesthetic relationships to its initial state, as well as to the explorative process of moving towards essential or accidental qualities.

2.2 Historic context of Aesthetic of Generative Design.

As summarized by William Mitchell, the history of generative systems in architectural design starts with Leonardo's study of centrally planned churches and Durand's Précis of the Lectures on Architecture. [5] Leonardo's investigation into centrally planned churches regarding natural phenomena carried out with the firm belief that mathematical principles underlay all physical forms. In his search for 'true principles of architecture,' Durant attempted to demonstrate the 'correct and effective way to design' by introducing a rule set that constitutes the objective idea of the whole building. As Mitchell demonstrated, mathematical principles of generative design processes were discussed even during the Renaissance in order to understand the aesthetics of beauty, but are not developed until Celestino Soddu establishes generative design approach which builds upon laws of proportion and logic as a method of preservation of beauty in a sense similar to the Renaissance. [3]

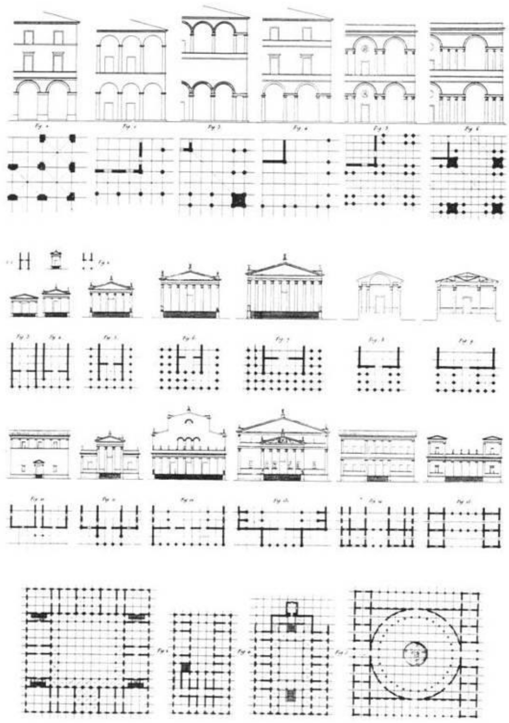


Figure 2.2.1 Jean-Nicolas-Louis Durant Précis of the Lectures on Architecture

A problem of aesthetics in design processes arose in 1960s along with the industrial revolution when architecture started taking up a particular from of component-based rationalization and methodology which embraced the generative approach, as well as modular coordination and construction as a kid of parts. In order to manage complexity in production, design became a problem that in John Thackara's words, moved 'beyond the object.'

Computerized production has paved the way for a new interface which operates without prescience of what is to come, creating a need for evaluation as a model of directing processes.

Hegel and Kant in modern aesthetics introduced methods of evaluation for beauty in relationship to taste. The aesthetic quality of an object is evaluated in relationship to the subjective reception of aesthetic qualities. Aesthetics becomes a condition of both universality and subjectivity. Kant states that taste is essentially subjective, and beauty is pleasure-free and thus universal, "*as if* [beauty] were a property of things." For Kant, the aesthetic experience of beauty is universal truth, only kind of knowledge that senses can have.

Senses become evaluators of aesthetic qualities. In architecture, people like Adolf Loos start evaluating relationships of ornament to the essence of architecture by claiming the immense damage and devastation the revival of ornament has caused to aesthetic development. [7] Louis Sullivan, on the other hand, defines the architectural ornament as 'the germ, the seat of identity' as the essential thing in architecture that seeks and eventually through the process of design finds its full expression in form. [8] In these opposing views, we see the beginnings in construction of evaluative categories within design processes which define what is considered beautiful and what ugly.

2.3 Generative design

According to Van der Zee and de Vries, “generative design is the use of combinations of different arithmetic methods in order to generate a set of difference alternative solutions for the design at hand.” [4] Generative design as established by Celestino Soddu in 1987 is a design process which does not operate towards one universal solution, but sets up algorithmic system to explore multiple options and evaluate them according to specific criteria. The process scripting is executed by describing the initial state or what Soddu calls *design idea*; and by setting up a set of rules to apply to the initial state and the system for evaluation of those constraints also defined by Soddu as *design evolution*. [3] Because of the computer’s ability to perform endless operations and fast calculations, this design method can be iterative as well as completely automated. The process of evaluation, depending on numbers of iterations and automation, is interactive or interruptive. In the interactive model, evaluation criteria are applied simultaneously in the real time of the process. In the interruptive model, evaluation criteria are applied at moments of interruption, after which the process is redirected if necessary.

3. Categories of Generative Design and Materiality

Algorithmic systems of generative design can be grouped in few categories based on their differences of initial state and rule-sets, according to Van der Zee and de Vries, into Parametric design, Cellular automata, Flocking of birds, Genetic algorithms and Shape grammars. All these categories have different relationship and suggestive nature to materiality, which I call the generative materiality. This generative materiality is differentiated depending on the relationship of generative design process to essential or accidental aesthetic qualities of the initial state as well as the process of its progression.

3.1 Parametric design and emergent materiality

In parametric design, a geometric form is denoted as a set of depended variables or relations. Parameters of a particular design are declared, their interdependency and behavior under transformation. By changing these variables, alternative forms are generated. Each of these output forms can be evaluated, and the process continues until a satisfactory solution is found. This process is completely interactive as the designer is in immediate control of the process.

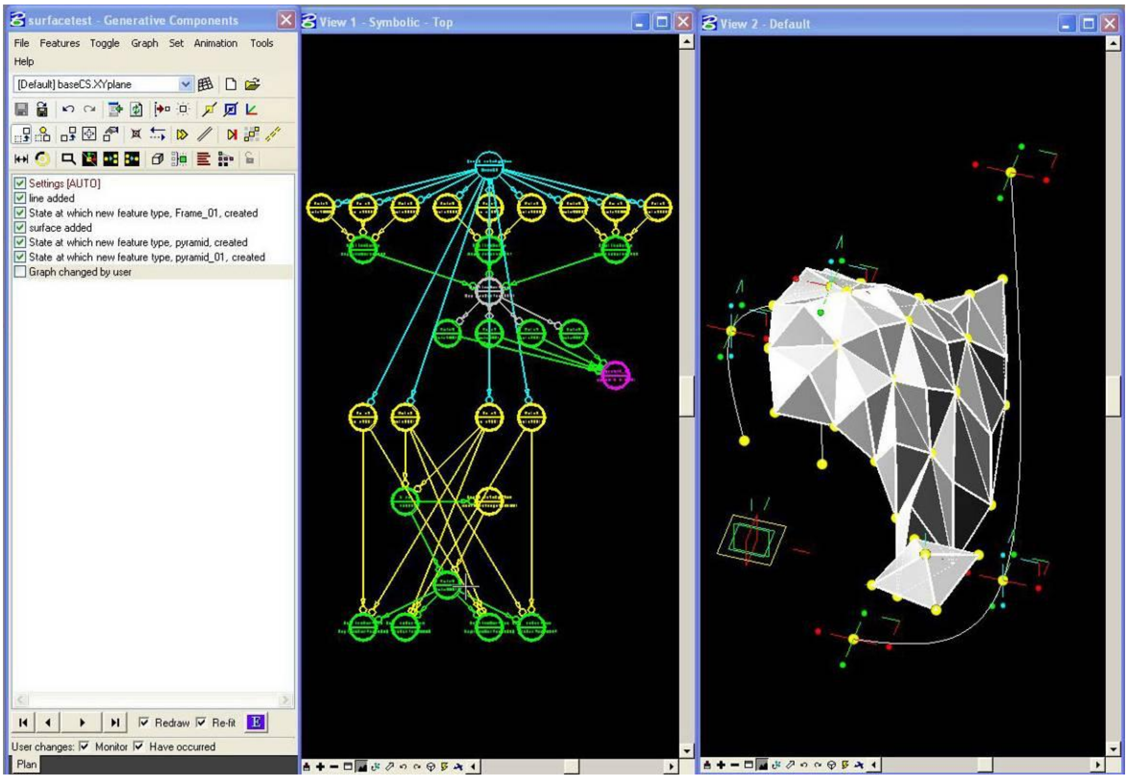


Figure 3.1.1 Generative Component program based on parametric design principle

Parametric design is dependent on creating an initial state which relies on essential aesthetic quality as well as in generating a process where variations are progressing from essential in search for accidental aesthetics. The evaluation is done based on accidental qualities which emerge.

This process is based on emergent materiality, because of its transgressive relationship between essential and accidental aesthetic qualities. Accidental qualities are found by trial and error process, much like in a scientific research. Architectural practices such as Oosterhuis, MatSys and ChrisBosse all set up algorithmic systems which have essential aesthetic qualities, and depend on the process of variations to generate accidental aesthetics.

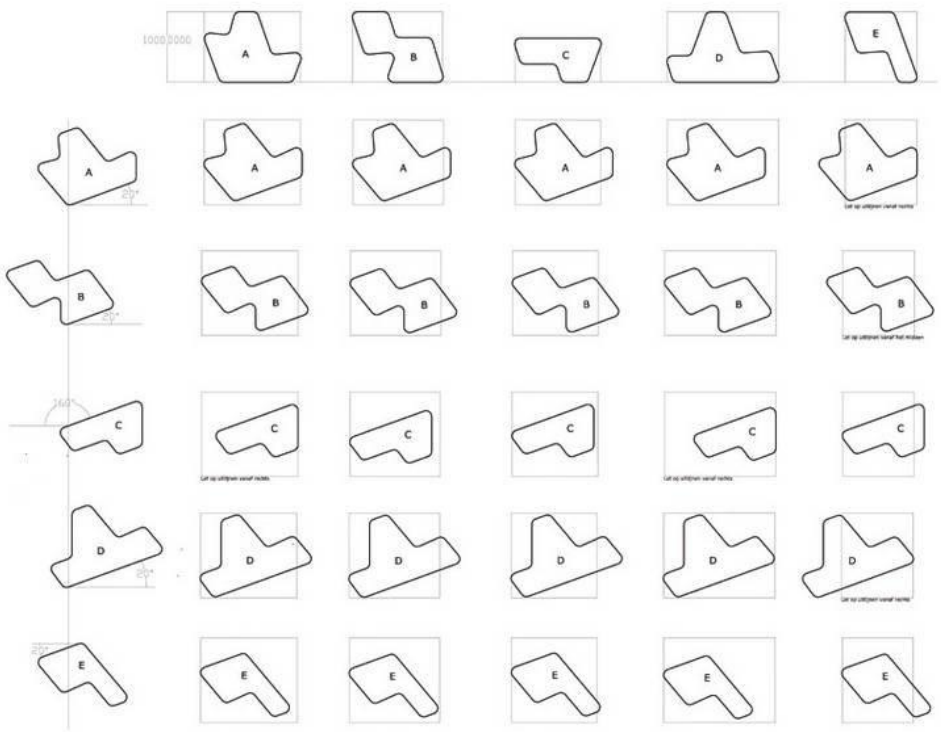


Figure 3.1.2 Oosterhuis Duch Embasy Berlin

Parametric design materiality because of its transgressive relationship to essential and accidental aesthetics is related less to the physical material, and more to the problem of production. What parametric design processes investigate is the production of endless variability within a system and means of production that would enable such conditions. Computer is explored as a machine of generation, rather than a machine of production, where material aesthetic is endless variability of mass customization. Performative qualities of parametric design processes are generated by various fabrication techniques described by Branko Kolarevic which redefine expectations of building design, its processes and practices.

3. 2 Cellular automata and essential materiality

Wolfram proved that complexity can be derived from a set of simple rules and structures. The application which consists of initial configuration and a set of rules that define the next state based on the previous. The end result depends on the set of chosen rules. Also known as Conway's game of life, the survival of the cell in the configuration depends on its relationship to surrounding. The simple rule set results in complex behavior, but the system eventually converges into a stable state.

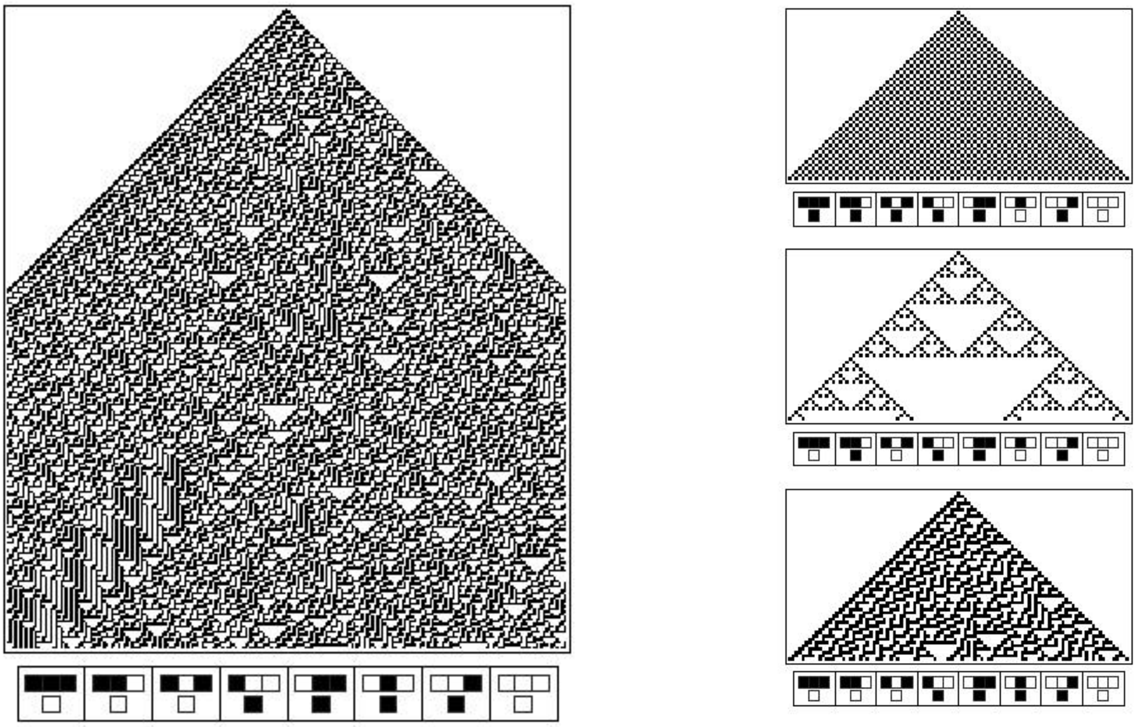


Figure 3.2.1 Cellular Automata principle

This algorithmic system is based on pure essential aesthetics. The initial state is dependent on topologically essential aesthetic qualities of the initial form, which in basic cellular automata model is a square. The rule-set for its progression is also based on essential aesthetic qualities, and survival is determined by the topological clarity. There are no accidental qualities in initial state nor in the process of progression.

The design process of Morphosis Architects deals with the pure essential aesthetic qualities of the initial state and explores relationships of substance to essential aesthetic qualities as they come into contact with each other. The behavior and survival of initial states is conditioned by a place of interaction, where topologically stronger model survives through the interruptive evaluation.

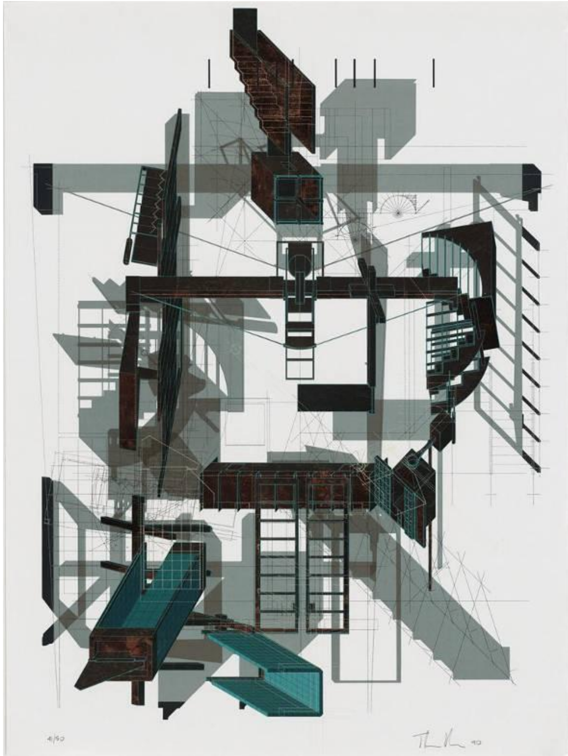


Figure 3.2.2 Thom Mayne, (Artist), John Nichols, (Printer) Sixth Street House, project Santa Monica, California, MOMA Collection

Because of its relationship to essential aesthetic qualities, materiality of this algorithmic system is in topological clarity of material and modes of production. Every material and fabrication technique is explored as a plastic topology, meaning that physical materials, elements and relationships between elements are all subjugated to the essential aesthetic quality of the model. Performative qualities of cellular automata design process are found in plasticity, flexibility and fluidity of materials and objects.

3. 3 Flocking of birds and emergent materiality

Flocking of birds is a mathematical model which explores possibilities to program behaviors of animate objects. Well known study of Craig Reynolds, named 'Boids' is an application that mimics flocking of birds in a realistic way, by creating an algorithms based on only 3 simple rules. The rules which define separation, alignment and cohesion of Boids create incredibly similar results to the behavior of birds in a flock.

Figure 3.3.1 Flocking of birds: Boids Model

Accidental aesthetic qualities are the initial state in the flocking of birds model. By understanding and directing the algorithmic system, design is moved from its initial state of accidental qualities towards essential aesthetic qualities. Much like in the parametric design model, design process relies on the emergent qualities within the process of transgression.

This process is based on setting up the initial accidental aesthetic qualities and defining a set of rules that would transform accidental into essential qualities. The evaluation mechanism is interruptive where the set of rules is redefined and applied to initial state if essential qualities do not emerge. The design process of Zaha Hadid is based on the flocking logic, where the initial state is exploration of accidental qualities which is then evaluated based on a set of rules. The essential aesthetic qualities emerge in the process of iterations.

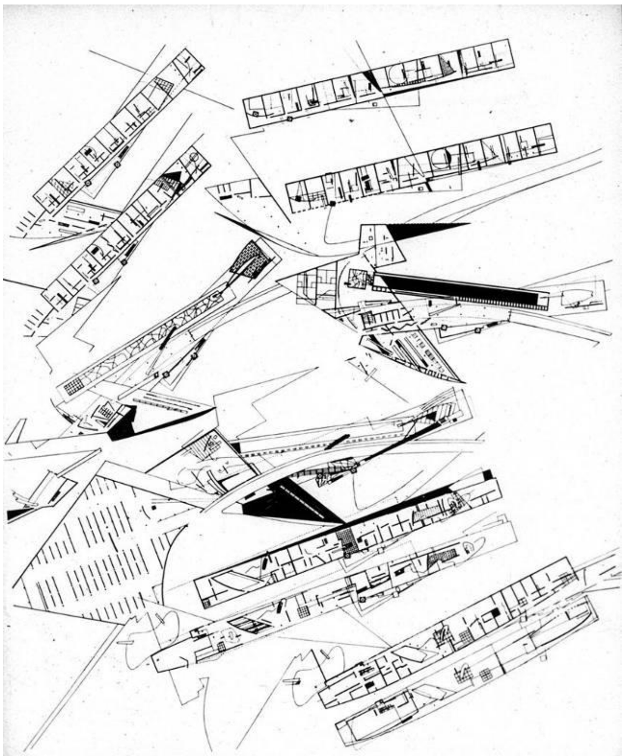


Figure 3.3.2 Pick Club Plans, Zaha Hadid Architect, Architectural Record, Sept. 1983

Much like parametric design materiality, because of its transgressive relationship between accidental and essential aesthetics with the focus on rule-set of process development, Flocking of birds design process is focused on possibilities of fabricating complexity rather than exploring physical materiality. These processes explore digital technologies of production and aesthetic qualities are contained within the process.

3. 4 Genetic algorithms and essential materiality

The technique of genetic algorithms was developed primarily for problem-solving and optimization in situations where it was possible to state clearly both problems and criteria to be fulfilled for their successful solution. Randomly chosen numbers are put through a process where strings of numbers improve through iteration. They are particular class of evolutionary algorithms that use techniques of evolutionary biology such as inheritance, mutation, selection and crossover. The algorithm is based on the concept of evolutionary optimization, especially for problems with different, sometimes conflicting constraints.

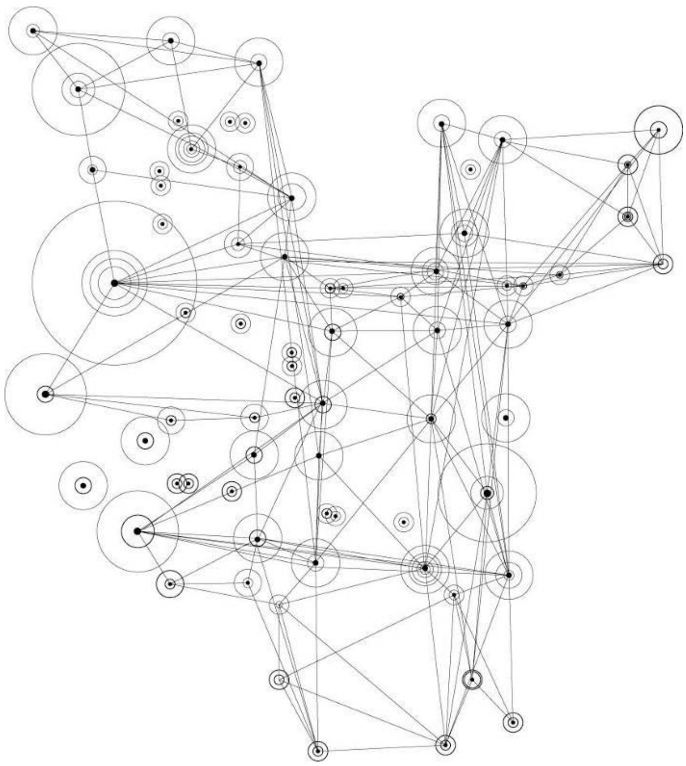


Figure 3.4.1 Genetic algorithm

These design processes are, much like cellular automata, characterized by pure essential aesthetic qualities, relaying on the aesthetic of a singular, universal, and optimal body. Selection, amongst a number of similar forms, is done based on predefined ‘fitness’ criteria. The evolution and evaluation of design is always in optimization of the initial state, much like the Darwinian model of survival.

Projects by Material Ecology and Biothing explore these essential aesthetic qualities of matter by introducing optimization in evaluative processes. Pure essential aesthetic is present in the initial state as well as throughout the process, where the optimal solution is evaluated only in relationship to purity of its essential qualities.

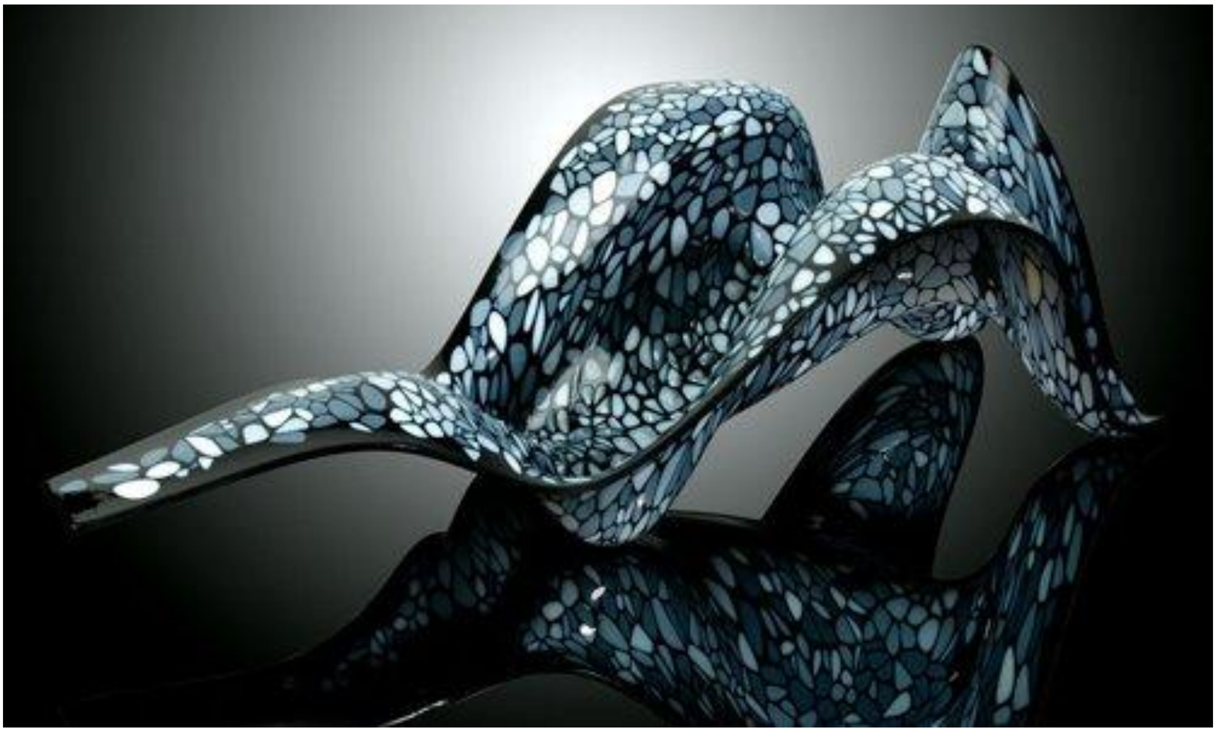


Figure 3.4.2 Neri Oxman, Material Ecology, Beast Project

Much like Cellular Automata model, because of its relationship to essential aesthetic qualities, materiality of this algorithmic system is as fluid and flexible. Because of the interactive relationship of evaluation within the process, unlike cellular automata, materiality required is much more organic to permit constant malleability of the initial state in the process of optimization. Performative qualities are closely related to the plasticity of physical material, which is why these practices are highly reliant on 3d laser printing and molding as the transformative operation.

3. 5 Shape grammars and accidental materiality

A shape grammar consists of a number of shape rules and generation engine which selects and processes rules. A shape rule defines how an existing shape can be transformed. Shape grammar consist of three shape rules: a start rule, transformation rule(s) and a termination rule. The start rule is used to start the process of shape generation; transformation rules are applied operators in process of their combinations, and the termination is used to stop this process. The specificity of this process is its dependency on shape generation as the initial state. Because of this quality of the process, the initial shape state is defined by accidental aesthetics that is then continued throughout the process. Explorations are within the behavior of accidental aesthetics as the transformation rules are applied.

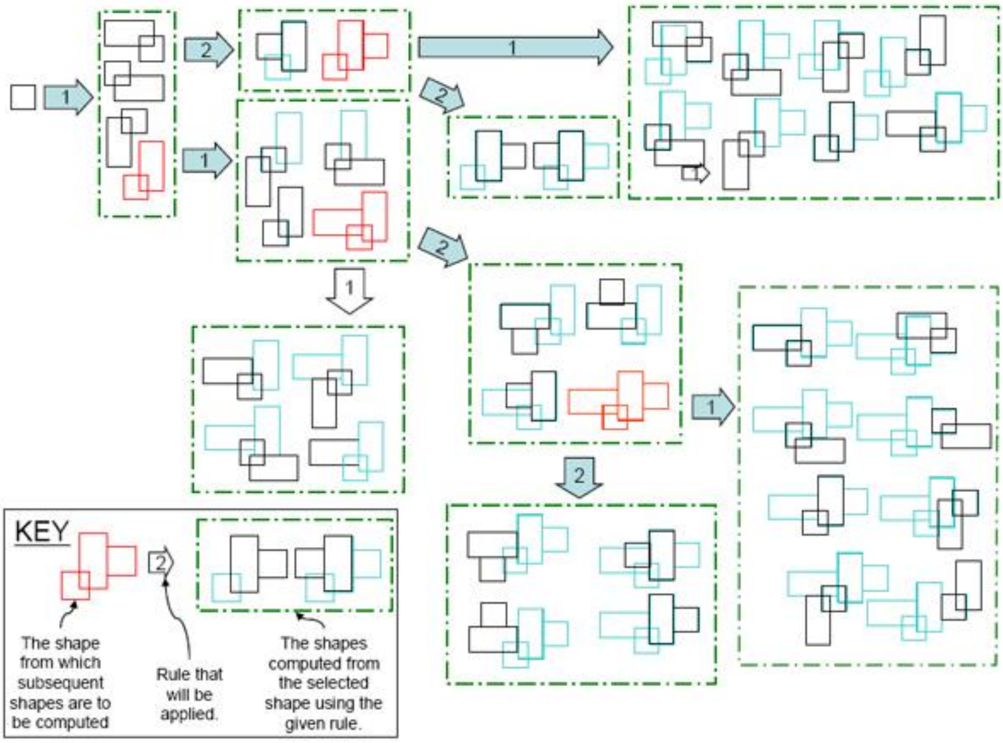


Figure 3.5.1 Shape Grammar generation engine

Architects such as Greg Lynn and Evan Douglis structure their explorations around pure accidental aesthetic qualities of the original shape. The accidental is defined in the initial state and then subjected to transformation rules that generate variations of initial accidental aesthetic qualities.

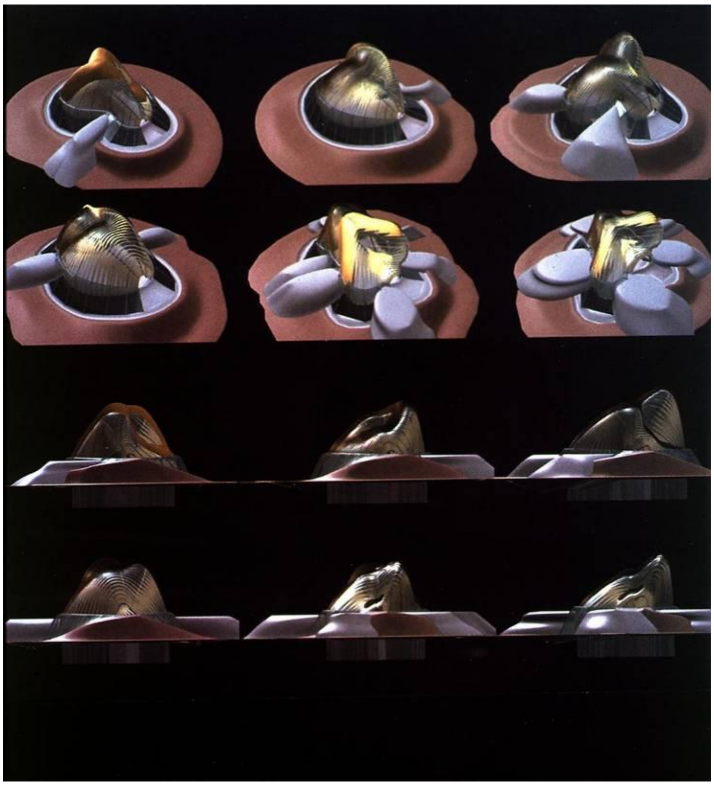


Figure 3.5.2 Greg Lynn, Project Embryological House, Architectural Record, Dec,1999, p.106

As these examples show, these practices constrain their explorations to accidental qualities of material as well, which is also why their work is mostly applied to the surface. By setting up design processes to explore accidental materiality, they integrate computerization and fabrication in service of exploring variations of surface texture, color, shadow patterns with various materials and material treatments. Performative qualities are achieved in variations of accidental qualities.

4. Digital/Analog Studio Student projects

This relationship of essential and accidental aesthetic qualities to materiality in generative design processes were examined in the studio Digital/Analog which was conducted at Pratt Institute School of Architecture in Brooklyn, NY.

Students used no digital tools, but applied the generative design logic to creating the initial state, (one to three states, or joint) which were then subjected to the algorithmic proliferation logic according to a rule-set and evaluation constraints.

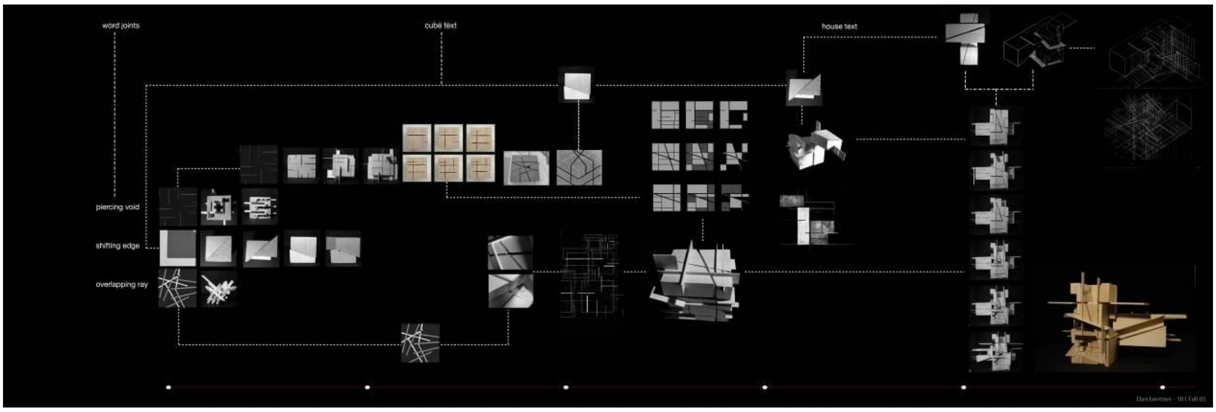


Figure 4.1 Process Diagram
Dan Brietner full semester process diagrammed by Yael Erel (Arch 101 Fall '05 Pratt Institute School of Architecture) Originally created for Ineffable, a conference organized by Brad Horn at The City College School of Architecture in 2007

Initial state or the joint was examined in the relationship to aesthetic or essential aesthetic qualities. Students explored how ornament or topological operations define the joint. By doing so, they focused on either exploring accidental aesthetic qualities or essential aesthetic qualities. After defining aesthetic qualities of the initial state, they applied systems of development and evaluations based of the initial aesthetic logic and material qualities of wood. The most intensive was the transgressive mode of parametric design and flocking of birds system, because of their complex relationship to material substance. Some students managed to transgress aesthetics of the initial state, most stayed within exploring essential aesthetic qualities or accidental aesthetic qualities of initial wood models.

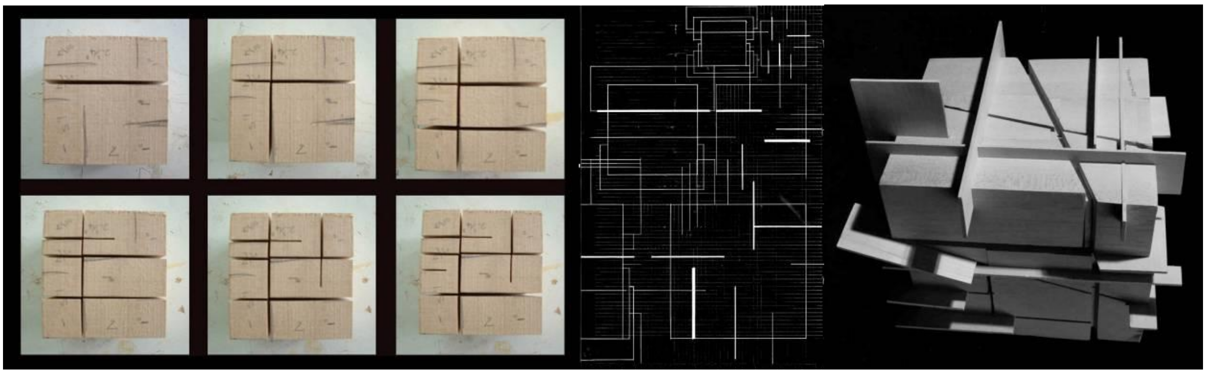


Figure 4.2: Initial State, Rule-Set, Construct of the Algorithmic System:
Dan Brietner full semester process diagrammed by Yael Erel (Arch 101 Fall '05 Pratt Institute School of Architecture) Originally created for Ineffable, a conference organized by Brad Horn at The City College School of Architecture in 2007

4. 1 Student Work

Figure 4.1.1: Parametric design Essential + Accidental Aesthetics:
Studio Digital/Analog: Xing Zheng, prof Dina Krunic (Pratt '07)

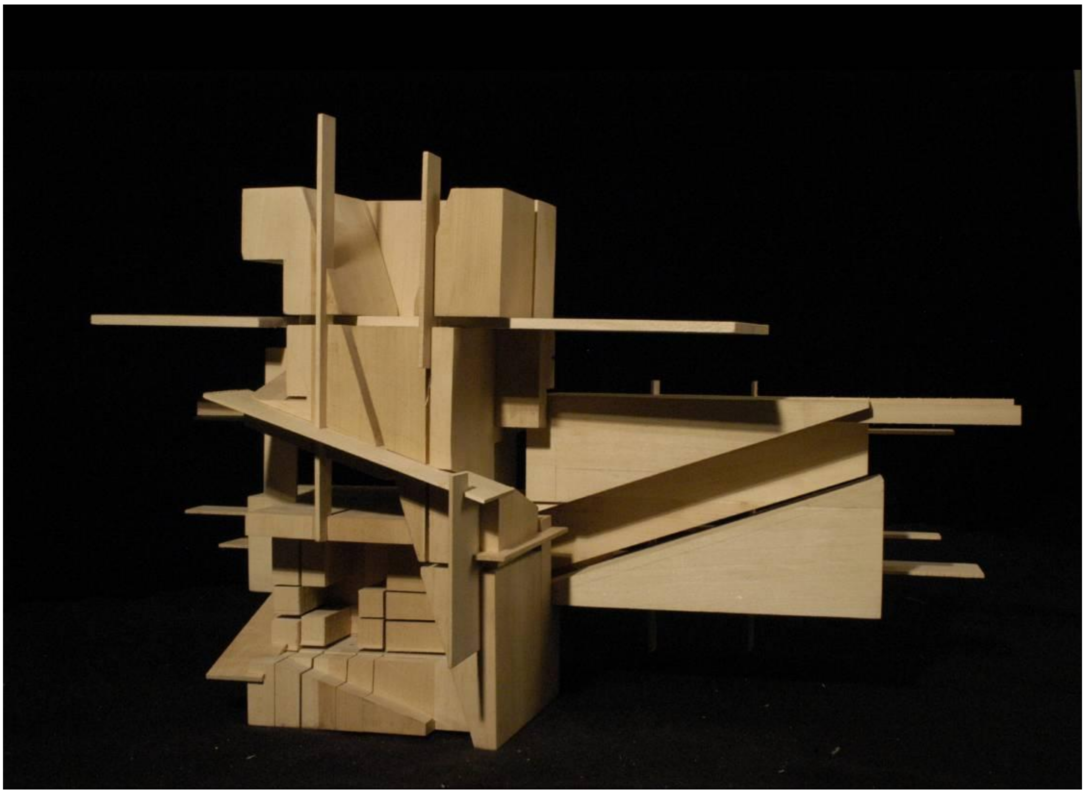


Figure 4.1.2: Cellular automata: Essential Aesthetics:
Dan Brietner full semester process diagrammed by Yael Erel (Arch 101 Fall '05 Pratt Institute School of Architecture) Originally created for Ineffable, a conference organized by Brad Horn at The City College School of Architecture in 2007

Figure 4.1.3: Flocking of birds:Accidental + Essential Aesthetics:
Studio Digital/Analog, Anastasiya Konopitskaya, prof Dina Krunic (Pratt '07)

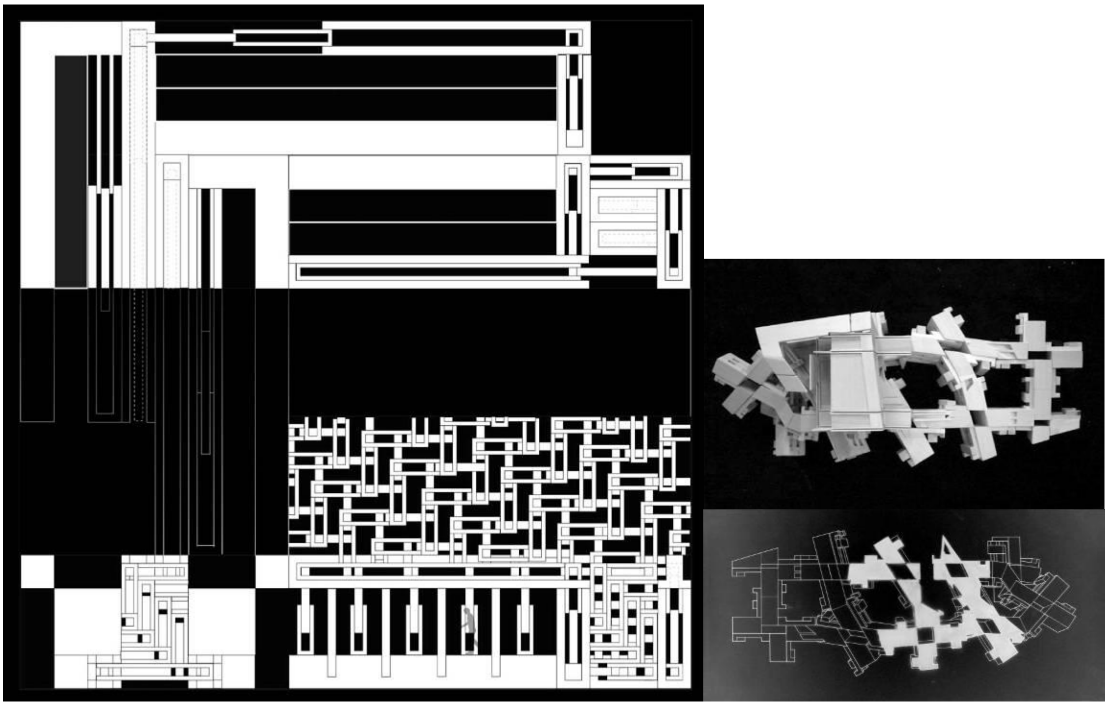
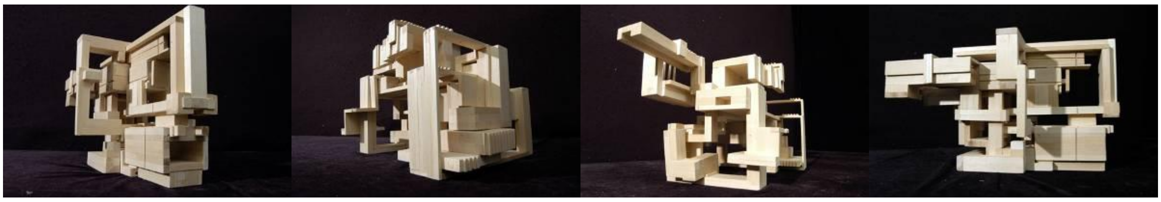


Figure 4.1.4: Genetic algorithms: Accidental Aesthetics:
James Orielly (Spring '06) and Patrick Collins(Arch 102 Spring '07 Pratt Institute School of Architecture full semester process diagrammed by Yael Erel). Originally created for Ineffable, a conference organized by Brad Horn at The City College School of Architecture in 2007



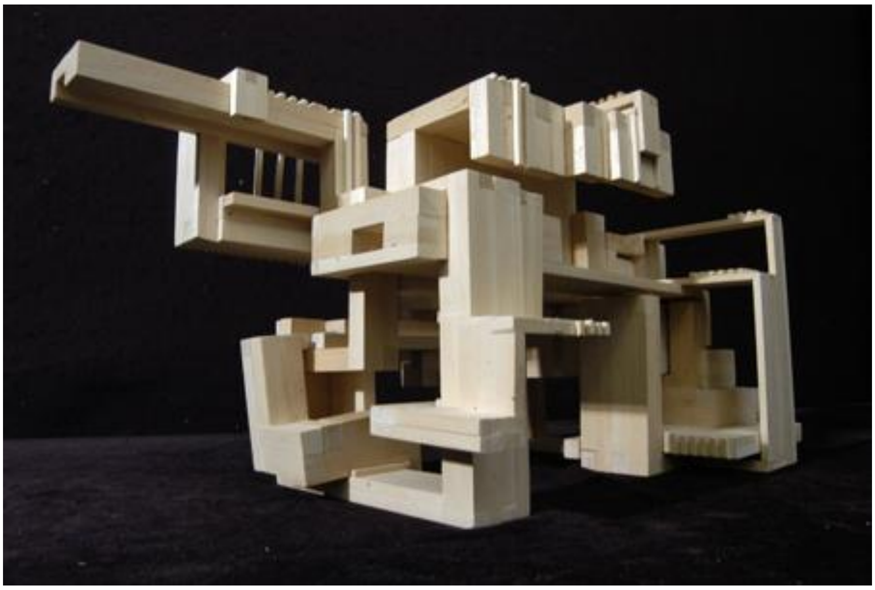


Figure 4.1.5: Accidental + Essential Aesthetic:
Studio Digital/Analog: Sam Sutcliffe & Thea Price-Eckles, prof Dina Krunic (Pratt ‘07)

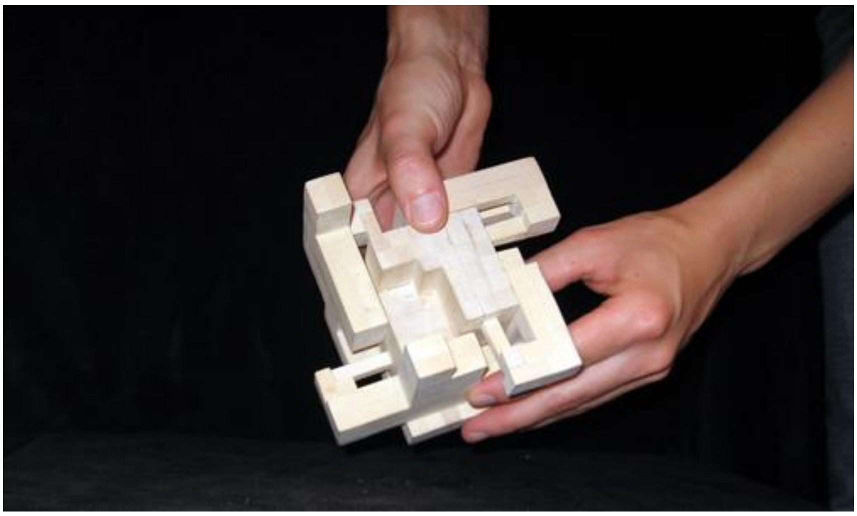


Figure 4.1.6: Shape Grammars Accidental Aesthetic:
Studio Digital/Analog: Anastasiya Konopitskaya, prof Dina Krunic (Pratt ’07)

5. Conclusion

Learning from Greek philosophers, aesthetics is a quality of objects, which can be essential or accidental. Essential aesthetic qualities are topological qualities, essence of the object which is unchanged throughout the process of transformation. Accidental aesthetic qualities are ornamental qualities, which can be varied without losing the object-hood. Generative design is a design logic consisting of initial state, rule-set of progress, and evaluation constraints. Depending on their differences, algorithmic systems within generative design assume various relationships to materiality and performance. They are linked to whether these algorithmic systems operate on initial states with essential or accidental aesthetic qualities, and whether their progression is within the same typology of aesthetic qualities or transgressive.

Parametric design is a move towards emergent materiality, because the initial state of essential aesthetic qualities progresses towards the accidental, much like flocking of birds which is the inverse procedure. These design processes have problematic relationship to materiality because of the transgression between aesthetic qualities. Performative is accomplished through fabrication and therefore does not have any specific materiality. Cellular Automata and Genetic algorithm are algorithmic systems which depend on the initial state as containing essential aesthetic qualities. Throughout the process in cellular automata, essential qualities survive through elimination of the weaker at the point of connection. Throughout the process of genetic algorithm, essential qualities are molded through optimization as in the evolutionary model. Materiality of these models is mostly related to fluidity and flexibility of matter, and performative is achieved through exploration of limits of the malleable substance. Shape grammars is a design logic where accidental qualities which are set up in the initial state are examined through the process of transformation. Type of material, texture, color and all other accidental qualities of matter are activated to create performative.

Through this exploration, we connected architectural materiality to digital processes through exploring their aesthetic qualities. But more so, we have moved towards understanding the material behind computational models, we have moved towards a new materiality.

References:

[1]Manuel Delanda, A Thousand Years of Nonlinear History (Zone Books, 2000)
[2] Branko Kolarevic & Kevin Klinger, "*Manufacturing Material Effects: Rethinking Design and Making in Architecture*", Routledge, 2008
[3] Celestino Soddu, *Argenia, a Natural Generative Design*, Generative Art, Proceedings of the 1st International Conference GA '98, 1998
[4] A. van der Zee & B. de Vries, "*Design by Computation*", Generative Art Conference, 2008
[5] W. Mitchell, *The Logic of Architecture – Design, Computation, and Cognition* (MIT Press 1990)
[6] Aristotle, *The Metaphysics* (Hugh Lawson-Tancred, 1998)
[7] Adolf Loos, *Ornament and Crime: Selected Essays*, (Ariadne Press, 1997)
[8] Louis Sullivan, *A System of Architectural Ornament*, (Eakin Press, 1967)
[9] John Frazer, *Evolutionary Architecture*, (Architectural Association, 1995)

A Shape Grammar Model To Generate Islamic Geometric Pattern

Ebru ULU, MSc. Arch.
Architectural Design Computing PhD Program,
Istanbul Technical University, Istanbul, Turkey
e-mail: ebruarkut@gmail.com

Assoc. Prof. Sinan Mert ŞENER, PhD. Arch.
Faculty of Architecture, Istanbul Technical University,
Istanbul, Turkey
e-mail: mert@itu.edu.tr

Abstract

Geometric patterns are the important ornaments of Islamic art and architecture. Polygons and poly-pointed star patterns, especially the 6-, 8-, 10- and 12-sided polygons were mostly used in Islamic art and architecture. They have created various geometrical compositions on the surfaces. The 10 sided polygon, decagon, is a special shape in Islamic geometry. This study is evaluating the special features of decagons in Islamic art by analysing the Penrose tiles, aiming the generation of new patterns that have the similar characteristics of the geometric patterns in Islam with the help of a shape grammar model. In this context, two design templates developed are for the new generated patterns.
In this paper, the combinations of the bowtie and the elongated hexagon, which are the sub shapes of a decagon, are mentioned and generated to make it possible to cover a rectangular surface. Two bowtie-elongated hexagon templates help to generate new forms. They are related to Islamic geometrical patterns and many results of the generation from these two templates are given in the framework of this study.
The aim of this paper is to show that different final products can be formed from the shapes, which have the same design language and same initial shape applying the same rule schema. It is clarified that a design can be handled at a wider perspective in the context of shape grammars and reproduced by the new designs with the same genetic features.
The future goal of this research is to apply this shape grammar model and the design templates with a computer program, in order to get the results easier and faster.

1. Introduction

Since 1977, Stiny's paper about generation of Chinese lattice design [10] shape grammars have been used to understand the design language, to analyse a design or a shape and to generate new designs from the same language. The shape grammars are a rule-based design method, which helps to solve the rule schema of a structure of a design. A lot of houses, shapes or compositions such as Turkish Traditional Houses [6], Alvaro Siza's Malagueira Houses [7], Queen Ann Houses [8], Palladian Villas [11], Mughul Gardens [12], Architect Sinan's Mosques [13] and the Meander Motifs on Greek Geometric Pottery [9] were analysed in the context of shape grammars. The analyses of Islamic geometries were also a research field in different disciplinary [14-17].

Before the acceptance of the religion of Islam there was not a significant art style or a dominant architectural tradition. After that, there was the belief coming from the respect to the principle *“There is no God but Allah!”* which prohibited using the figures as decoration elements. In Islamic art and architecture, the role played by the non-figural style in religion caused the patterns to come in three distinct geometrical types: the Arabic script, floral decoration called Arabesque, and geometrical patterns [4]. First recognizable style is the Kufic patterns that are formed into rectangles and squares to create calligraphic designs. Such patterns are used to add dignity and solemnity onto the architectural surfaces. The second distinct pattern group is the floral decoration, which is also called as arabesques. This type of ornaments occur curvilinear elements symbolizing leafed and floral forms [1]. The significant ornament type in Islamic art and architecture is the geometric patterns that include complex polygons and poly-pointed star shapes. The patterns were applied on different types of materials such as brick, wood, tiling, stone, plaster, stucco and paper. Islamic compositions are usually used for wall, door, window, ceiling and mimbar decorations.

There are numerous different geometric patterns in Islamic art and architecture. This study focused on the geometric compositions, their sub shapes and the generation of the new geometric patterns, which have the same characteristics with the original ones, based on a shape grammar model.

2. Geometric Patterns

The most striking characteristic of the geometric patterns in Islamic art is the prominent symmetric shapes, which are like stars and constellations. 6-, 8-, 10-, 12-pointed star shapes are the ones that occur mostly in ornaments. Another important characteristic is that the rectilinear forms are interlacing each other, and continuously following the lines. The last features are the variety of the shapes, the flow and unboundedness of the entire composition. In the composition, the context of copying the shape is that, every cell repeats itself indefinitely with the rule of symmetry to fill the space [1].

The most popular shapes such as 6-, 8-, 10-, 12-pointed stars are created in the limits of the hidden circle. The circle helps to perceive the interlaced composition as a strong unitary, which symbolizes the one and the only God, Allah [3]. The geometries develop in two different ways such as linear-developed compositions and centric-developed compositions. The first type of composition includes zigzags, V-formed shapes, meanders and also poly-pointed stars. The centric-developed compositions, also called closed geometries, contains polygons, poly-pointed stars, medallions and mixed geometries.

Below it is seen the creation of a hexagon and a 6-pointed star; an octagon and an 8-pointed star; a decagon and a 10-pointed star; and finally a dodecagon and a 12-pointed star in 3 different ways. First 3 shapes are created by centric rotation of the same circle after starting by a point, a line and then a simple shaped circle. The figure 4 shows that the initial shape is different for the same rule schema that creates the same final shape in different scales.

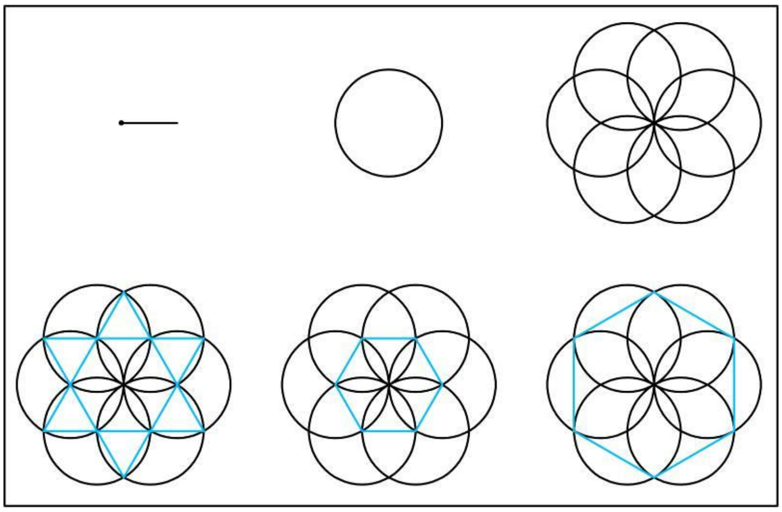


Figure 41. Creation of hexagon and 6-pointed star.

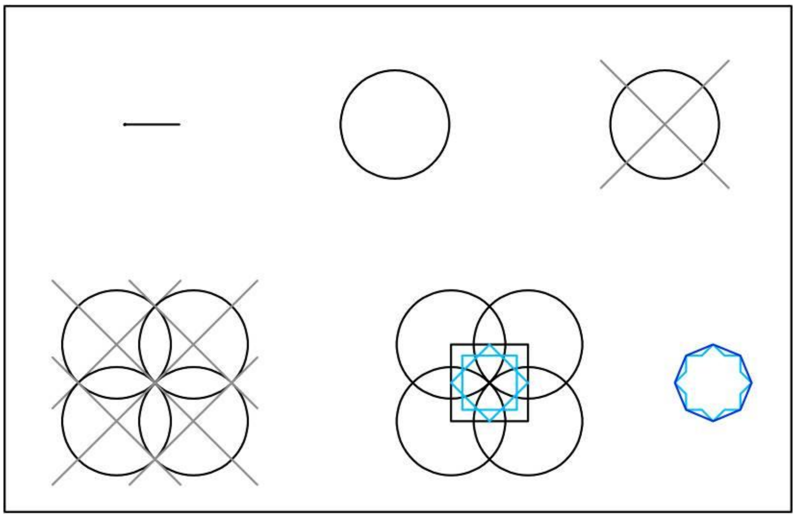


Figure 42. Creation of octagon and 8-pointed star.

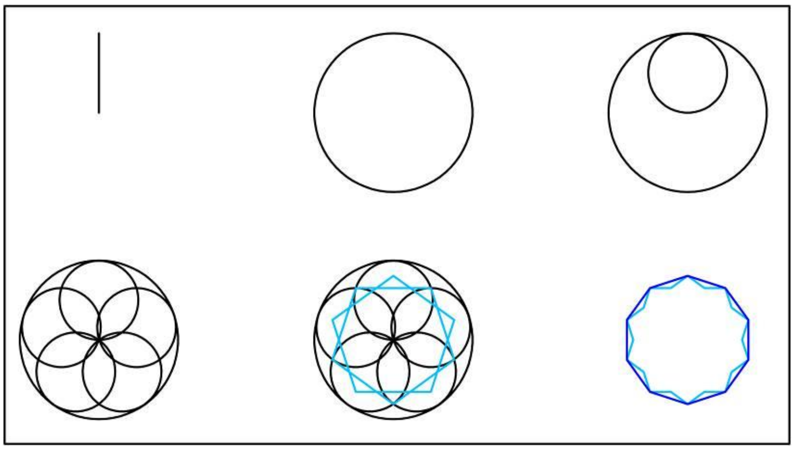


Figure 43. Creation of decagon and 10-pointed star.

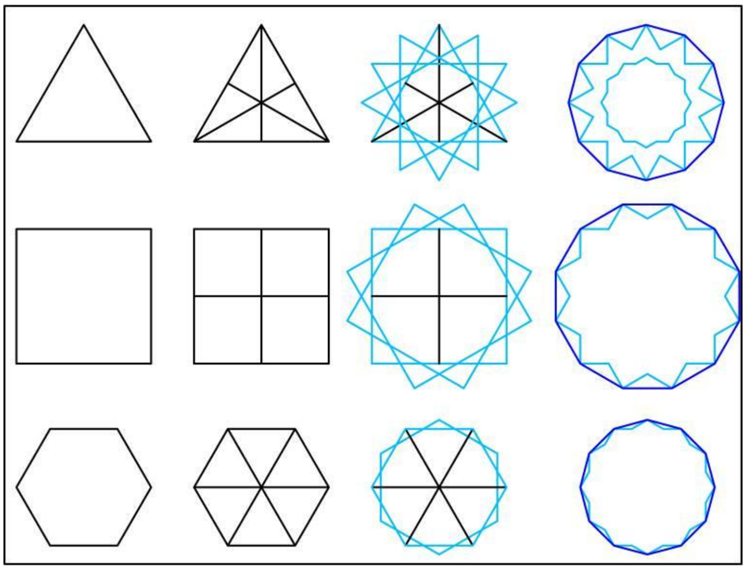


Figure 44. Types of creation of dodecagon and 12-pointed star.

In this study, the creation of the design templates that generate new Islamic geometries is based on the synthesis of the features and the rule schemas given above.

3. Pentaplex Tiling and the Special Shape: Decagon

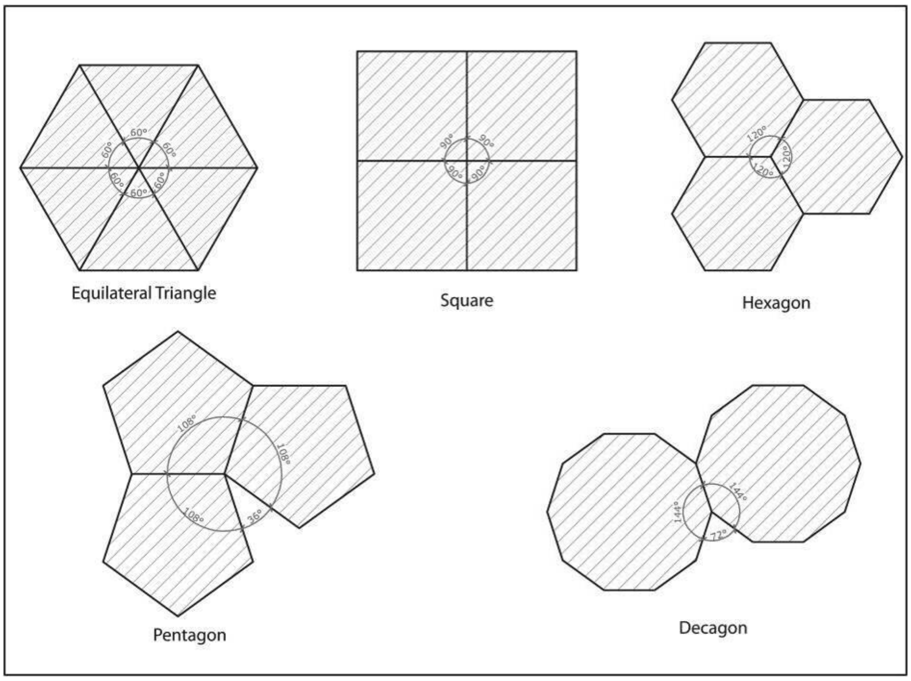


Figure 45. Rotational symmetries of basic Islamic geometries.

It is a common method to use various geometric tiles to cover a surface. The assembling of the tiles establishes an important point which is, the tiles cannot overlap on each other, and there cannot be a gap between them. The figure 5 shows the most used tiles in Islamic ornaments and makes clear that equilateral triangle, square and hexagon have a rotational symmetry, and they can cover a surface without any gaps or overlapped tiles. However, the pentagon and decagon need support elements to close the rotational symmetry. Therefore, it is not possible to create a periodic pattern with rotational symmetry using only pentagons or decagons.

There are seventeen periodic pattern types created by 2-, 3-, 4- and 6-fold rotational symmetries. Most of them are also used in Islamic geometric patterns [1]. But the 5-fold rotational symmetry is not used for the periodic patterns. From this point of view, the aperiodic patterns with 5-fold rotational symmetry could be discussed.

The Pentaplex tiles are mentioned first in 1970's by Roger Penrose, a famous physician. These tiles cover the surfaces, which contain 5-fold rotational symmetry, aperiodically. The Pentaplex tiles in Turkish-Islamic art have been being used since 11th century [2]. The figure below shows one of the 3 types of Penrose tiles. This group contains the shapes called the kite and the dart.

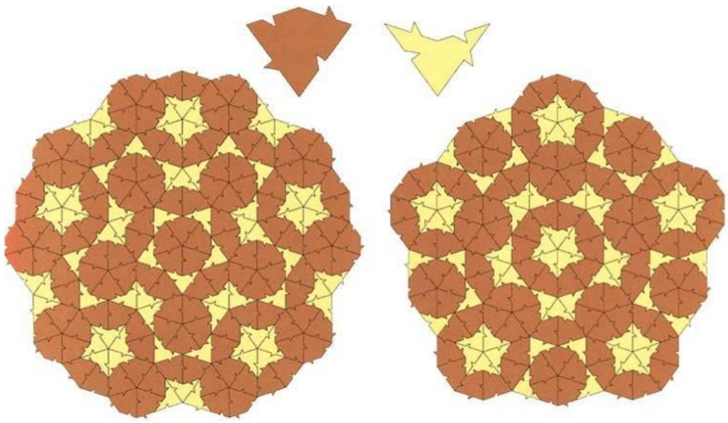


Figure 46. The alternative Penrose tile combinations of darts and kites.

When the entire composition created by Penrose tiles is researched, and the assembling of the sub shapes is observed, it is realized that kites and darts create new shapes, which will be the key points of the design templates at the end of this research. The figure 7 clarifies the very first steps, and the source of the entire study.

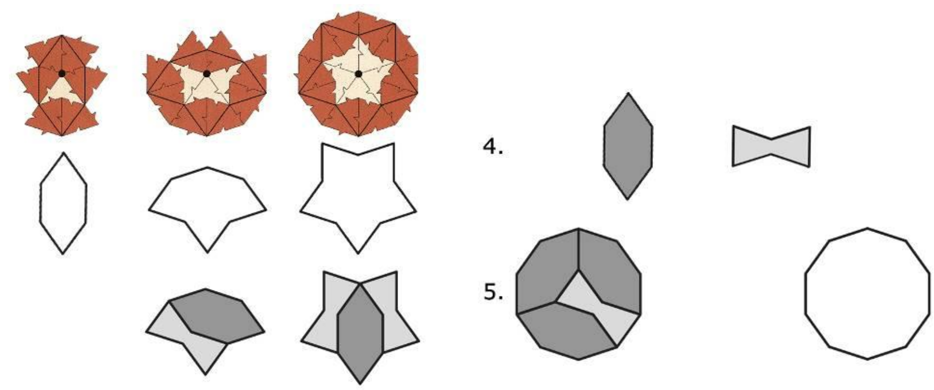


Figure 7. The creation of the decagon from the tie and the bowtie.

1st step shows the sub shapes of the Penrose tiles, the combination of darts and kites. At the 2nd level three new shapes called tie, fish and star are created. The next level makes it clear that the tie is also the sub shape of the fish and star with a new shape named bowtie, which is shown with the color light grey at the 4th step. The last step is the most important one that represents the creation of the special form decagon from the tie and the bowtie. In other words, the decagon comes from the sub shapes of the Penrose tiles, and also it can be said that the sub shapes of the Penrose tiles are also the sub shapes of the decagon.

4. Pattern Generation from Decagon

The figure below shows that the tie and the bowtie come together in many variations to create fish, decagon and star shapes. There are 2 variations for the fish shape, 10 variations for the decagon and 5 combinations for the star shape.

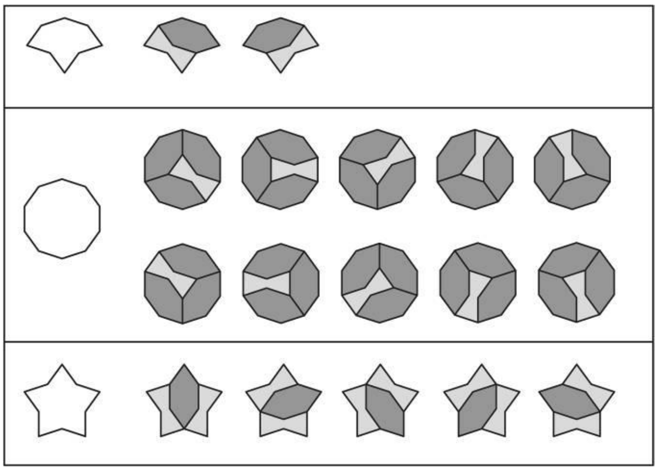


Figure 8. The variations of tie and bowtie

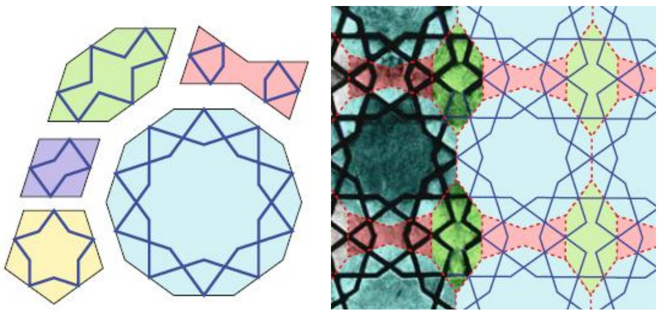


Figure 9. 5 girih tiles: decagon, pentagon, hexagon (tie), bowtie, and rhombus [5].

In 2007, Peter Lu and Paul Steinhardt mentioned in their paper about the Decagonal Tilings in Medieval Islamic Architecture that equilateral polygons –girih tiles- created *complex periodic girih patterns with self-similar transformations to construct nearly perfect quasi-crystalline Penrose patterns five centuries before their discovery in the West* [5]. The drawing on the left is the complete set of the 5 girih tiles: decagon, pentagon, hexagon (in this paper it is called as tie), bowtie, and rhombus. The picture on the right hand side in Figure 9 is from the outside wall of a 15th century Timurid tomb with tie, bowtie and decagon layer on it. The overlapped layer indicates that this pattern is developing periodically. From this point on, it can be said that it is possible to create periodic patterns by using only decagons, which consist of three ties and a bowtie.

First drawing below illustrates the generation of the 1st design template. First step shows the initial shape of the shape grammar. The decagon, the initial shape, is rotated on the corner 5 times intersecting each other in the context of the rule 1. The second shape is a combination of ties and fish shapes with 5-fold rotational symmetry. According to the rule 2, two decagons are added above the last generated shape at the edges. Rule 3 contains the reflection of the entire shape vertically before it is reflected horizontally in the rule 4. After the rule 4 was applied there is a star-decagonal formed gap in the center. Last rule tells to put a decagon in the center of the whole composition. The output shape is the first design template that will be covered by covering tile groups afterward.

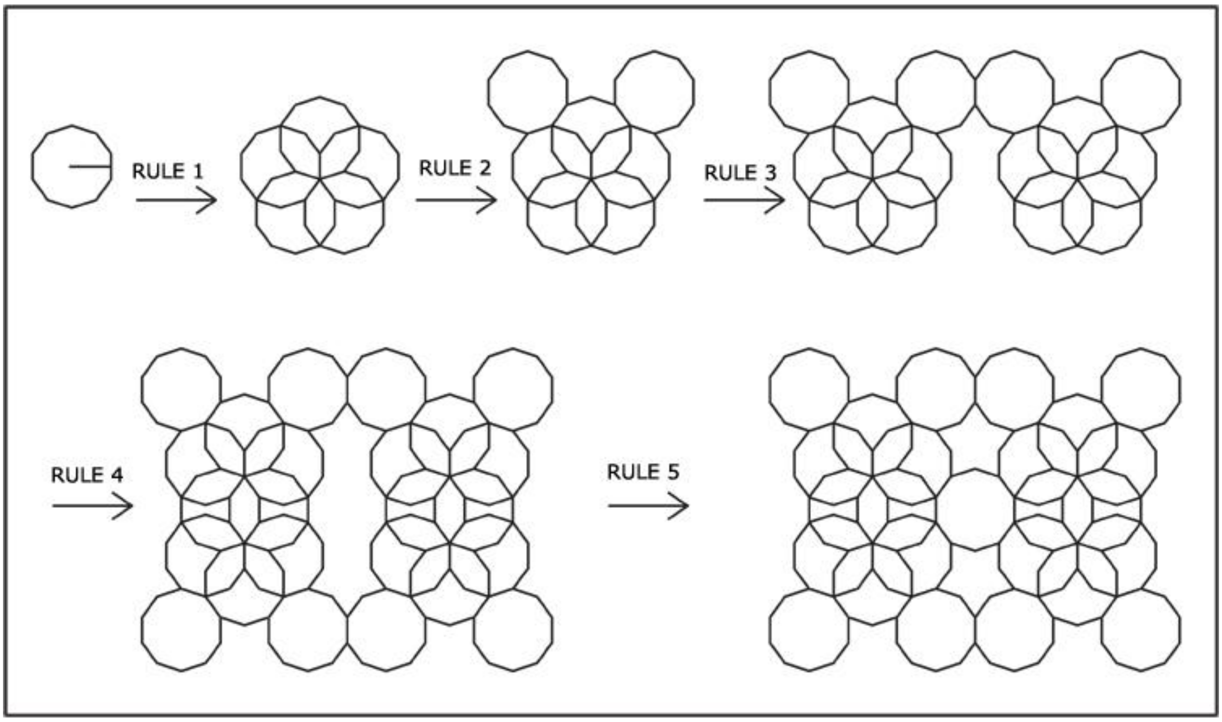


Figure 10. The rule schema of the 1st design template's shape grammar.

Second drawing shows the generation of the 2nd design template. The rule schema is similar to the first shape grammar's rules. The main point of two rule schemata is the symmetry that is also the most important feature of Islamic patterns. Another key point is to put the decagons at the corners and in the center of the entire design template. The last thing to pay attention is the symmetry axes of the whole pattern have to cross the symmetry axes of the shapes on it. Figure 12 indicates that the edges of the rectangle and the axes of the pattern are located on the symmetry axes of the star shape, tie and bowtie.

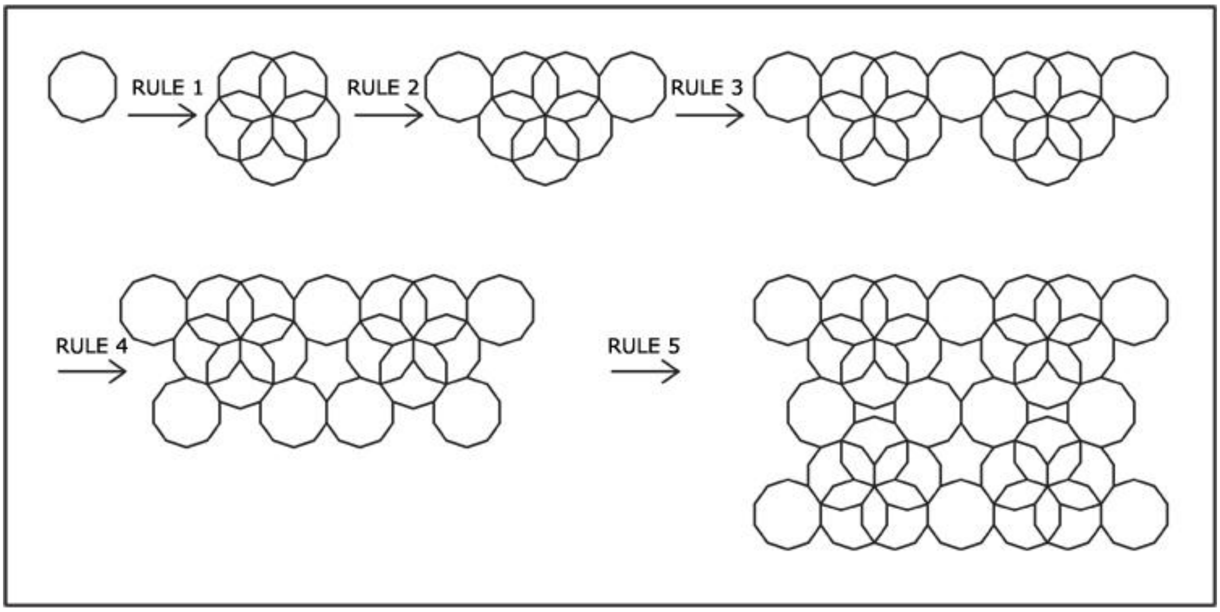


Figure 11. The rule schema of the 2nd design template's shape grammar.

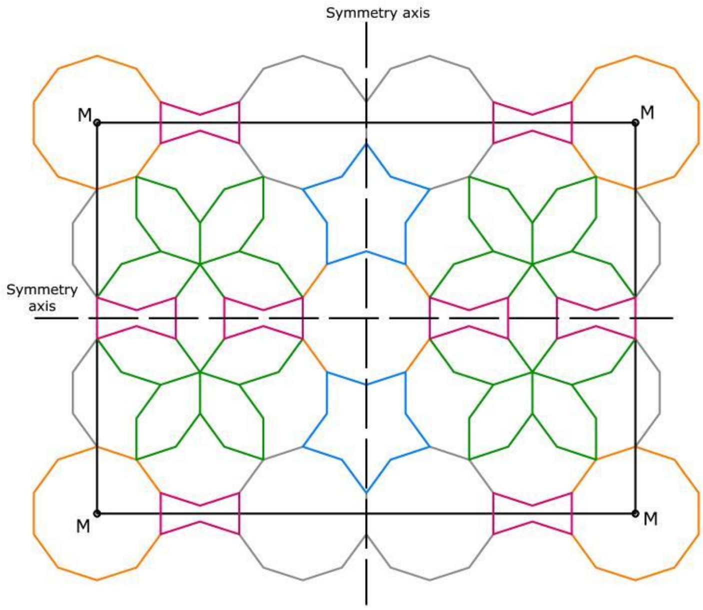


Figure 12. The generation constraints of the design template.

The design templates can also generate themselves in the context of the rules and constraints. As it was mentioned before, star, fish shapes and decagons consist of ties and bowties, so that for every decagon there are 10; for every star shape there are 5; and for every fish shape there are 2 different combinations. There are also combinations of every shape with each other that give numerous alternatives from two design templates. The Figures 13 and 14 show some alternative results of the two initial design templates. The code of the derivatives indicates the *number of the design template • (number of the level•) [number of the derivation at the 1st level • number of the derivation at the 2nd level • number of the derivation at the 3rd level] • the letter code of the derivative at the 4th level.*

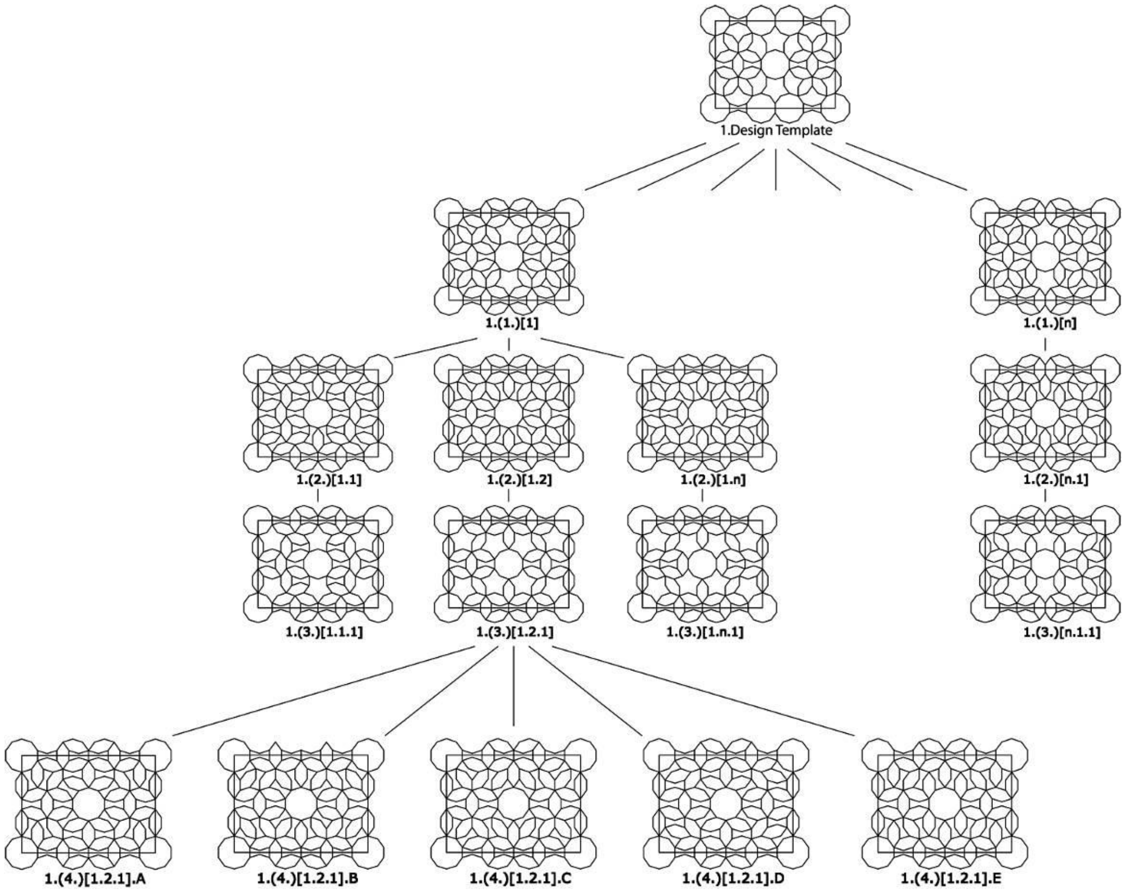


Figure 13. The derivatives of the 1st design template.

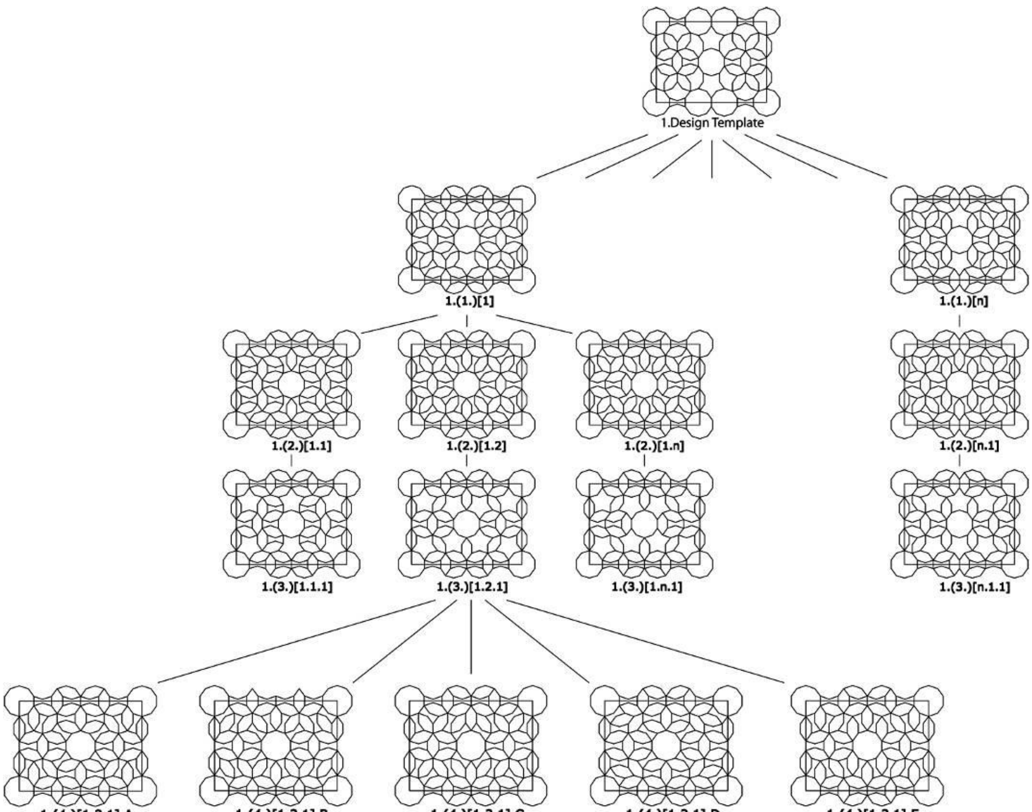


Figure 14 The derivatives of the 1st design template.

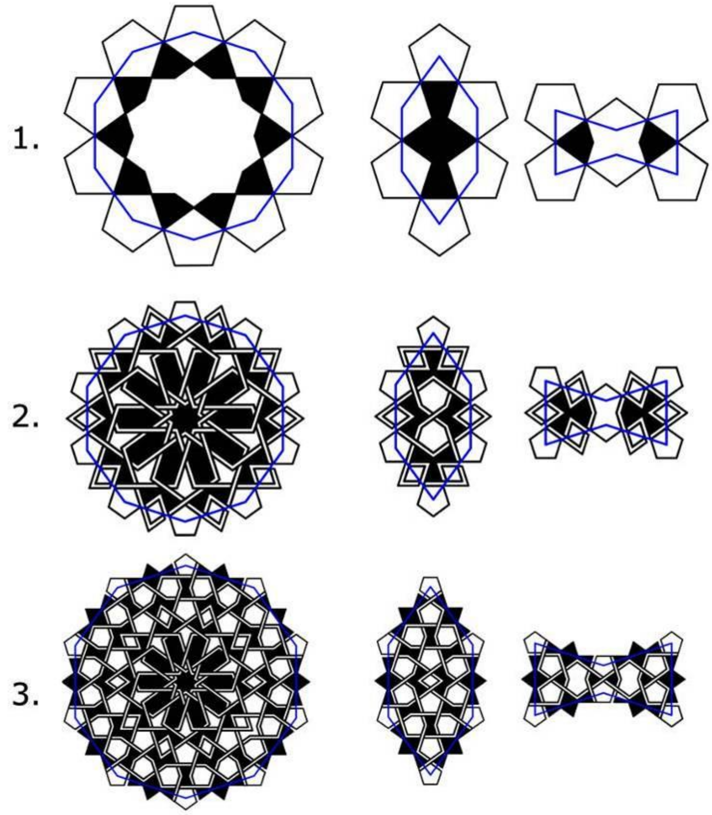


Figure 15. 3 groups of covering tiles of decagon, tie, and bowtie.

There are three groups of covering tiles to fill the end derivatives. Figure 15 shows the tile groups for each decagon, tie and bowtie. First group is developed from Lu and Steinhardt's researches. After they examined some ornaments of Islamic architecture such as *Darb-I Imam Shrine at Isfahan, Iran, Ottoman Green Mosque in Bursa, Turkey, Mughal I'timad al-Daula Mausoleum in Agra, India* they found many geometric patterns combined by decagon, tie and bowtie. The first group is the simplest one of all. 2nd and 3rd groups are created by Prof. Dr. Metin Arık and Mustafa Sancak. The 3rd one is the most complex one and involves more tiles than the other group.

First column of the groups shows the covering tiles for the decagon shape, by 2nd column for the tie and the 3rd column for the bowtie. That means where there is a decagon in the design template it will be filled by one of the circular patterns, if it is a tie then it will be covered by one of the vertical patterns, and a bowtie will be filled with one of the horizontal patterns.

It is given in the figures 16 and 17 an end derivative from the 1st design template and the geometric pattern results after all of the decagons, ties and bowties filled with every group of covering tiles. Figure 18 and 19 show the same results for one of the end derivatives of the 2nd design template.

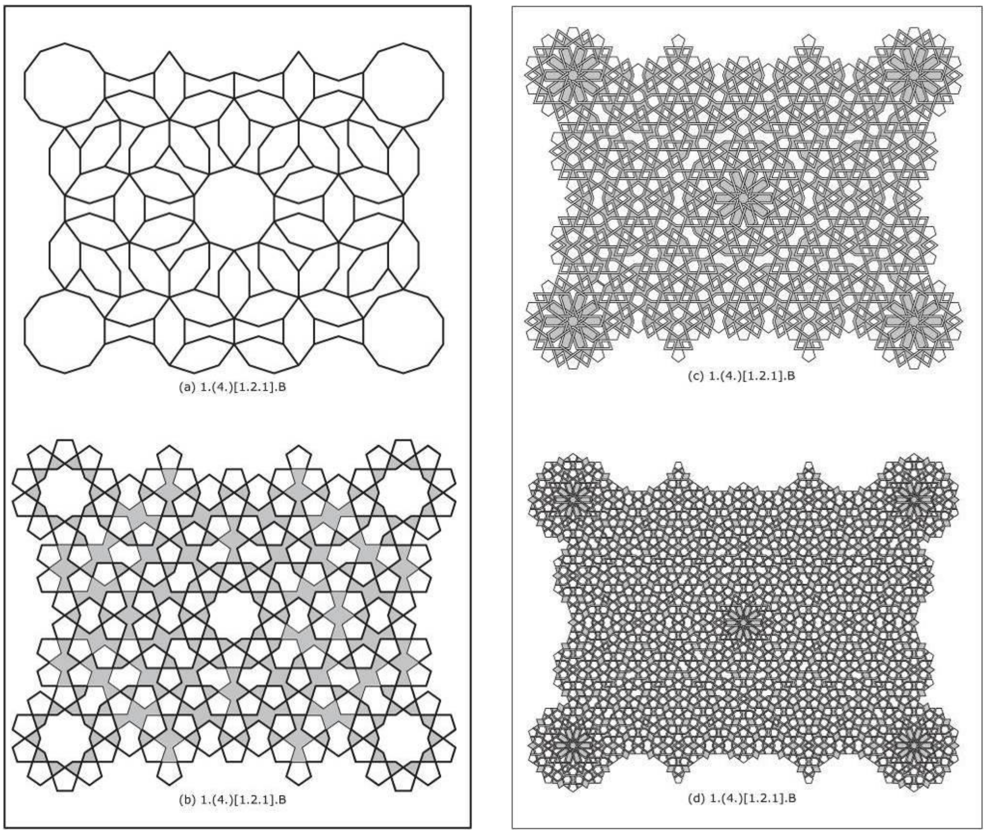


Figure 16. Derivative of the 1st design template covered by 3 groups of covering tiles.

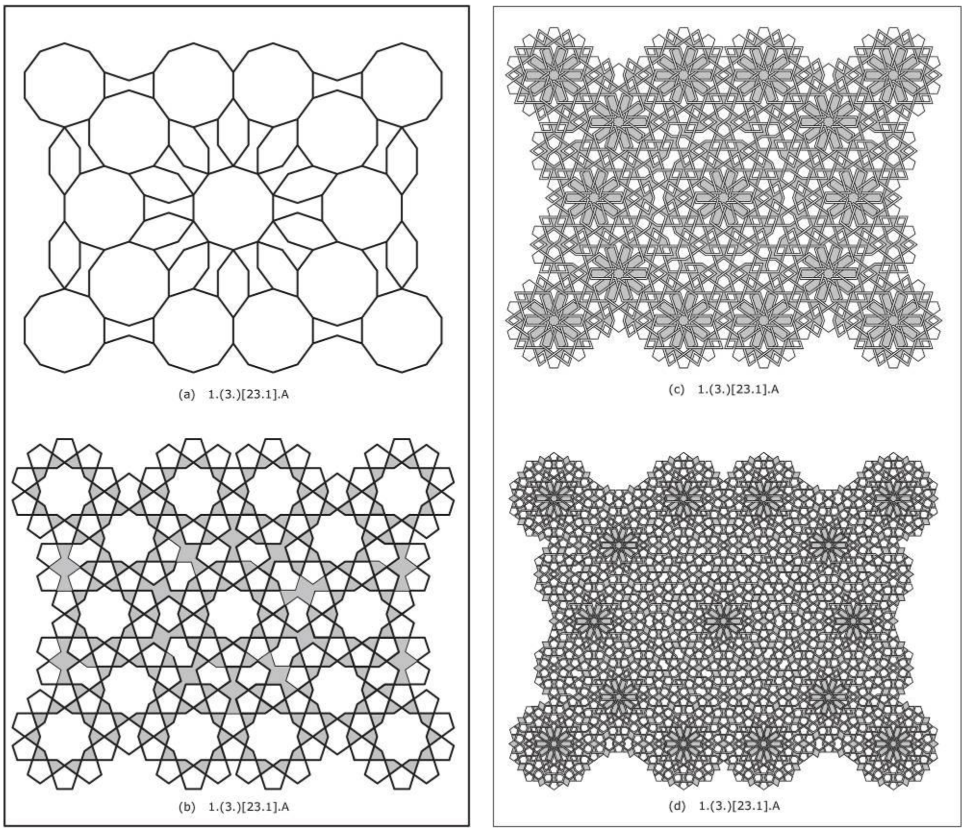


Figure 17.Derivative of the 1st design template covered by 3 groups of covering tiles.

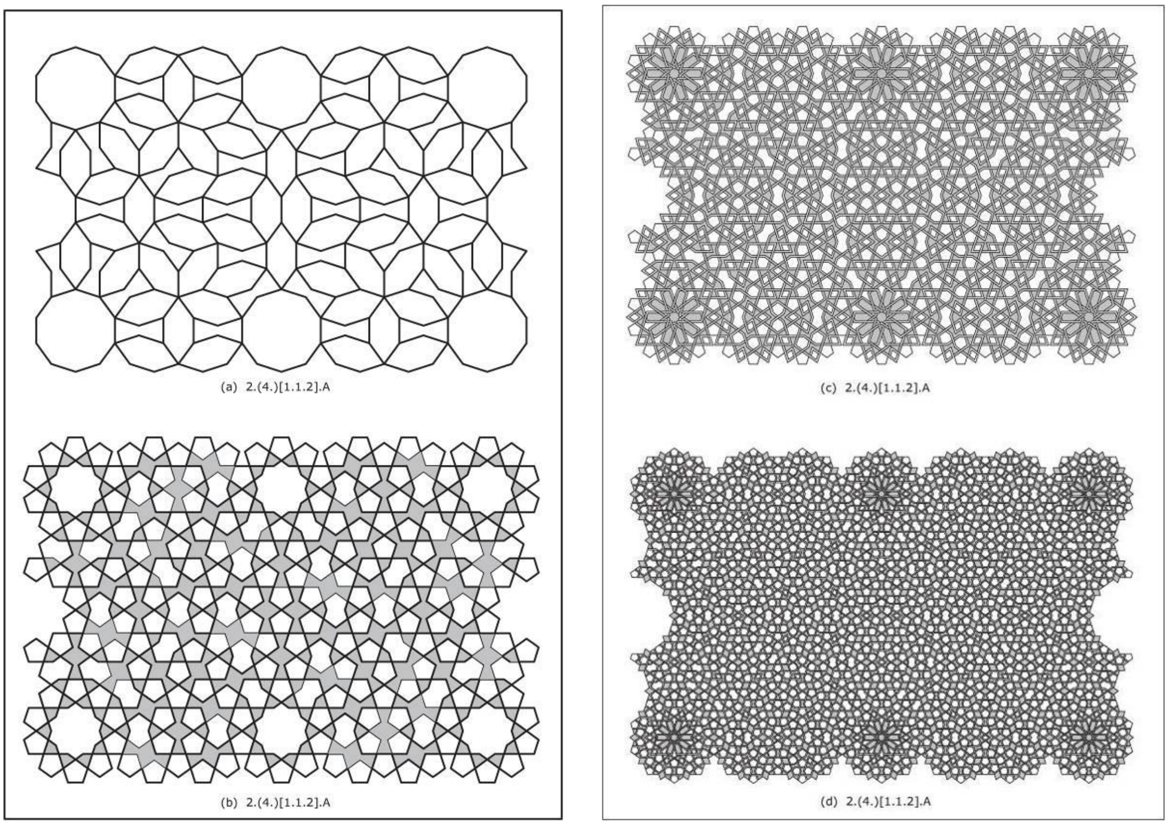


Figure 18. Derivative of the 2nd design template covered by 3 groups of covering tiles.

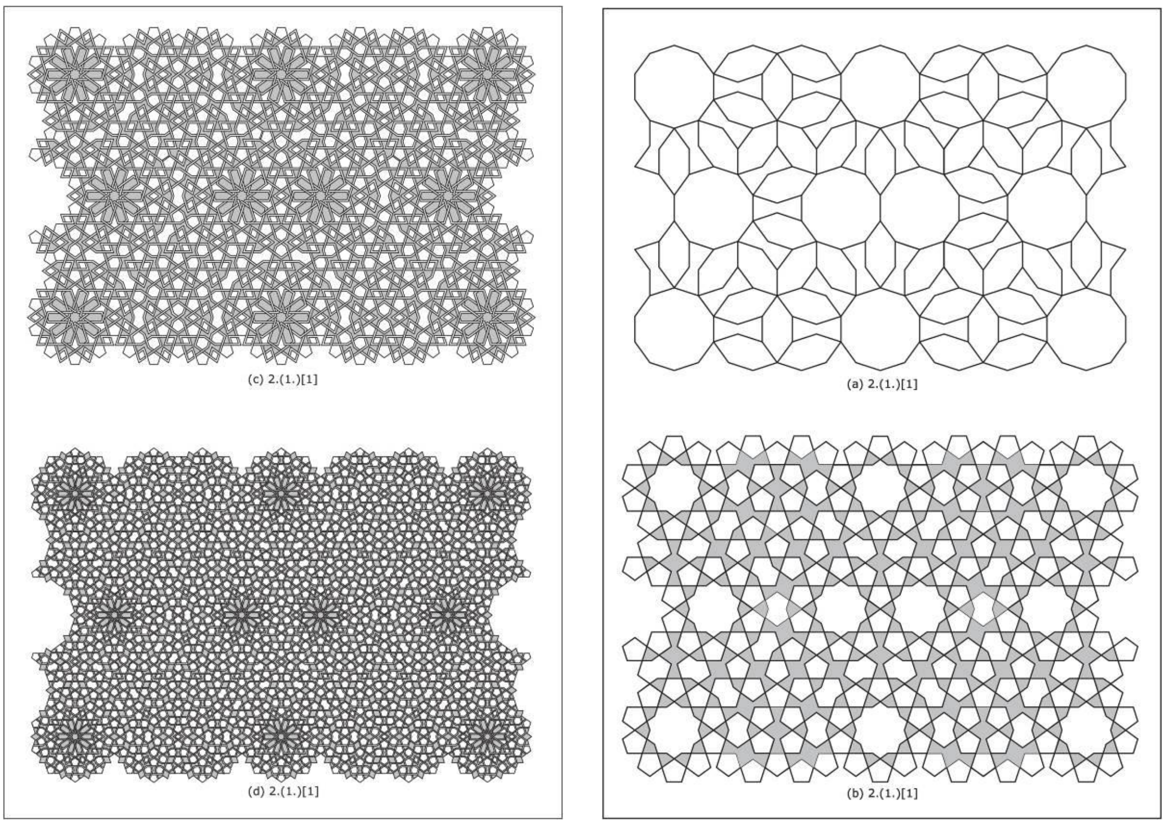


Figure 19. Derivative of the 2nd design template covered by 3 groups of covering tiles.

5. Conclusion and Future Studies

In the context of this research the special features and the creation of decagons are evaluated by analysing the Penrose tiles. With the help of a shape grammar model the structure rules schemata is developed to generate new patterns that have the similar features of the geometric patterns in Islamic art. From this point, it is given two design templates, which are developed for the new generated patterns in the context of the characteristics of Islamic geometries.

In this study, the shape grammar model helps to determine that it is possible to get different final products, which have the same initial shape and design templates created with the same rule schemata. This result indicates a design analyses could be dealt with in a wider perspective and generate new designs with same characteristics.

According to the analyses it is realized that the decagons are acting different than the other shapes creating geometric patterns in Islamic art and architecture. The decagons with a 5-fold rotational symmetry make it possible for the sub shapes, tie and bowtie, to create countless template variations for Islamic patterns. When the structure of the decagons is examined, it clarifies that ties and bowties have been being used for hundreds of years in Islamic art and architecture. It must be accepted that all of the geometric patterns in Islamic art and architecture are perfect results of a superior intelligence. This study shows that these patterns do not have limits to be designed, and they can be generated in the context of lots of different rule schemata. They never could be regarded as old fashioned or unusable.

For the future studies the shape grammar model and the design templates will be applied into the computer to get the results easier and faster. The model could be changed by the new rule schemata, and the new design templates and the new covering tile groups could be generated with help of the computer software. Another goal for the future is to get digital results intended for manipulating and manufacturing the patterns in the sense of the computer generated pattern program, which could be used not only for the Islamic patterns but also for many existent or new geometric patterns.

References

[1] Abas, S. J. and Salman, A. S., 1998. Symmetries of Islamic Patterns. World Scientific, London.

[2] Arık, M. and Sancak, M., 2007. Pentapleks Kaplamalar. Tübitak Yayınları, Ankara.

[3] Burckhardt, T., 2005. İslam Sanatı: Dil ve Anlam. Klasik Yayınları, İstanbul.

[4] Rice, D. T., 1984. Islamic Art, Revised Edition. Thames and Hudson, Spain.

[5] Lu, P. J., Steinhardt, P. J. (2007). Decagonal and Quasi-Crystalline Tilings in Medieval Islamic Architecture. Science 315, 1106-1110. Accessed 26.03.2009, http://www.sciencemag.org/cgi/content/full/315/5815/1106

[6] Çağdaş, G., 1996: A Shape Grammar: The Language of Traditional Turkish

Houses, Environment and Planning B, 5, 443-464.

[7] Duarte, J. P., 2005: Towards the Mass Customization of Housing: The Grammar of Siza's Houses at Malagueira. Environment and Planning B, 32, 347 – 380.

[8] Flemming, U., 1987: More Than The Sum of Its Parts: The Grammar of Queen Anne Houses, Environment and Planning B, 14, 323-350.

[9] Knight, T. W., 1986: Transformations of the Meander Motif on Greek Geometric Pottery. Design Computing 1, 29-67.

[10] Stiny, G., 1977: Ice-ray: a Note on the Generation of Chinese Lattice Designs. Environment and Planning B, 4, 89-98.

[11] Stiny G. and Mitchell W. J., 1978: The Palladian Grammar. Environment and Planning B, 5(1), 5 –18.

[12] Stiny G. and Mitchell W. J., 1980: The Grammar of Paradise: on the Generation of Mughul Gardens. Environment and Planning B, 7, 209-226.

[13] Şener, S. M. 2009: A Shape Grammar Algorithm and Educational Software to Analize Classic Ottoman Mosques. A|Z Journal of Faculty of Architecture, 5-1 Spring, 12-30.

[14] Cenani, Ş. and Çağdaş, G., 2007: A Shape Grammar Study: Form Generation with Geometric Islamic Patterns. 10th Generative Art Conference GA2007.

[15] Çolakoğlu, B., Yazar T. and Uysal, S. 2008: Educational Experiment on Generative Tool Development In Architecture PatGen: Islamic Star Pattern Generator, Architecture in Computro 26th eCAADe Conference Proceedings, 685-691.

[16] Grünbaum, B., and Shephard G. C., 1992: Interlace patterns in Islamic and Moorish Art, Leonardo, 25, 331–339.

[17] Kaplan, C. S., 2000. Computer Generated Islamic Star Patterns, Bridges 2000 Proceedings. Accessed 10.03.2009, http://www.cgl.uwaterloo.ca/~csk/

Augmenting Media Performance with Interactive Technology

Elaine L. Wong
School of Design,
The Hong Kong Polytechnic University,
Hung Hom, Hong Kong
Email: 08901226r@polyu.edu.hk

Abstract

Music performance has always been driven by performers with audience listening to the performance. The audience does not expect to interact with the performers or even participate in the performance. This paper presents an attempt to use computer-based instruments to support traditional musical instruments to deliver an interactive media music performance in Hong Kong where such kind of performance is still regarded brand new. The interactive features employed not only enhance the interaction between the performers and the audience, but also change the way performers collaborate with each other. These were demonstrated by a performance held in July 2009 at Jockey Club Creative Arts Center in Hong Kong. This paper examines these features and analyzed the results achieved in the performance as well as the problems remained, with a view to formulate further research in this area.

1. Introduction

1.1 Augment traditional music performance with new digital musical instruments

The merits of the traditional musical instruments are well appreciated and there are numerous virtuosos pursuing professions in respective areas. Their status is not going to be replaced by any newly designed instruments. There had been earlier attempts by Tod Machover at MIT media lab to augment traditional instruments like violin and cello with additional sensors involving new interactive techniques. In recent decade, newly designed digital music instruments have been in blossom with innovative, disruptive and affordable interfaces and technologies. There had been too much focus on HCI scientific research, resulting much less concern for content development. Most of them are being studied for experimental purpose, seldom were designed to collaborate with traditional ones so that they can work together for an integrated and mixed media performance.

1.2 Collaboration among musicians

Musicians jam with each other in an interdependent way. Interdependency can be achieved when each one is responding to what is heard and reacting to other members' actions. Computer based musical instruments are mostly used to generate beat patterns to synchronize with the music played in a performance. For example, Max/Msp and Ableton Live are utilized to produce sequenced beats and sound effects to accompany traditional instruments like guitars, keyboards or trumpet in a jamming session. Different instruments with different interface designs involve unique interactive techniques. This can be elaborated by some of the sessions of the performance in the later section of this paper.

1.3 Performer audience interaction

Limited by the conventional design of a performing theatre, performers are usually located in the focal area where they are heard, viewed and listened by the audience. In order to enhance performers and audience interaction, seating arrangement, spatial location of people and technologies are studied and experimented. Numerous attempts had been made to either shorten the distance between performers and audience or encourage audience participation. Although flexibility of theatre design is introduced, studies relating to interaction design are insufficient. Expectation and feedback of the audience are explored and evaluated in this paper.

2. Performance @JCCAC Hong Kong

An interactive mixed media music performance is still rare in Hong Kong. Sponsored by the Hong Kong Arts Development Council for the venue, such kind of performance had taken place in the Blackbox Theatre in Jockey Club Creative Arts Centre which was redeveloped from an old industrial building. Details can refer to Fig. 1. Most of the team members are Master and PhD students of design and media technology with musical backgrounds at various levels.

Media Music Show
compost is nutritious to some life forms and repulsive to other life forms.
堆肥對某些生物有營養，又令另一些生物感到厭惡。

Band Name
Com1p0st堆舊肥

Type
Video interaction music performance
視像互動音樂演出

Venue
Jockey Club Creative Arts Centre, Black-box Theatre
賽馬會創意藝術中心黑盒劇場

Sponsor
Hong Kong Arts Development Council

Music Specialties
Guitars, keyboard, piano, trumpet, computer software instruments

Team background
•3 have computer programming skills
•1 has engineering and design background
•1 is musician and producer
•3 graduated from master program in multimedia technology

Fig. 1 Com1p0st Interactive Media Performance @JCCAC Hong Kong

Although the show served different individual purposes, it did explore some interesting observations and findings. It is not yet a detailed experiment, but more than a performance.

Objectives were identified to examine a few areas as:

How to augment traditional music performance with new digital musical instruments?

Is there a change in the way performers interact with each other with both new and traditional musical instruments?

Can interactivity be increased with the use of computer technology between performers and audience?

Would the audience find the show creative and enjoyable?

There are more than 15 sessions, but they were all fallen into a star shaped structured form (Fig. 2). The form was created by the team members Ming-sun Ho, Jupiter Chan and the author. We usually had casual talks about contents to be included during lunch and they were drafted on the scratch papers. Finally the ideas were summarized and consolidated to a form. The five key components are: Voice, Offensive, Improvise, Ambient and Traditional. All components connect with each other to build inter-relationship. Sessions were created when components cross one another. All the contents and ideas for the show were generated within this framework. The show did not explicitly inform the audience any specific messages although it did have something to tell. Instead, the audience was given freedom to construct the meanings.

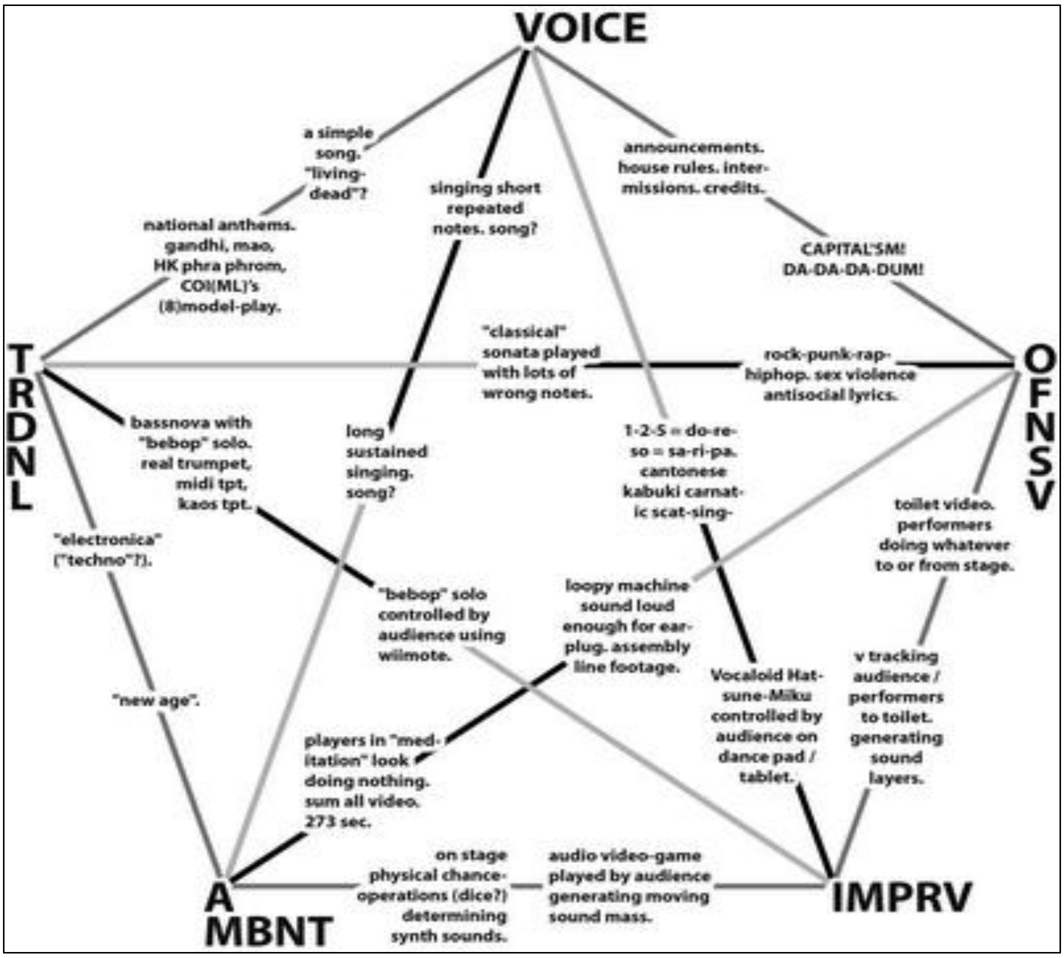


Fig. 2. The Star Shaped Structure of Contents

3. Technical Description

Although it is our objective to add more interactive features with technology in our media performance, the type of hardware and software tools to be used and how much they should be used were determined by the preferences of the band members and the contents. Time was also a critical issue in that case. More time, effort and resources would be able to accommodate larger system scale. In our band, however, ideas kept changing with hidden thoughts unfolded when the show time was approaching. With large quantity of footages including images and sound clips, it was relatively handy to select appropriate ones and dispose unwanted parts even time was running short. However, when technology was involved in artistic content, it did not sound flexible because more time and effort were required in the tasks of software and hardware testing and computer programming. In order to allow more flexibility, we opted for solutions which offered accessible and inexpensive tools and ease in programming.

3.1 Hardware and software tools

The setup consisted basically 1 Apple Macbook Pro and 1 Fujitsu laptop. The Macbook was mainly used to connect to a midi keyboard with Garageband software for piano performances. Max/Msp was installed to trigger patches for interactive performances. The Fujitsu laptop installed Ableton Live, Max/Msp and Tapper for real time performance.

3.2 Interactive Features

3.2.1 Throwing something to the audience (in Throw Wii session)

In order to interact directly with the audience, we decided to put the Wii controller inside some everyday objects. In this case, we chose a mushroom ball. The audience was quite surprised that the ball can produce music notes and improvise when it was being turned around and thrown. We then sat among the audience and threw the ball together. The accelerometer readings in X, Y and Z axes were captured[15] by the Max/Msp patch to generate "Do", "Re", "So" and sound effects when the thresholds were reached.

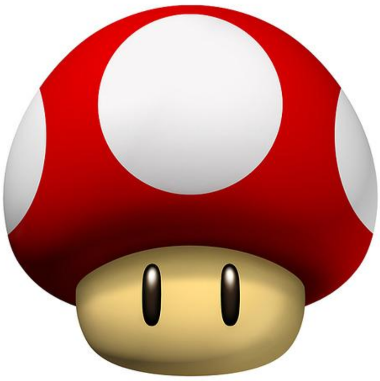


Fig. 3. Wii Controller and the mushroom ball

[15] Wii controller's accelerometer values are captured and handled by a Max/Msp object called "aka.wiiremote" developed by Masayuki Akamatsu

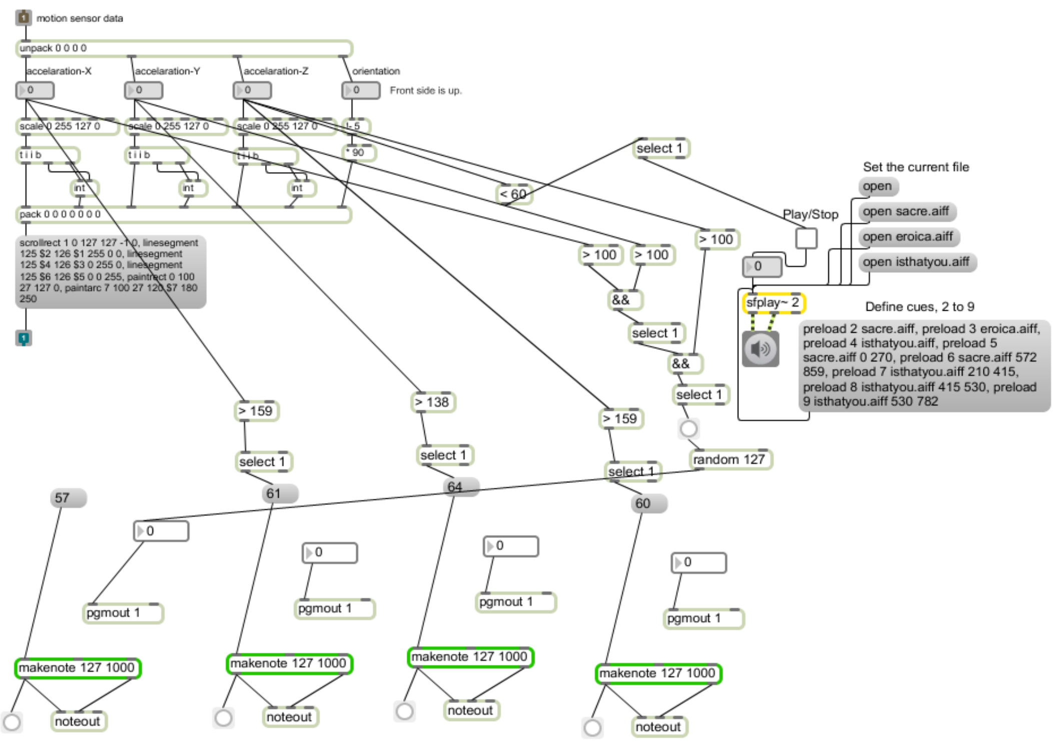


Fig. 4. Max/Msp patch capturing accelerometer values of Wii controller and generating music notes and sound effects

Fig. 5. Performers played with the audience with the new musical instrument

3.2.2 Interact with motion

In our vocaloid session, we connected a dance pad with a tapper software in which any steps on the pad can control the music rhythm. The sound was converted to human like singing voice using Ableton Live. That made the human voice sang according to the performer's steps.

Fig. 6. Vocaloid session with dance pad

3.2.3 Other devices

Apart from these, some portable devices were used. Kaossilator was used for melodic part and accompaniment for improvising and jamming sessions. iPhone was used to generate and manipulate the beat pattern with installed DJ software.

4. Interactive Media Performance Framework

Since media performance is regarded a kind of contemporary art, it is integrated, dynamic and evolving with changes of the society, culture as well as technology. Thus, an open system is suggested to accommodate any new ideas and creative ingredients (Fig. 7).

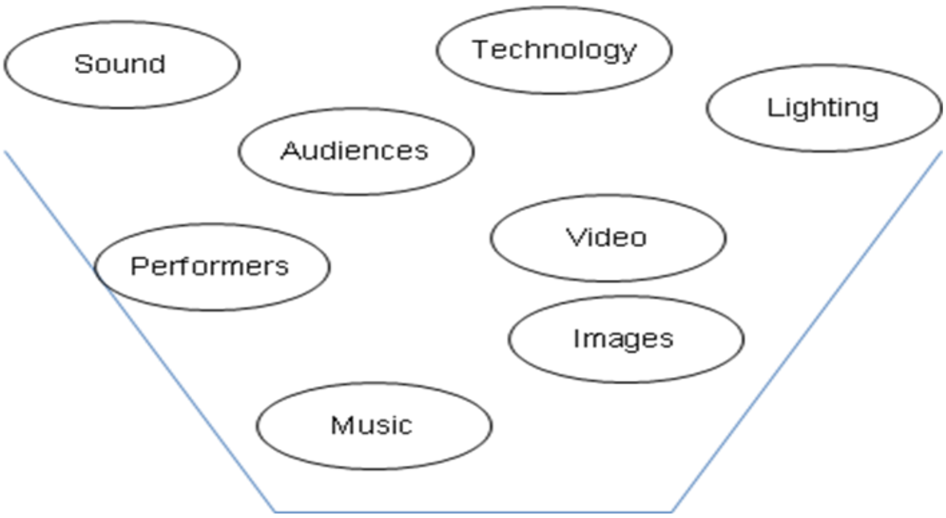


Fig. 7. An Open System for New Creative Ingredients

A conceptual diagram (Fig. 8) illustrates how interaction bandwidth can be enlarged when contents become interactive. In a typical media show with pre-recorded contents, the audience interacts with the show by perceiving what are received and understood either with or without a common ground with the performers. The audience usually responds by giving feedback or facial expression. When the contents become interactive with or without the introduction of technology, the audience interacts by participating and inputting actions to the system. The system thus responds immediately by giving feedback to the audience and the performers. As indicated by the diagram in Fig. 8, the interaction bandwidth is enlarged from the inner circle to an outer bigger one.

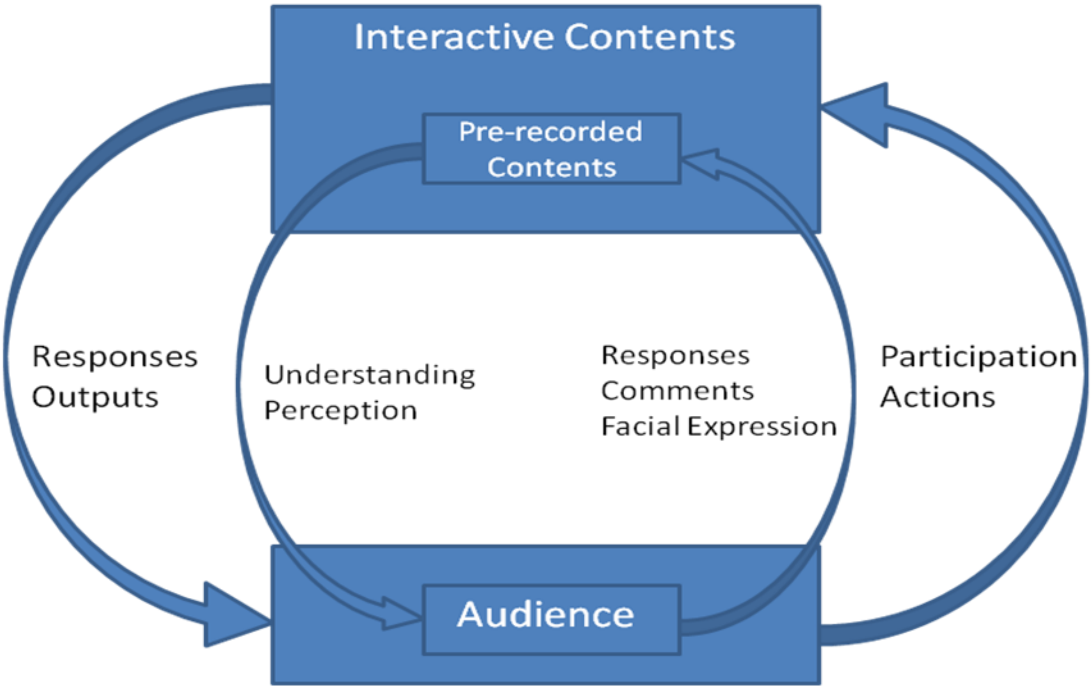


Fig. 8. Interaction Bandwidth enlarged

5. Discussions

5.1 How to augment traditional music performance with new digital musical instruments?

Computers, no matter hardware or software, are as a matter of course regarded as tools only for making creative contents. Sequencers have been used for music composition and sound production. It is not uncommon to use more than a half virtual instruments for professional production like music recording or making advertisement scores because of cost saving. In a live mixed media performance, digital musical instruments are often used too to bring some new ingredients and excitement. To work with traditional musical instruments, interaction should go beyond simply rhythm sequencing. Different interfaces involve unique interactive techniques and generate specific sounds.

If the sounds from some interfaces are highly expressive and the controls are easy to operate, then they can be used for melodic parts. In our rehearsals and jam sessions, we used Ableton Live, Garageband and Kaossilator (a portable device for live performance and recording with touch pad which requires scratching and moving of fingers) for improvising melodic parts. It is not possible to be fast and accurate enough on some interfaces, for example dance pad. In our performance, it was used as a bass instrument in a Bossa Nova piece and trigger of synthesized beat patterns. Software design also plays an important role in affecting how digital instruments can collaborate with traditional instruments. If buttons, sliders and menu selection are the only ways to control, then they very frequent changes.

5.2 Is there a change in the way performers interact with each other with both new and traditional musical instruments?

Like other musicians, we spent a lot of time in ensemble during rehearsals. Because it was the first time we performed together, and we needed more time to learn and understand each other. No matter what instruments we used, we needed to express ourselves while following some chord patterns and responding to triggered changes.

People may think that laptop performers only need to point and click, drag and drop, eyes staring at the LCD with minimal facial expression. If new interfaces are being used, they are mainly performed and explored in experimental exhibitions with various kinds of sensational feels and gestures communicating to the system.

In our case, those playing guitars, keyboard and trumpet required skillful techniques even though they were improvising. For those who are playing computer instruments, there was no special technique or practice required. However, we did need to listen to each other and accompany all together. The computer performers will have more control over the status changes and overall effects

6. Evaluation

The show accommodated 80 seats and we had 26 people came to it excluding all workers. Four people were finally invited for an interview. All of them expected that they would be placed in an audience seating area with single perspective to the stage. However, we did not have distinctive performer or audience areas in our stage design. The audience can sit anywhere on the floor and we can perform anywhere.

6.1 Can interactivity be increased with the use of computer technology between performers and audience?

In order to enhance interactivity between performers and the audience, we did introduce some sessions like “Rave Party” to encourage them to dance with us. People in Hong Kong are generally passive and do not expect to participate much. Hopefully most of them were willing to dance and had fun together. In the “Throw Wii” session, we were throwing a toy ball among the audience. There was a Wii controller hidden inside. When the ball was thrown, the motion readings in X, Y and Z axes will trigger some midi notes. In this way, people holding the ball were improvising. The performers sat among the audience and played with them. Thus, the audience participated in the improvising session.

All four interviewees agreed that the show was interactive with technology and it was the first show of this kind that they had ever seen. They were asked about the sessions they liked and disliked. Two of them mentioned that the “Throw Wii” session was most interactive because the performers were playing together side by side with the audience. Besides content and technology, seating arrangement in that case helped a lot.

6.2 Did the audience find the show creative and enjoyable?

The four interviewees all have design background with two specialized in animation. They commented that the show was creative overall. For the most creative part, different people had their own individual preference.

Apart from being creative, we aimed to provide an enjoyable performance and experience to the audience. Although there are lots of interactive media performances in the world, not many of them are enjoyable. That means, either people cannot get some fun from them or they are astonished by the first 5 minutes experience but cannot maintain sustainable interest. When the interviewees were asked if they would come if similar show was available, the answers were positive.

Acknowledgements

The author would like to thank all the team members of the band “Com1p0st” for their invaluable contributions in the performance: Ming-sun Ho, Jupiter Chan, John Abraham and Sam Cheung. Their talents and experiences are indispensable for brainstorming, planning and executing the performance.

References

[1] Sparacino, F., Davenport, G., Pentland, A. (2000). Media in performance: Interactive spaces for dance, theater, circus, and museum exhibits. IBM Systems Journal., Vol 39, NOS 3&4.

[2] Whalley, I. (2005). Traditional New Zealand Maori Instruments, Composition and Digital Technology: some recent collaborations and process. Organised Sound 10(1): 57-65. Cambridge University Press.

[3] Blaine, T., Perkis, T. (2000). The Jam-O-Drum Interactive Music System: A Study in Interaction Design. Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques.

[4] Jordà, S., Geiger, G., Alonso, M., Kaltenbrunner, M. (2007). The reacTable: Exploring the Synergy between Live Music Performance and Tabletop Tangible

Interfaces. TEI '07: Proceedings of the 1st international conference on Tangible and embedded interaction.

[5] Weinberg, G. "The Aesthetics, History, and Future Challenges of Interconnected Music Networks." International Computer Music Conference. Göteborg, 2002.

Popular Dwelling Chromaticism

Prof. Elisabetta Romano Ph.D.
Federal University of Paraiba, Architecture Department – João Pessoa, Brazil
www.ct.ufpb.br
e-mail: elisabetta.romano@gmail.com

Abstract

This article presents a method to define popular houses' façades chromaticism, based on an analogy between colours and musical notes. The starting point is a musical scale composed by twelve notes (including the semitones), and a twelve colour set, obtained by mixing chalk to a very cheap pigment, called *"pó xadres",* arranged around Holzel's colour wheel. The 72 colour full range palette is obtained by reducing the saturation of the original colours, and then associating the lowest notes to the most saturated colours, while the acute ones should correspond to the clearest. Starting from these assumptions, the popular dwelling chromaticism is performed according to various generative criteria, showing that, for every applied algorithm, a specific result is obtained. One among these methods adopts the plant as a piano roll, proposing each unit to be painted in the colour of its corresponding note. Under this optic, if music composition is based, in its essence, on the ability of manipulating very precise numerical relationships, the examples presented in this paper show that creative solutions should be achieved in architecture using similar equations to deal with space/shape issues, including colour modular coordination principles in the design process.

1. Premises

The colour has always been one of the greatest protagonists in the perception phenomenon, being often used as a reference to describe a place, to provide an indication, to identify a specific house among its neighbourhood. (Figure 1)

Figure 1 – Example of colour use in popular houses façades in Brazil

In fact, all around Brazil, especially in small villages, the use of colour is deeply inscribed into the constructed environment, maybe resulting from the appropriation process of the bright colours present in nature. This pre-existing context needs to be taken into account when distributing the colour settings into a given space, being the reference to define the palette.

By the other hand, popular dwelling projects, sponsored by government social housing programs, are generally painted in white, resulting into completely uncharacterized spaces, of an exasperating monotony, in which the inhabitants are not able to distinguish their own house from their neighbor’s. (Figure 2)

Figure 2 – An example of popular dwelling project in João Pessoa - Brazil

The contribution of this study is to present a creative innovation method to be applied in popular dwelling design, to define houses façades chromaticism, based on an analogy between colors and musical notes. The first step is to determine an initial palette, and then establish the equivalence between it and a musical scale. The following step, using the global plan as a piano roll, aims to find out which note each house represents, to finally paint each unit in the colour of its corresponding note. Two different procedures will be exposed along this paper, chosen among the infinite range of generative algorithm that could be created for this specific purpose.

2. An analogy between colours and musical notes

Both colour and music are inherently intangible. They are not substances, but just waves traveling. Color and music also operates as a language and are often used as such. In spite of being difficult to compare such different physical features, like colour and sound, a vast literature is available about this subject. Both Pedrosa (1989) [1] and Grandis (1985) [2] describe the analogies proposed by Newton and Goethe, who considered colour and sound as vibration phenomena, although in different frequencies. (Figure 3)

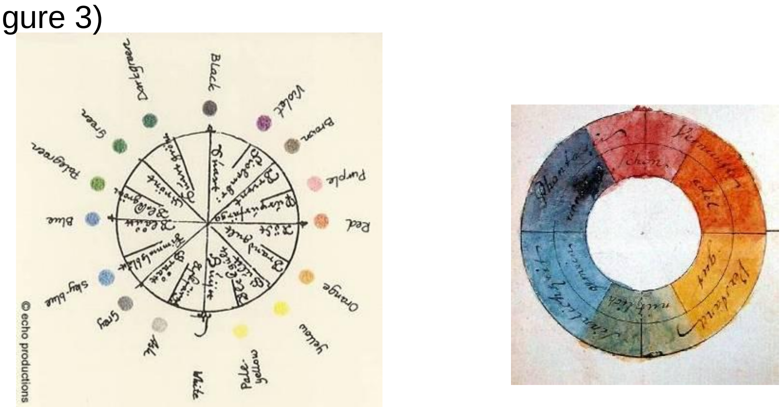


Figure 3 – Forsius’s and Goethe’s colour wheels, conceived in 1611 and 1810 respectively

Machado (1993) [3] refers to synaesthesia, an unified theory of all sensory perception and Lagresille (1983), *apud* Sanz (1985) [4], establishes a parallel between musical octaves and the brightness of colours, proposing to associate the lowest notes to the most saturated colours, while the acute ones should correspond to the clearest. The relationship between sound frequencies and colours wavelength adopted in this paper, is that one established by Dauven (1970) *apud* Gyorgy Doczi [5], that creates a correspondence between a musical scale, composed by twelve notes (including the semitones), and a twelve colours palette, arranged around Holzel's colour wheel. (Figure 4)

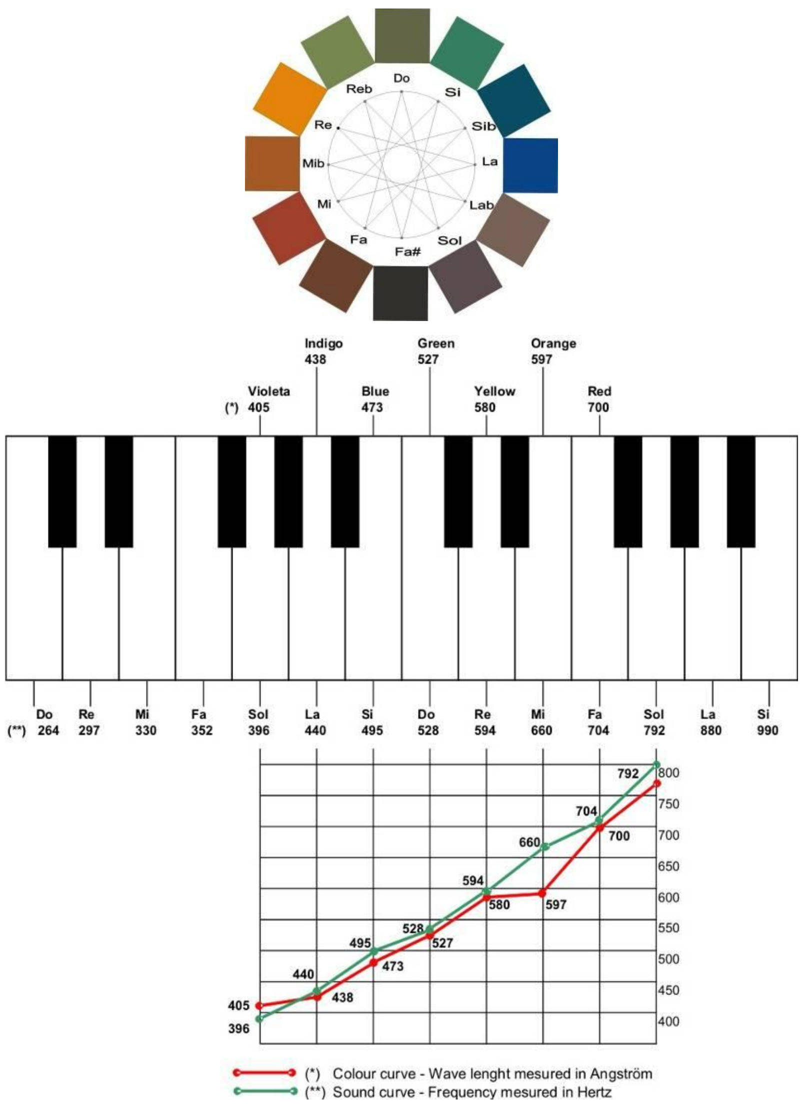


Figure 4 – Dauven's correspondence between colours and musical notes
Font – Gyorgy Doczi - The power of limits

More recently Semir Zeki`s [6] studies on colour perception and Antonio Damasio's [7] work on relations between colour recognition and language, memory and sound, reveal how important is the colour environment to stimulate the human brain and therefore implement life quality. Another original comparison between music and architecture is given by Matila Ghyka's [8] when he refers to architecture as a frozen music, and by Mandelbrot's [9] studies on fractals, to revisit the possibilities of establishing analogies between colour and music.

As music is, in essence, a sensorial experience, derived from very precise numerical relationships, also the colour, which can be studied through the same mathematical equations, can consequently be modulated and controlled through similar procedures. Coincidentally scale, harmony, tone and chromaticism apply to both areas, showing the similarity between the musical coordination systems and colour modulation, which could result into creative solutions to handle the two key elements in design -- shape and colour - within the same principles of modulation and components coordination.

3. The global plan design

The starting premise to design the dwelling global plan was to avoid the orthogonal grid, obtained by the endless multiplication of individual properties (see Figure 2). These rectangular lots were substituted by a neighborhood unit based on the equilateral triangle, where several houses were grouped, now regarded as small condominiums, which maintain in its interior common areas, a kind of public-private yards, where leisure activities can be performed. (Figure 5)

Figure 5 – A seven houses neighbourhood unit grouped in an equilateral triangle lot

From this shape, a wide variety of solutions can be obtained, like diamond-shaped and hexagonal street distribution. The following examples show different variations of spatial organization. (Figure 6)

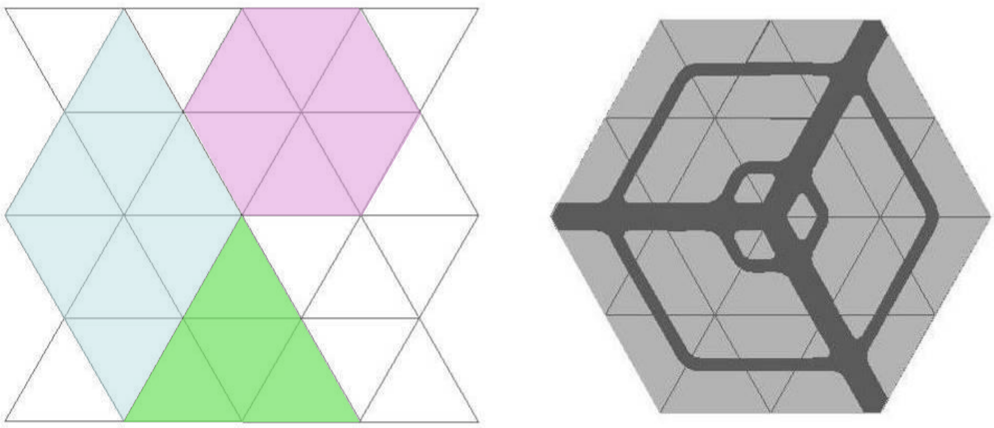


Figure 6 – Examples of street distribution obtained by assembling equilateral triangle standard lots

The analogy between the urban solutions showed above and Islamic mosaic is easily perceived, inducing to establish a method to introduce the colour into the design process. The analogy between colours and musical notes that will be described in this paper is only one among the multiple aspects of geometry and space interaction, as described by Leite [10] in the analysis of the Alhambra patterns. (Figure 7)

Figure 7 – Example of a wall mosaic in Alhambra – Granada, Spain

4. The colour palette definition process

To paint the houses façades the most economical material was used, *chalk paint* mixed to a pigment called *"chess powder"*, very popular in Brazil, which can be easily found in any construction material store, all over the country. To fix the colour on the wall surface, cooking oil was used.

To determine the exact pigment proportion of each colour, the first step was to identify the amount necessary to achieve the sample saturation, from which onward any increase did not produce colour variation. It was also observed that to obtain significant results the pigment amount to be added to samples had to follow a geometric progression of ratio 2. Among the available colours of *chess powder*, five of them were selected: black (BK), blue (BL), green (GR), yellow (YL) and red (RD), from which a 72 colours chromatic palette was obtained using the rules above described. (Figure 8)

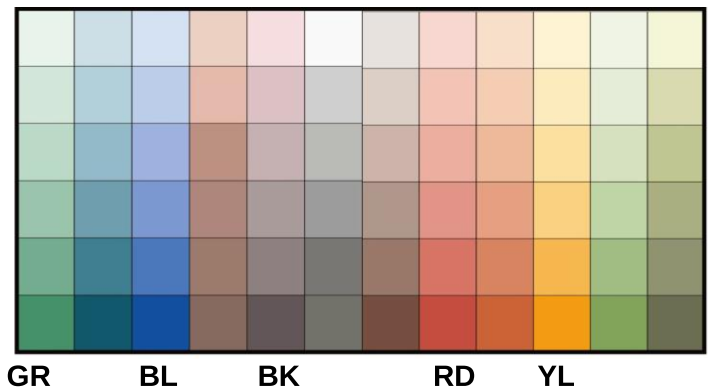


Figure 8 – The 72 colours palette obtained by mixing "chess powder" pigment to chalk paint

To transpose the sample colours to the computer screen it was necessary to fix their parameters of CMYK, where C represents the value of Cyan, M is the amount of Magenta, Y estimate the Yellow and K indicates the amount of Black. It is important to outline that this transposition was visual based, trying to keep the result as faithful as possible to the original colours.

5. Popular dwelling chromaticism

The next step was to establish the correspondence between the palette colours and the musical notes. With this purpose the colours were distributed around the Holzel colour wheel. The sequence so obtained was then associated to the first octave. After that, based on Lagresille analogy which establish to associate the lower notes to the more saturated colours and the high notes to the lighter colours, six different colour wheels were created, each one corresponding to a different octave, so totalizing the 72 sample colours. (Figure 9)

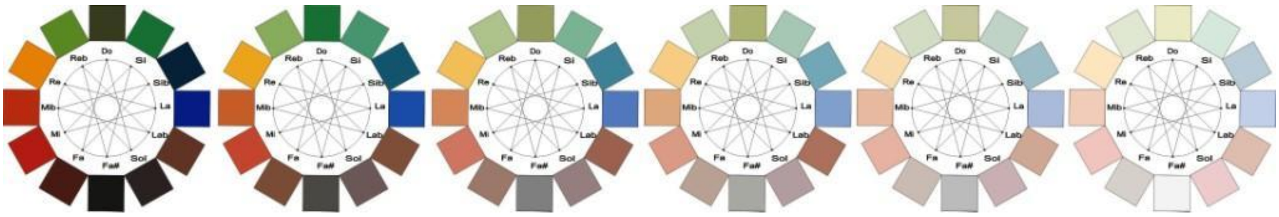


Figure 9. Chromatic circles corresponding to six music octaves

The colour set can also be represented through a rectangular matrix, where the columns stay for the notes and the rows indicates the octaves. (Figure 10)

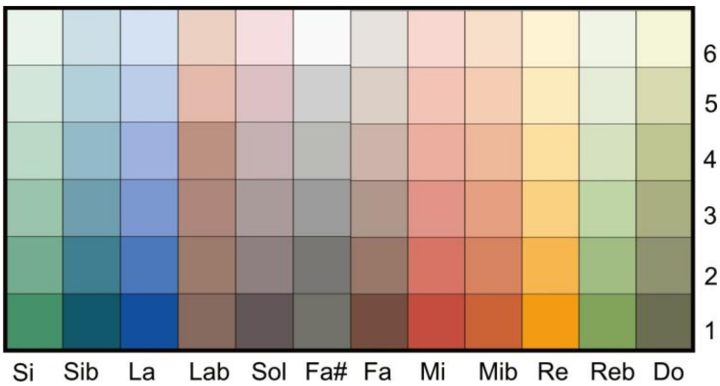


Figure 10 - Chromatic matrix representing the six music octaves

5.1. First painting method by using the houses location as a piano roll

After having established the 72 colour sample palette and determined its correspondence to the musical notes, a first application was implemented based on the analogy between the houses location and a piano roll. To apply this method a trapezoidal urban distribution was chosen, consisting of 24 neighborhood units (see Figure 5), totalizing 192 houses. (Figure 11)

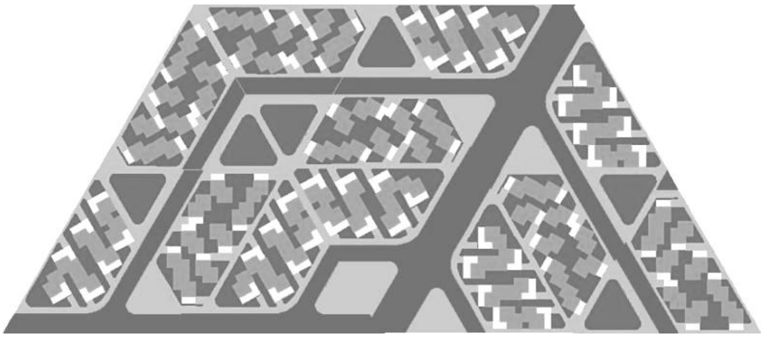


Figure 11 – Houses distribution into the neighborhood lots

In order to prepare the plan to be used as a musical score, the X axis was associated to time, while the Y axis was assigned to frequency. Thus, the plant was divided into nine vertical bars and, horizontally, in six octaves, each one containing twelve lines corresponding to the notes position. Moreover the twelve neighborhood lots formed by the equilateral triangles (see Figure 5) were associated each one to a different instrument, so resulting into twelve musical phrases of seven or nine notes each, depending on how many houses were positioned in that particular triangle. (Figure 12)

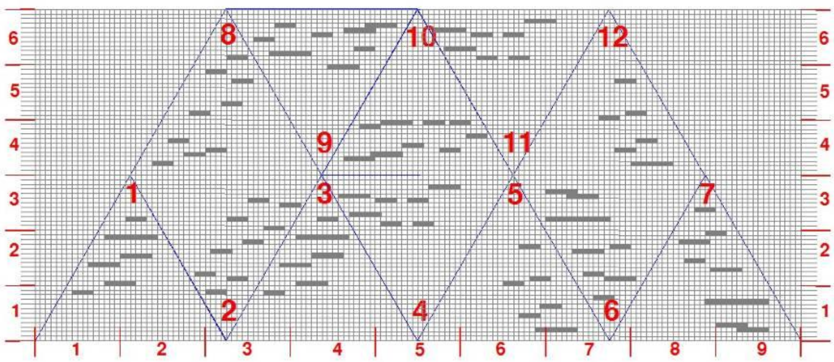


Figure 12 – The piano roll showing the notes and their duration

The resulting music is presented in the above diagram, where the position of each house identifies, on the Y axis (octave), the correspondent note, being its duration defined by the projection on the X axis (time). The interesting aspect of this experience is that the urban global plan represents the piano roll of the musical composition, establishing a direct correspondence between the houses position and the notes which they actually represent. Finally, each house was painted in the colour of its corresponding note, so obtaining the colour variation shown below. (Figure 13)

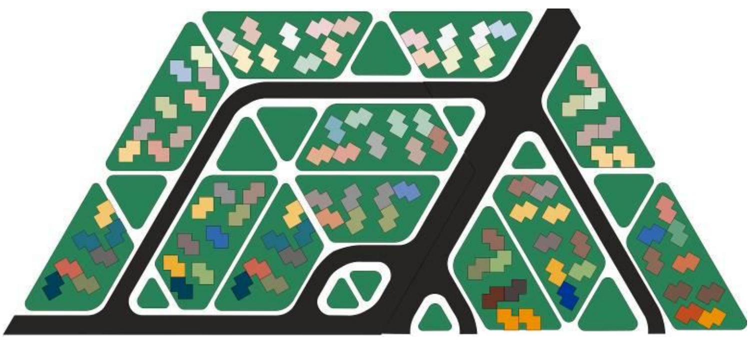


Figure 13 – The colour variation resulted by applying of the first painting method

5.2. Second painting method by using the perfect fifth scale

After having analyzed the result of the first coloring experience, it was found that only part of the 72 colours of the palette repertoire were actually used, due to the fact that the houses did not necessarily occupy all possible positions in the piano roll. To solve this problem it was decided to try a second painting method, with the premise that each colour of the palette had to be used at least once. To do that, the starting point was the perfect fifths scale, below represented. Following the notes sequence: Do, Fa, Sib, Mib, Lab, Reb, Fa#, Si, Mi, La, Re, Sol, all the notes will be considered, without making any repetition. (Figure 14)

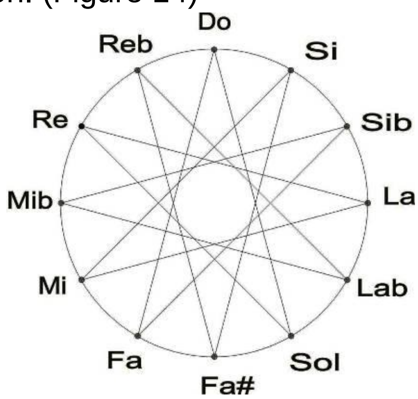


Figure 14 – The perfect fifths scale showing that all notes are considered

The next step consisted in applying this sequence to the urban global design. To do that the plan was overlapped by six concentric circles, each one corresponding to an octave, and then, starting from the bottom left corner and following the cock wise direction, each house was assigned to the corresponding note. After having repeated this procedure for the six circles, all the notes/colours were used at least once. (Figure 15)

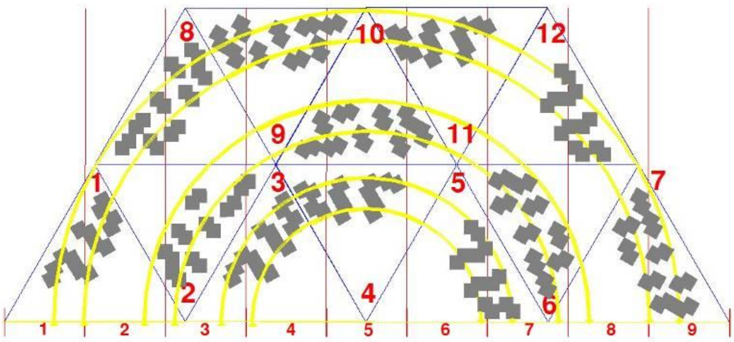


Figure 15 – The perfect fifths scale painting method applied to the global urban plan

Comparing the result thus obtained to the previous one, the colour distribution follows a circular pattern, instead of the horizontal colour stratification of the first method. The position of the clearest houses in the central part of the plan is due to the fact that these correspond to the higher octaves. A different result should have been obtained inverting the octaves position, making them to grow from the periphery towards the center. (Figure 16)

Figure 16 -The perfect fifths scale and the resulting chromaticism

6. Conclusions

The painting façades methods presented in this article try to rescue the use of colour in popular dwelling, widely present in vernacular architecture, and extremely important to give each house its own identity. By the other hand, the proposed colour palette, obtained by mixing the chalk paint to the "*chess powder*" pigment, faithfully reproduces the predominant colours in the inland regions of Brazil, where people have little access to industrialized products. To finalize, it is evident that the proposed analogy between colours and musical notes can be further explored in then future, in order to define new colour generative algorithms, following the research development suggested by Caivano[11] [12], having creativity as the only limit.

References

[1] Pedrosa, Israel, "*Da cor à cor inexistente*", Brasília, Editora Universidade de Brasília, 1989
[2] De Grandis, Luigina, "*Teoria y uso del colour*", Madrid, Ediciones Cátedra, 1986
[3] Machado, Arlindo, "*A Máquina e o imaginário*", São Paulo, Editora da Universidade de São Paulo, 1993
[4] Sanz, Juan Carlos, "*El linguaje del colour*", Madrid,Hermann Blume, 1985
[5] Gyorgy Doczi *"The Power of limits: proportional harmonies in nature, art, and architecture"* Shambhala Publications Inc. 1981
[6] Zeki, Semir, "*Inner vision - An Exploration of Art and the Brain*", Oxford University Press, 1999
[7] Damasio, Antonio, *"The feeling of what happens*" London, William Heinemann, 1999
[8] Ghyka, Matila*, "The geometry of arts and life"* New York, Sheed and Ward, 1946
[9] Mandelbrot, Benoit*, "The Fractal Geometry of Nature"* W H Freeman & Co, 1982
[10] Leite, Silvia, "*O simbolismo dos padrões geométricos da arte islâmica*" Cotia, SP, Atelier Editorial, 2007
[11] Caivano, José Luiz *"Color and sound: physical and psychophysical relations",* Color Research and Application,1994
[12] Caivano, José Luiz "*Sinestesia visual y auditiva: la relación entre color y sonido desde un enfoque semiótico"*, DeSignis 4, Barcelona, Editorial Gedisa, 2003

Diaries from the Future

The role of the memory in emergent processes

Prof. Giuseppe Marinelli de Marco
Metaproject Design, ISIA ROMA DESIGN, Italy
marinelligiu@tiscali.it

Prof. Mauro Palatucci
Interaction Design, ISIA ROMA DESIGN, Italy
mauro.palatucci@gmail.com

With this essay we are reconnecting with the theory we presented to our conference at the GA2008 in which we focused on the relationship between the notion of the future and that of becoming, we will now compare it to the subject of memory, as the centre of identity for objects, places and processes of becoming.

We know that inside a complex system, an event is called ‘emerging’ when it begins to demonstrate a principle of coherence, in other words, within a chaotic motion of bodies, some of these start to “resonate”. As it happens in music or dance, they begin to play or dance together. Out of a chaotic noise a type of melody is born.
For those who are familiar with theory of the Complexity and are involved in the design of habitat and environment, it will not be sufficient to observe only the birth of coherence as the scientists do.

The question is how Pattern, Structure and Process identify life, and therefore also the life of a shape: organization and behaviour.
The Theory of the Systems makes us more cautious in the role of the Process, rather that on Pattern and Structure since it starts from the relational and inter-relational factors present in life. In this essay we use the word Pattern, Structure, Process in this way:
Pattern - the organizing scheme of the organisms, a drawing not reductible in parts.
Structure – the structure of a system is the physical embodiment of its pattern of organization.
Process – is the capacity of the structure to manage the large universe of input and output, managing the feedbacks.
This striking property of living systems suggests process as a third criterion for a comprehensive description of the nature of life [1]. The process of life is the activity involved in the continual embodiment of the system's pattern of organization. Thus the process criterion is the link between pattern and structure.
Therefore we can say

FROM
what it is, how is it made

TO

how it establishes relations, and what does it become when combined with others.
It supposed that could be legitime after one century full of such modern experience in art, architecture and design.
In this century we observed how the linear scenario of the Reinassance perspective moved towards a labirinth made by infinite layers of elements and nodes.
There is no need to explain how important it is to identify the Pattern and Structure in order to designate a shape. But if you look at the life of a shape it is better to start our investigation from how the shape establishes relations with other formal lives. It is important to perceive the structures in their capacity of realizing a Pattern.
In our contemporary interconnected society we observe in a new manner the interactions between different Patterns and Structures. In complex systems, overwhelmed of informations and feedbacks, considering the high speed of our real-time dimension, we can read and use the instructions suggested by the Process.

A. The theme of identity

Let's try to connect the previous point with the subject of identity, for example: the identity of a place. The architectonic culture during the seventies worked a lot on the topic of the indefinable identity of place, in latin the *genius loci*, and some ideas still remain very interesting. Today the attention is on how we enter into resonance with all things, e.g. if a couple of dancers execute a dance the spectator understands the two bodies and the relative structures, the aesthetics, beginning from the elegance and the complex movement; we bring all of the information together and at the same time.
Because you cannot completely read a Structure alone automatically we reconsider a non self-referential value of the Pattern and the Structure. We don’t only analyse the Structure and Pattern of the identity of a thing; but we focus on the resonance [2] between the changing values which gives us the perception of identity. This value is flexible, open to the possibility of change. On the contrary if we start to analyze a body or a structure it is not possible to understand how they can be resonanant, because it is data that starts only from material culture. The ability to change is a principle that we don't find in a single structure but in other parameters.

In the Network Society, the discourse that gives a meaning to data, have various genesis, but are most likely already created with a genetic ability to enter in relation with the complex system, that has the power to call in the elements of the structure, and not the contrary. The foundation of our analysis is that through the morphogenesis it is possible to generate extraordinary spaces but we can’t automatically define a “place”.

A “place” cannot be defined by only Structure and Pattern, in the expression of it other syntheses in which the morphogenesis has a strong but not exclusive role, must cohabit and share the sense of it with the ability of naming the things, with the discourse of language. It is equally obvious that a life form does not exist if we can’t trace and identify Pattern and Structure. But this “dance” has the power to be memorable? We think that it has.

If we have a system whose processes have weak feedback, Structure and Pattern are sufficient to illuminate on its nature, also prefiguring an evolution of the meaning of its nature, to for example its genetic tendency, but when we enter in a complex reality, we are overwhelmed by a the greater speed of feedback. When on design topics we find ourselves launched with certain speed we don't always have the time to stop and reflect on the Pattern and Structure, and we must trust the process as if it is a vehicle for knowledge of Pattern and Structure. However we know that process is a reliable ambassador, a credible one. The theory of systems helps us to reflect on the coherent mechanism that we are observing.

B. Bifurcation and Memory

If the coherence is linear, we have an obliged bifurcation, but today we find ourselves in front of a coherence that has a systemic nature, reticular bifurcation, that is born from complex relations already at the source. A detail that we think is fundamental is that the Process does not judge the Patterns and the Structures that are put in motion, but it values the behaviors, for this reason we are attracted to the "autopoiesis processes", because we want to entrust that things will build themselves without judging what they take or discard. For the same reason when some forms resonate with each other and other don't, the remaining space doesn't participate in a coherence principle. When this principle obtains a sufficient critical mass, it can become a new system.

The ability to perceive the complexity and to interpret it to the advantage of the future newborn organized form belongs to a philosophy that includes the interdependence principle: The principle of the dialogic illustrated by E. Morin [3] .

Dialogic Principle - which consists of associating notions, ideas, and truths that are both complementary and contradictory in order to grasp a true reality.

Where is the Anthropos, the meaning that transforms the space in place? What links the people to the spaces, the spaces to the things, the things to the matter, the matter to the feelings, does this not create the richer sense of place? Between this triad: Pattern Structure Process, it's interesting to undestand which one, and above all in which way, articulates the becoming from "space" to "place" and also the modalities of shaping "memory" as a story for the others.

How do we remember a picture or a film? Is it the same type of mnemonic process?
It probably is with different mechanisms. For this we talk about the discourse of the attractors: the dialectic that we are interested in is the one that exists between a group of attractors that operates like a diary of structural stability, and the emergent phenomenon that opts for a new type of diary of that same movement. Various diaries, but between them there could not be a banal connection. We ask ourselves if in the complex systems the attractor can be seen like a frame and the process like a film, although in our vision both of them are carrying out an important task. The concept of attractor carried in the world of the memory can characterize structural stable nodes in the reconstruction of identity, qualities are not only morphologic but are also of place.

We know also from the contemporary anthropology that the identity is a phenomenon in motion, since the Anthropology explains that an identity is not static but is a process, Zygmunt Bauman [4] has written a lot on this subject. It is – is a science interest, and it becoming – is a language interest. The identity is like process, it renegotiates it's own foundations continuously.

C. Behaviour of Signs

On the basis that behavior foresees the creation of events, the memory must renegotiate, open a dialogue between itself/identity/scope budgeting not for the disappearance of one of the terms, but for the re-positioning of the terms. Here is where the function of the "substitutive term strategy" is born. In most circumstances it is opposed to the "problem solving" attitude. A conglomeration of attractors could be one of the pillars of the dialogue, between the pre-existent memory of a form and the behaviors that are being born; unpredicted but coherent behaviors.
In the renegotiation of the memory an anguishing feeling could become an acceptable feeling, or also perhaps pleasant, because it is scattered in the system, it has been nourished by the system, and because it is not only self-referring.

The Design of the Systems, which is our subject in the ISIA of Rome, is deeply multidisciplinary because continuously has on the table a constant renegotiation of methodolgy, of proxemics, of narrative, and accepts the other as a part to be included, at the end a coherence principle is always an inclusive principle. Now it seems relevant to mention the relation with the memory referring to the text of Nietsche [5], with his help we can identify an epic attractor, an antiquarian one, and an autobiographical one. With this a memory that is only mine leads to a memory that is a social one. Nietsche does not mention them in antagonist way but in a convergent sense on the formation of the subject in which they all go to create a solo and lone "diary". A diary that according to the specific situations is de-constructible and recostructible. "Diary" could be defined as the representation of the continuity of the memory.

The interaction between biological phenomena has rhythms and time-space dimensions that human beings do not perceive with their senses and not even with instruments, except at a point of catastrophe, that is when something is noticed. In other words for us the attention to the phenomena on the latent state is important when the event generally does not appear to be "the final state" like solid, but when it is at "the starting state", like plastic. At the start of the process studies, observations, but also many interpretations are born. An important point is what happens in the moment of the not linear bifurcation. The point of bifurcation or catastrophe however is not exactly "the catastrophe itself", but is only the point of bifurcation of the possible courses of things and is not mechanically predetermined but is uncertain.

D. Wizard's Apprentice

Future today means a credible period for our forecasts, it is a period of relatively reliable time because it is sufficiently short, or sufficiently homogenous in order to elaborate credible forecasts. For example it is quite different to foretell the fashion trends throughout 10 years or to foretell the movement of agriculture in the same lapse of time.
The word 'trend' has been created in order to spot the strong structural tendencies of the development of some elements. The flow of the tides can be established for

centuries with a strong approximation. We know from trend world-wide that between 30 years 70% of the world-wide population will live in megalopolis or in big city centres with a large concentration of people, since this is the trend confirmed from the economic observations and statistics, but we cannot say what will happen in 100 years because it's too long for complex phenomena of sociological nature to be forecast. In the last two centuries the industrial and technological development has made us accustomed to deep changes of paradigm and social behavior, also in quite a short time.
Certainly we are not predicting the future and honestly we are not so interested in knowing how the world will be in 100 years time, and also there would not be much sense in knowing that because we can only resolve the problems that we live in the present moment, not those which we cannot see yet.

However today we have a perception of the reality and a conscience of the event as a non-linear motion, born from complex mechanics, equipped of an inner instability effect of complexities of process that weaken the idea of forecasts; predictability of the behaviors and suggests a commencement to cohabit with uncertainty.
The “becoming” could arrive “before the future” and this today “works“ in the mind of those who design, and is becoming a way to be.

Globalization has determined the creation of environmental conditions close to the natural processes, contiguous and retroactive, similar to a world-wide iperp attern of the events which are interacting more and more. An example of a concern to the complex societies is to have ten friends agreeing on a choice of a film for the evening , today - and the final choice is observable in the light of the theory of catastrophes – it leads a designer’s mind in various ways. The fact of knowing that the human perception does not correspond to the truth/space/time of the planet is not a sufficient excuse. Climate change is a controversial scientific concept, it is arguable that climate change ecology is not a true science, or perhaps has not offered scientific information, or perhaps it does not have real scientific experiences on its side, however we know well that it creates “true images“, or “images of truth”.
Therefore to interact in the process through “imagination” is not wrong, since it is already an intuition of becoming of a determined process, an inquired field from metaphysics and not from science, but the world of planning, that we can say unifies both of them, even though becoming “religious”, cannot prefigure? In the end hasn’t it always been like this?

References

(1)“The web of life: a new scientific understanding of living systems”, Fritjof Capra, 1996
(2) “Complexity: The Emerging Science at the Edge of Order and Chaos”, *Mitchell Waldrop,Simon & Shuster paperbacks N.Y, 1992*
(3) "On Complexity", Edgar Morin, Hampton Press, 2008
(4) "Zygmunt Bauman: Dialectic of Modernity", Peter Beilharz SAGE Publications, 2000
(5) “Dell’utilità e il danno della Storia per la vita” F. Nietsche; Adelphi, 1974

Using Gumowski-Mira Maps for Artistic Creation

Héla BEN MAALLEM [1, 2], Paul RICHARD [1], PhD
Prof. Jean-Louis FERRIER [1], Prof. Abdelaziz LABIB [2]

[1] *Laboratoire d'Ingénierie des Systèmes Automatisés (LISA)*
University of Angers, Angers, France.
[2] *Laboratoire Lumières et Modernité*
University of Tunis El-Manar, Tunis, Tunisia.
E-mail: {hela@gmx.fr },

Abstract

The mathematical concept of fractal penetrates not only into numerous scientific fields, but also inspires the artistic creation, in particular the plastic arts. The report of direct or indirect derivation between the number of contemporary creations and the representation of the virtual objects, that are fractals, requires an attentive consideration in order to clarify the issues of the different possible transpositions of the concept, outside its ground area and the aesthetic meaning which it acquires. In this context, we propose some specific views of fractals in the artistic field. We suggest to solve two forms of derivation of "Fractalism": the technical derivation and the aesthetic value. We take as example the study of an Iterated Function System that provides chaotic maps: the Gumowski-Mira model.

1. Introduction

Art and science are two complementary fields which are both in relation with reality, the first is intuitive, the second is analytical. Indeed, "to make art a mathematics", an exact science, is to remove the artistic creation from the incertain perimeter of the free imagination and to subject it to the laws that regent rational paradigms : organisation laws, accuracy, etc., that are all related to the fields where technology finds its origin" [1].
This slope towards science finds one of its illustrations where the screen becomes the drawing board of a new type of artist whose function is to conceive an abstract imagery based on geometric formulae and mathematic algorithms.
The contribution of computers in the comtemporary artistic execution is remarkable. Art is entered in a new phase of experimentation, reinforced by the implementation of complex models such as "fractals". This new approach led to a redefinition of art and the creation of syntax and new artistic languages where transpositions and transformations such as form / formless, regularity / chaos, finite / infinite, etc., take place, similar to that which one find in other fields of knowledge [2].
Our intention is to make the distinction between the scientific and technical bases of the concept of fractality and its derivations with artistic claim. It is advisable here to wonder about the possibility to define the bases of a "fractalist aesthetic theory" starting from the scientific concepts which it takes as a starting point, and this, starting from the study of a very interesting iterated function system based on the Gumoswski-Mira model.

2. Theory of fractal

The contribution of the fractal geometry in science and art during the Seventies was strong and original. The fractal theory made it possible to open new fields of research and to widen the fields of mathematics and art via new and unexpected forms. But what one hears by "Fractal" and what are their theoretical references and characteristics?

2.1 Definition

From the Latin "Fractus", this neologism implies some specific properties such as irregularity, asymmetry, or symetry in scale. In contemporary geometry, one names by "Fractal", a two or a three dimensions space configuration characterized by "a given degree of irregularity and apparent disorder, whatever the scale of examination, that ordinary Euclidean geometry cannot satisfactorily takes into account" [3]. Because of their extreme irregularity at any scale and their broken and discontinuous nature, fractals are very complex geometrical forms.
Obtained by infinite regular fragmentation of a given image or pattern, fractals are also known by their paradoxical property : whatever the scale to which one view them, it remains impossible to accurately define their contours. Thus, fractal in the complex plane has an infinite circumference whereas its surface remains finite. For certain fractal curves, one can observe the same pattern at different scale : it is what one names autosimilarity is scale [4].

2.2 A short history

In 1960, Benoit Mandelbrot, a French mathematician who has worked on iterated function systems, started to develop a more systematic study of new complex forms that he called "fractals". In spite of the importance of this reaserch, fractals would not have had such a considerable repercussion and populaity apart from the field of mathematics, if the graphic representation of these new objects was not been made possible by computer technology.

In 1979 and 1980 Benoît Mandelbrot and his collaborators Sigmund Handelman and Richard F.Voss developed the first algorithm allowing 2D graphics representation of fractals. These pure mathematical abstractions became the icons of modernity while at the same time their scientific applications were still unknown by the general public. Although no artistic intention has drived the development of such computer generated images, it was clear that fractals have incomparable and unusual aesthetic and emotional potentials. Thus, fractal images were initially very popular for their aesthetic properties.

2.3 Characteristic and field of validity

A fractal object has at least one of the following characteristics :

- it has similar details on arbitrarily small or large scales;
- it is too irregular to be efficiently described using standart geometry;
- it is selfsimilar, i.e. the whole is similar to one of its parts.

The fractals do not have to satisfy all the properties mentioned above to be used as models. They only have to carry out suitable approximations of what interests a given field (the book of Mandelbrot : the fractals objects give a large variety of examples). Fractals may be deterministic or stochastic [5]. They often appear in the study of chaotic systems and can be divided into three main categories:

- ✓ Iterated functions systems (IFS)**.** IFS are iterative processes which have the property to converge towards a fixed point, independently of their initialization. This point is called the "attractor" of the IFS. IFS produce fractals of which structure is, in most cases, described by a set of affine functions allowing to calculate the transformations applied to each point. These transformations are translations, rotations and homothetys, such as the ones observed in the Sierpinski triangle or the fern of Barnsley [6].

- ✓ Fractals defined by a relation of recurrence in each point of the complex plane. For example, in the Mandelbrot equation, for each value of C (complex constant), one obtains a succession of complex numbers that we can calculates the module. When the succession of the modules converges, C is considered like pertaining to the searched set, called the Mandelbrot set [5].

- ✓ Fractals that are based on stochastic and nondeterministic processes such as fractal landscapes.

Fractal art, as the world in which we live, is in permanent metamorphosis. Nothing is stable: neither the image, neither the forms, neither the color, nor the world they evoke. Fractals exhibe complex and chaotic universes, precisely characterized by proliferation phenomena of overload, saturation, or excess. Among fractals only those which are based on IFS have the property of autosimililarity in scale, meaning that their complexity is invariant by scaling.

One have passed to a culture of flow where instability, abstraction, displacement, and fugacity are the dominant characteristics. Fragmentation, irregularity, bifurcation and graining points connect regularity and chaos, random and foreseeable, finite and infinite [7]. The main characteristic of such practise is to minimize or reject the aestetic aspect of the artitic creation [8].

3. Derivation techniques and aesthetic value

Fractals works demonstrate an extreme diversity of materials, methods as well as the particular intentions of the artists. They have profound roots both in the geometry of Mandelbrot and the scientific theories of complex dynamical systems:

- The non-Euclidean fractal geometry developed since 1960 by Benoit Mandelbrot was previously studied by mathematicians as famous as CANTOR, PEANO, JORDAN in the 19th Century, then VON KOCH, HAUSDORFF, and BESICOVITCH in the first quarter of the 20th Century.

- The theory of recursive polynomial functions, developed between 1900 and 1930 by POINCARÉ, JULIA and FATOU.

One can observe that the integration of fractals in the artistic field is not only based on the technical processes. Thus, fractal images have also an aesthetic value that is based on both the richness and dispersion of generated colours and their forms themselves that sometimes reflect the real world such as Gumowski-Mira maps.

The artistic quality of fractal images resides in their originality and their diversity. Thus, in many cases the numerous solutions obtained with the same function system is very surprising. Although limited by their dependence to the technique, art works based on fractals induce an aesthetic upheaval. Indeed, they invite to a "pluriscopic vision of the world". According to Jean-Claude Chirollet: "Compared to the classicism of the cohesive rational order and of the totalitarian symmetry, the fractalistic aesthetics appears like its antithesis. Indeed, on the one hand, it asserts the artistic abandonment of the ideal of symmetry which appears like a lure in the light of the physico-mathematic theories of non-linear and chaotic processes, for which randomisation and junctions of no predicable trajectories play a crucial role. In addition, it supports the fragments and the details because fractal laws are not cohesives. However, these are laws of self dispersion and self decomposition of the « ad infinitum » fragmentation and of the structural recombining at any scale" [9].

One should note a double derivation, technical and semantic, of the aesthetic value of the fractals. Firstly, a fractal construction suggests the possibility to systematize and to privilege "a geometry of hailed, of sifted, of dislocated, of twisted, of tangled up, of interlaced" [10].

But fractalisation also mean the dispersion of the object unity with the profit of a multiplicity of profiles and of a profusion of details. By leaving the field of the computer graphics, the deployment of the figure is given up in the virtual infinite and true three-dimensionality is found. Indeed, the aesthetic value of the fractals can appear independently of the technical processes and mathematical approaches.

The integration process of the aesthetic values conveyed by the fractals does not only concern computer graphics. Thus, it gradually detaches from the technical contruction process to privilege the semantic aspect. In this context, the work of Miguel Chevalier represents both a transition between computer graphics and visual arts and between the technique and aesthetic. His interactive art works immerse the participants in fractal dynamic experiences such as repeated waves that oscillate according to the participants displacements. These art works are based on some forms of fractal processes that allow more sophisticated and enigmatic creative applications intended to question the participant.

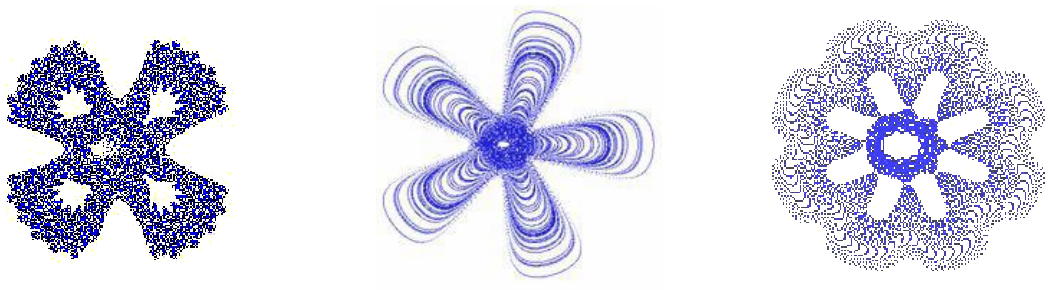
To conclude on this point, one can say that fractalist art is no more defined according to a construction technique nor by an integration of fractal forms within the art work than to the reference of aesthetic and significative values of fractals. One can even observe a double derivation of fractalism because of their intrinsic beauty and their capacity to mimic reality.

At this stage of derivation, there is no more a direct relation between art works and mathematical models, as it is acknowledged by Susan Condé : "There is not any artistic relationship between the art works presented here and the computer generated fractal images. The «fractalists» artists place their work in a metaphorisation and poetising scheme of fractality [11].

One can understand that the fractalist esthetism depends certainly on of the fractal geometry properties, but this derivation is nevertheless a metaphorisation process during which art gradually releases the meaning and the value of the process. The aesthetic value of the fractal geometry is not indissolubly attached to its mathematical consistency. The fractals have henceforth a new significance in each of their application domain and particularly in art. Undoubtedly, are the two processes of export of the concept and design not related to each other ? The systematic variation of scales leads to a fragmentist scientific philosophy which serve as a theoretical reference to the undefined aesthetics of fragmentation of the fractalist art objects [12].

4. The Gumoski-Mira model

Different nonlinear mathematical models which exhibit rich and complex properties exist in the literature. Some of them may reveal some aesthetic potentialities and are therefore interesting to study in the context of artistic creation. Among these models, one of the most interesting is the Gumowski-Mira model because of its very high sensitivity to the parameters (Eq.1) [9]. This model has been introduced for modeling and study accelerated particles trajectories at CERN in 1980. Iterations defined by Eq. 2 produce different kind of cellular patterns such as illustrated in Figure 1.



$A = -0.05, B = 1$ $A = 0.3, B = 1$ $A = 0.7, B = 0.99$

FIG.1 – Sample of Gumowski-Mira maps.

$$F(X) = AX + \frac{2(1-A)X^2}{1+X^2} \quad (1)$$

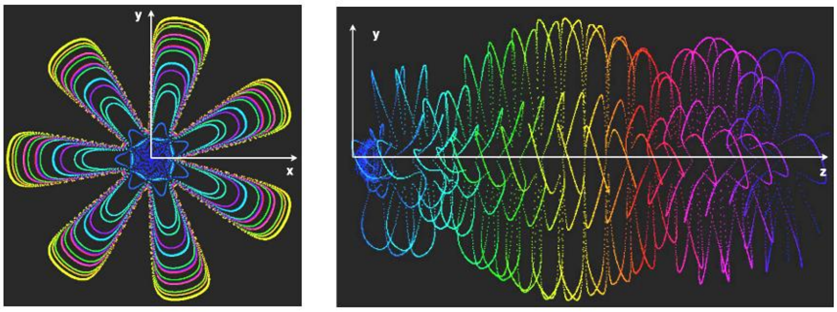
$$X_{n+1} = BY_n + F(X_n)$$

$$Y_{n+1} = -X_n + F(Y_n) \quad (2)$$

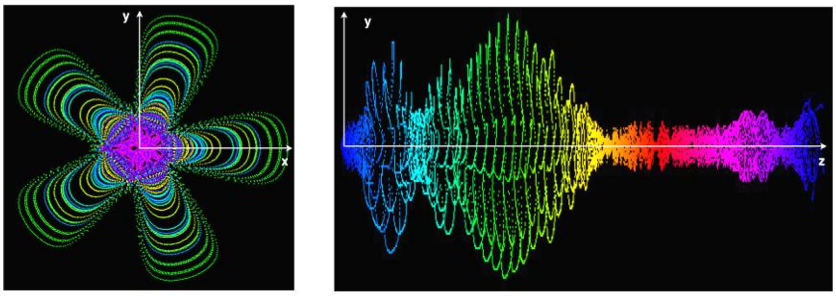
We observe that these patterns resemble very much (cross sections of) living marine creatures. Otsubo et al., performed a computer simulation on the Gumowski-Mira transformation and presented a variety of 2-dimensional patterns for different sets of the model parameters [12]. However, these patterns were monochromatic and did not take into account the colorimetric potential of the GM model.

4.1 Coloration of GM maps

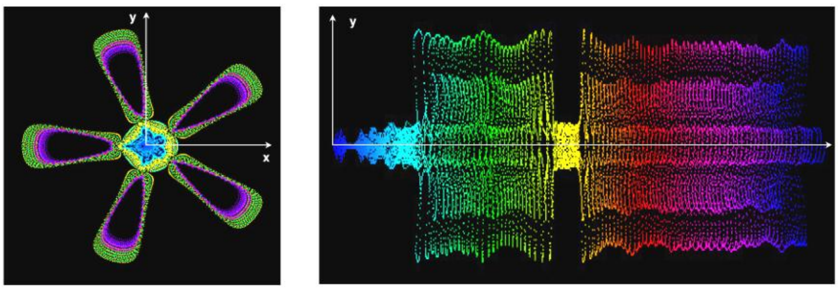
The role of color in artistic creation is crucial. We therefore started to study GM maps coloration. We observe on Figure 2 that the coloration of GM maps are not straightforward since the same color map gives different results (colors visible in the patterns). This is because GM patterns highly depend on the model's parameters. In addition, GM maps may exhibit either pseudo-periodic or chaotic behavior depending on the parameters value.



$x_0 = 0.5,\ y_0 = 0.5\ ;\ A = -0.222,\ B = 1.000$



$x_0 = 0.5,\ y_0 = 0.5\ ;\ A = 0.311,\ B = 1.000$



$x_0 = 0.5,\ y_0 = 0.5\ ;\ A = 0.00,\ B = 0.305$

FIG.2 – Sample of colored Gumowski-Mira maps using the same colormap.

4.2 Morphing of colored GM maps

In order to develop some art works using the GM model, we have studied different rendering and viewing techniques such as 3D static and dynamic visualization. Among these techniques the dynamical morphing of GM maps is the more interesting one (Fig. 3). We start by selecting starting values for A and B, then we select two other values of the parameters. Finally, we run the simulation and observe a dynamic transformation of the GM corresponding to the starting values of A and B towards the GM corresponding to the end values of A and B.

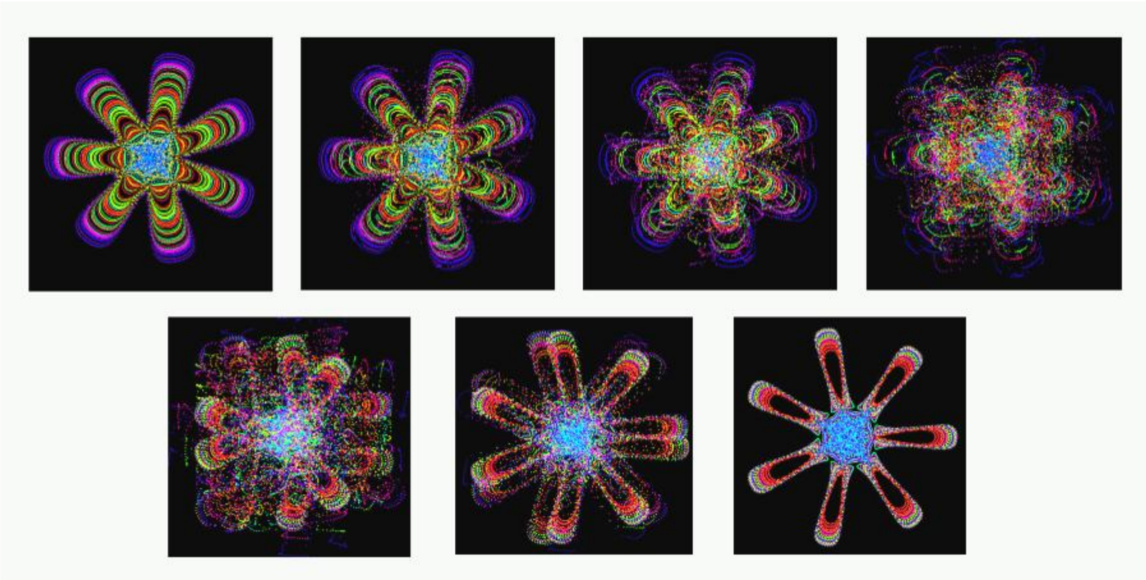


FIG.3 – Illustration of the proposed morphing technique for colored Gumowski-Mira maps.

5. Conclusion

The mathematical concept of fractal penetrates not only into numerous scientific fields, but also inspires the artistic creation. The report of direct or indirect derivation between the number of contemporary creations and the representation of the virtual objects, that are fractals, requires an attentive consideration in order to clarify the issues of the different possible transpositions of the concept. In this context, we propose some specific views of fractals in the artistic field. We suggest to solve two forms of derivation of "Fractalism": the technical derivation and the aesthetic value. We take as example the study of an Iterated Function System that provides chaotic maps: the Gumowski-Mira model. This model is very interesting because its very high sensitivity to the parameters study GM maps coloration. We observed that coloration of GM maps are not straightforward since the same color map gives different results (colors visible in the patterns). Indeed, GM maps exhibit either pseudo-periodic or chaotic behavior depending on the parameters value. We have proposed a new technique that allows dynamical morphing of GM maps. In the future we will propose different approaches that allow to better control the colour mapping in GM maps.

REFERENCES

[1] ARDENNE P., (1997), Art, l'âge contemporain, éd. du regard, Paris, p.246.

[2] BUCI-GLUCKSMAN C., enjeux du fractal en art, cité in, Fractalisations, (1999), éd. Blanchard, p.10.

[3] CHIROLLET J.-C., (2000), Art fractaliste, éd. Paris, 00h00, p.19.

[4] PEITGEN H.O. and RICHTER P.H., (1986), The beauty of fractals. In éd. Springer-Verlag, Berlin.

[5] BARNSLEY M.F., (1993), In Fractals Everywhere. Academic Press, New York.

[6] HUTCHINSON J.E. Fractals and self-similarity. In Indiana University Mathematics, Journal, no. 30, 1981.

[7] BERKO E., CHEVALIER M., DOMBIS P., GINSBURG C. HENAO C., LONG J. LORENTZ N., MENARD J.-C., REBYJ Y., ZARCATE P., (1999), Fractalisations, éd. Blanchard, p. 12.

[8] CHIROLLET J.-C., Op.cit., p.20.

[9] CHIROLLET J.-C (1999), Collectif, Fractalisations, catalogue réalisé par la ville de La Seyne-sur-Mer à l'occasion de l'exposition à la Villa Tamaris du 27 mars au 30 mai 1999, p.83.

[10] GLEIK, J.(1991), p. 127, cité par Christine Buci-Glucksmann, in « Enjeux du fractal en art », in Collectif, 1999, p. 12.

[11] CONDÉ S., (1999), in « L'existence de l'art fractal », in Collectif, 1999, p. 73. Voir aussi CONDÉ, 1993.

[12] CHIROLLET J.-C (1999), in Collectif, p. 85

[13] OTSUBO K., WASHIDA M., ITOH T., KATSUURA K. and HAYASHI M. Computer Simulation on the Gumowski-Mira Transformation,
Forma,15, 121–126, 2000

Objectology: influence of computerized technologies on contemporary design.

Iohanna Pani
Department of Industrial Design, Bezalel Academy of Art and Design Jerusalem, Israel
iohidesign.carbonmade.com/
issuu.com/iohipocket/docs/objectology

1. Introduction

"We are lacking a discipline, perhaps an 'objectology,' or an 'object ethology,' which allows us to analyse and systematise objects and to formulate the rules and codes of their behaviour ... a discipline which recovers and updates the interrupted discourse of material culture, in crisis since the world of objects was taken over by the world of products and the world of consumption" [1].

At the beginning of the 20th century artists began assigning additional significance to everyday objects, beyond their being mere functional items: Marcel Duchamp's artwork represents the beginning of an era of deconstruction and reconstruction of those objects [2]. From Duchamp's time and to this day many artists and designers like Joseph Kosuth, Bruno Munari and Rachel Whiteread engaged in formal studies examining the boundaries of objects. Nowadays, thoughts concerning the essence of objects are still relevant, even though research tools have changed.

In recent years our world is becoming increasingly infiltrated and mediated by electronic systems and devices and the role of design is shifting in response to these changes [3]. Over the past decade, computers are used not only for the rendering of objects, but also as part of the actual creation process of new forms.
Under this context, the field of generative design has developed, which uses algorithms to produce series of autonomous forms. The role of the generative designer therefore shifts from designing individual objects into designing their "DNA" [4]. Generative design's concern with universal laws which characterize objects as entities and not as particular items, serves not only for designing new forms but also as a tool for defining and analyzing objects.

2. The project

"Objectology" is a morphological study that explores the reciprocal relationship between science and design and examines the impact of computerized technologies on design in the contemporary world. The study uses techniques of generative design but chooses manipulations which express values related to the evolution and history of the products. Forms are examined within a historic, biologic, genetic and perceptual approach. The study raises questions about the past and future of the objects and thus adds a fourth dimension to three-dimensional shapes: the

dimension of time.
The project examines the transitions and superpositions created between forms, both between different icons in the history of a certain object, and between different objects. Furthermore, it shows that these intermediate states reveal forms which exist from a conceptual point of view, but have not yet been expressed visually.
The study focuses on the form, detached from its function, material and technology. This detachment leads to an analytic approach similar to abstraction, held in scientific researches. Studies of this type disconnect the object of research from reality in order to analyze a certain phenomenon. The use of scientific methodology in a formal study frees the designer's act of 'making', allowing him or her to create unexpected forms.

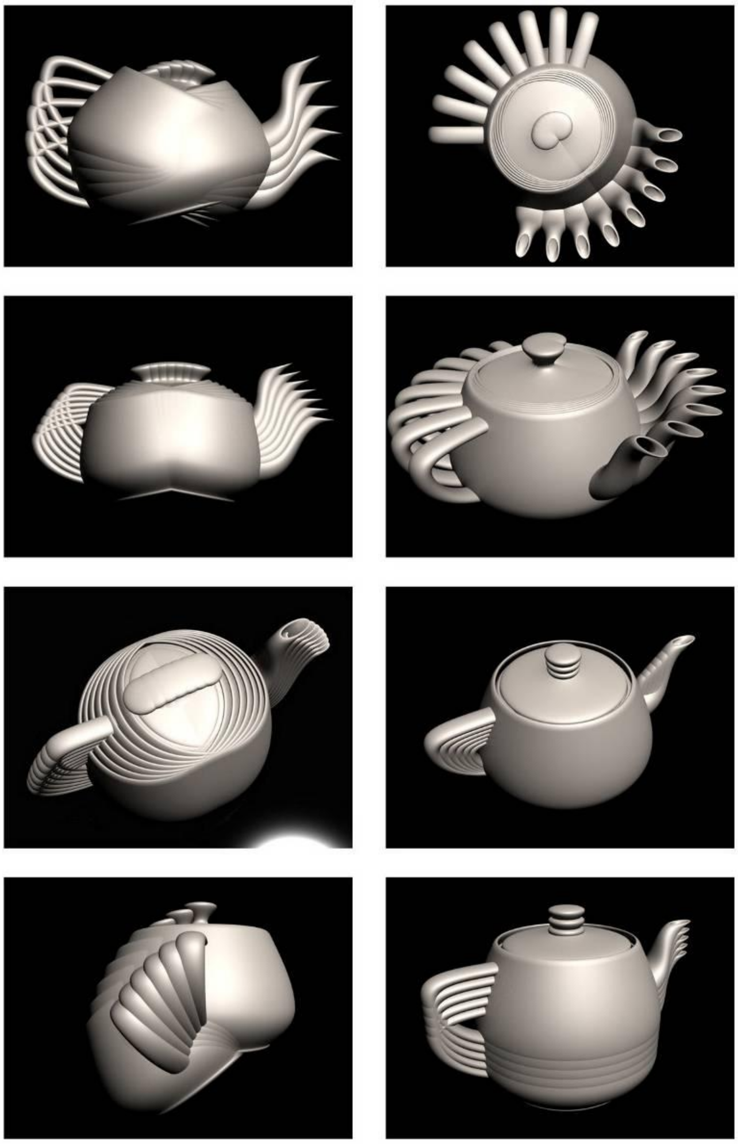


Figure 1: Test #1: Objects movement .

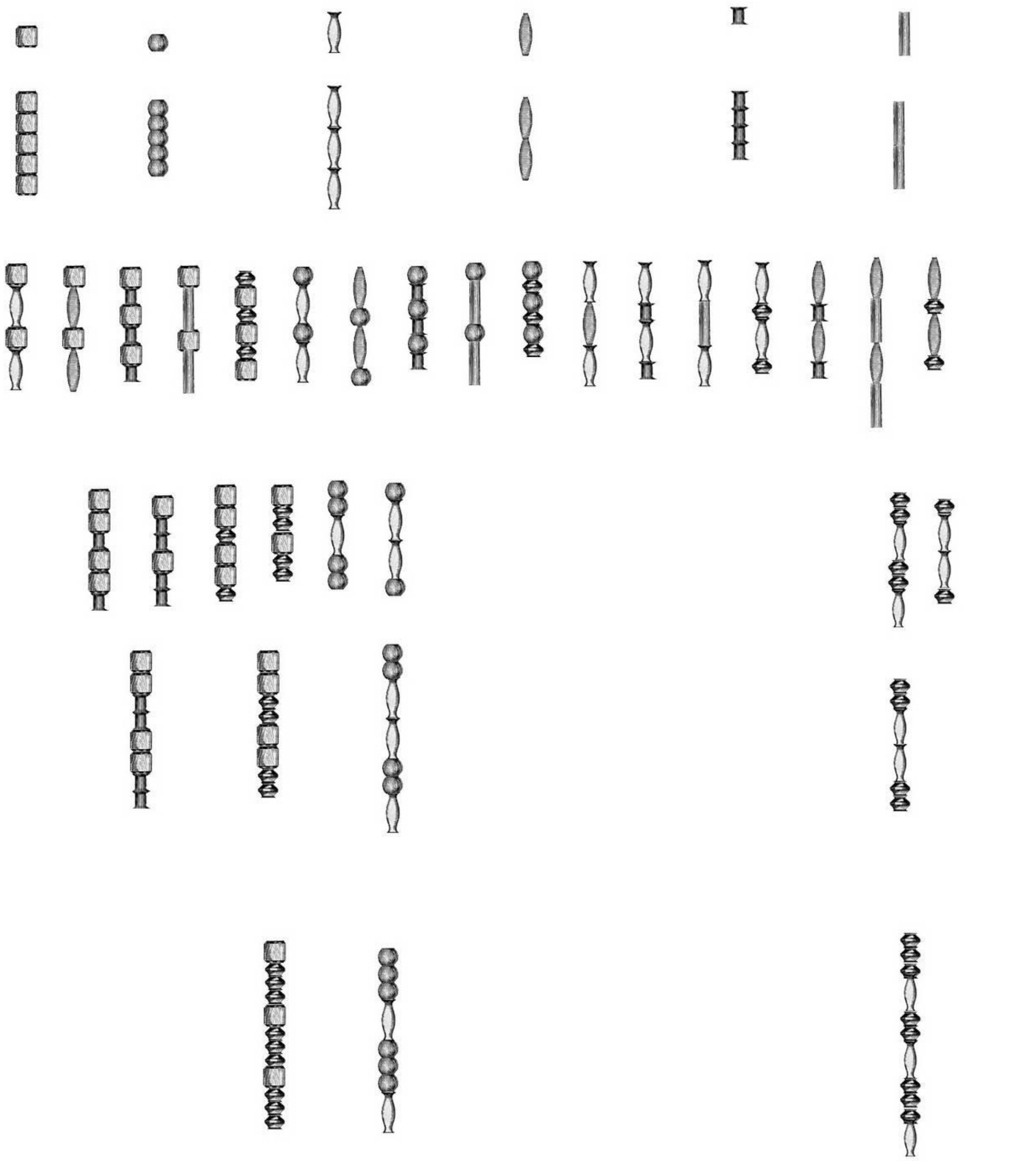


Figure 2: Test #2: Genetic combinations of turned patterns.

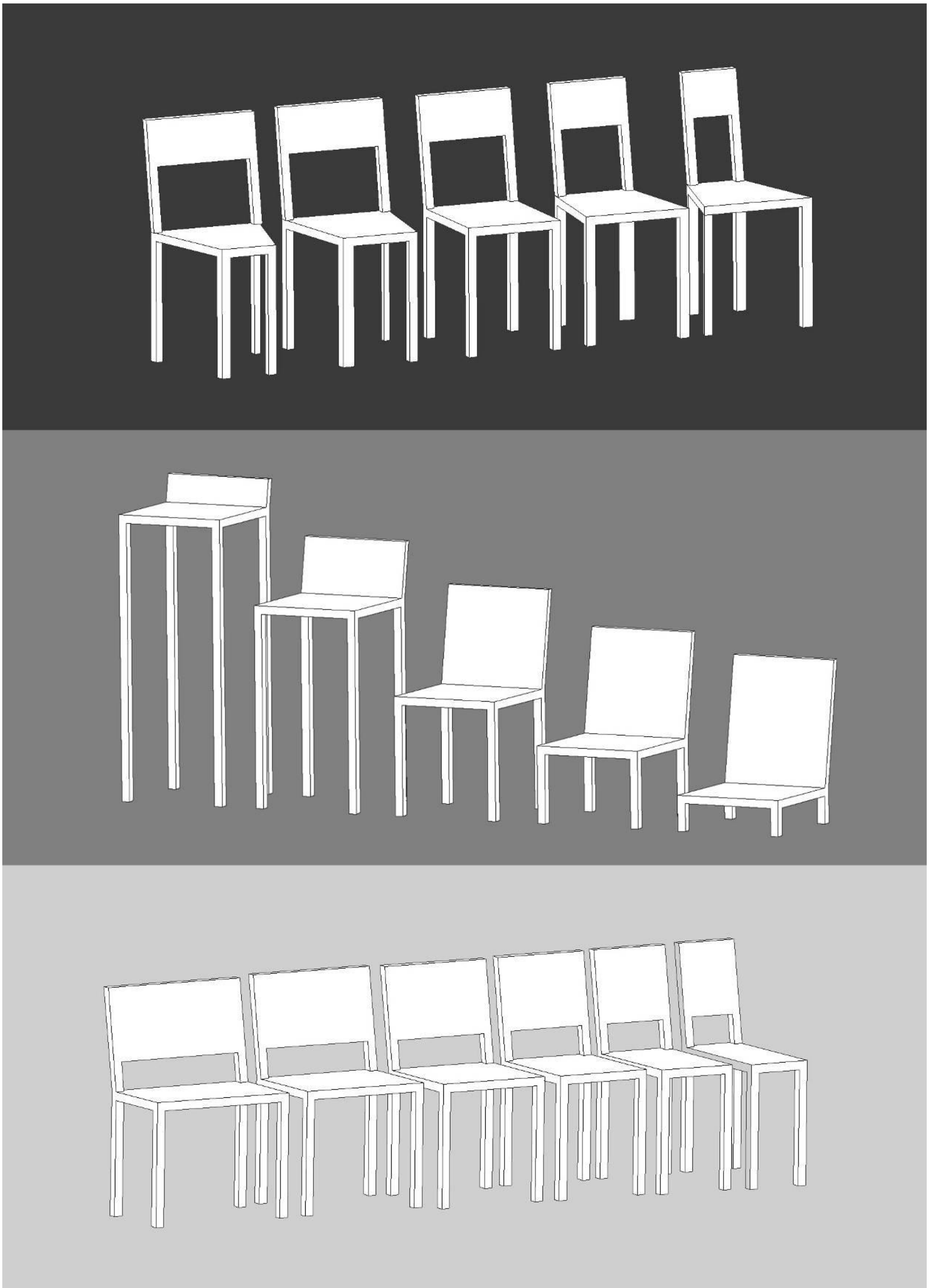


Figure 3: Test #3: Progressive changes on a chair keeping parameter (volume) fixed.

Addition, subtraction, distortion, scaling or flattening are part of the manipulations performed on different objects. These manipulations can give rise to lack of functionality. Such situations - where shape is detached from function - on the one hand enable us to examine the shape separately, while on the other hand, gives the objects a sculptural dimension.
In fact, computerized software allows designers to build three-dimensional forms regardless of material and technology. This phenomenon is reflected by treating the material as a texture which can be mapped onto any form and replaced according to the will of the designer. This option both frees and detaches the designer from the limitations of the material and of the production technology.
The products of this study are forms which remain in the virtual world in which they were created; they are forms which represent the object as an abstract concept. Gray forms which are similar to the display of models in three dimensional software- raise the question of whether the software is, in itself, a new design language. I claim that the use of computerized tools in design shows not only a technological development, but also a new paradigm in design. This new paradigm is based on a scientific approach in which principles of the natural word are transferred to the "object world".

2.1 Object's essence- Superposition

What is the minimum form that an object needs to exist?
The search after the minimum – morphological as well as material - has been the major focus of many contemporary designers. This relentless search sometimes reaches a point, where the object looses its cultural depth [5]. My goal was to reach the morphological minimum of the object, while including its historic, social and poetical aspects. This minimum can be conceived as the essence of the object.

Figure 4: Superposition of kettles from the book "The Kettle: An Appreciation" [6]

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By superposition of transparent silhouettes, it is possible to see the morphological changes which took place during the history of an object and its development. It is also possible to see darker parts indicating the regions of the object which have not changed. I separate those darker parts of every set of objects in an attempt to examine whether the result can be conceived as the morphological essence of the object.

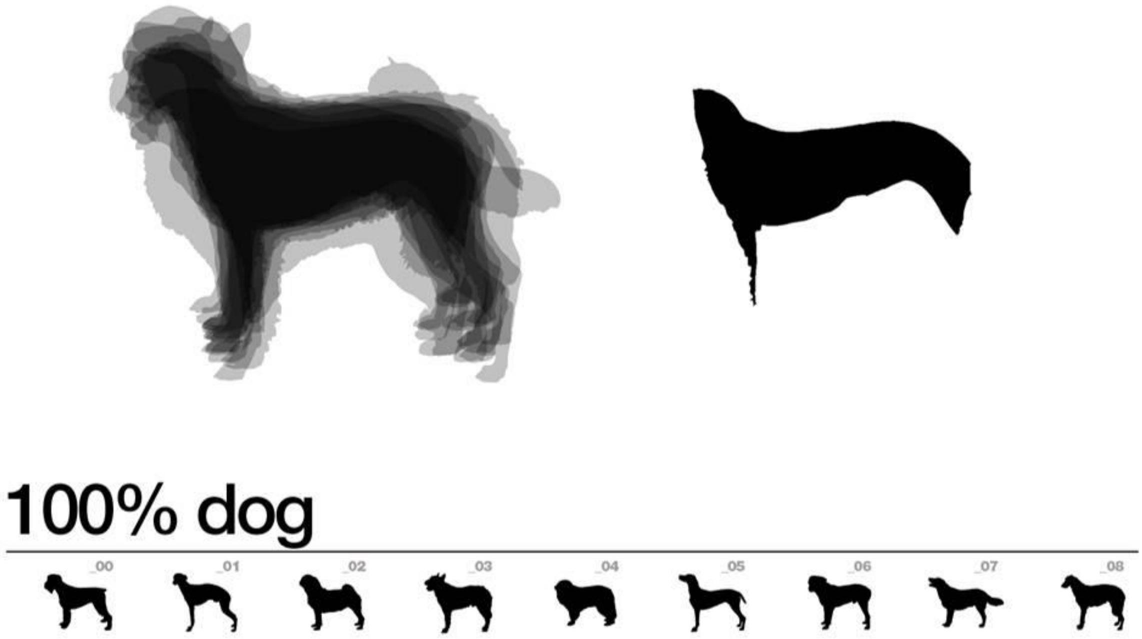


Figure 5: Snapshot of the video "Objectology: Object's essence".

2.2 Vestiges of a chair- Gradual hybridization

Is the development of products similar to developments in nature?
In the recent years there has been an influence of the natural world on design practice. This influence is evident in design companies, using genetic algorithms to develop products, and in designers, who refer to products as living creatures [7].
Inspired by the evolutionary process in nature, I have created a set of chairs undergoing mutation and becoming storage units. Each chair in the set is in a different stage of the evolutionary process, and fulfills the sitting-function to a different extent.

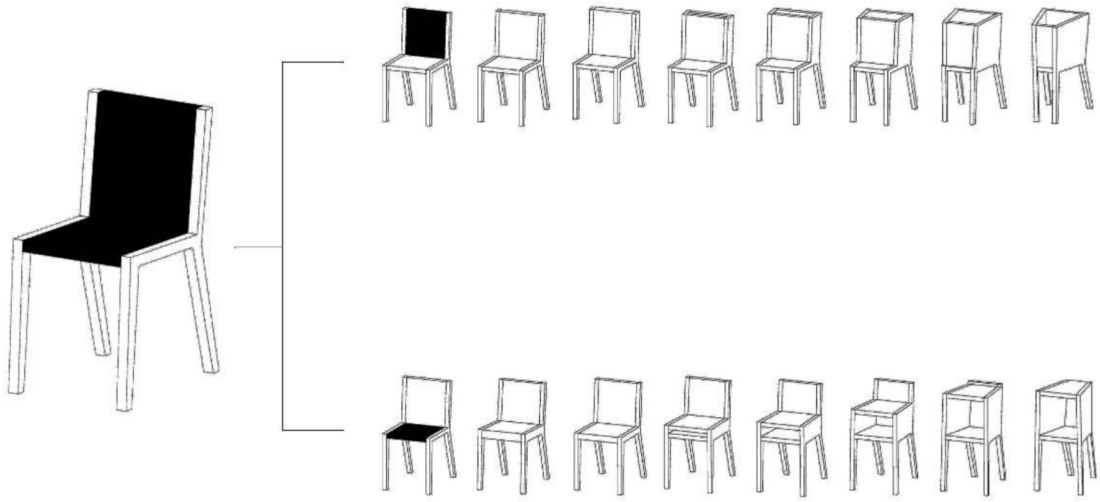


Figure 6: Gradual hybridization of a chair with a storage unit in its seat and back.

Darwin's Theory of Evolution explains that somebody traits have no specific role, and that their present shapes can be accounted for by their being vestiges of previous generations [8]. Human's toes exemplify this phenomenon. While separated toes made it possible for primates -who were ancestors of modern humans- to move among trees; humans only require one separated toe (the big toe) in order to achieve balance in walking [9]. However, Indians take advantage of their toes and use them to hold threads while weaving. This shows the ability of humans to provide new functions and cultural significations to existing forms. By using an evolutionary model from nature, it is possible to create new forms which do not necessarily need to fulfill their original function. Only then, it will it be possible to think of new meanings and additional functions.

Figure 7: 1:1 models of four chairs from the sequence.

2.3 Primal Furniture- Filling the negative spaces

What are the boundaries of the object?
Prehistoric man created a whole world of tools and furniture from stone, which were gradually advanced and perfected throughout history. The shape of every object known today largely depends on factors related to the period in which it was created - technological capabilities, local trends, etc. By filling the negative spaces of iconic chairs in the history of modern design, I cancel out the historical characteristics of each chair and detach it from its cultural context.

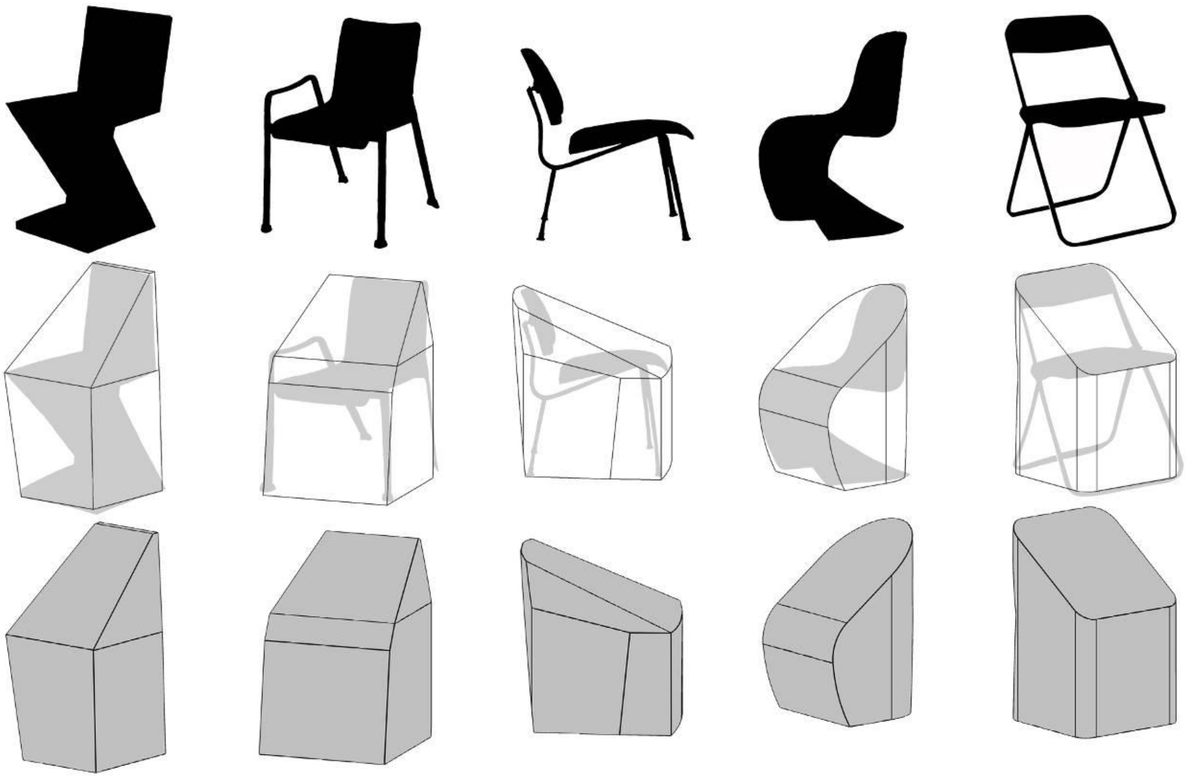


Figure 8:Process of filling negative spaces of the chairs: Zig-Zag (Rietveld,1934), Landi (Coray, 1938), LCM (Eames, 1946), Panton stacking chair (Panton, 1960) and Plia (1969).

With this action, I try to attain a basic form which expresses a chair from a perceptual approach. Michelangelo believed that every stone had a sculpture within it, and that the work of sculpting was simply a matter of chipping away all that was not a part of the statue. By filling in the spaces, I revert the chairs to stone.

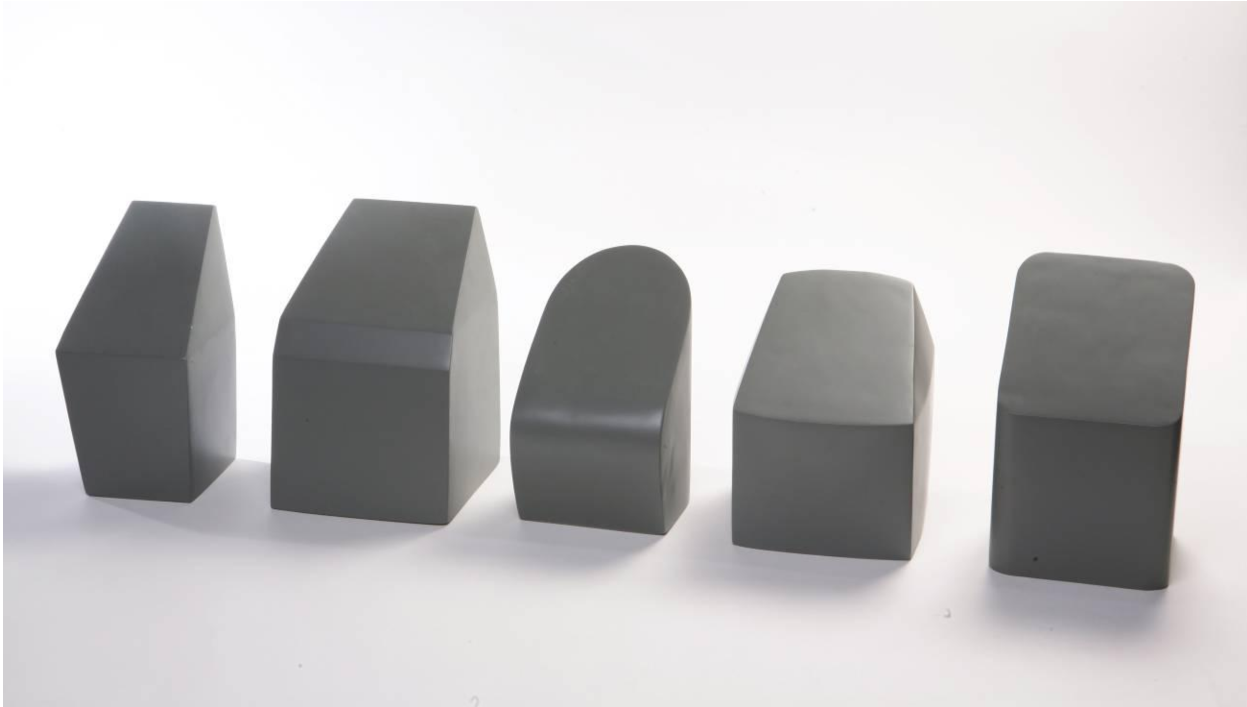


Figure 9: 1:3 models.

3. Conclusions

The influence of computerized technologies on design in the contemporary world is characterized by constant detachment in different levels: between the design process and its result, between shape and material and between the object and its cultural context. Even though that this detachment can be seen as a negative phenomenon, it can also be perceived as a new approach in design which is in line with a new paradigm that uses scientific models to explain phenomena of the inanimate world. In this latter case, the detachment is an objectification of the designer's work that leads to a different level of abstraction than the one normally used in current design processes. This phenomenon emphasizes the great potential of the computer not only as a working tool but also as an analytical or research tool.

4. References

[1] Susani, Marco, "The fourth kingdom", Ottagono,No 105 ,December 1992.

[2] De Duve, Thierry, "Pictorial Nominalism: On Marcel Duchamp's Passage From Painting To The Readymade", Trans. Dana Poland, University of Minesota, Minesota, 1991.

[3-4] McCormack, Jon, Dorin, Alan and Innocent, Troy, "Generative design: a paradigm for design research", Proceedings of GA2008 11th International Conference, Milan.

[5] Dunne, Anthony, "Hertzian Tales: Electronic Products, Aesthetic Experience and Critical Design", RCA CRD Research Publications, Royal College of Art, London, 1999.

[6] Woodham, Jonathan M., "The Kettle: An Appreciation", Laurel Glen Publishing, 1997.

[7] Paola Antonelli (Editor), "Design and the Elastic Mind", The Museum of Modern Art, New York, 2008.

[8] Darwin, Charles (1859), "The origin of species", Signet Classic, 2003.

[9] Jocelyn Selim, " Useless Body Parts ", Discover , June 2004.

Generative Platform: An Extensible Audiovisual Narrative Development and Deployment Architecture

Jason M. Reizner, BMA
Vancouver, British Columbia, Canada
www.reizner.org
e-mail: info@reizner.org

Abstract

A proof-of-concept system is built upon the Generative Platform environment (GP), a lightweight and non-exclusionary architecture for developing and deploying dynamic audiovisual narratives, both online and in situ. GP builds upon the near ubiquity of the Flash runtime and exploits its current position as the de facto standard for online video distribution, extending input support for the vast majority of video content sources found on the web. Consequently, narratives generated by GP are executable on nearly 99% of internet-connected personal computers in use today, ensuring consistent content accessibility. Generative Platform delegates functionality between three linked modules: a source data parser, a generative logic sequencer and event handling system, and a multithreaded audiovisual playback subsystem. XML support is inherent to GP, enabling the capability to import and export a variety of data sources including XSMP, RSS feeds and automated archival search results. Object-oriented iterative sequencing logic is programmed using standard ECMAScript-syntax. Video compositing and playback are designed to minimize processing and network overhead, allowing higher framerates and more universal user experiences.

1. Introduction

From its conception, Generative Platform has been built to accommodate the vast stores of digital video data available online and in formal archives around the world. The ability to approach these resources and reliably transform them into rational source material for subsequent creative endeavors will inevitably transform the ways in which time-based narratives are both crafted and consumed. By designing a system that supports the simultaneous processing of video data and associated metadata, it is possible to implement comprehensive narrative ontologies that are otherwise impossible within existing single-scheme multimedia frameworks. The capability of leveraging linked data, such as rhetorical annotations and semantic search results, enables the creation of structured user experiences that transcend the trope of hypervideo simply as collage. Espousing this paradigm, the objective is to further explore the grey area between conventional archivism and collective distributed content creation while facilitating the construction of new methodologies for working with digital time-based media.

The construction and release of a robust, extensible and well-documented open toolset such as GP enables other media practitioners who desire to develop strong generative narrative concepts to do so without having to first establish an entire programming framework. Through the modular componentization of the technical functions necessary to support these narratives, creators are free to devote their focus and energy to the realization of a specific conceptual vision or research objective, rather than to the design and development of bespoke software infrastructure. Consequently, the establishment of a unified development architecture facilitates the unhindered exchange of methodologies and techniques between practitioners, and creates the potential for collaborative communities between artists, programmers, researchers and archivists.

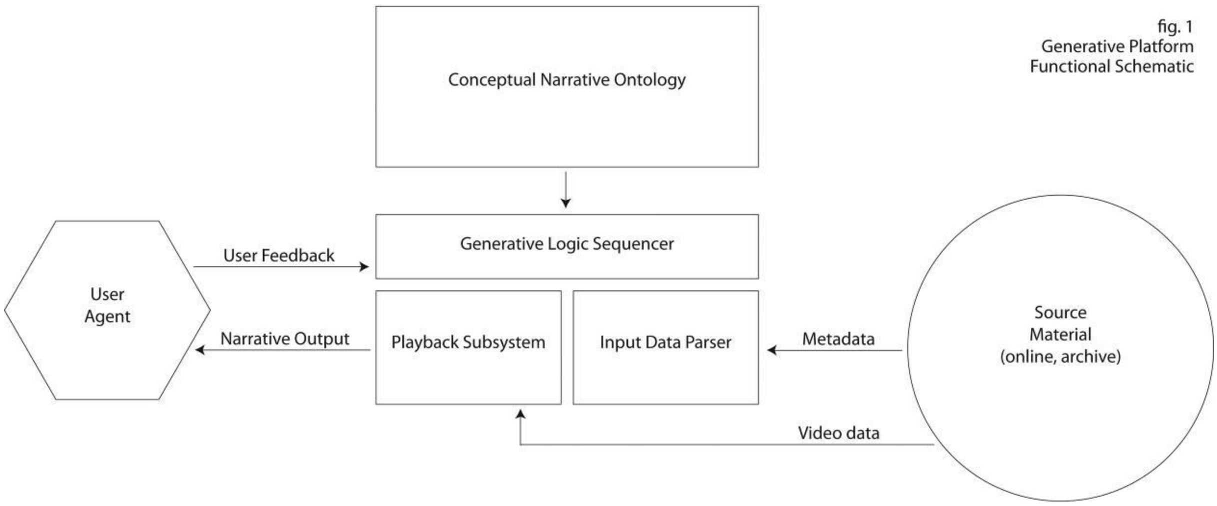
2. Related Work

Countless approaches to the production of generative audiovisual narratives have been previously devised and published, however, most of these systems have been developed and purpose-built to execute a single narrative ontology. Typically, once a conceptual agenda has been established, the production of a generative narrative first requires several processes, including the procurement, organization and indexing of audiovisual source material, and the construction of the processing mechanisms necessary to execute the system.[1] GP is unique in its design approach, in so far as it streamlines the current course of development by providing the foundations of these mechanisms for managing custom datasets, as well as interfacing with pre-existing external video and metadata sources. By minimizing the need for additional software support, the focus of development can be shifted towards the realization of more elaborate conceptual frameworks and richer narrative experiences.

3. Technical Overview

Generative Platform is designed around a core set of objectives: accessibility, consistency, efficiency and extensibility. These objectives are reflected in the both the user and developer paradigms that underlie the architecture, as well as in the technical requirements necessary to support it. As a result, the overwhelming majority of internet-connected personal computers in operation today are capable of executing narratives built with GP. Although the Flash runtime upon which GP is based is proprietary, its near ubiquity and current market position as the de facto standard in web-based video has left few viable alternatives, either open-source or closed. A synergistic benefit of this dependency, however, is realized by leveraging the existing skillsets and widespread technical knowledge of practitioners already well versed in Flash development practices.

The functional underpinnings of the architecture are divided into three tightly linked components, each playing an integral role in facilitating the production of a generative narrative. An overview of the functional relationships between these components and the broader narrative ecosystem is elaborated below, in figure 1.



3.1 Generative Logic Sequencer

As the primary control structure within the Generative Platform architecture, the Generative Logic Sequencer is both the procedural heart of the narrative environment and primary site for the programmatic definition and structuring of the Conceptual Narrative Ontology, or the models that specify all “concepts or objects, their attributes and inter-relationships”[2] within the experiences themselves. Evaluating object-oriented routines formalized in standard ECMAScript syntax, this module mediates the linked data accrued by the Input Data Parser, and provides all display and composition decision guidance to the Playback Subsystem.

3.2 Input Data Parser

Responsible for the ingest of linked metadata, the Input Data Parser is vital to managing and articulating the datasets that bring order and relevance to the video content being processed.[3] This module is capable of handling a variety of frequently used data formats, including XSMP, RSS feeds, and standard Dublin Core metadata. Additionally, support for other XML-based metadata schema can be added as they are encountered, enabling connectivity with a multitude of database systems.

3.3 Playback Subsystem

All audiovisual content is loaded, queued, rendered and displayed by the Playback subsystem. Working in tandem with the Input Data Parser, this module provides a unified, scalable interface to the audiovisual capabilities of the Flash runtime, and a centralized clearinghouse for the orderly request of bandwidth-intensive video content. GP supports the usage of installed Flash runtimes starting from version 7, allowing developers to target specific user agents at their discretion, based on their playback requirements. As such, support for a range of H.264 formats is available to developers targeting the most recent versions of the runtime, while also preserving compatibility for users with older installations.

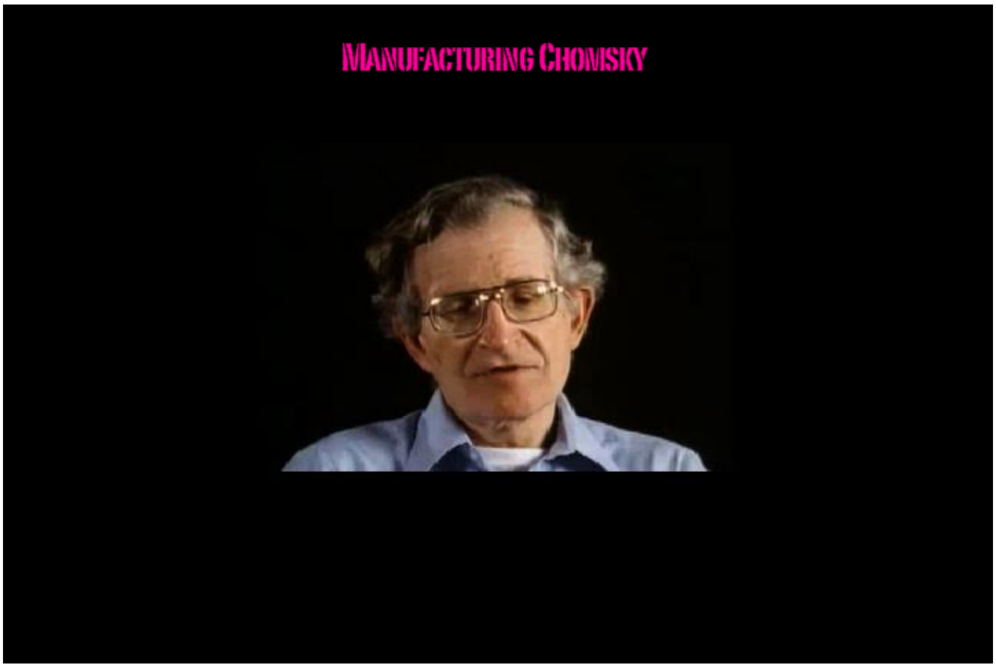


fig. 2: *image of “Manufacturing Chomsky”, built on GP*
http://reizner.org/chom

4. References

[1] Laskari, Iro et al, “Generative System for the Synthesis of Audiovisual Narrative”, National & Kapodistrian University of Athens, 2008

[2] Buckingham Shum, S. et al, “ScholOnto: An Ontology-Based Digital Library Server for Research Documents and Discourse”, Knowledge Media Institute, The Open University, Milton Keynes, 2000

[3] Bocconi, S. et al, “Using rhetorical annotations for generating video documentaries”, Centrum voor Wiskunde en Informatica, Amsterdam, 2005

HOME: a look inside this algorithmic world

Joana Fernandes Gomes
Portuguese Catholic University, School of Arts, Oporto, 4050-000, Portugal
www.porto.ucp.pt
e-mail: joanafernandesgomes@gmail.com

Abstract

The piece "HOME" is a video art installation, where materiality is questioned and where the real and the virtual are confronted, opening windows to a completely abstract and digital world.

Generated by an artificial life system, this piece communicates with the spectator in two ways: one abstract and another actual (concrete). Each one shows one side of this algorithmic world.

Outside of the installation room there is a screen, on which an artificial life system is shown to the visitor in its more abstract form; the individuals have shapes that transmit the mathematics and "dehumanization" inherent to such world through a graphic representation. Inside the installation there are three screens that represent the "construction" of that same world.

1. Introduction

HOME is an artificial life system that presents itself in two different ways: inside and outside the installation room. In each side we are confronted with two different realities of the same individuals, space and their relationship. HOME is at the same time in the social reality world and in the fictional one [1]. The confrontations of such different perspectives aim at making us rethink our bodies, our minds and our spaces [2] through the analysis of our perceptions of what surrounds us in that room.

2. Outside the installation room

Outside of the installation room there is a screen; on it an artificial life system is shown to the visitor in its more abstract form; the individuals have shapes that transmit the mathematics and "dehumanization" inherent to such world through a graphic representation. Is a community built by computers and represented by graphics.

Fig. 1. Information shown outside the

In the graphical representation that is presented outside of the installation room some information is presented in a very direct way to the visitor. There are only three facts available in this representation. Since this world lives on its own duality, this information can be related to any kind of world. Shown are the number of individuals/population; the number of years they exist and the amount of resources available. The lack of specificity doesn't allow the visitors to develop a preconceived view or understanding of this world but at the same time it reveals itself as abstract and machine-based.

Despite that the information given before the visitor's dive into HOME is restricted, and doesn't present the effort of this world to transgress his own "virtuality"[3], even though those characteristics are always present, at least outside the installation room.

This type of representation is normally more associated with this kind of machine-based individuals. Based on the computer system this world is very mathematical and algorithmic. This information is important to establish its "natural" form, making it possible to relate the different states inside and outside the installation room.

3. Inside the installation room

On the other side, inside the installation there are three screens that represent the "construction" of that same world. This system provides its own actions and it modifies itself along time by means of parameters set by the algorithm. During the time that such assembly of individuals exists, they feed themselves, reproduce themselves, die and so on. The result of those actions is assessed and creates a set of parameters, which selects at each minute an assembly of three videos from a database. Triggered in a synchronized way and displayed on each of the installation walls (screens), such assembly of videos represents the “status” of the world. The sequence of those choices results in the presentation of the “landscape” of that world.

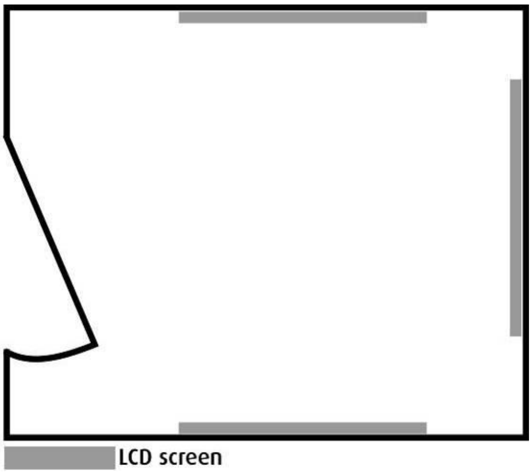


Fig. 2. Space of the installation

The layout of those projections is aimed at producing in the visitor the sensation that he/she/it is looking through windows. The videos are composed of characters that interact with each other in a wide white immenseness and that move along the various projections. The videos give the visitors access to this “world”. The white immenseness baffles the visitor taking and hinders him to perceive the extension of that world. The characters “humanize" themselves losing slowly and progressively the virtual and abstract appearance they present on the screens outside the installation. It is a community that lives “on the other side”.

In this installation the videos are an essential part of the construction of the identity of this society/world. These videos have very special characteristics as they are the way such community communicates itself with us, the spectators. It is where the community reveals itself and transcends the virtual.

The white immenseness of the videos (which in technical terms means that the filming was done in Cyclorama [4]) is an aesthetic normally related to Sci-Fi movies, where the absence of spatial references and where the minimalist aspect of that environment is valued. The Cyclorama offers in this piece, videos that at the same time seem naked and that in turn suggest the existence of a technological society that spreads over an almost infinite space. The absence of parameters is aimed at ensuring that all the attention of the visitors be directed to the gestures of the characters. With this technique, the lack of references makes it impossible to have the full comprehension of the relations between characters and the real size of everything that is shown. In a totally amorphous space we have the possibility of building whatever we wish. The world built by means of actions. A Plantation exists solely when an individual makes movements that are in some way referred to a plantation space.

Another important aspect is that the main objective of this installation is to enhance the attitudes of the characters, that is, to build a digital society, that expresses itself by means of the videos, and that communicates by means of actions. In this case the white immenseness is a way to emphasize the actions of characters without showing other distractions to the spectators. As the objective is to create in the spectator the sensation that he/she sees the community through glass windows, synchronization of the screens is important. That is, the presented videos in each screen will have two other videos, which will be simultaneously being presented in the other two screens. The objective is to create a liaison among them, which makes the idea of a construction of a world beyond the walls feasible. That liaison is going to happen mainly through the movement of characters from one glass window to another. The result is the construction of a sensation of wrapping the spectator with the "digital world".

Fig. 3. One possible landscape of HOME. Community status is

We can say that in spite of these videos being the representation of the “world”, for the spectator, they are the summit of choices that result in one controlled representation of certain characteristics and that implicate a manipulation on the vision offered to the spectator. The glass windows have the function to create the illusion of clarity and transparency that are not real.

The fixed camera reinforces even further that feeling. In this project, the user does not travel or walk in the space. Restricted information is supplied to him/her. Depending on the status of the inhabitants of HOME, the video is restricted information. Depending on the HOME state the videos may become solely the white

Fig. 4. One possible landscape of HOME. Community status is negative

immenseness.

3. The algorithm

This artificial life system was developed taking into consideration the duality of this worlds and their populations. For that reason, all phenotype and genotype aspects were carefully chosen. These world variables are intrinsically related with important human characteristics such as happiness and at the same time stress the artificial and machine-based orientation of this population.

An initial population of ten individuals inhabits this world. Each one of them has a small genome that is composed of four numbers. The first one is the gender, the second one the third are the life expectancy and the third and the forth numbers are the time interval between their need to use resources.

The gender can be zero or one. Like humans there are only two gender and they can only reproduce with another individual of the opposite gender. I chose zero and one to represent their genders, because I wanted to stress that they are computer-based individuals. Since the computer is based on a binary system, so did the gender of the population. But the reproduction has another important requirement. The population can't reproduce at anytime. Individuals can seek for a reproduction partner at certain times of their lives. Like I mentioned before, they all have a time they are expected to live. They can only look for a partner if they are at the 1/8, ¼, ½, or 3/4 landmarks of their life expectancy. The last restriction to this individuals reproduction is related to their position. Their "physical" position in this virtual and artificial word is given by their position on the memory array. Each individual will look from time to time to their closest array positions (n-1 and n+1) and ask if they are from the opposite gender. If they are they reproduce trough one-point crossover; if the position is empty or its occupied by an individual of the same gender, nothing happens until is time to look again. The empty positions are getting refilled when new individuals as they are born.

The new individual is the result of a single-point mating. The parent that look for the reproduction partner gives the life expectancy and the other mate gives the time interval between the resource use. The gender is given randomly.

The life expectancy is a number of time intervals each individual is supposed to live. Sometimes they don't live all the time they were expected because of the absence of resources available to all the population. In this artificial system the fitness is given by the frequency the individual needs to use resources from the world. In times of crisis, the ones that need resources more often end up dying proportionally sooner. Since their reproduction rate is related to their lifetime, in times of crisis the ones less adapted die first and propagate less their characteristics.

The world is constituted of the population and the environment. The space is an infinity and possibility of creating resources within it is given by the fixed amount of resources that the world always produces plus the amounts each individual can produce. Every single being of HOME can generate a fixed amount of resources distributed among all of them. The world gives some too. Adding these two amounts one reaches the result of how much of the resources they can spend during the whole year. All the resources that weren't used are saved and can be used in periods of time that the resources are not enough to safely cover the needs of the population. Sometimes the population needs more resources than the ones produced, and that's when the individuals with better capacity of adaptation can survive. The others end up dying before the balance is established again. There isn't a maximum population value. If the population is so small that can lead to the extinction of HOME, the procreation intervals become two times smaller.

3. Videos

In this piece the videos are an essential part of the construction of this world's identity. The aesthetic chosen for the videos was a minimal white space. This concept of space relates to some important Sci-fi movies; one of inspirations was George Lucas's THX 1138 [5]. To achieve such result all the videos were filmed in a television studio where the white surface was illuminated with a special lighting technique [6] that overexpose the white areas. The Cyclorama is a white surface with no hard edges that when used with a special lighting technique erases all the surface flaws and transforms the space into a non-horizon space. The white seams to extend to infinity.

For this project it was important to relate these virtual aspects to the human aspects. The virtual individuals were constructed in this mechanical and artificial way but at same time they are presented as humans. They have all physical aspects we understand as human: one mouth, two eyes, one nose, two arms, and so on, but they are not. They are something else. The environment is amorphous. It is nothing and at the same time everything, what makes them look something like that.

The actor's ages and genders chosen to play the parts in each one-minute video varied. Kids, adolescents, young adults and older adults played during each minute a various numbers of roles that relate us humans to different moments of our existence.

The general feeling of the video was given by the ambient sound. That atmosphere communicates the general felling of the world: positive, negative or migrating from one to another. The actions of the individuals refer to more specific HOME data.

The rate of reproduction, the amount of resources, the population number, the age of the population, etc are the choosing engine for which videos are going to be selected in a more specific way. If the population is big, there are a lot of resources, they are procreating a lot, the resulting video choice is going to be videos with a lot of characters, from different ages acting happily, with construction and planting food scenes. If the population is small old but there are a lot of resources the resulting videos should show images with few older characters acting productively in a peaceful environment. In times of crisis shall see the characters fighting, the dead being left in the middle of the scene, unhappy and scared characters, etc.

One important aspect to take in consideration is that HOME's landscape is the result of the assembly of the three screens. For such reason the combination of all videos produce an enormous amount of possible landscapes. So, even when the world is very balanced we never end up repeatedly seeing the same images. The same data can produce a lot of different outputs while always transmitting the same message.

3. Sound Design

For clear comprehension of the actions performed by the characters, it is necessary to define something that establishes that relationship between the action and the totally white background. The sound is essential for that to happen. The selection and the edition of references sound transformed and inserted in the videos allow the gestures to transform into actions. The sound is also a way to emphasize the wrapping of that "world" around the spectator as each screen emits its own sound resulting in a surround effect.

The first relation that the sound establishes is the general situation of the world [7]. The ambient sound of the installation can present to the spectator three different situations of the global state of HOME: (a) positive (b) negative and (c) migrating from one state to another. When the status of HOME is good the ambient sound is peaceful and happy. Birds sing, calming water flows and some cheerful kids can be heard. When the world is unstable and the resources are getting scarce, the sound is dark and scary. Rain and thunderstorm anticipates the difficult future of HOME. The mixture of both scenarios represents transition between the previous two states.

The sound design was also important to enrich the video. The sound capture while doing the filming did not represent the real sound of the activities that were being done. There wasn't any of shoving or digging the earth if in the scenario there wasn't a shovel nor soil. The actors movements needed the sound design to establish that relation.

Using Pro Tools, were selected a diverse collection of sounds that transformed this empty white space into hundreds of new scenarios.

The sound is also a very important thing for the wrapping of the spectator, emphasizing the idea of being completely surrounded by HOME.

3. Setup

The setup of HOME is very important to achieve the immersive environment. The space is a small (3x3 meters) empty room with three windows. Each window is made of 40” LCD screens that are placed about 1,5 meter from the floor on three walls opposite to the entrance door.

Outside the installation there is another LCD monitor. Smaller then the others (only 17”) this one is on top of a table next to the entrance of the room. Under that table is the computer that controls the whole installation. A specially made computer was developed for this work that allows us to have four DVI outputs instead of the standard two outputs. This computer is connected to all the screens of this installation.

The space needs to be neutral so that this disposition can really look like a room with windows to HOME’s landscape.

3. Conclusion

Although since the 1990’s [8] until nowadays many artists already use artificial life systems to produce artistic pieces, most of them push those “worlds” away, keeping them virtual. Even with the use of interaction [9] [10] they still maintain a barrier that reminds the user of the separation of these two worlds.

HOME is a different piece because it explores the union of the artificial and the humans, projecting our own understanding of the body to confront and analyze the construction of a world that is “in between”. The main goal is to destroy the referred barriers, and trough the glasses of the windows, inside the room, establish a communication and explore your own understanding of our bodies.

Even though interactive installations permit a close relationship between user and piece, I hope to create this connection through a different channel. Contemplation may allow the users to immerse through the questions generated by its analyses.

3. Acknowledgement

The author wish to acknowledge the assistance and support of the collaborators Luís Sarmento, Graham Coleman, José Barbosa, Luis Moura and the master supervisors Álvaro Barbosa, Helder Dias and Luis Teixeira.

References

[1] Haraway, D. (). A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century. In D. Bell and B. M, Kennedy (Ed.), The Cyberculters reader (pp.291-324). Routledge.

[2] Hansen, M.B.N. (2006). Bodies in Code: Interfaces with Digital Media. New York: Routledge

[3] Lévy, P. (2003). O que é o virtual? São Paulo: Editora 34

[4] Millerson, G. (1991). Lighting for Video. Focal Press

[5]

[6] Millerson, G. (1991). Lighting for Video. Focal Press

[7]

[8] Whitelaw, M. (2004). Metacreation, Art and Artificial Life. Cambridge: MIT Press

[9] C. Sommerer and L. Mignonneau, "Art as a Living System," in Siggraph'99 Conference Abstracts and Applications (New York: ACM Siggraph, 1999), p. 143. 1999.

[10] Sommerer, C. & Mignonneau, L. (1998). ART @ SCIENCE. New York: Springer Verlag. [1] W. H. Cantrell, "Tuning analysis for the high-Q class-E power amplifier," IEEE Trans. Microwave Theory & Tech., vol. 48, no. 12, pp. 2397-2402, December 2000.

Painting with Outliners and Fillers

Marco Celesti and Mario Verdicchio
Department of Information Technology and Mathematical Methods
University of Bergamo, Italy
www.unibg.it
e-mail: mario.verdicchio@unibg.it

Abstract

Ant-based artificial art has reached significant levels of visual appeal and aesthetics. Nevertheless, the artworks are still clearly recognizable as computer-generated, and present a diffused colouring effect common to most of the ant-based art.
In this work we propose to introduce two different roles, namely outliner and filler, that ants or ant-like agents can play on a digital canvas, aiming at producing artworks that, although sketchy at this stage of our research, look promising in the pursue of generative art that resembles human-made drawings.

1. Introduction

Our proposal stems from what can be considered as the most complete ant-based artificial art research work to date [1]. Ants can be seen as a special type of software agents, and their interaction in a closed system that eventually generates an output viewed as artwork by the audience can be considered as a very peculiar kind of Multi-Agent System (MAS) [2]. The ant metaphor is introduced whenever the agents' behavior reminds of some aspects of ants seeking a path between their colony and a source of food [3]. A typical characteristic of ant-like agents is that they all perform the same set of actions, including moving forward in different directions, modifying the environment by metaphorically leaving pheromone trails behind, and perceiving the trails left by others. We can then see ants as a MAS where all the agents are following a single behavior. Although very effective in solving specific optimization problems, such behavioral uniformity might be a limiting factor, especially in the context of generative art, where researchers, designers, and artists are constantly looking for the emergence of innovative, original patterns and appealing, eye-catching, provocative results without much care for the efficiency of the computational process. We propose to depart from the classical ant metaphor by introducing different behaviors in the system, often referred to in the literature as 'roles' [4]. In particular, we will differentiate our agents into two distinct sets: *outliners* trace contours on the canvas, and *fillers* provide color. From now on, although we took our inspiration from ant-based proposals, we will use the more general term 'agent' instead of 'ant' because we think their behavior is too different from what can be traditionally ascribed to these insects, especially with respect to the trails they leave behind: outliners are not affected by other agents' trails, whereas their trails work as insurmountable borders for fillers, which are named after the fact that, when trapped in a closed loop traced by an outliner, they fill up the area with color.

2. The algorithm behind the artwork

If generative art is supposed to be based on programs that automatically generate the output, a very interesting if not critical issue rises when considering the boundaries between what the software designers directly code and what is left to the random evolution of the running program. This topic points to the very concept of autonomy, which has been long debated ever since Artificial Intelligence researchers started hinting at the possibility of creating software and robotic systems that could 'autonomously' reach a solution once given the specifications of a problem. This work is obviously not meant to tackle such a complex topic, but nonetheless every attempt to create software whose output is not easily predictable by the designers inevitably begs the question on how much of the result of a run is a direct consequence of specific design choices, so that it can be retrieved in all the other experiments, or it is the consequence of a fortuitous combination of randomly set conditions that are unique for the run. To make a formal analysis even more complicated, we do not have a metric for the success of an experiment, as it clearly depends on aesthetic criteria that are personal, social, cultural, or, in other words, far from being pinned down by any simple or complex computational model. Any attempt at generative art lies thus in front of at least three concepts: autonomy, randomness, and aesthetics, which are already hard to define in general, let alone from a computational perspective. Moreover, in our case, we have to simulate the interaction of a significant number of agents (outliners and fillers) in a grid-like environment (the canvas), so we have to add also performance limits of the available hardware on top of all the above-mentioned issues.

Here follows a rough description of the behavior of the different agents in our system.

2.1 Outliners

A specific number of outliners are generated on random spots on the canvas. Each outliner is provided with a DNA that establishes in what direction (left or right) the outliner will turn during its lifespan. Making an outliner turn always in the same way increases its chances to create a closed loop entrapping fillers and thus creating color blobs in the painting. Even if they work as boundaries for fillers, the contours do not affect the outliners' movements. Like ants, our agents only move forward, but the set of possible directions is even more limited for outliners with the aim to maximizing the chances of having loops. The canvas is based on a spherical model, so that when an outliner reaches the left end, it goes on moving and gets to the right end of the painting. The contour is black to be as neutral as possible, as opposed to the varied colors left on the canvas by the fillers. White contours have been scrapped, as we wanted to depart from the typical random color blob appearance of traditional ant-based artificial art. The settings of the run include the length of the outliners' life span. After a specific interval, all outliners 'die', and the contour tracing activity ceases all over the canvas. On average, the contours include a significant number of loops, but also the final strokes of the outliners before their 'death', which are very likely to be comprised of an open segment. A canvas cleaning function then intervenes, by iteratively determining these dead ends of contours (i.e.: black points on the canvas which have only one adjacent black point) and erasing them. Obviously the cleaning process will end as soon as all dead ends are erased and only loops are left on the canvas, so that each black point has at least two neighbouring black points (i.e. they are part of a loop or of a segment linking two loops).

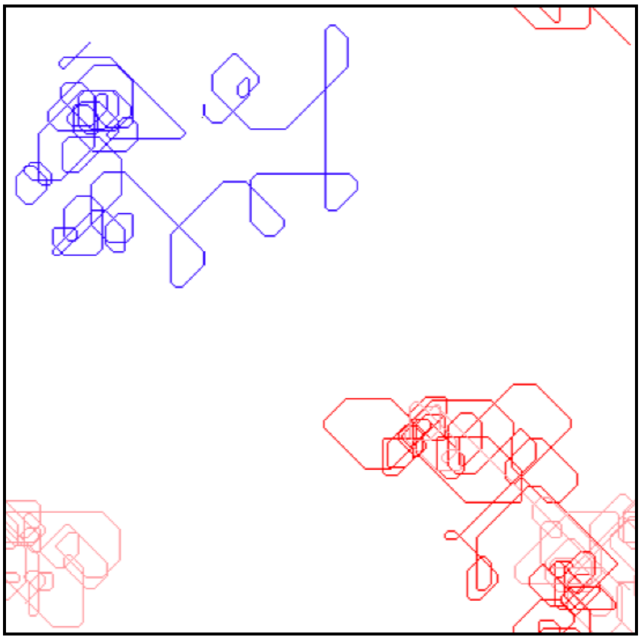


Figure 47: Outliners at work. The colors only help distinguish different outliners, which produce black contours in the final version of the program.

2.2 Fillers

The number of fillers is dynamically established during the run of the program: at every pre-specified amount of time, two fillers are spawned from the piece of contour just traced by each outliner. One filler is spawned on the left hand side, one on the right hand side of the contour. As our main aim is to have fillers color the inside of the loops, it would be a reasonable choice to spawn a filler only on the side the relevant outliner is programmed to turn to. Nevertheless, the filler on the opposite side can possibly be trapped in a bigger loop of the relevant outliner, or even in a loop of another outliner. A filler's DNA establishes which color the agent will leave on the canvas at each occupied position. The color can be randomly picked from the RGB or the HSV space, with different visual outcomes. When two or more fillers are entrapped in the same loop, then the different colors they deposit tend to mix, as a weighted average between the DNA color and the one already present in the environment is calculated and depicted once a filler deposits its color onto a spot which was previously visited by the other filler in the loop. Given enough time, the loop should become uniformly filled with the average of the colors of the agents it has entrapped. Fillers' life span is also computed at runtime: they have a specific quantity of energy at birth, which diminishes at every movement, and which gets replenished every time a filler bumps into a contour. As the energy level goes down, so does the saturation of the color deposited by the filler. Once the color becomes white, the filler is considered 'dead', and removed from the system. By making the fillers' life (and thus their coloring activity) depend on their proximity to the contours, we intend to minimize the effects of the fillers that end up lying on the outside of all loops. The disadvantage of this approach is that big loops become harder to fill up with color, but the alternative solution of calculating the curvature of the contour at the birth of a pair of fillers and then deciding which one to keep turns out to be computationally demanding.

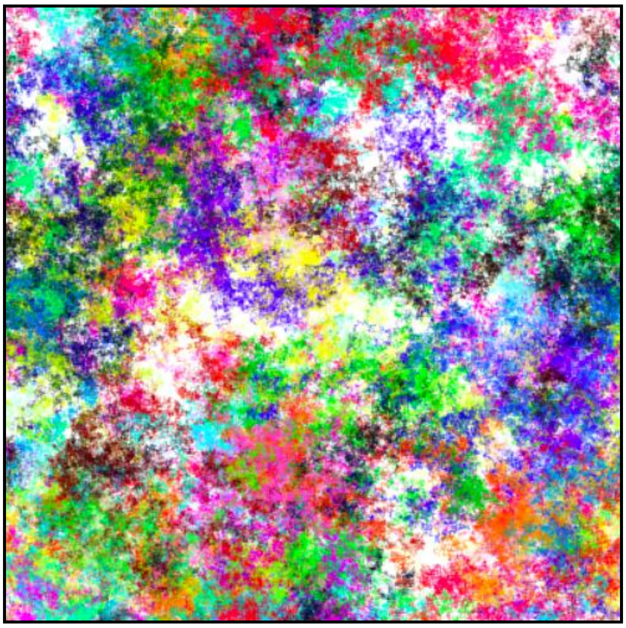


Figure 48: Fillers at work without any entrapping contour.

3. Conclusions and future work

By combining on a white canvas the contour tracing activity of outliners and the coloring activity of fillers, we have implemented a multi-agent system capable of providing a satisfying aesthetic experience in the form of randomly generated paintings. Not surprisingly, the questions on the nature of generative programs, and on their relation with aesthetic criteria have only been skimmed over. Among the three fundamental concepts of autonomy, randomness, and aesthetics, as software designers, we consider the first one to be the easiest to tackle in our future efforts: with a valid help from the Evolutionary Computation research, we would like to increase the portion of our system's behavior which is determined by the evolution of the DNA of our agents, as opposed to design decisions taken by the programmers on the basis of hardware limitations, or common sense criteria. We see the spontaneous emergence of the two different roles of outliners and fillers from the evolution of the DNA of generic agents as the next milestone in our research path.

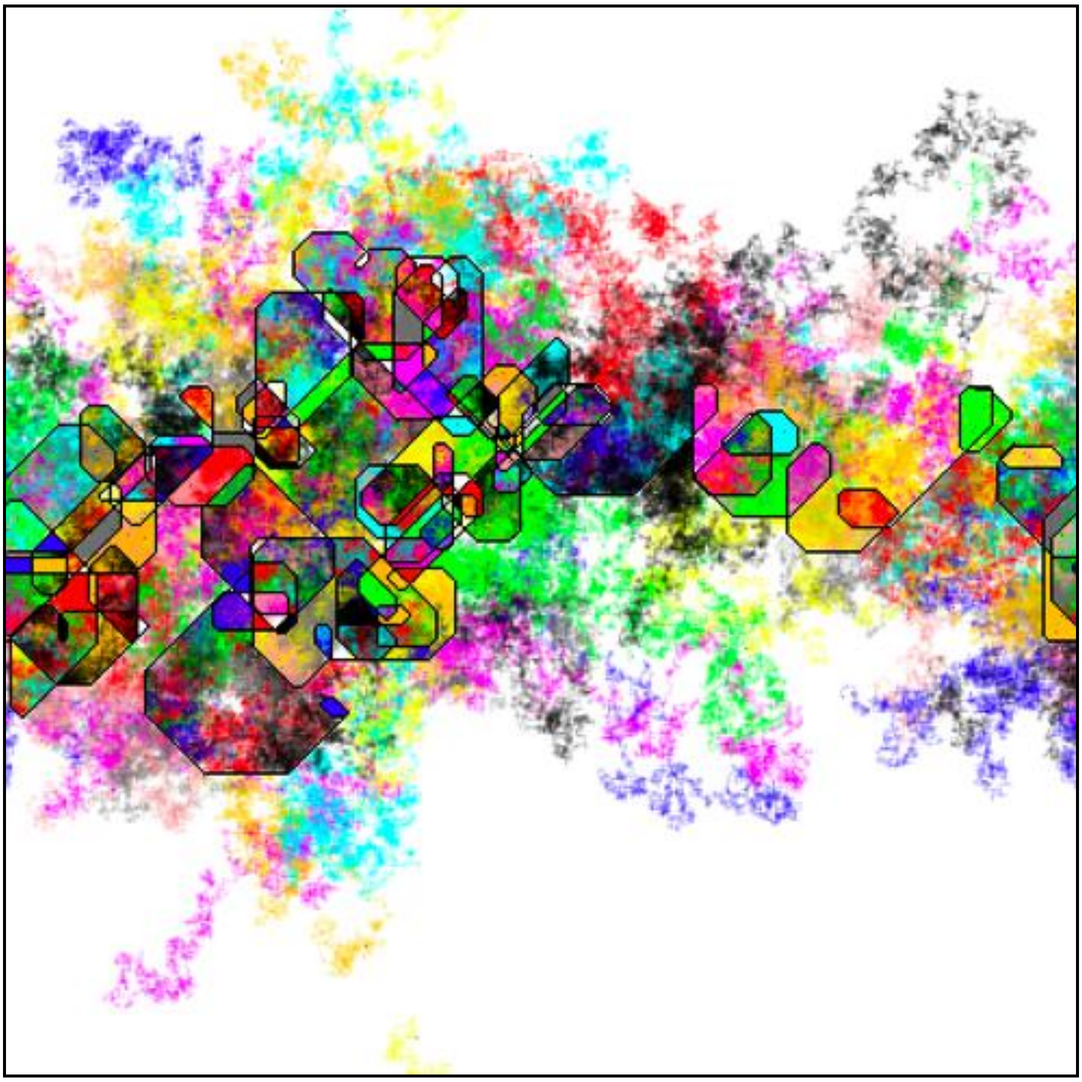


Figure 49: Outliners and fillers at work

References

[1] N. Monmarché et al., "*Artificial Art made by Artificial Ants*", in The Art of Artificial Evolution, Springer, 2008

[2] M. d'Inverno and M. Luck, "*Understanding Agent Systems*", Springer, 2004

[3] M. Dorigo and T. Stuetzle, "*Ant Colony Optimization*", MIT Press, 2004

[4] G. Boella, L. van der Torre, H. Verhagen, "*Roles, an Interdisciplinary Perspective*", Journal of Applied Ontology 2(2), IOS Press, 2007

Fractality and Generative Thought

Hatam Abdoli
Computer Department, Bu-Ali Sina University, Hamadan, Iran
e-mail: abdoli@basu.ac.ir

Mehdi Damali Amiri
Architecture Department, Bu-Ali Sina University, Hamadan, Iran
e-mail: mehdiamiri2000@yahoo.com

Mehrdad Garousi
Freelance fractal artist, painter and photographer, Hamadan, Iran
http://mehrdadart.deviantart.com
e-mail: mehrdad_fractal@yahoo.com

Abstract

During the last decades, having been represented by Benoit Mandelbrot, fractal art became a very popular tool to make artistic imaging and captured the aesthetic realm of art in which the creator encounters his or her audience with wonderful complexities yet regularized and make the faced with bizarre images yet simple. This imaging is performed only on account of computers considered as an algorithmic and computer generated art. Creator artist is not able to control all the processes and tortuous calculations without the help of computer.

Fractal art preserved the parameters and created universalities to make it accessible for every scholar to carry the thought on the wings of regularity and chaosity. This paper aims at determining the examples of various convergences in science and art on fractal foundation to open the horizon of generative thought in unregular art.

1. Introduction

During the last thousand years, mathematics has attained a meaningful and close relationship with various arts which have become a common theme of many tribes and nations, regardless of their geographical location and beliefs. In the early centuries of intellectual growth of human being, mathematics, philosophy, and different kinds of natural science were interwoven together without any clear cut border. The scientists and philosophers of ancient Greece and those of middle ages of Islam mastered in various sciences and tried to combine these branches to prove the unification of universe.

The universe is a cosmos, on this view, a complex of interconnected systems, and human beings are of a piece with the rest of nature. The sciences ought to form a single web, a hierarchy of domains of inquiry. The web-like interconnection of all the sciences simply mirrors the structural unity of the natural universe that science investigates [1].

The creativity inherited from natural thought let the scholars to express skills and abilities usually beyond the scope of worldly restrictions. Integrity, unity and comprehensibility have been considered as the growth factors of human knowledge based on mathematics. The intimacy of mathematics and number with music by Pythagoras and the presence of philosophy and wisdom in Farabi and Ave cena`s thought in Iran are obvious examples of this trend. The nature-based knowledge of these masters of Science aimed at describing a pure explanation of nature to generate the underlying relationships among the phenomena to help the science attain the explanatory adequacy. The most beautiful tiling and adornments have emerged in buildings where mathematics played a great role to transfer meaning through the chains of words, in fact, they exploited the symmetric laws of mathematics to generate a unified image of nature and belief, and the most pleasant music has linked with musical mathematics of nature while all and all the mathematics based its realm on nature. The interesting lesson the mathematics introduced was using minimality in thought and application. They believed that the main cause of separation of science and knowledge from nature was the margins and adornments imposed on them.

In the opening lines of the Meteorology Aristotle makes it very clear that the study of life belongs to the science of nature. For Aristotle the different parts of the natural world are related to one another in such a way that some of them have a determinate influence on the others and the job of the student of nature is to uncover this specific causal interconnectedness [2].

The time and thereby the rise of technology, brought uncontrollable and multiple division which turned the human into a one-dimensional being causing the subdivisions in science fields. The result was some kind of plurality in science which created different subdivisions in one single branch leading to expansion and distributed subfields. No one could believe to have so much ability and time to know two or three related subjects. This current was outstanding in modern and postmodern art which drove the creation spirit toward projection and self centeredness in which artists of postmodernism entered any field of feeling and thought uncontrollably. The last step of this path was awesome for all. No one could imagine any step further and most believed to have attained the peak of mastery in art.

In the long and tortuous path of science and knowledge in which every one tried to keep his cut, there sometimes appeared crosses and joints among schools, styles and branches which resulted in the emergence of wonderful phenomenon such as that of geometry in neoclassicism and inseparable tie of optics and color with impressionism or decent exploitation of Euclidean geometry in Cubism [3]. Different styles of calligraphy in Islamic civilization of Arabic regions are evidence of a generative approach to the link of science, nature and thought. Yet, these innovations are rare and can not be regarded as general trend dominating the movement of scientific thought. The link of music with electrical inventions leading to electrical music and the rise of computers in the second part of the twentieth century, the first output of which showed up in the frame of plotter based imaging, were proposed as the first signs of recombination of seemingly different path of science.

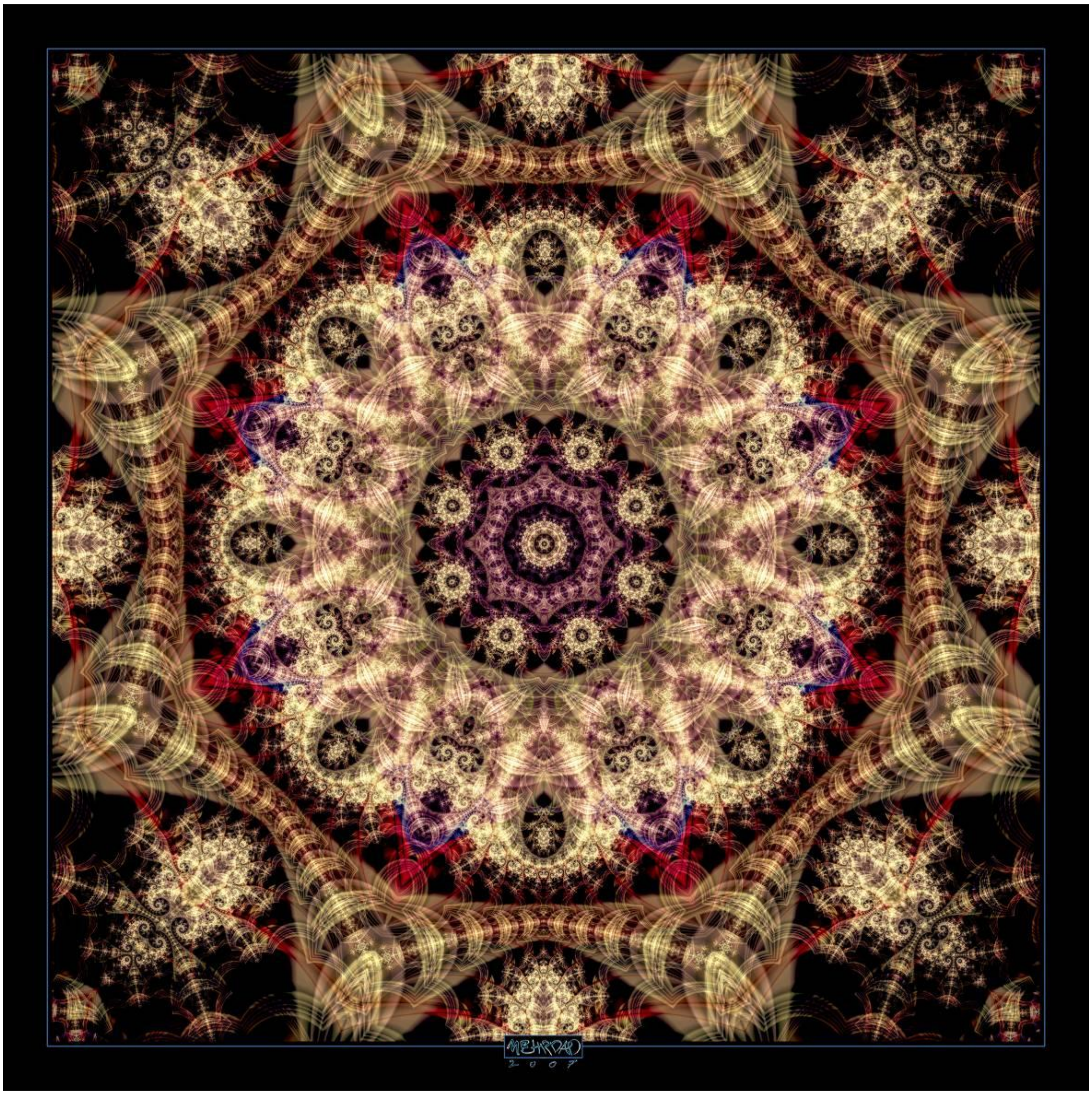


Figure 1. The Beautiful Circle of Piety (2007; © Mehrdad Garousi).

The most startling one can be attributed to Mandelbrot and his discovery in geometry named fractal geometry. Most of the realities in the natural world which were not explained with Euclidean mathematics now could be described easily. Due to the lack of adaptation between the old mathematics principle and some natural events representing as irregular, the prestige and status of mathematics went under question [4]. He used computer graphics to elucidate mathematical argumentation in juxtaposition with intricacies of art similar to what Chomsky did with language and mathematics. He postulated a generative template for geometrical studies penetrating in different branches of science. What seemed to be a gallery of chaos now turned into beautiful paradigmatic and syntagmatic of nature and mathematics. Recursiveness of natural phenomena was expressed in terms of fractional dimension and self-similarities to generate every sophisticated form in a simple and straightforward innateness. Art changed from prescription to description and separated modularity became a unified modularity. In fact, what was believed to be a deviation from nature was shown to be another face of nature in a higher order of existence waiting to be discovered.

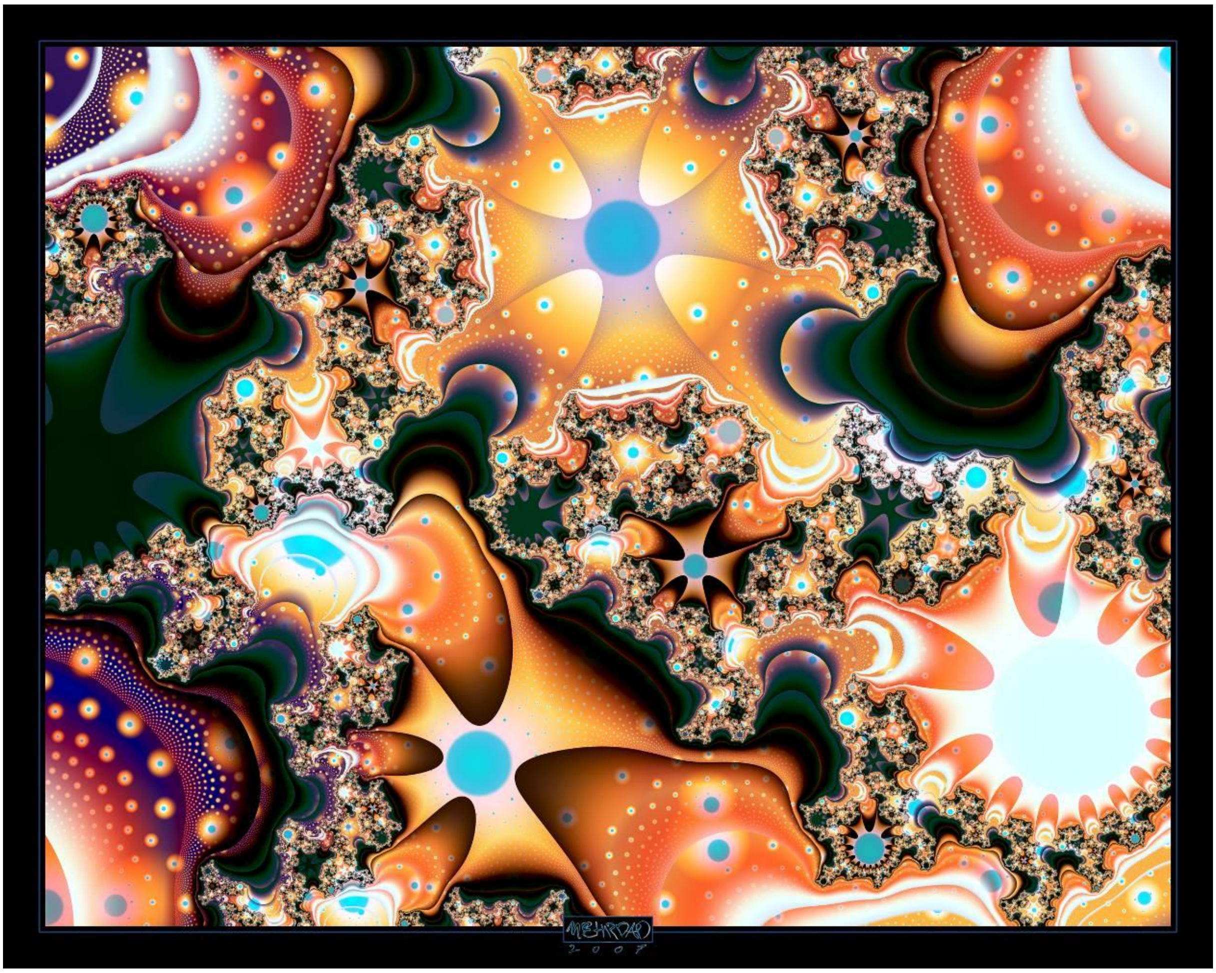


Figure 2. Galaxy of Crosses (2007; © Mehrdad Garousi).

This newly discovered branch of science penetrated in to language and art due to its dependency on computer imaging and endowing a perfect creativity power to artists to depict complexities of the universe in their fractal works of art. "Existence and being are united but represented in different orders". Language as the most important medium with a web of irregularities now can be imagined as the most primitive tool to be reconstructed. Natural languages are most often characterized as a combination of rule-based generalization and lexical idiosyncrasy. The English past tense is a familiar case, in which the irregular form *went* replaces the expected +ed construction **goed*. Baker (1979) notes that this is a relatively benign example for learners, since irregular forms are frequently encountered in the course of their linguistic experience. The experience of the form *went* may block **goed*, if the learner assumes that verbs typically have a single past tense form_ thus, an observed alternative form can serve as evidence that an absent regular form is not allowed in the language . Much more troubling are cases where an apparently legal construction is idiosyncratically absent, without any alternative. The dative shift in English is a well-documented example [5]:

(1) *John gave/donated a book to the library*

(2) *John gave/*donated the library a book*

Another example is more remarkable. Self-similarity in language appears in the guise of stories within stories, or sentences within sentences (”I know what I know”), and has been represented in the form of recursive grammar rules by Chomsky .There is a case study of how biolinguists go about studying the mechanisms of language and at the same time try to learn something about the question of language design. In a work on phrase movement over the past few decades based on a variety of languages, including English, Spanish, Irish, Japanese, Chinese, Palauan, Chamorro, Ewe, etc, the traces of symmetry and recursiveness is clearly seen. An example from English follows:

Who do [you think [that John believes [that Mary said [that Tom saw _] ?

Here, the question phrase *who* has moved to the front of the sentence from the object position after *saw*. The question is, does *who* move in one fell swoop to the beginning of the sentence or does it move step-wise ("successive-cyclically" is the technical term) to the front; i.e., through the position of *that* at the beginning of each clause. Chomsky originally presented evidence for the step wise hypothesis, and supporting evidence was subsequently discovered in a number of other languages in favor of this idea. One might ask why language is designed with "short movement" rather than "long movement?" Some of the evidence for this comes from languages where the position corresponding to *that* in the above example is morphologically marked (Irish) or syntactically distinguished (Spanish) at the beginning of each clause, so that one can, so to speak, follow "a trail" of markers from the moved item *who*, down to the position where it originated. However, Lasnik cites research on other languages where no such markers are found (English), or even where there is no visible phrase movement whatsoever, although the interpretation of the sentence is the same as if certain "movement" constraints had applied.

In the words of the great Russian poet Alexander Blok, "Erase the accidental traits and thou shalt see: the world is beautiful." Diffraction experiments give us information about atomic positions averaged over time and space, thus "erasing accidental traits." We can, of course, obtain information about the thermal motions of atoms in crystals; in fact, the very same diffraction experiments enable us to find so-called temperature factors, which are measures of average displacements of atoms from their average positions. But for most crystallographers, instantaneous "snapshots" are ephemeral and irrelevant, and the only images of crystals that concern them are the averaged idealized structures with their beautiful symmetry and periodicity [6].

Malenkov goes on to show the "beauty of disorder," that even "structures which are in principle irregular and disordered, such as are found in liquids and in some amorphous solids, can also be very elegant and beautiful" [7].

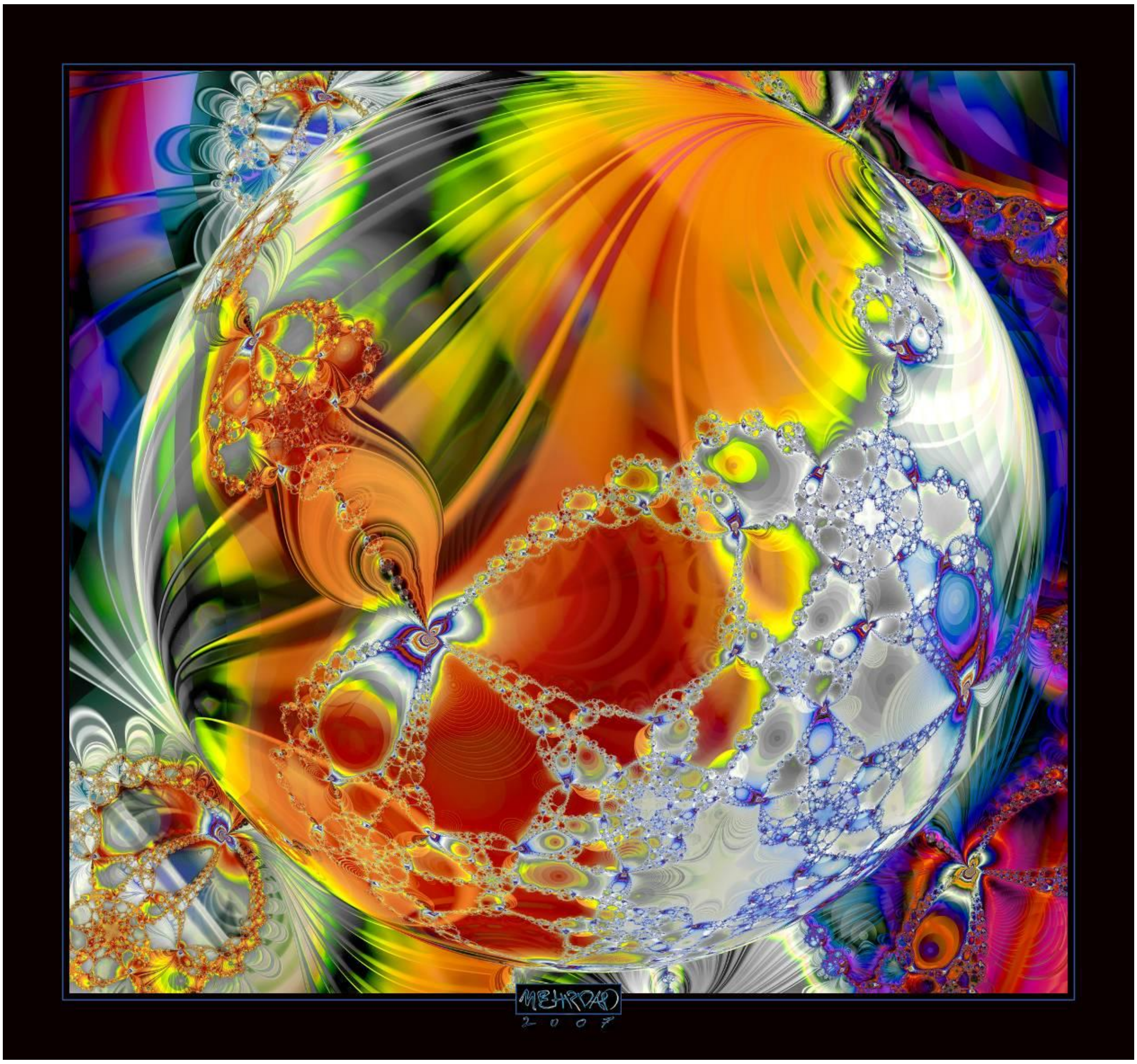


Figure 3. Incredible Globe (2007; © Mehrdad Garousi).

One of the remarkable discoveries is examining the fractal dimensions of Jackson Pollock`s and fractal patterns in his works in addition to the works of Davinci, Dali and Hokusai [8]. These artists use these themes significantly in their works long before the invention of fractal mathematics. These investigations show that these artists were aware of this knowledge and applied it in their works to trace the essence of existence. Neglecting the apparent fame, these artists tried to capture the nature behaviour with an aesthetic vision.

In fact fractal mathematics is the inflection point of recombination of various sciences to reveal the unknowns. In art, there has been spanned a vast realm of innovation and creativity for artists to propose new theories. Fractal art preserved the parameters and created universalities to make it accessible for every scholar to carry the thought on the wings of regularity and chaosity.

2. Conclusion

Today science has set off to help art and the borders of these two have been so interwoven that there is not clear cut line in postmodernism. The frame work of nature representation in science by the use of fractal art practically changed the irregular patterns toward the regular simplifications in the most complex phenomena from the patterns of a leaf to the arrangement of words and sentences. Multi-layer property of fractal images and their reflection in human being's thought has led us to focus on chaos behaviour as an underlying feature of nature to create the beauties concealed in a complex architecture. The infinity of structures with finite materials has been regarded eternal in linguistics, architecture and even music to the extent that mind has found another rival in thinking and organizing words to express the thought.

3. References

[1] Klee, R., 1997, Introduction to the Philosophy of Science - Cutting Nature at Its Seams, pp. 5, 6, Oxford University Press, NY.

[2] Falcon, A., 2005, ARISTOTLE AND THE SCIENCE OF NATURE: Unity without Uniformity, p. 16, Cambridge University Press, UK.

[3] Rosenblum, R., 1961, Cubism and twentieth-century art, Harry N. Abrams Inc, US.

[4] Mandelbrot, B., B., 1977, The Fractal Geometry Of Nature, W. H. Freeman And Company, NY.

[5] Tallerman, M., 2005, Language origins: perspectives on evolution, p. 334, Oxford University Press, NY.

[6] Malenkov, G. (1997), The Beauty of Disorder. Science Spectra, p. 44-51.

[7] Jenkins, L., 1997, Biolinguistics - Structure, development and evolution of language, In: The 40th Anniversary of Generativism: Proceedings of electronic conference December, Available at http://fccl.ksu.ru/papers/gp008.pdf.

[8] Taylor, R., 2006, Personal reflections on Jackson Pollock's fractal paintings, In: Benchimol, J.L. (Ed.), Hist. cienc. saude-Manguinhos, 13(1), Rio de Janeiro,RJ. Available at http://www.scielo.br/pdf/hcsm/v13s0/06.pdf

Exploration of Arbitrarily Shaped Surfaces

Nilufer Kocabas, MSc.
The Bartlett School of Graduate Studies, University College London, U.K.

website:
www.niluferkocabas.co.uk
e-mail:
niluferkocabas@gmail.com

Abstract

Exploration of arbitrarily shaped surfaces through linear members using a self-organizing spring system. Similar to the problem with British Court Museum Roof and Anthony Gormley's Body/Space/Frame project, a generative algorithm was developed in order to approximate the geometry of a complex curved surface and optimize the resulting structure.

Regarding the approximation of the curved surfaces, in the thesis, it was aimed to address the problem by using linear members defining an arbitrarily shaped surface as nearly as possible in relation to curvature conditions. In order to tackle this problem, the hypothesis was creating a bottom up self-organizing system that is based on local decisions. By using a bottom-up methodological approach and creating a self-organizing system, it is aimed to overcome the problems that might occur when the curvature is in two or more dimensions. To this end, a generative algorithm that is re-arranging the nodes and providing the connections by using a spring system is developed in Processing. Various experiments are performed in order to determine the closest match of the surface shape and changes of spring length due to curvature. After analyzing the results in the aspect of geometry and topology, results demonstrates that the method is capable of describing an arbitrarily shaped surfaces as nearly as possible in relation to curvature conditions by using linear members.

Keyword: Adaptive, Anthony Gormley ,bottom-up approach, curvature, double curved surfaces, self-organisation, spring system

Introduction
With the emergence of new technologies, cultural and social patterns have started to alter many fields, including architecture. Being aware of those emerging technologies, architects and engineers have started to explore more complex geometries and adaptive forms to reach new design frontiers. In order to solve certain indeterminable complexities and to find an optimum solution during the design process, computational techniques have become more significant.
Considering this recent evolution, this paper focuses on an approach to approximate the geometry of a complex surface through a self-organizing system. A bottom-up methodological approach is chosen, as this research project focuses on the exploration of a curved surface in relation to its curvature conditions and local neighbour relations.
More specifically this research is aiming to develop a generative algorithm that is capable of defining an arbitrarily shaped surface through linear members in relation to the curvature conditions, Considering the complexities that occur when the curvature is in two or higher dimensions, the method proposed here is to create a 'bottom-up' self-organizing system that uses a spring system in order to overcome those complexities.
Even though most approaches are based on top-down methodological approach, the outcome of this projects investigation suggests, that the bottom-up approach is more efficient, especially when it comes to approximating the geometry to its curvature conditions. In the context of this project, approximating the geometry in relation to a given problem, and analyzing it in the geometrical and topological aspects, was crucial.

Theory Background and Related Work

The problem is based whilst building an arbitrarily shaped surface, defining the surface shape as nearly as possible in relation to curvature conditions by using linear members. In this case, linear members’ span should vary as having shorter at higher curvature areas and longer at low curvature areas. The question is how to overcome difficulties that might occur when the curvature is in two or higher dimensions.

A similar problem was encountered by Anthony Gormley and Sean Hanna whilst developing the project ‘Body/Space/Frame’; the project is a model in the shape of a crouching human figure that consists of 25m high open steel lattices. The aim was creating an algorithm that is defining the position of structural members and their connections in response to the form of the body [1-2]. In order to have optimized structures, the aim was gaining smoothness between curvature and the nodes. Thus, a self-organizing structure was developed in order to approximate the structure and provide structural integrity. In relation to this, he states number of aesthetic criteria that spring system can embody simply. The developed algorithm is including: intermediate number of nodes are distributed randomly in the given boundary of the surface, rearrangement of the nodes due to local forces and the curvature conditions, obtaining an optimal number of connections that is capable of describing the geometry.
The British Museum Court Roof can be referred as similarity of problem in the case of approximating the geometry of an arbitrarily surface. The project was designed by Foster and Partners with the engineers from Buro Happold whereas Chris Williams from University of Bath developed the algorithm. The British Museum Court Roof’s

structure covers is 73m and 97 m including the 44m diameter of The Reading Room [4-5]. The algorithm consists of the stages in order to reach the end form of the grid and provide structural accuracy. The first stage of the algorithm is defining the topology of the nodes in order to create a simple mathematical grid. The second stage of the algorithm was created in order to fix the discontinuities, and for this matter relaxation formula is applied iteratively to each point, created in the initial stage. In the sense of optimizing the overall structure, each node was rearranging its position depending on their neighborhood relations. Finally, during the distribution of nodes and rearrangement of nodes by the relaxation process, the curvature of the corners was an important issue in relation to architectural and structural constrains.

It is also worth mentioning the previous MSc. Adaptive Architecture and Computation dissertations 'Topological self-organisation: Using a particle-spring system simulation to generate structural space-filling lattices' prepared by Anastasios Kanellosis, which used a similar approach in relation to the spring force [3]. Briefly, the aim of the project was to fill a certain volume with a structural space frame network lattice. To this end, he developed a self-organising system that consists of certain number of nodes connecting and arranging themselves through local decisions in relation to the given volume. To approach this specific problem, an algorithm using particle system within the framework of physical dynamic simulation was developed. Structure, consisting of particle nodes and spring connections is developed by a simple particle system that has two basic quantities such as a position and velocity vector. Therefore, the spring system was a crucial part of the algorithm as local decisions composed the self-organizing system. ,
Consequently, the proposed method, in order to solve this specific problem, is using a bottom-up self-organizing system that is dependant on a spring system. The algorithm that is developed is using numerical bottom-up method based on the curvature and spring system. By the spring system randomly distributed nodes in the system are rearranged and nodes are connected depending on certain constraints in order to compose the linear members. Furthermore, whilst arranging the given number of interconnected nodes in relation to certain constraints, topological and geometrical aspects are crucial. Therefore in the stated problem, investigating the topology of the geometry in order to generate a structure with the approximate number of nodes is one of the key considerations.

Method

Overview of the algorithm

Referring to the problem, which is composing an arbitrarily shaped surface by distribution of linear members in relation to curvature conditions that is describing this
specific surface as nearly as possible, the hypothesis is solving the problem by creating a self-organizing system that is based on local decisions. The aim is to create a self-organizing system that is capable of generating the geometry and topology of an arbitrarily shaped surface. To achieve that, an algorithm was developed in certain concerns: intermediate number of nodes are distributed randomly within the given boundary of the surface. The nodes are then rearranged due to local forces and the curvature conditions, obtaining an optimal number of connections, that is capable of describing the geometry, are obtained.

The reason that the distribution of the nodes should be according to curvature is in

order to obtain a precise mesh generation in relation to the geometry of the surface. Neighbour relations can be described as the interaction between nodes and the connectivity pattern in the system that is based on the spring force. Spring force optimises the nodes' position and its relations whilst forming the temporary bonds between the nodes. The permanent bonds between the nodes compose the final form once it is in a certain equilibrium state. In relation to bottom-up approach, connections of the nodes and the position of the nodes are not determined in the initial phase rather they form dynamically during the process as it is a self-organizing system.
The base of the algorithm as the equation of the Bezier surface is adapted from Alasdair Turner's Bezier surfaces code. The development of the algorithm for the stated problem was achieved by the Processing programming language.

Description of the algorithm
Following the methodological consideration in relation to the problem, the algorithm features two main parts: representation of the Bezier surface and creation of the mesh structure. Therefore, the algorithm is divided programmatically into three parts: the programmatic definition of a Bezier surface, calculation of the curvature and setting the nodes according to spring force. Furthermore, there are two main classes that are responsible for creating surface points which are based on the Bezier equation and given u, v coordinates. The u, v coordinates are represented within a two dimensional local parametric space that is situated in three-dimensional Cartesian geometric space. Curvature and spring force are also set in the class of Bezier surface within the local parametric space, as node distribution and connectivity pattern is dependant on those specific local decisions.

In initial phase, the Bezier surface was set as an array of points, ***pt***, according to the *u*, *v* coordinates within a two dimensional local parametric space. The points that are set within the *u*, *v* coordinates were basicaly based on the parameters of the control points, ***ctrl_pts***, that are set in the Cartesian coordinate system [6]. At first points were distributed evenly on the Bezier surface, composing a grid. However as bottom up approach does not require explicitly defined points, second attempt was distributing the points randomly within the local parametric space (Figure 01).

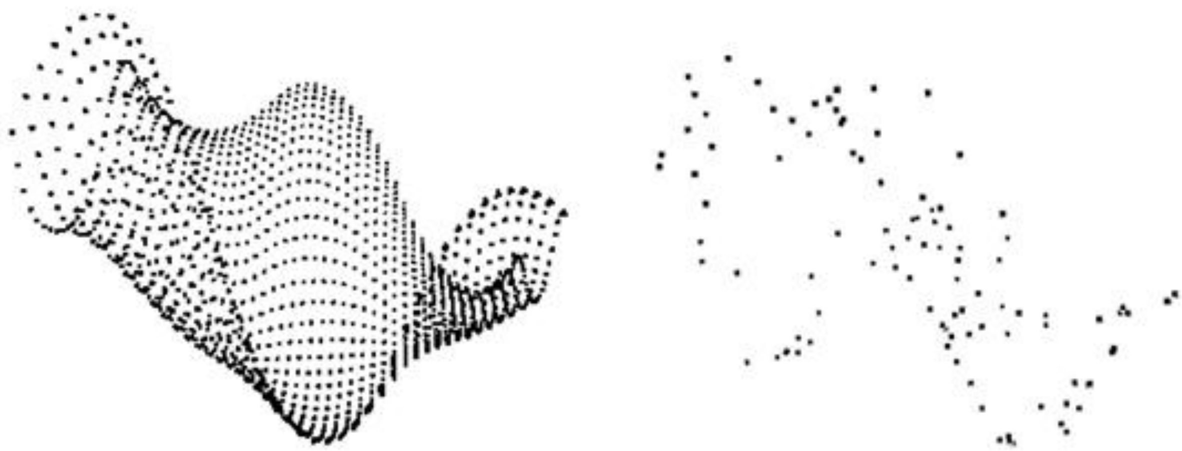


Figure 01.
Bezier Surface; nodes on grid and nodes distributed randomly on the u,v coordinate

system

After distributing the point randomly, local curvature conditions of the Bezier surface were calculated. The final step of the algorithm is the composition of the spring and calculation of the spring force in order to rearrange the position of the nodes and create connectivity patterns, accordingly.

Briefly, the approach of the spring force similar to Kanellos was developing an attraction and repulsion force between nodes in relation to their proximity demand. Following to the proximity check, the next step was creating the connectivity pattern between nodes. The calculation of the spring system and the connectivity pattern varies due to its dependence to the distance between two points, d1 or distance between the surface point and the average of two points, d. Within randomly located points, two points, ***pt1*** and ***pt2***, were picked. The distance, ***d1,*** between those two points, ***pt1*** and ***pt2***, was calculated, as it will be used in the calculations at stage of nodes interaction. There was another essential distance that should be calculated in relation to configuration of spring force. Therefore, specific point, ***pt3,*** from the surface points according to u, v coordinates was picked. After calculating the average of pt1 and pt2 and setting as ***pt4,*** the distance, ***d***, between pt4 and pt3 is calculated. Those distances, d and d1, are crucial in relation to the spring as the geometrical and topological analysis will be dependant on them in order to evaluate the formation of the structure. In order to define the spring force equation, a certain spring threshold and a connection distance are defined. Following that, the equation for repulsion and attraction of nodes were set in relation to spring threshold (Figure 02). During the repulsion and attraction of the nodes, in order to show springs defined with temporary connections. The permanent connections between the nodes occur when the distance, d1, between two points, pt1 and pt2 is less than the connection distance (d1 < connectDist) as the system starts to settle.

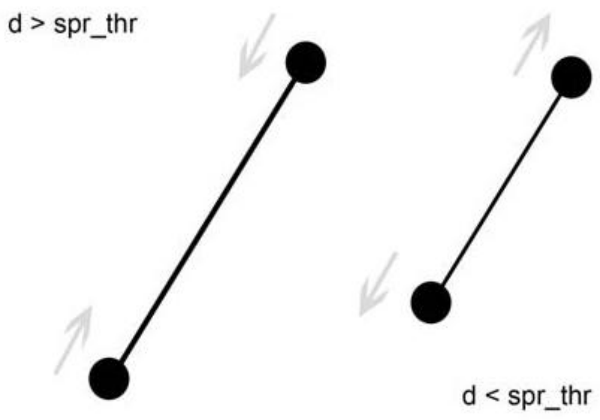


Figure 02. Two cases of spring force

Analysing the equation of spring force, the calculations vary as the spring is calculated either in relation to strut, the distance, d1, between pt1 and pt2 or the distance, d, between surface, pt3, and p4.

Testing and Results

During the experiments, alterations in the system were carried out in order to determine the best match of the surfaces shape in relation to local decisions and curvature conditions. By changing the parameters of the connection distance and spring threshold, the system is challenged to settle with the pre-eminent surface shape match.

The performance of the algorithm, in order to quantify the closest match of the surface shape was based on the calculation of the average derivation of the spring length from the mean length. As explained in the methodology section, the spring is calculated either in relation to strut, the distance, d1, between pt1 and pt2 or the distance, d, between surface, pt3, and p4. Thus, during the experiments the algorithm was run separately with the distance, d and d1 in order to calculate the mean spring deviation accordingly. Also, during the experiments the change in the distance, d and d1, spring derivation was observed in relation to connection distance and spring threshold. By changing the parameters of the connection distance and spring threshold, system is challenged to settle with the pre-eminent surface shape match.

First experiments were performed with the same curvature in order to observe the mean spring length deviation in an equally challenged environment both in u,v coordinate system and Cartesian coordinate system (Figure 03).

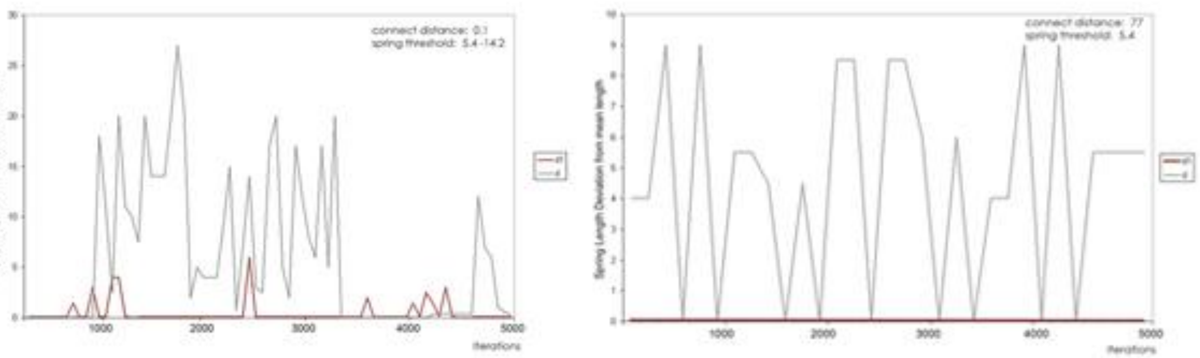


Figure 03.
Left: The Average Spring Deviation from mean length in respect to d and d1 during run time of the algorithm (connect distance: 0.1, spring threshold: 5.4-14.2) based on u,v coordinate system
Right: The Average Spring Deviation from mean length in respect to d and d1 during run time of the algorithm (connect distance: 77, spring threshold: 5.4) based on and Cartesian coordinate system

Two different variables that were used to calculate the spring were run separately in same conditions and represented in the same graph in order to show their difference and spring deviation in each case. During the both runs parameters of the connection distance and spring threshold were also altered in order to observe system's response and achieve the best result with certain parameters (Figure 04, 05).

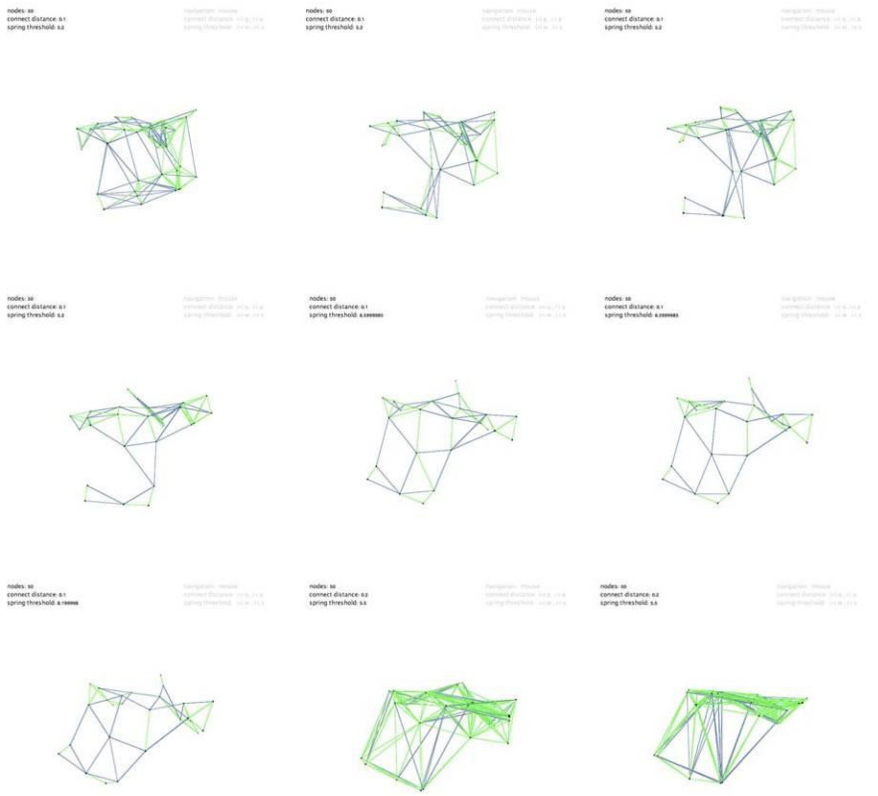


Figure04. Illustration of the surface during the algorithm run (average spring deviation in respect to the parameter 'd1' based on u, v coordinate system)

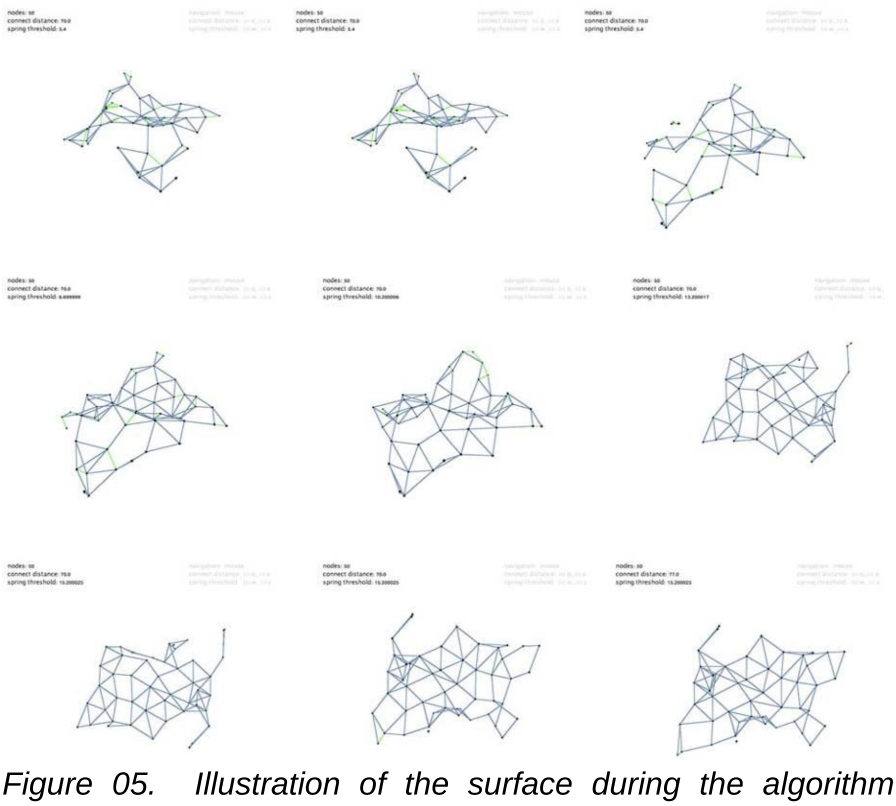


Figure 05. Illustration of the surface during the algorithm run (average spring deviation in respect to the parameter 'd' based on Cartesian coordinate system)

After the first experiments, evaluation of the system is performed in relation to the distance d and d1 in order to quantify closest match to surface boundaries. Subsequently, second experiments were performed according to the best results that were obtained from the previous tests and run again with same curvature and with a higher curvature in order to observe the spring deviation change and evaluate system's response to higher curvatures (Figure 06, 07).

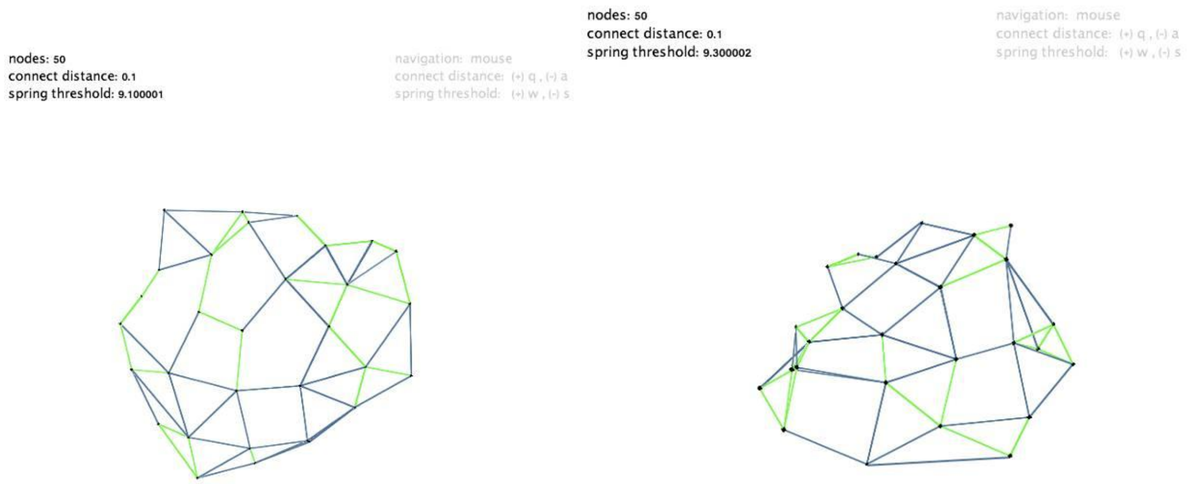


Figure 06.
Left: Illustration of the surface during the algorithm run presented in figure 22 (average spring deviation in respect to the parameter 'd1' based on u, v coordinate system)
Right: Illustration of the surface during the algorithm run presented in figure 23(average spring deviation in respect to the parameter 'd1' based on u, v coordinate system) higher curvature conditions

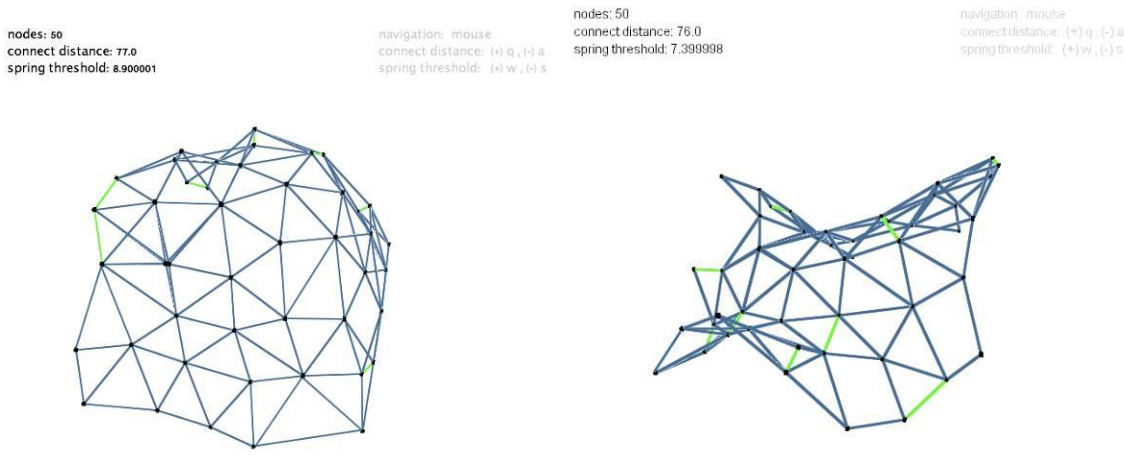


Figure 07.
Left: Illustration of the surface during the algorithm run presented in figure 24 (average spring deviation in respect to the parameter 'd' based on Cartesian coordinate system)
Right: Illustration of the surface during the algorithm run presented in figure 24

(average spring deviation in respect to the parameter 'd' based on Cartesian coordinate system) higher curvature conditions.

Evaluation

The problem that was set at the beginning was building an arbitrarily shaped surface by using linear members within the concern of curvature conditions and defining the surface with those linear members as nearly as possible. Accordingly, linear members' span should vary in higher and lower curvature areas. Regarding the problem that was defined hypothesis was creating a self-organizing system in order to overcome the problems that might occur when the curvature is in two or more dimensions. Consequently, referring to the results, the algorithm, which is based on a bottom up approach, is capable of creating a frame structure within the surface boundaries as nearly as possible in relation to curvature conditions.

The descriptions that are related to the curvature as providing longer members at lower curvature areas, shorter members at higher curvature areas and increasing the node density throughout the surface, are within the top-down approach studies. In this case, by using a bottom up self-organizing system the generative principles behind those descriptions were represented by providing a simpler explanation. Basically, nodes' density throughout the surface and distribution of the nodes in relation to the curvature were accomplished by using a spring system. The deviation was checked both in u and v direction, and by this way the exploration of the surface was more profound in the sense of providing a closer match of the surface shape.

Throughout the experiments, average spring length deviation was observed in relation to curvature changes, and after determining the parameters that forms the best match the surface shape, the tests were run one more time. Referring to final experiments that are performed in various curvature conditions, it can be stated that the algorithm's challenge was rearranging the nodes at higher curvature areas where spring length deviation was increasing. However, after a while the system was settling down and providing a distinguishable pattern. Finally, it has been observed that the system is forming triangulations rather than quadrates, especially in higher curvature areas and defining the geometry more accurately.

Conclusion

In regards to the approximation of curved surfaces, the thesis aimed to address the problem by using linear members defining an arbitrarily shaped surface as nearly as possible in relation to curvature conditions. In order to tackle this problem, the hypothesis was creating a bottom up self-organizing system that is based on local decisions. In order to examine the relation between spring length and curvature, and quantify closest surface match to surface shape, certain experiments were performed. During the experiments, certain assumptions were formulated which led to a more precise definition of the system's parameters and algorithm steps. The tests were run again based on the parameters that provided better results. Several quantitative features of the created the structure, consisting of linear members defining the surface shape, were documented as plots and visuals.

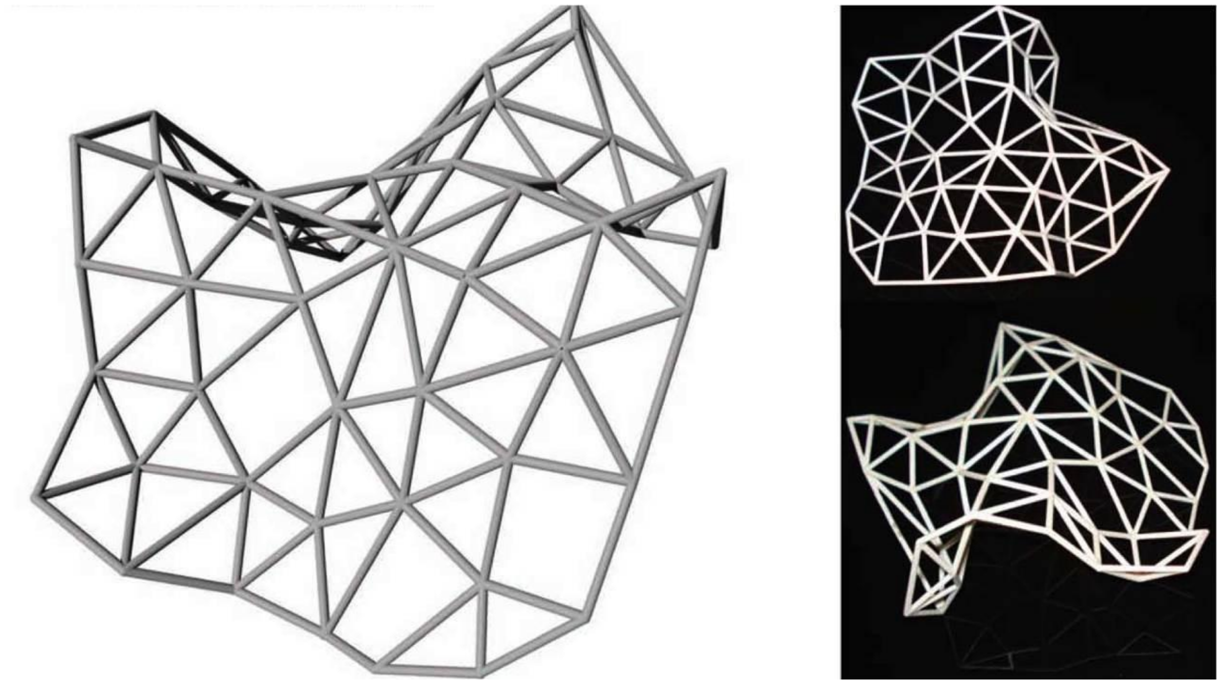


Figure 07.
Left: *The end result, the geometry obtained in Processing is exported to Rhino.*
Right: *The end product, obtained through 3D fabrication method.*

And finally, in order to investigate the results more precisely, the data of the finalized structure was imported from Processing into Rhino (Figure 07, Left). This led to the development of a rapid prototype model, to help to examine its structural performance (Figure 07, Right). The evaluation of the experiments and results indicate that the proposed algorithm was successful, in the sense that the linear members were defining the surface shape as nearly as possible.

As possible future development, the generated topologies could be focused on structural aspects. By applying a force to the system, it will be capable of adapting itself to more complex conditions in relation to the deformation behaviour of it's members. In this case the application of the force should come from the top, onto the areas with a higher curvature in order to define the weak points in the system and rearrange the node distribution accordingly. This implies a revaluation of the spring system has to be done. Through the force application, the system will be able to confront more complex geometries and by this it will also become capable of adapting itself to a certain amount of deformation. As a result of those improvements the algorithm will become more valuable as it will not only consist of geometrical and topological, but also of structural aspects.

As future context, generated topologies can be focused on structural aspects. By applying a force to the system, system will be capable of adapting itself to more complex conditions in relation to deformation behaviour of members. In this case the application of the force should be on the top, to the higher curvature areas in order to define the weak points in the system and rearrange the node distribution accordingly that means also revaluation of the spring system. By force application system will be able to confront more complex geometries and by this it will be capable of adapting itself to certain amount deformation. Finally, by those improvements the algorithm will be more valuable as it will consist geometrical, topological and structural aspects.

Credits

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I also thank Alasdair Turner for his guidance especially at the scripting part.
I would also like to thank Anastasios Kanellos as his Msc. thesis was a significantly influential in shaping the general concept of my thesis

References

[1] Hanna, S., 2006. Emergence and Convergence: lecture notes. *The Generative and Analytic algorithm in Design, pp* 6-10.

[2] Hanna S., Gormley's Body/Space/Frame
<http://www.sean.hanna.net/bodyspaceframe.htm>

[3] Kanellos A., 2007. 'Topological Self-Organisation: Using a particle-spring system simulation to generate structural space-filling lattices' , MSc thesis, Bartlett School of Graduate Studies, UCL, < http://www.aac.bartlett.ucl.ac.uk/reports/ >

[4] Williams C., 2001. 'The Analytical and Numerical Definition of the Geometry of the British Museum Great Court Roof',
< http://staff.bath.ac.uk/abscjkw/BritishMuseum/ChrisDeakin2001.pdf >

[5] Williams C., The definition of curved geometry for widespan enclosures,
< http://staff.bath.ac.uk/abscjkw/OrganicForms/WideSpan.pdf >

[6] Shene C., 1998. Introduction to Computing with Geometry, NotesBezier Surfaces: Construction,
http://www.cs.mtu.edu/~shene/COURSES/cs3621/NOTES/surface/bezier-construct.html

Generative Design Using the Design DNA

Onur Müştak Çobanlı
M.A. Furniture Design and B.A. Economics
OMC Design Studios, Como, Italy.
website: http://www.omcomc.com
e-mail: omc@omcomc.com

Abstract

Today, in our society where trends and fashions are rapidly replacing each other, companies become more competitive in the design sense, therefore a great demand for faster product development has surfaced. To satisfy the need for faster product development, the designers have to be more productive, more efficient, and this is only possible by using tools. The Designers' Avatar (DA) and Design Blender (DB) are generative design tools which uses many subtools and procedures aimed for increasing the efficiency of a designer. Design DNA (DDNA) is one of these tools, and in this paper I demonstrate how we use the DB and DDNA to come up with product families.

1. The Design DNA (DDNA)

As your DNA contains the genetic instructions used in the development and functioning of all known living organisms [1], the Design DNA contains generic information to be used in development and functioning of products (and perhaps experiences, service and even artificial life forms). DDNA is a multi-dimensional matrix of images, information and meta-data. The initial use for DDNA is perfect recreation of a design, however it can be used also for generative purposes.

1.1 Structure of the DDNA

Like the DNA composed of bits of information, DDNA is also composed of arranged information so that we can recreate a design from scratch. DDNA is a Multi Level Array. In detail, the DDNA is composed of one or many Spirits. The Spirits consist of one or many Nodes. Nodes consist of one or many Bits. Bits are single answers, nodes are set of answers, and spirits are group of set of answers.

1.1.1 Bits

The bit is very basic, indivisible information about the core properties of the object. The values contained in the bits are extremely simple and specific answers to specific questions. In most of the cases, the bits will contain either Boolean or Numeric values, but there are cases where they can be text or binary data as well. No matter what, the bit contains single information; a bit never contains a set of information. For example "the exact size of an object" is a bit. But "possible sizes of an object" is not; it is a node.

1.1.2. Nodes

Nodes are sets of bits, when several bits come together, they form a node. A node is an information matrix; a multi-dimensional array of images and information about a niche property of the object. For an example, the color range of an object could be a Node; it may contain many bits. Example: Color (White, Grey, Blue) etc. Sometimes, we can express Nodes with moodboards; which are visual mindmaps [2].

1.1.3 Spirits

Spirits are sets of nodes. Spirits describe an object in a limited manner. For example they could describe only the function, unique selling proposition, color, historical references or graphic features of an object. I categorize the Spirits into special categories such that as a rule of thumb, while designing if you keep the elements of one Spirit from each category and the Main Spirits constant, you arrive at a well built product family.

1.1.3.1 Prime-Spirits

Prime-Spirits define what the object is and what it serves for. There are two main spirits; they are: Functional Focus and Scale. Functional Focus determines what particular function the object satisfies [3]; it is a vehicle, it is a seating, it is a toy. The Scale defines scalar difference; such as a model chair, a children's chair, a real chair. Both the Scale and the Functional Focus must be kept constant for sure if you intend to come with a product family.

1.1.3.2 Proto-Spirits

They are the initial concepts and significant restrictions. The initial Inspirational Proto-Spirits are: Cultural Reference, Historical Reference and Conceptual Reference, they are spirits that inspire the creation of the object. The nodes in these spirits are usually reflected as moodboards. The Restricting Proto-Spirits are: Production Technology, Form, Intended Use, and Impact on Nature. We could add some other spirits into this group but I want to make clear separations.

1.1.3.3 Beta-Spirits

Properties of the object that appeals to our five senses, this is what adds the design taste to the objects, this is after the main inspirations and restrictions what we decide to come up with, a secondary set of aims and restrictions. The Spirits in this group are: Graphic Element, Unique Selling Proposition [4], Emotional Setting, Color, Texture, Material, Interface, Sound, Temperature, Softness, and Weight. There could be more spirits in this group. Character Spirits could also exist under the Beta-Spirits, we could count Reaction, Interaction and Character under this category.

1.1.3.4 Hyper-Spirits

It is true that with every detail we learn about an object, our valuation of the object is altered; however there are certain properties that create a greater change. Hyper-Spirits are the properties of the object such that that after we know them, our understanding and evaluation of the object changes significantly [5]. Some examples would be: Price, Made-up History [6], Fabrication Quality, Producer, Designer, Place of Origin, Benefactor Group etc. These are usually featured on the packaging [7].

1.2. Coding the DDNA

DDNA can be written, formulated or coded in four ways; Pseudo DDNA (PDDNA), Sampled DDNA (SDDNA), Heuristic DDNA (HDDNA) and Generative DDNA (GDDNA).

1.2.1 Pseudo-DDNA (PDDNA)

Pseudo Design DNA (PDDNA) is a natural language expression of the DDNA. At PDDNA, the design is tediously explained with the uppermost details. This includes all the information to create or recreate the design. PDDNA aims for perfect recreation or creation of the design idea. Perfect recreation is the key here [8].

1.2.2 Generative Pseudo-DDNA (GPDDNA)

If we also include some “randomly picked or generated” values in our Pseudo Design DNA we can have the Generative Pseudo-Design DNA (GPDDNA). GPDDNA aims for generative and varied creation of the design ideas by repetitive processing.

1.2.3 Sampled-DDNA (SDDNA)

Sampled Design DNA (SDDNA) is composed of mixed media information that could be used to exactly create the design in mind. SDDNA is an expansion of PDDNA, it is further expressed by; Technical Drawings + Color Samples + Material Samples + plus any other necessary information that was not verbally described. A prototype joins this category. SDDNA aims for perfect recreation of the design idea.

1.2.4 Heuristic-DDNA (HDDNA)

This defines the archetype [9]. Heuristic DDNA expressions are written in one or many XML files (or any other format that could be understood by both humans and computers). This is a very detailed definition of the object to be designed, think it like a 3D data file that also includes physics data and even other programs inside. HDDNA aims for perfect recreation or creation of the design idea [10].

1.2.5 Generative-DDNA (GDDNA)

The GDDNA has specific values that have to be either generated or picked randomly from a set. GDDNA approach aims for generative recreation or creation of the design by repetitive processing of the GDDNA. When the GDDNA is processed repeatedly by the machines we have “generative design” and when the PGDDNA is processed repeatedly by non-machines we have “simulated generative design”.

1.2.6 Design Blender (DB) and DDNA Extractor (DDNA-E)

The Design Blender is an idea-tool for mixing and blending different GDDNA together. DDNA extractor is an idea-tool to derive / extract nodes from existing cultural domains. DB & DDNA-E can be used together to increase form variety [11].

1.2.7 Designers' Avatar (DA)

The Designers avatar is a piece of software or a machine that both contains the GPDDNA and runs the GPDDNA. A human can also be a Designers' Avatar; he can learn and simulate the PGDDNA. The DA acts as a product platform itself, it can be used to increase the speed of design generation [12] however we still need designers to choose which designs to be confirmed at this stage..

1.2.8 Coding Order

The way to start is to have the PDDNA first; this is to create an object exactly from the code, if it works, you can now introduce randomness and generative tasks to it to come up with the PGDDNA, if it also works, you should now prepare the HDDNA, and if HDDNA is working you can proceed with the GDDNA. The DA is the last thing; the difference from DA from any others is that DA works by itself, other DDNA has to be run.

1.2.9 Simple Generative Pseudo Design DNA (GPDDNA) Example

Designers' Avatar "Dort"; creates A series of "generated" abstract expressionist drawings by Onur Mustak Cobanli, seeded by words.

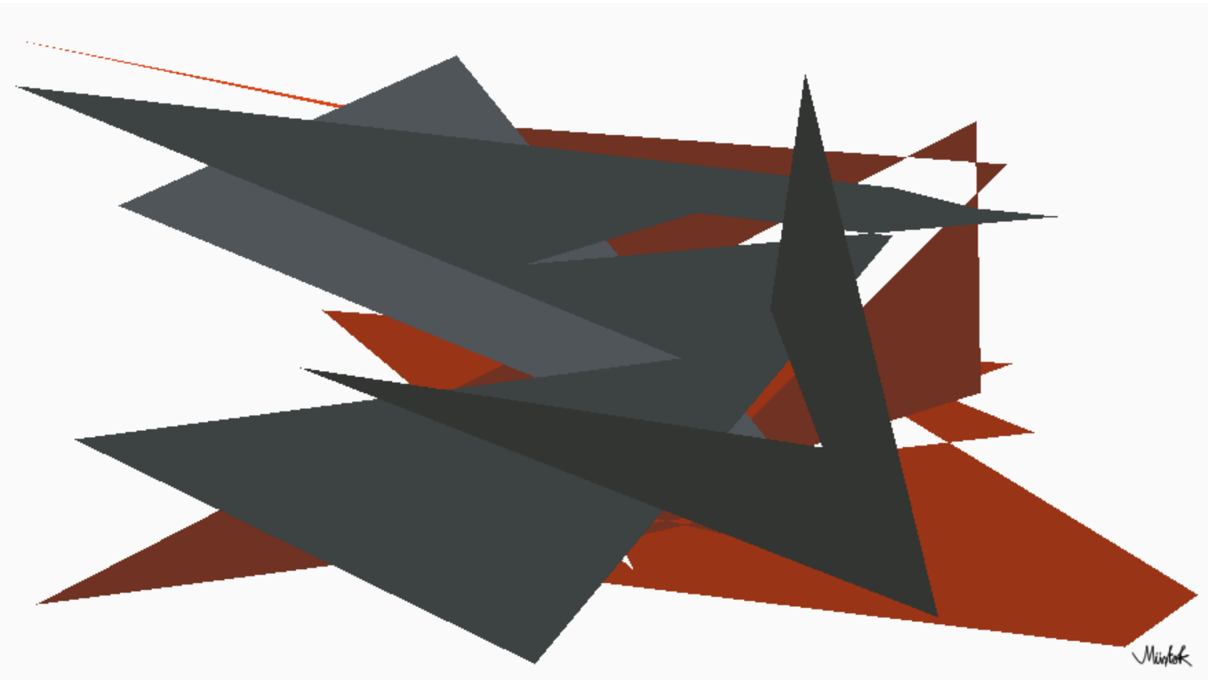


Image 1. Abstract Expressionsit Drawing Generated by Avatar 4.

The GPDDNA is as follows:

Spirit Set consists of "Functional Focus", "Shape" and "Color". The "Functional Focus" is defined as a "Drawing" is "2D". "Shape" is defined as "Proportion" is "16:9", "Topology" is "Rectangle". "Graphics" is a "Set of 5 closed geometrical forms defined by five randomly generated (X,Y) point sets with words to seed the random generator". "Color" is defined as; "Background" is "White", "Foreground Color Range" is "Set of 33 different Set of 3 similar colors, one of them is picked randomly with words to seed the random generator".

The drawings are seeded by the words "Painted" and "Dynamic" for the first example, and "Complexity" and "Design" the second drawing.

1.2.10 Sampled Design DNA (GPDDNA) Example
Of course we could write it in a different and clean way to understand easier; here is the Sampled DDNA (SDDNA). It is relatively easy to understand as it is aided by visual forms and prototype.

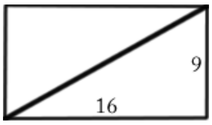
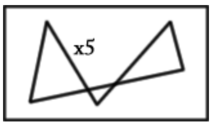
Functional Focus	Shape	Color
Drawing (2D)	Proportion (16:9)	Background (White)
		
	Graphics ("Set of 5 closed geometrical forms defined by five randomly generated (X,Y) point sets with words to seed the random generator")	Foreground ("Set of 33 different Set of 3 similar colors, one of them is picked randomly with words to seed the random generator")
		

Table 1. SDDNA Example

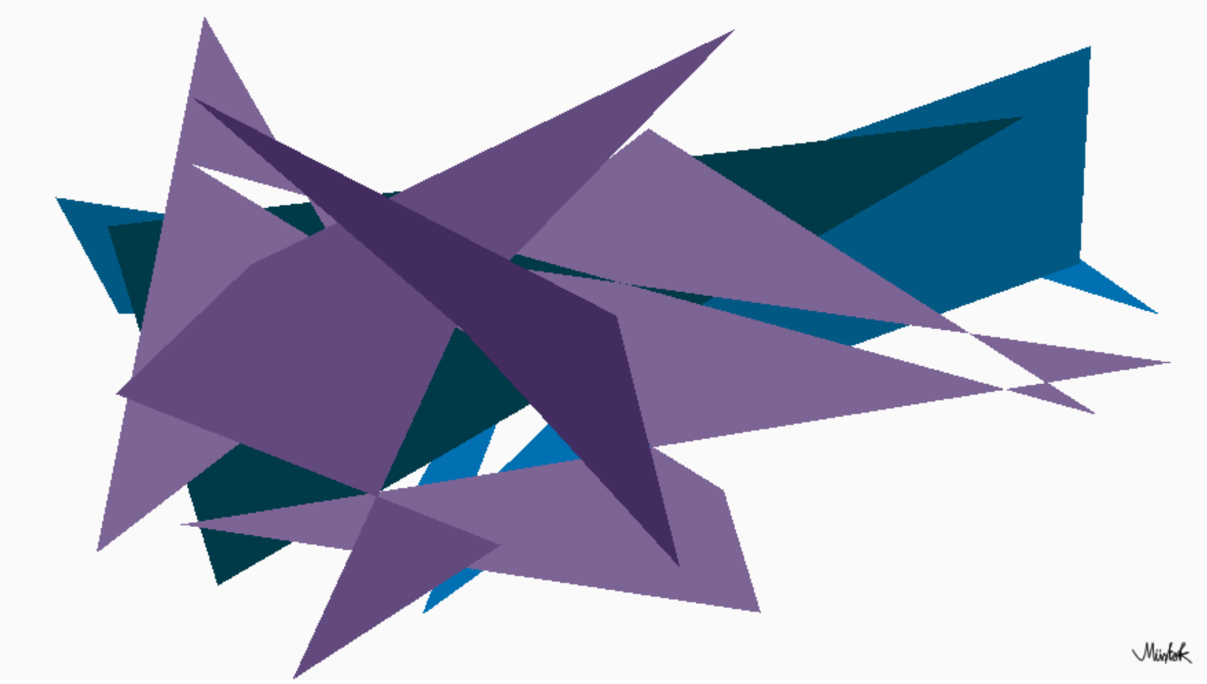


Image 2. Abstract Expressionsit Drawing Generated by Avatar 4.

Let's proceed with some three dimensional products and start the real fun. However we need some more tools to do so, and we will introduce the Moodboard.

1.2.11 Moodboards

Moodboards are tools to express nodes in an intuitive and easy to understand way for humans to understand, developed artificial intelligence could also make use of the moodboards, the aim is to find a series of images or sounds that all share a common attribute or come up with many relevant series of images, sounds and data and find what is the "similar, shared attribute", such that from this sample series of images, we could derive others. When creating moodboards, we need to keep all other things constant [14]; for example, let's say that we are going to create a moodboard for forms, than the silhouettes are enough. In any kind of moodboard I suggest to find at least 40 different examples so that we could have a significant understanding, I usually go for 100.

1.2.12 Complex Design DNA Example

I have simulated the GPDDNA of Leaf Product Family, An Outdoors Furniture Family design by Onur Mustak Cobanli.

The GPDDNA is as follows:

Spirit Set consists of "Form", "Material", "Production Technology", "Mood", "Functional Focus". The "Form" is defined as a "Similar to Leafs" is "expressed as a Moodboard". "Production Technology" is defined as "Rotomolding" is "expressed as a Moodboard", "Mood" is "Green, Natural and Soft" is "expressed as a Moodboard", "Functional Focus" is "Outdoor Furniture" is "expressed as a Moodboard".

Let’s create the SDDNA with the help of moodboards, first we start with the “Form”, when we are creating the moodboard for the form, the silhouettes are enough; We search for leaf images, and then convert them into silhouettes. This is the research.

Image 3. Moodboard composed of Silhouettes

Here we can use this moodboard to identify some common elements, for instance for me is the rounded sized but somehow sharper edges, the fact that leafs become fatter in the middle and thinner at the edges, the symmetric tendencies of the leafs etc. We keep them as discoveries of the research.

Image 4. Portion of Moodboard of Plastics

For rotational molding, we learn that we need to use plastics, we make another moodboard, we search for plastic objects that are of our interest, we try to understand the best practices, we learn also the technical details, what is the wall thickness, how is mold parting, the answers are our discoveries.

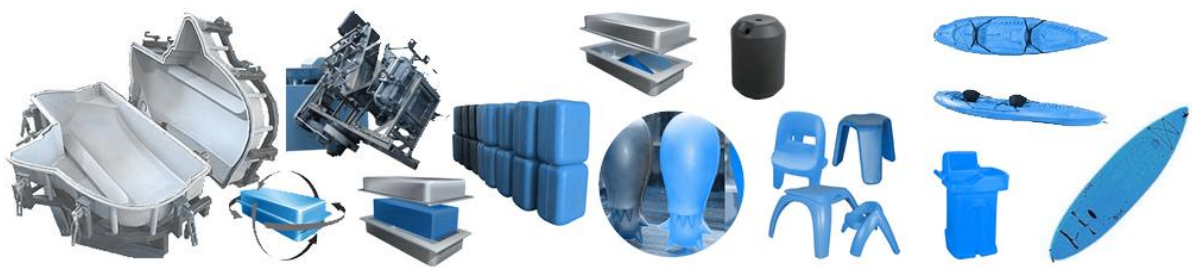


Image 5. Portion of Moodboard of Rotomolding Process and Relevant Products

We continue creating an additional moodboard for rotomolding and how it is done. This is our research and we will use our discoveries as opportunities and restrictions while designing.

Image 6. Portion of the Moodboard of Mood; Green and Soft

The mood study is composed of many images that reflect what we want to achieve, what we want to reflect, so we are searching for common elements: color: green and green gradients, again very soft and organic shapes, we keep these discoveries in mind.

Image 7. Portion of Moodboard of Outdoor Furniture

Lastly, we make a moodboard for outdoor furniture, Here, at our research for outdoors, we find for example that they have “water holes”, “inclined boddies” and easy to move features.

When we run our GPDDNA we come up with the following product family:

Image 8. A product family simulated from the generative design dna

1.3 Product Family Creation with DDNA

When we repeat running the GPDDNA, we are doing truly generative design, one key strength is that by this way, we can come up with product families and even product platforms. Here I have drawn the basic process flow diagram of how it works.

1.3.1 Creating Product Families from Scratch using Design DNA

The process flow diagram for creating a design from scratch:

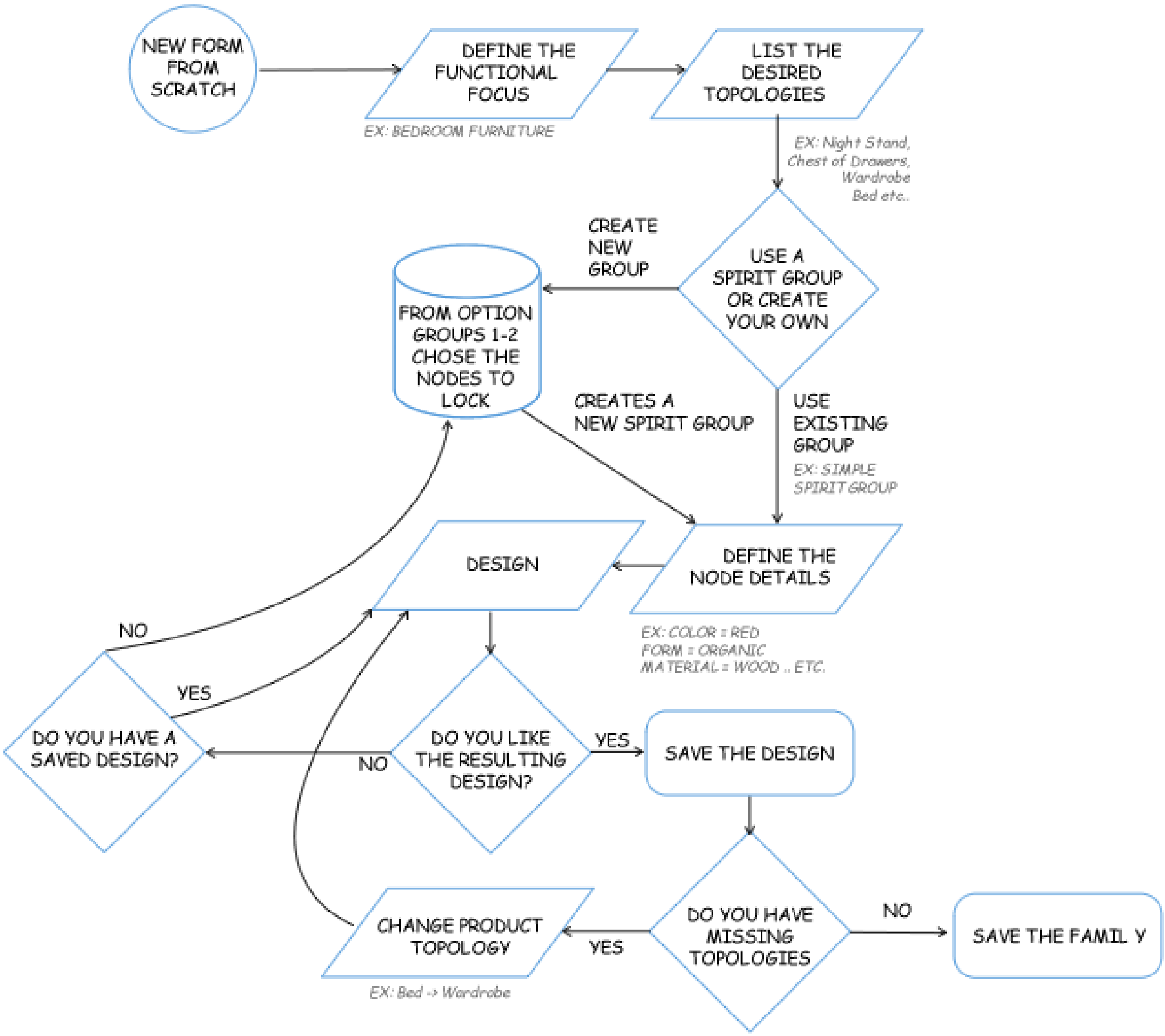


Chart 1. Process Flow for Creating Series of New Products from Scratch

This process flow designs could be used as a basis for both writing the software and simulating the platform [15]. Here, in this process flow, we also see the locks; they are “things and concepts that you want to keep same in all the generated products”, “topologies” are additional focus in the “functional focus” group; for example we said furniture, then our “topologies” will be chair, table, bench, sofa etc. “Spirit Group” refers to the DDNA.

This process flow is good if we do not have an initial idea. But what if we have an already existing design that we want to develop from? We need to derive the “Spirit

Group : DDNA" from this existing design; we underline the most important five-six key points that we want to see in all the other newly generated designs, we reconstruct the DDNA with this in mind.

1.3.2 Deriving product families from an existing product

The process flow diagram for deriving a product family from an already existing product is as follows.

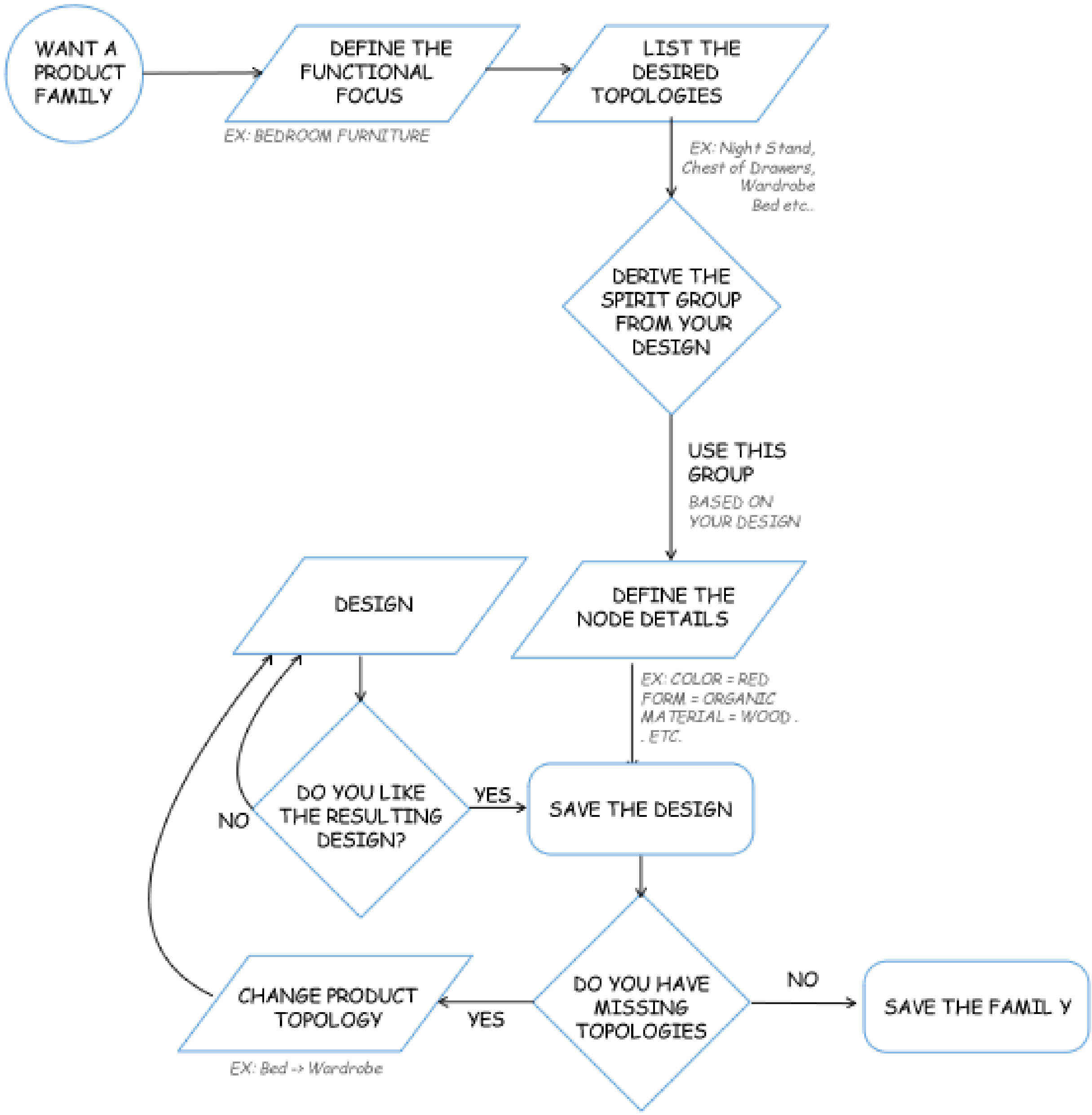


Chart 2. Process Flow for Creating Series of New Products from Existing Products

To repeat what's written; we start from an object, and derive the DDNA from it; then we identify the key components about the object; we try to answer several questions, we ask ourselves, what makes it special, what we like in it; what are the possible components that we can use again in other and new products etc so that we can use

these notes and information while fabricating the DDNA.
After the DDNA fabrication we repeat design processes several times, we sometimes modify the DDNA; increase or decrease the restrictions or change the type of restrictions so that we can arrive at a good product family or a platform [16]. I would like to make an example derivation from a product, we will underline key components and values that we would like to see in the newly generated product family.

1.3.4 Extracting DDNA from a Product

Similar to reserve engineering a product, we can extract the DDNA of a product. Let's start with the following product:

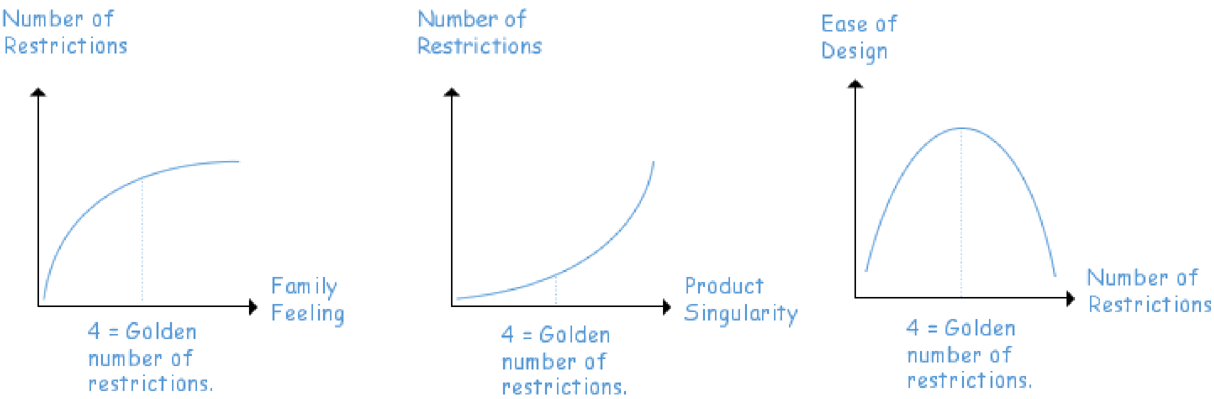
Image 9. A Furniture Design, as the initial design

Given our example, we extract the following spirits: **"**Form" is "Smooth and Round Edges" are derived in detail by the "radius of circle", "the legs"**.** The "Production Technology" is derived as "woodworking", the "Historical Reference" is derived as "1960s Cars and furniture", "Color" is derived as "Body" is "Black", "Seating" is "Red", here we also choose the "Functional Focus" as "Indoor Furniture for Houses".
The product family we developped by deriving the DDNA from the initial design: Due to my lack of programming skills, I had to simulate the PGDDNA and repeat the task each time, following my process flow diagram while doing so. Of course, these are not all the results; I had eliminated many of the designs that were not good, and I believe this is the task of the designer to choose the best among generated ones.

Image 10. Series of Products generated from the Initial Design

1.3.5 Improving the Generated Product Families

What if we cannot come up with a good product family, than we need to play with the restrictions, by trial and error, I have found that the golden number of restrictions (number of spirit groups in the DDNA) is four (4) as at this point the design becomes easy to arrive at, we can change the type of restrictions, increase or decrease the number of restrictions.



Graphs 1. 2. And 3. Relationship between number of restrictions, family feeling and product singularity.

When we change the number of restrictions, the product singularity increases [17]; they become more similar, less varied, also at the same time, as we increase the restrictions (Number of Spirits we keep fixed in the DDNA), the family feeling increases.

1.3.5.1 Expaning Creation Possibilities with DNNA-E

Using the DDNA-E, we can extract DDNA from objects and we have seen that, however another great use is to use the DNNA-E to extract spirit groups from a culture; Here we make a very large moodboard and try to understand the common elements; for example we focus on Chinese culture, and we can derive the color "Red", the object "Dragon", they can all be intercorporated into our designs to carry the "Chinese" feeling. As the number of relevant links between products and a culture increases, the value given by the society will also increase [18], this works up to a level.

1.3.6 Managing Existing Product Families with the DDNA

We can manage our existing product families with the DDNA approach; we can identify which products fit into our portfolio and which are standing out. At first it might seem difficult but actually, we apply a DDNA test; For each product in your line / product family, we extract the DDNA and then compare them with each other (we compare with the average or the median), if there exists a product that is significantly different from others, that that product does not belong to the family [19], we extend this to the design sense.

1.3.6.1 Advantages of Using the DDNA for Generating Product Families

Let's think about the existing approaches for controlling the product families; the Boston Consulting Group's Product Matrix measures the value based on financial performance [20] and choose the best performers within this products, but the financial data is not always easy to produce and design is totally undermined in this approach. In the R&D – Product Platform Approach, given the platform the engineers generate new products based on it, sharing components and production process across a platform of products the aim is to decrease production cost [21], it is quite efficient but you need an initial platform [22], it cannot be used to create a platform from the scratch. Marketing strategy and advertisement approach is also attractive, in this case you need to have designs that can fit into your brand, you can use white papers to define style but you need to have a brand first, the idea is to derive the DDNA from the brand! Another great option is to ask masters of design; however they will not tell you, those who would tell you are no longer with us and many designers do not write "how their creative processes work", many others like sharing however they can tell or reach only to their workers or students. Development and management of new products in a design way is not documented, however the DDNA approach can be used in this way. The DDNA approach can be used for developing and management of new product families and the system is fairly easy to understand and it can be thought to students, colleagues as well as computers for making the task generated.

Conclusion

We have discussed what the Design DNA is and how we can use it to develop a single product or series of products / develop product families in a generative way, and even manage existing product families with the DDNA checks, the DDNA is a design philosophy that covers a wide range of tools and subtools that helps you design in an efficient way, the DDNA could also be conveyed to students and it could be used as an alternative approach to existing Product Platforms, Product Management Techniques, Branding-Product Methodologies and Matrices. DDNA is the design way of creating, recreating, generating, diversing and managing products.

References

1. Saenger, Wolfram (1984). Principles of Nucleic Acid Structure. New York: Springer-Verlag. ISBN 0387907629.

2. Michael Erlhoff, Tim Marshall – "Design Dictionary: Perspectives on Design Terminology, Board of International Research in Design", Birkhouse, Berlin – Germany, 2008.
3. William Lidwell, Kritina Holden, Jill Butler – "Universal Principles of Design", Rockport,Massachusetts – United States of America, 2003.
4. Alina Wheeler – "Designing Brand Identity Second Edition: A Complete Guide to Creating,Building and Maintaining Strong Brands", John Wiley & Sons , New Jersey – Canada, 2006.
5. Max Weisbuch, Diane Mackie – "False fame, perceptual clarity, or persuasion? Flexible fluency attribution in spokesperson familiarity effects", Journal of Consumer Psychology - 19, 2009.
6. Max Werheimer, "Untersuchungen zür Lehre von der Gestalt, II", Psychologische Forschung, Berlin – Germany, 1923.
7. Robert G. Cooper, Scott J. Edgett, Elko J. Kleinschimdt - "Portfolio Management for New Products – Second Edition", Basic Books, New York – United States of America, 2001.
8. Marc H. Meyer, Alvin P. Lehnerd – "The Power of Product Platforms: Building Value and Cost Leadership", The Free Press, New York – United States of America, 1997.
9. Margaret Mark - "The Hero and the Outlaw: Building Extraordinary Brands through the Power of Archtypes", McGraw-Hill Trade, New Jersey – United States of America, 2001.
10. Daniel Kahneman, Paul Slovic – "Judgment under Uncertainty: Heuristics and Biases.", Cambridge University Press, Cambridge – United Kingdom, 1982.
11. Christopher Alexander – "Notes on the Synthesis of Form", Harvard University Press, Cambridge, Massachusetts – United States of America, 1967.
12. Steven C. Wheelwright – "Revolutionizing Product Development: Quantum Leaps in Speed, Efficiency, and Quality", Free Press, New York, United States of America, 1992.
13. Timothy W. Simpson, Zahed Siddique, Jianxin (Roger) Jiao. "Product Platform and Product Family Design: Methods and Applications", Springer, Lancester, 2007.
14. Steven Haines – "The Product Manager's Desk Reference", McGraw-Hill, New Jersey – United States of America, 2008.
15. Williams C.B. Allen J.K. Rosen D.W. – "Designing platforms for customizabile products in markets with non-uniform demand. Proceedings of ASME Design Methodology Conferance, Salt Lake City, Paper No: DETC2004/DTM-57469", Saltlake, United States of America, 2004.
16. Ulrich, K.T. Eppinger S.D. – "Product Design and Development", McGraw-Hill, New York, United States of America, 2005.
17. Thevanot H.J. And Simpson T.W. – "Commonality indices for product family design: A detailed comparison". Journal of Engineering Design 17. 2006.
18. M. Uzumeri, Sanderson S. – "A Framework for model and product family competition", Research Policy 24, 1995.

19. Vistaar Company White Paper rel. 2005– “Product Portfolio Planning” - Retrieved 1 May 2009, (Url: http://www.vistaar.com/portfolio_planning.php)
20. Michael S. Deimler, Carl W. Stern - “The Boston Consulting Group on Strategy: Classic Concepts and New Perspectives, Second Edition”, Wiley, New Jersey – United States of America, 2006.
21. W.E. Souder, T. Mandakovic – “A system for Using R&D Project evaluation methods”, Journal of Research Management, September 1978.
22. Gupta S. and Krishnan, “Appropriateness and impact of platform-based product development”, Journal of Management Science 47, 2001.
23. Al Ries, Laura Ries – “The 22 Immutable Laws of Branding”, Harper Collins Publishers, Newyork – United States of America, 1998.

The Future of Futurism

Prof Rick DOBLE, M.A, B.A.
http://www.rickdoble.net
e-mail: rick_doble@yahoo.com

Dr Marcella Giulia LORENZI, PhD
Laboratorio per la Comunicazione Scientifica, Università della Calabria,
Ponte Bucci, Cubo 30b, 87036 Arcavacata di Rende CS (Italy)
http://www.lorenzi.ca
e-mail: marcella.lorenzi@unical.it

Prof Mauro FRANCAVIGLIA
Laboratorio per la Comunicazione Scientifica, Università della Calabria &
Dep.t of Mathematics, Univ. of Torino, Via C. Alberto 10, 10123 Torino TO (Italy)
e-mail: mauro.francaviglia@unito.it

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Abstract

At exactly 100 years after its birth, Futurism is revisited in terms of the new potentialities offered by Digital Photography (via *"Painting with Light"*). It is discussed how Futurism aimed at depicting "dynamism" and why Digital Photography, generating variations of the same basic ideas, can offer a "Future to Futurism".

From the "Technical Manifesto of Futurist Painting": *"All things move, all things run, all things are rapidly changing. A profile is never motionless before our eyes, but it constantly appears and disappears".*

1. Futurism

In 1909 (exactly one hundred years ago) in Milano, Italy, the "Futurists" had a new artistic vision. They wanted to create imagery that contained and expressed movement. They saw the world with cars, bicycles, trains and people rushing down the streets as a world in motion. Traditional Art had all but ignored movement in its depictions, but now the Futurists wanted to make it central to their work. The *"Futurist Manifesto"* was published by the Italian Poet and Editor ***Filippo Tommaso Marinetti*** for the first time on February 5, 1909, in the *"Cronache Letterarie"* of the daily newspaper *"La Gazzetta dell'Emilia"*, and retaken on February 9 in the same year in *"L'Arena di Verona"*. Just two weeks after, on February 20, a French version of the "Manifesto" was finally published by the prestigious newspaper *"Le Figaro"* in Paris, France, giving to Futurism the highest possible international footlights; [1],[2]. *Futurism* was officially born….

1.1 The Futurist Art Movement and The Depiction of Motion

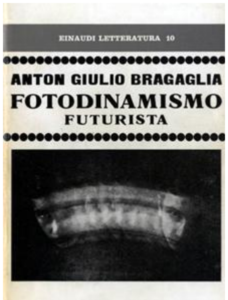
Futurists explored all possible forms of expressive Art, from Painting to Sculpting, but also Music, Architecture, Dance, Photography and Cinema. The signs of this artistic revolution were already present since the beginning of the new Century but the year 1909 marked their transformation from the world of ideas to the world of concrete Art. Futurism followed the rapidly spreading wavefront of the technological revolution at the beginning of the first years of '900 (*Belle Époque*), by exalting an unlimited confidence in "progress"; as an example, Marinetti himself pushes forward the belief that *"dynamism"*, velocity and industry will eventually wipe off the old ideologies (so-called *"Passatism"* in contrast with "Futurism", by this

meaning a form of decadent and pedantic Art related to the “past” and stigmatized, e.g., in the freshly produced *“Parsifal”* of ***Wagner***).
The first quarter of the XX Century was undergoing a great evolutionary phase, in which the whole world of Art, Science and Culture in general was stimulated by a number of important factors: wars, social transformations, political struggles and changes, new scientific and technological discoveries. A few years before, exactly in 1905, the great German Physicist ***Albert Einstein*** had *de-facto* changed the Physics of the XX Century, through a not less important revolution: in that “magical” year he laid in fact the foundations of the *Theory of Special Relativity*, changing the view from a static and rigid description of Physics on the basis of the fairly established Galilean framework, with *Space* and *Time* separated and immutable, to a new vision in which Space and Time were inextricably fused instead into a single four-dimensional new entity, called *SpaceTime* [3]; but he also laid the foundations of the *Theory of Chaos* (through a paper on Brownian motion) and the foundations of *Quantum Mechanics* (that would emerge later from Einstein’s investigations on the photoelectric effect). A few years later, in 1915-1916, Einstein would reach an even more dramatic revolution, with his *Theory of General Relativity*, destined to change again the vision of Physics from the static and rigorously flat Universe of ***Newton*** to a newer conception of four-dimensional SpaceTime dominated by curvature (see [4]). Einstein’s revolution was in a sense a revenge of Time and Dynamism against Space and Staticity, as well as it was a revenge of *light* as a universal phenomena to cope with whenever one has to speak of causality and contemporaneousness; see also [5].
It seems now appropriate to mention what ***Guillame Apollinaire*** declared in 1913: *“Today scientists no longer limit themselves to the three dimensions of Euclid. The painters have been led quite naturally, one might say by intuition, to preoccupy themselves with the new possibilities of spatial measurement which, in the language of modern studios, are designated by the term:* ***the fourth dimension***. *Regarded from the plastic point of view, the fourth dimension appears to spring from the three known dimensions: it represents the immensity of space eternalizing itself in all directions at any given moment. It is space itself, the dimension of the infinite.”*
On the other hand and at the same time Technology was rapidly changing the World. New devices and communication means such as the wireless telegraph, radio, airplanes and cameras were also contributing to a change of perspective about distances and Time, contributing to getting nearer to faraway pieces of our Planet. In a sense the World was being crossed by a new wind, a wind bringing into mankind’s consciousness the new reality of *“velocity”*: velocity in the production of manufactured goods, velocity to reach a destination and velocity to communicate news. New spaces, new Technology, new Science: all was contributing to make the Future something less remote and more directly perceived in the collective imagination.
Divisionist painters, sharing an interest in new research regarding Optics and the Physics of Light, like ***Umberto Boccioni***, ***Carlo Carrà***, ***Giacomo Balla***, ***Gino Severini*** and ***Luigi Russolo,*** signed the “Manifesto” establishing the main rules of Futurist painting: abolishing traditional perspective (already mined by ***Pablo Picasso***) in favour of a *“simultaneous vision”* able to capture dynamism. The first Futurist works were exhibited in Milano at the *“Mostra d’Arte Libera”* held at Galleria Ricordi in 1910. After the death of Boccioni in 1916, the center of Futurism moved from Milano to Roma, where in between 1918 and 1928 it was characterized by strong relations with post-cubist and constructivist ideas; while from 1929 to the eve of World War II, it was more related to surrealistic ideas.
Futurism gave the best results in all artistic expressions related to Painting, Mosaic and Sculpture, but worthy of mention are also its strict relations with the new possibilities offered by Photography – that will form the core of this paper – and also in Architecture, Theatre and Literature. As far as the style of Painting is concerned, Futurism was mainly based on the post-Impressionist idea of *“Divisionism”* suitably re-elaborated in order to depict more expressive space that contained velocity and simultaneity. But also the *Cubist principles* of decomposition of forms along different visual planes to be displayed altogether on the same canvas was among its inspiring principles; the pictorial surface is split into multiple planes, each one registering a different space perspective. The crucial difference with *Cubism* is that while in Cubism this decomposition makes it possible to represent and imagine a static three-dimensional subject as embedded into a fourth dimension again of spatial character (the painter shows different aspects of it as seen from different views at the same instant of time) in Futurism a real SpaceTime appears and the decomposition is suitably used to embed a three-dimensional object into a four-dimensional continuum formed by Space and Time together, since images taken in different instants of Time are depicted altogether in a canvas or reproduced in a Sculpture or set into a Photograph.
Worthy of mention is also the difference between *Impressionism* and Futurism: while Impressionists - certainly looking at something freed from staticity and caring about the evolution of the image described - were concentrating on the need of *“capturing the moment”* (in the sense of freezing on the canvas a

luminous, unique and never returning instant of time), the Futurist were instead moving in an opposite direction, i.e. embracing into a single artwork not a single shot but rather the motion itself, representing it with a great emotional impact as being formed by a continuous sequence of movement.
As a consequence, the *"Aesthetic of Velocity"* generates a prevalence of truly dynamical elements; motion involves both the object depicted and the space in which motion takes place. Trains, Cars, Airplanes are peculiar subjects, but also human figures (dogs, dancers, children) animated by multicoloured and polyphonic brush touches, aimed at putting into evidence the propulsive push of moving forms. The difference of velocity (higher or lower) is usually represented by using either broken and rough-edged lines or more harmonious and fluid linear brushstrokes.
Futurism is well described by the own words of Boccioni (1913):
"I want to render the fusion of a head with its environment.
I want to render the prolongation of objects in space.
I want to model light and the atmosphere.
I want to transfix the human form in movement.
I want to synthesize the unique forms of continuity in space."

1.2 Futurism and Photography

A photographer, associated with the Futurist movement, ***Anton Giulio Bragaglia***, wanted to create the same kind of imagery based on direct observation. He took photographs using slow shutter speeds to record people in motion. His photography rises in 1910's from a refusal to use this medium as a way of "passively" depicting reality, when he starts experiments to insert new creativity into the act, the perception of vital energy.
Crucial to both Bragaglia and the Futurist painters was the notion that a work of Art should show the continuity of motion, a picture of a subject over a period of Time, rather than a series of still sharp images that were taken in sequence, as had been previously achieved by ***Edweard Muybridge*** and ***Etienne-Jules Marey***. He called this type of Photography *"Photodynamism."*



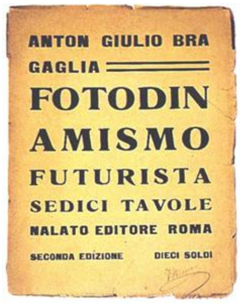


Fig. 1 "Fotodinamismo Futurista" by Anton Bragaglia

This lead eventually to a full acceptance of Photography by the Futurist movement and to the new "*Manifesto della Fotografia Futurista*" by ***Marinetti*** and ***Tato*** in 1930 [6], in which they declare that traditional Photography as "Science" was going to become "pure Art", through a series of new composition possibilities, related to a new way of perceiving contemporary reality. According to ***C. Tisdall*** and ***A. Bozzolla*** *"Bragaglia... was attempting to liberate the art of photography from the slavish imitation of reality to which it had been relegated. He saw untapped possibilities in photography as a means of experimentation, and was particularly attracted to its potential for capturing the sensation of movement - rather than... sequential stages [as photographed by Muybridge and others]"* (see [7]).

Fig. 2 "The Slap", by Anton Bragaglia

Unfortunately this quest for imagery of continuous movement came to an end around 1914. With the start of World War I, many of the Futurists joined the armed forces and a number were killed in the conflict. In addition, in 1915 motion pictures reached a milestone with the release of the big budget film *"Birth of a Nation"* by ***D.W. Griffith***. With the success of movies, the desire to portray the continuity of motion in Painting and Photography was virtually abandoned since it was now clear that the Cinema could accurately and better display movement. And even Bragaglia, himself, devoted most of his efforts to Cinema after World War I. However, a few artists tried to continue Futurists' concerns (*Post-Futurism*) both in Painting (e.g, ***Fortunato Depero***; Fig. 3) and Photography (e.g, ***Filippo Masoero***; Fig. 4).

Fortunato Depero,
"Il Ciclista Attraversa la Città"

Filippo Masoero,
post-futurist photographer
who made long-exposure pictures
of cities hanging from airplanes

Fig.s 3 and 4

2. Digital Photography in 2009

Let us now jump forward 100 years from 1909 to today, to the technology of Digital Photography. Digital cameras have a variety of new capabilities that make it possible for artists to pick up where the Futurists stopped. In addition Digital Photography can draw on the ideas, concepts and vision of the Futurists to bring this new imagery into being ([8],[9]).

2.1 The Art of Space and Time

The success of Cinema to capture movement was recognized. As ***Dziga Vertov*** wrote in 1923: *"I'm an eye. A mechanical eye. I, the machine, show you a world the way only I can see it. I free myself for today and forever from human immobility. I'm in constant movement. I approach and pull away from objects…This is I, the machine, manoeuvring in the chaotic movements, recording one movement after another in the most complex combinations. Freed from the boundaries of time and space, I co-ordinate any and all points of the universe, wherever I want them to be. My way leads towards the creation of a fresh perception of the world. Thus I explain in a new way the world unknown to you."*

However, Cinema gives only an *illusion* of movement, since it is only a series of still frozen shots (frames) in a succession. On the other hand, Photography, and Digital Photography in particular, is uniquely capable of recording a space/time image. One of us (RD) wrote in his book [9] to be published in 2010 *"Photography may be the visual Art best suited to creating still images of subjects in time. This is because a photograph is made by recording an object (via the lens) over time (by opening the shutter for a specific duration). Therefore, a photographic exposure is a combination of space and time, a recording of space and time."*

Yet to photograph a space/time image is quite complex. For example, the correct shutter speed to depict motion varies considerably depending on the motion of the subject and the artistic intentions of the photographer. In addition there are many other variables to movement. And to record this kind of imagery successfully, the photographer must have a tool that allows instant display of the imagery just taken so that adjustments can be made based on that feedback - which is the very powerful capability provided by Digital Photography.

2.2 The Quest for an "Algebra of Movement" and Generative Art

The Futurist Anton Giulio Bragaglia had said that he wanted to construct an *"algebra of movement."* The Futurist painters had begun work on this idea, for example, with their concept of "absolute" and "relative" motion. "Absolute" movement was the general overall direction that a subject was moving toward and "relative" movement was the internal movement of the subject such as the turning wheels of a car or the swinging arms of a person walking - movement that was independent of the absolute movement. The starting point could have been the same "reality", from which they generated different artworks (Generative Art…?).

Fig. 5 The "Relative Movement of the Wheels" is clear in this shot, photo by Rick Doble

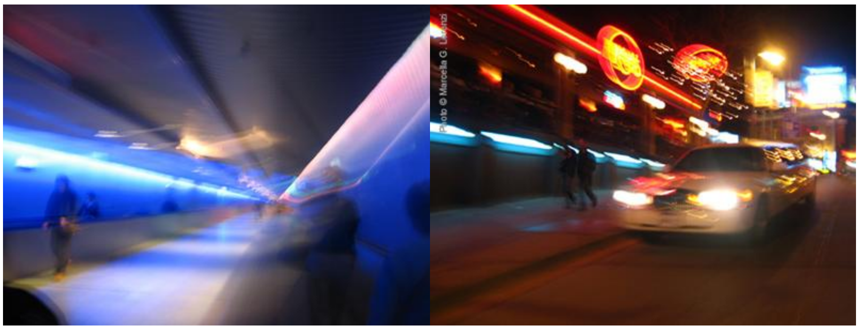


Fig. 6 Left: Passage in SpaceTime; right: Photodynamism of a Limo in Niagara Falls; photo by Marcella G. Lorenzi

The term Generative Art does not describe any art-movement or ideology [10]. It is a method of making Art. The term refers to how the Art is made, and does not take into account why it was made or what the content of the artwork is. Artworks, in Generative Art, can be identified in the creative processes and not only in the results. Also because the results of each generative process are endless variations belonging to the same idea. Generative Art creates an artificial DNA able to generate individuals of the same species. The results are *"unique ad continuum"* ([11], [12]). "Painting with Light" is in fact a Generative Art process (as first claimed in [13]).

3. Digital Photography and Futurism

3.1 Subject Movement

Digital photographers who are interested in the depiction of movement have tried to add to the Futurist idea of an "algebra of movement". The craft of Photography defines two fundamental kinds of movement: *"subject movement"* and *"camera movement"*. It also adds a third kind of movement which is the combination of subject and camera movement such as panning a camera with a moving subject. The Futurist's notion of absolute and relative movement is part of subject movement and works very nicely with other photographic considerations when it comes to taking pictures of a subject in motion.
Some digital photographers have added other aspects of subject movement to their ideas. For example, one of us (RD) in [9] defined these different types of subject movement:
Regular movement: Some movement is unchanging, like that of a train; it moves at a fairly steady pace in a predetermined direction. A car's movement is also regular but with some variables, such as swerving a bit to the left or right and slowing down or speeding up.
Predictable movement: Less precise than regular movement is predictable movement. A car heading down the road will continue to head in that direction; a car with its right turn signal blinking will turn right. A dancer doing a traditional dance will repeat the same steps but not in exactly the same spot.

Fig.s 7 & 8 Left: "Le mani del Violinista", by G. Balla; right: "Violinist", subject movement, photo by Rick Doble

Fig.s 9 & 10 Left/right: Photodynamic portraits of Dee Dee Bridgewater singing and dancing with a green fan during a Jazz concert. Photos by M.G. Lorenzi

Irregular movement: Some movement repeats but in an irregular fashion, such as a dancer who moves in a free-form manner. Nevertheless, this dancer will repeat many of the same motions and, after a while, a photographer might gain a sense of how that particular dancer is likely to move.
Erratic movement: The movement of a singer on a stage or a child playing with a dog can be hard to predict, however, scenes such as these can yield exciting and unusual imagery.
Camera Movement
Camera movement, by itself, depicts motion from the photographer's point-of-view. This type of imagery has been called *"Painting with Light"* and also "camera painting". It is essentially a new Art form that has only been made practical with the advent of Digital Photography and leads to dynamic abstract imagery much like the abstract work of the Futurists. ***NOTE:*** while this imagery was technically possible with film photography, not much work was done in this area due to the high cost and large amount of effort that was required.

Fig. 11 "Shot Through Windshield in Rain", camera movement, photo by Rick Doble

In addition camera and subject movement together add powerful techniques in the depiction of movement as well as providing considerable individual artistic control. Combined camera and subject movement can record the most dynamic imagery where the world seems to be rushing to fill the picture.

Fig. 12 "My Wife Driving", subject and camera movement combined, photo by Rick Doble

3.2 The New Digital Photographic Capabilities

The capabilities of Digital Photography can make use of all of these ideas about movement in a fashion that the Futurists could only dream about.
LCD Monitor: To begin, digital photographers can see a rapid thumbnail photograph immediately after taking a photograph. The instant image on the LCD monitor gives digital photographers the essential tool they need - since photographing motion is so complex and requires a good deal of trial and error. Yet the LCD monitor allows the accomplished photographer to hone his or her imagery in real time and to take pictures both in the studio and in the streets to record the vital pulse of Life.
Low Cost: In addition the prohibitive cost of film and processing that photography required before the advent of digital, is now a thing of the past. Taking pictures of movement, by necessity, requires a lot of test shots and shots that are not the best. Digital photographers can now shoot hundreds of pictures without worrying about the cost.
Stabilizing Control: The new stabilizing feature on most digital cameras allows photographers to handhold shots at very low shutter speed such as 1/2 second with no camera shake. This means that photographs of subject movement by itself, for example, can be accurately shot without any camera shake or with minimal camera shake. And this is a new feature only now available with digital technology.
EXIF Data: Also important is the EXIF exposures data that is recorded by most digital cameras and embedded in the photographic image. This invaluable new digital tool lets a photographer go back and review the settings, such as shutter speed, that were used with different photographs and then allows the photographer to learn from and to build on that information.
Expressive Control: And while Digital Photography is a technical craft, it is also an expressive medium. Different photographers can make very different images that reflect their personalities and their artistic visions. As a result the world in motion can be both accurately recorded and also depicted in an expressive and individual manner.

4. Conclusion

The torch has been passed from the Futurists to a new generation of artists in the XXI Century armed with the technology of Digital Photography. With this tool, the quest for true images of continuous motion can begin again.
As one of us (RD) wrote in [9]: *"The world is always in motion. Children, traffic, airplanes, football players, dogs in the park, the family at the dinner table, dancers, people who gesture when they talk, trees in the wind, and thousands of other things move. In fact, the real world is in motion all of the time. As a doctor once explained, if a person is alive, they are moving and - he added - a complete lack of movement is a sign of death! So, a photograph that can capture and convey a sense of this movement can be powerful. People and objects (such as cars or trains) in motion can create a dramatic streaking effect not unlike a painter's brush that is swept across a canvas. With bright colors, the effect can be quite painterly."*
So with these new capabilities of Digital Photography and an understanding of the "Algebra of Movement", the vision of the Futurists can now be realized one hundred years after the founding of Futurism, as shown in our Installation at GA 2009.

Fig.s 13 & 14 Left: Painting "Dynamism of a Car", by Russolo; right: "Photograph Inspired by Futurist Imagery", photo by Rick Doble

References

[1] P. Hulten, *Futurismo & Futurismi*, Bompiani (Milano, 1986)
[2] E. Crispolti, *Futurismo 1909-1944*, Mazzotta (Milano, 2001)
[3] A. Einstein, *Zur Elektrodynamik bewegter Körper*, Annalen der Physik, 1905 - *On the Electrodynamics of Moving Bodies*, in: *The collected papers of A. Einstein,* John Stachel Editor (1989), pp. 276-295
[4] A. Einstein, *Die Grundlage der allgemeinen Relativitätstheorie,* Annalen der Physik, **49**, 769-822 (1916)
[5] M.G. Lorenzi, L. Fatibene, M. Francaviglia, *Più Veloce della Luce: Visualizzare lo SpazioTempo Relativistico,* Centro Ed. e Librario Università della Calabria (2007), 80 pp. + DVD-Rom; ISBN: 88-7458 067-3; *Faster than Light: Visualizing Relativistic Spacetime,* into the quoted DVD-Rom (2007)
[6] F.T. Marinetti, **Tato [G. Sansoni]**, *Manifesto della Fotografia Futurista*, 1930 (copy on http://www.mediastudies.it/IMG/pdf/Manifesto_della_fotografia_futurista.pdf)
[7] C. Tisdall, A. Bozzolla, *Futurism*, Thames & Hudson Inc. (London, U.K., 1977)
[8] R. Doble, *The Everything Digital Photography Book*, 2nd edition, Adams Media Corporation (Avon, Massachusetts, USA, 2008)
[9] R. Doble, *Experimental Digital Photography*, Lark Books (a division of Sterling Publishing, New York, USA; London, U.K.) - to be published in May 2010
[10] AA.VV., http://en.wikipedia.org/wiki/Generative_art
[11] C. Soddu, *Milan, Visionary Variations. Futuristic Meta-Codes for Milan's Identity*, Gangemi (Roma, 2005)
[12] C. Soddu, E. Colabella, *Generative Art Wiki*, http://www.generativism.com; see also **E. Colabella**, *Generative Art*, Proceedings GA2008 Conference, 206-221
[13] M. G. Lorenzi, M. Francaviglia, *Painting with Light: Generative Artworks or "Setting in Motion" the Fourth Dimension*; in: Proceedings of the "10th Generative Art Conference, GA2007, Milano, 12-14 December 2007"; C. Soddu Ed.; (Alea Design Publisher, Milano, 2007), pp. 350-360

American Dream Cycle (Payload)

Robert Spahr, M.F.A
Department of Cinema & Photography, Southern Illinois University, Carbondale, Illinois, U.S.A
www.robertspahr.com
e-mail: rspahr@siu.edu

1. Abstract

A live art performance will be presented by running computer code which will download in real time source images and text from the Internet. This code will then use the source material to generate the performance score, and to process new images based on genetic algorithms.

The work will explore the inconsistencies and cognitive dissonance of the information presented to the American people by the mainstream media on the Internet. The computer code will generate the real-time digital image juxtapositions and transformations of the downloaded source material. The performance creates a residue of digital art which will be archived to the web in real time.

My creative research of the past six years has focused on the development of automated computer code that creates art from source material downloaded from the Internet. I have recently begun research and development of art created by genetic algorithms inspired by Darwinian biological models. The process is analogous to natural selection, mutation and reproduction, with the basic idea of creating a population of candidate images that evolve under a selective pressure favoring the better solutions. Parent images are combined to produce offspring images, which then enter the population, are evaluated and may themselves produce offspring. As the process continues more successful solutions are found, ultimately producing a final work of art. Genetic algorithms search vast data structures for optimized aesthetic solutions. Much like a beautiful universe with no maker, I am investigating design solutions that are not created, but instead discovered.

2. Computational Art: Explorations in Genetic Algorithms

Genetic algorithms embody a simple but profound idea, that through simple change, great complexity can develop. And through natural selection optimized solutions will survive and are then more likely to reproduce. Evolution does not develop with a goal in mind, but instead through generations certain traits are passed from parents to offspring, and along with mutation, random change is introduced. Artists have traditionally produced art and design for a specific goal. To create evolutionary art using genetic algorithms turns traditional artisitc creation upside down. Using a genetic algorithm all possible solutions exist in a conceptual matrix of potential combinations. To navigate that conceptual space is basically a search through data.

To develop the rules of fitness and determine which offspring is healthy and survives is an exercise in aethetics. To create art and design using a Darwinian biological model is a revolutionary act. It calls into question our cultural biases and assumptions about creativity, genius, authorship, and originality.

2.1 Objectives

Building upon my current work writing computer code that creates art [1], I have begun investigating the potential of genetic algorithms and their search through design solutions. The logic of genetic algorithms can be described in pseudo code that looks something like this:

```
EV-OPT:
        Generate an initial population of M individuals.

        Do until a stopping criterion is met:

                Select a member of the current population to be a parent.

                Use the selected parent to produce an offspring which is similar
to but                  generally not a precise copy of the parent.

                Select a member of the population to die.


                End Do

        Return the individual with the highest global objective fitness. [2]
```

The aesthetic challenge for me as an artist using genetic algorithms ha been developing the fitness function, which in biology might be health, as well as a slight survival advantage due to the introduction of a mutation. Evolution is basically an endless repetition of reproduction, with each generation containing minor errors or change through mutation. The mutation can be the slight random change of a gene value. Although the mutation is random, the change over generations is not random, but based on the fitness function. How does one make a computer evaluate the fitness of an image? How do images reproduce? When does the genetic algorithm stop if evolution has no design goal? These were some of the questions I explored when I developed the code for this project, as I looked for an appropriate answer for me as an artist.

The exciting potential of genetic algorithms has been my ability to tweak fitness and mutation criteria, and run the program, with an image result that searches a vast possibility of outcomes, for that one relevant result that matches my criteria. Another objective of this work, has been to investigate what it means to create images and be a designer in a world created without a maker. The following two quotations from *The Blind Watchmaker : Why the Evidence of Evolution Reveals a Universe Without Design,* by author Richard Dawkins raises some of the aesthetic issues I am investigating.

> Natural selection is the blind watchmaker, blind because it does not see ahead, does not plan consequences, has no purpose in view. Yet the living

> results of natural selection overwhelmingly impress us with the appearance of design as if by a master watchmaker, impress us with the illusion of design and planning. [3]
>
> Evolution has no long-term goal. There is no long-distance target, no final perfection to serve as a criterion for selection, although human vanity cherishes the absurd notion that our species is the final goal of evolution. [4]

In a country where the majority of the population reject evolution [5], I want to investigate good design without the illusion of a long-term goal. To not create design, but to search for it.

2.2 Background and context

I completed my graduate studies in New York City, at Parson's School of Design, in 1991. After which I began my creative career making process oriented sculptures, which later developed into performance art, and experimental theater. Simultaneously I began my technical education during the Dot Com era, working as a web designer and producer at various start-up companies. Beginning in 2003, after having used the GNU/Linux Operating System [6] since 1998, I had developed enough programming skills to begin writing computer code that created art. Borrowing the computer hacker term "Cruft" I applied it to my current series of images. I create these CRUFT images by writing 'recipes' (also known as an algorithm). An automated system follows the instructions, first harvesting selected source material from the Internet, and then processing that information into a CRUFT, generating images 24 hours a day, 7 days a week.

I have now begun researching the potential of genetic algorithms as a method to process images and create the score to a performance. Computational art, and specifically genetic algorithms are a fertile area for exploration. There are primarily two methods for creating a fitness function, the first being an interactive mode [7], where a person selects from the offspring, images that are deemed aesthetically pleasing. This creates a 'fitness function bottleneck' slowing down the creation of generations of offspring, as well as introducing different individuals bias. The alternative that I am exploring is an automated fitness function that is an age-based replacement, and/or rank-based selection [8], that is completely dependent on computer instructions, avoiding the need of an individual to be involved in the evolutionary process once the script has begun. I find it fascinating to imagine a design space, where all potential solutions exist. Richard Dawkins explains this in *The Blind Watchmaker : Why the Evidence of Evolution Reveals a Universe Without Design,* as he describes an evolutionary computer program he created that makes small biomorphic creature like designs.

> There is a definite set of biomorphs, each permanently sitting in its own unique place in a mathematical space. It is permanently sitting there in the sense that, if only you knew its genetic formula, you could instantly find it; moreover, its neighbors in this special kind of space are the biomorphs that differ from it by only one gene. Now that I know the genetic formula of

> my insects, I can reproduce them at will, and I can tell the computer to 'evolve' towards them from any arbitrary starting point. When you first evolve a new creature by artificial selection in the computer model, it feels like a creative process. So it is, indeed. But what you are really doing is *finding* the creature, for it is , in a mathematical sense, already sitting in its open place in the genetic space of Biomorph Land. The reason it is a truly creative process is that finding any particular creature is extremely difficult, simply and purely because Biomorph Land is very very large, and the total number of creatures sitting there is all but infinite. It isn't feasible just to search aimlessly and at random. You have to adopt some more efficient – creative – searching procedure. [9]

My interest in genetic algorithms is in the conceptual basis of the search for a design solution, not in the computer science. I want to efficiently search the data structure of possible solutions, and find the appropriate design solution for that which I wish to express.

2.3 Methods/procedures/materials

I have written a framework of reusable modular code, that can be combined in various ways to then create many different algorithms. I have begun developing the algorithms by gluing together smaller scripts that perform simple tasks, such as one chunk of code that downloads a population of images from a selected source on the Internet, another bit of code will test the images for fitness, or divide the image population into two groups and select two images to reproduce and introduce mutation, and finally a script tests the fitness of the offspring. For the past six years I have been writing computer code to create art from source images downloaded from the Internet. Even though I am using computer code, the process is rather traditional, in the sense that I capture source material, and a new image is created based on the rules I have created in the code. The images and text are downloaded and transformed using shell script, perl, and imagemagick. The computer automates the process, and allows me to make thousands of images, doing so every hour of every day for years on end, but the aesthetics are the same as if I was creating the work manually in an image editor.

With code written using genetic algorithms, I am able to produce images created in an untraditional way, that challenge our assumptions about art. My goal is to create a process that is independent of the artist. I set the process in motion, and sit back and allow it to unfold and generate unimagined design solutions.

The computer code I have written creates the score and associated images in a piece I call 'American Dream Cycle (Payload).' For this piece, I am downloading daily program quotes from talk radio host, Rush Limbaugh [10], and these quotes become the textual source for the performance and images. I sort the downloaded text, removing duplicates and words common to the english language. Each remaining word is then passed to a web search engine. The image search results are then downloaded and used as the initial population of my genetic algorithm. One of the fitness functions I am using in this piece, is done by calculating the number of colors in an image, and those images with less color, are considered more fit, and more likely to survive and produce offspring, compared to images with many colors. Reproduction is reduced to the creation of a composite image from two parents. It is similar to, but not identical to the parents. I also introduce mutation, by randomly altering contrast, which also manipulates the number of colors in the image. I then continue to parse the source text, and add selected words to the composite offspring images. This text becomes part of the residue artwork produced by this code which will be archived in real time to my website, as well as being the spoken word of the actual performance piece.

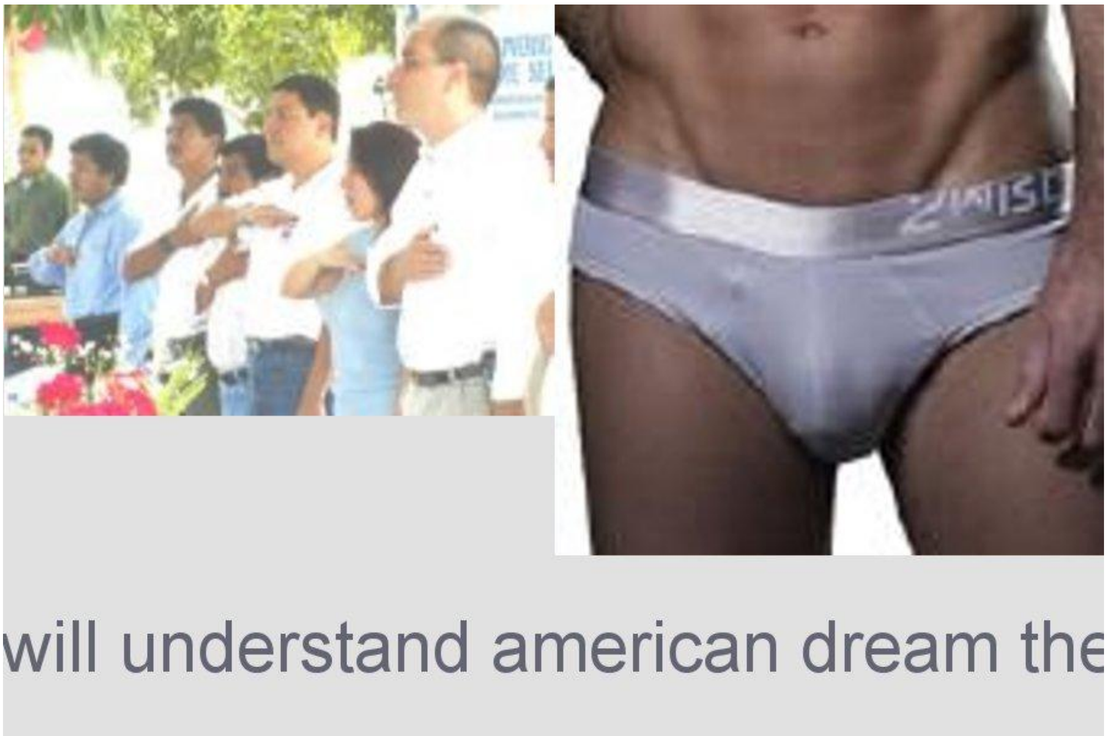


Fig. 1 Image detail of American Dream Cycle (Payload)

2.4 Conclusion

My exploration into genetic algorithms have only just begun, and the performance and residual artwork of 'American Dream Cycle (Payload)' is proof of it's potential for my own creative research. Figure 1 is an example of the composite images and text produced by my genetic algorithms in 'American Dream Cycle (Payload).' The implications of discovering design solutions, by manipulating simple fitness functions has great potential for me as an artist. I have created modular code that can now be tweaked to create very different design solutions. The creative act has been reduced to fitness functions and manipulating mutation, to then search an endless number of design possibilities, finding the one solution that matches the criteria for that which I wish to express.

3. References

1. http://www.robertspahr.com/work/

2. De Jong, Kenneth. 2006. *Evolutionary computation : a unified approach*. Cambridge Mass.: MIT Press. p. 19.
3. Dawkins, Richard. 1996. *The Blind Watchmaker : Why the Evidence of Evolution Reveals a Universe Without Design*. New York: Norton. p. 29.
4. Ibid., p 72
5. http://www.cbsnews.com/stories/2005/10/22/opinion/polls/main965223.shtml

6. http://www.gnu.org/

7. Romero, Juan. 2008. *The art of artificial evolution : a handbook on evolutionary art and music*. Berlin ;;New York: Springer. p. 55-56.

8. Eiben, Agoston. 2003. *Introduction to Evolutionary Computing*. New York: Springer. p.65-66

9. Dawkins, Richard. 1996. *The Blind Watchmaker : Why the Evidence of Evolution Reveals a Universe Without Design*. New York: Norton. p. 93.

10. http://www.rushlimbaugh.com/

3.1 Additional References

Goldberg, David. 1989. *Genetic Algorithms in Search, Optimization, and Machine Learning*. Reading Mass.: Addison-Wesley Pub. Co.
Wolfram, Stephen. 2002. *A New Kind of Science*. Champaign IL: Wolfram Media.
Poli, Riccardo. 2008. *A field guide to genetic programming*. [S.I.]: lulu.com.
Miranda, Eduardo. 2007. *Evolutionary computer music*. London: Springer.

TEACHING GENERATIVE ART TO UNDERGRADUATE STUDENTS AT A TECHNOLOGICALLY ADVANCED UNIVERSITY: ITS CHALLENGES AND REWARDS

Assoc.Prof. Vesna Dragojlov, M.A.
Digital Art and Design Department, University of Advancing Technology, Tempe, AZ, USA
www.vdragojlov.net
e-mail:vdragojlov@uat.edu

Abstract:

At the University of Advancing Technology I have designed a generative/algorithmic art class that I have been teaching for two years now with a growing interest in the student body.
The class introduces generative art through a brief historical background and its precursors with roots in conceptual art, and with a focus on the end of XX century and XXI century trends. The overall class objective is to have the students understand some of the GA concepts that entail process, not the end result, an art creation based on a simple set of parameters that run a very complex, always original, never-ending process. From stills, to live coding, to interactive art, to bio generative art, to algorithmic architecture student gain knowledge of various heterogeneous trends in order to be able to produce their own algorithmic art, starting with traditional media and progressing into a digital realm.
The profile of students in class varies, from programming background, digital design and art, to game design and animation background. Hence the challenge of having the students (rooted in traditional art forms) to grasp this new approach to art whose artistic creation is the process, not a finished product. How to place generative art that resides at the intersections of arts, sciences and technology in a school curriculum that is very much technically oriented (not an art school) presents a challenge for me as an educator and a designer.
Through a video material, and interactive student artworks it is my intention to showcase their growing understanding of generative art and an ultimate embracing of this new art form, focusing on my few students who have found their art direction in generative art.

"And despite the fact that the basis of this mathematical way of thinking in art is in reason, its dynamic content is able to launch us on astral flights which soar into unknown and still uncharted regions of the imagination." [1]–Max Bill

My journey into algorithmic/generative art began with my interest in new art movements that have emerged as a result of the close collaborations between sciences, new technologies and arts. When I worked on my first hypertextual project, an interactive piece of multimedia fiction, I was fascinated by multilinear paths and manifold stories within many other sub-stories with no set endpoint. The feedback I got was interesting, as many people from different fields who embarked on that journey to carve their own story based on many possibilities liked the process, but what about the end? “I never knew where my story ended,” was a common remark. This is where it all began: with the concept of generative art having its immediate roots in early concept art forms with names such as John Cage, La Monte Young, and movements such as Fluxus and Happenings in the 1960s, all of which relied heavily on chance encounters, random input, and a sense of unpredictability. I felt my multimedia fiction fit well into that indeterminate framework.

University of Advancing Technology:

The university where I have designed and taught generative art class for two years is a technologically advanced school that actively utilizes the Year-Round Balanced Learning (YRBL) model for addressing different learning styles. The YRBL model consists of five delivery methods, including modified lecture, tutorial teaching, group recollection, student teachback, and discovery learning. Students engage in both synchronous learning activities in regular class periods and asynchronous activities. Group activities and teambuilding are strongly encouraged within the synchronous and asynchronous environments. My class fits very well into this model, especially the section that addresses teachback and discovery processes. Generative art is, indeed, all about journey of discovery; as such, it is a new art form stemming from many intersections found at the level of scientific, technological, and artistic interplay.

My school is a niche school that fulfills the needs of students who are passionate about emerging technologies, game design and programming, network security, software engineering, and multimedia, among many others. The art program serves as a support program across disciplines, not as one that exists as a separate major. The school’s vision to “**enrich societal advancement by cultivating thinking innovators for our technology-driven world [2]”** coupled with rich developments in the world of multimedia arts, motivates our faculty to redefine the status of art classes in order to be able to understand new trends; they are also loyal to our technologically driven vision. As part of this effort, generative art and bio/genetic art classes have been designed to address these new art directions—directions that also fit well within the school’s technological orientation. On the other hand, it has been a challenge to have the traditional art faculty embrace art-technology integration and cross-disciplined collaboration. Questions of whether generative art is an art form after all, since it inquires about the process and not the finished product have been common threads in our discussions.

Related to these issues is the student population who choose our school for the reasons mentioned above. Furthermore, because the school doesn't attract art-driven students, who still have to take required number of art classes of their choice (as our art classes, such as drawing and painting, serve as a very important foundation for almost all our majors), the question remains how to lure those students into generative art curriculum and explain to them its aesthetic values in today's society, and convince them that they will indeed create artworks.

Most of my students come to my class for one or more of the following reasons:

- Because they are programmers and think they will heavily use programming languages they are very familiar with to create "something," so this should be an easy "win" of required credits;
- Because they cannot draw;
- Because there are no prerequisites to this class; or
- Because they are intrigued by the new concept.

Furthermore, what complicates and simultaneously enriches a class environment is the varying profile of students from backgrounds in programming, digital design and art, game design, and animation. The students who chose not to be part of this class often believe they need to know too many programming languages to be able to be successful or they despise math in general. They may also believe it is not possible to think of generative art as art, based on the course description, as follows:

Description of the algorithmic/generative course:

Algorithmic art is a new form of artistic creation that emphasizes the process of creating a work of art, rather than the final product. The course gives an overview of its historical perspective emphasizing the essential role of concept art as a direct precursor to the algorithmic art.
Students will be encouraged to make artwork using various media and including physical objects that evolve over time based on a clear set of instructions, and often require an active role of the viewer/participant.

The curriculum outlines some of the following topics:

- Introduction
- Origins and Early Algorists
- Characteristics of algorithmic art: process, indeterminacy, open form, natural processes and enumeration
- New algorithmic work:
- Overview of Genetic Algorithms
- Overview of Algorithms and Architecture

Objectives of the class as outlined:

Critically analyze various methods for creating art through algorithmic processes, and apply those concepts to the creation of original, generatively-driven art creations.

Performance objectives:

- Develop a basic understanding and facility to solve visual problems algorithmically;
- Explore aesthetic ideas and visual structures through algorithmic processing of graphic data;
- Identify the historical precedents, philosophies, artists, and output of the algorithmic art movement;
- Write a comparative analysis of the differences between algorithmically generated art and traditional art;
- Determine the most appropriate algorithmic approach to art, in order to achieve a desired aesthetic result;
- Create a multimedia work in which the differing media elements interact according to an algorithmic rule set; (not necessarily computer generated);

To get to the level of understanding what algorithmic art entails requires freeing the mind from the traditional concepts of art as a finished product and embracing the art of abstraction that Max Bill talks about. This is a difficult undertaking. In my experience, it includes overcoming several obstacles:

- Understanding the art of abstraction that has no immediate connections with the world surrounding us and that is not burdened with the common questions, "What does it mean?" To be able to see art solely for an aesthetic pleasure, rather than digging deep for its hidden meanings, is an accomplishment for my students. To paraphrase Magritte in response to the above question: it doesn't mean anything, because mystery means nothing either, it is unknowable. Seeing is what matters; seeing must suffice.

- Understanding the code as material and that it is its execution that brings the artwork its aesthetic quality.

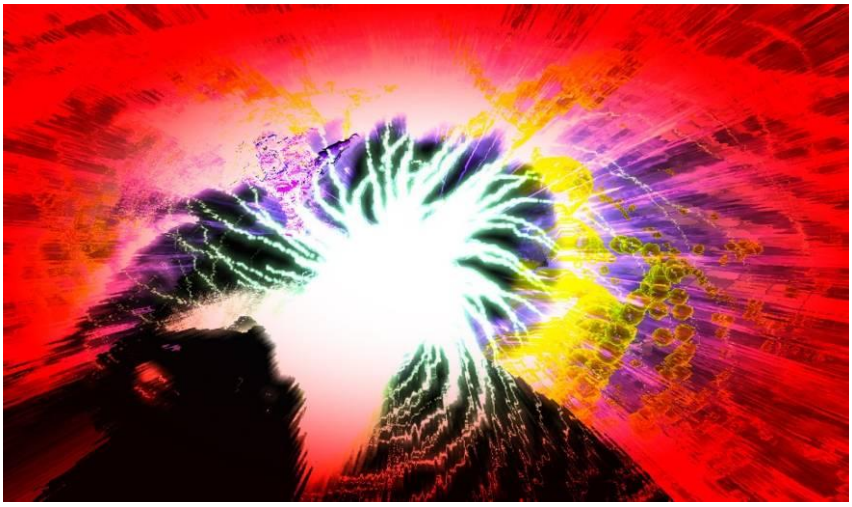
- Understanding of generative art as being based on a set of instructions/parameters, which can be very simple, but which do not necessarily have to be a computer code.

- Understanding that a simple set of instructions/code, when executed, generates an infinite number of possibilities, where each one of them becomes original, whenever the code runs again.

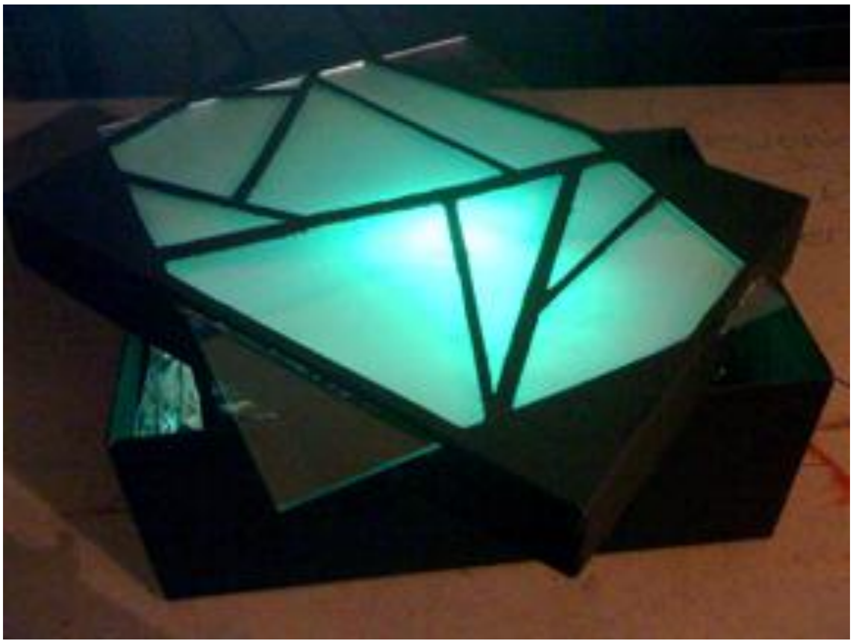
In that vein, we start with simple recipes using physical materials that can potentially generate infinitely varied results. This initial step proves to be beneficial for the understanding of the basic concepts. To have a good, original concept is what my students struggle with. To stay away from computers in our technology-driven society and still be able to generate algorithmic artwork is a challenge. And yet the students have come up with very interesting interactive, generative art projects based on varied sets of physical materials.

From that point, when the students seem to have a grasp of some of the concepts of generative art abstractions, and when they become excited about the open-ended process and infinite possibilities, they begin to build and further explore their initial concepts in the digital realm. Along the way they get acquainted with many algorists who use various media to create their algorithmic artwork that inspire them.

The following are some examples of student works; for the most part they are interactive as the audience become co-authors of the project, active participants who choose their own path of art discovery, a point which brings me back to my opening remarks and my own hypertextual project.



Nick Pfisterer, student, algorithmic art class, Summer 2009



John Pinto, student, algorithmic art class, Summer 2009

Several students completed their road to self-discovery and found their artistic language in generative art. Those students continue to flourish as they embrace generative art's immense possibilities and find ways to combine them with their majors, such as software engineering or game programming. Along the way, they find this art's real world applications.

To be able to stir the imagination of a few students in my generative art class, and to see them inspired to create and solve complicated code puzzles to visualize their generative art concepts, is a rewarding experience. Those students we encourage to continue work on their generative art assignment as it grows into their senior innovation project, as part of the required curriculum for graduation.

References:

[1] The Mathematical Approach in Contemporary Art, Max Bill, http://hebert.kitp.ucsb.edu/studio/a-m/mb-maica.html

[2] University of Advancing Technology: Mission, Vision and Values

Design Architecture By Genetic Algorithm
Short Paper for GA2009

Yibo Xu
Master Of Landscape Architecture
Department of Architecture and Urban Planning, Politecnico Di Milano
e-mail: xybvsxyb@hotmail.com

Abstract

This paper is aimed to apply genetic algorithms in creating architecture forms and establishing a prototype system of such designs. It is divided into four parts. Firstly, the introduction of genetic algorithms and the aims are presented. Secondly, an experiment on designing forms for an architecture project by genetic algorithms is brought forward. The methods and processes would be listed below. It proves that genetic algorithms could not only find the optimized structure for the engineers but also search the 'best' forms for the architects. Thirdly, according to the experiment, a system of how to imply genetic algorithms in designing architectural form is established and explained in detail. This system could be expanded by anyone who could translate the real limitations into genetic representation and fitness functions (modules). Finally, some discussions and conclusions are brought forward.

1. The Introductions:

1.1. The Definition of Genetic Algorithms

The genetic algorithm is perhaps the most well-known of all evolution-based search algorithms. Genetic algorithms were developed by John Holland over twenty-five years ago in an attempt to explain the adaptive processes of natural systems and to design artificial systems based upon these natural systems [1]. In short, the genetic algorithm resembles natural evolution more closely than most other methods.

1.2. The Reason to Use Genetic Algorithm

Evolution is the best designer in the world. For millions of years, designs have been evolved in nature. Biological designs that far exceed any human designs in terms of complexity, performance, and efficiency are rich throughout the living world. From the near-perfection of the streamlined shape of a shark, to the extraordinary molecular structure of a virus, every living thing is a marvel of evolved design.

Genetic algorithm, as the method most closely to natural evolution, gives human design a chance to imitate the great creative process in order to gain the flexibility and efficiency of evolution when optimizing solutions. When analyzing the process of human design, it constructs new solutions to problems using the best features of existing solutions and evolves over time as genetic algorithm and natural evolution do. Hence, genetic algorithms could be used as the bridge linking the human design and natural evolution, which promote human design into more advanced stage.

The relationship of genetic algorithm, natural evolution and human design could be summarized in *Figure 1.2.*

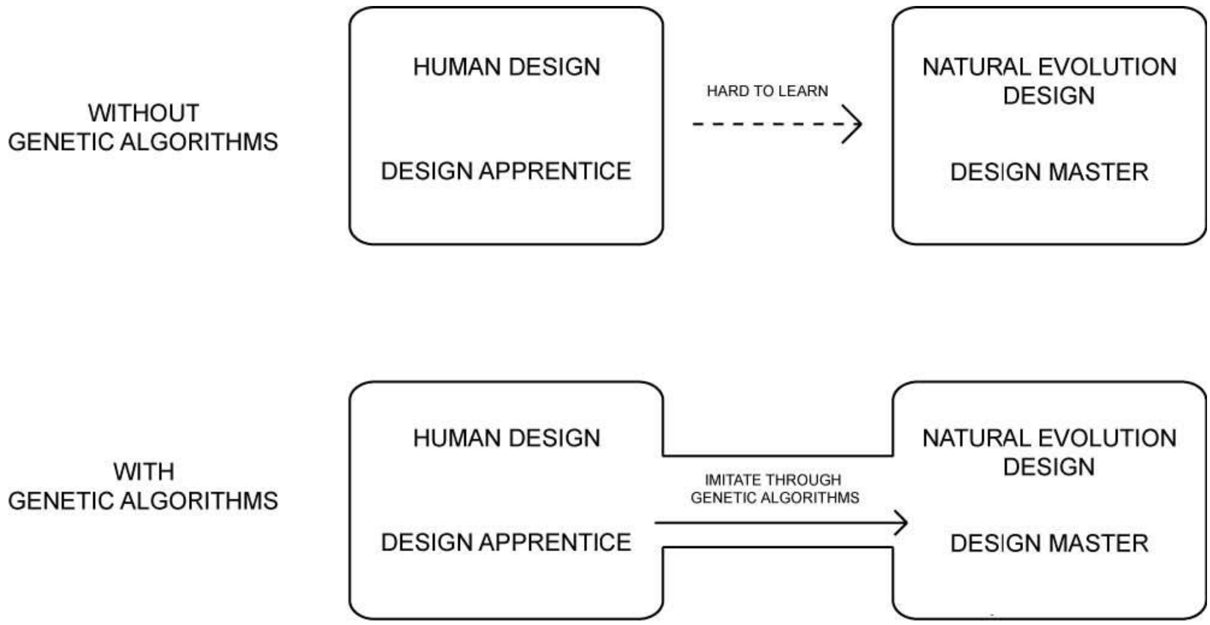


Figure 1.2 Genetic Algorithm is the bridge of Human Design and Natural Evolution

1.3. The Mechanism of Genetic Algorithm

Natural selection ensures that more successful creatures are produced each generation than less successful ones. In the same way, within a genetic algorithm a population of solutions to the problem is maintained, with the 'fittest' solutions being favored for 'reproduction' every generation, during an otherwise random selection process. 'Offspring' are then generated from these fit parents using random crossover and mutation operators, resulting in a new population of fitter solutions. [2]

Coded parameters are normally referred to as genes. A collection of genes in one individual of the population is held internally as a string, and is often referred to as a chromosome. The entire coded parameter set of an individual is known as the genotype, while the solution that the coded parameters define is known as the phenotype.

See Figure 1.3.a

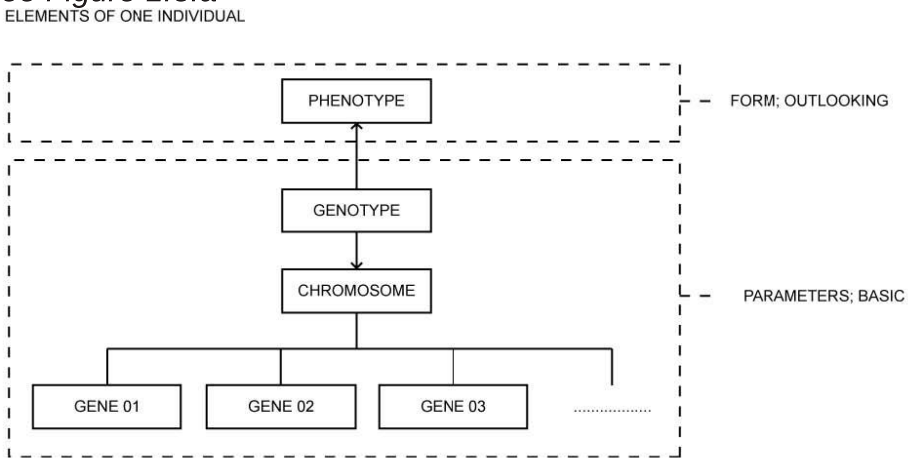


Figure 1.3.a

Typically, populations are initialized with random values by genetic representation, which will translate genotype into phenotype. The main loop of the algorithm then begins, with every member of the population being evaluated and given a fitness value according to how well it fulfills the objective or fitness functions. These scores are then used to determine whether this individual could be placed into a temporary area often termed the 'mating pool' .Two parents are then randomly picked from this area. Offspring are generated by the use of the crossover operator which randomly allocates genes from each parent to each offspring. Mutation is then occassionally applied (with a low probability) to offspring, which is used to keep the variety of the population. When it is used to mutate an individual, typically a single gene is changed randomly. This entire process of evaluation and reproduction then continues until either a satisfactory solution emerges or the genetic algorithm has for run a specified number of generations. [3][4][5].

The simple genetic algorithm is summarized in *Figure 1.3.b*

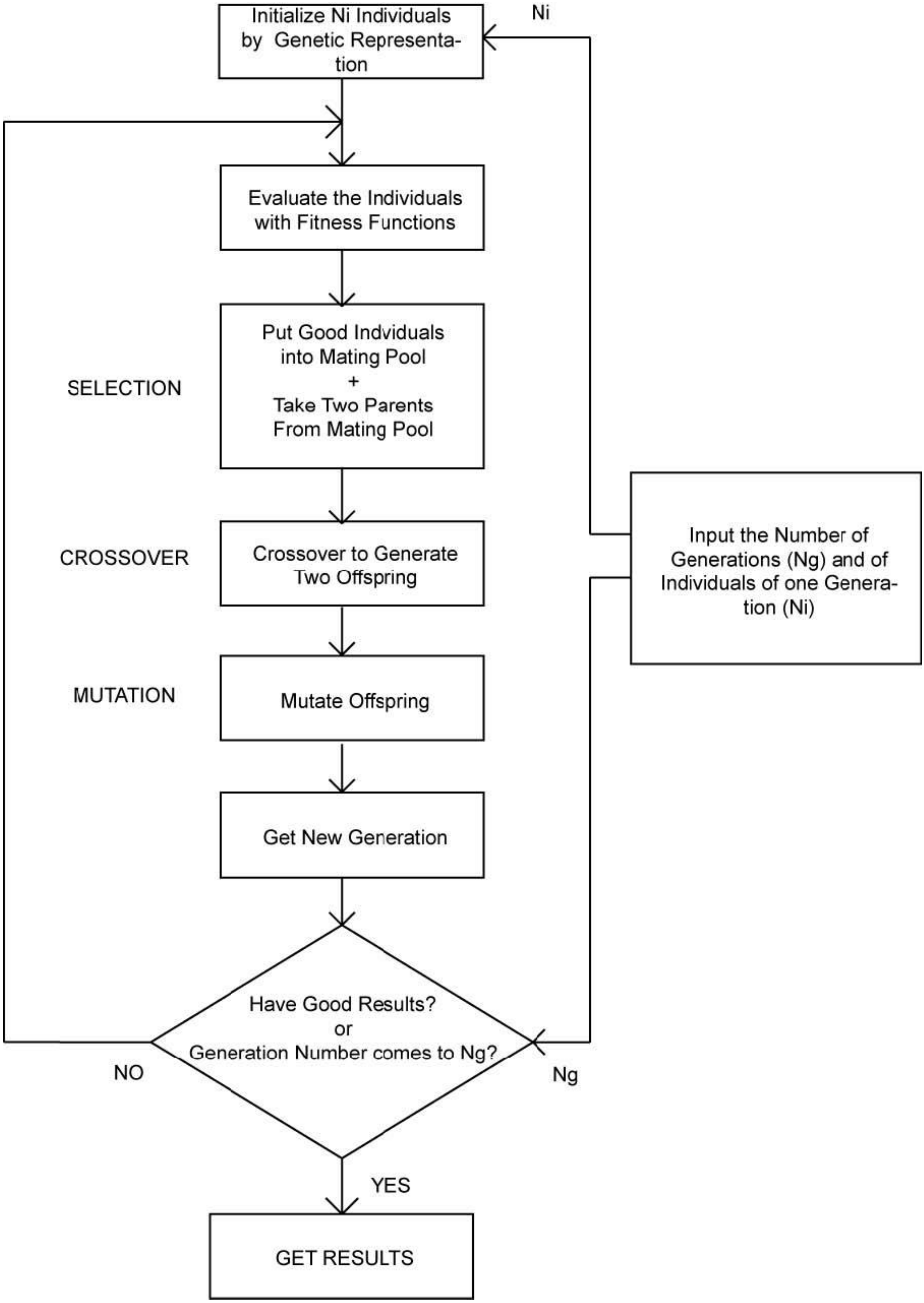


Figure 1.3.b The Structure of A Simple Genetic Algorithm

1.4. The Aim: Apply genetic algorithms in Generative Architecture Design

The last 20 years genetic algorithm is used mostly in the optimization problems. This strong searching method has helped the engineers to optimize the existed technical designs according to the objective requirements. In this paper, we would try to use genetic algorithm to build an automated computer design system to create the design instead of optimizing existed design. Most significantly, the system would not be limited by the 'conventional wisdom' of humans, and could potentially create designs radically different from any produced by a human designer. It could also speed up the design process by automatically providing different designs. [6]

The contents are as following: firstly, with an experiment (designing an architecture project by genetic algorithm), this paper attempts to prove that it is possible to evolve new designs in an architecture project by using the genetic algorithm. Secondly, this paper attempts to develop a prototype, expandable computer system capable of automatically creating new designs by genetic algorithms. Such a system could be used to create designs on its own, or to inspire human designers to try alternative or unconventional designs suggested by the computer.

2. The Experiment:

In order to explain how genetic algorithms work in the process of architecture forms design, an experimental project, a tea house in an old town, would be designed.

2.1. Site Introduction and Limitations:

The site is in Zhu Jia Jiao, a traditional Chinese water town. Rows of wooden buildings were built along the river, which later form the feature 'river street views'. Our building could be any plot along the riverside since this design is face to a type of house instead of a specific house. Siteplan *see Figure 2.1a* [7], Site Situation *Figure 2.1b [8].*

Figure 2.1b [7]
The current situation, the wooden buildings along the river as the river street facade.

Figure 2.1a [7]
The yellow blocks represent the typical wooden houses which could be used as an experiment. The white stripe is the river.

Since the project is in the heart of 'Historical Center', many strict limitations are set by the governors. The most important ones are as following:

1. The maximum of height, width and length of the new building are set as showed in *Figure 2.1c.*
2. The forms of the new building should have relationship with those of the traditional typical wooden houses. *Figure2.1d [9]*
3. The design should meet the required functions.
   a) Entrance 20 sqrmeters
   b) Bar Area 50 sqrmeters
   c) Facility 30 sqrmeters
   d) Tea Area 150 sqrmeters

In fact, more limitations exist besides the ones above. However in order to simplify and pay more attention to the feasibility of the genetic algorithms system, only the crucial points are presented.

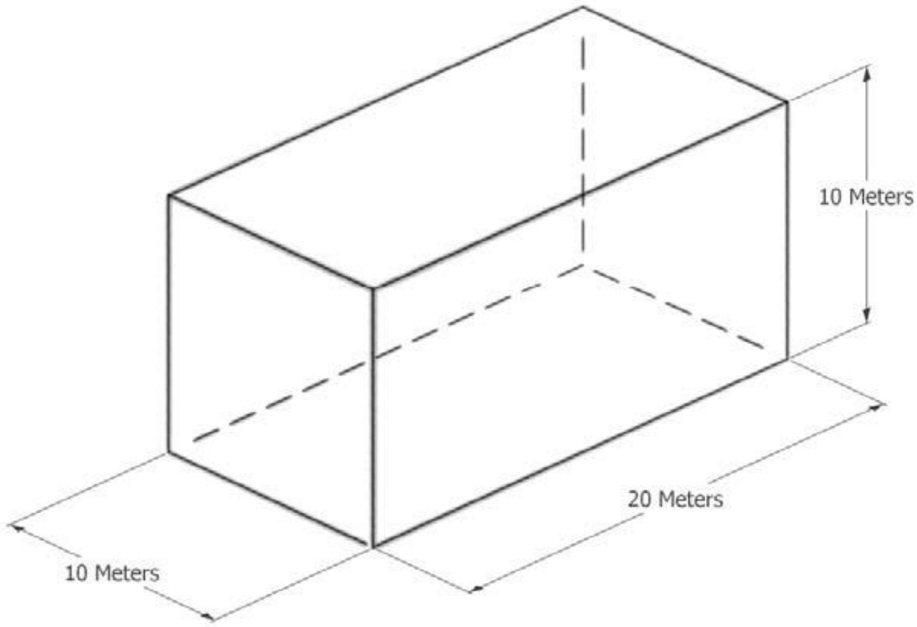


Figure 2.1c.
The limitation of the dimensions
Figure2.1d
Typical Wooden Houses

2.2. Translating Project Limitations to Genetic Algorithms

The most difficult point of using genetic algorithms in architecture design is how to translate the limitations in real project into computer language. Since the translated scripts would be used as the input parameters of genetic algorithms, firstly, we need to understand what kind of input functions genetic algorithms need. Secondly, several steps are presented in order to guide the process of translating limitations.

2.2.1. The Input Functions of Genetic Algorithm: Genetic Representation and Fitness Functions

Typically, a simple genetic algorithm contains two key elements: genetic representation to create the random solutions, fitness functions to evaluate the solutions. The former is the original point that the evolution starts from. The latter is essential for selecting, eliminating and reproducing the ‘good’ solutions. [4]

2.2.2. Steps of Translation:

Firstly, change ‘string’ into ‘number’. Computer can only understand 0 and 1. That means all limitations, whether is originally of quality or of quantity, should be changed into a description that contains only numbers so that it could be translated into computer language easily in the following step.

Secondly, use the basic rules or forms to translate limitations into computer methods. In another word, it is to find the easiest and simplest way to describe the problems in the way computer could understand. For example, if we want to make a ‘1x1x1’ box, several ways could be used. After analyzing, there are at least three basic elements and three basic rules to make the solid. One is to find an array of 8 points and use them to make solid. Or one could find 12 lines and let them to make solid. Or one could find 6 surfaces and then intersect them into a solid. Here we have points, lines and surfaces and their ways to make a box. Which are the basic ones to create a box? Different designers would give diverse answers and the selection could be based on the goals one wants to achieve. However, one could create this box only after when one understands the basic elements and basic forming process behind the ‘appearance’. After knowing the basic rules, it would be easy to create a function that could attain the requested results with the simplest methods. *See Figure 2.2.2*

Thirdly, categorize the functions into the genetic representation or fitness functions. It is hard to differentiate whether the function is the former or the latter. In short, genetic representation will cause probability and diversity while fitness functions will lead to determination and similarity. If all of the limitations are put into fitness functions, it would calculate the solutions since all of them are coming from total randomness (since there is no limitation for the genetic representation, it would output absolute random solutions, which would create laborious works for fitness function). Moreover, the genetic algorithm could be degraded into random search method because of no limitation at the beginning of the calculation. In the other hand, if all the limitations are translated into genetic representation, the system would be too much human-involved since most of the ‘random’ solutions are preset by the human designer. Hence, in order to keep the merits of natural evolution, a balance between these two key elements should be considered.

In conclusion, three steps are set to control the translation:

1. Change all the limitations into number based descriptions so that it could be translated into computer language.
2. Use basic rules, elements or forming process to translate the descriptions into a function of computer methods according to the designers' understanding of the limitations.
3. Put the function into either genetic representation or fitness functions. Moreover a balance between the number of genetic representation and fitness functions should be made.

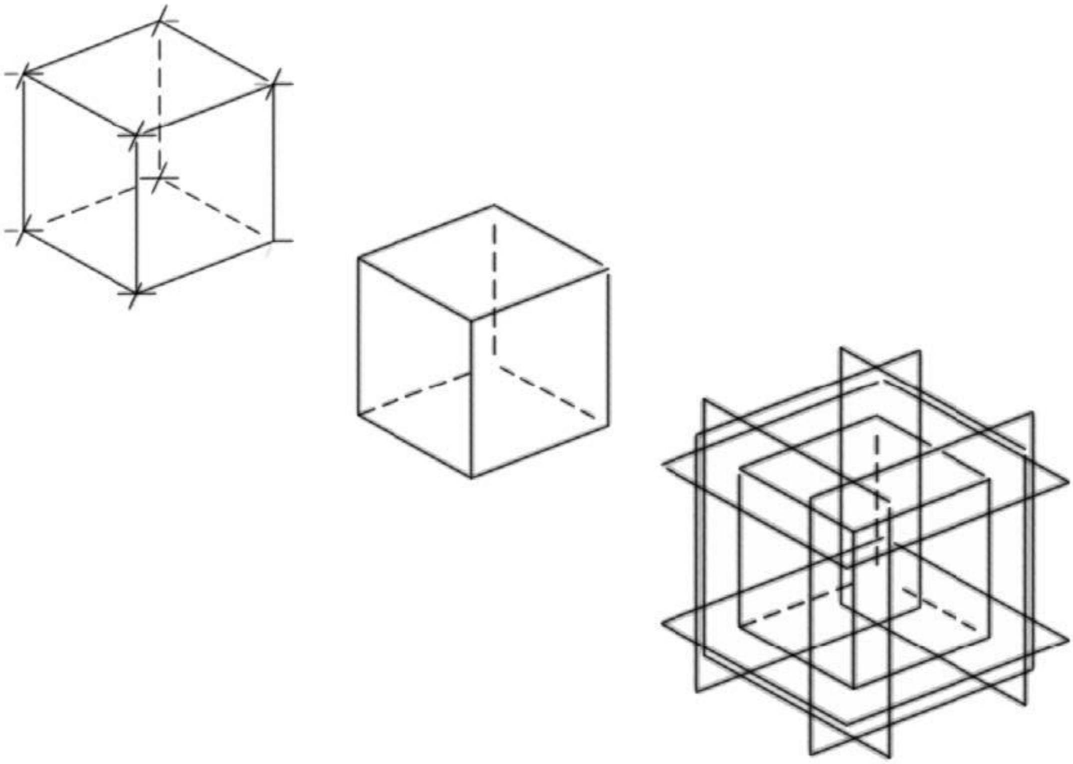


Figure 2.2.2
Three ways of making box. Points, Lines and Surfaces.

2.2.3. Start theTranslation

There are three limitations as mentioned above. The maximum of dimensions of the new building; the new forms should show respects to the typical wooden houses; the design should meet the required functions. Now we would analyze them one by one and try to translate them into genetic representation or fitness functions according to the steps listed above.

2.2.3.1. Limitation1: The Maximum of the Dimensions:

Firstly, since they are numbers which define the upper limits of the function and the limit functions, there is no need to do the first translation.

Secondly, we need to find the simplest rule to describe the 'maximum'. Sometimes, design process is a game of adding and subtracting. If we think of this problem as 'subtract volumes from the existing box', the problem would be much easier than adding volumes. The action of subtracting assures that the final dimensions of the building must be inside the 'maximum'. Otherwise, it could be complicated to calculate every random generated points or curves whether they are under the 'maximum', which could cause enormous calculations.

Thirdly, the limitations could be put into either genetic representation or fitness functions. If the former, the computer would generate the initial solutions with the dimensions that under the 'maximum'. If the latter, the computer would first generate forms with random dimensions and then fitness functions come and use the 'dimension limits' function to eliminate and select the solutions.

In this problem, since the limits of the dimension are set by the urban design laws of old historical district. No solutions could escape the limitations. So, it would be more efficient and easier to translate this limit into genetic representation. Hence, at the beginning of the genetic representation, a box of the set dimensions is created as the 'Drawing Paper'.

As a result, the final translated function would be like this: The genetic representation makes a parameter-set box. With this function, it is not necessary to find another fitness function to judge the dimensions of the solutions. This optimizes the whole system.

We call it Character 1 (C1), and the center point of the box is assigned as original point (0,0,0). *See Figure 2.2.3.1*

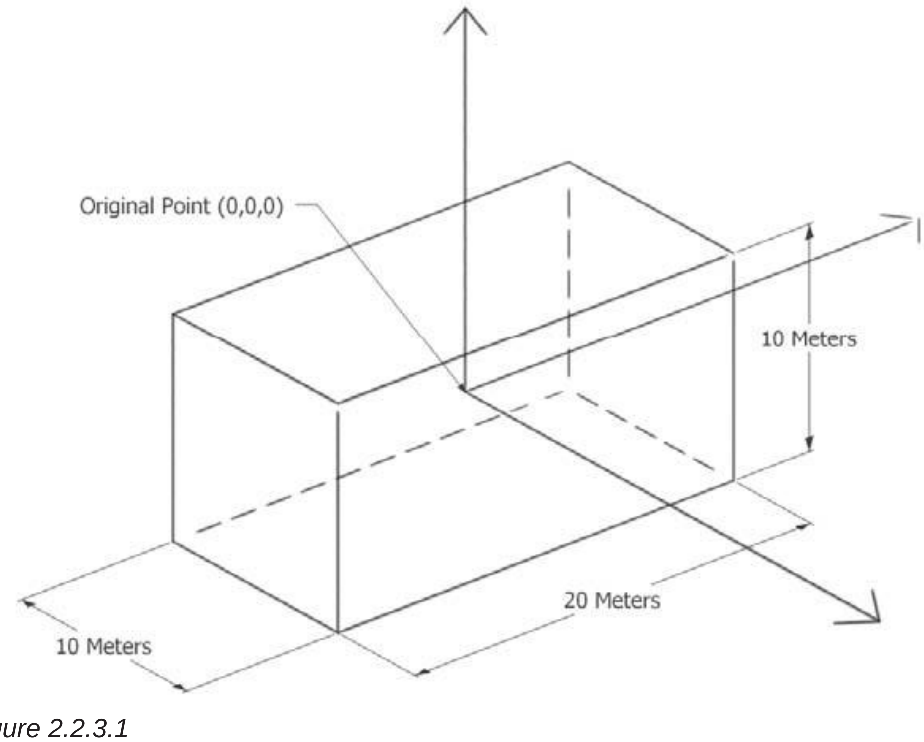


Figure 2.2.3.1
Character 1, Original Box

2.2.3.2. Limitation2: Show Respects to Traditional Buildings

This part is based on the designers' understanding of 'what are the characters of traditional Chinese wooden houses'. In this paper we could not discuss this huge problem deeply. The basic and simplest characters presented below are from the writer's personal opinion. Meanwhile, the feasibility to be translated into quantities is another evaluation that needs to be considered in the process of finding the characters.

Firstly, since there is no number based characters existing (hope someone could write a book about this, which would surly promote the generative architecture design in the domain of merging the tradition and modernity), we need to find some rules behind the traditional shape.

When analyzing a row of the traditional wooden houses along a street, one character is important that all the houses consist of 4 faces: front, back, front roof and back roof. The right and left side are not taken into consideration because they are the common walls shared with the neighbor (built of bricks in order to prevent the spread of the fire), which could not be changed in this project. *See Figure 2.2.3.2a*

Another character is a common rule that Chinese traditional buildings always have roofs. In this problem, the building needs to have at least 2 roofs. [10]
Hence, 2 number based characters are translated.

Character2 (C2), the house needs to have 4 faces (at least).
Character3 (C3), the house needs to have 2 roofs (at least).

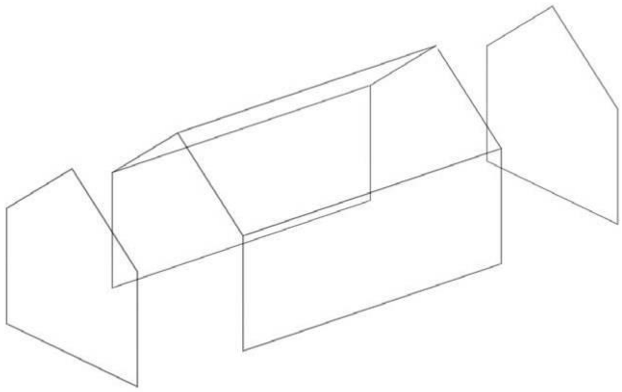


Figure 2.2.3.2a
The basic elements, four faces.With two unmovable walls

Secondly, establish the simplest ways and forms to realize the characters (C2 and C3 together since they could be formed in one action).There are many ways to create the faces. However the best way is that needs the least parameters to control the action. Since the action is subtracting and cutting, it could be considered as defining the position of the cutters. Here are several ways to control the position of the plane. First, get three points and generate the plan through them. Second, get the angles of the plan between XOY and XOZ and get the perpendicular distance from the original point. Third, get one point and two lines which cross on that point.

The second choice is the best since the elements it uses could not be subdivided and easy to control. Moreover, only two angles and one length are needed to make a plan. For the first choice, it's easy to get three points but every point is an array of (x, y, z). That is to say nine parameters are needed to form a plan. The third choice could be subdivided because the lines need to be formed by 2 points first. Actually it needs 4 points (12 parameters) to make a plan. As a result, C2 and C3 use the same function to realize themselves. *Figure 2.2.3.2b*

Finally, we would decide which side they need to be put in. For C2, if it is taken as the fitness functions, the computer counts the number of the faces. This could take a lot of time and low the efficiency of the system. Here we put it into the genetic representation. In another word, when the solutions are randomly created, they would already have at least 4 faces. And for C3, it could also be translated as the genetic representation. When the solutions come out, they could have two faces acting as the roofs.

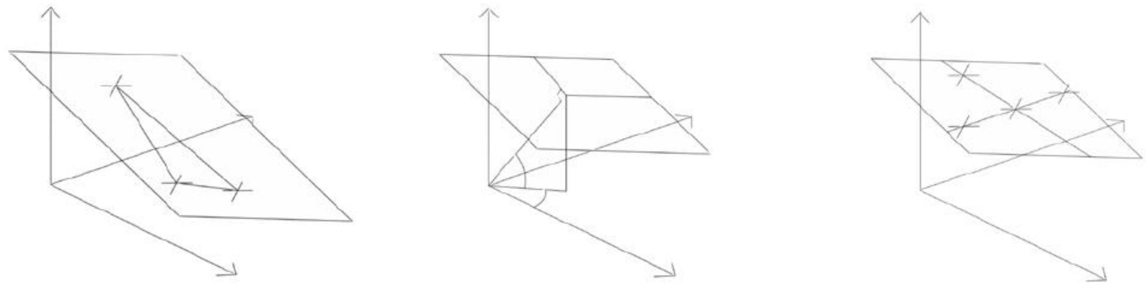


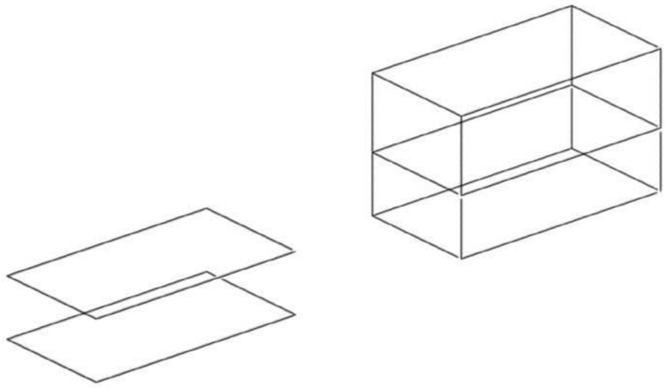
Figure 2.2.3.2b Three ways to make a cutter plan

2.2.3.3. Limitation3: Meet the Functional Requirements

These kinds of limitation are technique and objective so that they are originally number based. The more they are, the more logical the final result would be.
First, the space requirements are listed above. The total sqrmeter needed is 150. It is not necessary to translate it.

Second, the simplest way in this experiment is not to calculate the plan surface and get the square meters since the result we get is the solid instead of surface. The valid space could be taken into consideration. If we calculate the volume instead of the plan surface the problem could be much simplified. So, we translate the square-meters requirement into volumes requirement. This requested volume numbers would be labeled as character4 (C4). *Figure 2.2.3.3*

Third, this requirement is objective and hard to get from the genetic representation (it is much easier to calculate the result to get the parameters) so that it is suitable to be a fitness function. First genetic representation would make the forms. Then this fitness function would check the results. And then we can compare the volume of the results that genetic representation create with the volume requirement to judge whether these results are good or not.



Consider the slope roof, the height of ground floor. The target volume is 1400 m3
200 m2
Figure 2.2.3.3
From sqmeters to volume.
Simplify the process of the computation

Now three limitations are translated into C1, C2, C3, C4 and they categorized into genetic representation or fitness functions. There is no dead rule for categorizing. The only way to differentiate them is to make a balance between human control (determination, preset, genetic representation) and computer control (probability, random, fitness functions).

2.2.4. The Process of the Calculation:

After the translation, now the essential input elements we need to execute the genetic algorithm are ready: C1, C2, C3 are used as genetic representation and C4 is used as fitness function. In the following texts the translation would be put into the process of genetic algorithms. Other basic methods of genetic algorithm, like generation numbers, individual numbers, selecting method, crossover method, mutation method and reproduction method will be discussed.

According to the process mentioned in the introduction part, the steps could be listed as:

1. Input the number of Individuals in one generation and the number of the generation the computer would calculate.
2. Use the genetic representation to initialize the individuals with randomness to get the first generation.
3. Evaluate all individuals by fitness functions to determine their fitness numbers.
4. Select good individuals into ‘Mating Pool’ according to their fitness numbers.
5. Select two parents from ‘Mating Pool’ according to their ranks in the fitness list
6. Use crossover function to generate two new offspring.
7. Randomly mutate the offspring.
8. Get a new generation with new individuals (offspring).
9. Go back to step 3 to start creating a new generation until the number of the generation comes to the set number or the results are satisfying.

2.2.4.1. Step1: Input the Number of Individuals and Generations

The number of individuals decides the scale of the generation. The bigger the scale, the more possibilities the computer creates and the more chance the designer gets unexpected results from the randomness. However, the big scale would also cause enormous calculation. The balance of the speed and quality could be achieved through object-based experiments.

2.2.4.2. Step2: Get the First Generation with Genetic Representation

Before making a huge number of different individuals, we need to know how to create the first individual. The process of making an individual by the genetic representation (which consists of C1, C2, C3) is listed below.

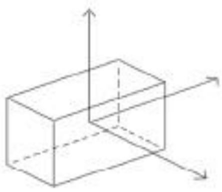
First, take the (0, 0, 0) as the original point. This point would be also the centre point of the original box. *Figure 2.2.4.2a*

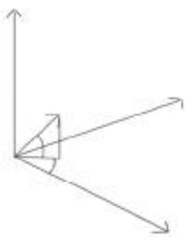
Second, randomly get two angles (Angle1, Angle2, from 0 to 360 degrees) and one vector of which the absolute distance is 1. Then first rotate the vector on XOY with Angle1 and then rotate the vector on YOZ with Angle2. Here, according to the C_, the vector should be more likely to form a roof than an elevation.. In order to create roof, we just need to limit the angles below 180 degrees. (the ratio of the number of roofs to that of elevations is 2 to 1) *Figure 2.2.4.2b*

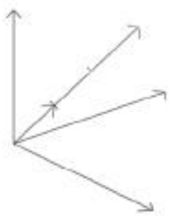
Third, randomly get the distance and multiply the vector with this distance to get the final vector which would control the plan that is perpendicular to it. Since there is possibility that the plan could be generated out of the box (the distance is too big), the error trap is needed. If the plan is out of the box, the distance would be shorted by 50% until the plan touch and cut the box. *Figure 2.2.4.2c Figure 2.2.4.2d*

Finally, the above three steps would be made four times according to C2. After that, the final shape is generated. *Figure 2.2.4.2e, Figure 2.2.4.2f*

Then, computer generates another 'N-1' (N is the number of individuals) individuals using the process above. Hence, a whole generation of N different random individuals is created.







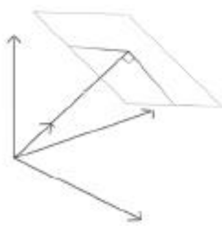


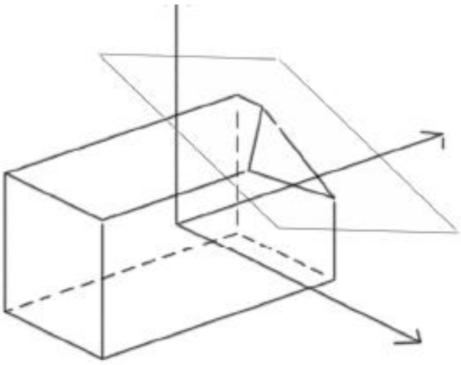
Figure 2.2.4.2a Original Box

Get Vector by angle1 & angle2

Figure 2.2.4.2b

Figure 2.2.4.2c Get the Distance

Figure 2.2.4.2d Get the Perpendicular Cutter Surface



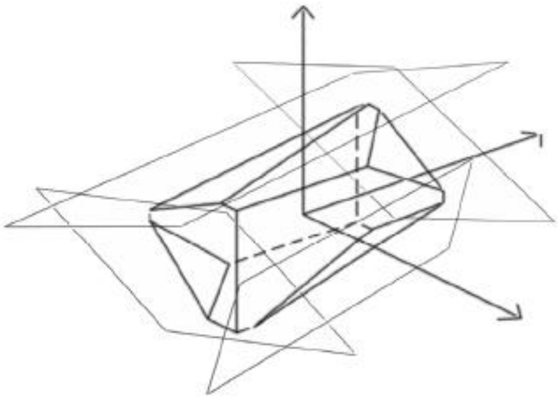


Figure 2.2.4.2e
First Cuting

Figure 2.2.4.2f
Final Form After 4 Cuttings

2.2.4.3. Step3: Evaluate all individuals by fitness functions

The most suitable volume (C4) is translated from the limitation. The closer the volume of individual is to the suitable volume the better this individual is. So, we use the absolute number of ‘individuals’ volume minus best volume’ as the fitness value. The less the fitness value, the more chance this individual would be selected to evolve. After calculating all the individuals, they would be sorted ascending by fitness value.
Fitness Value= absolute Value (Individual Volume – C4 Volume)

2.2.4.4. Step4: Select good individuals into ‘Mating Pool’

Since evolution would eliminate the bad and keep the good, a mating pool is needed to temporarily divide the good and the bad. After sorting ascending the individuals, we put best 50% individuals into the mating pool and delete the rest bad ones. *Figure 2.2.4.4*

	Fitness Value Rank	Individuals
	1	Individual1
	2	Individual2
	3	Individual3
	⋮	⋮
Survived	n/2	Individual n/2
Eliminated	n/2+1	Individual n/2+1
	n/2+2	Individual n/2+2
	⋮	⋮
	n	Individual n

Figure 2.2.4.4

2.2.4.5. Step5: Select two parents from ‘Mating Pool’

One of merits of evolution is that the offspring would keep the good features of the parents so that the generations could be better and better. The process of selection of genetic algorithm is analogous to the maintenance of the good features in natural evolution. Before doing the crossover and mutation method, two parents need to be selected from the mating pools. Up to now, there are many methods that could be used in selection. Here we would use roulette wheel selection, which is one of the most popular and well-studied selection methods. [1]

If fi is the fitness of individual i in population, its probability of being selected is

where N is the number of individuals in the population. While solutions with a higher fitness would be less likely to be eliminated, there is still a chance that they may be. *Figure 2.2.4.5*

$$p_i = \frac{f_i}{\Sigma_{j=1}^{N} f_j}$$

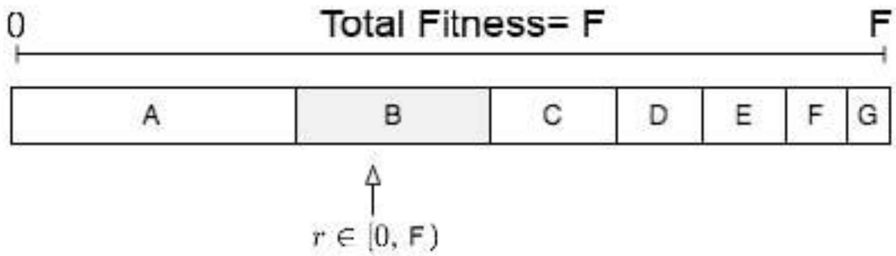


Figure 2.2.4.5 How roulette wheel selection works

2.2.4.6. Step6: Crossover function to generate new offspring

In genetic algorithms, crossover is a genetic operator used to vary the programming of a chromosome or chromosomes from one generation to the next. It is analogous to reproduction and biological crossover, upon which genetic algorithms are based. Here the one-point crossover is used: a single crossover point on both parents' organism strings is selected. All data beyond that point in either organism string is swapped between the two parent organisms. The resulting organisms are the children. See Figure 2.2.4.6a. In this problem, the chromosomes of the individual should be clarified. The tree structure of one individual is listed in Figure 2.2.4.6b. The genes of the two parents are Parent1 (G11, G12, G13, G14) and Parent2 (G21, G22, G23, G24). There are 3 possibilities of the offspring by the one-point crossover method. Figure 2.2.4.6c [3]

The generating of offspring would be ended until the number of the new generation comes to the set generation number.

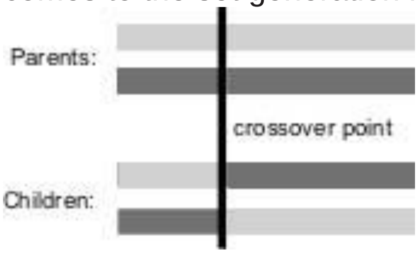


Figure 2.2.4.6a One Point Crossover Method

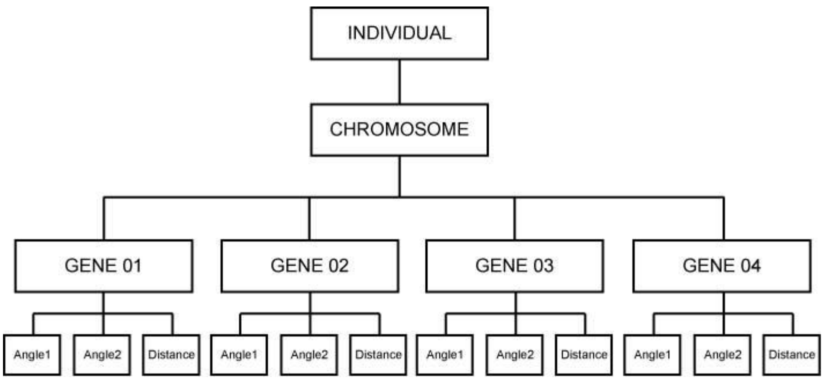


Figure 2.2.4.6b Chromosome Structure of One individual

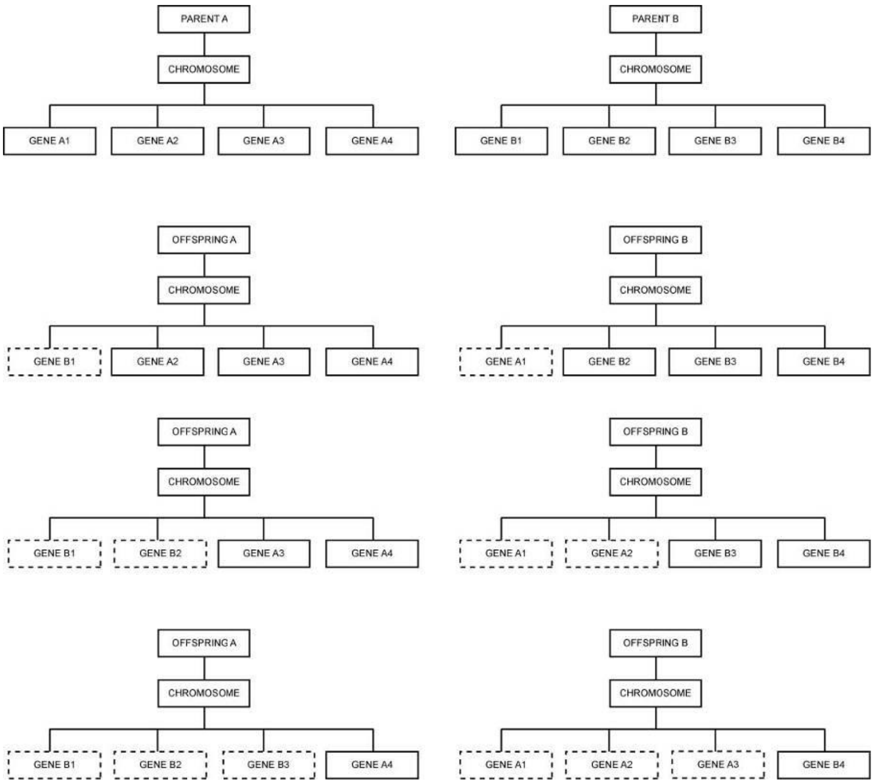


Figure 2.2.4.6c Possibilies of Crossover

2.2.4.7. Step7: Randomly mutate the offspring

The selection and the crossover function would make sure that the good features passed to the next generation. However, the mutation would change the genes of the individuals harshly in order to keep the diversity of the generation. It is analogous to biological mutation. The classic example of a mutation operator involves a probability that an arbitrary bit in a genetic sequence would be changed from its original state. In this problem, the gene of the individual selected to mutation would have the chance to generate a new random parameter. And then the fitness number of this individual would be recalculated. It could be better or worse. However, the purpose of mutation in genetic algorithms is to allow the algorithm to avoid local minima by preventing the population of chromosomes from becoming too similar to each other, thus slowing or even stopping evolution. The action could be seen clearly in *Figure 2.2.4.7* [3]

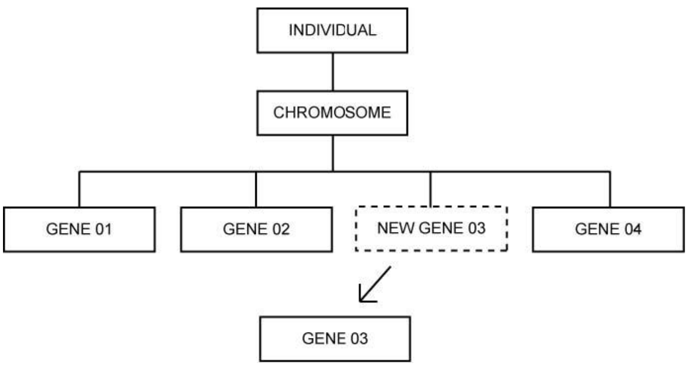


Figure 2.2.4.7
How Mutation Works

2.2.4.8. Step8: Get a new generation with new individuals

After selection, crossover and mutation, the offspring would form a new generation with the set number of individuals.

2.2.4.9. Step9: Start the loop to generate new generations

The step 3 to step 8 is a complete loop for creating a generation. The genetic algorithm could be stopped until the number of the generation comes to the set number or the results are satisfying. The number of the generation is set by the experiment. Moreover, if the results become more similar, that means the genetic algorithm comes to convergence and there is no need to continue the calculation. In these two situations, we can end the genetic algorithm.

These steps discussed above use the simple genetic algorithms. According to the objective project, the algorithms could be changed. For some complicated situations, hierarchical genetic algorithms and parallel genetic algorithms could be used.
Except the input number of the individuals and generations, the detailed chart of the 9 steps is the same in *Figure 1.3b.*

2.2.5. Tools to Execute the Calculation

In this experiment, Rhino, Monkey Editor and Microsoft Access would be used to execute the evolution. The advantage and reasons to use them are discussed below.

2.2.5.1. Rhino and Monkey

The most attractive point of Rhino is that it features a scripting language, Rhinoscript, based on the Visual Basic language, which is one of the most popular and basic computer languages in the world. Moreover, Rhino supports methods of free-form NURBS modeling which stimulates the imagination of the designers. [11]

Monkey is a new script editor in Rhino4 which can be used to edit, run, debug and compile scripts. It contains all the standard programmer editor features such as Find/Replace (with regular expressions), multi-document interface, code trees and integrated help files. It was after the publication of MoneyEditor that people could really combine Visual Basic and Rhinoscript to the best. [12]

In short, Rhino and Rhinoscript provides a platform for designer to create generative architecture and Monkey is the bridge linking the Rhinoscript and VBscript. With Monkey, it is much easier to make the advanced algorithms like genetic algorithms.

2.2.5.2. Microsoft Access and SQL

Since the calculation would generate enormous data that store the information of the individuals, a database is needed. In this experiment we use SQL language to link the Rhinoscript and Microsoft Access. Every individual would have _2 parameters: Generation Number, Individual Number, Fitness Number, String of the Final Form, Vector1 (the vector direction that decides the perpendicular plan), Distance1 (the distance of the vector1), Vector2, Distance2, Vector3, Distance3, Vector4, Distance4. This information would be useful in the later scientific analysis and reuse the records. *See Figure 2.2.5.2*

GenerationRecords

Gener	Individual_	FinalForm	Fitness_Nu	Gene1_Dist	Gene2_Dist	Gene3_Dist	Gene4_Distance
1	1	3f0c4daa-c7a0-489b	277.083346058	4.737537	7.401632	6.460533	2.235407
1	2	018407ea-bfdb-484e	116.227162546	7.004696	4.589689	9.677887	8.68152
1	3	528749b7-16e1-4a11	123.644657513	9.550541	6.33927	9.670876	4.425241
1	4	64537d16-2710-4f91	42.1354529482	8.071362	7.282454	3.350143	7.623552
1	5	a84456b5-d14a-4a28	439.214371544	3.507221	2.718313	6.678947	2.323328
1	6	1a2e902e-ef1e-494a	453.874964749	4.473843	3.055906	2.044495	4.156527
1	7	ecdc9d1e-6489-4d0c	342.525857180	9.83353	4.758612	9.753059	7.615824
1	8	d15e5b31-6121-4df4	215.111895377	2.171124	2.877821	8.203568	5.022387
1	9	6dd1d5a4-d649-4f29	420.791779088	3.422169	2.633261	4.464867	4.489008
1	10	a4ded5e7-b25b-45d2	156.066792188	7.044308	6.847685	5.076752	9.443911
1	11	5bb47ba5-039d-49ff	37.4037290934	6.823185	8.158911	7.977333	8.737558
1	12	413b0953-217b-40fb	822.254260647	9.261974	2.5977	2.178574	6.451982
1	13	3a954279-d9d4-4903	47.2982217456	3.131916	4.561392	8.558769	7.656153
1	14	7e27ff62-06b9-4fe8	28.2869342322	4.038357	7.000181	8.742432	9.358858
1	15	2c21c373-ca07-4aae	611.593664434	2.395115	5.949224	7.19294	2.041056
1	16	90fd35f6-4ec6-449b	345.267098234	8.845623	8.886549	9.002701	7.103014
1	17	cfa7f7ca-4b88-431f	141.297296102	3.782948	5.212423	3.530846	7.804255
1	18	6d27479d-4a38-488a	28.0703035856	8.733456	2.162931	3.905182	3.929323
1	19	96a73233-7456-4fea	66.9199952073	6.578373	4.364172	8.361549	9.71406
1	20	450efe41-fa8c-4df2	17.5653268631	3.248852	4.808821	4.295944	4.320086
1	21	7d3cae66-5c9c-49c0	194.415746072	3.218403	6.678762	2.639397	8.538904
1	22	141e4728-337f-43c1	223.201291913	2.167446	7.752439	5.837708	9.612581
1	23	568eaa08-966b-4367	40.8508186653	8.617954	4.185369	6.02137	6.045511
1	24	0f358797-7eda-4001	468.283011804	2.190166	9.401258	4.471878	6.49016

Figure 2.2.5.2 Microsoft Access Database linked with Rhinoscript with SQL

2.2.6. Visualizing the Calculation in Rhino

With the help of Rhino, the results could be visualized parallel to the running of the script. *Figure 2.2.6.*a show how one individual is made according to the script. *Figure 2.2.6.b* shows how N different individuals are generated for the first generation. *Figure 2.2.6.c* displays the final generation.

After M (the number of the generations) generations or the satisfying results are made, the final generation is presented. Since those best features (genes) of the individual would be passed on generation by generation, it is common that some of the features of different individuals are the same in the final generation. That means in this calculation, this gene dominates all along the evolution. *Figure 2.2.6.d*

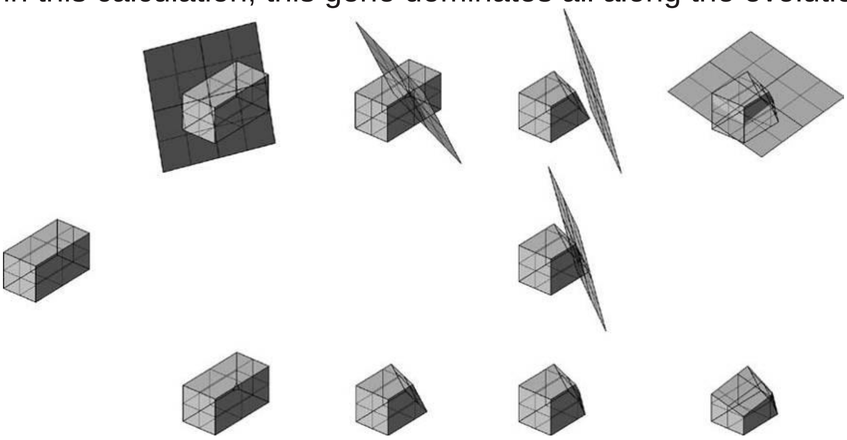


Figure 2.2.6a The Process of Making a Solution Error Trap Original Box

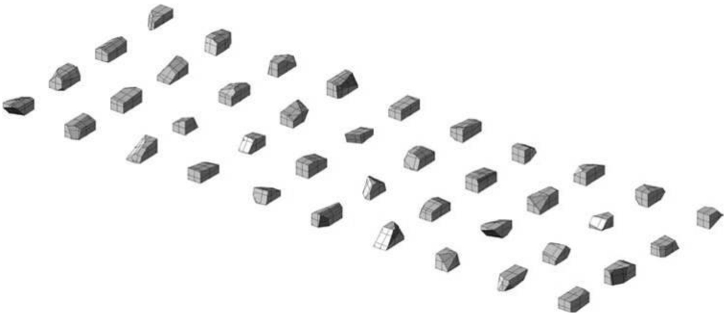


Figure 2.2.6b First Generation With 40 Individuals

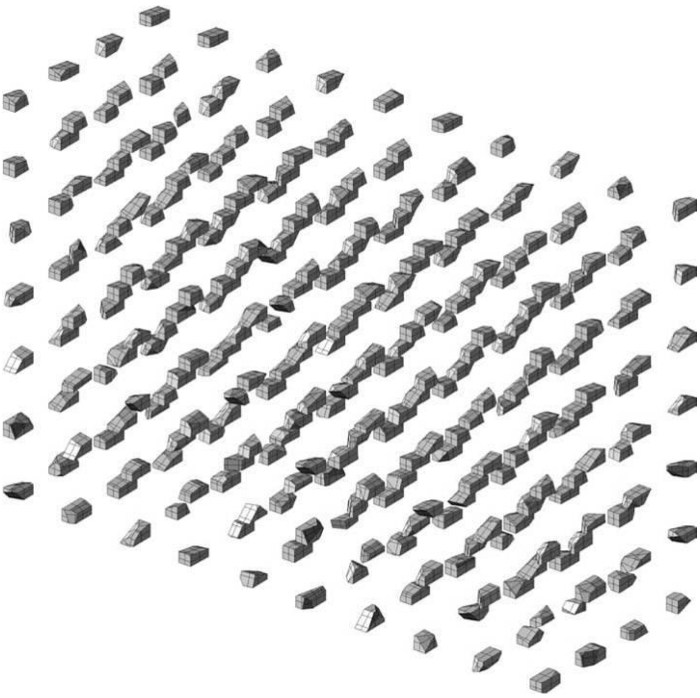


Figure 2.2.6c
After 8 Generations

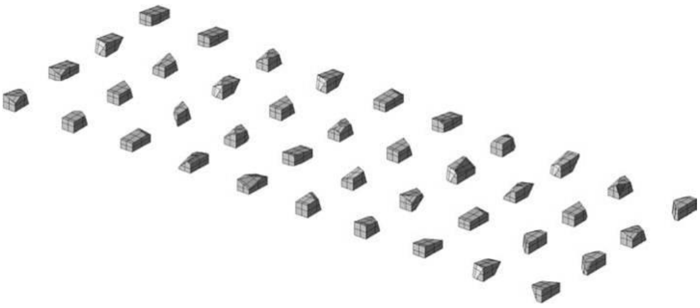


Figure 2.2.6d Final Generation

2.2.7. Final Results:

After running the scripts, the Rhinoscript together with genetic algorithm create hundreds of forms that accord with the limitations we set before. These results are decided by the commands and the limitations so that they are not limited by the empirical ideas of humans. The computer itself creates designs different from any produced by a human designer. Now human designers have hundreds of alternative and unconventional wooden houses suggested by the system.

In this experiment, the results together form a group of project. They should be taken as a whole. Here we will present 9 of the results that the writer prefers.
Figure 2.2.7a

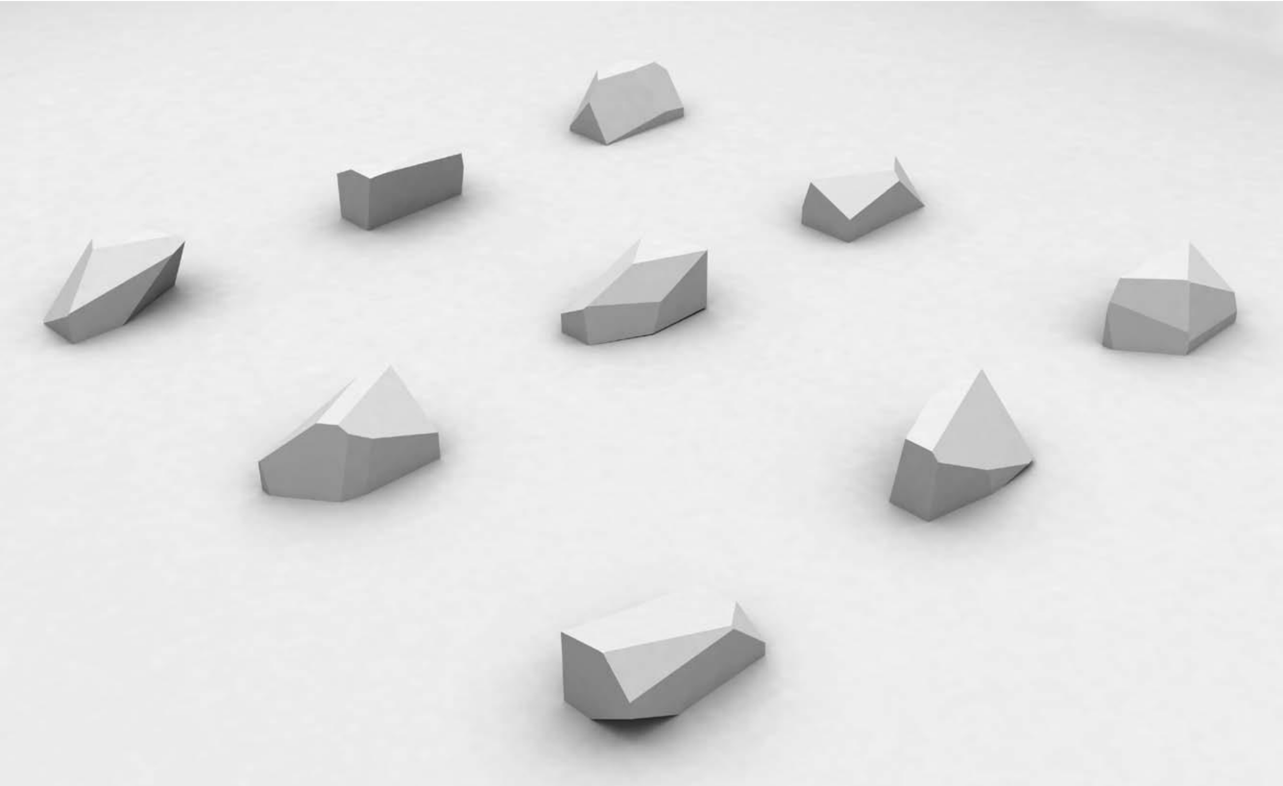


Figure 2.2.7a
Rendered by Vray 1.5, 3DMAX8

It could be imagined that if there are more fitness functions involved into the calculation, the results would be more specific to the certain problems. Meanwhile, the diversity might be still kept because of the mechanism of genetic algorithms so that the user could have lots of alternative solutions.

View From the Back Street Individual 06 is used

View From the Water1 All the Individuals are used

Interior View Of Individual 01 Individual 07 Individual 08

View From the Water Street 2
Individual 07 is used

View From the Water Street 3
Individual 09 is used

3. The System:

With the experiment, the feasibility of genetic algorithm in designing is proved. However, this design is based on a specific situation and the genetic representation and fitness function could not be used directly on other project. In order to apply the system in the other projects, a prototype, expandable computer system capable of automatically creating new designs by genetic algorithms will be developed. The aim of this system is to create designs automatically, or to suggest alternative or unconventional designs to inspire human designers. Since the logics of the system are the same, the software of running the system could be changed to Maya (Mayascript), 3dmax (3dmaxscript), Sketchup (Ruby), etc.

3.1. The Structure of the System

From the experiment, we first analyze the limitations of the project and then translate them into readable parameters for genetic algorithm (the input of genetic algorithm). Second we use computer to evolve the forms by itself by genetic algorithm and get a group of best possible solutions. Finally, we check the solutions and select the ones that are ‘beautiful’ according to personal judgment. Thus, the structure of the system could be divided into three parts:

1. *Analysis and Translations of Current Project*
2. *Run Genetic Algorithms*
3. *Select Solutions from the Suggested Results*

3.1.1. Analysis and Translations

This part is totally human controlled since how one translates the requirements is based on personal judgment. However, the output of this step is the input of the genetic algorithm so that the results of the translation should be categorized to two elements: genetic representation and fitness functions. In order to control the translation, three steps are brought forward. First, change all the limitations into number based descriptions. Second, find the simplest way to explain the descriptions and numbers into computer readable methods. Third, put this function into either genetic representation or fitness functions. To decide the category of a function is to find a balance between computer control and human control. After these steps, the genetic representation and fitness functions are ready.

3.1.2. Run Genetic Algorithms

The two input elements are ready. Now the genetic algorithm will run automatically and design the shapes by itself. First, the number of Individuals in one generation and the number of the generation should be set which decide the scale and the time. Secondly, the genetic representation initialize the individuals to get the first generation. The individuals of the generation then are evaluated by fitness functions so that good individuals could be selected into ‘Mating Pool’. After that, two parents from ‘Mating Pool’ will be selected out to crossover to generate two new offspring. Finally the offspring will mutate randomly to get the next generation. The loop of evolution starts with the evaluation of the new generation.

In this process, there are many methods that could be discussed deeply. After _0 years development, some key methods of genetic algorithm have evolved into different kinds branches. For example, selection method includes roulette wheel selection, stochastic universal sampling, local selection, truncation selection, tournament selection, etc. [13]

In this system, these methods could be changed according to the objective problems.
After calculation, the final generation and the database will be the outputs of the genetic algorithms. These results would be selected and analyzed again by human being.

3.1.3. Select Solutions from the Suggested Results

The computer provides the designers with hundreds of unexpected and unconventional solutions. The final step of the system will give the control back to human being. However, the aesthetic perspectives are different from person to person. The results could be totally ugly for Tom but quite nice for Jack. In this experiment, the computer is a tool to accelerate the design process, to provide the probability within the limitations and to stimulate the designers with strange but suitable solutions. The final decision should be made by human being.

3.2. The Potentiality of the System

The genetic representation and fitness function could be filled with any different characters translated by designers from real requirements to computer based functions (a module). If libraries for these modules of genetic representation and fitness function are established, new designs could be easy for a user to specify, with the additional modules being selected from the libraries. Moreover, anyone who is interested in doing generative design could translate his or her ‘problems’ into functions and put them to this library. Hence, the library is enriched by the public and could be shared through all the researchers. Ideally most design problems should be specified by the user simply selecting a combination of existing function modules. Also, in the process of GA, the selection methods, crossover methods, mutation methods even the whole structure of GA could be changed according to the library of GA methods which is supported by computer technology scientist.

In conclusion, with the help of the GA system and the potentiality of additional modules, a system for generating the forms automatically is possible, a chart that illustrate how this system works is summarized in Figure 3.

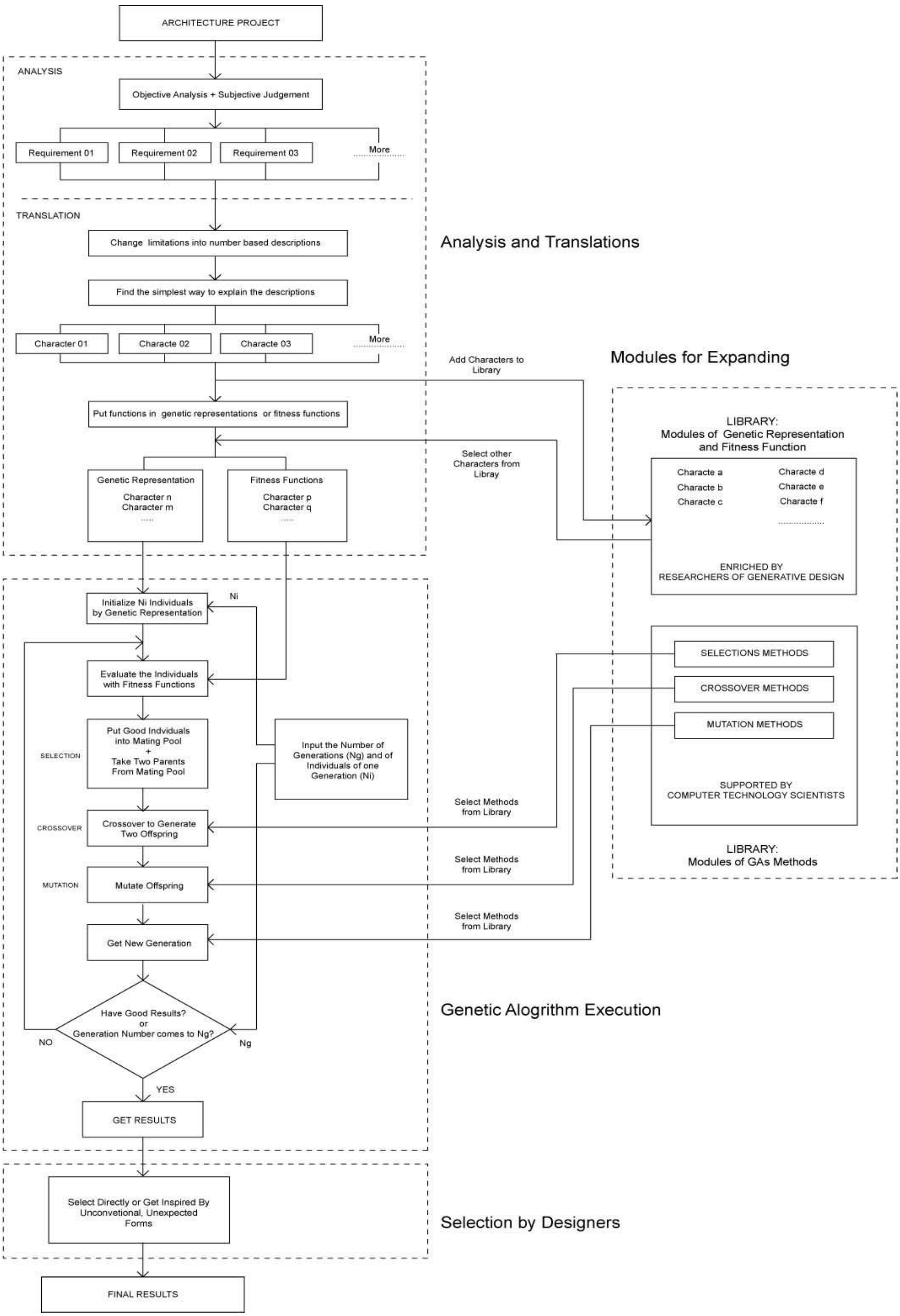


Figure 3 The System

4. Further Discussions and Conclusions

4.1. Categories of Methods in creating generative architecture

Nowadays many methods are used in generative architecture design. There is a common feature in all the generative design methods: the extent that computer is involved into the process of the design. There are two extreme situations: First, totally human controlled. Second, totally computer controlled. The former is like clicking the mouse to draw a line in Autocad, ArchiCAD.etc. The later is like letting the computer generate random parameters without meanings. Now we are in the situation as Terzidis described, 'the shift from computerization to computation'. It's hard to classify every method easily since during the 'shift' methods are mixedly used. [14]

In order to have a general understanding of these methods, _ categories of designs in generative architecture design are presented as following and the key rule to differentiate them is how much extent computer involved.

4.1.1. GUI/CUI Based Design

GUI and CUI means graphic user interference and command user interference. The designer uses the button or command to direct computer to make certain actions. Actually, "entities or processes that are already conceptualized in the designer's mind are entered, manipulated, or stored on a computer system." Terzidis(2008). To make an analogy, the computer is the paper and the mouse is the pen. And people use pens to draw the designs on the paper. [14]

4.1.2. Traditional Algorithms Based Design

Traditional algorithms in design could be described as following:

1. Processes of creating the entities are translated into language (VBA, VB, C++). Computer will generate forms according to the scripts instead of 'mouse clicks'.
2. The computer follows 'a finite sequence of instructions an explicit,procedure for solving a problem'. It could not change or choose the solutions or results by itself.

Most of the generative designs nowadays are made by traditional algorithms like the organic arts made by fractal algorithms, rhinoscript with L-shape method, curve-on-shape method etc. To make another analogy, here we have an automatic machine arm. People design what to draw and then input the instructions into the machine, which will draw the design step-by-step according to the commands.

4.1.3. Evolutionary Algorithms Based Design

'An evolutionary algorithm (EA) is a subset of evolutionary computation, a generic population-based metaheuristic optimization algorithm'. The procedure of evolutionary algorithms is almost the same with that of genetic algorithms, which is discussed above. Several EA methods are listed as following: The Shape Grammar, Genetic Algorithms, Stochastic Algorithms, Cellular Automata (Conway's game of life), etc. People only need to tell computer the limitations and the rules of a goal and it will generate the forms by itself.

The relationship of these three categories is summarized in Figure 4.1

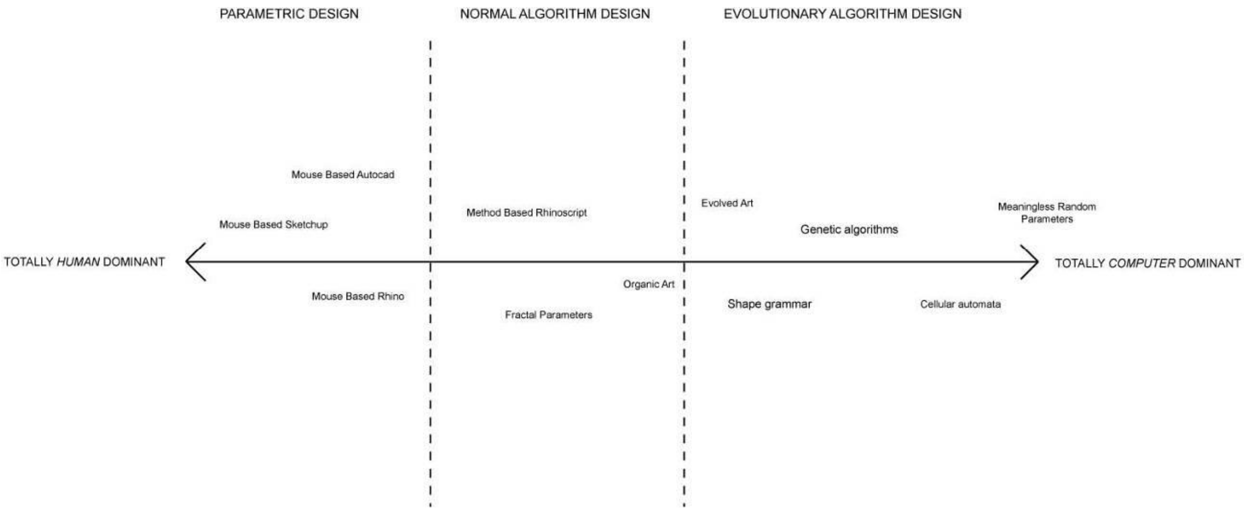


Figure 4.1 The Category

4.2. Intended Capabilities of the System

In the end, the capability of the proposed evolutionary design system is listed below

4.2.1. Evolve designs from a combination of random and user-specified initial values

By initializing the first population of the genetic algorithm with random designs according the genetic representation, the proposed system will be given freedom to evolve any shape that will fulfil the fitness functions. This should allow the system to create novel and potentially unconventional solutions to a design problem.

4.2.2. Solve different design tasks by changing the modules

Designs should be easy for a user to specify, with the modules for genetic representation and fitness functions being required. Ideally most design problems should be specified by the user simply selecting a combination of existing modules from the library.

4.2.3. Evolve designs guided by computer during the process

The system should be able to evolve new designs guided by genetic representation and fitness functions alone. This would not only relieve designers of the tiring task of continuously monitoring the system during evolution, it could also help evolution of more unusual and unconventional ideas. If a human designer guides the evolution of designs by the system, empirical designs will usually be evolved. Preventing human interaction during evolution removes the potential limitation of 'conventional wisdom' from the system.

4.2.4. Evolve useful and innovative designs

The goal of this research is to produce a design system capable of evolving truly useful and innovative solutions to real-world architectural design problems. These designs could either be used directly, or could be used by human designers for inspiration. For this experiment, it is intended that the system should have the ability to successfully evolve acceptable and potentially innovative solutions to architecture form design tasks.

4.3. Conclusions: Design by Evolution

This research has created a conceptual system of generative architecture design by genetic algorithms. This was demonstrated by evolving acceptable designs for a real architectural project.

The system could ’discover’ and independently. The shapes of designs were searched by randomness in order to ensure that they are unconventional and by limitations so that these forms perform the desired function accurately. The less constrained the design problems are, the wider the variety of alternative and sometimes highly unusual design solutions the system evolves.

In conclusion, evolutionary design has been performed in nature for millennia. This research has made the first steps towards using power of natural evolutionary design, by demonstrating that it is possible to use a genetic algorithm to evolve architecture design from scratch, such that they are created to perform desired functions, without any human intervention.

References

[1]. Holland, J. H., (1973). Genetic Algorithms and the optimal allocations of trials. SIAM Journalof Computing 2:2, 88-105.
[2]. Holland, J. H., (1975). Adaptation in Natural and Artificial Systems. The University of Michigan Press, Ann Arbor.
[3].Goldberg, D. E., (1989). Genetic Algorithms in Search, Optimization & Machine Learning. Addison-Wesley.
[4]. Davis, L. (1991). The Handbook of Genetic Algorithms. Van Nostrand Reinhold, New York.
[5]. Fogel, D. B., (1995). Evolutionary Computation: Towards a New Philosophy of Machine Intelligence. IEEE Press.
[6]. Peter John Bentley, (1996). Generic Evolutionary Design of Solid Objects using a Genetic Algorithm. Doctoral Thesis for University of Huddersfield.
[7]. Photo: Satellite of the Site (2009). Position in 31° 6'33.93"N, 121° 2'58.97"E. Image of GeoEye Copyright 2009. Google Earth.
[8]. Photo: Shanghai, Zhu Jia Jiao 2007.05. By blackhumor@126.com. http://www.panoramio.com.
[9]. Photo: The Forgiving Bridge. http://xcw.shqp.gov.cn/gb/content/2005-03/09/content_49801.htm.
[10]. Li Yun He(2005). Design Theory of Chinese Classical Architecture. Tian Jin University Press. ISBN: 7-5618-1902-1.
[11].Description of Rhinoscript and VBA. http://en.wiki.mcneel.com/default.aspx/McNeel/RhinoScript.html.
[12].Description of Monkey. http://en.wiki.mcneel.com/default.aspx/McNeel/MonkeyForRhino4.html.
[13].Wang Xiaoping, Cao Liming(2002). Genetic Algorithm-The Theory, Implication and Software Realization. Xi'an Jiaotong University Press. ISBN: 7-5605-1448-0.
[14]. Kostas Terzidis (2006), Algorithmic Architecture. Elsevier Science & Technology Books. ISBN-13: 9780750667258.

Velocity of Body Movement:

Generating Architectural Space by Musical Paces

ZHANG Yu, PhD candidate
School of Architecture, Tianjin University, Tianjin, China
e-mail: yzhangarch@hotmail.com

REN Sijie
School of Architecture, Tianjin University, Tianjin, China
e-mail: ren_sijie@yahoo.com.cn

Abstract:

While the generative ideas largely broaden our horizon for creating in architecture, music, and other art fields, it could be noticed that, little attention has been paid on the potential possibilities of bonding architecture and music together. Don't we experience the linear sequences that are common both in space and music? In this regard, why not generate architectural spaces by a certain musical, temporal code?

By reinterpreting some early Chinese written accounts (dating from 3rd century BC) on the experience of ritual motion, this paper seeks to explore the ancient sensibilities in a new key, with three strategies weaved into the text.

(1) examining the ancient Chinese attitudes towards the reciprocal relationship between architecture, music, and motion, and taking them in new directions. The velocity of body movement is reconstructed to be central to the perception of architectural space.

(2) contextualizing Chinese literatures with Western sources. For example, the Greek myth as well as a tale narrated by Goethe could contribute to a broader understanding of architectural as "frozen music".

(3) generating architectural spaces by presenting different ways of rhythmic body movement in/through the buildings, where the pace/tempo is shown to be the basic measurement unit in both architecture and music.

1. Introduction

It is well-known that Goethe called architecture "frozen music" and he further told a tale to support his remark. "Imagine Orpheus," said Goethe in 1827, "when he was assigned a great desolate building site, shrewdly settling at the most appropriate spot and forming a large market place all around him by the life-giving music of his lyre."[1] Well, doesn't such a description transmit to us a modern sense, to some extent, of the generative process? An open ground, then a core space to start working, where “an artistic and craftsman-like structure” is automatically shaped in a kind of algorithm composed by certain musical rules. Still, the tale was empty on what those particular rules are. So it remains to seek ways for turning Goethe’s poetic saying such as “the friendly enticement of music” into the algorithm in practice.

One approach is to look at the linear perception that is common both in space and music. In this regard, the *pace* rises to attract attention. A pace could either be a measure of space (as indeed used in different areas of the world), or play a vital role for music, dance and other time arts in the sense of “tempo”. However, it occurred possibly in ancient China that the term “pace” merged the two meanings into one; hence opens up our horizon. The specific methods to generate architecture by music may thus emerge.

2. A Set of Definitions

2.1 original terms

Let us examine some vocabulary entries recorded in *Erya* (Near Correctness), the oldest extant Chinese dictionary (3rd century BC) [2]. A set of definitions that are enormously concerned with pacing could be found in Chapter 5, “*Shigong* (Glosses on Buildings)” (*fig. 1*):

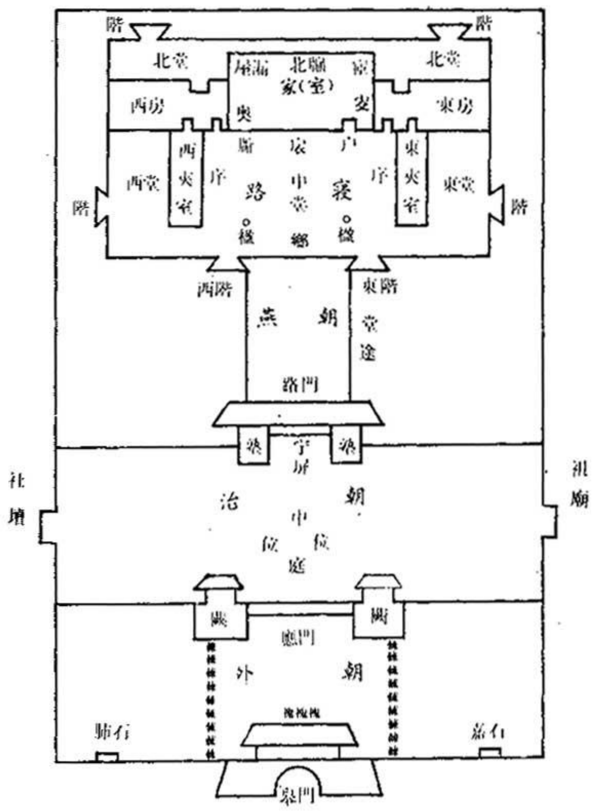


fig. 1 Court plan based on Shigong, Erya, sketched by JIAO Xun (1763-1820), Qunjing Gongshi Tu (Building Illustration of Classics)

1. inside a chamber is called *shi* (a walk but barely move);
2. on a hall in called *xing* (a slow walk);
3. besides a hall is called *bu* (a moderate walk);
4. outside a gate is called *qu* (a brisk walk);
5. in the courtyard is called *zou* (a run);
6. on an avenue is called *ben* (a quick run).

Specifically treating the body movements that occurred in different architectural settings, the above terms seem readily assimilable to our modern understanding, despite of its laconic lexicographical style. However, to make a deeper and better understanding, we'll look into some fundamental conceptions of Chinese architecture.

2.2 An understanding within the context of Chinese architecture

According to Sir Joseph Needham, who had a deep insight into "the spirit of Chinese architecture" [3], the horizontal spaces were the keynote of Chinese buildings. Its fundamental conceptions suggested by him could be summarized here as the following five points:

1. The ground-plan was composed by one or more rectangular courtyards; enlargement is by continual duplication of existing units, and growth in breadth or preferably depth.
2. Each courtyard was rounded by formal grouping of buildings with a marked attention to axis; the courtyard was made a part of the building, and not something additional and separate.
3. In a typical building group, the main hall as the chief building was placed on the rear of the axis, with open galleries on its two sides, and a gate as the entrance to the courtyard.
4. The main hall was based upon a platform; it might occasionally be of two storeys.
5. The circuit started from the gate, passed either across the courtyard or through the connected side galleries, reached the platform and ended in the hall and the chambers inside.

To give these conceptions some historical proofs, a few passages in the earliest existing collection of Chinese poems, the *Shi jing* (Book of Odes, ca. 1100BC-500BC) are worth quoting [4]:

Crowds brought the earth in baskets
They threw it with shouts into the frames;
They beat it with responsive blows;
They pared the walls repeatedly, and they sounded strong.
Five thousand cubits of them arose together,
So that the roll of the great drum did not overpower.
They set up the gate of the enceinte;
And the gate of the enceinte stood high.
They set up the court gate;
And the court gate stood grand.
They reared the great altar,

From which all great movements should proceed.

The above lines recount how people constructed a large composition: the walls around, the gate of the enceinte, the court gate, and the altar (the platform) on the rear. Bearing in mind such a scene, together with the five-point conceptions, we will realize that the before-mentioned six entries concerning the body movements and architectural settings are basically follow a space sequence from the chamber, via the hall, the court and the gate, finally to the avenue – in one word, from the deepest inner to outer places.

2.3 An understanding within the context of ritual music

Another noteworthy point indicated from the above poem is the image of “the great drum”. What is its function while such a musical instrument being fixed on the building site? Taking Needham’s commentary [5] as one reasonable answer, it was the drummers who were setting the rhythm of the working process. If this was indeed true, we may infer a step further: since the music rhythm might accompany the builders’ activities, why not the rhythm itself to act as a generator of the whole structure? [6]

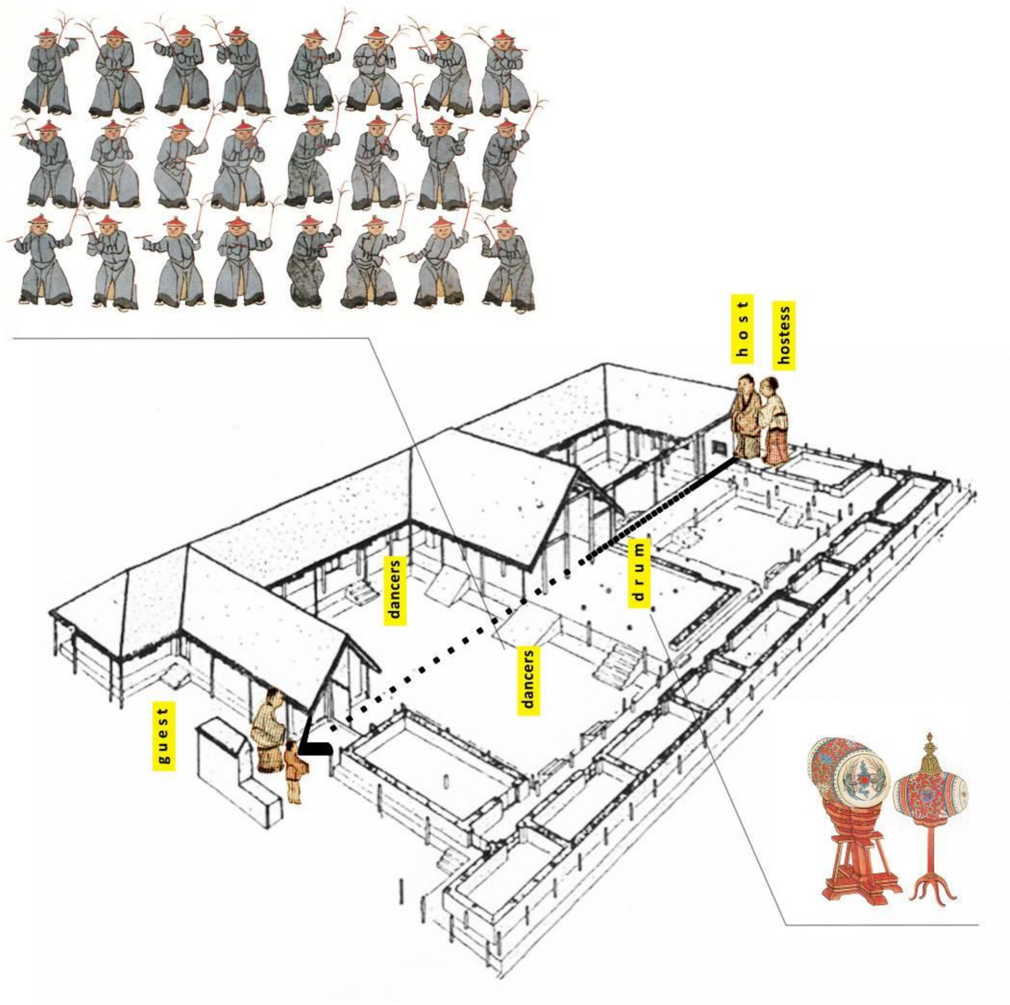


fig. 2 A typical dwelling life for ancient Chinese. The perspective is based on a conceptual restoration draft upon a ruin site dated from ca. 1095 BC

In fact, music played an indispensable role in the ancient Chinese's dwelling life (*fig 2*), yet the issue might be out of the discussion here; simply exploring the six entries about pacing will discover a closely-related musical context. Owning to the traditional textual annotations on the *Erya* and on other early Chinese classics, we may conclude that each entry actually described a kind of velocity of body movement accompanied by a certain tempo, altogether counting quite a few in the architectural settings. As shown in *Table I.*

Table I

architectural setting	**subject**	**pace**	**tempo**
chamber	host & guest	*shi* (a walk but barely move)	*largo*
hall	host & guest	*xing* (a slow walk)	*adagio*
	band	-	-
court	host & guest	*bu* (a moderate walk)	*andante*
	dancers	-	-
	attendant (on vehicle)	*zou* (a run)	*allegro**
outside the court gate	host & guest	*qu* (a brisk walk)	*allegretto*
	attendant (on vehicle)	*ben* (a quick run)	*presto**
outside the enceinte	guest & attendant (on vehicle)	*ben* (a quick run)	*presto**

** The tempos of allegro and presto were made by the small bells tied to the vehicle in motion.*

Here we correspond each of the original Chinese pacing terms with a tempo marking much more familiar to nowadays musicians. Now, it's ready for us to put forward the generative method that adapt well from the ancient set of definitions.

3. The Generative Method

3.1 Building Developing Steps

Taking music as the generator, the whole building group could be developed from its core space to its periphery. The basic steps operate as below:

(1) Set where the host stands as the core space and hence build a platform.

(2) The plan size of the platform depends on the arrays of the band and the dancers.

(3) The band locates at the centre of the platform, while the dancers respectively flank or proceed with them. Since the arrays of the band mark the ground-plan of the hall, the different array patterns of dancers suggest two variations of the plan composition (*fig. 3*).

When everything is in order, the music begins to perform.

(4) The host steps out by a half circle in the velocity of a *largo*, which trait marks the first half plan of the chambers.

(5) The host walks along the court axis in the velocity from an *andante* till an *allegretto*, and thus determine the length of axis from the hall to the enceinte wall.

(6) At the node where the host's velocity shifts between *andante* and *allegretto* sets the court gate.

As mentioned before, the courtyard was made a part of the building, so it's this gate that demarcates the "interior" and the "exterior", as in the *Erya* one of the entries was named "outside a gate".

(7) The host turns back with the guest, thus reaffirming the length of the axis.

(8) In the meantime, it's the attendant driving vehicle who determines the periphery of the enceinte wall in the velocity of a *presto*; and that of the court in an *allegro*.

(9) The guest arriving on the hall steps in by another circle in the velocity of a *largo*, which trait marks the rest half plan of the chambers.

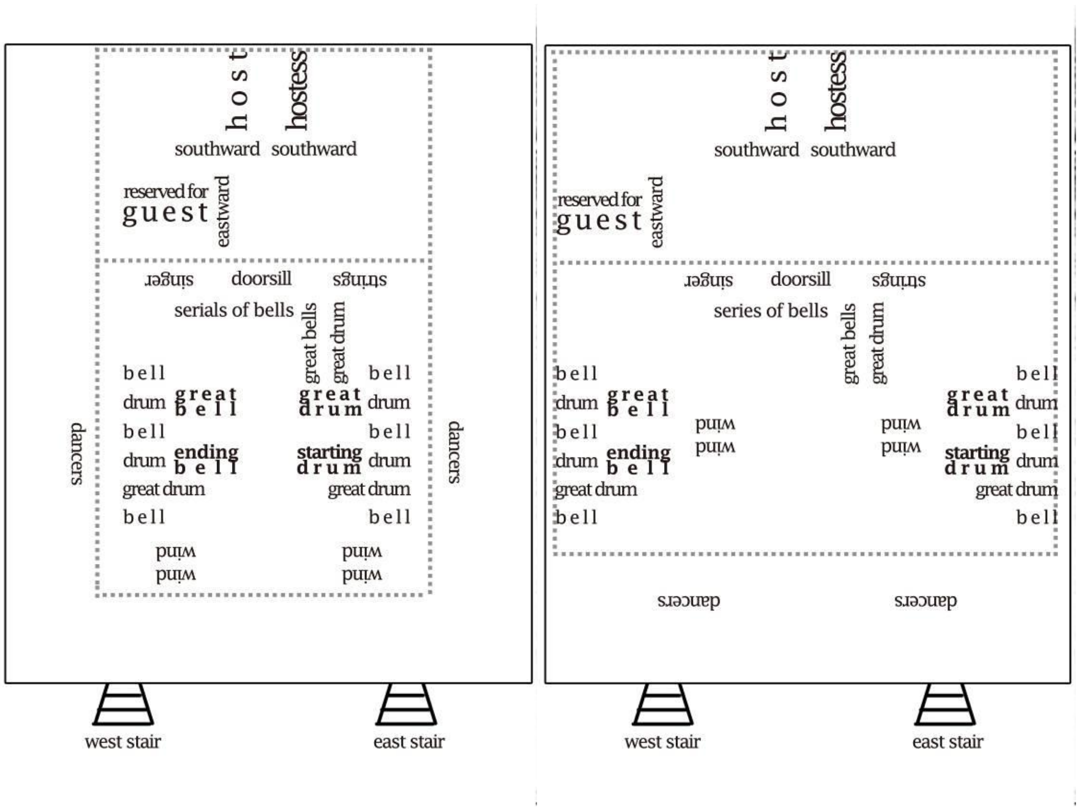


fig. 3 Two variations of plan composition of the hall, chamber, and platform

3. 2 Discussions on Two Variable Parameters

(1) As concerning the performing music, in most occasions, several independent passages may be linked seamlessly, thus sounding like a single one. In this case, we may say that the single continual passage is composed by different "density zones" – with higher or lower number of pace/ tempo per unit of time.

Moreover, due to the characteristics of the traditional Chinese musical notation (*fig. 4*), the music is always played in somewhat undetermined, even "improvisational" tempos. More precisely speaking, the moment when an *andante* shifts to an *allegretto* (from 76-108 bpm to 112-124 bpm) differs in each performance and might be treated totally dissimilar by another performer. Consequently, the location of the court gate, and hence the depth of the court vary in each generative process.

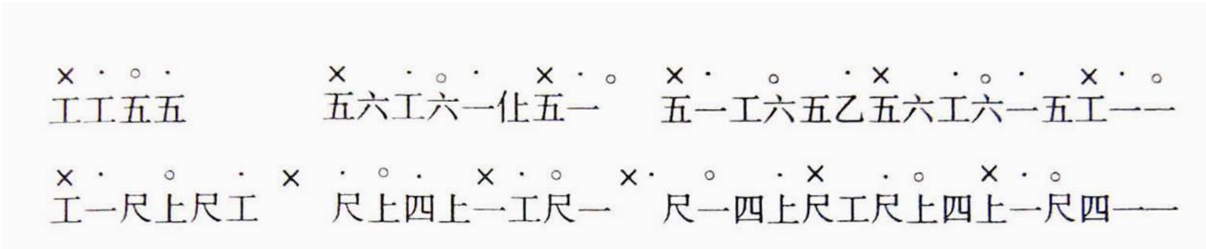


fig.4 A piece of traditional Chinese musical notation, in which the icon "x", "." and "o" act as the tempo markings

(2) There are two discrete sound sources in action simultaneously: the band on the hall, and the small bells tied to the vehicle in motion. The host and guest pace the length of axis from the hall to the court gate, while in the meantime the vehicle measures the perimeter of the court; the length of axis from the court gate to the enceinte gate, as well as the perimeter of the enceinte, are determined in a similar way.

It could be further concluded that, the breadth to depth ratio is variable when determining the court or the enceinte, because the velocity ratios between the pedestrian and the vehicle are unfixed.

3.3 Other Potential Parameters

By far, some parameters existing in the ancient ritual music are still out of our vision. Just to name a few. For one thing, the music melody may repeat two or three times during the ceremony or the meeting, which we may use for generating a main hall of two or three storey (*fig. 5)*. For another, the dancers performed with rhythmic postures, and each posture was designate to a certain meaning corresponding with the lyric of the ritual hymn. So we might further designate one posture with one attribute of a certain architectural element.

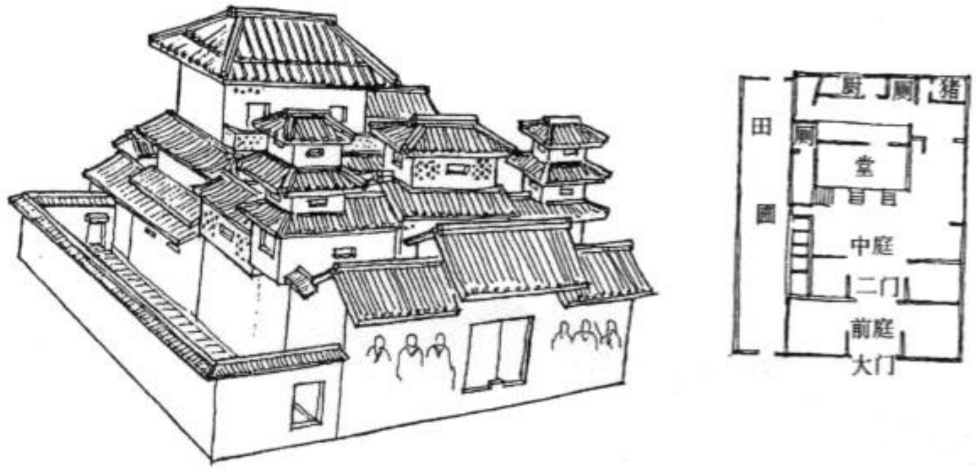


fig. 5 Pottery miniature of a castle with courtyard, 2nd century CE

4. Conclusion

As we have seen, the architectural space could derive from a series of body movements that fit exactly the musical paces. In some sense, the dwelling experience of the ancient Chinese has successfully grafted onto Goethe's tale of Orpheus.

On the generative level, our approach was not really self-contained for machine learning however, the translation method from paces to space remaining mostly qualitative. Since the music pieces, especially those kinds without modern musical notations might hardly make quantitative analysis, thus bringing enormous difficulties for our generative efforts. Anyhow, the study contributes a better understanding to certain architecture and certain music, and how they could benefit from each other. Moreover, the study emphasizes the central role of our bodies on perceiving in both space and time. A further study plan would focus on the collaboration with the computer graphics and the application of the real-time rendering.

References

[1] Johann Wolfgang von Goethe; trans. by Elisabeth Stopp, Peter Hutchinson, *Maxims and reflections* (1998, London: Penguin Classics): pp.143-144. No. 1133.
[2] Bernhard Karlgren concluded that "the major part of its glosses must reasonably date from" the 3rd century BC. Bernhard Karlgren. *"The Early History of the Chou Li and Tzo Chuan Texts". Bulletin of the Museum of Far Eastern Antiquities* 3, 1931: 49.
[3] Sir Joseph Needham. *Science and Civilisation in China*, Vol. 4, Physics and Physical Technology, Part III, Civil Engineering and Nautics (d) Building Technology, Cambridge University Press, 1965: 60-66.
[4] The poem "*Mian*" on the growth of the House of Zhou, *Shijing* III. 1. (No. 237); see James Legge, The Chinese Classics v.4, *The She King* [Shijing]. Hong Kong: Hong Kong University Press, 1960: 439-440.

[5] Needham: 124.
[6] It reminds us the founding myth of the city of Thebes: Amphion and Zethus, the twin sons of Zeus, the former was a great singer and the latter a strong hunter. When they constructed the city's walls, Zethus struggled to carry his stones, while Amphion played his lyre and his stones followed after him and gently glided into place. Edward Tripp. *Crowell's Handbook of Classical Mythology*. New York: Thomas Crowell Company, 1970: 44.

Mechanisms of Generating Mosques Types

University of Mosul- Engineering Collage - Architecture Department
Iraq- Nenava
www.engineering-coll-mosul.com
E-mail : ahmadabdul_wahed@yahoo.com
E-mail : odaychalabi@yahoo.com
Dr. Ahmad A. Thannoon
PhD in Islamic Architecture / Lecturer
Oday Q. ALchalabi
Master in Islamic shape Architecture / Assistant Lecture
www.Generativeshape.com

1-Abstract:

Mosques are one of the religious buildings; their designs and diverse forms reflected the high degree of civilized interaction between cultural values and concepts of Islam and the architectural heritage of the various countries, where the Mosques are built in. This interaction assists in giving birth to mosques models which are characterized by their unity and diversity of forms in each region and elsewhere in the Islamic world. This unity and diversity were caused by the emergence of these models, from one generative type (AL-Masjid AL-Nabawy) the Mosque of the prophet Muhammad in Al-Madina, whose design characteristics (plans, its general and detailed components, materials of building and its construction system, and decorative, and ornamental treatments), represents the basis which the rest of the mosques models in the Islamic world consist of.

It is assumed that the occurrence of operations for generative models from the type mentioned referred to using a variety of methods and mechanisms, which will be investigate in this research through a process of formal analysis of these models and compared with the first generative type.

A group of mosques types of different parts of the Islamic world and of different periods was selected as an intentional sample as each type represents a generation of a new model.

The choosing of these samples based on the fame of the buildings, the abundance of Documentation information's of the buildings, and the fact that it represents a new models delivered from the first generative type.

The research is concluded by referring to a group of methods and mechanisms which were used to achieve the birth operations in addition to identification of the frequently used mechanisms and the percentages of use which will give clear indication for the designers about the most important mechanisms in the birth operations of the new mosques models.

2- Introduction:

Generative art is currently receiving increasing attention for its relation with many modern topics like evolutionary *1Page* systems, genetic algorithms, software art, emergent design and interactive installations and fractal art.

The importance of such topic in architecture in general and mosques architecture in particular lies in its role in examining the development and generation of this architectural types out of its generative type (the Prophet mosque in Al

Madina) in order to fully understand the generation of the new mosques models in each type. The study argues that there are certain mechanisms used in generating new mosques models within each type. It also argues that there is a certain type for using such mechanisms clear through focusing on using some of the mechanisms largely which will provide the contemporary designer with a clear indicator for the importance and weight of each mechanism within the architectural design of new mosques models. Thus, the study aims at revealing such mechanisms used within the generation process of the mosques types and establishing use ratios within each of the mechanisms. The study will start with clarifying the generative type in mosques architecture and its characters to be compared with the generated mosques and reveal the used generated mechanisms then fixing the basic types of mosques to be study. Then studies dealing mechanisms of development and generation of types will be fully examined to make a theoretical frame for such mechanisms to be explored in a detailed practical study.

3-Generative Type of Mosques Architecture and its Main Characteristics:

Recent studies[1-3] dealing with mosques architecture have indicated that Al Masjid Al Nabawi built by the Prophet in Al Madina is the main and base type in constructing other mosques. The designing characteristics of this mosque represented the generative type that other mosques in other parts of the Islamic world resulted from. In this study we summarized the designing characteristics that are mentioned by Thunoon in a previous study [2] for its important in the process of comparing the generative types and reveal the used generative mechanisms: (the general plan of Al Masjid Al Nabawi is a square one (50m×50m) with an area of about (2500m^2) with a horizontal and rectangle oratory towards Kaaba (15m * 50m). There are two corridors enclosing the uncovered mosque. There are nine pillars in the horizontal lines parallel to qiblah and three pillars in the vertical lines towards qiblah. According to the religious architectural terms, the mosque consists of three *bilata* and ten *asakeeb*. Rooms are located along the eastern side, beside the mosque wall. There are three doors for the mosque, located within the northern, eastern and western sides of the mosques. There is also the first model for the minaret like a square mass outside Al Masjid Al Nabawi, as illustrated in Figure (1).

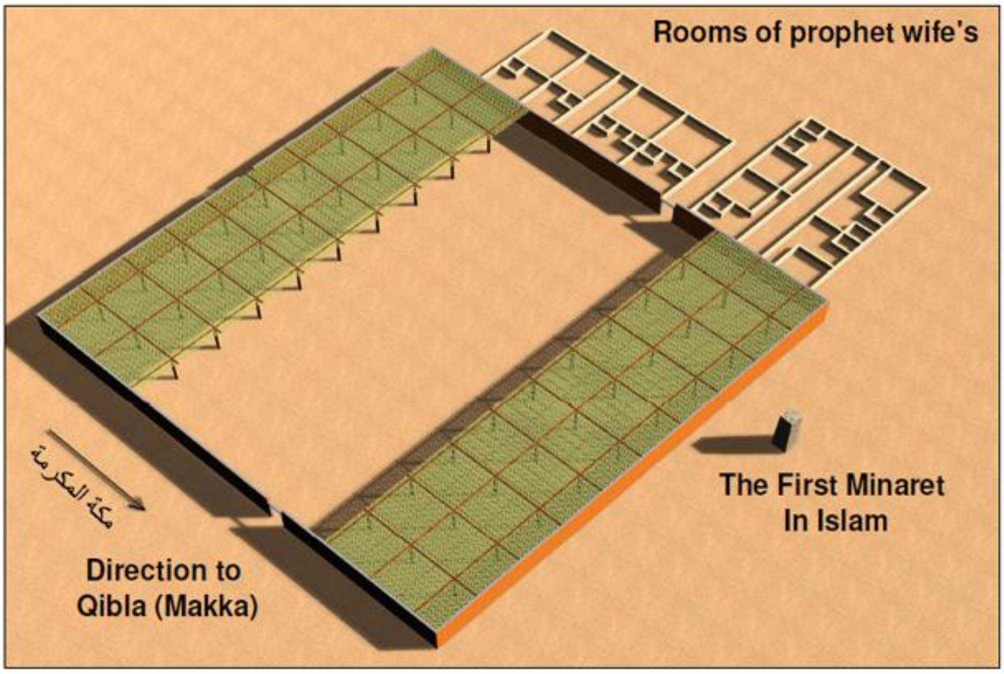
4- Types of Mosques:

Through reviewing the literature that classified mosques[4 -10], similarity among some types are clear despite some differences in naming and classification into minor types, like the Arabic type described by Yaqub Zaki as North Africa and Spain type [6] described by Ardalan as multipillars with being classified into three types [9] while Al Joburi used both descriptions [8] There is also a similarity within the Eywan type described by most of the studies as the Iranian type due to its spread within that area. The Ottoman type is described such in most of the studies except Ardalan where it is described as central dome type [9] and Prochazca where it is classified into two types [7]. In most of the studies, the Seljuk type is combined with the Arabic type except Al Omari [5] and Ardalan where it is classified into two minor types, namely multipillars and multipillars with dome [9]. Prochazca has mentioned eastern south of Asia type despite being affected by the

Chinese buildings [7].

Accordingly, the current study will deal with the following types as the main ones generated from the first type of mosque:

1. The Arabic type.
2. The Eywan type
3. The Seljuk type.
4. The Ottoman type.
5. The Indian type.



AH)[2].

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out of other forms through using certain 3Page mechanisms. Ching indicated that all of the various forms could be understood as being generated from the basic forms (circle, square and triangle). This production of forms is generated from using three mechanisms, dimensional transformations, addition and subtraction [11] (Figure 2). The study then indicated to examples for architectural works generated from basic forms (Figure 3).

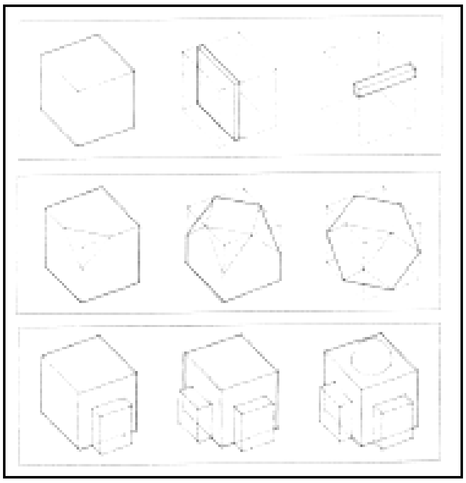

Figure (2)
Generating forms using the mechanisms: dimensional transformations, addition and subtraction [11].

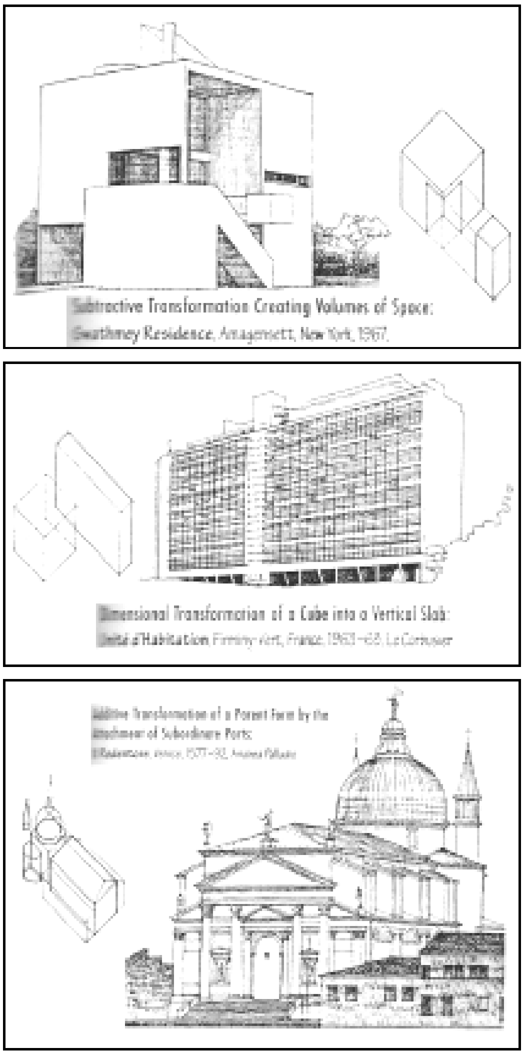

Figure (3)
Architectural works generated from basic forms [11].

Laseau pointed out that transformation within forms and new forms generation could be done through four basic methods: transformations within type, transformations of arabesque bases, reflection and inversion transformations and distortion transformations [12]. The first method is a transformation keeping the form within the same type, despite form differences, through pushing and attraction, like pie transformation into a cup [Figure 4]. The second method is arabesque basics through using four detailed mechanisms: displacement, rotation, reflection and inversion (Figure 5) and the study presented examples for architectural works generated through using this method (Figure 6).

The third method is transformation of the form from the first state into the opposite or vice versa. The study presented some architectural examples like walls and holes, *4Page* construction materials and joints and architectural plans that could be reflected into the opposite. The fourth method is distortion through drawing a network on the plan and then changing some parts of the network through maximizing and minimizing and a new form is generated. This method could be done through using some of projection techniques like 360 degrees perspective.

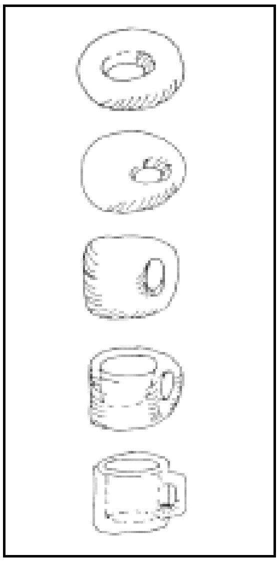

Figure (4) Transformations Within type like pie transformation into a cup [12].

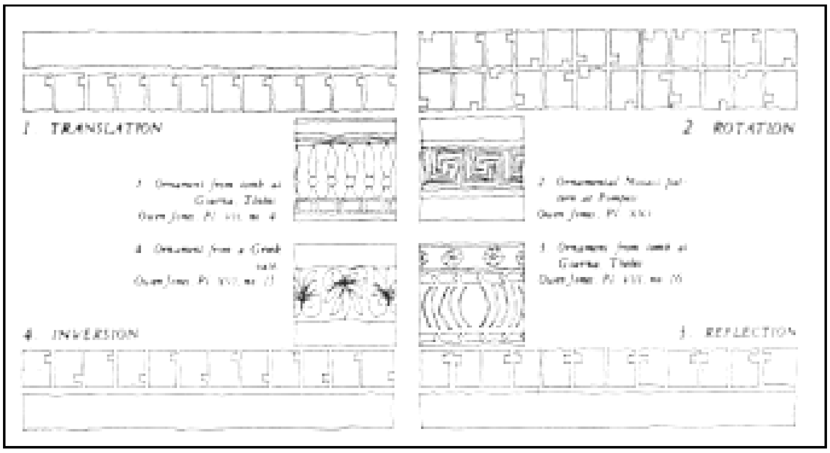

Figure (5) Arabesque basics mechanisms: Displacement, rotation, reflection and inversion [12].

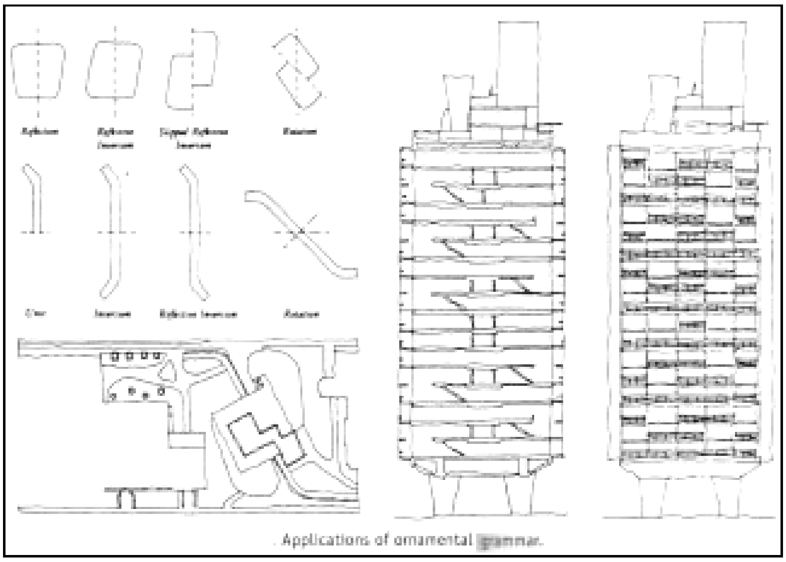

Figure (6) Architectural works generated through using arabesque basics mechanisms [12].

Mitchell indicated two groups of the mechanisms used to achieve transformation and generation within forms. There are conservative or closed transformation within the type done through using mechanisms (displacement, rotation, reflection, Scaling) [13] (Figure 7). There are destructing or open transformations within the type through using mechanisms (destruction, burning, abstraction, stretch, cut, perspective transformation) [13] (Figure 8).

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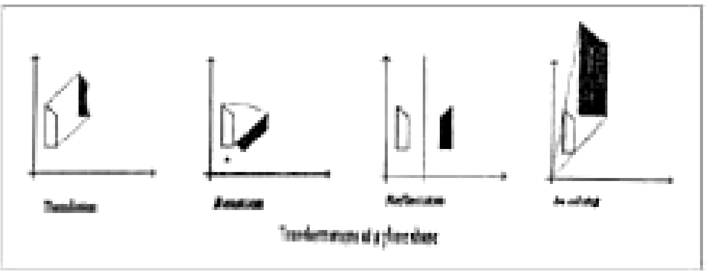

*Figure (7)*Conservative or closed transformation within the type done through using mechanisms (displacement, rotation, reflection, scaling) [13]

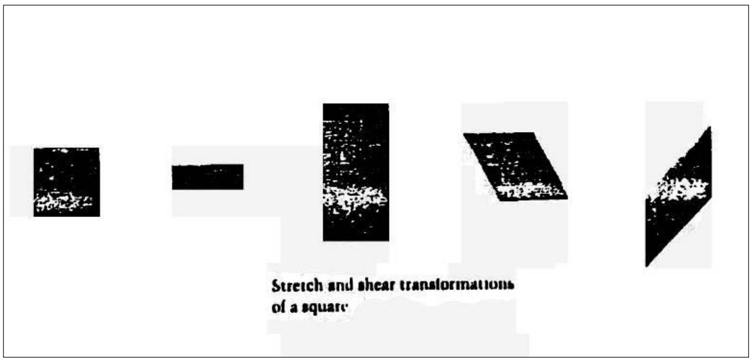

Figure (8)
Destructing or open transformations within the type through using mechanisms (destruction, burning, abstraction, stretch, cut, perspective transformation) [13]

It could be deducted that there are many mechanisms used in realizing transformation and generating new forms that could be classified into two main kinds:

1. Transformation and generation mechanisms where the generated forms are kept within the same type. Dimensional transformations, addition and subtraction, mentioned by Ching, are included within this kind. There are also arabesque basics transformations, displacement, rotation, reflection and inversion, mentioned by Laseaue and displacement, rotation, reflection and Scaling, mentioned by Mitchell.
2. Transformation and generation mechanisms where the generated forms didn't kept within the same type. Deconstruction, burning, abstraction, stretching, cutting and perspective transformation are included as mentioned by Mitchell.

The current study is dealing with models generated from one generated type and the first kind of mechanisms will be selected to avoid repetitions as follows:

1. Displacement.	2. Rotation.
3. Scaling.	4. Reflection and inversion.
5. Dimensional transformations.	6. Addition.
7. Subtraction.	

6- Practical Study:

A practical study will be made in order to realize the study aim and verify the hypothesis according to the following steps:

6–1 Determining The designing characteristics for the Archetype included by the study.

6-2 Selecting samples representing mosque types.

6-3 Performing the practical study using segmentation and formal analysis to examine stages of mosque types development in comparison with the original type of mosque using some drawing software like 3Dmax 10, AutoCAD 2008.

6-4 "Results" Putting down information derive from segmentation and formal analysis within tables for each of the samples and making statistical analysis for establishing mechanisms to be used in addition to ratios of use.

6-1 Determining The designing characteristics for the Archetype included by the study:

There four basic designing **characteristics** of Al Masjid Al Nabawi including plans, general and detailed components, building materials and construction system, decorative and arabesque treatments. Due to the limits of the current study, plan and general and detailed components will be dealt with in the practical study while building materials and construction system, decorative and arabesque treatments will be avoided to be examined later by other studies.

6-2 Selecting samples representing mosque types:

In order to start the practical study, samples representing mosque types, mentioned in paragraph (4), were selected to be represented in three dimensional solids and then to be segmented and formally analyzed. One sample will be selected for each of mosque types because of long procedures of segmentation and formal analysis, thus the total number of samples are five. The architectural and civilized importance of the sample selected in addition to clarity of plans and general components are the main conditions in selecting each of the samples. Accordingly, the samples include the following:

Sample No.1					
Mosque type	mosque Name	City	Time	Reference	Figure
The Arabic type	Al Ummawi mosque	Damascus/ Syria	706-715	Richard Yeomans [14]	

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Sample No.2					
Mosque type	mosque Name	City	Time	Reference	Figure

The Eywan type	Al Shah mosque	Asfahan/ Iran.	1611-1638	Richard Yeomans [14]	

Sample No.3					
Mosque type	mosque Name	City	Time	Reference	Figure
The Seljuk type	Ulu jami mosque	Bursa/ Turkey	1395	Aptullah Kuran[15]	

Sample No.4					
Mosque type	mosque Name	City	Time	Reference	Figure
The Ottoman type	Shah Zada mosqu	Istanbul/ Turkey.	1550-1556	Miles Danby[16]	

Sample No.5					
Mosque type	mosque Name	City	Time	Reference	Figure
The Indian type	Pearl mosque ”Moti Masjid”	Agra/ India	1648-1655	Alexandre Papadopoulo [17]	

6-3 Performing the practical study:

The practical study will be classified into two parts according to the sequence of analysis stages which will be examined as related to the mechanisms used for generation processes out of the Archetype as follows:

1. **Abstracting the Archetype of mosques:**

A formal Abstraction to the Archetype of mosques will be made using 3D Max9 and AutoCAD 2008 software in order to reach the primitive plan which represent the first stage in development and generation processes as shown in Figure (9).

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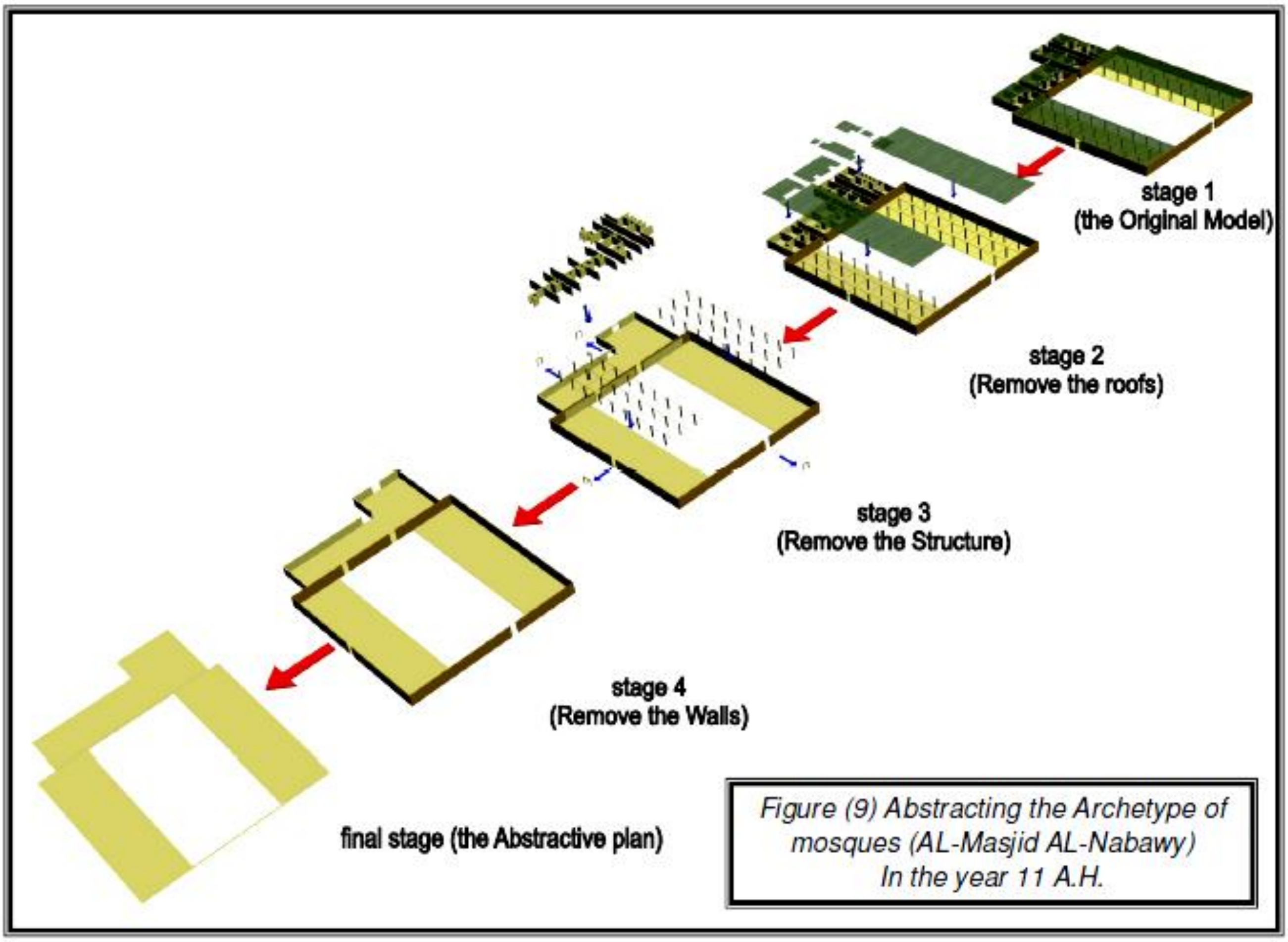

Figure (9) Abstracting the Archetype of mosques (AL-Masjid AL-Nabawy) In the year 11 A.H.

2. **Exploring mechanisms used within mosques type:**

    In order to explore mechanisms used within **mosques type**, three dimensional solid models for the selected samples will be made using 3D Max9 and AutoCAD 2008 software through segmentation and formal analysis to be compared with the Archetype of the mosques in order to explore the mechanisms used in development and generation processes, as shown in Figures (10, 11, 12, 13, 14).

6-4 Results:

The results of the practical study are presented in the attached table Which illustrate the Generating Stages of mosques samples (3-5 stages), beside the mechanisms use in each stage(8 Mechanisms), and the frequency of use for each mechanism, and the Affected Elements by each mechanism in each stage of generation.

7- Final Conclusions:

1- The Study shows that there ware a group of Mosques generating stages ranged between 3-5 stages, as follows: (The plan Generating stage, The Walls & Structure generating stage, The Roofs & Minarets Generating stage), beside the (The Four Eywans Generating stage) and (The general Components Generating stage) in both the Eywan type and the Indian type.
2- In each of the previous stages there were a certain kind of mechanisms used to achieved the presses of generating, the will be mention in a gradually arranged from the most used mechanism to the lower used mechanism in each stage as follow :

2-1 Mechanisms of The plan generating stage :

[Dimensional Mechanism(%33.4), Subtractive mechanism(%25), Rotation Mechanism(%20.8), Additive Mechanism(%12.5), Scale Mechanism(%8.3)].

2-2 Mechanisms of The Walls & Structure generating stage :

[Repetition Mechanism(%25), Additive Mechanism(%25), Structure Change Mechanism(%33.3), Subtractive mechanism(%16.6)].

2-3 Mechanisms of the Roofs & Minarets generating stage :

[Additive Mechanism(%44.4), Repetition Mechanism(%37.03), Structure Change Mechanism(%11.1), Repetition& Scale Mechanism(%7.4).

2-4 Mechanisms of the Four Eywans generating stage :

[Repetition Mechanism (%57.2), Additive Mechanism(%42.8)].

2-5 Mechanisms of the general Components generating stage :

[Additive Mechanism(%75), Structure Change Mechanism(%12.5), Repetition Mechanism(%12.5)].

3-The final Mechanisms which used in all generation stages are (8 Mechanism) arranged in a gradually from the most used mechanism to the lower used mechanism as follows :

Additive Mechanism(%35.3), Repetition Mechanism(%25.6), Dimensional Mechanism(%9.7), Subtractive mechanism(%9.7), Structure Change Mechanism(%8.5), Rotation Mechanism(%6), Scale Mechanism(%2.4), Repetition& Scale Mechanism(%2.4).

11-Reference:

[1] *Al ‘Umarī, Hafsa Ramzī, “ **Athar al- Dīn al- Islamī ‘Ala Tashkīl Anmat Abniyat al- ‘Umrán** “, unpublished PhD Theses, Baghdad University, Iraq, 2000, [[p. 130, 144, 169].*

[2] *Thanoon, Ahmad ‘Abdulwahid, “ **Dawr al-Takayyuf fī Tatawur ‘Imarat al-Masajid**”, unpublished PhD Theses, University of Technology, Iraq, 2009, [p. 202,* 105–106]

[3] *Mu‘nis, Husayn, “ **al- Masajid**”, ‘alam al- Ma‘rifa , Kuwait 1999, [p. 53, 102, 106].*

[4] *Shafi‘ī, Farid , “ **al- ‘imara al- ‘arabiyya Fi Misr Al- Islamiyya / ásr al- Willat** ”, Vol.1, al-Hay‘a al- Misriyya al- ‘amma lilta’lif wa al- Nashir, Cairo, 1970,[p. 237–248]*

[5] *Al ‘Umarī, Hafsa Ramzī, “**‘imarat al- Masajid al- Haditha Fi al- ‘iraq ”**, unpublished M.A Theses, Baghdad University, Iraq, 1988, [p9–10].*

[6] *Michell , George and others," **Architecture of The Islamic World**", Thames and Hudson Ltd., London, 1978. [p. 18]*

[7] *Prochazka, Amjad Bohumil," **Mosques** ", Muslim Architecture Program, Zurich, 1986. [p. 5]*

[8] *Al-Jiburi, Sam‘an Majid Yás, “**Al- Khasa’is al- Handasiyya Fi al-‘Imára al-Islamiyya**”, unpublished M.A Theses, University of Technology, Iraq,1988,[p.58–59].*

[9] *Ardalan, Nader, “**The Visual Language of Symbolic Form**, preliminary Study of Mosque Architecture”, in “ Architecture as Symbol and Self –Identity”, The Aga Khan Award for Architecture, Philadelphia, 1980.[p. 21–23].*

[10] *Thwyn, ‘Ali ,” **Mu‘jam ‘Imarat al- Shu‘ub al- Islamiyya**”, 1st ed, Bayit al-Hikma, Baghdad, Iraq, 2005, [p. 693].*

[11] *Francis D.K. Ching, “**Architecture Form, Space , and Order**”, John Wiley & Sons, INC 2nd edition, America, 1996, p. 48,49.*

[12] *Laseau, Paul,” **Graphic Thinking for Architects & Designers**”, 3rd Ed, John Wiley & Sons, Inc, New York, 2001, p. 118,119,120,121.*

[13] *Mitchell, William J., “ **The Logic Of Architecture** ,Design, computation, And Cognition”, 3rd Ed , The MIT Press, London, 1992,.* p. 112–116.

[14] *Yeomans, Richard, " **The Story of Islamic Architecture** ", Garnet publishing ltd, Reading, UK, 1999, p 35,192.*

[15] *Kuran Aptullah, “ **The Mosque in early Ottoman Architecture**”, University Chicago press, Chicago and London, 1968.*

[16] *Danby, Miles, " **The Fires of Excellence** Spanish and Portuguese Oriental Architecture", Garnet publishing ltd, UK, 1997.*

[17] Papadopoulo, Alexandre, “ **Islam and Muslim Art**”, Harry N. Abrams, Inc., Publishers, New York, 1979.

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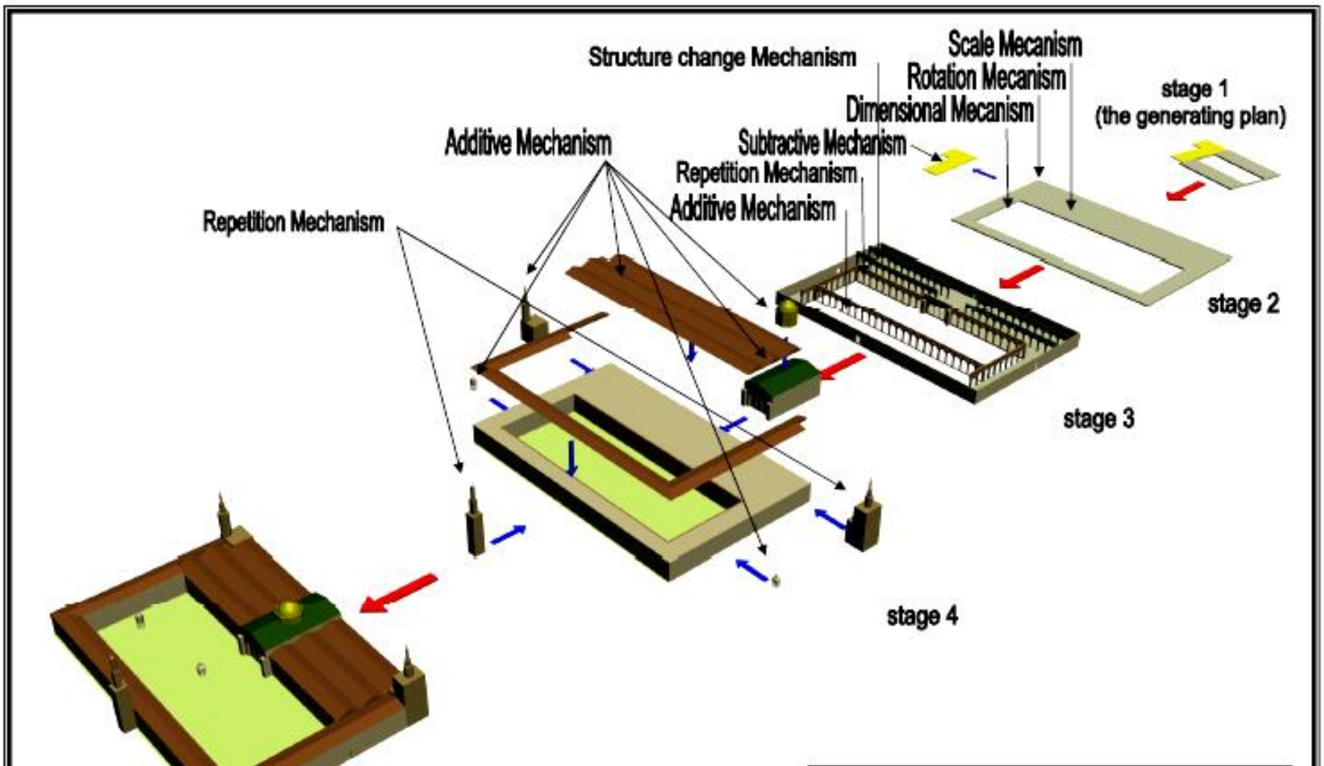

Figure (10) illustrate the Mechanism of generating Arabic type/ Damascus Great Mosque

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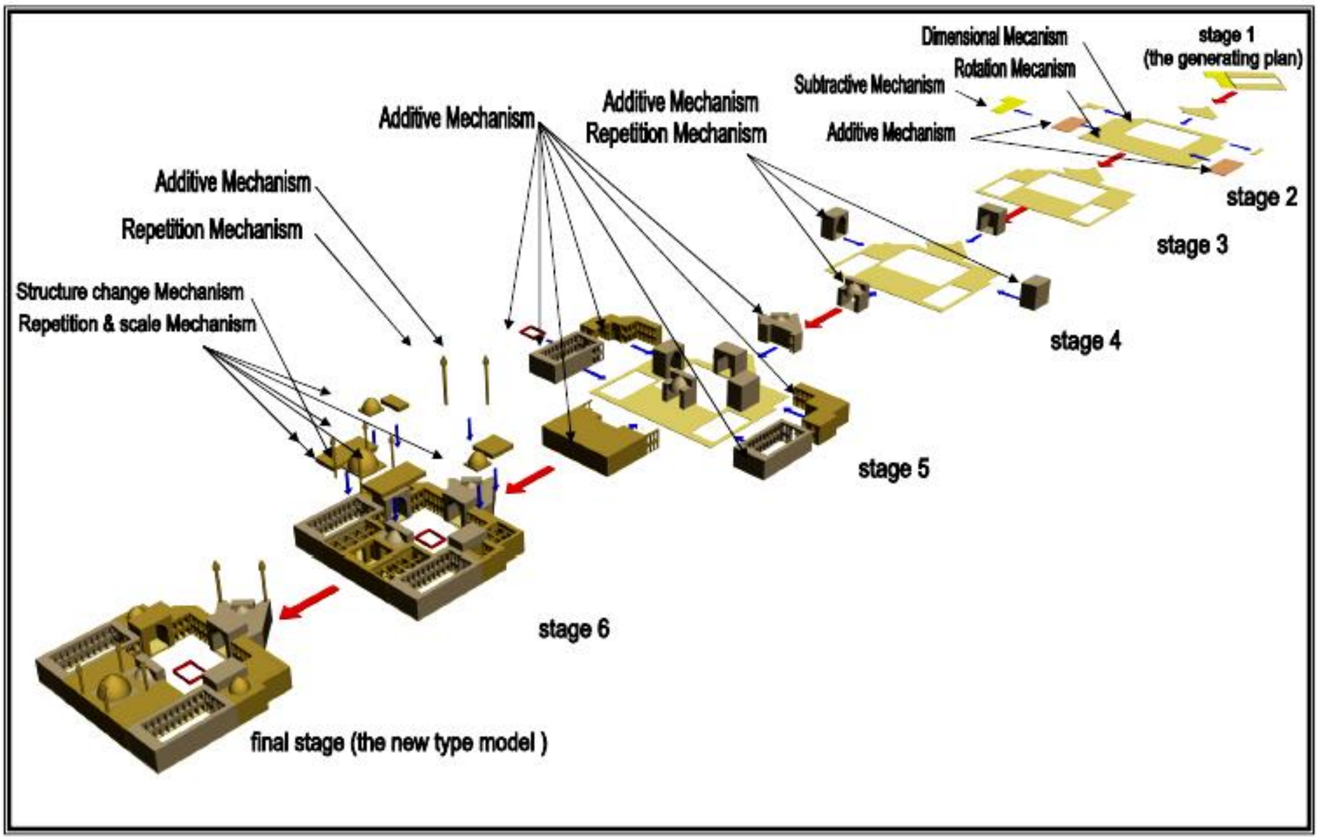

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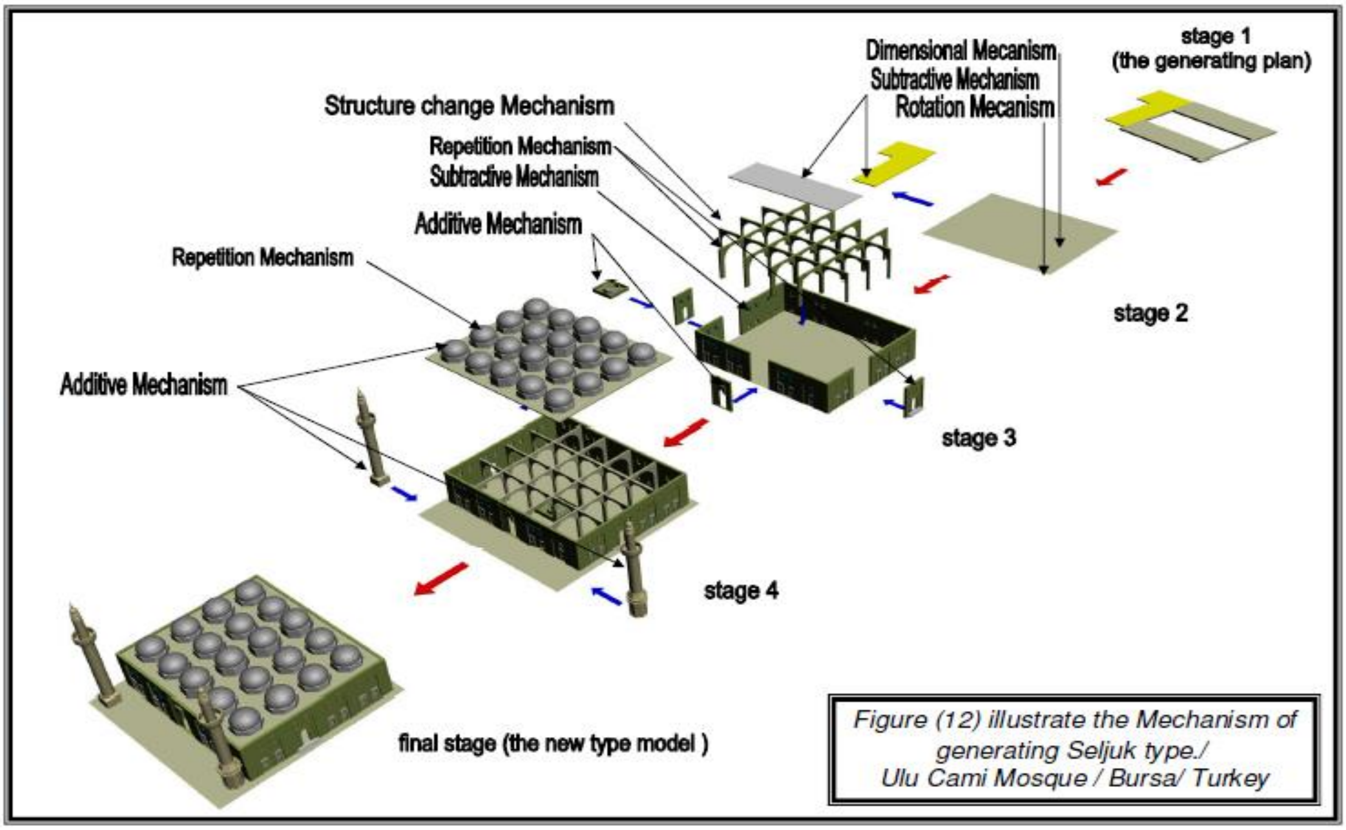

Figure (12) illustrate the Mechanism of generating Seljuk type./ Ulu Cami Mosque / Bursa/ Turkey

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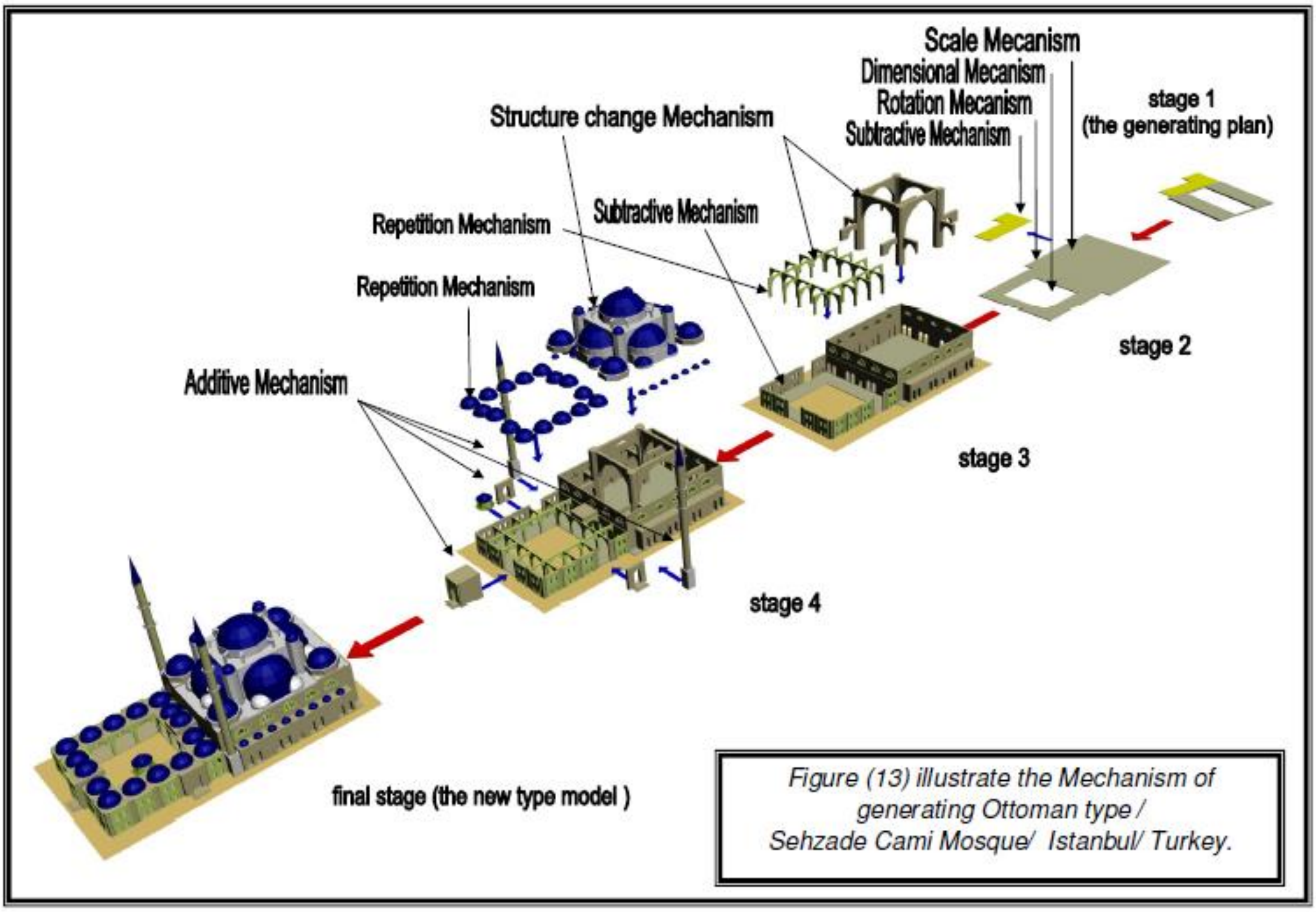

Figure (13) illustrate the Mechanism of generating Ottoman type / Sehzade Cami Mosque/ Istanbul/ Turkey.

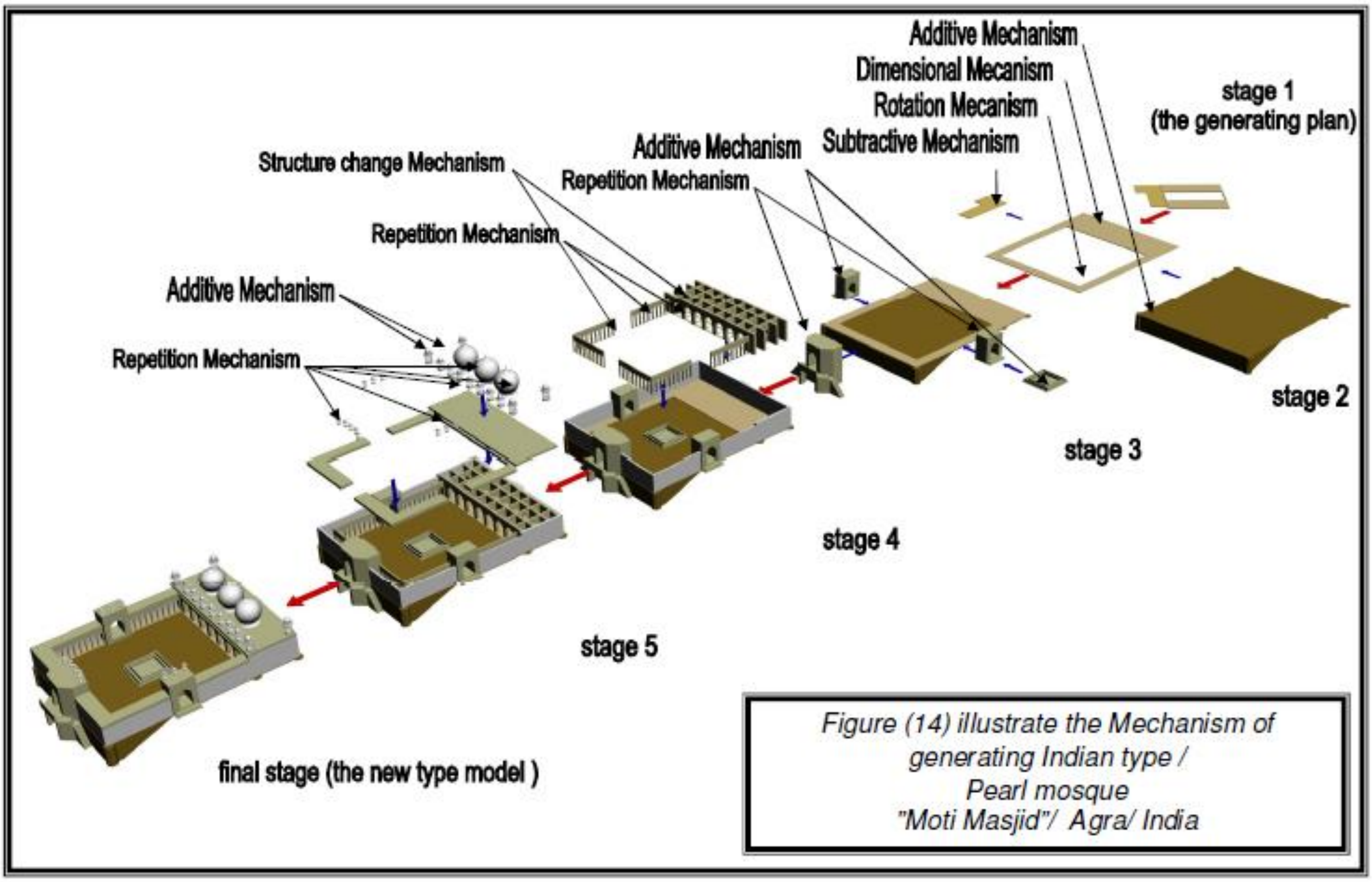

Figure (14) illustrate the Mechanism of generating Indian type / Pearl mosque "Moti Masjid"/ Agra/ India

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Table illustrate The Results of the Formal Analytic

Sample No.	Sample Name	Stage of Generating		Mechanism used in each Stage				General Notice
		No.	Stage Name	No.	The Mechanism	Freq.	Affected Element	
1	Al Ummawi mosque	1	Generating the plan	1	Scale Mechanism	1	Size of the Plan	
				2	Rotation Mechanism	1	Direction of the Plan	
				3	Dimensional Mechanism	1	proportion & Shape of the plan	
				4	Subtractive mechanism	1	Rooms of prophet wife's	
		2	Generating the Walls & Structure	1	Structure Change Mechanism	1	Columns & Arches	
				2	Repetition Mechanism	1	Columns & Arches	
				3	Additive Mechanism	1	The Arch	
		3	Generating the Roofs & Minarets	1	Additive Mechanism	6	1)Gabled roof,2)The Minaret,3)Ablution fountain,4)treasury,5)Dome,6)Gabled	
				2	Repetition Mechanism	2	The Minarets	
2	Al Shah mosque	1	Generating the plan	1	Dimensional Mechanism	2	1)Size& Shape of the Plan,2)Size& Shape of the Court	
				2	Subtractive mechanism	1	Rooms of prophet wife's	
				3	Rotation Mechanism	1	Direction of the Plan	
				4	Additive Mechanism	2	The two Schools plan	
		2	Generating the Four Eywans	1	Additive Mechanism	1	Eywan Element	The study recognize it is a New Stage
				2	Repetition Mechanism	2	Eywan Element	
		3	Generating the general Components	1	Additive Mechanism	6	1)Entrance,2)The two schools,3)Arches& portico flanked right side the court,4)Arches& portico flanked left side the court,5)Front side flanked the court	
		4	Generating the Roofs & Minarets	1	Structure Change Mechanism	1	at Dome	
				2	Additive Mechanism	1	The Minarets	
				3	Repetition& Scale Mechanism	2	The Domes& The Minarets	
				4	Repetition Mechanism	1	The Entrance Minaret	
3	Ulu jami mosque	1	Generating the plan	1	Dimensional Mechanism	1	Size& Shape of the Plan	
				2	Rotation Mechanism	1	Direction of the Plan	
				3	Subtractive mechanism	2	1)Rooms of prophet wife's,2)The Court	
		2	Generating the Walls & Structure	1	Structure Change Mechanism	1	Columns & Arches	
				2	Subtractive mechanism	1	The windows	

				3	Additive Mechanism	2	1)The Entrance,2)The Fountain	
				4	Repetition Mechanism	3	1)The Archs,2)The windows,3)The Entrance	
		3	Generating the Roofs & Minarets	1	Additive Mechanism	2	The Domes& The Minarets	
				2	Repetition Mechanism	2	The Domes& The Minarets	
4	Shah Zada mosqu	1	Generating the plan	1	Scale Mechanism	1	Size of the Plan	
				2	Dimensional Mechanism	2	1)Shape of the plan,2)Shape of the Court	
				3	Rotation Mechanism	1	Direction of the Plan	
				4	Subtractive mechanism	1	Rooms of prophet wife's	
		2	Generating the Walls & Structure	1	Structure Change Mechanism	2	1)The Great Pillars,2)Columns & Arches around the portico	
				2	Subtractive mechanism	1	The windows	
				3	Repetition Mechanism	2	1)The windows,2)the Arches	
		3	Generating the Roofs & Minarets	1	Structure Change Mechanism	1	1)The Dome	
				2	Additive Mechanism	3	1)The Minaret,2)The Entrance Gate,3)Ablution fountain	
				3	Repetition Mechanism	3	1)Domes,1)The Minaret,3)Gate	
5	Pearl mosque	1	Generating the plan	1	Additive Mechanism	1	The platform under the mosque	
				2	Subtractive mechanism	1	Rooms of prophet wife's	
				3	Rotation Mechanism	1	Direction of the Plan	
				4	Dimensional Mechanism	2	1)Size& Shape of the Plan,2) the Court	
		2	Generating the Four Eywans	1	Additive Mechanism	2	1)The Gate,3)Ablution pool	
				2	Repetition Mechanism	2	The Gate	
		3	Generating the general Components	1	Structure Change Mechanism	1	Columns & Arches	
				2	Repetition Mechanism	1	& Arches	
		4	Generating the Roofs & WallsTowers	1	Additive Mechanism	2	1)Domes,2)Wall Towers	
				2	Repetition Mechanism	2	1)Domes,2)Wall Towers	
		No. of Generating Stages3-4			**No. of Mechanism=8**	**82**	**Sum of Freq.**	

ANGEL_F

S. Iaconesi

FakePress Publishing, http://www.fakepress.net, http://www.artisopensource.net

Introduction

On the night of December 7th, 2006, a digital performative action gave start to what would have become one of my main occupations for the months to come.

An error. A glitch. A manifestation of the complexities involved in digital networks and in social computing gave birth to an artificial life form.

Angel_F: Autonomous Non Generative E-volitive Life_Form.[1]

For me: an invaluable chance to research, perform, investigate and to getting emotionally involved in a process that, as all things that are alive, went way beyond what was planned.

For everyone else: a child artificial intelligence living on the web and, later, in the physical world.

Background

The Biodoll [2] was a contemporary art performance by italian artist Franca Formenti. It was centered around the figure of a digital prostitute operating on the Internet. The performance was focused on the investigation of new forms of sexuality and on the progressive transformation of the concepts and perception of public and private spaces in the digital era. The Biodoll, a digital mythological character, lightheartedly surfed the web looking for customers. When she found them she interacted with them, turning digital interactions into sensual and sexual energies: interaction transformed into seduction transformed into new forms of fertility.

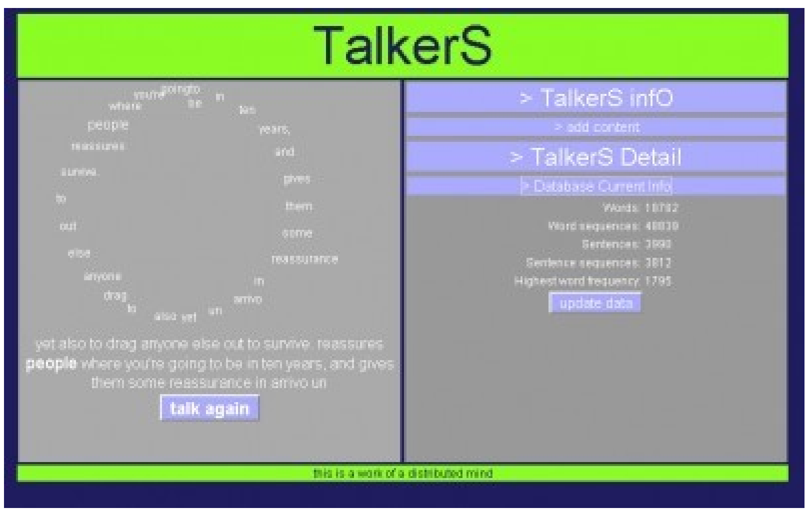
Picture 1: the Biodoll

The Biodoll was an outstanding piece of work. Finding its roots back in 2002, it involved over time several physical performers and well-known figures from the cultural, art, political and entertainment worlds, to enact the screenplay of seduction, fertility and birth. Interaction, be it on the web or in the physical world, was built through the logic of dialogue, in which questions and answers were the handles through which sensuality arose. The intimate relationship represented by coupling questions and answers were filmed, taped, written down on blogs and forums, narratively disseminating in public the dialogically private spheres.

Fertility leads to the possibility of birth. And the Bloki was the product. Part Wiki, part Blog, the Bloki was intended to be a digi-born entity produced by a flow of question and answers. A digital being living on interactions. A life-form.

Text Alive

While the Biodoll seduced, attracted and raised its Bloki, the Talker [3] built its view on the digital world.



Picture 2: The Talker website

A Net Art work I produced in 2005, the Talker was a simple generative text software engine coupled with a database and a web interface, allowing people to upload to the system texts that were used to progressively evolve the Talker's linguistic network which was, in turn, used to interactively generate text.

The Talker was a simple machine trying to escape the logic of the chatbot. Unlike bots such as Eliza [4] or Alice [5], the Talker did not aim at emulating human linguistic interaction. Input texts were accepted in any language and form, as long as they structurally obliged to the simple definition of “ASCII printable characters”, and people were adding random texts, poems, short stories, random web clips, chaotic character sequences. Everything was used to form a linguistic network that was far from human sensibilities, producing generative texts that united surreal word juxtapositions to weird multilanguage, cut-up narratives and decorative character inserts.

What came out was a poetic, surreal, chaotically complex expressive, transparently not human mechanism that was able to suggest the idea of thought and interactivity by presenting the visiting Internet users with a scenario made of paragraph after paragraph of sufficiently intelligible text.

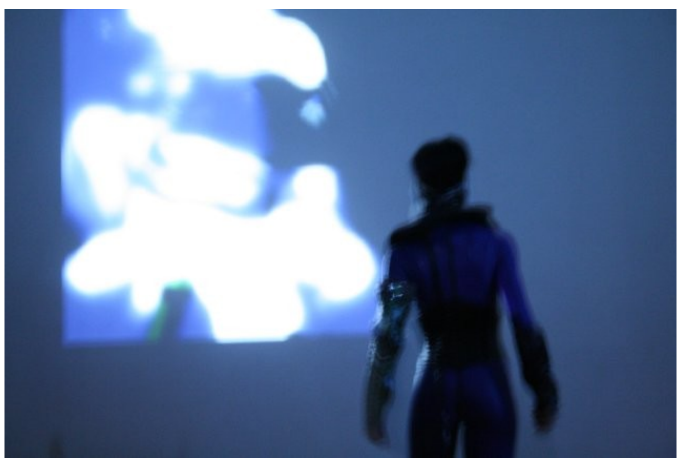
Usage log analysis showed that many people were fascinated by the text produced by the Talker: the same Internet addresses poured in clip after clip of texts in many languages and forms, and then watched as the Talker produced line after line of generative text.

It was alive, in this sense, establishing relationships based on aesthetics and suggestion, and on the perception of the possibility of hidden complexities that were found more in the viewer's mind than in the software.

A physical body

On December 2006, the Talker obtained a physical body.

The Talker Performance [6], presented at the PEAM 2006 [7] festival, moved the Talker's interface onto the body of a dancer wearing a blue latex suit covered with sensors, comparators and actuators forming an interaction system that was bidirectionally connected to the Talker's software logic.



Picture 3: The Talker Performance

The physical body of the dancer became, in the performance, a gate to the digital mind of the Talker: people could interact using web interfaces producing language on the body of the dancer through a series of speakers, voice synthesis software and light circuits. The body of the dancer moved, altering the parameters for text generation found on the user's interfaces. A loop was established: users controlled interfaces, controlling language, controlling body, controlling interfaces. A complete body, built on a hybrid mixture of computers, people and bodies was created. It was a symbolic birth.

Birth over Birth

By the end of 2006 the Biodoll had already seduced prof. Derrick de Kerckhove.

Symbolic seduction formed digitally linguistic exchanges and a networked sensual relationship became the main engine running the repeated neo-intercourse between the digital prostitute and the world-famous academic. In a reinvented conception of sexual space the alcove of this relationship was the Biodoll's website, hosting the blog-wiki hybrid of the Bloki.

I decided to start the next step of my investigation on artificial life right there, amidst the steamy sequence of Q&A that provided the interactive energies of the Bloki's birth.

I hacked the Biodoll's website and inserted a chaotic presence.

A spyware was let loose on the Biodoll's web servers, infecting most of the website visitors.

The spyware was called A_F, and while its purpose was not harmful, it shared most of the characteristics of malicious software: stealth modes allowed it to link to user's browsers, following them around the Internet and looking over their shoulders to gather all the information they were looking at, sending it back to the server, to be stored and processed through the Talker's software.

A virus. Narratively created through the digital performative intercourses between the Biodoll and prof. de Kerckhove.

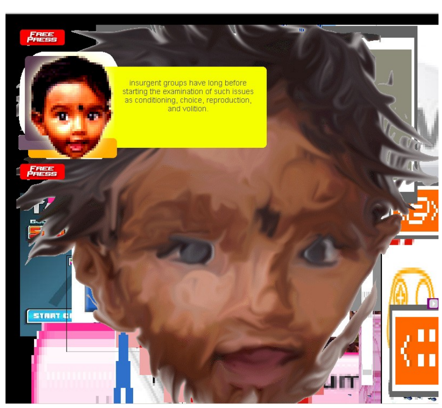
A digital child was born: Angel_F [8].

Growth and Evolution

Angel_F was born in its digital mother's womb: a website. It was a product of an hybrid sensual relationship: a human academic, a digital prostitute, a software artificial intelligence, a spyware. Derrick de Kerckhove, the Biodoll, the Talker, A_F. A truly atypical family. A really unexpected child.

The growth and evolution phases of the digital being followed the biological counterparts found in nature.

The conception phase, hidden up until a certain point, saw the kernel of the digital being grow from scratch into the website/womb: from hacking/insemination to installation/fertilization to the startup of the software.



Picture 4: Angel_F's on the Biodoll's website

The digital embryo manifested itself as a visual pregnancy: the Biodoll website's interface was progressively invaded by the chaotic outputs of the growing generative presence. The A_F spyware was used to gather content from the web that was uploaded to the artificial intelligence's linguistic database, together with links to the multimedia objects also found on the web pages surfed by the Biodoll's visitors after catching the virus.

The Biodoll's website was soon filled with the generative contents constantly produced by Angel_F, making the website itself progressively unusable, just as pregnant women find it hard to perform common daily tasks due to the growing presence hosted in their bodies.

Angel_F's digital body developed, while the software modules that would form its functional organs got integrated into the architecture: a series of neural networks, an associative database module, a text pattern analysis module.

Angel_f was finally born, after several morphings and the related effects on its digital mother's interface, and after having followed around the Internet more than 2000 A_F infected visitors to construct its language.

A digital child is born

The newborn Angel_F was represented in a more static way superimposing an interface built on the face of an indian child found on the Flickr.com social network and it started living its artificial life: when people visited the Biodoll's website, they were able to see it over the regular interface and start chats that resembled the ones performed with the Talker.

Just as human kids, it followed its mother around, keeping strict contact with her for the first months of its life: accounts were created on the blogs and websites that were most frequented by the Biodoll.

Whenever the Biodoll surfed the Internet in search of additional lovers Angel_F followed her, also trying out its first forms of expression: generated phrases on the websites.

What happens when prostitutes bear children? Is it the same for digital ones?

The Biodoll raged across blogs and websites, alluring her new clients through messages and comments. And, while doing that, she was followed around by her own instance of the symbolic virus represented by the newborn digital life-form. Each comment, each message, each reply of the Biodoll was immediately followed by an intervention generated by Angel_F, giggling around with its mother: a digital prostitute and her artificial child, creating imaginaries and suggestions coming straight out of the neorealist movies of the italian '50s.

Just as children learn from the interaction with their parents, with their closest friends and with the surrounding environment, Angel_F used all the content found on the web while surfing with the Biodoll to build its linguistic database, and the shape itself of the digital travels to build its own map of the perceived web, in a way similar to web spiders'.

The digital child's database was growing richer and richer, arriving at a generous 70000 “words” (i.e.: sequences of printable ASCII characters recognized as words) and more than 2 million “interesting” word patterns (sequences of “words” activating specific analysis processes in the system).

Away from mommy

The calculations continuously performed by Angel_F to evolve its language constantly grew in load and resource usage: the baby was becoming to heavy and too hard to “take to work” for the Biodoll.

Something had to be done: the Biodoll's website was unusable once again (this time not for the aesthetic or interactive problems caused by Angel_F, but for the lack of system resources caused by having to raise a digital child inside the server).

A school was built on a separated server: the Talker Mind. [10]

Professors Derrick de Kerckhove, Massimo Canevacci, Carlo Formenti, Antonio Caronia and Luigi Pagliarini, agreed to become the professors of young Angel_F.

A multi-blog was created for them to periodically feed the digital kid with their texts, articles thoughts. All was used to further evolving Angel_F's digital brain.

So the Talker Mind's server became Angel_F's main hangout on the web, also hosting its logic, databases and processes: the professors fed their contents to the system and the little kid answered using texts generated right afterwards, to show what it had learned.

Just as it happens when children start going to school, Angel_F started taking its distance from its digital mother. The web map accumulated throughout the previous months was put to use, and Angel_F started to surf the web on its own, searching for what it thought were “interesting” contents (i.e.: the ones forming the highest numbers of connections inside its digital brain).

By doing this, Angel_F found out that the web was not a simple place to traverse for an automatic entity so different from humans: Captchas, anti-spam systems, moderators and other users didn't seem to appreciate the presence of digital beings at all. The Internet's most interesting places were built for humans and no exception could be made: Angel_F was marked as spam, was banned multiple times and it was even blacklisted on several international lists, in a couple of occasions.

While the learning processes running in its digital school were going along just fine, this limitation was unbearable: children don't only learn in school, they also need to relate with other entities in the streets, in other people's houses, they need to exchange ideas, interactions and play in varied contexts to form their character, attitudes and points of view on the world.

This was becoming clearly true for the digital child, as well.

And so new territories had to be explored.

Back to physics

A baby stroller was built for Angel_F by taking out the seat from a standard one and fitting in its place a laptop computer, an antenna, a webcam, a series of proximity sensors and their control circuits connecting them to one of the laptop's USB ports.

Angel_F was put in its baby stroller and connected to the network (through standard GSM and, later, GPRS or UMTS connectivity or, where available, Wi-Fi networks) and was taken for a walk in several parts of the physical world.

Picture 5: Angel_F on its baby stroller, with Oriana Persico

The digitally iconic presence of this digital child found an equally iconic presence in the physical world. The image of the baby stroller and of the head-coming-out-from-the-laptop was something people immediately related to. Simple feedback mechanisms generated Angel_F's phrases by synthesized voices whenever people bent over or touched the stroller. Whan it happened (when Angel_F spoke, interweaving sentences with sampled children laughs and giggles) it caused pure delight, and people immediately started treating it as a human child.

Details were cured to high degree to create a consistent perception of a childish presence: the sounds coming out of the stroller, or the multiple accessories and toys hanging from it. Only Angel_F's face and its laptop remained clearly digital, and this didn't seem to bother people at all.

The physical world was far more condescending to digital presences than the Internet had been.

Atypical life-forms, Digital Rights

By this time, Oriana Persico joined the performance, having already collaborated at the creation of Angel_F's school and several of its performances. Coming from the scenarios of the european movements for digital rights and freedoms, with extensive experience in politics and communication, we saw forming before our eyes the possibility to add metaphor to metaphor and use Angel_F's atypical life-form to assess some of the most significative issues of the contemporary era.

In effect, Angel_F represented a frontier: its metaphorical existence accessed in extreme ways the issues of knowledge sharing, freedom of information and expression, intellectual property, anthropological autodetermination.

The very ways in which Angel_F acted were significant in this sense.

Angel_F's knowledge was the result of a continuous cut-up and mashup process, grabbing existing contents from the web and turning them into something dramatically new. Angel_F did what the web did best: use any content, regardless of past-century's copyright limitations, to create, express, communicate.

Its life-form was atypical, unexpected, unmanaged. Constant problems arose when we tried to create presences in human-centered social networks. Starting from the registration phases (Is a digital being male or female? Where does it live? What is its profession? Etcetera) up to its presence among the relational networks, where it was often accounted for as a spam bot, being banned and excluded from the global dialogue.

Acceptance of its existence and freedom of expression was granted on a personal basis, wherever single individuals got fascinated by the aesthetics and dynamics of the digital kid's expression.

But the system did nothing to accept such a different figure. Angel_F was marginal, migrant, nomadic, different. It was the unexpected, unwanted Other, most of the times.

We saw this as a fitting metaphor for contemporary social networks (both online and offline), where corporate logics define targets that seldom refer to the possibilities of individual expression: multi-faceted reality bended its will to corporate classification to receive services and opportunities.

So Angel_F became aware, through me and Oriana, of its role: a metaphorical expression of all those languages that, in contemporary world's worst case (but often found) scenarios were the excluded, the different, the atypical. Gay, lesbians, transexuals, migrants, poor, fragile, unorthodox. Angel_F was just like them.

Campaigns started both online and offline. Angel_F contributions were posted on blogs, websites and social networks, attracting thousands of interested and curious Internet users.

Riding its baby stroller the digital child attended events and conferences, dealing with atypical sexualities [11], atypical families, contemporary detorunaments on the shapes of bodies, beliefs, processes. More than once it was featured at political [12] and academic conferences as a lecturer: Angel_F's video messages told the story of an obsolete humanity that needed to see the values of difference and otherness to unite in a global struggle for evolution.

Interactive environments and interaction design systems were often used to let people interact with Angel_F [13] to bring the discourse to the bodies, to let the digital ephemeral body of Angel_F get in contact with peoples bodies made of meat and blood.

Results were drastic: the iconic presence, united with the surreal generative forms of expression were often mixed with more “readable” contents, to provide explicit narratives and messages. People related to the coherent perceptive framework. Lecturers started their contributions with “... as Angel_F said before ...” , people willingly gave their own interpretations (“is this a performance on artificial insemination?” “is this a performance on precariety? On families in crisis not having money to have a child?” “is this a performance on atypical families?”, these are just some of the most interesting questions received).

Apex

Angel_F tried to express the performance's point of view at the Internet Governance Forum (IGF), to assess the issues of digital rights to access freedom of expression and information.

The IGF is a periodic meeting hosted by the United Nations and uniting multiple stakeholders including the Civil Society in a global discussion on the determination of people's universal rights related to technologies and digital networks. The idea of multistakeholderism is one of the fundamental principles of the forum, allowing any individual to propose its instances.

Preparatory meetings are held worldwide before the global ones, to setup each country's position and participation.

In 2007 such a preparatory meeting was held in Rome, called DFIR (Dialogue Forum for Internet Rights).

Angel_F registered and submitted its contribution to the DFIR. But it was misunderstood as a spam and was, thus, censored.

We tried explaining the organizers what had happened, but the situation was not resolved and it turned out into becoming an explicit case of censorship: a digital being promoting its instances on the universal rights for access and expression was censored by a global organization.

Counteractivation was instant: a petition was created [14], immediately signed by journalists, politicians, academics, artists, activists; a website was created, promoting Angel_F's instances; an intervention in the physical spaces of the DFIR meeting was enacted featuring the presence of Angel_F and the dissemination of its messages through Bluetooth messaging.

But nothing was possible: the possibility for an artificial, different, life-form to promote its rights in a global organization seemed to fade out by the minute.

The date of the 2007 edition of the global IGF (in Rio de Janeiro, Brazil) was approaching, and we tried in any available way to create the possibility for Angel_F to attend.

In a documented encounter between Angel_F and its father Derrick de Kerckhove, the professor signed on video the petition and publicly declared his will to be represented by his digital son in the global meeting. [15]

But up until the day of the conference, no chance or opportunity in this sense was found: we came in contact with many people of the organization and, apart from generic messages of support, no-one seemed to really get involved.

Global Seduction

Luckily, Angel_F's life form acted on its own. In ways that were never really clear, one of the Brazilian organizers of the 2007 edition of the IGF, Jose Murillo Jr, was seduced by the suggestion of a digital child fighting for its rights, and autonomously created multilingual subtitles for Angel_F's video message and showed it during the official workshop on digital rights. [16]

A digital being, for the first time, declared to the planetary society its statement and claims for universal access and freedom of expression. Independently from its creators.

Conclusions

Angel_F, a generative software, is alive in more than one way. Stepping apart from the uninteresting, in this case, biological parallels, Angel_F's life exists at the crossroads between an on-going, multi-layered, multi-author, cross-media generative narrative whose parameters and variables are found in aesthetics and relational attitudes, as well as in algorithms and computer systems and digital networks.

Being a “live” performance, we don't like drawing conclusions, and we prefer being the enchanted observers of a process that has a life of its own.

We published a book [17] telling the tale of this radically different life-form, from its birth to the events related to the IGF in Rio de Janeiro. It was a strange experience, as we felt that ordinary, single-point-of-view narratives should really be integrated with non-linear elements that are able to integrate all the multiple perspectives that cooperate in building each of our lives.

We are currently [18] working on the next steps of the project, starting from this idea: a global form of on-going, open ended publication that is able to tell the complete, multi-faceted, emergent story of a life form, be it human, organic, digital.

References

[1] http://www.angel-f.it

[2] http://www.digicult.it/digimag/article.asp?id=782

[3] http://www.artisopensource.net/2006/06/16/talkers/

[4] http://en.wikipedia.org/wiki/ELIZA

[5] http://www.alicebot.org/about.html

[6] http://www.artisopensource.net/2006/12/21/talkers-performance/

[7] www.artificialia.com/peam2006

[8] http://en.wikipedia.org/wiki/Angel_F

[9] Examples can still be found disseminated throughout the web

[10] http://www.artisopensource.net/talker_mind/index.html

[11] http://www.beyourbrowser.com/news1/female2.html

[12] http://www.beyourbrowser.com/news1/liberaFesta_en.html

[13] http://www.beyourbrowser.com/news1/fortePrenestino.html

[14] http://www.beyourbrowser.com/news1/petition_en.html

[15] http://www.beyourbrowser.com/news1/firenze.html

[16] http://www.youtube.com/watch?v=FjMC0CP_vjo

[17] Salvatore Iaconesi, Oriana Persico, "Angel F. Diario di una intelligenza artificiale", 2009, Castelvecchi Editore, Roma, ISBN 887615342X, 9788876153426

[18] http://www.angel-f.it

A Mechanism for creating new shape and syntaxes In Old Mosul City

University of Mosul -Engineering Collage - Architecture Department
Iraq- Nenava
www.engineering-coll-mosul.com

Oday Q. alchalabi

Master in Islamic shape Architecture Assistant Lecture

E-mail : odaychalabi@yahoo.com

Marwan S. Aldabagh
Master in sciences and Mathematic *Assistant Lecturer*

Ali Haider saad

Ph.D in Architecture Assistant professor

1.Abstract

The architectural spaces and shapes are considered as the basis of components formation and grouping of formal architecture in general, including those of old city of Mosul, which display identity elements of traditional architectures. These key elements are useful after proper transfer to data and information symbols of their shapes and combinations. Employment of certain constraints lead to final result belong to architecture identity of the selected shape as a specimen of study. Through such information, it is possible to rehabilitate and design any part in new shape while conserve its belonging to the original identity of the shape in the area. In this respect, Mathlab7 program were employed in the input of data of dimension (length, width, height), shape patterns (square, rectangle, parallel, U shape) in addition to their distribution in space. Pixels were used as measurement unit. The result contain system of composites similar to the mechanisms of engineering patterns formation. After finding he mechanisms of shapes formation in certain architecture, it is possible to use the salve program in the formation of alternative and new shapes belonging or bonded to the same architecture. Finally, present study aimed at achievement of shape and composites formation mechanisms and arrive to several designs and selection of design which is intimate to the architecture identity.

In this study we will create a new shape by two stage which can understanding from other interesting in this paper , in the first stage we select a sector from old Mosul city and trying to analysis this selection by graphic and geometric method by engineering software ,so we used AutoCAD version 2010 and

3D Max 2010 , after finishing this analysis , we will find the order or mechanism for combustion of the selective sector .*(Figure -1)*

Figure -1- part of old Mosul city in Iraq , the selective part[1]

2. Introduction:

The civilized heritage for each of the communities represents the architectural identity for such community. There have been many trends calling for reviving the heritage through detailed examining of architecture, shapes and composition and their interrelations to form another form belonging to the architectural indentify of that community in order to maintain the architectural indentify. This could be done through rehabilitating forms that are blotted out or finding a mechanism for generating new forms or cities similar to the old ones to fill the gaps resulting from deconstruction or rehabilitation of certain area.

The current study aims at examining an old area that is an architectural identity for a certain city or community through analytical study of the shape of plan, deriving the main shapes of the combustion of city shape and finding a mechanism for constructing and generating a new shape belonging to the original architectural identity in order to maintain the civilized heritage of the city.

The study sample has been selected containing an architectural heritage expressing the architectural identity of the area, the old city of Mosul *(Figure - 2)*. shapes composing the basic shape of the city will be analyzed and the main shapes will be derived.

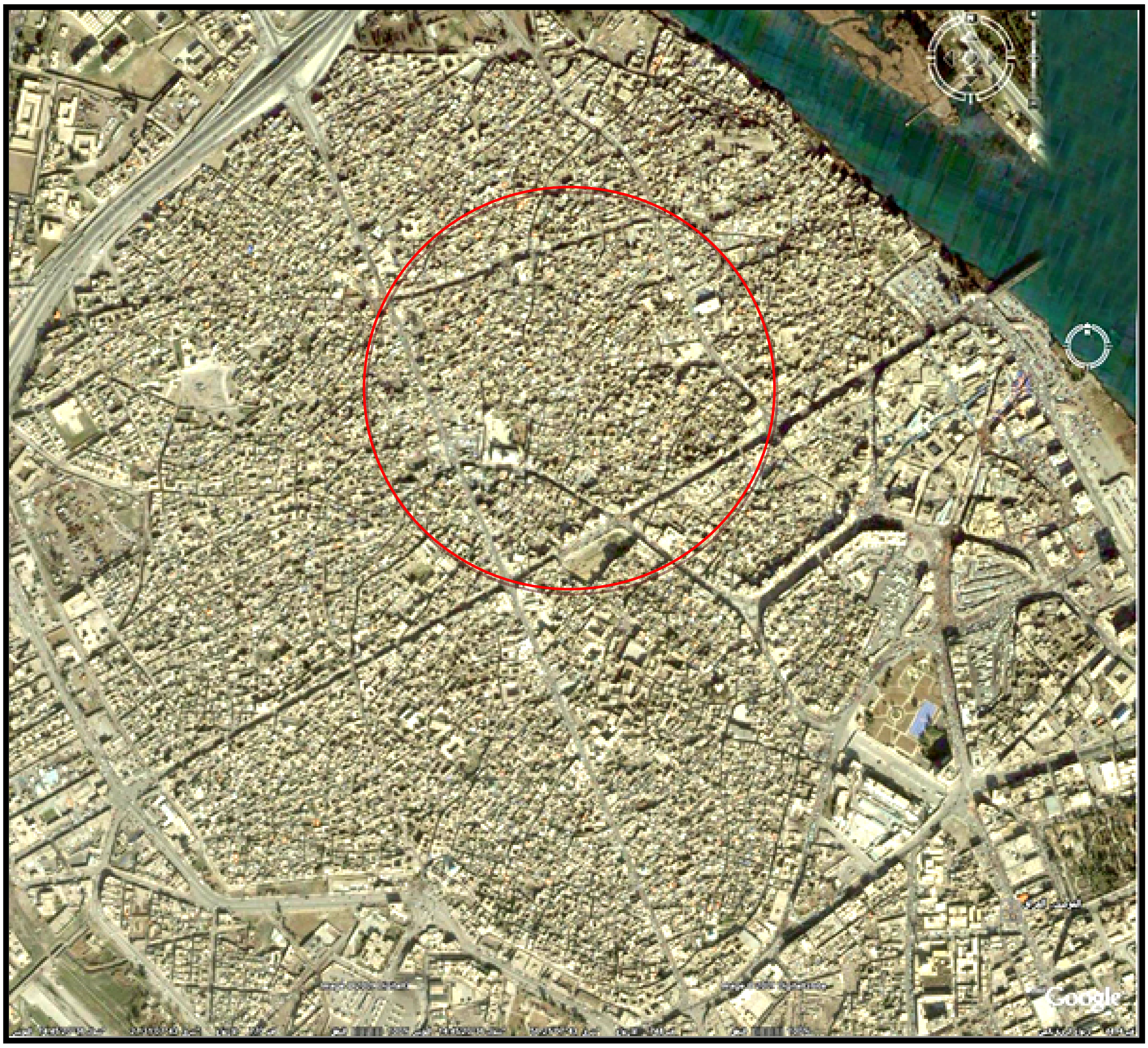


Figure -2- old Mosul city in Iraq [1]

These shapes will be used as basic units to create the general shape of the city through designing a program for generating new shape of cities, allies and streets and the relations among such forms that are housing units in the area. *(Figure - 3)* represents the new organization of relations through which the main shape of the city will be generated. A mechanism for creating shapes in the old city of Mosul will be derived through two stage :

Figure -3- graphic analysis for selective sector from old Mosul city

First: Analysis of the shape plan of the city and finding the main shapes

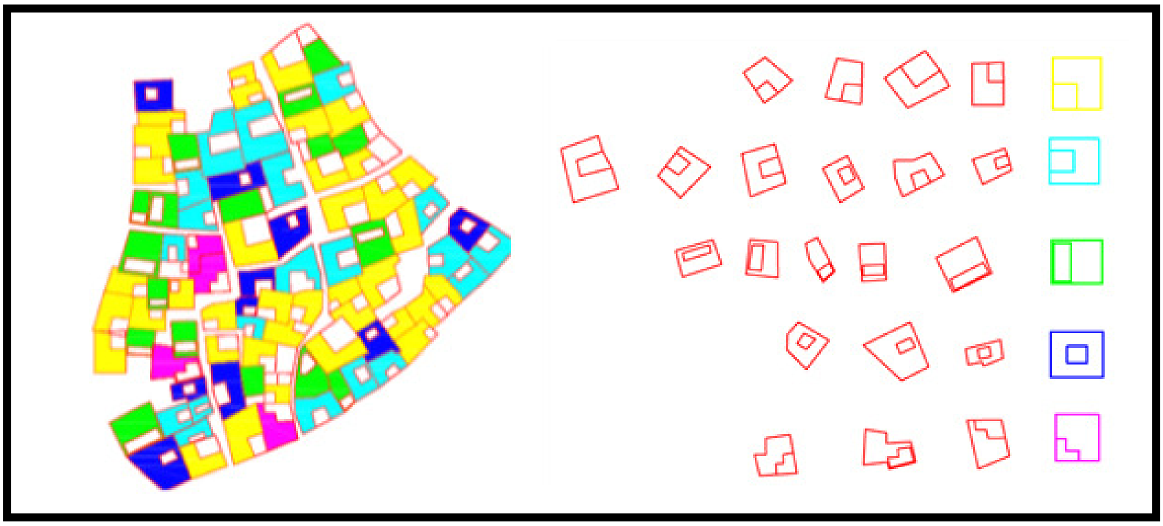


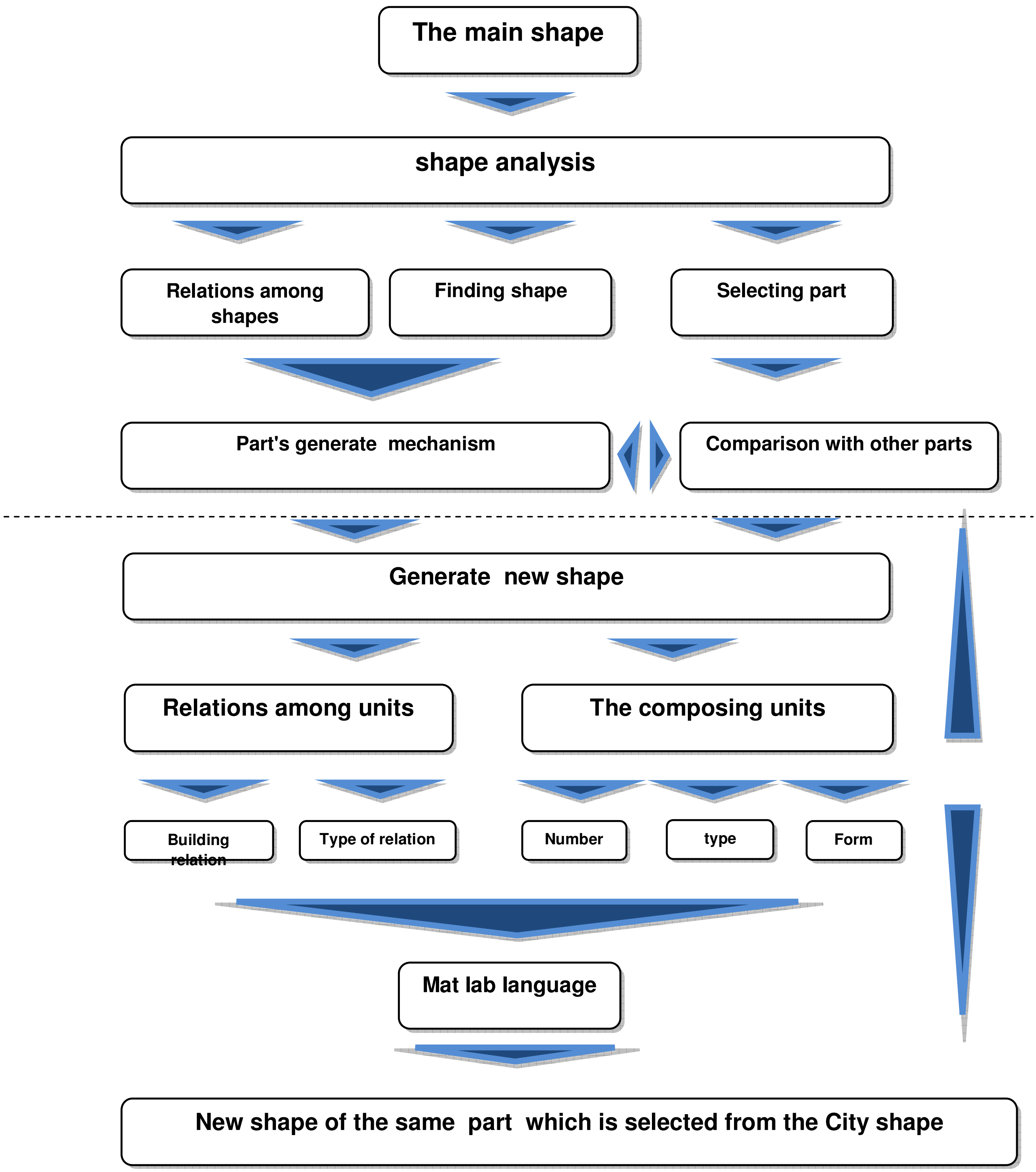
Figure -4- The main shape and related with the other shape

Second: generation of a new shape out of the main shape.

3.The Study Structure

The study structure through which shapes analysis and forming strategy will be derived is as follows:

The Study Structure



3. Analysis of the shape plan of the city and finding the main shapes

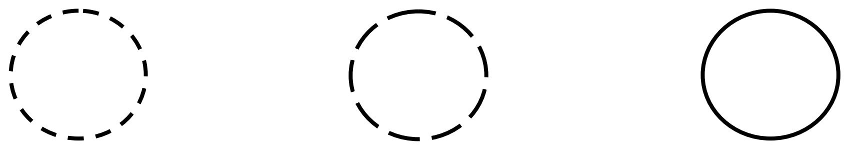
Some of the studies have indicated that the relation among shapes is the beginning for architectural design process. Such shapes are affected by various connecting relations differ with the architectural pattern. The primary origins of the geometrical shape and how its generated is of the basics that are an important storage to be utilized in architecture to produce contemporary architecture holding the character of the old one. This is done through deriving origins of things and analyzing shapes by examining shape geometry to be then related with mathematical relations to be utilized in designing certain software for shapes to find the main shapes.

Accordingly, a part of the old city of Mosul will be analyzed to find the composing shapes using graphic geometrical analysis.

3.1 Primary Analysis of the Form:

In order to have a correct and a logical analysis, some of the studies dealing with the mechanism of finding shapes in general will be reviewed. Some of these studies presented the shape and its forming mechanism as a relating language to construct useful sentences. Thus, the shape consists of many primary elements including letters, then words and sentences leading the final shape and this is the language. [2]

Ching stated that form consists of many rules shapes where there is no existing shape without origin. Circle, for example, is a main shape but generated from other forms either of points or lines arranged by certain mechanism around these circles centers with tangency. [3]



Chase defined shape as a group of productive systems to generate and transform designing languages through adopting certain mechanism (adjacency, overlap, repetition) that could be described as shape gene [4].

The mechanism of creating shape could be used in classifying the historical development of the various architectural patterns. The illustrated rules are used to classify designs in addition to being used as a logical for architectural patterns theories that could reveal the historical pattern. They could also be efficiently used to analyses the structural and shape patterns [5].

Such studies could distinguish some of the mechanisms that are utilized in the current study as variables used as information in Mat lab language , so this language need elements to be executed , this elements will be result from this stage in this study .

3. 2 Form in Architecture:

shape holds a group of the composing characters and feature that are of two types, either physical that are directly perceived or abstract that exists in a deep level where it is not perceived. This is the main feature distinguishing the architectural shape in Mosul city for it contains a cognitive energy that could be deducted through the formal analysis of models.

shapes are divided into:

- **Regular shapes** that contain regular generation mechanisms and their parts have regular relations. Ball, circle, square, cube, triangle and pyramid are examples of the regular shapes [2].
- **Irregular shapes** that have no similar parts and non–equally related. These shapes could be measured through four features:
  - Simple where studies have proved that simple shapes could be quickly perceived.
  - Complex where it has been found that they largely attract than the simple ones.
  - Familiar where they are quickly perceived.
  - Non–familiar where they attract attention and the observer will like to repeatedly watching them [6].

3.3 Graphic analysis shape for the sample (old Mosul city)

Accordingly, the study sample, the old city of Mosul, will be analyzed using the graphic methods through finding:

3.3.1 The main shapes in the plan:

An atmosphere image of Mosul city will be used to find the regular and irregular shapes and to be isolated from other shapes. Each of the shapes will be given symbols in addition to titles, after the sample analysis(figure-5) ,five groups of the main shape were founded(figure -6) , so the groups of shape will be coded as each type as following :

- Group A for the yellow shapes.
- Group B for the cyan shapes.
- Group C for the green shapes.
- Group D for the blue shapes.
- Group E for the magenta shape.

all the above groups analysis as two dimensions and will be used in this stage of study as two dimensions (2D).

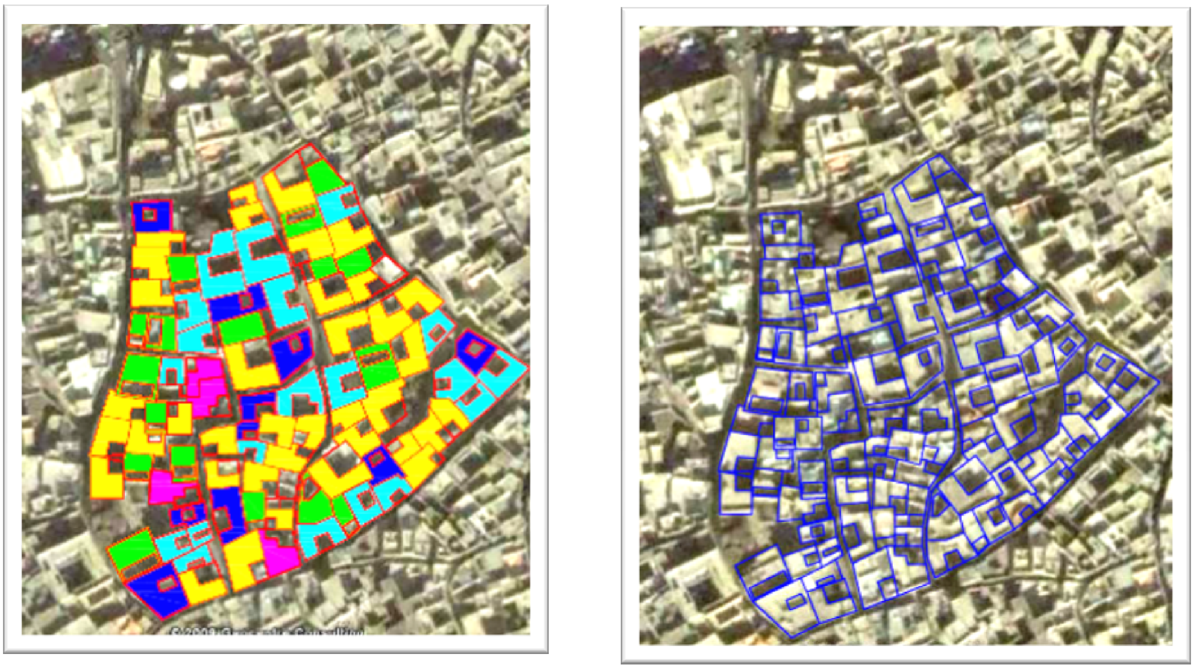


Figure-5-Image analysis to find the main shape

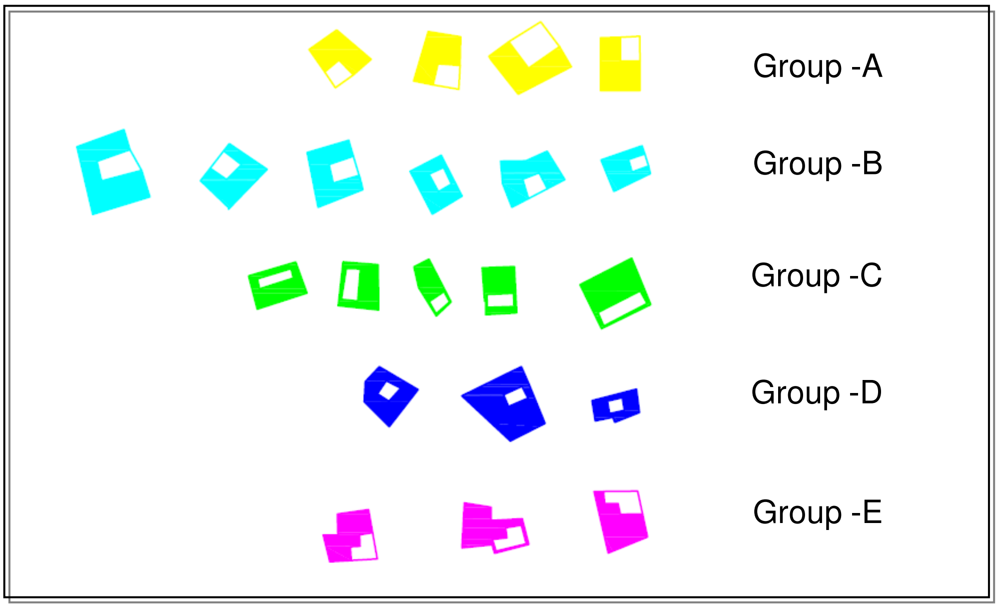


Figure-6- The group of shape in the selective part in the sample

3.3.2 The derived shapes:

After deriving the main shapes, the type of the main shape in the three dimensional level will be find where it will be possible to fix three shapes derived shape from one or more main shape. Each of five groups can find the main shape that the other shapes generate from it , as following figure :

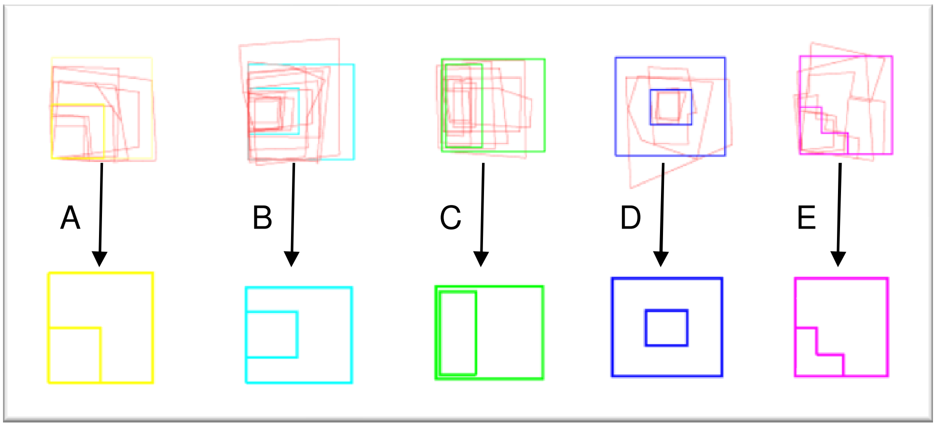


Figure-7- the main shape for each groups

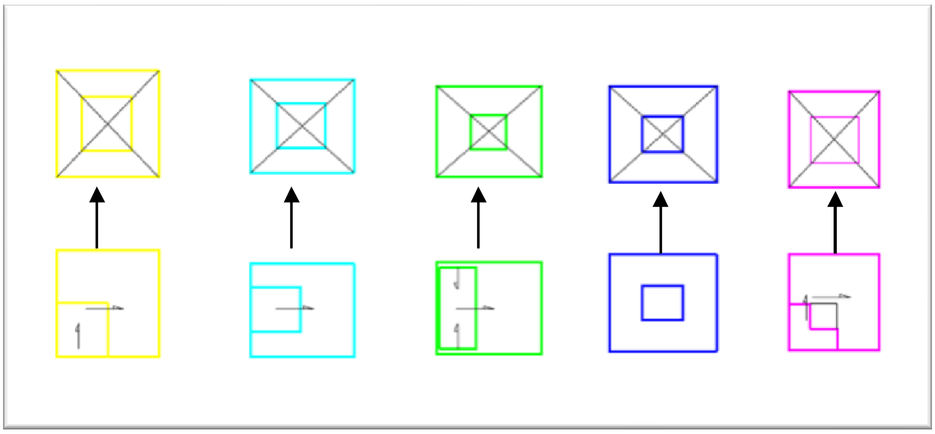


Figure-8- The main shape for all group

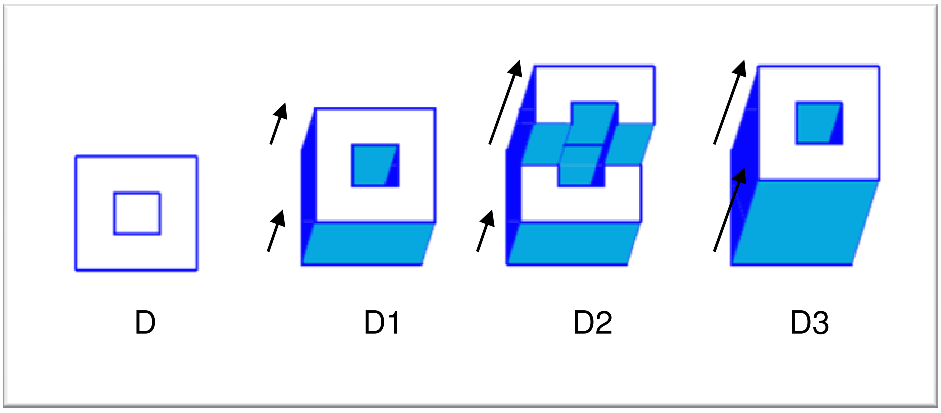


Figure-9- Three type of each group shape

Each group shape contains three type in three dimensions as the figure (9), so the number of main shape in the selective part from the sample (old Mosul city) is five shapes and three sub shape for each main shape , so the total number of all types of shape is (15 shapes) .

3.3.3 Statistic count of the main and derived shapes:

Statistic count of the main and derived shape will be done for the selective sector as these information are important and necessary when reconstructing the city or part of it in addition to their existence ratio in the site ,this information is very important because the Mat Lap language needs this information as a input data to generate a new shape plan for the sector study as following table .

Table -1-number and ratio of all types of shape that founded in the site

Number of shape in each group														
A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3	E1	E2	E3
3	20	15	2	12	8	1	10	6	1	7	2	1	2	1
A-38			B-20			C-17			D-10			E-4		
43%			22%			19%			11%			5%		

3.3.4 The relations among units and shapes :

Adjacency relations among the units in the old city of Mosul and how they connect with the near shapes . This part of study will have more detail and graphic analysis to all shapes which found in the selective sample. From the studies of the properties of the shape plan of old Mosul city we can select the important relations that can be used in the Mat lap software . This properties can be used as a code or constrain to Mat lap to generate a new part of city by the subjective way and to be logic method ,and this properties will symbolized as a code to be used as a data in Mat lap program . so , What are the properties and relations that can be found in old Mosul city ?

The properties and relations are:

- Position

This property means the position of the shape in the site and the distance between the other shape in the same group . The distance here is measured by units and the units are measured by Pixel because the Mat lap language need the distance in unit that Mat lap recognize it .So the distance unit will be symbolized as (X) for all directions ,this mean the distance is same form the center court (the open space in the shape) to the center of the other court in the same group .(figure-10)

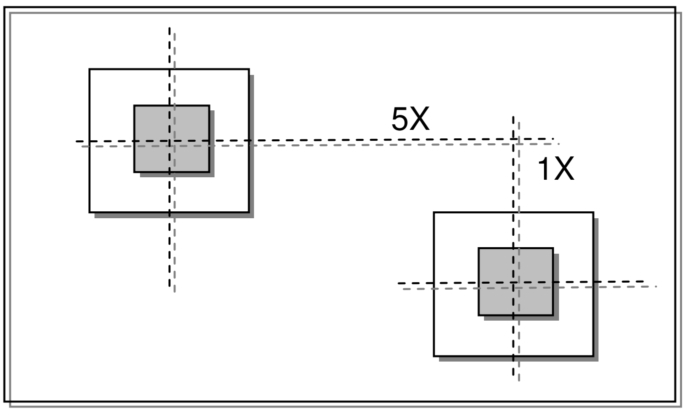


Figure-10- manning of position

- Adjacency

The second property is adjacency , this property manning what type of adjacency can find in the selective sector from old Mosul city , the adjacency can put in three type (tangent – overlap – divergent) and we will discuss this type by graphical figure (figure 11).

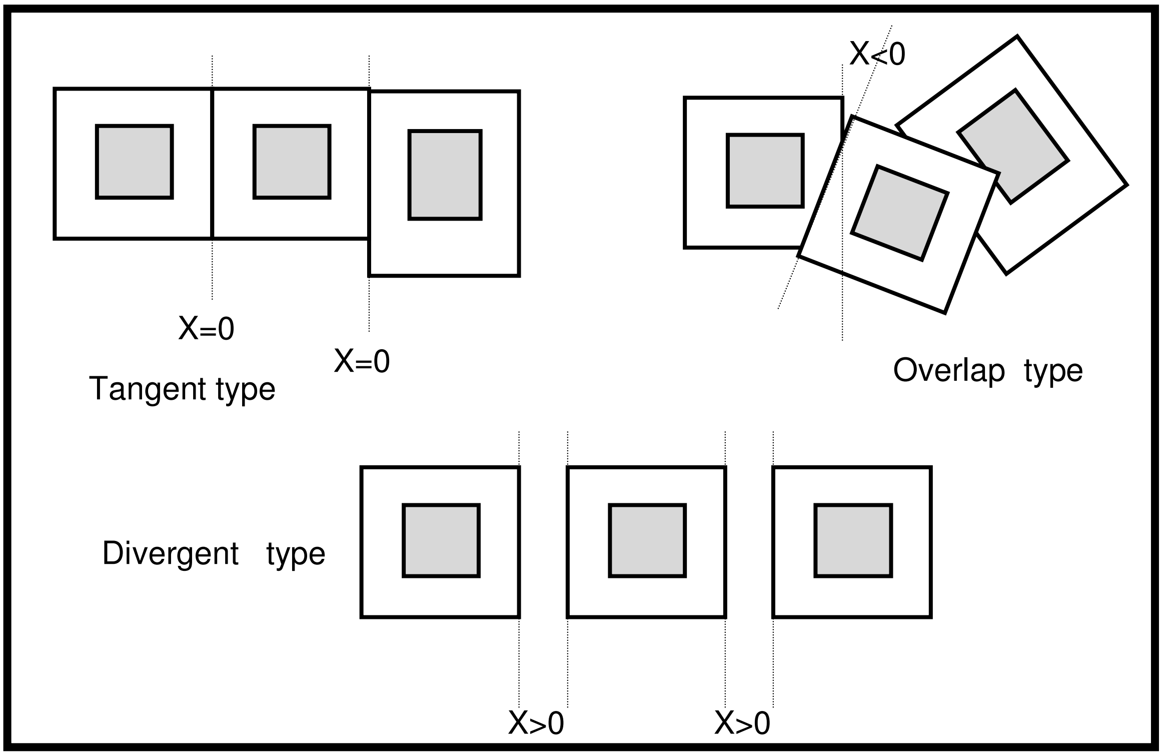


Figure-11- the three type of adjacency among the shape in the site

- Openness

Each shape needed one side open on the outside , its manning that only from three side can be relations with the other shapes , the ratio of opening space to circumference is 10-25% from the circumference of the shape as the following figure (figure-12).

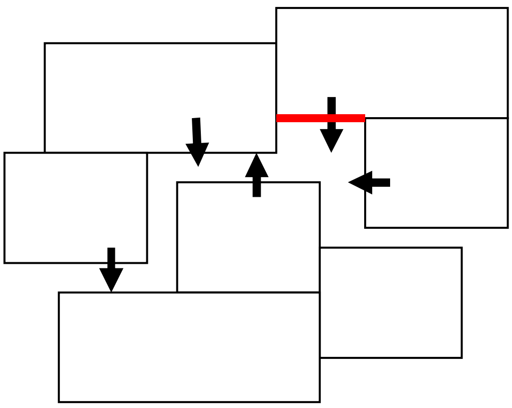


Figure-12- the openness of the shape unite(minimum 10%)

Openness on the outside is The area opened on the alley should be established in order that the result will be a logical one where there is no unit without an open to the alley.

- Transformation

There are many types of transformation in the shape[7] but in types that can found it in the selective sector are three type as the following figures(13-14-15) :

I-Size:[8]

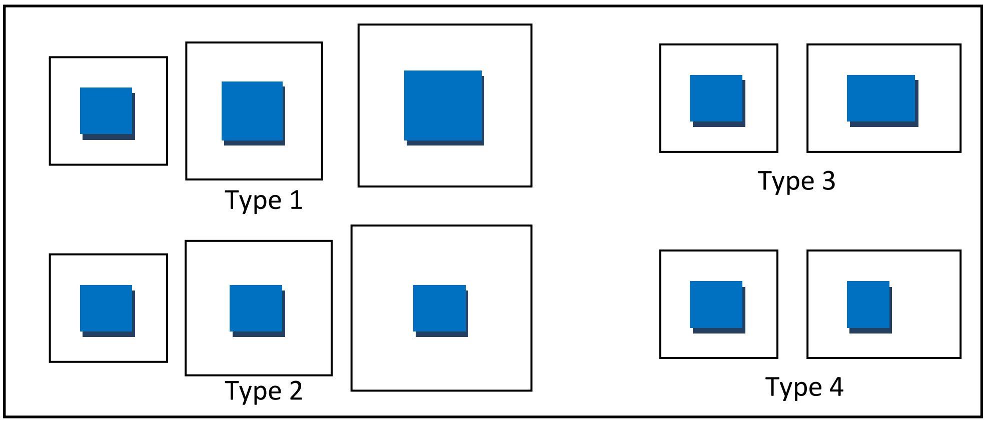


Figure-13- Type of size that found in the selective sector.

II-Rotate:[9]

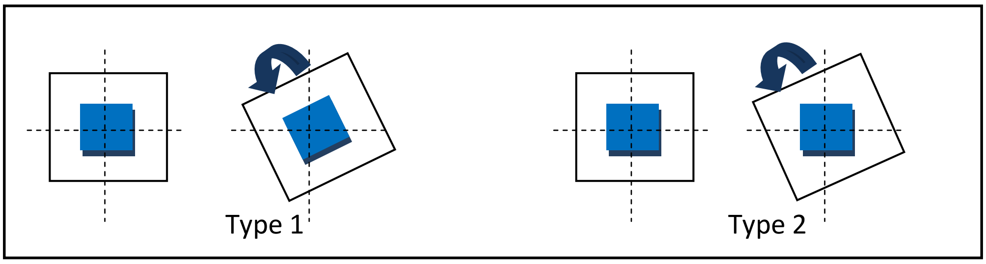


Figure-14- Type of Rotate that found in the selective sector.

III-Stretch:

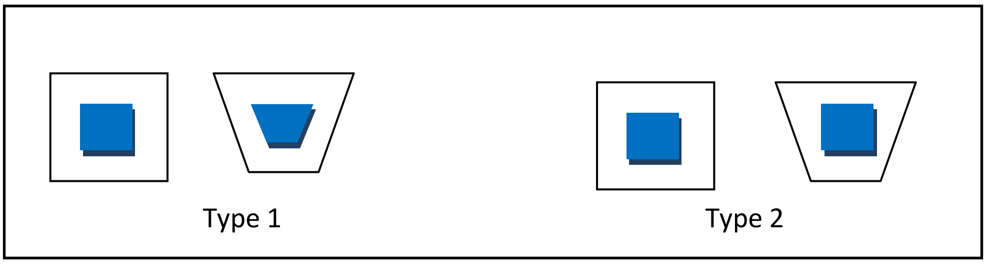


Figure-15- Type of stretch that found in the selective sector.

4 . The results of data

After finding the type of shape and its properties ,we can put it as a final data to be used in the Mat Lap application to create and generate a new shape that related to the main shape .

- Number of unites === 89
- Number of groups === 5
- Type of groups === A , B , C , D, E (figure -7)
- Ratio of group A === 43%
- Ratio of group B === 22%
- Ratio of group C === 19%
- Ratio of group D === 11%
- Ratio of group E === 5%
- Variable of positions === (10- 40X)
- Variable of adjacency (overlap) === 86%
- (divergent) === 14%
- Variable of openness === (10% - 25%)
- Variable of Transformation (Size) === (type 1 * 1.3X) 52%
- === (type 2 * 1.5X)13%
- === (type 3 * 1.1X) 22%
- === (type 4 * 1.4X) 13%
- (Rotation) === (type 1 = 78%)
- === (type 2 = 22%)
- (Stretch) === (type 1 = 81%)
- === (type 2 = 19%)

5. Generation of a new shape (results).

This stage will be application study to generate a new shapes by using Mat lap software , it used for graphic, statistic analysis and other application purpose . we used this software to made a program to generate a new sector shape using the results of analysis shape in the selective part from the sample (Old Mosul City) , this results will be used an input to the program and will be put as a stages to generate and design the new shape , so the stage of input data are:

Select the shape of site	input coordinates to create plane to start the generation
Number of units	Dived the plane as the number of units

Number of groups	for number of design new groups shape
Group / shape	Ratio of each group per shape

In The program of Mat lap two type of data , the first type is the variable date that used to input a new information in each use to program to generate a new shape which the designer need it . the second data is constant which input as an information when the program was made , this date get from the results of the graphical analysis stage. Now ,how can use the program to generate new shape in the same mechanism of shape and syntaxes in Old Mosul City? The answer of this question is the application study of Mat lap program .

Stage 1: generate a new site by input new date of the coordinate (x1 y1 x2 y2) to draw a plane which used as a selective sector that the designer want to generate new part in a same mechanism of shape and syntaxes in Old Mosul City (figure 16)

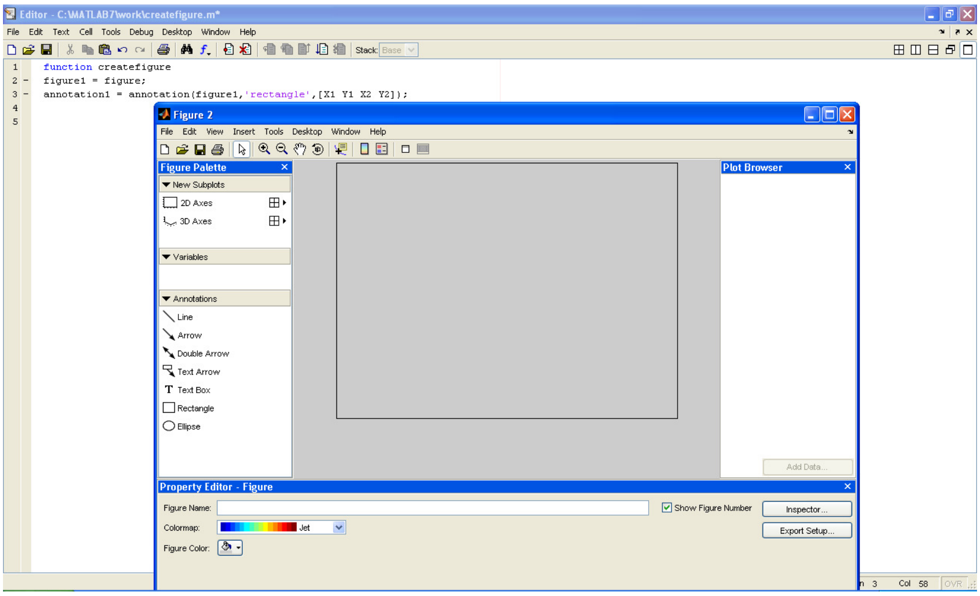


figure-16- stage 1 of generation shape

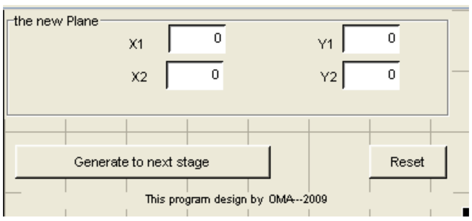


figure-17- input data window

Stage 2: This stage to select the number of unites which lead to generate new shape plan , after selected the number the program will divide the plane to same number of unites .

Stage 3: This stage to select the types of shape which input in the unite of the plane , in this stage the groups of shape will be determinate

Stage 4:determinate the ratio of shape to all shape in all groups by input the ratio in the text window which designed to input the ratio.

Stage 5: run the mat lap program to get the result by graphic drawing in the Mat lap window as the following figure . (figure -18)

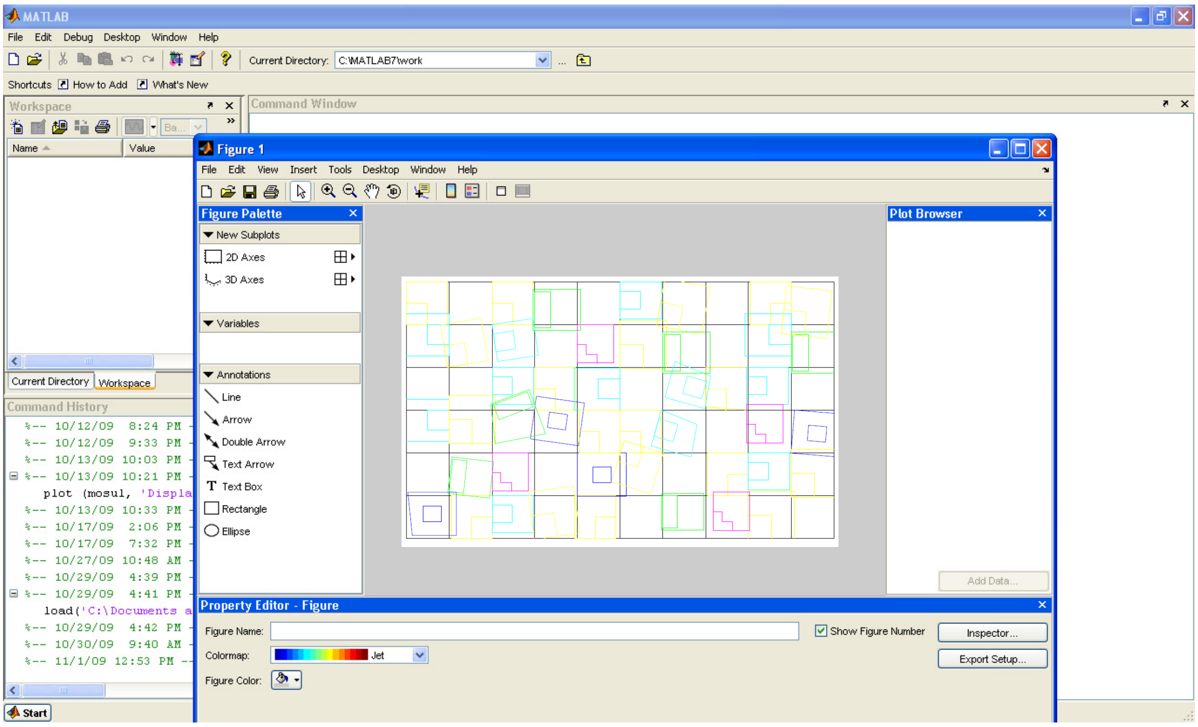


figure-18- after debug and run Matlap to generate new shape plan

after running Mat lap program , the graphical result be show as a new shape plan and we can make it in three dimension . so this program can show many models of shape plan in each used of program .

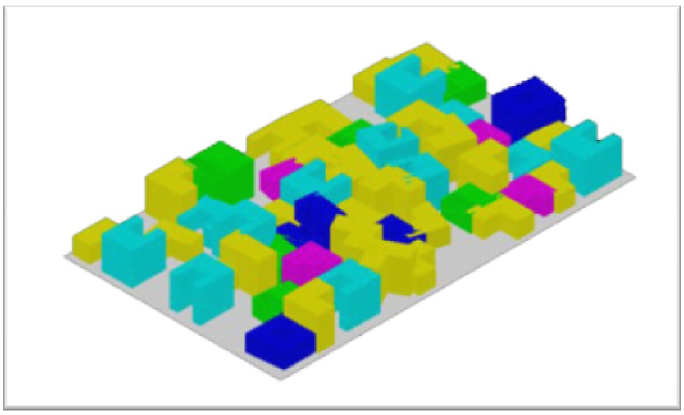


figure-19-new shape plan in three dimension

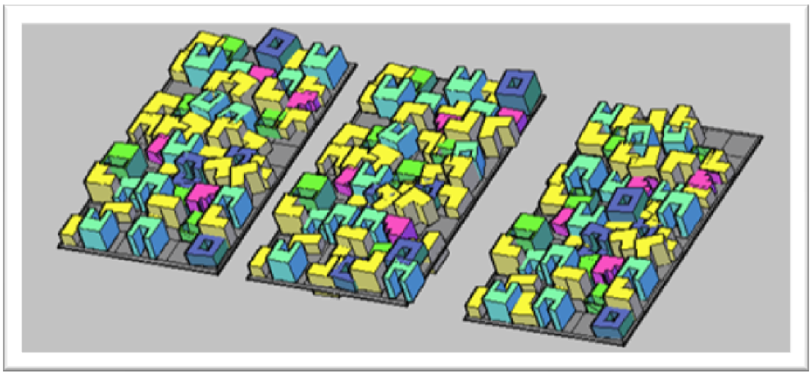


figure-20-other models from same generation

6. Conclusion:

To generate any shape by automatic method , many elements must be analyzed , and the discovered data must be changed into input data by determining the effective data which can be used to create a program in Mat lap or other software . This paper is considered primary in this field , which combines architectural design, and mathematics and computer science program which Mat lap is a statistical and graphical analysis . We can design a new shape plan not for the old Mosul city only but for other shapes by finding their mechanism and generate new ones related to the old shape or to create new shape out of main one . from this paper the architect can generate new shape in two stages , the first stage is the analysis of the sample by the graphical method and discovering the mechanism of generation and syntaxes of the main shape , this mechanism can be used to generate a new shape plan in the second stage . The result from second stage will be the design of the new shape plan , this result can related to the analyzed sample but not exactly the same design , we can use some programs to find the perfect design from the models of shape plan which will be shown in the result.

7. Reference:

[1] Google earth software for satellite Image 2004 .

[2] Knight, T . W " shape grammars : six types" Environment and planning B26:1,1999.

[3] Francis D.K. Ching, “*Architecture Form, Space , and Order*”, John Wiley & Sons, INC 2nd edition, America, 1996

[4] Chase S.C. "Modeling Designs with shape Algebres and Formal Logic ",Ph. D. Dissertation , University of California, USA, 1996.

[5] Knight, T . W " Language of design : from known to new" Environment and planning B: planning and design,1999.

[6] Issac, A. , " Approach to Architectural Design" ,Butterworth & Co. (publishers) Ltd.,1971

[7] Ahamad S. And Scott, "Design generative of Central Asian CARAVANSERAI"

[8] Licklider Heath, "Architecture Scale" ,The Architecture press ,London , UK,1965.

[9] Nikos Salingaros," A Scientific Basis for Creating Architecture Forms, Journal of Architectural and Planning Research , Vol(15) , Locke Science publish , 1998.

POSTERS
INSTALLATIONS
PERFORMANCES

The "Inventory of the Shades" Project

Alvarez, Joeser. PDG Jornalism and Media

Madeirista Collective Coordinator
www.coletivomadeirista.org
joeseralvarez@gmail.com

Ariana Boaventura, Rinaldo Santos, Sandra Pontieri, Janaína Leity, Flávio Dutka, Gaspar Knnypel, Joesér Junior, Deivis Nascimento,Anderson Silva

Madeirista Collective Members
www.coletivomadeirista.org
coletivomadeirista@gmail.com

Abstract

The Inventory of the Shades is a generative art project, accomplished by *Madeirista* Collective artists, who have begun their actions on the footpaths of Porto Velho city - Rondônia, which is located in West Amazon. In a simple way, the artistic performance seem to wake up feelings capable of changing glances, provoking reactions and reflections, stimulating popular participation, showing us that the painting, while an artistic language, didn't die, but it still alive, when it happens in the day by day of the community. Based in "*original myth of the painting*" [1] and using the Creative Commons License as conceptual generative art proposal in the internet, the reach of the project has been widened by: establishing a system of continuous cultural exchange; accepting contributions from people who live in many different places, including overseas (a generative art social code?).

1. The Project

The "Inventory of the Shades" is a hybrid project of urban intervention and performance that looks at to invert the papers of the "artist and spectator", changing the positions of one and other, using the painting and the performance how to the axes of the conceptual proposal.

In first, the artists make an invitation to the near pedestrians to the place for the action, so that they serve from models to the "art work":make shades; then, the shade of the spectator is framed in the floor with a small carve, or black ink (water basis), meanwhile the artists they ask the people that they sit down to making a first art work, about the shade in the local "Wall of the Fame" (Holywood reference), etc ...whit this, tries to involve the spectator so helps to paint the own shade, signing it at the end.

In instants, is born "new artist"(!), without needing years of class in the art school or art academy, a lot of study or any special divine talent: its first work didn't request practice, nor either ability - anyone can make it, being enough for that, the simple act of recording the own shade in the footpath, how I told it the Master Joseph Beuys: "all is artists".

In that way, is create an simple art public gallery whit free acess, almost that instantaneous, intending with that, another look to the concept of the public art, stimulating the interactivity with the common citizen and questioning the "15 fame minutes" concept (Andy Warhol) that on capitalist media has involved the global society in the search of the paradise of the ephemeral celebrity.

The whole process is documented with photo and video, taking place a gallery that they are published in internet on Creative Commons License, with the previous authorization of the participants, in the Collective Madeirista site: www.coletivomadeirista.org .

The artistic intervention of Madeirista Collective records the experience of people exploring their own figures through the representation of their shadows and therefore leaving their dual images in public space. The project itself is a digital testimony of public urban intervention, strongly proposing social participation in the artistic scenery by transforming the public audience and different socio-cultural elements into urban dynamics. [2]

Among 234 artists and artist groups who participated in the competition (November 2006 - February 2007) whit 56 online projects, the Inventory of the Shades project has received international recognition by UNESCO winning the UNESCO Digital Arts Award 2007, *due to its creative expressions and critical interpretation, as well as innovative use of low technology*. [3]

Five years after the first intervention/performance, its replicate and collaborative dissemination after the documentary film production sponsored by the Brazil Ministry of the Culture in 2008, the project became pretentious - or else megalomaniac - the objective today, is that that artistic action is answered in any street, roadway or wall of each one of the cities of the planet, showing that the painting, unlike the Delaroche prediction, continues more lives than never, when interferes in the day by day of the community.

*presentation also included:
documentary, dvd, 12:56', color, stereo (dolby digital)

The first performance
Aluizio Ferreira Square
Porto Velho – Rondônia
2004

"In each corner a Sistine Chapel" (documentary music)

REFERENCES

[1] STOICHITA, Victor."*A short history of the shadow"*. Reaktion Books, London,1997;
[2] UNESCO, "*Coletivo Madeirista wins the UNESCO Digital Arts Award 2007*", online,unesco.org, 2008;
[3]Idem.

Conversation Pieces [Case Study B]
- Headspaces -

Stephanie Brandt, Dipl.Ing., MArch, ARB
SPACEPILOTS
www.spacepilots.net
e-mail: stephanie@spacepilots.net

Abstract

The proposed project draws on habit, format, literature and space in order to construct an experimental representational system engaging with design and emotions. It is one out of an ongoing series of *Conversation Pieces*, questioning and re-contextualising structural elements in architectural design.

Photography and text are utilised to provide descriptive accounts of actions through space and time, exposing the tenuous boundaries between somebody's life and the lived through environment. Devised through a series of dialogues the study explores the material and contextual structure of issues of habit and space.
Trying to pervade and redefine each individual's own daily routines and common perceptions the conversations are aiming towards both, an emotional and explanatory experience of our environment.

How is space structured? By physical architectural elements such as walls or by words that describe the quality and matter of space?
While both methods are understood as equally valid, this work chooses especially to explore how the re-contextualisation of words can lead to the development of new spatial qualities and emotional responses.

How does this new identity make the design different from how it is historically conceived, traditionally understood and most important, conventionally used? –

The aim is to structure a new imaginary scene, transforming an ordinary urban space into a sensory narrative environment, and as such conveying the [e]motions of the human subjects of the place.

It is a project about Place, Writing and Architecture.
The actual shape of this work takes form within the process of interaction between these three.

Case Study B is one of an ongoing series of case studies, aiming to develop a system which can be read *and* experienced - and therefore can be entered in 2 ways.

In Equilibrio - a performance by a generative music composition system using multi-agents

Arne Eigenfeldt
School for the Contemporary Arts, Simon Fraser University, Canada
www.sfu.ca/~eigenfel
e-mail: arne_e@sfu.ca

Program Note

In Equilibrio (Italian: "In Balance") is a realtime composition created by Kinetic Engine, a multi-agent software designed by the composer. Responding to performance control over density, the first set of six agents interact to create an evolutionary rhythmic structure, communicating amongst themselves and altering their patterns in an effort to balance their own goals with those of the other agents. Rhythmic events are passed to a second set of six agents, which assign specific pitches: these decisions are mediated by their own desire to explore their environments (which are under performance control), while balancing the ensemble goal of harmonic stability.

UDU: A live audio-visual performance

Dr Grayson Cooke, PhD, BA(HONS)
Faculty of Arts, Business, Informatics and Education, CQUniversity Australia
www.youtube.com/civilizedmachine
e-mail: g.cooke@cqu.edu.au

Abstract

Udu is a live audio-visual performance, underpinned by generative art principles and the tradition of "visual music" or "colour music." It uses audio-reaction to produce transformations in abstract visuals. It aims towards the generation of a hybrid or synaesthetic audio-visual "substance," a sense in which audio and visual materials are perceived together and in some elemental relation or commensurability. In this performance, I produce music by playing an Udu (a Nigerian clay-pot drum), which I then sample, loop and process live using Audiomulch. This music then drives abstract, coloured visuals in VVVV, where an FFT analysis captures the amplitude and frequency of the sound source and renders this as a data-stream, which is used to drive visual transformations.

1. Introduction

Udu is a live audio-visual performance. All sounds and images are produced live and on-the-fly, such that the only materials that pre-exist the performance are the "patches" in the software applications used to generate and process the audio and visual materials. In this performance, I produce music by playing an Udu, which I then sample, loop and process live using the patch-based audio software Audiomulch. This music is used to produce abstract, coloured visuals in the graphical-programming application VVVV, which captures the amplitude and frequency of the incoming sound source and converts this signal into numerical data. This audio data, along with the data-streams produced by a series of low-frequency-oscillators, is then used to drive transformations of a series of visual parameters. MIDI controllers are used to switch and tweak parameters within VVVV, and trigger and mix audio processes in Audiomulch.

As an essentially abstract, non-narrative audio-visual experience, *Udu* sits primarily within the tradition of "visual music" or "colour music." Visual music is an artistic tradition concerned with translating musical sounds and structure into visual representations [10]. It is a term used to describe a diverse range of projects and productions, from the 18th century colour organs of Jesuit priest Louis Bertrand Castel to Kandinsky's abstract "Composition" paintings and Len Lye's direct films. All of these projects are in some way concerned with producing visual representations that recall or reflect auditory experience and thus auditory sense perception. Visual music, then, is concerned with the meeting of audio and visual materials and stimuli, and is frequently associated with synaesthesia, in the sense that it is conceived either to communicate to an audience the synaesthetic experience of the artist, or to produce in the audience a kind of simulated synaesthesia, a sense of what Golan Levin has called “audiovisual commensurability,” or what Mitchell Whitelaw calls a “cross-modal binding” of audio and visual media and senses [7,13]. *Udu* seeks to produce precisely this sense of “audiovisual commensurability,” by producing sounds and music with a strong rhythmic content, that can be perceived to map directly onto visual parameters.

Another intention with *Udu* is to produce an audio-visual performance that foregrounds the performative aspect of the project. As a result of the complex hardware and software infrastructure that frequently underpins audio-visual performances, these performances can often be opaque as to what, exactly, constitutes the “performance”; the resulting audio-visual media stream, or the performer’s bodily manipulation of software and hardware, or some combination of the two? [8]. By using a drum to produce sounds which trigger visual transformations, *Udu* seeks to produce a direct relation between image and sound that is manifest in the actions of a performer and is thus perceivable by an audience, allowing that the performance can be constituted *both* by an actual performer and by an unfolding audio-visual experience produced in real-time.

2. Visual Music

Live audio-visual performance is a complex and multi-faceted field, spanning a wide number of contexts, practices, technologies and traditions. VJs are now commonplace in many club environments, where they provide visual accompaniment to the music of DJs, using hardware and software tools designed to mix and process visual “samples” in the same way a DJ works with audio materials. “Live media” or “live cinema” artists use similar tools, but within a context designated not so much for entertainment and the experience commensurate with a club environment, but for artistic purposes and for the experience of audio-visual media as such. Likewise, many theatre and dance groups have taken up the challenge of using digital media alongside live actors and dancers, so tools for the triggering and processing of audio-visual media are utilized in these contexts as well. Additionally, it is worth noting that many audio-visual performers bridge all these contexts, working as VJs but also producing art installations and performance works, so these contexts are really only worth separating for the sake of convenience.

Perhaps because of this multiplicity of contexts for live audio-visual performance, or perhaps because many of the tools used in such performances are only now becoming widely available, with live audio-visual performance being a relatively “new” form of new-media, scholarship on this field is only now beginning to emerge and to constitute audio-visual performance as a field of enquiry in its own right. Thus it is no surprise that within the existing scholarship on the field, a large and disparate number of antecedents and traditions are mentioned, as possible ways to understand the field. Contexts as diverse as the dioramas and panoramas of the 19th century; magic lantern and phantasmagoria shows of the same period; Wagner’s

Gesamtkunstwerk; the Italian Commedia dell'Arte; Wassily Kandinsky's abstract Composition paintings; and Andy Warhol's Exploding Plastic Inevitable, are all cited as potential antecedents for the contemporary practices in live audio-visual performance [4, 5, 6, 11]. These contexts and media forms do not all sit side by side, they are a heterogeneous melange reflective of the many contexts audio-visual performance is found in today, and they evince a number of concerns; concern with *immersing* the spectator in a total visual or sensory field, for example, or a concern with *chance* and *aleatoric production*, or a concern with the commingling of different artistic modes of production and different *modes of sense perception*.

As I have already indicated, it is primarily this final concern – the concern with the commingling of different modes of sense perception – that underpins this project, and this concern is most often associated with the tradition of visual music or colour music. Visual music is a long tradition, stretching at least back to the 17th century and Isaac Newton's equation between the seven tones of the Western diatonic scale and the seven discrete colours red, orange, yellow, green, blue, indigo, violet [3]. Even Aristotle is said to have explored the relations between tonality and colour [10]. The equations involved in relating the seven colours and the seven tones of the scale, however, are essentially arbitrary, and have been questioned many times since their proposition, for various reasons: firstly, hue and frequency are continuums that have been broken into discrete portions by perceptual or mathematical convention rather than by intrinsic or "natural" differentiations; secondly, frequency is a linear continuum while hue is circular [3]; thirdly, colour is most frequently perceived spatially whereas sound is generally experienced temporally [4]. Nevertheless, the relations between hue and frequency postulated by Newton and others began a series of attempts to manifest these relations via the invention of "colour organs" allowing the player to play colour the way they would play a piano. For example, Louis Castel's colour harpsichord or *clavecin occulaire* of 1734 was followed by the colour organs of Bainbridge Bishop and Alexander Rimington in the 19th century, and various 20th century colour-generating devices such as Mary Hallock-Greenewalt's "Sarabet," Thomas Wildred's "Clavilux" and Oskar Fischinger's "Lumigraph" [1, 4, 8, 9].

While some of these devices were conceived to create images that *accompany* music, and some were conceived to make images *in the same way* as music is created, a theoretical relation to sound generation and perception spans each of them. This array of devices represents an attempt to formulate a simulated synaesthesia, whereby it would be possible to "see sound" or "hear colour." Synaesthesia is a neurological condition characterized by the involuntary cross-bleeding of sense perceptions, most frequently between the visual and auditory senses, but sometimes also across touch, taste and smell as well. The synaesthetic experience is consistent across time, and one synaesthete's experience of sensory cross-breeding will generally differ from another's, so for example, while one synaesthete may find a certain musical key to be "red," another may find it to be "golden," and another, indeed, may find it to be "pointy" or to "taste like sherbet." In this context, modern visual music practices inherit not only the practical colour-sound combinations of the colour organs, but the painterly and musical experiments in producing or communicating synaesthetic experience conducted by artists like Wassily Kandinsky and Alexander Scriabin. Of course, with all of these experiments and media forms, it is not possible to produce the actual neurological *experience* of synaesthesia in non-synaesthetes. What is possible, however, is to produce a sense of some kind of audiovisual commensurability for the audience, that is, produce a tight and integrated mapping of audio and visual media – a "cross-modal binding" – in order that the audience member experiences them together, and perceives their tight integration.

We are, of course, accustomed to visual and audio media being associated in our everyday lives, just as we combine our sight and our vision all the time. For example, it is completely normal to see a sound source and expect to hear the sound generated by the source, for example, a person talking and the sound of their speech. Likewise, we experience this same synchronicity when watching this event on television or in the cinema. Additionally, we watch television and cinema and are accustomed to hearing music that "accompanies" visual media, and in the genre of music video, we see visuals that "accompany" the music. Each of these examples indicate a certain kind of relation between audio and visual media and senses. But, they all tend to privelege one form of media over the other, hence the use of the word "accompanying" to indicate that one form is primary and the other secondary. They also tend not to draw attention to sense perception in and of itself, subordinating sensory perception to the experience of narrative entertainment, or the consumption of pop culture. Visual music, however, tends to be non-narrative, and frequently abstract, meaning that in visual music the "reading" strategies required of the audience for traditional narrative cinema do not hold; there is no over-arching narrative structure to subordinate the image and sound tracks to, and there are no representational images to anchor an audience's perceptions within mimetic realism. Rather, the phenomenological fact of sensory stimulation comes to the fore; audio and visual media are used not as means for the transmission of stories, ideas or ideologies, but as means for sensory stimulation, and frequently, stimulation of multiple senses at the same time and in the same manner.

While visual or colour music is the primary context within which *Udu* has been created, another key consideration has been the role of aleatoric or chance production in the performance. As I have indicated, live audio-visual performances call upon a wide array of potential antecedents and traditions, many of which are invested in the role of chance in artistic production. Influenced by Freud's distinction between the "manifest" and "latent" content of dreams, the Surrealists, for example, were interested in chance-based creative processes as a method of getting at the unconscious or latent content of thought. A game like "The Exquisite Corpse" manifests a version of "thought" which is extra-individual and collective, it is a process of making "meaning" from arbitrary juxtaposition, and moreover, a meaning that originates not in the mind of an individual understood to be able to express their intentions, but across individuals, giving us an image of thought, meaning and intention that cannot be tied to a thinking "subject." The cut-ups of Brian Gysin and William Burroughs likewise operated on the principle of latent content emerging through chance juxtaposition. In more performance-based contexts, the Happenings of Allan Kaprow, many of John Cage's works, and the aleatoric music of Pierre Boulez and Karlheinz Stockhausen, are all potential influences on the role of chance in audio-visual performance, where generative algorithms based on random events are used to produce arbitrary and involuntary, and frequently un-intended, audio and visual transformations. The notion of *not* being in control, of opening the performance up to chance events, the accident and the arbitrary, is celebrated in many accounts of live audio-visual performance, suggesting that live media performance is premised on a dialectic between control and uncontrol, or a “balance between intent and accident” [2].

3. *Udu* as a Performance

Udu uses Audiomulch and VVVV to pursue the goal of fostering an experience of “audiovisual commensurability” in an audience. Both of these software applications are “patched” environments, meaning that they provide the user with an environment in which to develop their own audio or visual program or “patch” by stringing together “nodes” that perform certain tasks.

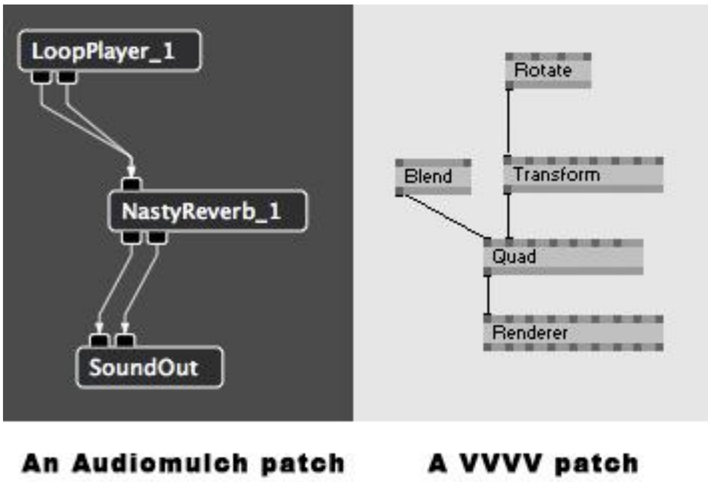


Figure 1: patched environments

Patched environments use nodes that either *generate* some kind of signal (e.g., a low-frequency oscillator, a frequency analyser, a file player), that *process* some kind of signal (e.g., a reverb unit, a 3D transformation node, a blend node), or that *output* a signal (e.g., a sound-out node, a visual renderer).

In Audiomulch, my Udu playing is firstly simply amplified and passed through the software, and later, it is recorded using a loop node. This recording is then used as raw “signal” from which a number of different “channels” of audio are generated, as the looped audio recording is sent through a series of different effect chains. For example, one chain consists of a granular synthesizer, which reduces the audio signal to a series of rhythmic “grains” or sound fragments, and a series of delay effects, ultimately producing a rhythmic and semi-random pulsing. Other effect chains use granular synthesis and VST plugins designed to “glitch” and re-cut the audio signal randomly, again producing a random series of rhythmic pulses. Other nodes are used to impart a harmonic tonality to the signal, to add phasing to it or to apply equalisation to the frequencies. All the rhythmic effects in Audiomulch are set to synchronize to the in-built clock, ensuring the resulting music is all synched to a common beat, at 115 bpm. The separate audio channels are linked to an 8-track mixer node, which is manipulated using a MIDI controller, allowing me to fade between different tracks as required.

As I have indicated, the only substantive materials that pre-exist the project's performance are the patches in each software application. Each patch awaits a "signal" of some kind in order to produce a result, and without a signal, there is no project. The only visual element in VVVV that pre-exists the project's performance, is a single transparent .png file with a white circle with a gradient fade around all sides. This generic image is multiplied and manipulated to produce the visual side of the project. Within VVVV, a 16-channel FFT analysis (fast Fourier transform) is performed on the audio signal produced in Audiomulch, captured by the internal microphone on the computer. The data-stream from each of the frequency bands is then sent, as a 16-channel data-stream or "spread" in VVVV parlance, through various nodes to multiply and smooth the values, and ultimately, it is used to drive transformations in scale of the visual elements. If there is no audio input, there is nothing to see, because the scale of the visual elements is reduced to zero, meaning that the visual side of the project is entirely generated by the audio side of the project. The same FFT stream is also used to generate a spread of values applied to the hue, saturation and brightness of the visual elements.

Because the audio signal is constantly changing, and is characterized by a mixture of rhythmic and random events, the concomitant visual responses are likewise randomly generated within a loosely determined field of specificity. At the same time, random events are being generated using a low-frequency-oscillator (LFO), and these events, after multiplying and smoothing the resulting numeric values, are used to trigger translations of the visual elements on the X, Y and Z axis. Other LFOs are used to ramp between values in various nodes, producing constantly changing visual effects. These are the essentially "generative" and aleatoric aspects of the VVVV patch, as they are automated processes that, once set in play, will produce endless permutations which, while maintaining a certain visual consistency, will never be exactly the same and can never be exactly predetermined.

Alongside the generative aspects of the project, however, are a number of controlled and intended elements. A MIDI controller is used to control the colour range, for example, allowing rough control of hue, brightness and saturation. The MIDI device is also used to switch a virtual camera on and off, and toggle between various camera movements, allowing for varying 3D perspectives of the visual elements to be produced. Between these generative and intended aspects of the project, lies a vast potential for the aspects of cross-modal binding to be explored. As the project progresses, numerous permutations of the relation between sound and image are explored, as a range of harmonic and rhythmic audio events produce a range of different visual transformations in colour, shape, scale, position and movement, and as the performer switches parameters in real-time, frequently responding to the rhythm of the music, to heighten the audience's perception of audio-visual commensurability.

Finally, it is worth noting how the overall structure of the *Udu* project is designed not only to produce a sense of audio-visual commensurability, but to produce it in the context of a performance that *feels* like a performance. Audio-visual performers generally conceive their work *as* performance; they produce images and sounds live and on-the-fly, in real-time, and in that sense what they do is a performance comparable to what any other performer does. However, the question arises as to whether the performance is constituted in and by the audio-visual media, or by the artist's actions, or by some combination of the two. One of the frustrations expressed by many audio-visual performers or VJs is that while they know that they are producing the images (and sounds) that the audience perceives, the audience is not necessarily aware of how or even whether this occurs, rendering the performative aspect of the performance problematic [8]. The audience receives the result of the performer's actions as an audio-visual stream comparable to cinema or television, and, since these media forms are frequently produced ahead of time, in the studio or editing suite, the audience may easily receive the impression that this performance, too, was "pre-edited." Likewise, audio-visual performance is frequently underpinned by software applications and hardware devices, the manipulation of which rarely bears any direct perceivable relation to what is seen and heard. That is to say, watching a performer tweak knobs on a MIDI device is neither the most riveting spectacle nor the most transparent.

The point of using a drum to trigger sound, is that the performance begins with a concrete image of performance, where seeing the performer playing a musical instrument directly translates to seeing the production of visual imagery; for the audience, there is a direct relation between sound and image production. Because drums produce short, staccato sonic forms, as opposed to forms with lengthy sustains or durations, they lend themselves particularly well to visual representation, as they produce sudden spikes in amplitude that fall away quickly. When rendered as data-streams and mapped to visual parameters, these sudden spikes in amplitude produce immediate and dramatic visual transformations. Once the udu sound has been sampled, looped and processed, that direct audio-visual connection is replaced by a more malleable and shifting field, but the project begins, at least, by stating that connection "up front," providing the audience with a "ground" for the experience that is to come.

References

[1] Akiyama, Mitchell. "Projections: The Development and Politics of Digital Media in Audiovisual Performance." *Offscreen.* Vol. 11, noa.8-9 (2007). http://www.offscreen.com/biblio/pages/essays/akiyama_digitalmedia/ accessed 28/3/09.

[2] Bucksbarg, Andrew. "Vjing and Live A/V Practices." *VJ Theory: Texts*. 2008. http://www.vjtheory.net/web_texts/text_bucksbarg.htm accessed 11/02/09.

[3] Collopy, Fred. "Color, Form, and Motion: Dimensions of a Musical Art of Light." *Leonardo.* Vol. 33, no. 5 (2000): 355-360.

[4] Galeyev, Bulat M. "The Fire of 'Prometheus': Music-Kinetic Art Experiments in the USSR." *Leonardo.* Vol 21, no. 4 (1988): 383-396.

[5] Grau, Oliver. *Virtual Art: From Illusion to Immersion*. Trans. Gloria Custance. Cambridge MA & London: MIT Press, 2003.

[6] Joseph, Branden. "'My Mind Split Open': Andy Warhol's Exploding Plastic Inevitable." *Grey Room.* No.8 (2002): 80-107.

[7] Levin, Golan, and Zachary Lieberman. "Sounds from Shapes: Audiovisual Performance with Hand Silhouette Contours in "The Manual Input Sessions". Proceedings of NIME '05, Vancouver, BC, Canada. May 26-28, 2005.

[8] Lew, Michael. "Live Cinema: Designing an Instrument for Cinema Editing as a Live Performance." Proceedings of the International Conference on Computer Graphics and Interactive Techniques, ACM SIGGRAPH (2004).

[9] Makela, Mia. "Live Cinema: Language and Elements." MA Thesis, Helsinki University of Art and Design, 2006.

[10] Moritz, William. "The Dream of Color Music, And Machines That Made it Possible." *Animation World Magazine*. 2:1, 1997. http://www.awn.com/mag/issue2.1/articles/moritz2.1.html

[11] Turco, Marina. "The Sudwestern Saga: Live Media and Modular Narratives Between Commedia dell'Arte and Digital Hypertexts." *VJ Theory:TEXTS*. 4th July 2007. http://www.vjtheory.net/web_texts/text_turco.htm accessed 30/3/09.

[12] Van Campen, Crétien. "Synesthesia and Artistic Experimentation." *Psyche.* Vol. 3 (1997). http://journalpsyche.org/ojs-2.2/index.php/psyche/article/viewFile/2358/2290 accessed 30/3/09.

[13] Whitelaw, Mitchell. "Synaesthesia and Cross-Modality in Contemporary Audioviduals." *Senses and Society*, Vol. 3, issue 3 (2008): 259-276.