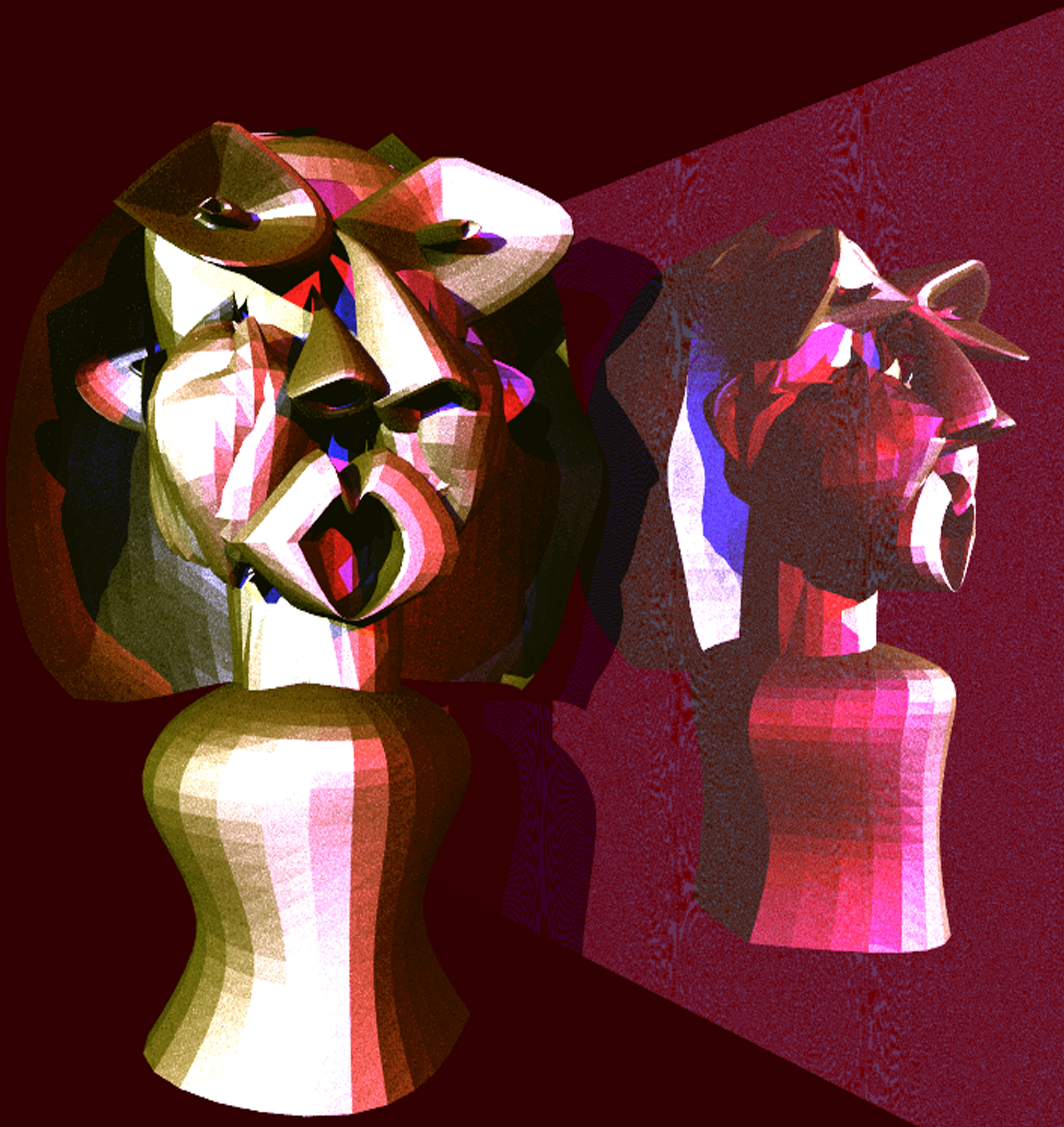


# GENERATIVE ART

Proceedings of GA2013

XVI International Generative Art Conference

edited by Celestino Soddu and Enrica Colabella

Domus Argenia Publisher

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

***In the cover :***
***"Generative 3D Portraits "Homage to Francis Bacon", interpreting the Bacon portraits with generative logics.***
***As Francis Bacon interpreted Van Gogh, and Velasquez, Celestino Soddu tried to interpret Francis Bacon moving from 2D to 3D events.***

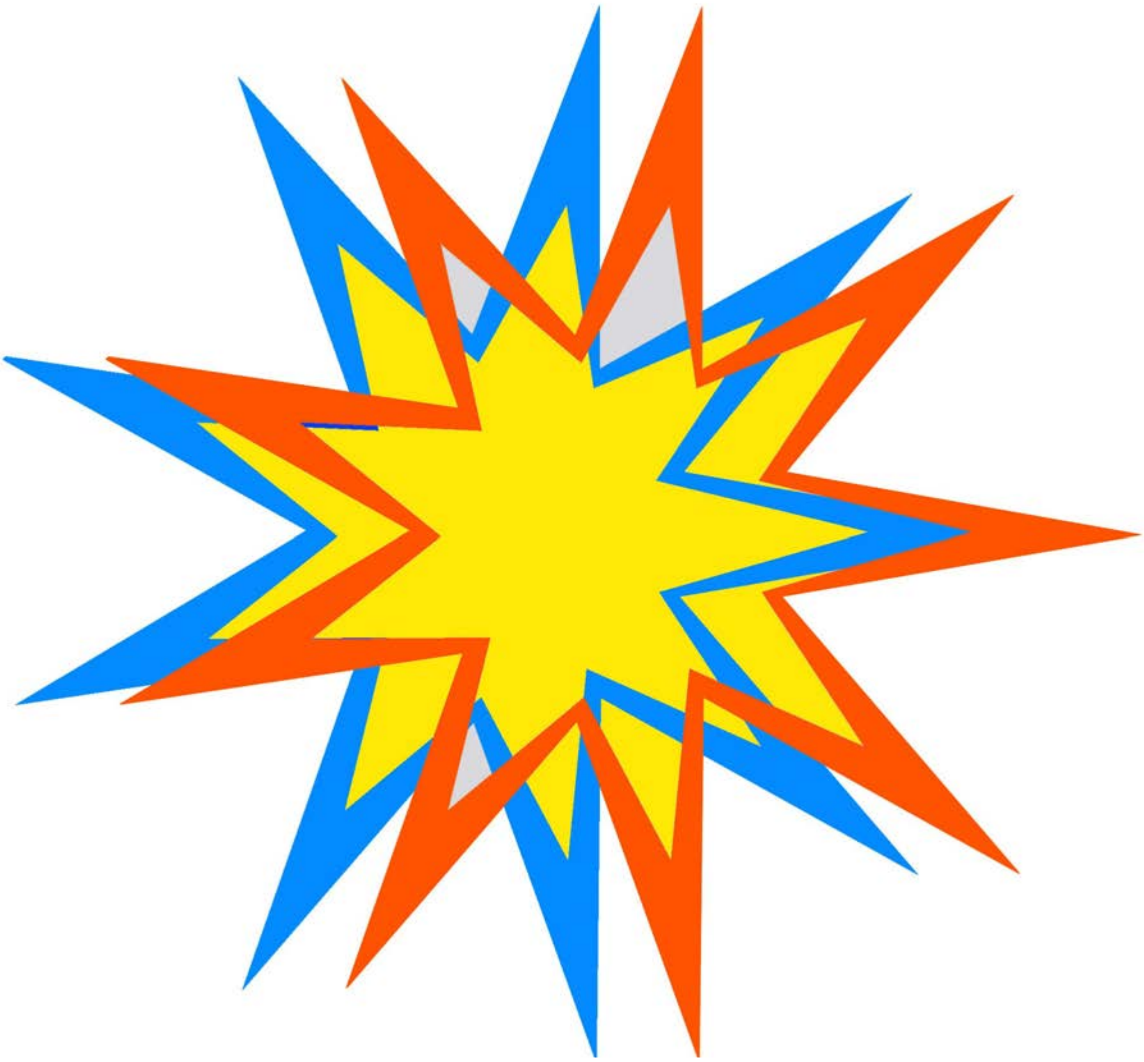
***Each proceedings book is personally dedicated to one of the GA2013 participants as author. The unique cover represents one variation of 40 variations of Generative Portraits performed for this book.***

www.generativeart.com
www.generativedesign.com
www.gasathj-com

***Celestino Soddu dedicated to each participant a***
***unique generative atwork variation***

***Printed in Domus Argenia Center the 26th of November 2013***

***Domus Argenia Publisher***
***ISBN 978-88-96610-25-1***



# GENERATIVE ART 2013

***GA2013 - 16th International Conference***
***Milano 10, 11 and 12 December 2013***
***La Triennale di Milano***
***Italy***

***Proceedings***
***Edited by Celestino Soddu and Enrica Colabella***
***Generative Design Lab - Politecnico di Milano University, Italy***
***Generative Art Lab - Domus Argenia Center, Sardinia, Italy***

**Domus Argenia Publisher**

# Why Generative Art?

Why Generative Art? And why, after 16 years of Generative Art conferences do we continue to follow this approach and do we continue to use this term for identifying our work?
More, why did Generative Art increase in these last years its importance and is it, at now, one of the new creative approaches used by artists, designers, musicians and architects? And why, in the universities all over the world, can we find the "new" teaching courses of Generative Art?
Generative Art, the term with the meaning that is today used, was completely unused before of the beginning of this conference in 1998.
Generative Art has the age of our GA conferences.

The main answer is owing to the character of the Generative Approach, that moves the creative acts from static events to dynamic transformations. This dynamic process could be easily represented and managed with a set of algorithms. Each algorithm represents a rule as a fragment of the our own vision, of "how" we think to transform the past in the future.

There are four main reasons why we approach Art using the generative way.

1.The first one is that, using this approach, we can increase, in subsequent moments, the already reached quality. We can do that, also if we are developing a completely different theme. This normally happens in all artist artworks, in architecture, in design, in visual art and in music. But instead of re-designing each time the same logical sequences for progressively increasing the complexity and quality of our artwork, we can use the previously-designed transformation rules. The peculiarity of algorithms is to represent a transformation. By using these our own tools, we can easily, and in a reduced time, arrive to a comparable quality by re-using in different contexts the rules that we have already performed. But we must clarify that we can also use other tools different from algorithms because, following a different field like mechanical or chemical fields, we can create logical dynamic sequences with the same structure of the algorithms.

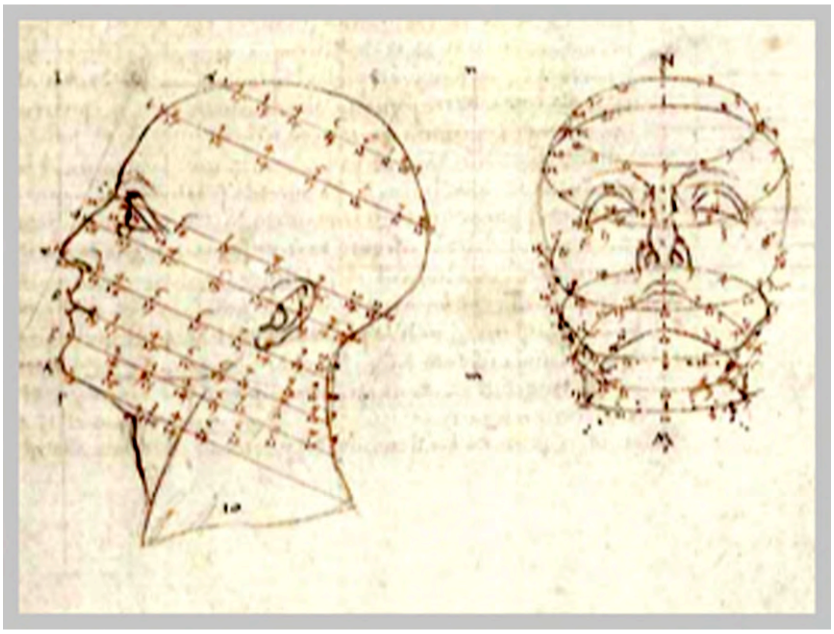
2.The second reason is that, with a generative approach, we can manage easily the complexity of the creative process. Because we can go ahead step by step in creating and controling our artwork. We don't need to strain our creativity in representing a whole complex system only with a single creative act. We know that we cannot represent a whole complex system in only one step. If we try to do that, (sometimes happens that we are forced to simplify our work) we reduce deeply the quality of our results.
Complexity is necessary because only artworks with a large range of possible different interpretations can be really accepted by the large public. Not complication but complexity as power to offer a wide range of possible answers to the unpredictable subjective requests of the public.

3.The third reason belongs to the possibility to identify and recognize each possible result as belonging to the artist vision. We can recognize artworks, musical pieces, architectures, objects as belonging to the creative act of an identifiable artist, as normally happens for the great artists. With the generative approach each artist can construct, step by step, his / her clear recognizable style, by writing in progress the rules that each subsequent artwork will follow as a possible increasing complexity.

4.The fourth reason is the most important one. Generative approach helps the human creativity. It gives to each artist the possibility to represent their idea in an open way. When an artist performs an idea, normally he tries to represent it with some artworks, but each result is not a full representation of his idea. It's only one of the possible partial performing artwork. When the artist creates a generative dynamic artwork able to generate variations, he is able too to create in progress, algorithm by algorithm, a representation of his own idea able to communicate his vision of life. That's art. Or better that's Generative Art.

After the debacle in art of the last century with the declaration of the author death, GA had rediscovered the main character of the human beings: the creativity. This is able to follow the transformation of the “reality” into a possible world closed to an harmonic vision. In line with the philosophy of Renaissance where the center of the art process is configured in the man/universe duality as a dynamic process toward infinite. As Piero della Francesca docet.

Celestino Soddu and Enrica Colabella, Chairs of Generative Art Conferences, 2013



Piero della Francesca
De Prospectiva Pingendi

# Index

## Papers

## ARTWORKS and INSTALLATIONS

with the artworks of:


and in memory of


## Live Performances


Francis Bacon,self portrait 1973 and 1969

# PAPERS

**Alain Lioret**

# Time Beings :Quantum Beings for Art Exploration and Creation

***Topic: Artificial Life***

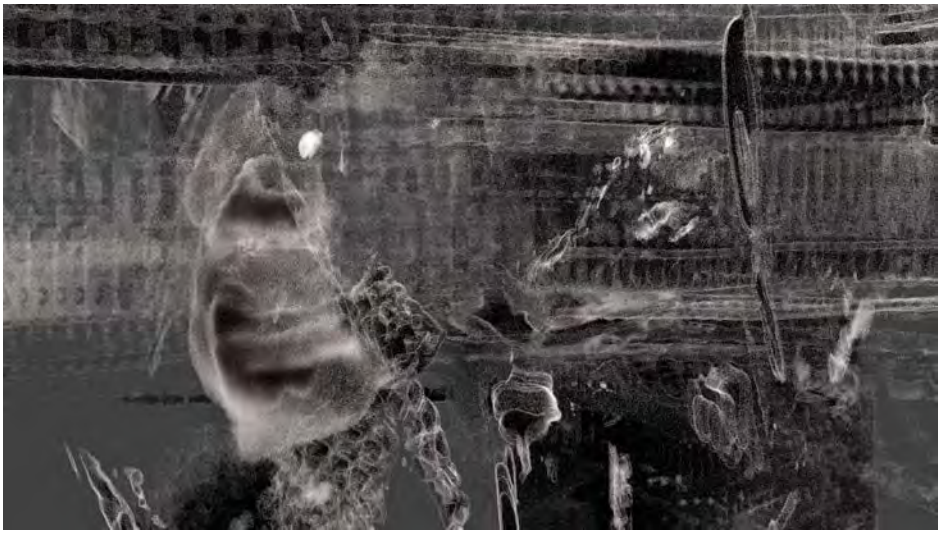
***Authors:***
***Alain Lioret***
Université Paris VIII, Arts et Technologies de l'Image
www.alainlioret.fr

***References:***
[1] Gavin Parkinson . Surrealism, Art, and Modern Science: Relativity, Quantum Mechanics, Epistemology. Yale University Press, 2008.
[2] Mitchel Whitelaw. Metacreation: Art and Artificial Life. The MIT Press, 2006.

www.generativeart.com

***Abstract:***

Time Beings are a population of creator artificial beings. They take various forms of elementary corpuscles, according to various types of artwork (pixel, frame, vertex, note, word). They operate on the basis of quantum properties and can travel in space-time works of art. Their purpose is artistic exploration and/or creation. Relying specifically on computation of superposition states with Qubits and rules of Quantum Cellular Automata, Time Beings open new ways for artistic creation.
They offer an innovative method for Artistic Time Travel, with scaling in the image space, film space, object space, score space and paper space.
Time traveling in space is one of the great fantasies of humanity. Inconceivable according to the principles of classical physics, this theme is back strongly, thanks to quantum mechanics.
However, this remains a great utopia for the world-scale physics of our universe. How about in the art world? It is known that quantum principles apply only at very small scales at the atomic level. However, art can explore ways that are often unreachable for scientists.
The work presented here, based on the concept of Time Beings as artificial creators, tries to translate the principles of quantum mechanics and Time Travel into the realm of artwork. Projection from our real space on a canvas painting, a sculpture, poetry or film, opens new perspectives for very interesting artwork explorations, and also methods of creation.



*Quantum Exploration of the film « Back to the Future ».*

***Contact:***
***alainlioret@gmail.com***

***Keywords:***
Artificial Life, Quantum Mechanic, Cellular Automata.

# Time Beings.
# Quantum Beings for Art Exploration and Creation

**Alain Lioret.**
*Arts et Technologies de l'Image. Université Paris VIII*
*www.alainlioret.fr*
*e-mail: alainlioret@gmail.com*

## Abstract

Time Beings are a population of creator artificial beings. They take various forms of elementary corpuscles, according to various types of artwork (pixel, frame, vertex, note, word). They operate on the basis of quantum properties and can travel in space-time works of art. Their purpose is artistic exploration and/or creation. Relying specifically on computation of superposition states with Qubits and rules of Quantum Cellular Automata, Time Beings open new ways for artistic creation.
They offer an innovative method for Artistic Time Travel, with scaling in the image space, film space, object space, score space and paper space.

## Introduction

Time traveling in space is one of the great fantasies of humanity. Inconceivable according to the principles of classical physics, this theme is back strongly, thanks to quantum mechanics. [1].
However, this remains a great utopia for the world-scale physics of our universe. How about in the art world? It is known that quantum principles apply only at very small scales at the atomic level. However, art can explore ways that are often unreachable for scientists.
The work presented here, based on the concept of Time Beings as artificial creators, tries to translate the principles of quantum mechanics and Time Travel into the realm of artwork.  Projection from our real space on a canvas painting, a sculpture, poetry or film, opens new perspectives for very interesting artwork explorations, and also methods of creation.

## Theories of Quantum Mechanics

In the early 20$^{th}$ century, in the field of the infinitely small, Max Planck invented the Quanta Theory including the famous length (10-$^{35\ m}$) and time ($10^{-43}$ seconds) constants, which remain barriers. Since then, Quantum Mechanics has become very popular.
In the scientific community, we have seen the famous theoretical battle between Einstein and Niels Bohr about the uncertainty principle enunciated by Heisenberg [2], and many other in-depth discussions about disturbing statements of this Quantum Theory, which go against general relativity. The paradox of Schrödinger's Cat is at

the center of these issues. [3].
The principles of Quantum Mechanics have had a great influence on art since the beginning of the 20th century, and they have inspired many artists and writers.

## Context: Art, Time Travel and Quantum Mechanics

Time Travel and Quantum Mechanics have been used in many pieces of art in the past artistic history. Here are some major examples:
The theme of time travel appeared very early in literature. Before publishing his famous novel, *The Time Machine*, in 1895 (adapted for the movie screen for the first time by George Pal in 1960), HG Wells published *The Chronic Argonauts*, in 1888, and Mark Twain published his satire *A Connecticut Yankee in King Arthur's Court*, in 1889 (Adapted for the screen in 1921). Since then, many other authors have used the theme of time travel.
Time travel and wormholes as quantum alternatives have often inspired artists, including filmmakers. Among the most famous works, we can mention: *Planet of the Apes* (by Franklin J. Schaffner in 1968), the *Back to the Future* trilogy (Robert Zemeckis, 1985-1990), *Star Trek IV: The Voyage Home* (1986, by Leonard Nimoy) and more recently, *Men in Black 3* (2012).
Here we cannot make a list of all the artists who are interested in the theme of time, nor those whose artistic pieces have links with physics. The excellent book by Leonard Shlain, "Art & Physics" [4] gives a good comprehensive overview of this field.
We note the admirable work of Claude Monet, and his temporal versions of Rouen Cathedral, but also his extensive research in the quest for other dimensions.
Cubists, such as Picasso, produced paintings where one can see all facets of an object at the same time, in the same artistic space. Also, Marcel Duchamp used to say:
"*I was thinking of art in a broader perspective. We were discussing altogether fourth dimension and Euclidean geometry. These were amateurs' points of view ... But, despite all our mistakes, these new ideas freed us from the conventional language – from our coffee shop platitudes.* "[4].

*Figure 1: Marcel Duchamp. Nude Descending a Staircase, No. 2 (1912). Oil on canvas. 57 7/8" x 35 1/8". Philadelphia Museum of Art.*

The work of the Italian Futurists, such as the Nude Descending a Staircase by Duchamp and the Surrealists (including for example *Figure Pandynamique* by Wolfgang Paalen, one of the major surrealist quantum works) was also strongly influenced by quantum mechanics [5].
Meanwhile, the search for a fourth dimension in art was superbly analyzed in the works of Linda Dalrymple Henderson [6] (a great specialist about study of the cultural history of the “fourth dimension”) and Tony Robbin [7] (a pioneer in the computer visualization of four dimensional geometry) in particular.
Artists such as Julian Voss-Andreae, who implemented Quantum Theory in the field of sculpture [9], Lynden Stone [10] author of quantum installations, and Servant-Ermes, a French painter, based much of their art on quantum theory.
Quantum physics has also inspired many scientists to create artistic images. These artists include Eric J. Heller, who made beautiful pictures based on quantum theory and wrote many papers [8] (well known for his work on time dependent quantum mechanics, and also for producing digital art based on the results of his numerical calculations).

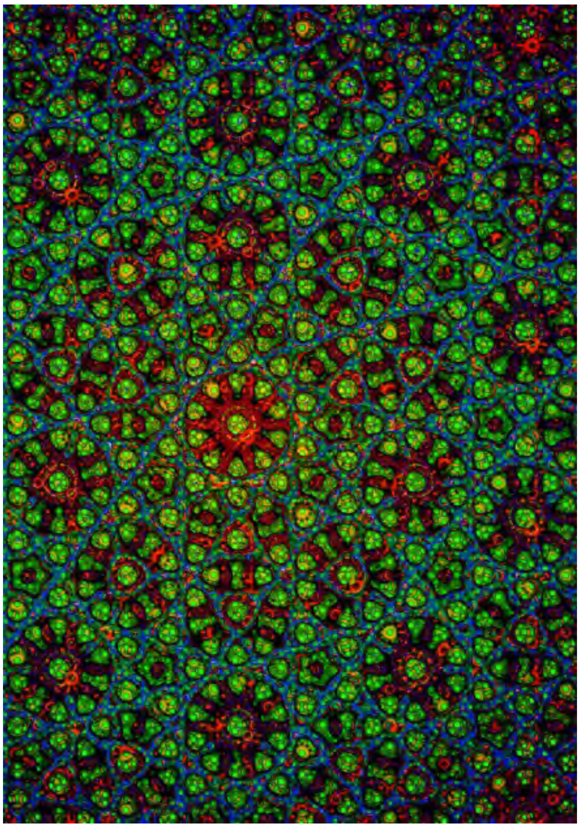


*Figure 2: Quasi Quasi. © Eric J. Heller.*

Finally, the Quantum Aesthetics Group, established in 2000 by Gregorio Morales, set up quantum principles as guides to creation. [11] One of the major artists of the group, the Spanish painter Xaverio, is known for his quantum art, including the series *Petrales*. While this group, which is mainly composed of authors, used quantum principles as metaphors in their creations, Morales and his friends are at the heart of deep thinking. The artwork done here with Time Beings is obviously closer to their theory.

## Tools for Time Travel

The quantum theory is an important tool to enable travel in what is often called the fourth dimension, which is Time. It is especially an important part of the functioning of wormholes [1], which can help build bridges in space-time.
Moreover, in his manifesto for the quantum aesthetic, Gregorio Morales [12] gives an interesting list of quantum principles that can be applied to art. Among these, we have selected the following list:

- The Principle of Complementarity: a corpuscle is sometimes a wave, sometimes a particle.
- The Principle of Uncertainty: It is not possible to determine the position and the momentum of a particle through a single measurement.
- The Schrödinger Paradox: The observer modifies the experiment with his observations.
- Non Separability / Entanglement: As Francis Thompson said: "One cannot uproot a flower without disturbing the stars"…
- Acausality: Any event is not necessarily the result of another event.
- Complexity: Trends in the composition of complex structures.
- Ubiquity: Particles may be in many places at once.

## Artificial Beings for Artistic Creation

The association between Artificial Life and Art has been for thirty years a good field of experimentation for a number of artists, including an excellent overview of this kind of art, given by Mitchell Whitelaw in his book MetaCreation [13] (a very good survey of artists adapting the techniques of a-life science to create a-life art).
As far as I am concerned, I have been working with artificial beings for 10 years. My first experiments were carried out between 2002 and 2005 with Plant Beings (morphogenesis based on L-Systems and Cellular Automata), Light Beings (for photosynthesis), and Painting Beings (self-organized artificial pigments for painting) [14].
Also present in the artwork of Cinema Beings, introduced in 2012 [15][16], Time Beings have proved to be an excellent path to novel techniques for creative practice.

## Time Beings as an Artistic Exploration Tool

Time Beings can take different forms. These artificial beings will thus be classified into different types, depending on the type of artwork they will put into action. Each category corresponds to a minimal entity (a corpuscle or atom). For music, this entity is the note (3D space), while it is the word for Literature and Poetry, the pixel (2D space) for painting and photography (digital), the vertex (3D space) for sculpture and architecture, and the frame (4D space) for Film and Video, etc.


*Figure 3: Exploration of the film 'Le Ballet Mécanique' (Fernand Leger, 1924) by Time Beings.*

To understand what Time Beings are, let us give some examples of major artistic explorations that may be feasible by Time Beings:

In a 2D space, the basic element is the pixel. It is located on a plan (which is the image plane) and its position determines the distance in number of pixels relative to its neighbors: for example the pixel with coordinates (x1,y1) at (0,0), has a distance value of 10 from the pixel (x2,y2) at (10,0), using the classic formula:

$$D=\sqrt{(x2-x1)^2+(y2-y1)^2}$$

These distance values can also be used as a time travel scale. While you look at an artwork, the journey time is real. If you move closer to see the details of a certain part, it takes a certain time to explore other areas of the work (see figure 4).

Here, Time Beings can be compared with virtual eyes, navigating on the picture space.

Thus, Time Beings have a "wormhole" function included in their system, which allows them travelling almost instantly through the space-time distance between two pixels located at the ends of the wormhole (like a virtual camera going from one pixel of a picture, directly to another one). The notion of scaling in space-time is crucial here: it is what defines the course of the work, with more or less detail.

The above description relates to a finished artistic work. But Time Beings are also able to explore a more interesting space-time which connects to the time used to make the artwork. For this, we must of course have several images, taken at different times during the artist's work in progress (for example, photographs of a painting, during its evolution). In this case, "Virtual Wormholes" work not only in the 2D space of the image, but also in multi-dimensional spaces and time series images. Thus, the exploration of a work can begin from a pixel of the final picture; go on to a pixel of a previous image from the process of creation, move back to a later one, etc.

*Figure 4: Exploration of Mona Lisa (Leonardo Da Vinci) by Time Beings. (With Quantum Cellular Automata Patterns)*

The exploration of film artworks is even more interesting. Time Beings consider a film as a 3D volume, composed of frames. They use virtual wormholes to travel through the time and space of the film, and thus view the movie in completely new ways.
As for still images, the course of Time Beings can travel in different versions of a film, from simple animated storyboards to final film, through various intermediate stages (animatics, rushes, etc.).
Just imagine you have a virtual camera, viewing one frame of your film, then going directly to another one, and so on. Thus, you can explore a movie, with strange way, and discover new interpolations between different frames.

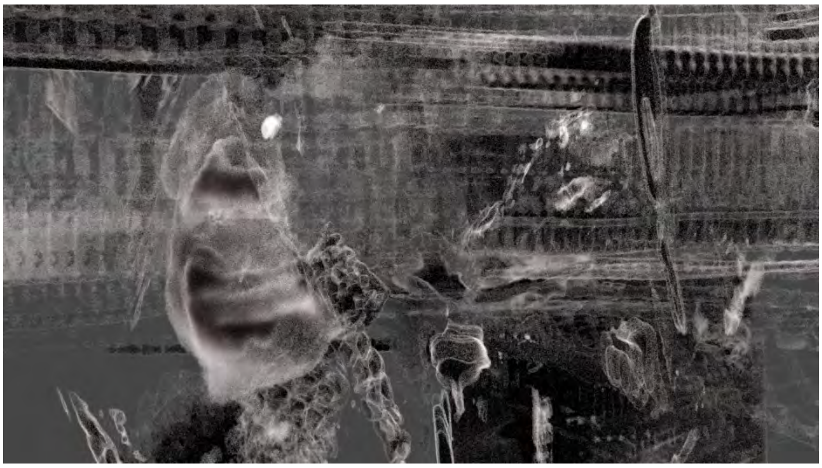


*Figure 5: Quantum Exploration of the film « Back to the Future ».*

Another aspect of Time Beings allows them to explore 3D geometry, based on the vertices coordinates, which are the main components of digital volume creations. In this case, the travel in time space is inside the 3D space of the sculpture or architecture (digital or scanned), from one vertex to another. We use the same formula as above, but with three dimensions:

$$D=\sqrt{(x2-x1)^2+(y2-y1)^2+(z2-z1)^2}$$

Note here that the more advanced methods for traveling in a creation's space can be employed using the rules of Quantum Cellular Automata [19] (a special kind of cellular automata, using quantum computation), which themselves are based on the principles of superposition of states, allowed by the use of Qubits [17] (a special kind

of bit, that can be 0, 1, or a superposition of both.), replacing the use of normal bits for digital creation.
Thus, the virtual camera (Time Beings) can travel from one vertex to another one, using cellular automata rules, instead of the “wormholes method”, described previously. For example, the vertex with coordinates xyz equal to (5,8,1) can be followed by (5,9,1) or/and by (5,8,2). If the superposition state is chosen (“and” mode), the system use compositing rules to make the picture (“add” mode as in Photoshop software).
Time Beings are also present in musical pieces of art. Here, the musical note becomes the elementary corpuscle, and time travel in the artwork occurs in the 2D score’s space. For example, Time Beings can read a score, not linearly, but from one note to another one, using cellular automata or virtual wormholes.
Similarly, the exploration of textual works is done with words, allowing Time Beings to create suites of poetic words, in the same way as described above.
Here is a small table illustrating some of the exploration experiences that are possible with Time Beings:

| **Experimentations** | **Painting/ Photography** | **Cinema** | **Sculpture/ Architecture** | **Music** | **Poetry** |
|---|---|---|---|---|---|
| ***Corpuscle*** | *Pixel* | *Frame* | *Vertex* | *Note* | *Word* |
| ***Space*** | *Picture (2D)* | *Volume of all frames (3D)* | *Object (3D)* | *Score (2D)* | *Book (3D) or paper (2D)* |
| **Time Travel with Wormhole** | Start with pixel 1, zoom into a detail, space-time travel to pixel 2 by Time Being. | Start with frame 1, Time Being travels in the volumetric space-time of the film to the frame 2. | Start with vertex 1. Time Being travels to the Vertex 2. | Start with note 1, the sound is played, and then Time Being travels to note 2 (played). | Start with word 1. Time Being travels to word 2 (read). |
| **Schrödinger Cats, Quantum Superposition** | Several versions of an image available. Beings travel within pictures with quantum superposition states (Qubits calculations). (Example: Monet, Rouen Cathedral). | Several versions of the film available (animatics, final film, etc.). Time Beings travel in different versions and frames using calculations of quantum superpositio n with Qubits. | Several versions of the 3D object available. Beings travel between shapes (vector calculation of displacements and superposition of states with Qubits calculations. | Several versions of music available. Quantum superpositi on states for music. | Several variants of a text. Time Being travels by quantum superpositi on between existing versions. |
| **Quantum Cellular Automata. (QCA) Using Hadamard Gates and Pauli Gates.** | Using QCA rules for navigating in a picture. | Using QCA rules for navigating between frames of a movie. | Using QCA rules for navigating in the geometry of an object. | Using QCA rules for playing music. | Using QCA rules for reading a text. |

## Time Beings as a Creation Tool

Another very important aspect of Time Beings is that they can also be used for artistic creation. The operations here are very similar to the exploration ones and use the same basic tools (Qubits, Quantum Cellular Automata, Virtual Wormhole, etc.).
In order for Time Beings to be able to create, a minimum starting axiom is required: a pixel, a frame, a vertex, a note, a word, etc. Time Beings are autonomous beings that include self-organization parameters for creation, and work with various quantum rules, as listed above.

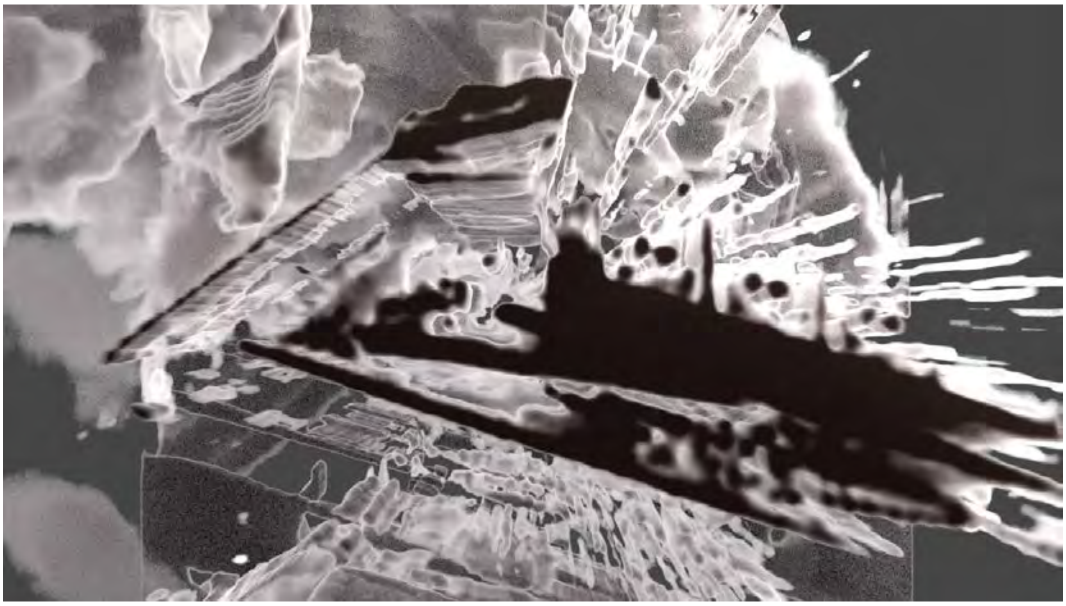


*Figure 6: Cinema Quantum Creation, by Time Beings*

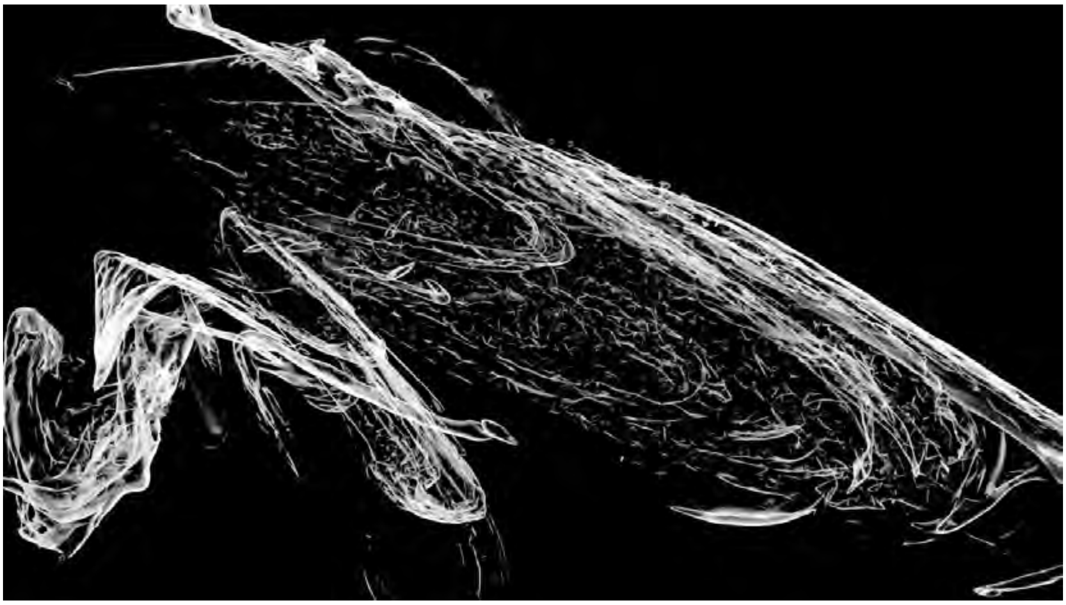


*Figure 7: Digital Sculpture Creation, by Quantum Time Beings.*

## Most important Quantum Art Exploration and Creation Methods

Each art form has its elementary particle/atom (various kinds of Time Being) and uses various methods.

| Art | Painting/Photography | Cinema | Sculpture/Architecture | Music | Poetry |
|---|---|---|---|---|---|
| Particle/Atom | Pixel | Frame | Vertex | Note | Word |
| Wormholes | From pixel to pixel | From frame to frame | From vertex to vertex | From note to note | From word to word |
| Uncertainty Principle | Pixel coordinates or color | Frame number or color histogram | Vertex position or color | Note pitch or duration | Word position or length |
| Complementarity / Duality | Particle (pixel, frame, vertex, note, word) transformed by a Wave Function(*) | | | | |
| Schrödinger Superposition | Qubit values for parameters calculations (0,1 or superposition of both) | | | | |
| Entanglement | Particles are linked (shared state / parameters) | | | | |
| Schrödinger Paradox | The observer modifies the artwork (for example pixel color, frame contrast, vertex position, note pitch, word position) | | | | |
| Ubiquity | One particle in two different places at the same time (parameters copied) | | | | |

*(*) Wave Function : See definition at http://en.wikipedia.org/wiki/Wave_function (Sympy implementation)*

## About Techniques for Time Beings

To give a very simple example: a red pixel will be translated in the picture's space-time, according to two superposed states (by Qubit calculation), and thus will take two positions and two new colors in the image (for example, one blue and one green). These two new pixels themselves will then be transposed by the same process. Thus, a quantum image is created! Similarly, the creation of films, 3D objects, music, and poetry will use the same processes, possibly using other items (from all musical notes, words from a dictionary, etc.).
It seems important to use simulation tools to implement quantum Time Beings. In fact, why not take advantage of the possible use of Qubit superposition of states [17], instead of the traditional bits; giving only deterministic values (O or 1)?
Without going into a technical description which would be too long to develop here, we can just say that the world of Time Beings is developed in Python language, based primarily on the Sympy module of Quantum Mechanics [18] and the concept of Qubits, allowing the superposition of the two states (linear combination of 0 and 1).
Much of the movement of Time Beings artworks is based on Quantum Cellular Automata, as described initially by Jonathan Grattage [19].

## Future Work and Conclusion

The concept of Time Beings thus opens up new ways of artistic exploration and creation. However, although we are not interested here in observing the exact scientific formulations, many algorithms from quantum computation can be used to achieve more new experiences. The range of possibilities for creating and exploring Time Beings is wide, and largely undiscovered.

Heidegger, in his major work “Being and Time” [20] says about his Dasein concept (Heidegger uses the expression Dasein to refer to the experience of "being" that is peculiar to human beings):

"*Dasein is its past, its mode of being, which comes every time from the future.*"

So, it will be very interesting to study the concept of Time Beings regarding the Dasein theory.

## References:

[1] Paul Davies. How to Build a Time Machine. Orion Productions. 2001.
[2] A. Einstein, B. Podolsky, and N. Rosen, Can quantum-mechanical description of physical reality be considered complete? Phys. Rev. 47 777 (1935).
[3] Erwin Schrödinger. The Present Situation In Quantum Mechanics: A Translation Of Schrödinger's "Cat Paradox Paper" (Translator: John D. Trimmer) Section I.11 of Part I of Quantum Theory and Measurement (J.A. Wheeler and W.H. Zurek, eds., Princeton university Press, New Jersey 1983)
[4] Leonard Shlain. Art & Physics. New York. Morrow. 1991
[5] Gavin Parkinson . Surrealism, Art, and Modern Science: Relativity, Quantum Mechanics, Epistemology. Yale University Press; First Edition, 2008.
[6] Linda Dalrymple Henderson . The Fourth Dimension and Non-Euclidean Geometry in Modern Art: Conclusion Leonardo, Vol. 17, No. 3. (1984), pp. 205-210.
[7] Tony Robbin. Shadows of Reality. The Fourth Dimension in Relativity, Cubism, and Modern Thought. Yale University Press, 2006.
[8] Eric J. Heller, Publications at: http://www-heller.harvard.edu/pub.html
[9] Julian Voss-Andreae. Quantum Sculpture: Art Inspired by the Deeper Nature of Reality. LEONARDO, Vol. 44, No. 1, pp. 14–20, 2011.
[10] Lynden Stone. Work at: http://www.lyndenstone.com.au/
[11] Gregorio Morales. Publications at:
http://www.terra.es/personal2/gmv00000/english.htm
[12] Manuel J.Caro, John W. Murphy. The World of Quantum Culture. 2002.
[13] Mitchel Whitelaw. Metacreation: Art and Artificial Life. The MIT Press, 2006.
[14] Alain Lioret, Painting Beings. ACM Siggraph, Los Angeles, 2005
[15] Alain Lioret, Past Images From the Future, Ylem Journal, 2006
[16] Alain Lioret, Cinema Beings, Computer Art Congress, Paris ,2012
[17] Qubits definition: http://en.wikipedia.org/wiki/Qubit.
[18] Quantum Mechanics Module from Sympy :
http://docs.sympy.org/0.7.2/modules/physics/quantum/index.html
[19] Jonathan Grattage. Quantum Game Of Life.
http://www.jgrattage.webspace.virginmedia.com/jon/3DQCA/
[20] Martin Heidegger. Being and Time. Harper Perennial Modern Classics; Reprint edition (July 22, 2008).

**Aghlab Al-Attili**
**Ehab Saleh**
**Alaa I Al-Attili**

*Paper:* **Generative Tectonics: Environmental performance and parametric design morphology**

***Topic: Architecture, Computing***

***Authors:***
***Aghlab Al-Attili***
SOAS, University of London, UK
www.soas.ac.uk
***Ehab Saleh***
Al-Baha University, KSA
www.bu.edu.sa
***Alaa I Al-Attili***
AlZahra University College, Oman
www.zcw.edu.om

***References:***
[1] Schwinn, T., *et al*, "*Machinic Morphospaces: Biomimetic Design Strategies for the Computational Exploration of Robot Constraint Spaces for Wood Fabrication*" (ACADIA), San Francisco, : 2012
[2] Hensel, M., Menges, A. (eds.), "*Form Follows Performance*", ArchPlus No. 188, ArchPlus Verlag, Aachen, 2008.
[3] Schneider, C.W. & Walde, R.E., *L-system computer simulations of branching divergence in some dorsiventral members of the tribe Polysiphonieae*. Eur.J.Psychology.,29, 1992.

***Abstract:***

This paper reports on the collaborative experimental work carried out in the University of London to deploy generative processes to parametric elements of design using environmental parameters to trigger design morphology. The experimentation culminates in the installation of the 3-D parametric model. Subjects' interaction with the 3-D-printed parametric model provides insights inro human interaction with space in its physical and virtual modes. It also provides an insight into the effects of environmental performance on human interaction with space.

The project has three distinctive parts. In the first part, a procedural programming language (C++) is used to develop the interface and inputs that deploys the generative algorithms and activate the access to a pool of 3D primitives that act as the building blocks of the parametric design. It also provides the environmental performance's interlocking loops of environmental inputs. In the first loop the environmental parameters affect the initial process of generating the design, but in the second it affects the design reaction to environmental parameters, which results in the interactive environmental performance. The first part generates real-time parametric structures that are used in the second part.

The second part of this project utilises the parametric design elements of structure by 3D-printing them and assembling them in a physical interactive installation that continuously reacts to environmental variables. The installation forms a technical artistic piece of parametric elements, light sensors, heat sensors and mechanical arms that affect the parametric elements' formation. The installation is in the inner circle of Regent's Park, London, UK.

The third part involves a qualitative study of subject interaction with the installation, and analyses the outcome in an effort to further understand human embodiment and interaction with interactive space. It also evaluates the questions of evolution and continuity through algorithmic events, and the resulting time-based 3D modelling of abstract spaces.

The project is a collaboration between three universities in their effort to address topics pertaining to design morphology, environmental performance, and human embodiment and interaction with space. The team combined researchers from Computre Science, Human-Computer Interaction and Architectural Design.

***Contact: aghlab.al-attili@soas.ac.uk***

***Keywords:*** Generative Art, Parametric Design, Environmental Performance, C++, Artistic Installation, Embodiment, Interaction,

# Generative Tectonics: Environmental performance and parametric design morphology

**Dr. Aghlab Al-Attili PhD.**
*SOAS, University of London, UK*
*Aghlab.Al-Attili@soas.ac.uk*

**Ehab H. Al-Sheikh Saleh MSc.**
*Al-Baha University, KSA*

**Alaa I. Al-Attili MSc.**
*Al-Zahra University College, Muscat, Oman*

## Premise

This paper reports on the collaborative experimental work carried out in the University of London to deploy generative processes to parametric elements of design using environmental parameters to trigger design morphology. The experimentation culminates in the installation of the 3D parametric model. Subjects' interaction with the model provides indicators of human interaction with space in its physical and virtual modes. It also provides an insight into the effects of environmental performance on human interaction with space.

The project has three distinctive parts. In the first part, a procedural programming language (C++) is used to develop the interface and inputs that deploys the generative algorithms and activate the access to a pool of 3D primitives that act as the building blocks of the parametric design. It also provides the environmental performance's interlocking loops of environmental inputs, which results in the interactive environmental performance. The first part generates real-time parametric forms that are used in the second part.

The second part of this project utilises the parametric design elements by assembling them in a physical interactive installation that continuously reacts to environmental variables and users. The installation forms a technical artistic piece of parametric forms, light sensors, thermal sensors, motion sensors and mechanical arms.

The third part of the project performs a qualitative study of subject interaction with the installation, and analyses the outcome in an effort to further understand human embodiment and interaction with reactive space. It also evaluates the questions of evolution and continuity through algorithmic events, and the resulting time-based 3D modelling of abstract spaces.

The project is a collaboration between three universities in their effort to address topics pertaining to design morphology, environmental performance, and human embodiment and interaction with space. The team combined researchers from Computre Science, Human-Computer Interaction and Architectural Design.

## 1. Interaction, the *'generative'* and *'Technomethodology'*

The development of Human-Computer Interaction (HCI) is founded on the design, evaluation and implementation of interactive computing systems. Interaction came in many different styles that ranged from command line interface to three dimensional ones. The drive behind the development of these interfaces was the need to enhance the interaction between the user and the machine. As a result, the field of Interaction Design (IxD) came to lay the groundwork for intangible human experiences. Many areas of research overlap with HCI, however; arguably the most important element in the development of HCI is the distribution of user-centred design approach to encompass multi-users. The ethnographic studies of the environments in which users participate extended to encompass human experience (Agre 1997). *Technomethodology* (Dourish 1998) came as a result of the amalgamation of these concepts, which in turn shifted the emphasis from the *system* to the *interaction* within the 'interactive system design' (Benyon *et. al.* 2005) (Newman & Lamming 1995).

*Technomethodology* addresses the context with terms such as *space*, *place*, and *locale* (Dourish 2001). The authors argue that the approach has a significant relevance in the case of generative design; however, the generative process requires a different approach based on the profound understanding of the concept of responsiveness and its implications on immersion and interaction.

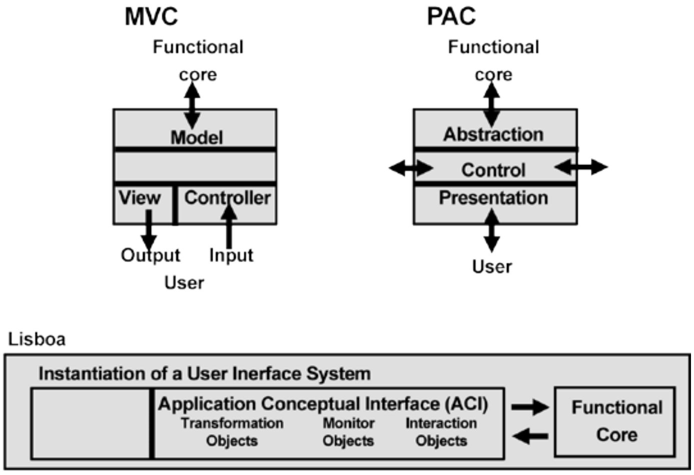
Fox and Kempt explore the notion of interactivity in relation to the built environment with focus on the concept of responsiveness. They argue that the user and the environment are linked through a conversation (2009). The researchers argue that this conversation introduces a 'Husserlian' notion of intentionality on behalf of the generative environment. The duality of action and reaction, Fox and Kemp argue, implies an intermediate stage of processing. In its totality, the implied potential which is incidentally suggested by the idea of 'generative art' is a duality that has the quality of a binary opposition system. Karandinou suggests that the traditional binary opposition of form and matter is changing and she uses Derrida's temporal notion of 'opening up' to indicate new found elements in this binary opposition (2011). The researchers in this paper argue that the simpler schema of sensor's input, processor, active output implies notion of intentionality of action. This implied notion is further pushed forward by the complexity of the algorithm and its responsiveness to human interaction in conjunction with environmental performance.

The project highlights the notion that familiar interaction forms the basis of embodied interaction, which, in turn, triggers the sensors providing them with an input and, therefore, resulting in an output that reflects the original embodied action. A deeper understanding of this interaction may provide a better understanding of the resulting environment. In a way, the project deploys a '*generate and test procedure'* proposed by Rowe (1987).

In order to understand the process, the researchers abstracted the process in an effort to simplify inputs and outputs. What follows will describe the system.

## 2. System design

An interactive system is designed using a procedural programming language (C++). The system architecture is modelled using collaboration agents such as presentation-abstraction-control (PAC). The system is used for to its hierarchical structure, which naturally lends itself to the processes implicated in this activity. Previous incarnations of this design interface witnessed the use of model-view-controller (MVC) and using the slightly different Lisboa collaboration objects architecture.

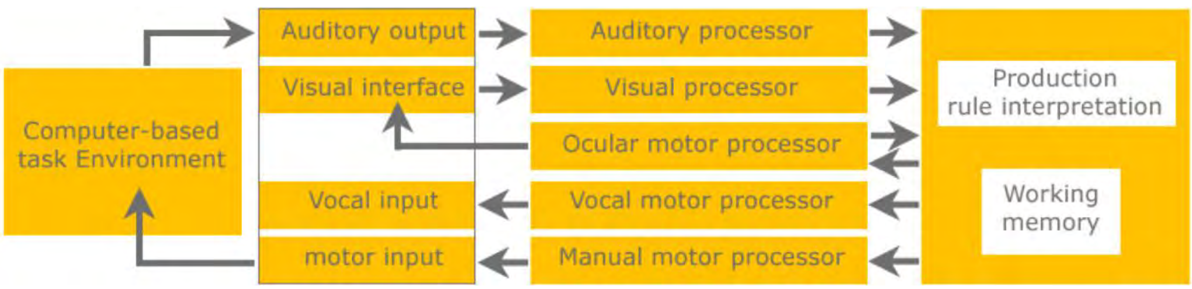



*Conceptual architectural models of interactive systems (Palanque et. al., 2000)*

The interface deploys inputs to operate the generative algorithms and to activate the access to a pool of 3D primitives that act as the building blocks of the parametric design. Several variations are rendered using the L-system. In its simplest states, the system is composed of:

- Variables (V) = a set of 3D primitives, of which
- Origin (O) = the initial primitive to be deployed
- Rules (R) = the rules that decide which primitive to generate next

The 3D primitives are parametrically linked using rules that adapt width, height and depth in reaction to the inputs. Kieras and Meyer's diagram of potential inputs and outputs provides a useful summary upon which the researchers relied to experiment with the inputs. The ultimate reason for using this model is the implied intention of enabling HCI capability, if even on an initially abstract level.




*Human-Computer processing and interaction systems (adapted from Kieras and Meyer 1997)*

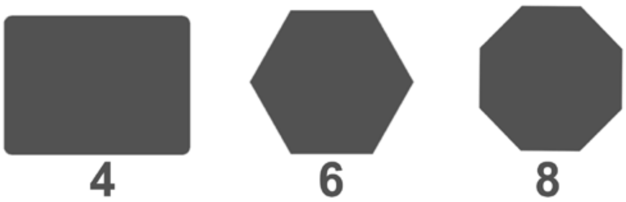
The resulting outcome is an input-enabled software that has the capability of receiving four inputs that are modified by the algorithm to produce the output. The enabled input sensors used are light

- Thermal detection sensor
- Light detection sensor
- Motion detection sensor

The output is in the form of an electric impulse that activates a unit, which contains a linear actuator attached to a set of elements. The unit mobilises the set of shapes that in their totality engulf a primitive shape that mirrors the corresponding generated primitive. The following part describes the primitives and how they are formed.

## 3. Primitives and variations

The values generated by the sensory inputs, when using hardware, or from manual inputs through the interface, are used to activate the access to a pool of 3D primitives that act as the building blocks of the parametric design. The generated primitives were limited to three levels for the purpose of experimentation. The primitives are: rectangle, hexagon and octagon.

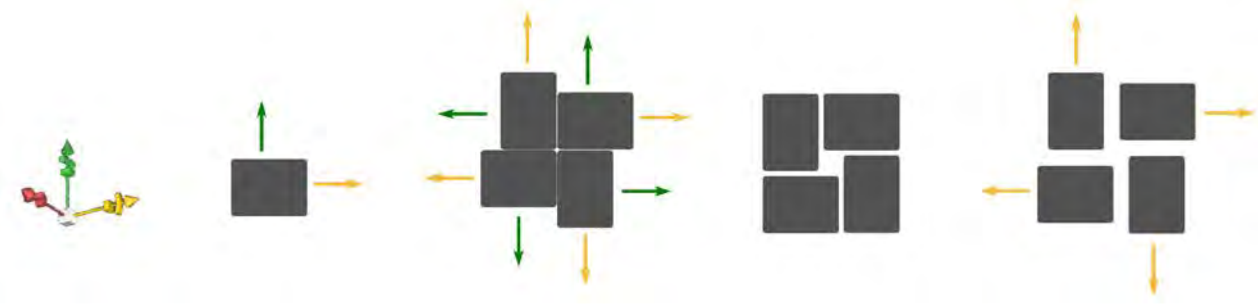



*The three primitives that can be generated: Rectangle, Hexagon and Octagon.*

The dimensions of the primitive is decided by the algorithm but is influenced by the sensory input. When transformed into the installation, the *Gestalt's foreground / background principle of* perception is deployed, and the primitive becomes the void which is formed by the surrounding primitives. This transformation facilitates dimensions control and therefore reinterprets the generative capability, which, otherwise, would have been difficult in an installation.

*The primitive is the white void appearing in the middle, and is formed by the conjoined dark shapes*

The movement of surrounding primitives to form the void is controlled by linear actuators. The distance and direction of movement is delivered through the actuator attached to each shape, but is decided by the algorithm. The shapes are generated inside a 3D virtual environment to provide a point of origin and the corresponding values. Each shape can perceptually move in four directions. By perceptually, we mean that a single shape moves in two directions only since the linear actuators operate in two directions. However, since the panels are aligned in perpendicular position to each other, extra two dimensions can be achieved perceptually by moving the perpendicular panels.



*The shapes move in four perceptual directions. The change in location changes the size of the void.*

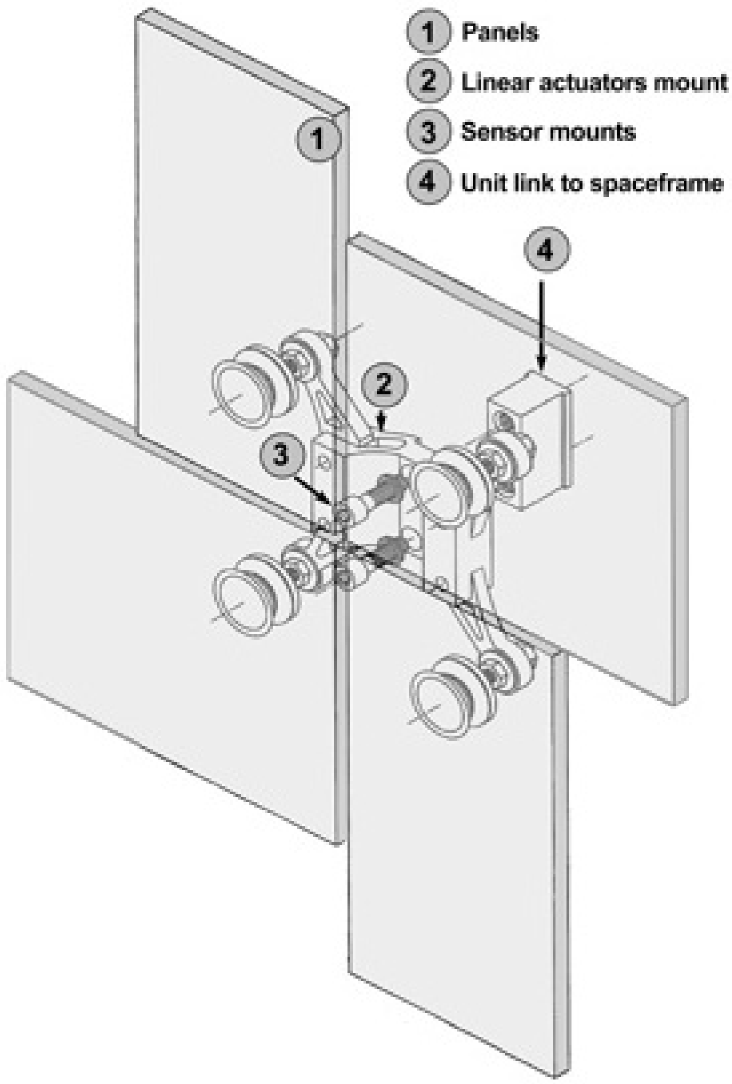
The design of the system and the algorithm that runs belong to the realm of the theoretical, however, to realise the design in reality is a different challenge. The following section will address this side of the project.

## 4. Enacting a generative process

The set of processes implied in realising an installation are different than those encountered in the design stage. To assemble a physical interactive installation that continuously reacts to environmental variables requires a prototype modular unit, which can be replicated. What follows will describe the modular unit.

### 4.1. Mechanisms and sensors

The isometric figure, which follows below, illustrates the composition of the elements that form the unit of structure in the case of the rectangular composition. Each void is formed by four shapes, which form a unit. Each unit, of four shapes, is equipped with three input sensors and four linear actuators. Upon the receipt of an output, each shape reacts in an identical manner, but in a different direction. As such, each of the four linear actuators belonging to one unit, behave in an identical manner, however, and depending on the way they are positions, the resulting movement is different. It is possible to utilise the same unit output to control other units. This suggests that sensors can be attached to one unit for input, but the output can be utilised for more than one adjacent unit. It is also possible to interpolate the output of two units to have variations in the formations.

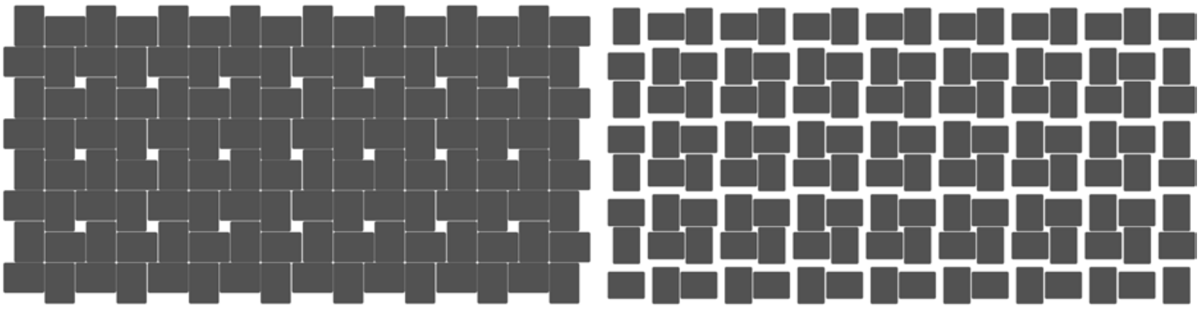



*The shapes move in four perceptual directions. The change in location changes the size of the void.*

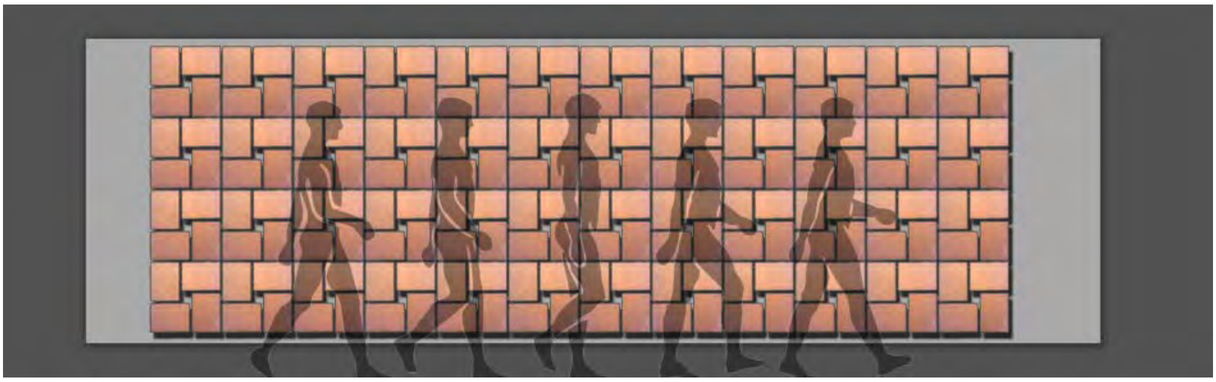
The figure above constitutes a unit in the installation. The unit is mounted into a spaceframe that holds other units. The link to the spaceframe is equipped with the technological wiring in order to connect the sensors and to connect the linear actuators. The panels are mounted on adjustable revolving screws in order to fine tune the panels and to change the alignment as necessary.

### 4.2. Assembled structure

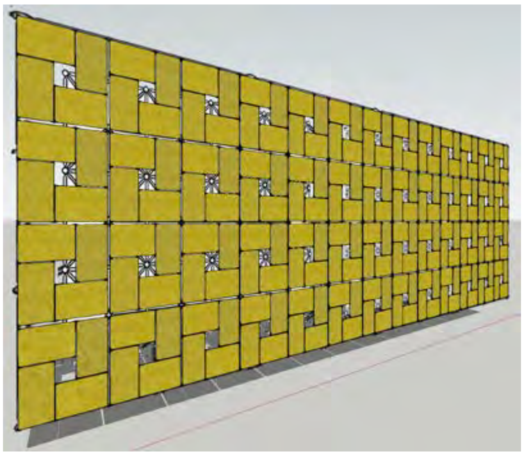
When the units in the diagram above are joined together and mounted on the spaceframe, the result is a wall that seemingly has a similar pattern. The centre point of each pattern contains the sensors and therefore, they are exposed to changes in the environment only when a human user passes by, or is visible to the centre of the unit.



*The assembled units displaying two different behaviours reacting to two sensory inputs.*



*The assembled units in relation to human scale.*



*A 3D rendered scene of the assembled units.*

The figures above demonstrate the different behaviours in reaction to sensory inputs triggered by human or environmental factors. While the environmental factors triggered light and thermal sensors, human factors triggered light and motion sensors. To measure interactivity a qualitative study was prepared with random subjects picked from the visitors of this installation. This was done using an unstructured interview where the main objective was to explore the theme of interactivity. In this process of exploration, other themes that either supported interactivity, or opposed it were probed. Several themes relating to interactivity emerged from the interviews. One of the major themes was the sense of the installation being ‘alive’. Subjects expressed the sense of dealing with a ‘conscious’ or an intelligent entity. Along these lines several expressions were used, such as ‘*smart* wall’, ‘motors were *breathing’*, ‘is *it feeling* hot?!’ and ‘I don’t want to *annoy it*. *It* might decide to *swallow me*!’ (italics for emphasis)

## 5. Discussion and conclusion

Minsky proposes a frame of reference that is used by humans in their perception and interaction with the environment. He suggests that this frame of reference is representative of knowledge (1975). We cultivated this sense by introducing a modular unit that acts as a frame of reference for the user’s and the system’s knowledge. In this process we rely on the nature of the parametric design which equally relies on the concept of the reference point, albeit for different reasons. Subject’s ability to recognise patterns and associate knowledge to the behaviour suggests more complex processes taking place at the same time. Simon characterises these by their iterative nature (1973). The researchers characterise the behaviour of the system as being generative, which is not due to the algorithms deployed, but due to the environmental factors and human behaviour affecting the output. The characterisation finds resonance in Steadman’s problem solving approach (1979). Accordingly, subjects viewed the installation as an entity. This characterisation of an object is due to the subject’s ability to attribute the qualities of an entity to the installation. The installation did not have the image of an entity, but had the qualities of an entity. The qualities were evidenced by the themes expressed by subjects. The qualities were generated by the system, and the randomness of reactions applied an element of familiarity. The value of familiarity is preserved through interaction; therefore, interactive objects are familiar objects. Familiarity when expressed by subjects appeared to be an abstract feeling; however, when experienced, appeared to take place with a tangible object.

The researchers realise the limitations of this experiment since it is still far from providing a formal testing procedure. They also note that this is the nature of experimental work.

## 6. Notes

The researchers in this project would like to acknowledge the research institutions that made this project possible, namely, SOAS, University of London (UK), Al-Baha University (KSA), Al-Zahra University College (OMAN) and the Arab Society for Computer Aided Architectural Design (ASCAAD). The authors would like to acknowledge the support provided by 'Attil Educational Trust' in aid of publication.

**References:**

Agre, P.E., (1997). Computation and Human Experience. Cambridge: Cambridge University Press.

Benyon, D., Turner, P. & Turner S., (2005). Designing Interactive systems. Edinburgh: Pearson Education Limited.

COYNE, R., (1999). Technoromanticism, Cambridge, Mass.; London, The MIT Press.

Dourish, P., (2001). Where the action is: the foundations of embodied interaction. Cambridge, Mass.: MIT Press, pp. 87-88.

Dourish, P. & Button, G., (1998). On "technomethodology": foundational relationships between ethnomethodology and system design. Human-Computer Interaction, 13 (4), pp. 395-432.

Fox, M. and Kempt, M., (2009). Interactive Architecture, New York: Princeton Architectural Press.

Hensel, M., Menges, A. (eds.), (2008). "*Form Follows Performance*", ArchPlus No. 188, ArchPlus Verlag, Aachen.

Karandinou, A. (2011). Beyond the binary, EAAE-ENHSA. 'Rethinking the Human in Technology-Driven Architecture', CMA,. Chania.

Kieras, D. E., and Meyer, D. E., (1997). An over view of the EPIC architecture for cognition and performance with application to human-computer interaction. Human-Computer Interaction, 12(4), p. 391-438.

Malkawi, A. M. 2005. Performance Simulation: Research and Tools. In: Malkawi, B. K. A. A. M. (ed.) Performance Architecture: Beyond Instrumentality. New York and London: Spon Press.

Minsky, M., (1975). A framework for representing knowledge. In P. H. Winston, ed. The psychology of computer vision. New York: McGraw-Hill.

Minsky, M., (1988) The Society of Mind. new york, NY, Simon and Schuster.

Newman, W. & Lamming, M., (1995). Interactive system design. Cambridge: Addison-Wesley Publishers Ltd.

Palanque, P. & Paternò, F., (eds.), (2000). Interactive systems: Design, specification, and verification. 7th International Workshop, DSV-IS 2000, Limerick Ireland. Revised Papers. Lecture Notes in Computer Science Vol. 1946. Springer Verlag, p. 192.

Rowe, Peter G., (1987). Design Thinking. Cambridge, Mass.: MIT Press.

Schneider, C.W. & Walde, R.E., (1992). *L-system computer simulations of branching divergence in some dorsiventral members of the tribe Polysiphonieae*. Eur.J.Psychology, 29.

Schwinn, T., *et al*, (2012). "*Machinic Morphospaces: Biomimetic Design Strategies for the Computational Exploration of Robot Constraint Spaces for Wood Fabrication*" (ACADIA), San Francisco.

Simon, h. A. (1973). The Sciences of the Artificial. MIT Press: Cambridge, MA.

Steadman, P. (1979). The Evolution of Designs. Cambridge university Press: Cambridge.

Sterk, T.d'E., (2006). Responsive Architecture: User-Centered Interactions within the Hybridized Model of Control, in Proceedings of the GAME, SET, MATCH II, Technical University of Delft, Delft.

**Alejandro Lopez**

**Le hasard à l'œuvre (the random in the artwork)**
*Paper and Live Performance*

***Topic: Art, Mathematics and A.I.***

***Authors:***
***Alejandro Lopez Rincon***
Institut de Mathematiques de Bordeaux, Universite Victor Segalen Bordeaux 2,

***References:***
[1] Gildas Bourde "*Peintures et Dessins*", CASTA DIVA, Paris, 2012.
[2] Inside The FFT Black Box. Serial And Parallel Fast Fourier Transform Algorithms, March 2001CRC Press.
[3] Software for inverse voltage calculations in the heart's surface Ainseba, B. ; Bendahmane, M. ; Lopez, A. Electrical, (CONIELECOMP), 2012 22nd International Conference on Publication Year: 2012 , Page(s): 34 - 39

***Abstract:***
Although art abstract paintings are fairly chaotic, certain patterns can be extracted from some artworks. The idea is to develop software that tries to imitate the development of a painting using equations to model it. Then, using this principle try to create an experienced based software using artificial intelligence (A.I.) to develop images which depend on what the user considers as beautiful. To explain it in detail; we will use as an example the Fig. 1 (left) from artist Gildas Bourdet[1]

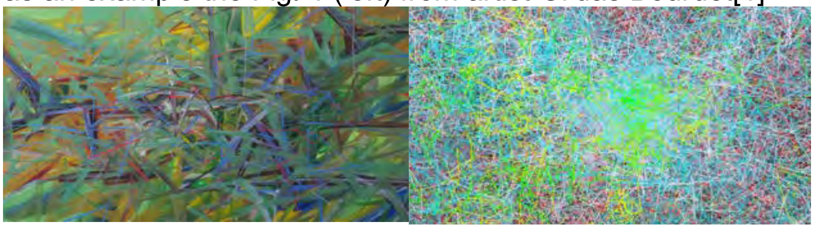


*Figure1. Painting made by [1] (left) reconstruction using software (right).*

In this paiting although created using random strokes, we can see that there is a center point from which all strokes originate. This was modeled by an algorithm which creates a set of strokes each millisecond based on the equation of the spiral by introducing random variables in the equation. If instead of using random variables in the code we used fixed values for length, angle and color we get the results as in Fig 3 (left).This is the base of the algorithm for A.I.. Instead of using random parameters for the spiral equation in time, we used the Fast Fourier Transform (FFT) [2] to obtain the coefficients by analyzing different signals using music (Fig. 2),or using the heart-beat [3] (Fig. 3) (right).

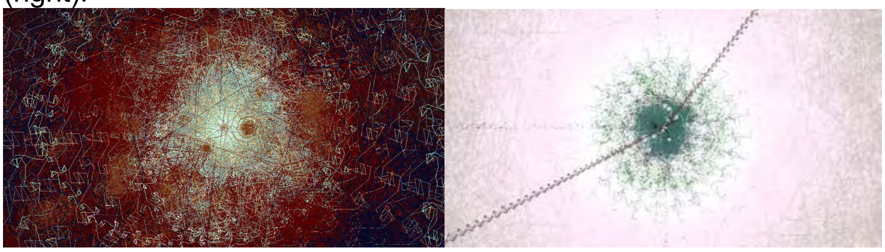


*Figure 2. Images created using FFT analysis.*

The A.I. is included in the fact the user can choose an image, and the software will try to build similar results. The software works dynamically; this means it generates a different image each ms. There are no 2 equal images.

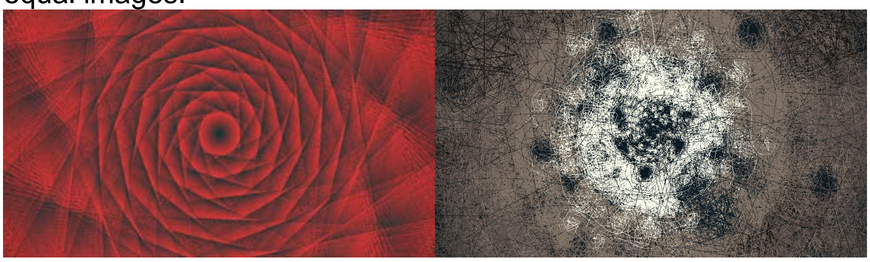


*Figure. 3. Image created using the spiral equation with fixed parameters (left).Image created using the heart-beat as base (right).*

***alejandro.lopezrn@hotmail.com***

***Keywords:***
Artificial intelligence, spirals, heart-beat, FFT, art

# Le hasard à l'œuvre (the random in the artwork)

**PhD Candidate Alejandro Lopez Rincon**
Institut de Mathematiques de Bordeaux, Universite Victor Segalen Bordeaux 2,
*e-mail: alejandro.lopezrn@hotmail.com*

## *Abstract:*

Although art abstract paintings are fairly chaotic, certain patterns can be extracted from some artworks. The idea is to develop software that tries to imitate the development of a painting using equations to model it. Then, using this principle try to create an experienced based software using artificial intelligence (A.I.) to develop images which depend on what the user considers as beautiful. To explain it in detail; we will use as an example a painting from artist Gildas Bourdet.

In the paiting although created using random brushstrokes, we can see that there is a center point from which all strokes originate. This was modeled by an algorithm which creates a set of brushstrokes each milisecond based on the equation of the spiral by introducing random variables in the equation. If instead of using random variables in the code we used fixed values for length, angle and color we get the similar results. This the base of the algorithm for A.I.. Instead of using random parameters for the spiral equation in time, we used the Fast Fourier Transform (FFT) to obtain the coefficientes by analyzing different signals using music or using the heart-beat.

The A.I. is included in the fact the user can choose an image, and the software will try to build similar results. The software works dynamically; this means it generates a different image each ms. There are no 2 equal images. This leads to an important question: how much random does an artwork really has?

## 1. Introduction

The mission of art is not to copy nature but to express it [4]. The title Le hasard à l'œuvre (the random in the artwork) comes from an art exposition in the Galerie MLS at Bordeaux. This work started from the analysis of the art work from painter Gildas Bourdet[1], which is shown in the Figure 1.

**Figure 1 "Untitled" reproduced here with express permission from the author.**

Although the artist started making this picture with no calculated pattern, a similar image can be generated using an algorithm. We will explain this using the painting as a basis to our algorithm. Let’s consider the artist used a starting point (consciously or unconsciously), and from there he started making the brushstrokes until he fill the image, the starting point in question is marked in Figure 2.

**Figure 2 Supposed starting point for the brushstrokes.**

Using an algorithm we can create a similar image or at least with the same principle (Figure 3). The base to this image is the model of the spiral in time.

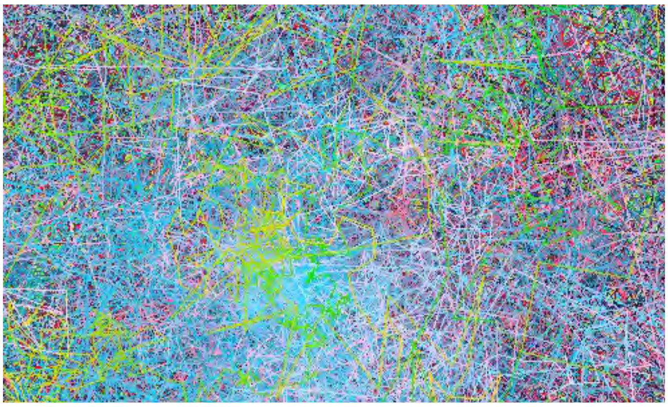


**Figure 3 Created Image trying to imitate the painting's procedure.**

To develop a software to create images similar to the paintings, we used turtle graphics. Turtle graphics is a way to draw curves in the plane [5]. The idea of turtle graphics comes from the concept of a turtle moving in one direction and its tail leaving a trace. It consists of four basic instructions:

- Move forward a fixed length *l*, and draw a line from the last position to the new one.
- Move forward a fixed length *l*, and move from the last position to the new one (do not draw a line).
- Turn left by a fixed angle α.
- Turn right by a fixed angle α.

If we choose randomly the length *l*, and the angle α we will create a sequence as in Figure 4.This is known as random walk.

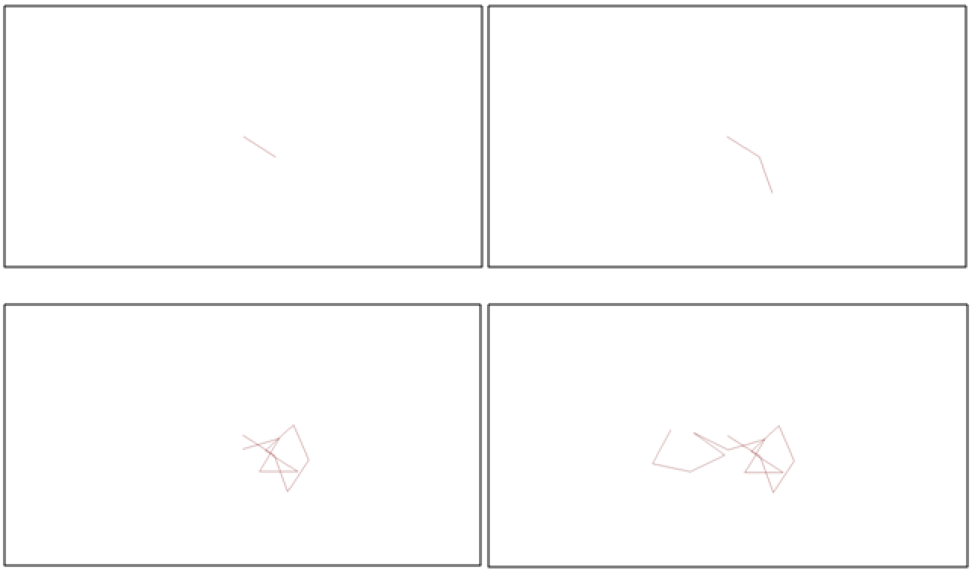


**Figure 4 Procedure to create sequence using Turtle Graphics.**

Repeating this procedure several times, until we fill the canvas we can construct an image as in Figure 3.

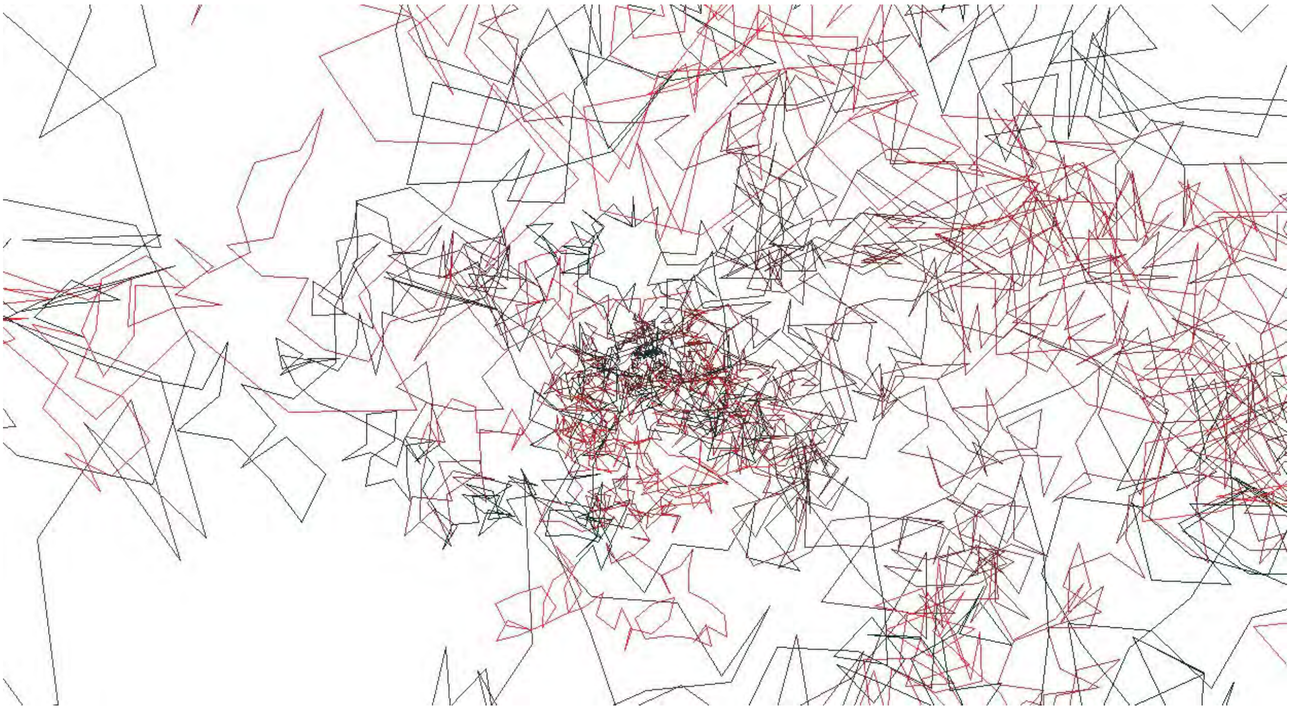


**Figure 5 Procedure to create a random image.**

This seems as an arbitrary set of lines, but actually this is the model of the spiral. If we fix the angle α, and we draw a series of lines using the turtle graphics we can create a series of orderly images. We will declare an interruption each amount of milliseconds to draw in the canvas, and using the following function for N lines:

```
for (M = 0; M < N; M++)
{
        Turtle forward(M);
        Turtle turn left(α);
}
```

Using this procedure we can create an ordered spiral, as in the following images (the chosen colors are a function of time):

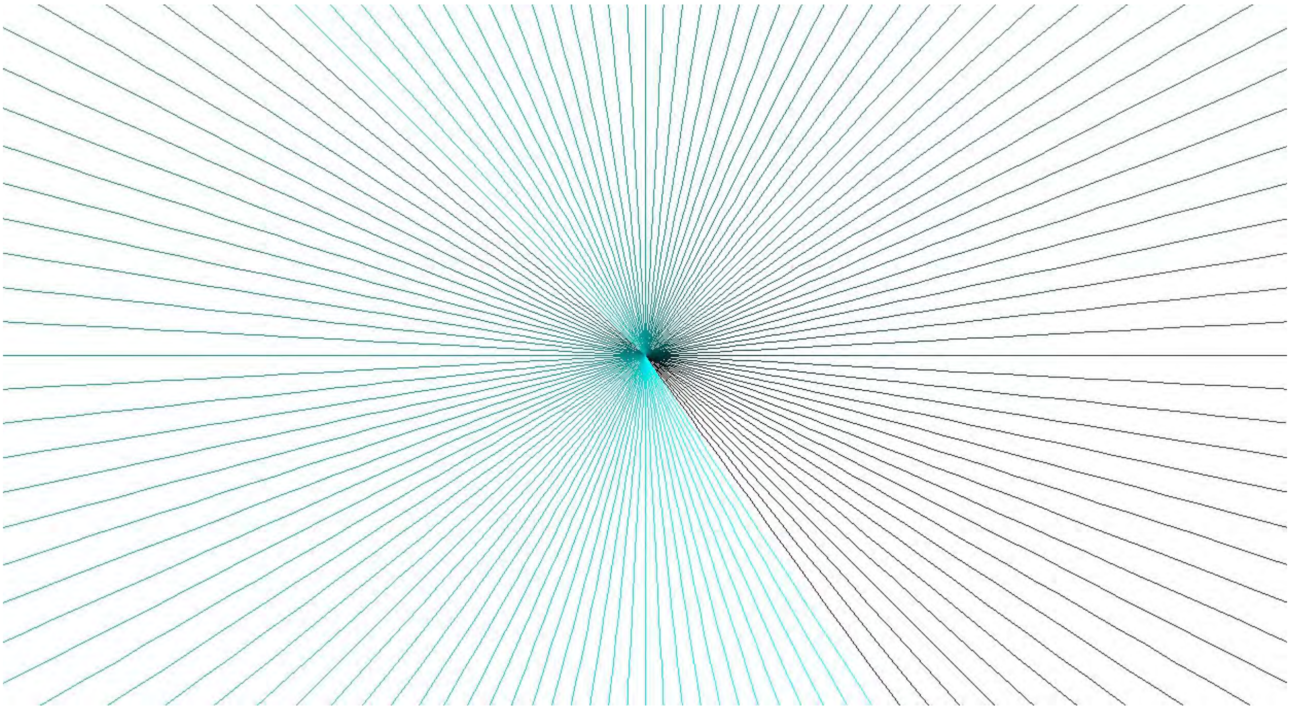


**Figure 6 Generated image using α=0.**

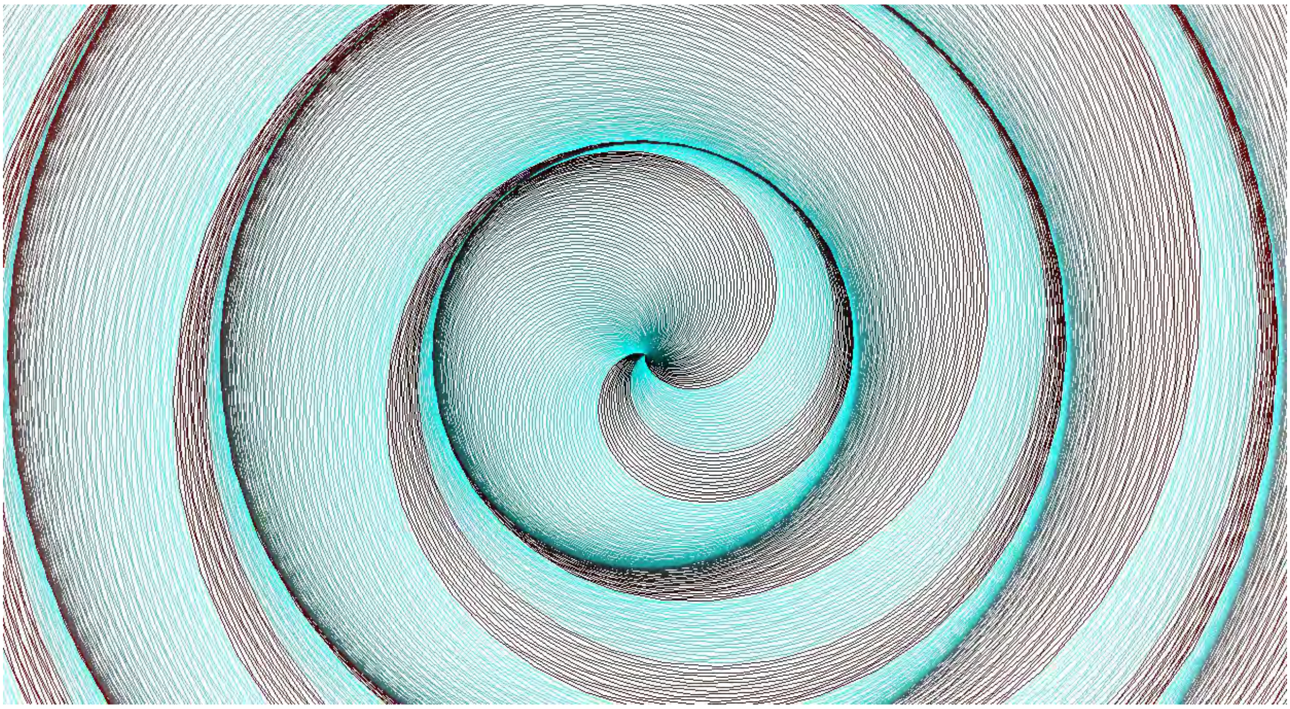


**Figure 7 Generated image using α=10.**

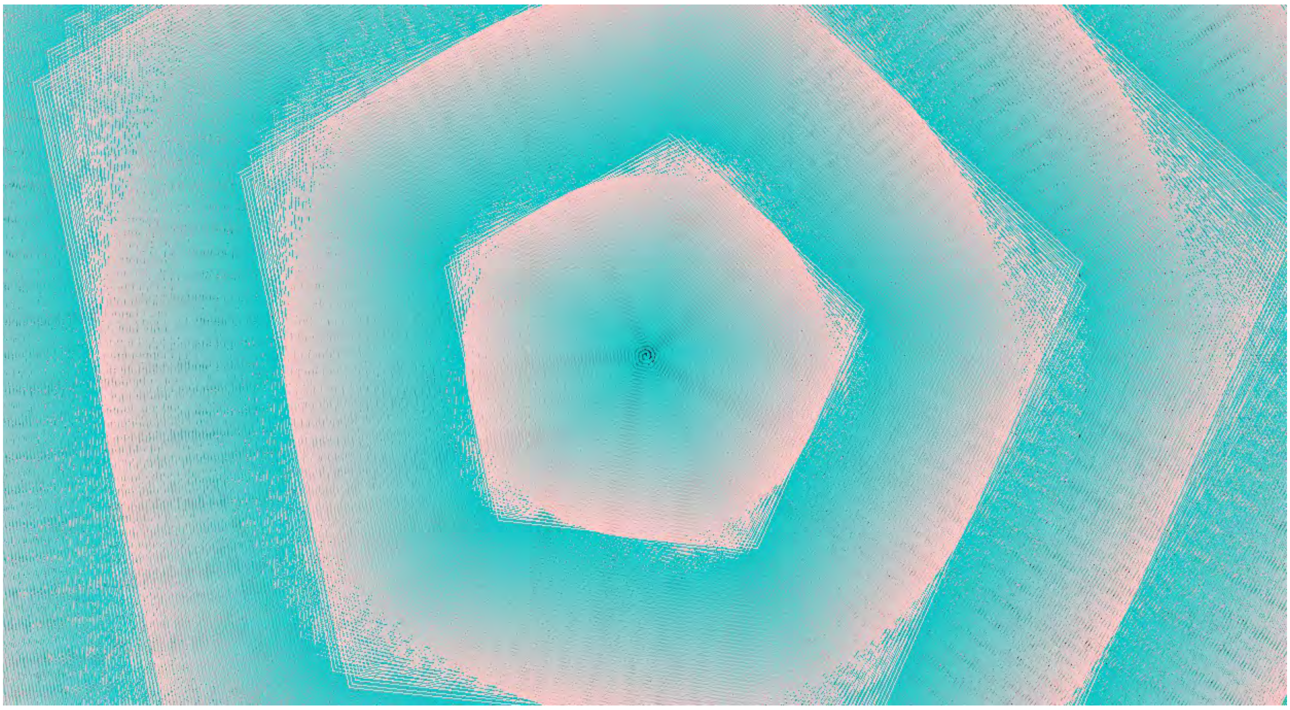


**Figure 8 Figure 7 Generated image using α=72.**

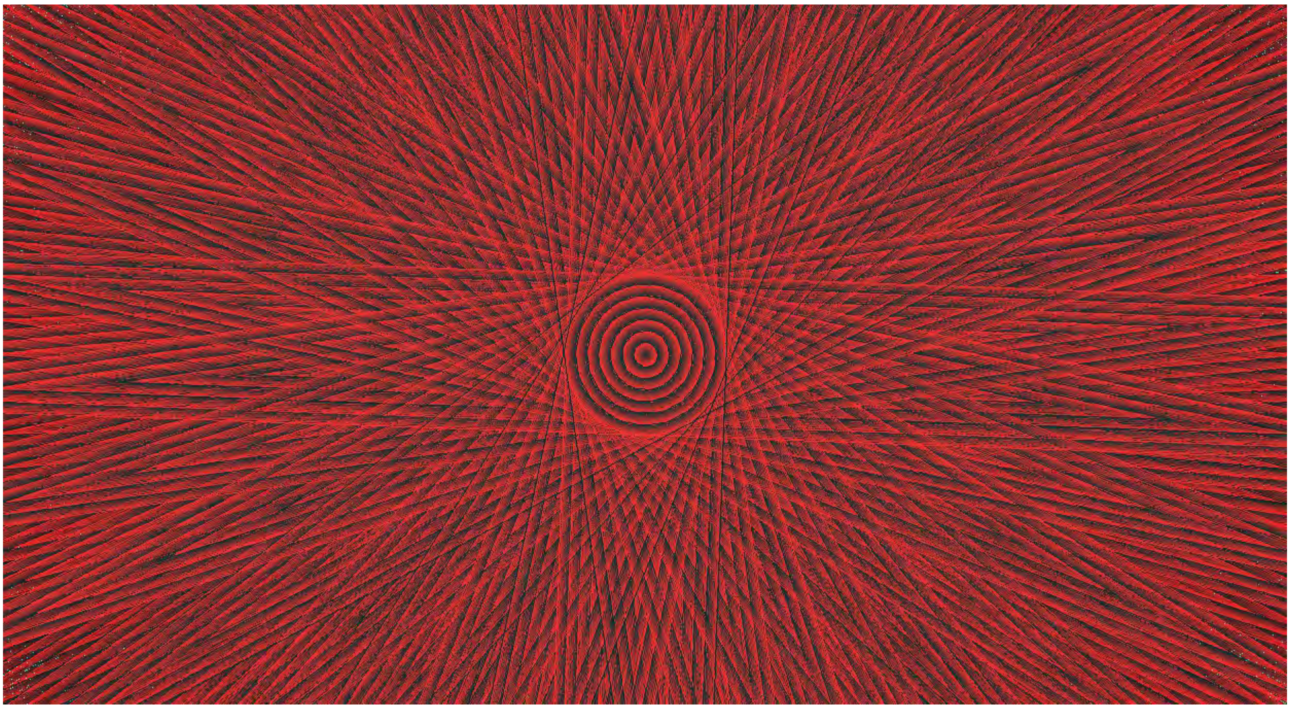


**Figure 9 Generated image using α=170.**

These images can be seen as ordered spirals, this was the base to create our artwork. . Spirals appear in a lot of models in nature , for example in the model of electrical activity of the heart an impulse is generated at a point and it propagates through the plane creating a spiral wave depending of the conductivites in the heart, similar examples can be found in other models of nature.

As an example the simulation of the electrical activity of the heart in 2D and 3D using the bidomain model [6]:

**Figure 10 Simulation of the electrical activity of the heart in 2D from [8].**

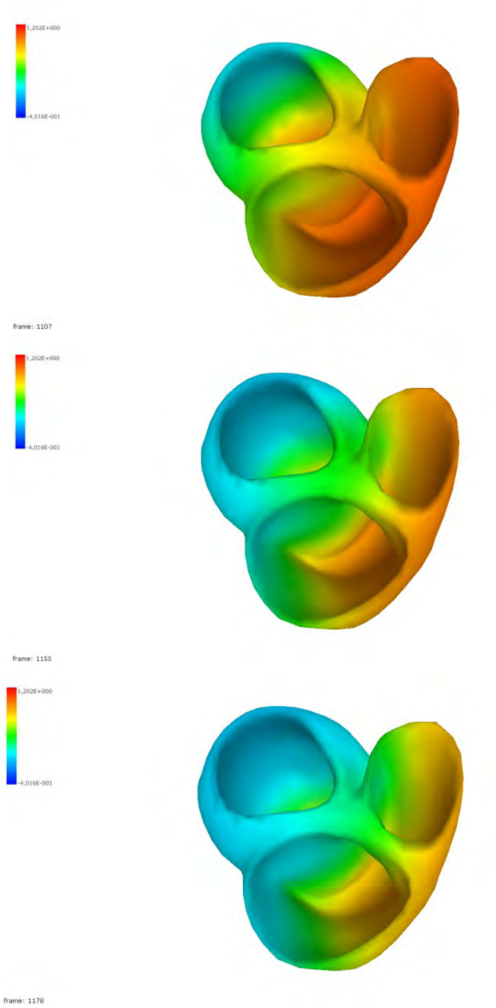


**Figure 11 Propagation of the electrical spiral wave in the heart in 3D in the ventricles [3].**

## 2. A step forward

Taking the spiral model in time as explained in the above section we used it as a base to create a new set of images. Instead of just creating random walk with random colors; we controlled the parameters of the created images choosing the different values from a set of coefficients. The pseudo code for the algorithm is the following:

```
for (i = 0 to i < FFT length)
{
        values_n[i] -= (values_(n-1)[i]);
}

for (M = 0; M < N; M++)
{
        Color =function(values_n)
        Turtle forward(M and function(values_n));
        Turtle turn left(function(values_n));
}
```

As we can see the colors, length (*l*) and angle α will be chosen by the a set of values (*values*$_n$) this values will be given by the decomposition of signals using the Fast Fourier Transform [2]. The resulting images one may consider that in every case they are the same for the same signal, but it is not the case. The algorithm depends of the processor interruptions, therefore it creates randomness implicitly due to the timer interruption in the programming language is inexact, although if necessary random variables can be introduced into the system explicitly. Using music as a base for the system we can create theoretically infinite sets of images, some examples:

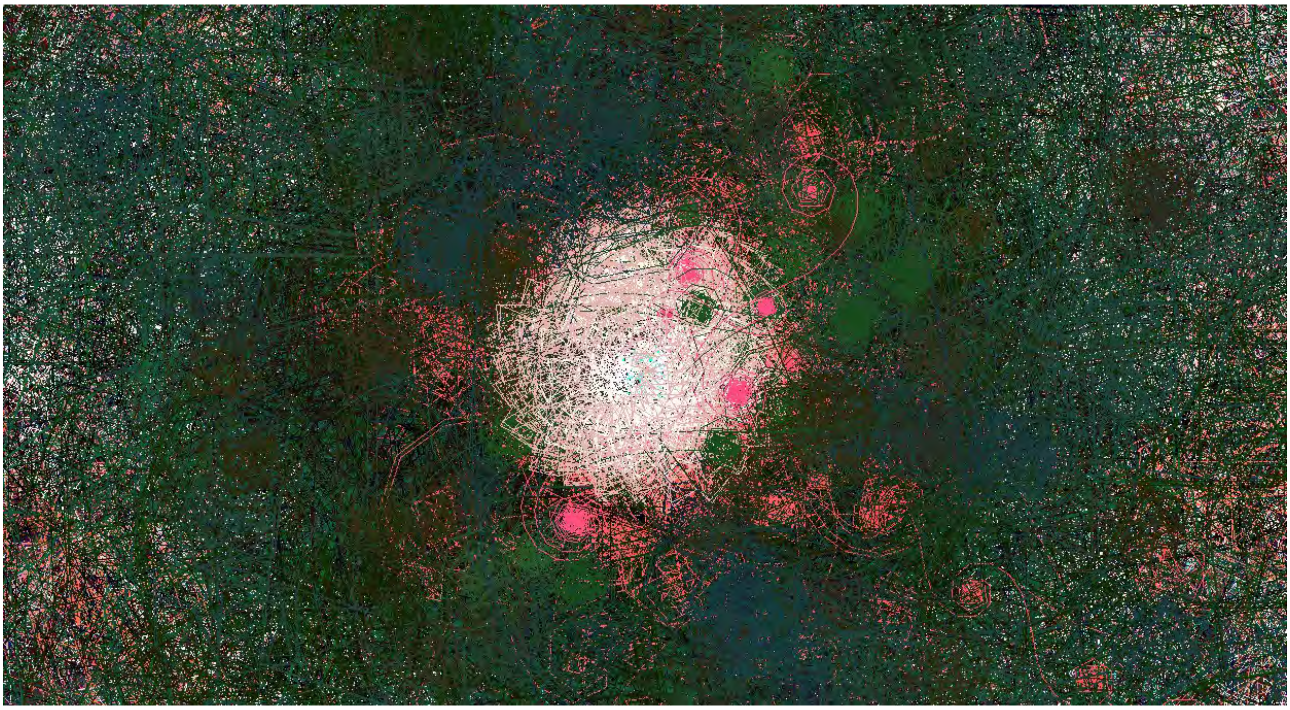


**Figure 12 Untitled.**

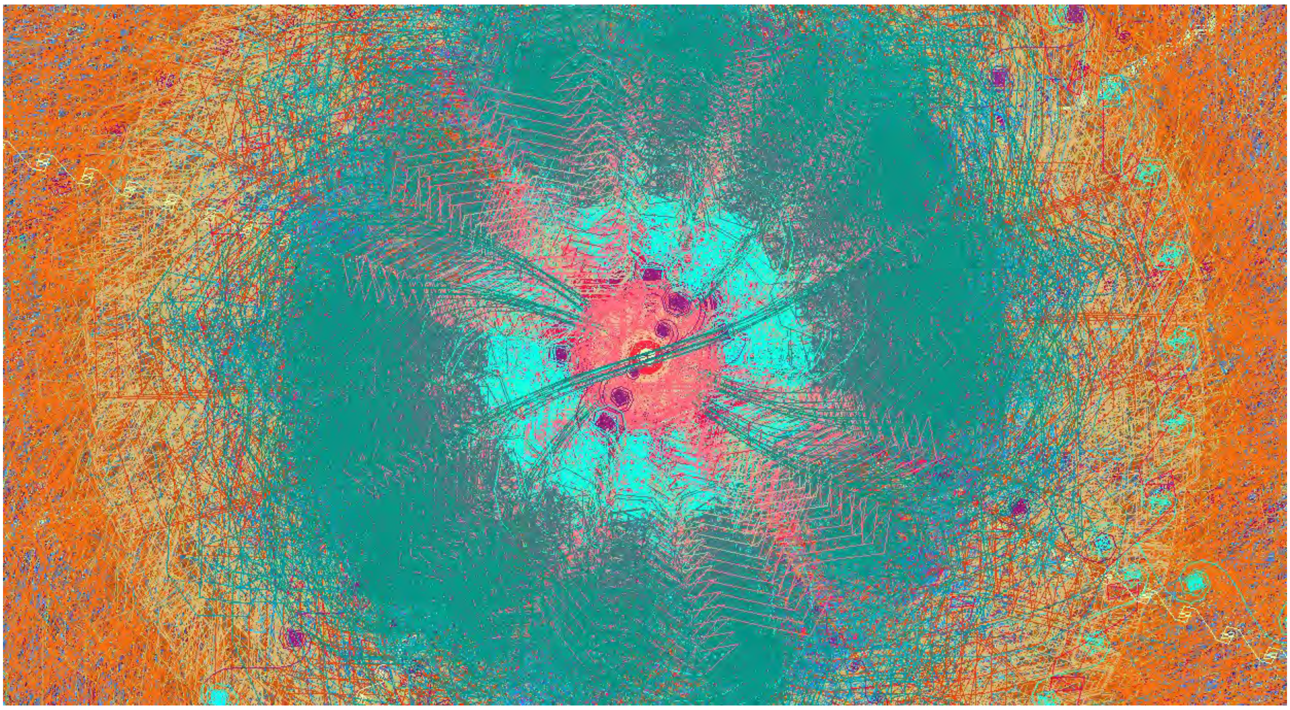


**Figure 13 Untitled.**

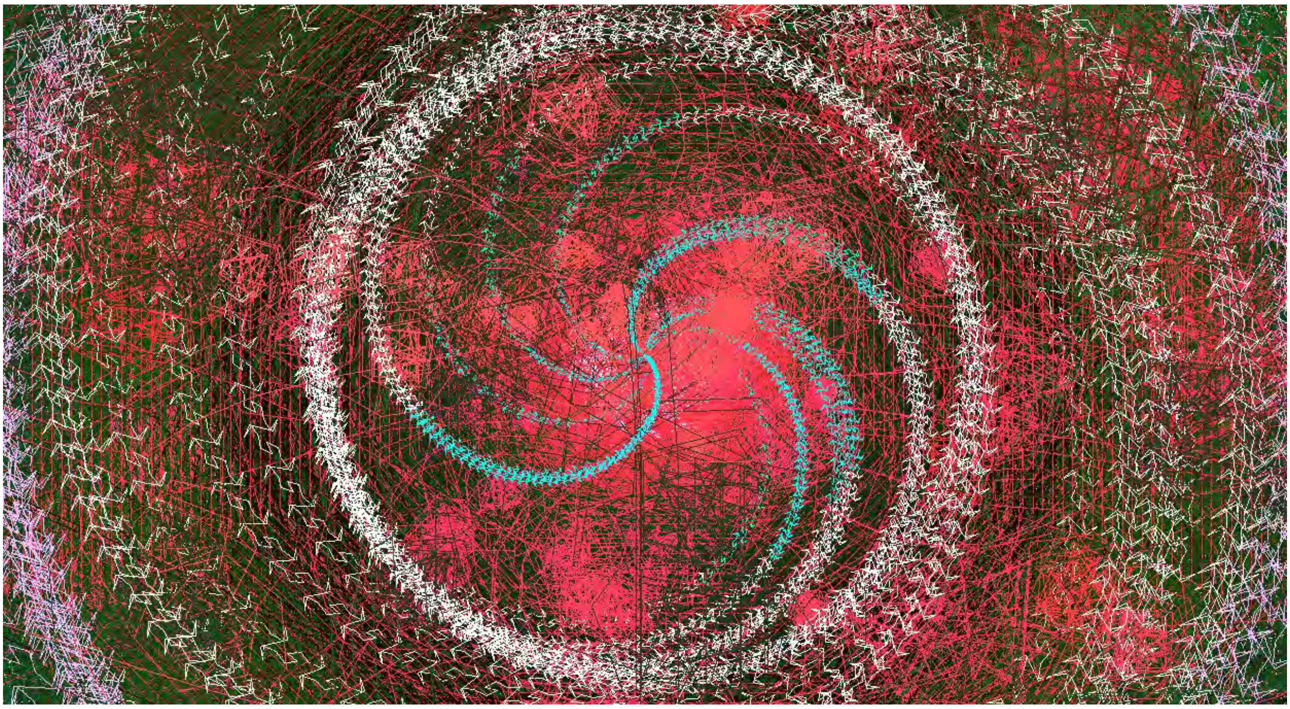


**Figure 14 Untitled.**

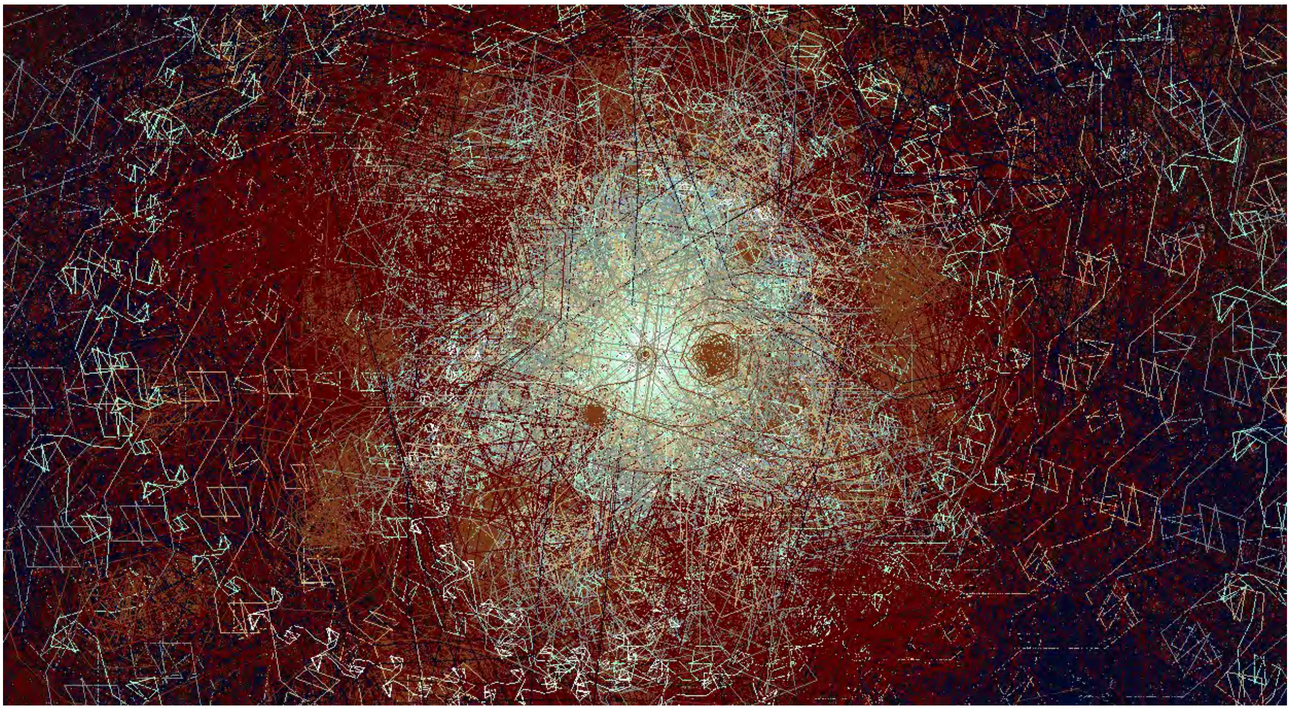


**Figure 15 Untitled.**

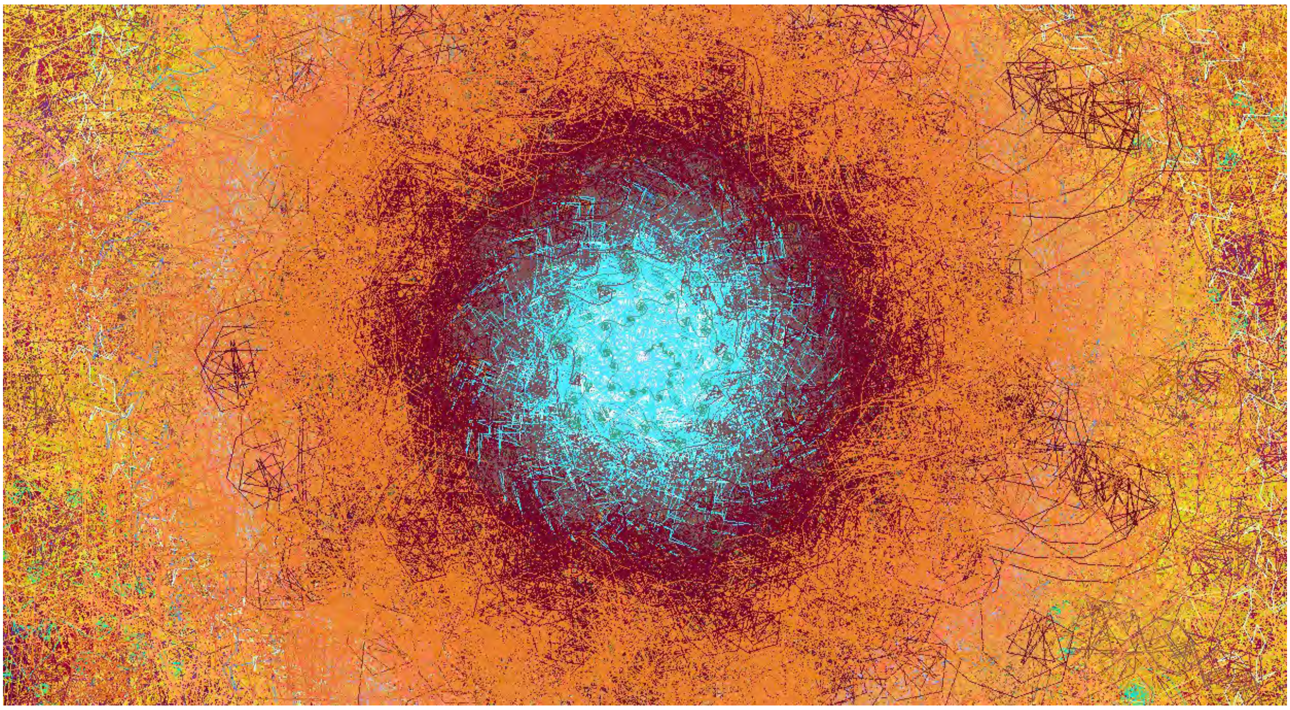


**Figure 16 Untitled.**

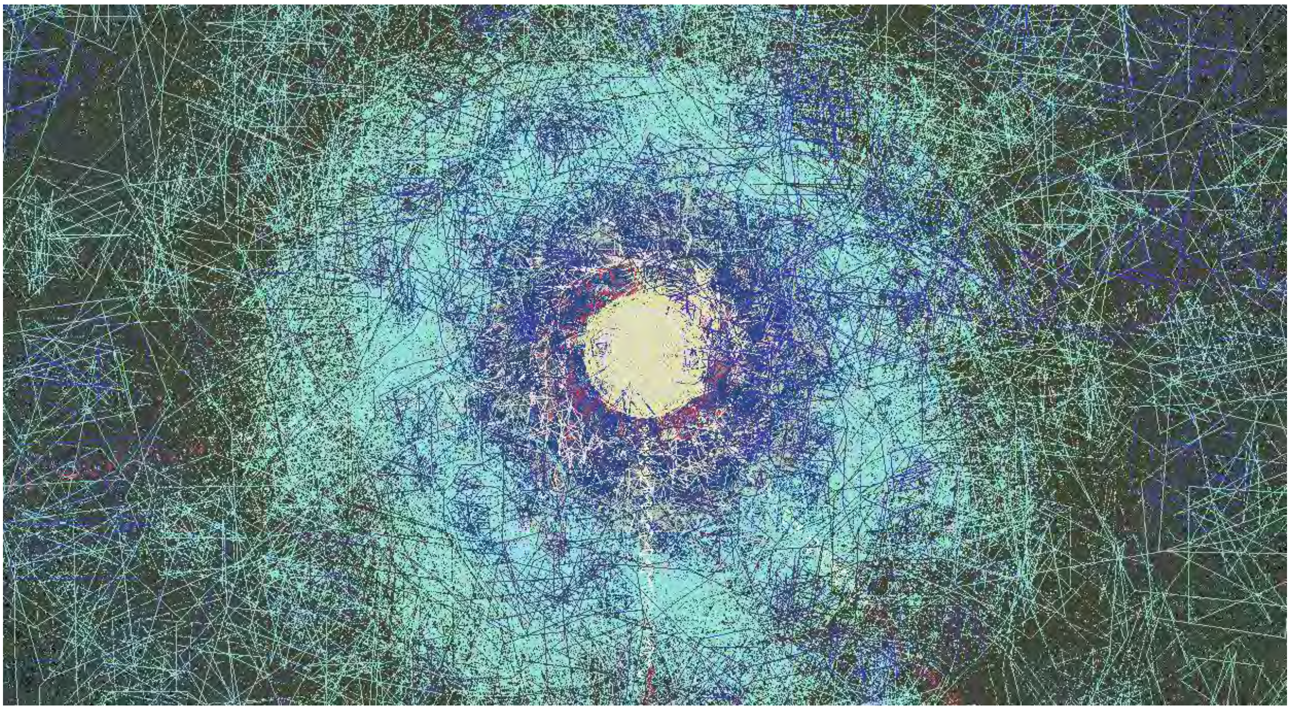


**Figure 17 Untitled.**

## 3. Coding the Heart

The images of the last section were created using music for the signal that will be traduced into images. The following set of images was created using the heart beat as the base of the signal. This is a project in development.

To capture the bioelectric signal coming from the heart, it is necessary a circuit to capture the signal in a bipolar lead configuration. The bipolar lead is to put two electrodes over the chest, and an extra electrode as a reference.The electrodes are made of AgCl and a gel to avoid mechanical noise.

In Figure 18 there is the used front-end to acquire the ECG signals. The circuit amplifies 500x the bioelectric signal using a differential amplifier. The circuit has 4 filtering stages, and an adding level stage to have the voltages in the range of the microcontroller (0-5 V). The first one is an active shielding. The second one is a resistive-capacitive low-pass filter with a 97 Hz cut frequency. The next stage is a first order high-pass filter with a cut frequency of 5 Hz. The last stage is a noth sallem-key filter with a center frequency of 60 Hz. This filter can be easily modify for a center frequency of 50 Hz (europe).

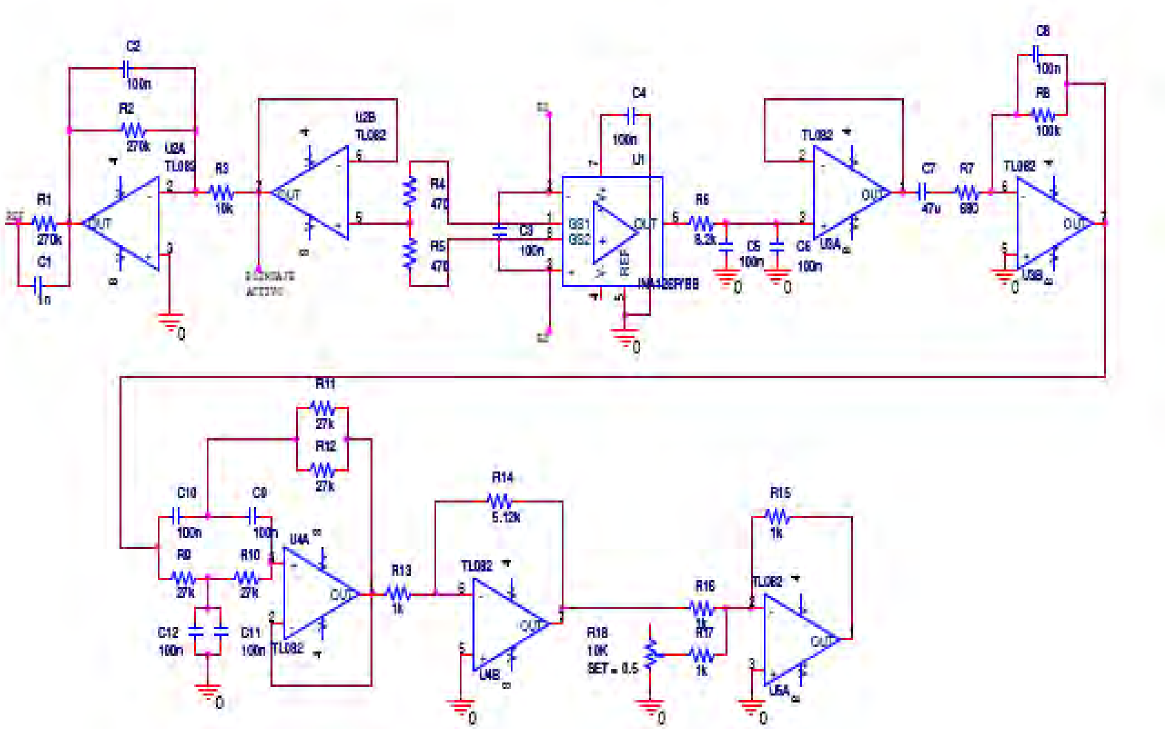



**Figure 18 Electronic acquisition hardware.**

For example in Figure 19 we can see the measures of the heart, and in Figure 20 the FFT transform [2].

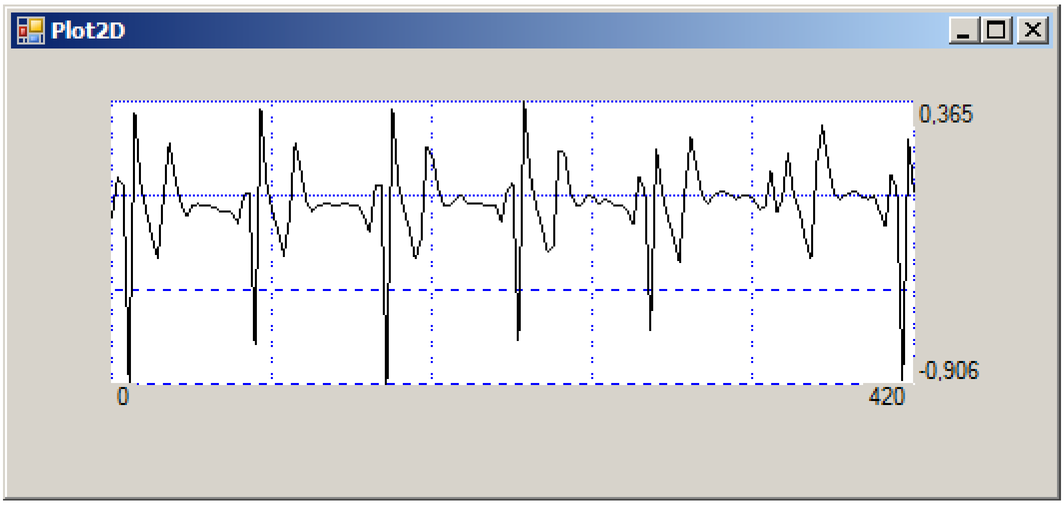



**Figure 19 Heart Measures.**

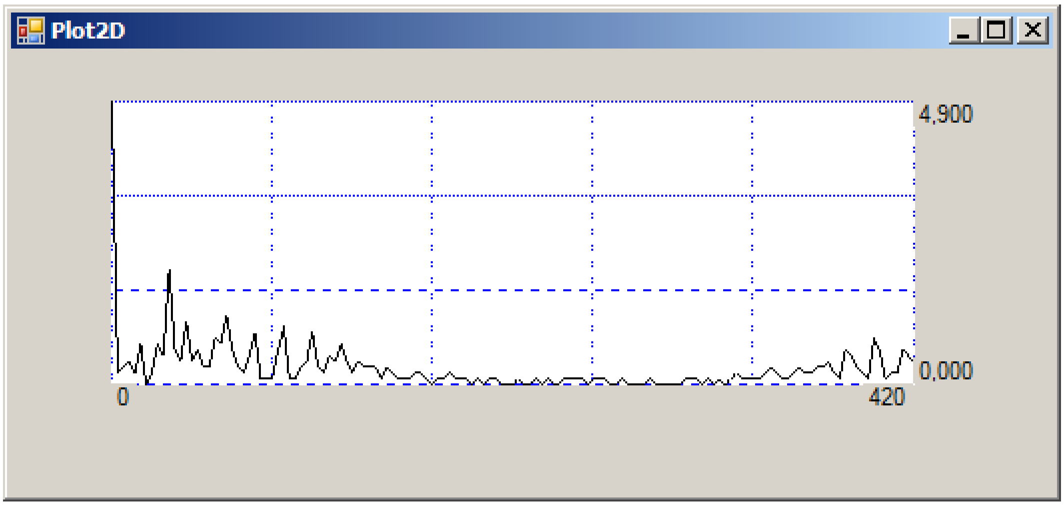



**Figure 20 FFT Transform.**

From my heart measures we create a set of images using the FFT coefficients:

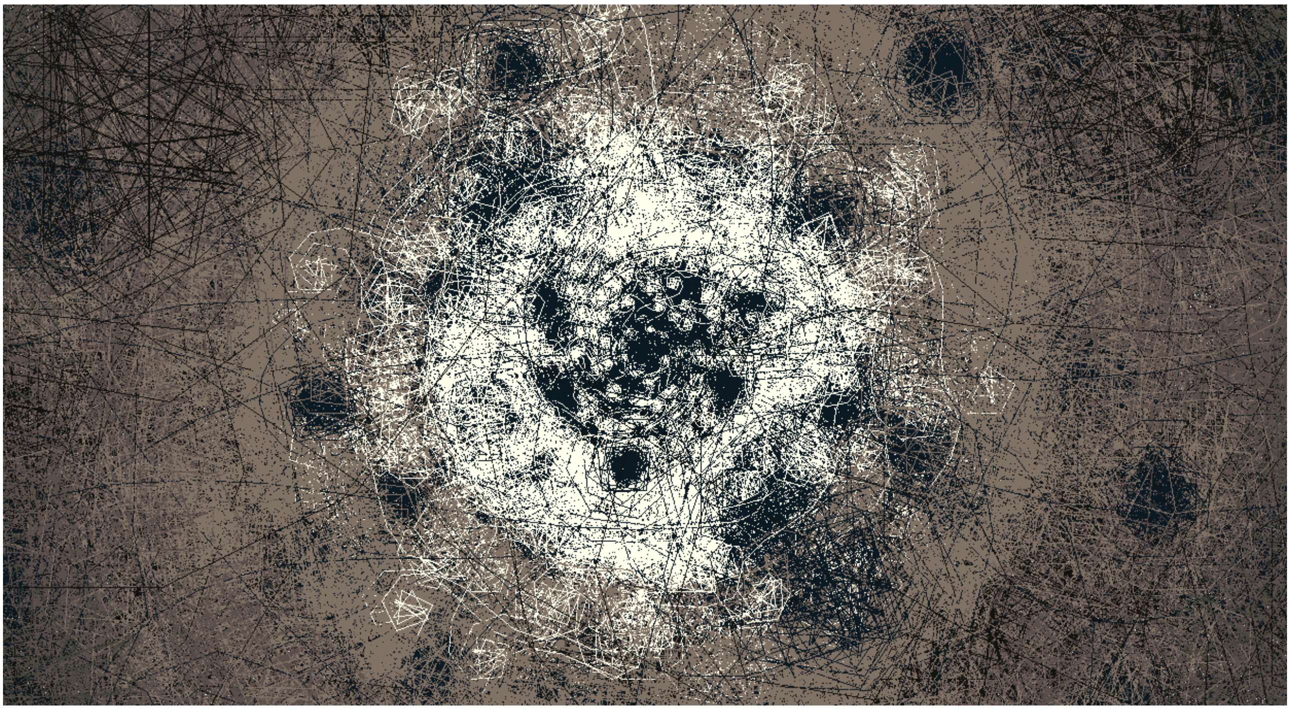


**Figure 21 Love Declaration I.**

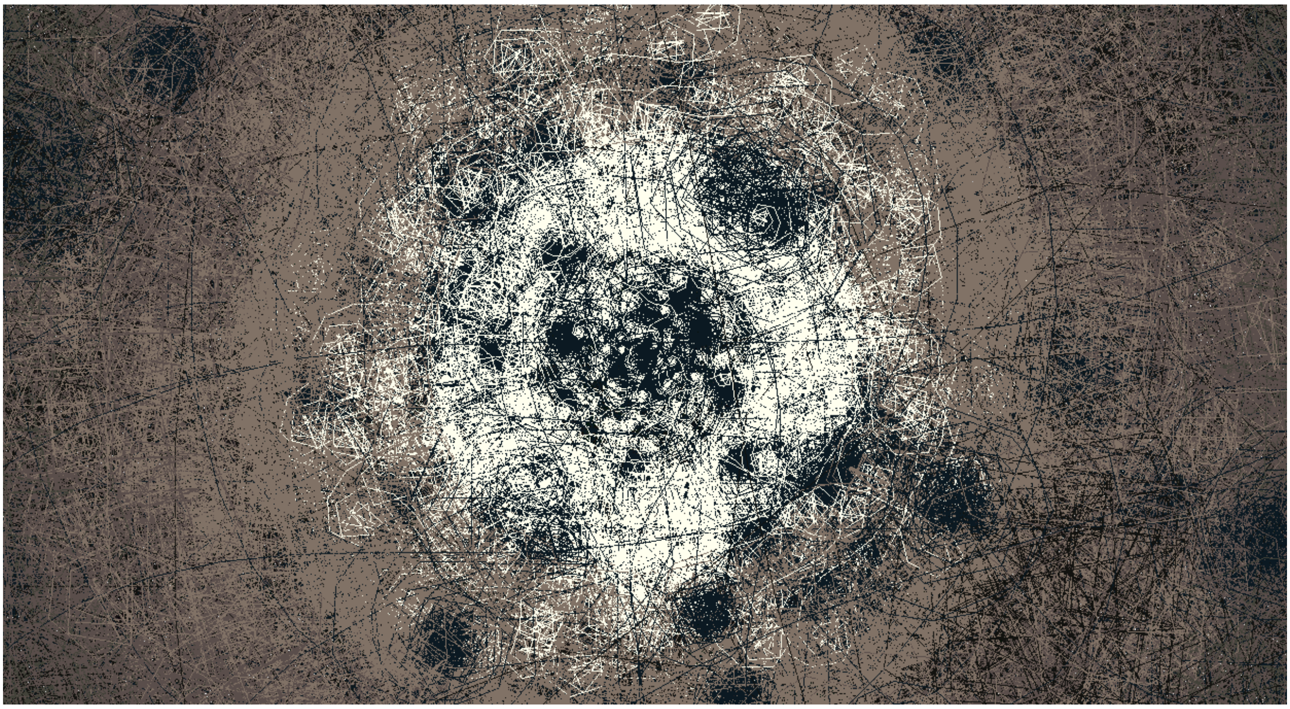


**Figure 22 Love Declaration II.**

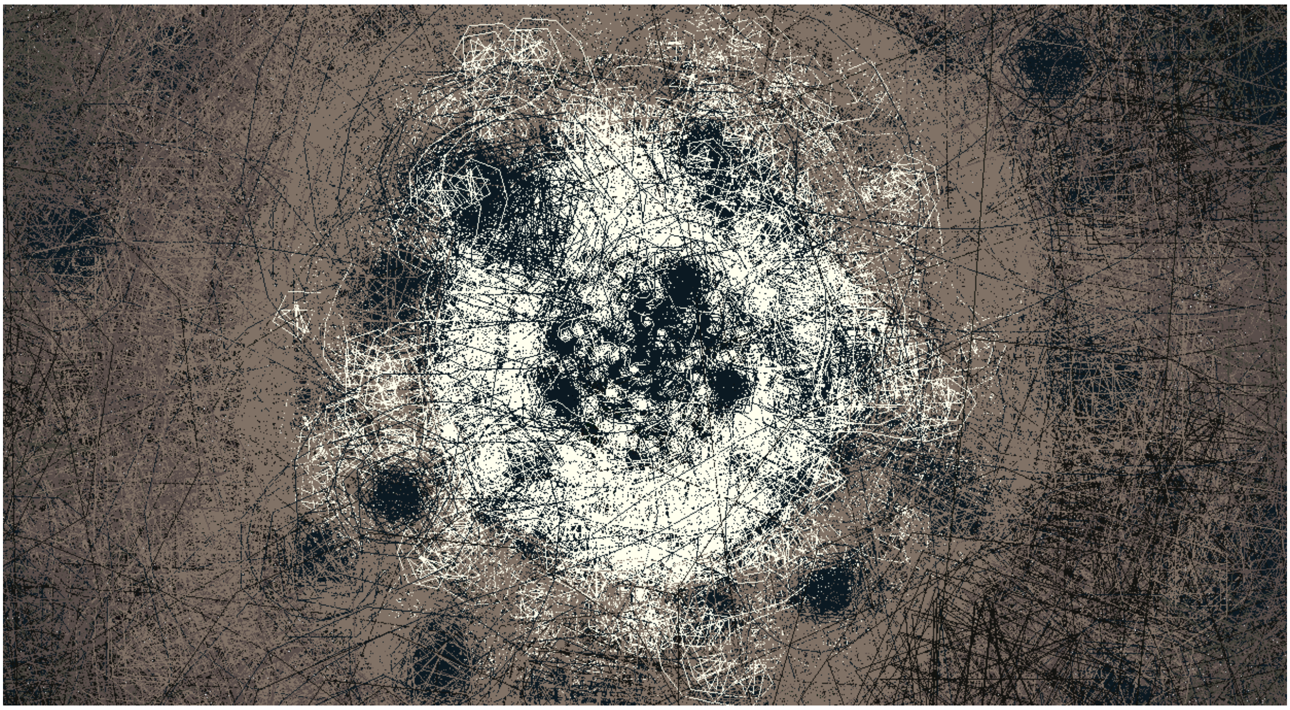


**Figure 23 Love Declaration III.**

## 4. The Next Step

There are two paths to continue developing this project. The first one is to bring the images to the real world using classical techniques. For example from Figure 24 we create a painting using acrylic on canvas (Figure 25). The same case for Figures 26 and 27.

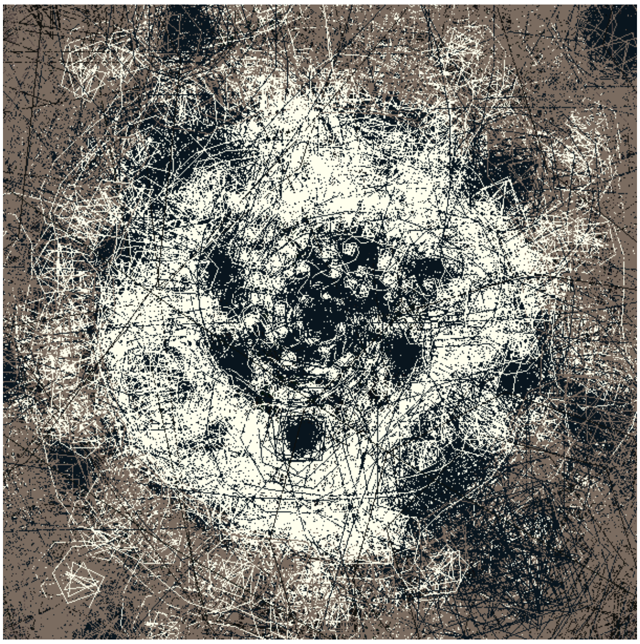


**Figure 24 Love Declaration (detail).**

**Figure 25 Love Declaration (acrylic over canvas).**

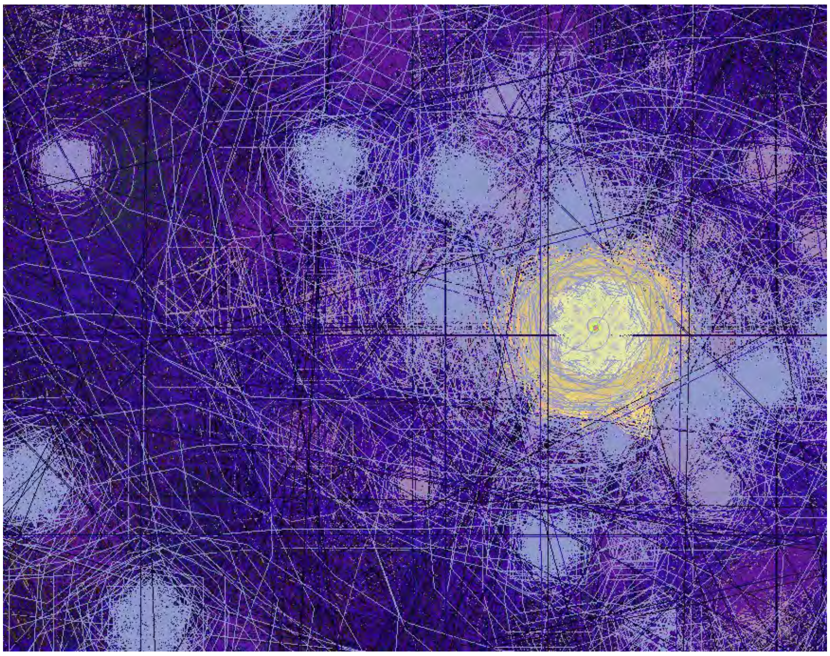


**Figure 26 Galaxia.**

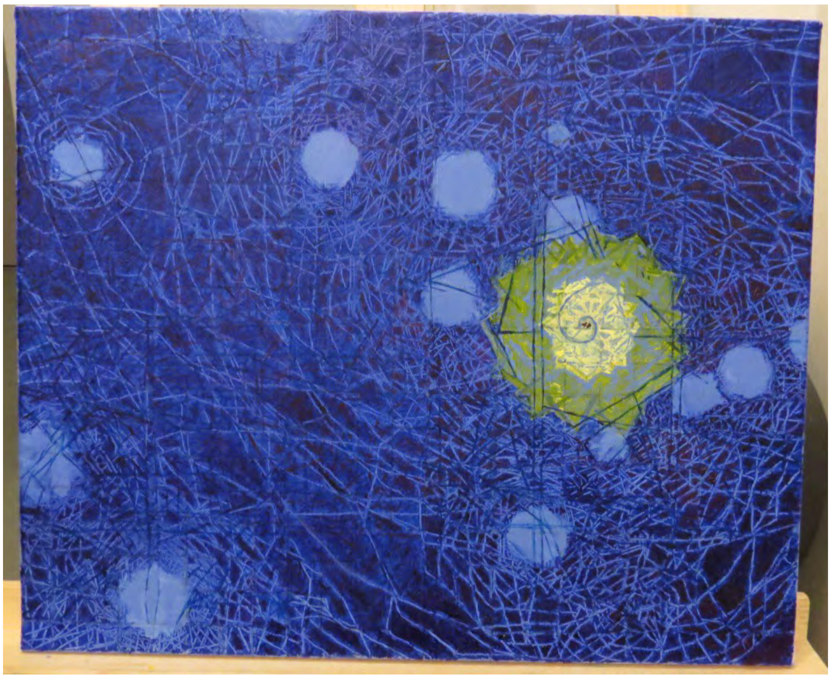


**Figure 27 Galaxia (acrylic on canvas).**

The second path is to develop the software using artificial intelligence (AI). Using particle swarm optimization (PSO), we created a software that while using music as a base for the images; when the user loves an image; then it saves the coefficients and starts generating similar images.

PSO is a population-based evolutionary algorithm. based on the social behaviour of birds flocking and fish schooling, it was firstly introduced by Kennedy and Eberhart [7]. The population denominated as swarm uses a number of particles (candidate solutions) which are moved around the search space to find best solution using their positions. Each particle cooperates with the others during the search process by sharing the information of its current position with the best position that it and the other particles in the swarm have found.

Initially, a number of particles *N* of the swarm *xi* are randomly positioned in the search space and random velocities *vi* are assigned to each particle. Then, each particle is evaluated by calculating the objective function. Once the particles have been evaluated the values of the particle's best position *pi* and the global best position *g* are calculated. Next, the algorithm iterates until the stopping criterion is met; that is either an acceptable minimum error is attained or the maximum number of iterations is exceeded. In each *k* iteration, each particles position *xk*+1*i* and velocity *vk*+1*i* are updated following the next equations:

$$v_i^{k+1} = \omega \cdot v_i^k + c_1 \cdot r_1 \left(p_i^k - x_i^k\right) + c_2 \cdot r_2 \left(g^k - x_i^k\right)$$
$$x_i^{k+1} = x_i^k + v_i^{k+1}, \qquad (1)$$

where *ω* is a real constant called inertia weight, *c*1 and *c*2 are the acceleration coefficients that moves the particles toward the local and global best positions; and *r*1 and *r*2 are both random values uniformly distributed between zero and one. The process is repeated until the stopping condition is met; the final value of *gk* represents the optimum solution found for the problem optimized using this algorithm. This module is in development.

For example using this module we choose the following figure, created randomly (no base);

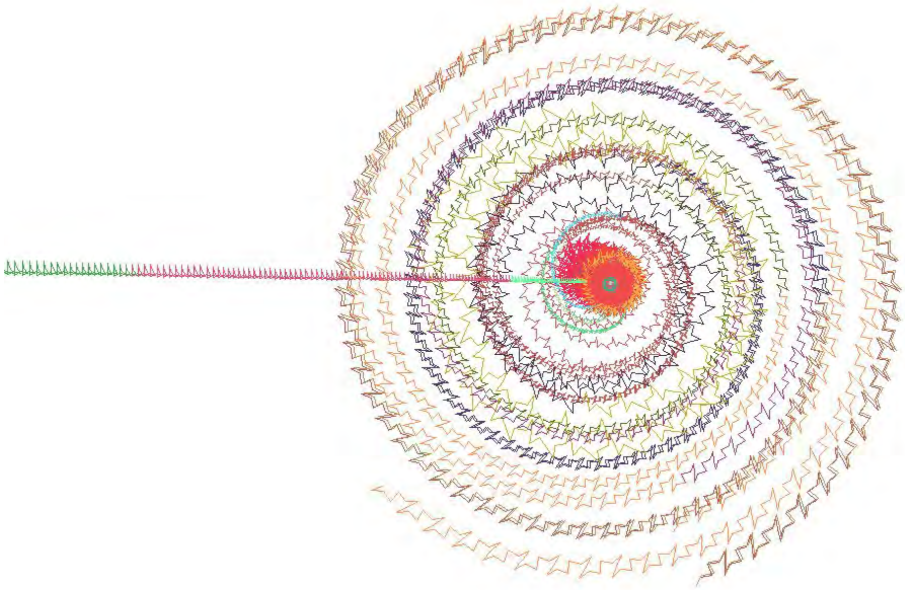


**Figure 28 Randomly generated Image.**

Using the coefficients to create this picture, we create a series of images (Figures 29-31).

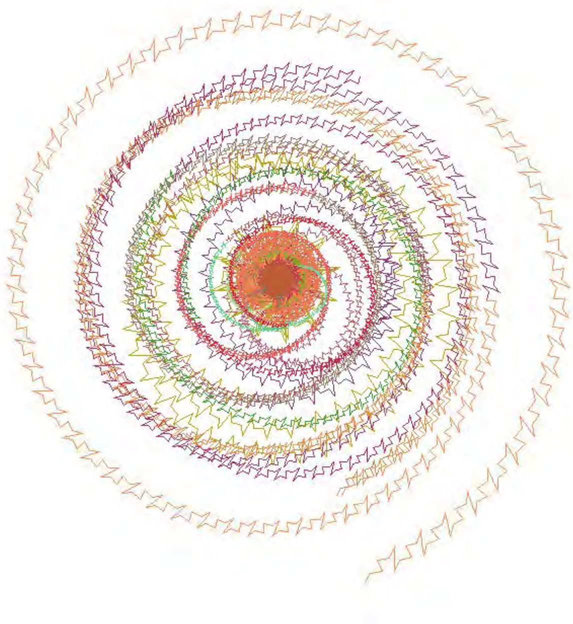


**Figure 29 A.I. I**

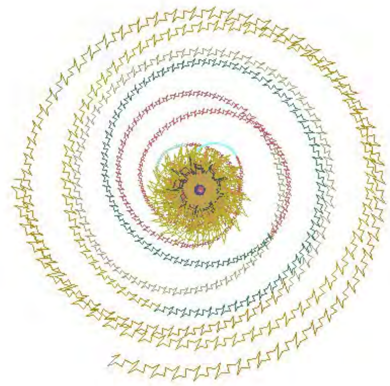


**Figure 30 A.I. II**

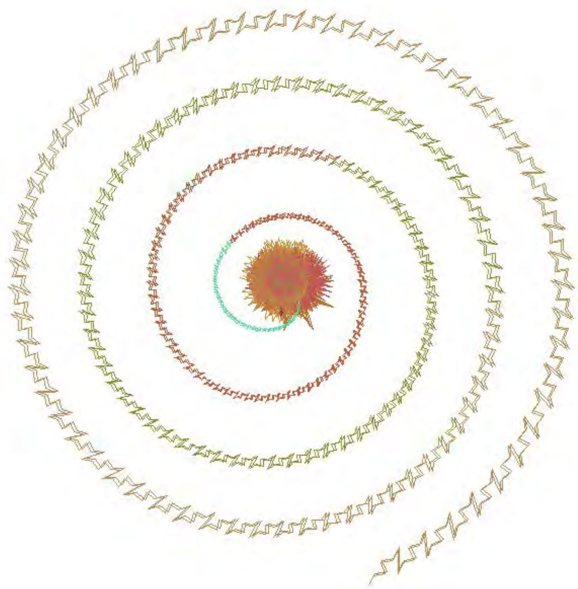


**Figure 31 A.I. III**

## 5. Acknowledgements

I would like to thank the Institut de Mathématiques de Bordeaux (Université Bordeaux Segalen), Galerie MLS, and the artist Gildas Bourdet.

## 6. References

[1] Gildas Bourde “*Peintures et Dessins*”, CASTA DIVA, Paris, 2012.

[2] Inside The FFT Black Box. Serial And Parallel Fast Fourier Transform Algorithms, March 2001CRC Press.

[3] Software for inverse voltage calculations in the heart's surface Ainseba, B. ; Bendahmane, M. ; Lopez, A. Electrical,(CONIELECOMP), 2012 22nd International Conference on
Publication Year: 2012 , Page(s): 34 – 39.

[4] Balzac, Honoré De, and Honoré De Balzac. *Le Chef-d'œuvre Inconnu*. Paris: Éditions De L'Abeille D'Or, 1926. Print.

[5] Peitgen, Heinz-Otto, H. Jürgens, and Dietmar Saupe. *Chaos and Fractals: New Frontiers of Science*. New York: Springer-Verlag, 1992. Print.

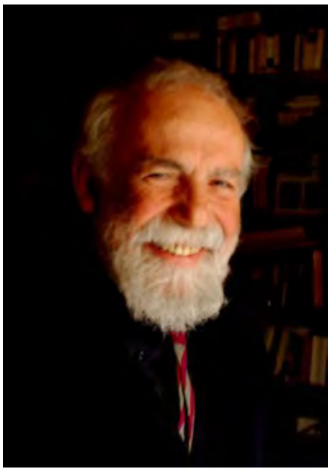
[6] L. Tung. A bi-domain model for describing ischemic myocardial D-C potentials. PhD thesis, MIT, Cambridge, MA, 1978.

[7] Kennedy J, Eberhart RC. 1995. Particle swarm optimizationIn: *Neural Networks, 1995. Proceedings.,IEEE International Conference on*. Perth, WA, Australia. Nov. (. ; vol. 4). IEEE. pp. 1942–1948 vol.4.

*[8] Mostafa Bendahmane, Raimund Bürger, Ricardo Ruiz-Baier: A finite volume scheme for cardiac propagation in media with isotropic conductivities. Mathematics and Computers in Simulation 80(9): 1821-1840 (2010).*

**CELESTINO SODDU**

*Paper:* **MUSICABLU. Generative Music Design software for increasing human creativity and generating unique and not-repeatable musical scores**



***Topic: Generative Music***

***Author:***
***Celestino Soddu***
Generative Designer.
Politecnico di Milano University

***References:***

[1]www.generativedesign.com
[2] Celestino Soddu, Music Generative Design, Gasathj Journal issue #2, www.gasathj.com
[3] http://www.youtube.com/embed/TLe_qySq09s?rel=1
[4]J.S.Bach, Art of Fugue and Goldberg Variations
[5]W.A.Mozart. Sonata in C major K545
[6]J.Coltrane, My favourite things, Bessy blues, Afro blues
[7]Beatles, Yesterday, Hey Judy, Imagine and others
[8]Modern Jazz Quartet, Blues on Bach, 1973
[9]Anton Webern "Der Weg zur Neuen Muzik" 1932-1933

Following the generative approach that I developed in the last thirty years, I worked on a project of music design able to produce musical pieces and to record each result in a midi file with fifteen tracks, each one generated following a peculiar instrument and a peculiar and identifiable player. This was the main choice: it doesn't generate the sound but the musical score. These scores can be played using other programs and, if necessary, they can be upgraded with different instruments. More, they can also played and interpreted by an human orchestra.
Following that, the focus of the generative process is in the musical Idea and its structure and not in the sound, that belongs to the player's performance and to his subsequent interpretation. This approach mirrors what happened in the time of Bach and Mozart: The musician creates his music writing the score. Only in a second moment the composer plays his music or another player can interpret and performs the piece using this score.
I had developed this project starting from 2003. But until now it was in a starting phase. I only presented the live performance “Out of hours” at GA2005 interacting my generative music with a human jazz singer, Josette Marcial, the poetic text by Enrica Colabella and the live-generation of my woman portraits able to interact, in real time, with the music. But this year I suppose to have reached more advanced results and, for the first time, I am happy to present MusicaBlu at this Generative Art conference.
The aim was to create a generative software able to support the musical creativeness following the own cultural references and the own subjective preferences. This in tuning with my preceding experiences in generative design that involved different fields, from the visual art to the architecture, from the city design to the industrial objects: interpreting own imaginary references and creating transforming rules able to perform events in tune with our peculiar vision.
But the jazz approach was only the starting point.
The aim was to simultaneously acting on the various logical components of a musical composition. That works not limited to the interpretation and the progressive variations on a theme, as happens in Jazz but directly involving the music creation. So following the tradition, the generative software involves the generation of the riff, the melodic construction, the harmonic construction, the rhythm and the adjectives that identify it: “largo”, “adagio”, "andante", "allegro", "allegretto ma non troppo", “prestissimo”, and so on.
More, my aim was also to operate generative actions on the orchestra and on the management of the player group considered as different and identifiable soloists, rhythmic group and accompaniment group.
The more important and *hard* part was designing the algorithms able to generate the melodic construction. I tried to enlarge the field of melodic possibilities. Melodies are not only confined to "classical", “Jazz” and popular music but I have also experimented "numerical" melodies and dodecaphonic melodies, having as reference, in this last case, the structure proposed by Webern in its 1932-1933 famous conversations "Der Weg zur Neuen Muzik". This is my experience for experiment the borders of the generative approach in contemporary music.

***Contact:***
***celestino@soddu.it***

***Keywords:***
Generative, Music, Score, midi, counterpoint, melody, harmony

# MUSICABLU

# Generative Music Design software for increasing human creativity and generating unique and not-repeatable musical scores

**Celestino Soddu, Generative Designer**
*Director of Generative Design Lab, Politecnico di Milano University*
*Professor of Generative Design at the School of Design, Politecnico di Milano*
*www.generativedesign.com*
*e-mail: celestino.soddu @ generativeart.com*

## Premise

Following the generative approach that I developed in the last thirty years, I worked on a project of ***music design*** able to produce musical pieces and to record each result in a midi file with fifteen tracks, each one generated following a peculiar instrument and a peculiar and identifiable player. This was the main choice: ***to generate the musical score and not only the sound***. These scores can be played using other programs and, if necessary, they can be upgraded with different instruments. More, they can also be played and interpreted by an human orchestra.

Following that, the focus of this generative process is in the musical Idea and its structure and not only in the sound, that belongs also to the player's performance and to his subsequent interpretation. This approach try to mirror what happened in the time of Bach and Mozart: The musician creates his music writing the score. Only in a second moment the composer plays his music or another player can interpret and performs the piece using this score.

I had developed this project starting from 2003. But until now it was in a starting phase. I only presented the live performance “*Out of hours*” at GA2005. It was performed by interacting my generative music with a human jazz singer, Josette Marcial, the poetic text by Enrica Colabella and the live-generation of my woman portraits able to interact, in real time, with the music. This year I suppose to have reached more advanced (also if not “final”) results and, for the first time, I am happy to present MusicaBlu at this Generative Art conference.

The aim was to *create a generative software able to support the musician creativeness by following the own cultural references and own subjective preferences*. This approach is in tuning with my preceding experiences of generative design that involved different fields, from the visual art to the architecture, from the city design to the industrial objects. **This generative structure is based on the interpretation of my own peculiar imaginary references and works by creating**

**a set of transforming rules (algorithms) able to perform events in tune with own peculiar vision.**

So I used this approach also in the music field. My generative software ***MusicaBlu*** is based on my subjective vision, and particularly on my experience as jazz player in the sixties. By the way, this experience was at the base of the generative approach that I have developed in all my experimented creative fields.

As in a jam sessions, the main elements are:
1. the composition of a melody, and/or of a motif;
2. the subjective structure of riffs able to identify own musical character;
3. the creation of an harmonic and rhythmical structure;
4. the improvisation and the subjective interpretation as transforming process;
5. the harmonic and melodic interpretation;
6. the use of the cultural references in the field of the music, but not only;
7. the possibility to interact with the other soloists during the dynamic evolution of the musical session. And to develop together unpredictable musical events.

In order to clarify, and to specify my adopted references, most of all related to baroque and to the sixties and seventies, my main references were: Bach, particularly the Fugues, Mozart, the Modern Jazz Quartet, Miles Davis, Coltrane, the Whether Report and the Beatles.
I have built in progress the software *Musicablu* by actively interpreting these references.

But the jazz approach was *only the starting point*.

The aim was to ***simultaneously act on the various logical components of a musical composition*** not limiting me to the interpretation and the progressive variations on a theme, as happens in Jazz, but directly involving the music creation. These logical fields are the *generation of the riff*, the *melodic construction*, the *harmonic construction*, the *rhythm* and the *adjectives* that identify a piece of music: "*largo*", "*adagio*", "*andante*", "*allegro*", "*allegretto ma non troppo*", "*prestissimo*", and so on.

More, my aim was also to operate generative actions on the orchestra and on the management of the players group considered as different and identifiable soloists, and also the rhythmic group and the accompaniment group.

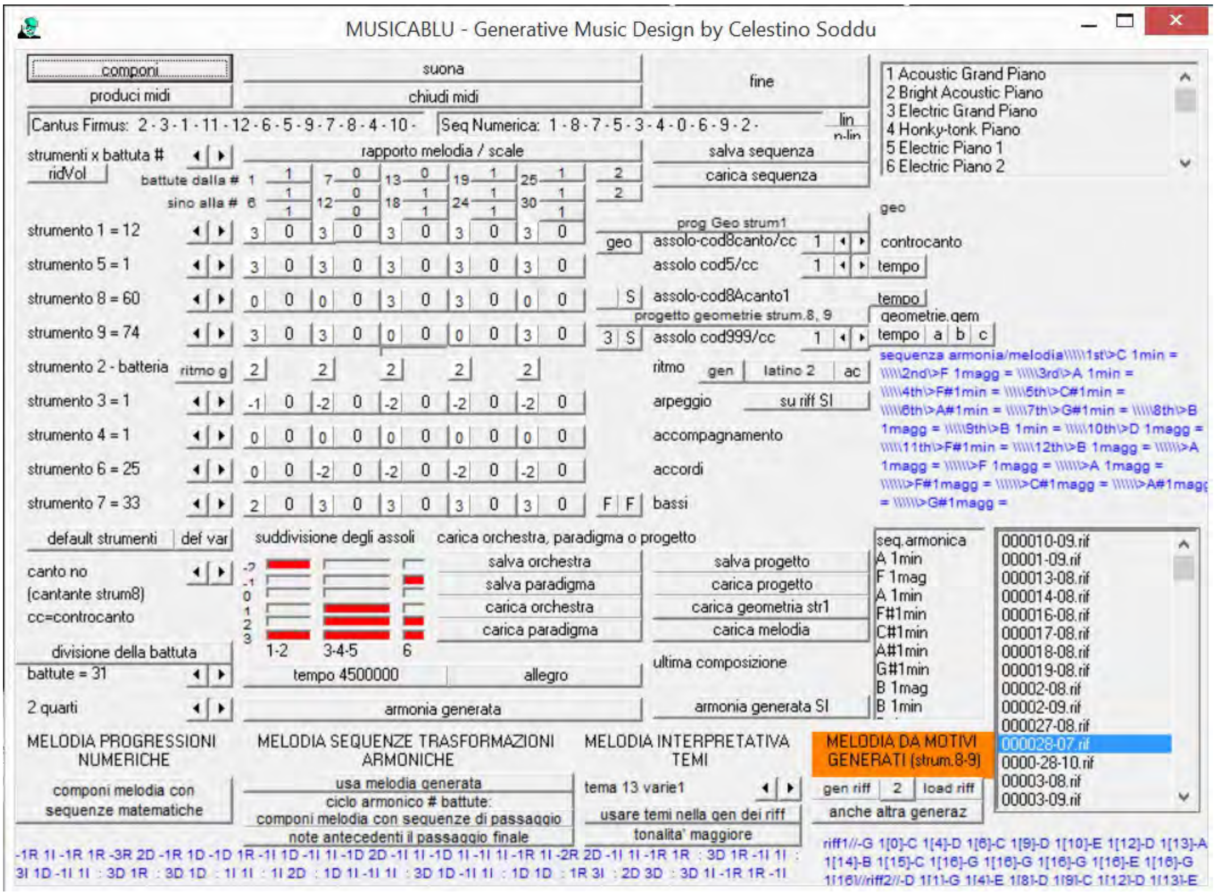
The most important and hard part was designing algorithms able to *generate the melodic construction*. I tried to enlarge the field of melodic possibilities. Melodies are not confined to "classical", "Jazz" and "popular" music, but I have also experimented "numerical" melodies and dodecaphonic melodies, having as reference, in this last case, the structure proposed by Webern in his 1932-1933 famous conversations "*Der Weg zur Neuen Muzi*k".

## The structure of *MusicaBlu*

As well as in all my experiments of Generative Art, this generative software is structured in two parts: *the first part* for managing the piece, concretely for creating and managing the paradigm of possible results, and the *second part* able to manage the music generation by using parallel transforming devices and their reciprocal contamination and interactions.

The **structure of the paradigm** is based on the possibility to choose the orchestra and the schedule of each player. Together with the character and the possible instrument of each player. This orchestra can be created and used in different generative paths. The paradigm of the orchestra is the basic choice since the beginning of each generative process. The paradigm doesn't have inside generative algorithms but only requests of specific characters and “constraints” able to control, in progress, the music generation.

The second part is a **set of generative devices** structured as a not linear system. These devices work in parallel and are focused on different fields: the generation of riffs, of melodies, of the progression of harmony, of rhythms, of time geometry inside each bar and each bar sequence, of various symmetries among notes, riffs and melodies.



*Screen-dump of MusicaBlu interface.*

## The Melody

Going in deep about the melody generation, I have designed the generative algorithms for *four different generative devices* for fitting a range of four possibilities related to the structure of the melody. These four sets of algorithms create four parallel devices able to work together, interacting among them and managing reciprocal contaminations.

## The Melody generative device #1 - Numerical sequences

The first melody generative device uses the ***structure of numerical sequences*** as the *Prime* numbers, the sequence of *Fibonacci*, the sequence of the *squares*, the sequence of *Hailstone* numbers and the sequence of *Alcuin,* but also it is used a calibrated mix of these sequences. This mix is structured following a similarity with a sequence of different accords inside the structure of harmony. For example, the first numbers of Fibonacci seems more closed to a major accord when the Prime numbers seems closed to a fifth diminished accord. So it was possible to manage the moving from different numerical sequences as well as the moving from an accord to the next one.

These numerical references are used for ***creating the base of each small sequence of notes***, from two to a maximum of 9 notes, that will fit the generated harmony sliding the starting point to the tonic and, sometimes, to the 5th dominant.

The character of this generation belongs, obviously, to the 12-tone chromatic scale. But the parallel generation of the harmonic sequence will also interact with the numeric sequence by applying a subsequent transforming action involving the notes. This could be done by increasing or decreasing each note of an half-tone; by enlarging the time of the notes in a way that it will fit the harmony; or by decreasing the time when it don't fit the used scale and accord. For example, a possible feedback from the generated sequence of notes and the parallel generation of harmony is to move to a minor accord if the generated notes is the 3rd minor, and so on.

## The Melody generative device #2 - Dynamic structured passages

The second melody generative device works through the ***generation of notes of passage among notes distant each other from three to seven half-tones***, with few exceptions. This possibility was created for interpreting the possible structures of the *catchy songs and* of the catchy motifs.

"**How**" the motif *begins*, how the motif *runs in the movement from one accord to the subsequent one,* how *the last three, two or one notes are structured before the final note*, and so on, were considered and interpreted with generative algorithms.

The aim was to create, interacting with the parallel generation of harmony and rhythms, generated **riffs** that could fit the character of a catchy motif. The results were interesting but, as normally happens in music composition, not all the variations fit this quality at the best.

This generative device can also work applying these "*passages*" to the motifs generated by the other parallel devices, in a way that it's possible to increase quality and character to the musical piece.

## The Melody generative device #3 - Imaginary structured references

The third set of melody generative algorithms uses a ***structure of references*** from Bach to Coltrane from the Beatles to Mozart. These references are ***logically interpreted as progressive dynamics*** and as relationship among norm and exception. The algorithms produces a progressive sequences of notes.

This third possibility works as the previous one, but the structure of the passages are constructed starting by the interpretation of well identified references, well identified melodies.

The possibility to quote own references but *not to excerpt a copy* is based on the structure of subsequent transformations managed by the generative algorithms. *The own imaginary interpretation operates by identifying one of the possible sequence of few notes inside the melody and* ***focusing only a peculiar aspect of the geometric structure*** *of a sequence*.

In a second step the sequence will interact with a generated geometry able to redefine the time sequence. More, each sequence will be transformed, upgraded and structured through the concomitant generation of harmony and rhythm.

The aim was to reach the construction of possible variations; and to reach results where the reference will be not so explicit and cannot be easily recognized. But the generated music will be able to communicate a recognizable feeling, as happens when we appreciate the improvisation of a jazz player.

In other terms this set *doesn't use a database of melodic references but uses logical possible interpretations of passage sequences from one note to another*, trying to identify a dynamic structure able to perform a recognizable feeling.

## The Melody generative device #4 - Riff generation and progressive transformations

The fourth possibility, that iI consider the **most productive melody generative device**, works through the complete generation of a "new" **riff**, a small and catchy motive that *will be interpreted by the other parallel generative structures for transforming it into a melody*. This is not in alternative with the previous three sets of algorithms. It performs a starting possibility that will be developed by the other three devices. The results of this algorithm, as completely new riffs, are used as reference by the other devices and, sometimes, interact with them for increasing its possible quality.

More, each riff is directly generated as a set of several matrices able to perform notes, duration, accentuations, volume and characters and it contains several other parameters as the number of notes and the geometry of the bar.

A particular attention is focused on the downbeat or upbeat of each note, following a possible harmonic geometry.

Each riff is generated in *four parts*, where the first one is the main riff, the second, third and fourth are riffs directly contaminated by the first one but with more soft sequences, that means with more long notes and with different structure of time sequence. The reference was to the main motif of a song and to the variation used for composing an insert. This second associated riff, is generated completely different but with identifiable point of similitude with the main one. Each riff, when generated, is recorded in a separate file so that it can be used again, in another piece of generated music.

Two bars of sax solo generated through a riff generation:


But the riff is not the melody. For moving from the riff to the melody, the riffs must be used by the generative engine many times. Each time it will be transformed with the contamination of the other devices and with a set of transforming rules created following the concept of **counterpoint**. This works by using different symmetries and some mirroring possibilities. *Inverse canon* and/or *retrograde canon* are the two most used transforming rules in Musicablu. There are also inside the generative engines a set of other transformations, coming from my experience in 3D geometry. These are used in peculiar events.

## The harmony

The generative device for the structure of the harmony was the more easy to design, in how a lot of explicit references exist. It's possible to follow these references for performing the sequences of accords and reach appreciable results. Also if some exceptions and peculiarities can be managed for reaching more rich results.

Also in the dodecaphonic music, called also twelve-tone composition, the structure of reference is able to be easily interpreted with algorithms working essentially with mathematical rules. The sequence of notes, for example, could be managed structuring a sequence of 12 notes, that might be called “cantus firmus”, where no note will be repeated before starting a new sequence, as Webern said. An example of a possible Cantus Firmus might be: 8 - 4 - 2 - 11 - 5 - 10 - 7 - 9 - 12 - 3 - 6 - 1

More, it's possible to opt for working with an harmony in the classical sequence of the 12 bars of the Blues or with four bars of the song in major or minor tone, and with other classic harmonic structures.

But MusicaBlu is not limited to these possibilities. The generative approach was used to **produce, in real time, progressive dynamic sequences of accords** and to operate interactively in real time with the melodies produced by the parallel algorithms.

This last possibility is, for me, more interesting because the dynamic harmonic sequence runs following the different harmonic consolidated possibilities. But it is open to change, also in unexpected way, by following the melody just generated in real time. In the meantime the melody develops itself, following the interaction and contamination with the harmonic structure.

The main element able to manage these incoming unpredictable contaminations is the **character** of each virtual player. Each of the fifteen players has its own character but the interactions with the harmony is designed only for the **four soloists**. Normally each soloist plays alone but they can play also together in a progressive counter melody.

A sequence of accompanying Bass:

## The Rhythm

The structure of the rhythm has two generative options.

The *first* option was designed on the beginning of this experience and it is an **interpretation of several rhythmic structures**. These are the consolidated and used rhythms in jazz. The generative possibility that I developed in this first option is mainly based on the interpretation of the rhythmic section of the Modern Jazz Quartet. It was developed through the transforming codes able to represent the variations inside the swing operated by drums and bass. But this was only the first approach.

The *second* generative set of algorithms, instead, works directly on a rhythm generation based not only on my explicit references but, above all, on **the use of geometric variations able to structure the dynamics of the sequences and the timbre of the sounds.** This possibility was developed after the first opt and it is certainly more strong and *more generative* then the previous one. It was build reporting to my experience on the geometries and their variations that were developed in the generative software that I had designed for different fields.

*This generative rhythm device works in two parallel paths*, managing the contamination of their structures. The rhythm is generated by the different sound (no sound too) of each beat that follows the character of the geometric paradigm. The two parallel paths are similar to the two hands of a drums player.

The progressive contamination between rhythms and division of the bars, the number of beats, from 2/4 to 7/8 has allowed to generate rhythmic events sometime amazing but always belonging to my musical vision. In the same way, the interpolation and contamination among various percussion instruments and the relative sounds are designed to generate unpredictable rhythms.

An example of a bar with double generated drums sequence:


## The evolution of Complexity, The counterpoint and the interactivity among parallel generations.

All this is, naturally, only the first step in the generation of a musical piece.

To reach a richness and acceptable complexity, the generative program ***MusicaBlu*** operates both on the orchestra, both on the interactions among instruments, and on the possible *counter melody* and *counterpoint* among parallel musical sequences.

This happens:

*First*, adopting the **counterpoint variations proper of the Fugues of Bach inside the transformation of the riffs**, small sequence of a motif, when this motif becomes the structure of a melody. The used counterpoints are, as I already said, the inverse canon and the retrograde one, and, in least part, also others proper of the Fugues of Bach or belonging to a geometric interpretations of possible symmetries and of the variation of points of view.

A really interesting possibility is the **variation of the point of view**, that is the change of the reference harmony or the change of the geometry of the time schedule, or the change of other characters. These variations of the points of view transform, *as well as a possible unpredictable subjective interpretation*, the music in progress and give to the piece a range of unusual possibilities.

This use of different points of view is also used in managing the structure of the *counter melody*. Some instruments have this possibility and, in front of each sequence of notes, a counter melody is produced and performed by another or by the same instrument.

An example of counter melody generated for a piano. The generated counter melody, in this case, is played by a piano too.


*Second*. The "players" themselves have, each one, a **peculiar character**: They are musically identified with *specific subjective attributes*. These characters are not related to the instrument, that, by the way, could be changed. They belong to a peculiar feeling that should suggest us to think to a soloist with a recognizable identity of his music.

Naturally these "soloist" are interpretations of the musicians belonging to my musical background. I could call them Milt Jackson, Miles Davis, John Coltrane, John Lennon, J.S. Bach, W.A. Mozart... The philosophy of this generative approach is constructed in a way that **each reference has its own peculiar identity but these identities are managed through generative interpretations for constructing the own subjective vision**. As happens when, in the history of art, each artist made own artworks by redrawing his masters: Picasso done it with Velasquez, Francis Bacon done it with Van Gogh, The Modern Jazz Quartet done it with Bach, quoting only some examples. And it's clear that the results were not copies but creative interpretations following and expressing the strong subjective visions of each artist.

These are the first results of Musicablu. It's clear that the steps for reaching real recognizable, harmonic and melodic results, are really *hard*. The walking is in progress toward new codes.

References

J.S.Bach, Art of Fugue and Goldberg Variations

W.A.Mozart. Sonata in C major K545

J.Coltrane, My favourite things, Bessy blues, Afro blues

Beatles, Yesterday, Hey Judy, Imagine and others

Modern Jazz Quartet, Blues on Bach, 1973

Anton Webern "Der Weg zur Neuen Muzik" 1932-1933

Celestino Soddu, “Music Generative Design”, Gasathj Journal #2, 2013

**Daniela Sirbu**

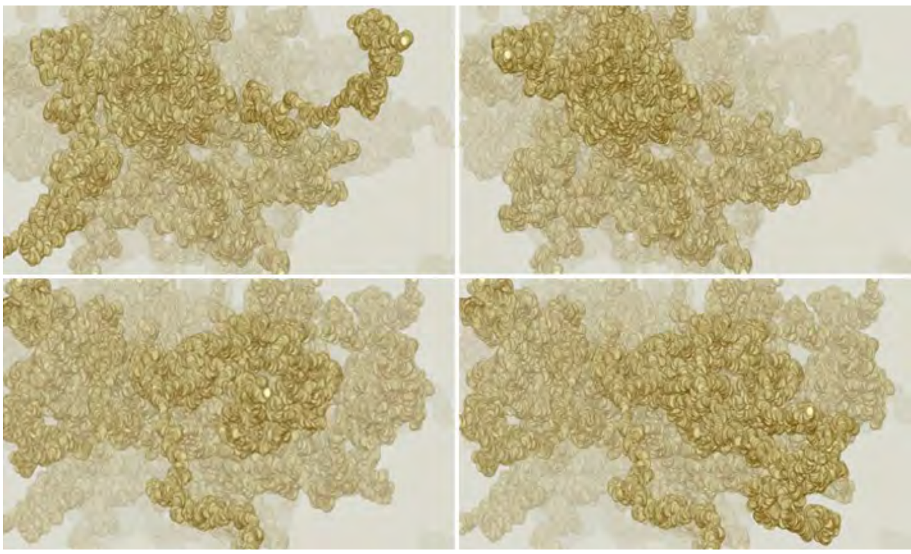
*Paper:* **Emerging Visual Structures from a Random Walker**

***Topic: Architecture***

***Authors:***
***Daniela Sirbu***
University of Lethbridge, Department of New Media
Canada
http://www.uleth.ca/finearts/new-media

***References:***
[1] Reas, Casey and Chandler McWilliams. 2010. *Form + Code in Design, Art, and Architecture*. Princeton Architectural Press.
[2] Reas, Casey and Ben Fry. 2007. *Processing. A Programming Handbook for Visual Designers.* Cambridge, MA: MIT Press.
[3] Shiffman, Daniel. 2012. *The Nature of Code: Simulating Natural Systems with Processing*. The Nature of Code 1st ed.

***Abstract:***
The present paper presents a one-agent based artificial system for generating visual structures that respond to known principles for organizing the visual field in art and design. The algorithm is meant to aid the artist in the process of generating a very large number of compositional variations that are impossible to produce by the human artist alone. The human intervention is limited to the selection of parameters in code before launching the system. The algorithm works independently in generating visual structures and interacts independently with elements that define the perceived dynamics of the emerging compositions. Variations of the algorithm allow the artist to interact with the working agent and contribute more actively in the process of positioning the emerging form clusters and introduce colour accents in the composition. However, apart from the initial selections of parameters, the algorithm is able to produce autonomously visual structures that are organized in compositions that are coherent from an artistic standpoint.
The system functions in the two dimensional field and it is based on a random walker algorithm working in tandem with a visual fader. This combination is meant to induce the feeling depth in the emerging visual compositions.
Considering the different degrees and the nature of artist's active involvement with the artificial system in the process of visual structure development, the paper analyzes the nature of the creative act in relation to the software based medium and the emerging notion of artificial creativity.



*Cluster of compositions sampled from the visual random walker, version 3.*

***Contact:***
daniela.sirbu@uleth.ca

***Keywords:*** generative art, computational art, algorithmic art, artificial creativity, processing programming language.

# Emerging Visual Structures from a Random Walker

**Daniela Sirbu, Associate Professor**

*Department of New Media, University of Lethbridge, Canada*

www.uleth.ca/westgrid/vr/contact.html

*e-mail: daniela.sirbu@uleth.ca*

**Abstract**

The present paper presents a single-agent based artificial system for generating visual structures that respond to known principles for organizing the visual field in art and design. The system is meant to aid the artist in the process of generating a very large number of compositional variations that are impossible to produce by the human artist alone. The human intervention is limited to the selection of parameters in code before launching the system. The system works independently in generating visual structures in interaction with elements that define the perceived dynamics of the emerging compositions. Variations of the basic algorithm through which the system is implemented allow the artist to interact with the working agent and contribute more actively in the process of positioning the emerging form clusters and introduce colour accents in the composition. However, apart from the initial selections of parameters, the system is able to produce autonomously visual structures organized in compositions that are coherent from an artistic standpoint.

The system functions in the two dimensional space and it is based on a random walker algorithm working in tandem with a visual fader. This combination is meant to induce a feeling of depth in the emerging visual compositions.

Considering the different degrees and the nature of artist's active involvement with the artificial system in the process of visual structure development, the paper discusses the shift in our understanding of the creative act in relation to the software based artistic medium and the emerging new notion of artificial creativity in the contemporary digital art practices.

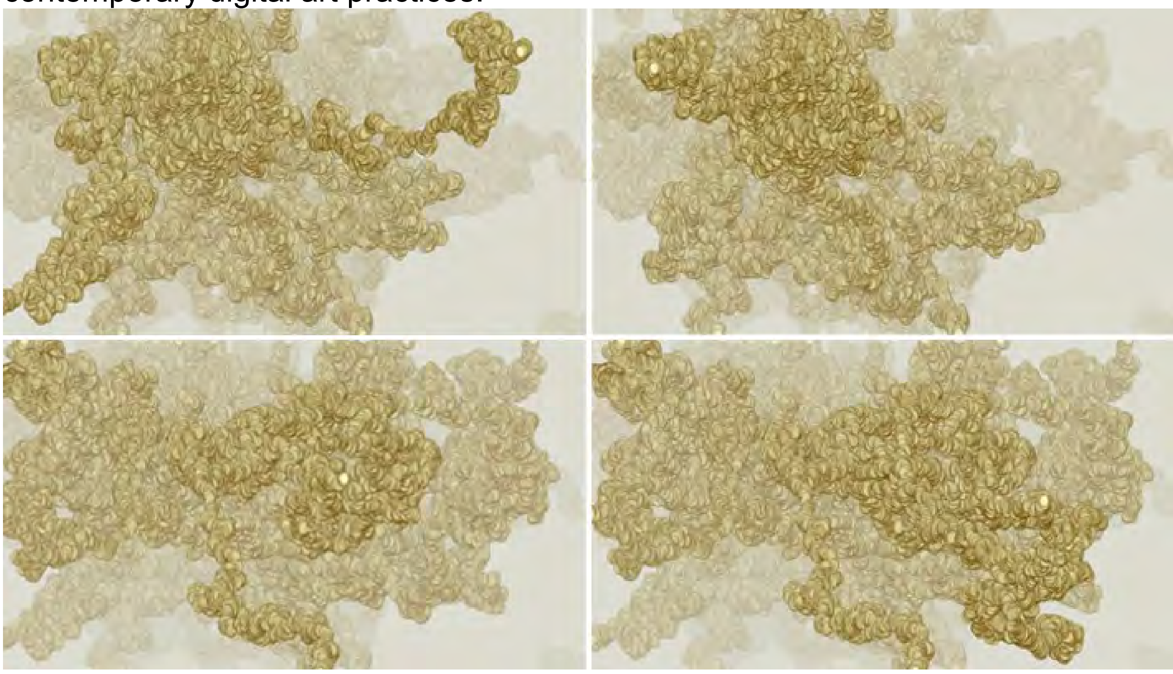


*Figure 1. Compositions sampled from the Visual Random Walker, version 3.*

## 1. Introduction and Background

This section explains what has inspired the use of random walks as the basis for the development of visual structures in artificial systems.

The random walk algorithms are related to the analysis of particle movements in physical systems with the first published observations on Brownian movement of particles in liquids made by Robert Brown in 1827 [12] and the first formalized description of diffusion laws provided by Einstein [2], [12]. Einstein's diffusion laws show dependencies of the particles' movements on such parameters as temperature, viscosity, number of particles, and gas constant. Eventually, the random walks emerged as an adequate model of diffusion with the random walker taking at each discrete moment in time a unit size step along the positive or negative direction of one axis in n-dimensional spaces. The probability to take any of these directions at each moment in time is of value 1/(2n).

The classic random walk algorithm can be applied to different spaces and depending on the nature of these spaces and of the objects associated with them, the meaning of the walker's steps and paths may change. Other extensions of the classical random walker are based on different methods of random selection of the direction at each moment in time and various implementations of these lead to significant changes in the general behaviour of the random walker.

In spite of its apparent simplicity, the random walker provides a starting point for simulating natural movement in artificial systems. The artistic community has shown an increasing interest in creating such simulations of the natural world using software for the development of applications to serve visual explorations of new art forms based in software [3], [8], [9], [10].

The visual constructor algorithm described in this paper is based on a discrete classical random walker moving in the bi-dimensional space of the picture plane [4], [8], [11], [13]. The output is concretized in graphical forms structured in comprehensive abstract designs. The continuous Brownian motion of the random walker underlies the permanent changes that reconstruct these designs into emerging new ones [5]. While the laws of diffusion relate to physical properties that influence the Brownian motion in physical systems, our algorithm takes into consideration changes in variables that affect the visual properties of the emerging visual designs. This paper presents changes brought into a classical random walker algorithm so that the new algorithm underlies the generative development process of abstract designs on continuous basis or until ended by the user.

## 2. **The Visual Constructor Algorithm**

This section describes the artistic and engineering thinking underlying the behaviour of the single random walker agent so that in time it generates multiple and varied visual compositions that are coherent from a visual design standpoint.

### 2.1. Brief Summary and Main Goals of the Visual Constructor

The goal of the algorithm at the basis of the artificial constructor of visual designs is to organize the bi-dimensional structures generated by the random walker in the visual field in accordance with recognized principles and rules of visual composition [14]. It captures in the same time the nature of the human designers' loose approach and unpredictable decisions that seem to deny such principles and rules. In addition, our visual constructor algorithm aims to create a feeling of depth and induce the illusion of volumetric definition while working on a bi-dimensional surface.

Considering that the random walker is in fact a model of Brownian movement, it is expected that the emerging visual structures (Figures 1-3 and Figure 5) remind to a certain degree of natural structures formed in fluids or gas like, for example, clusters of matter in the cosmic space (Figure 4).

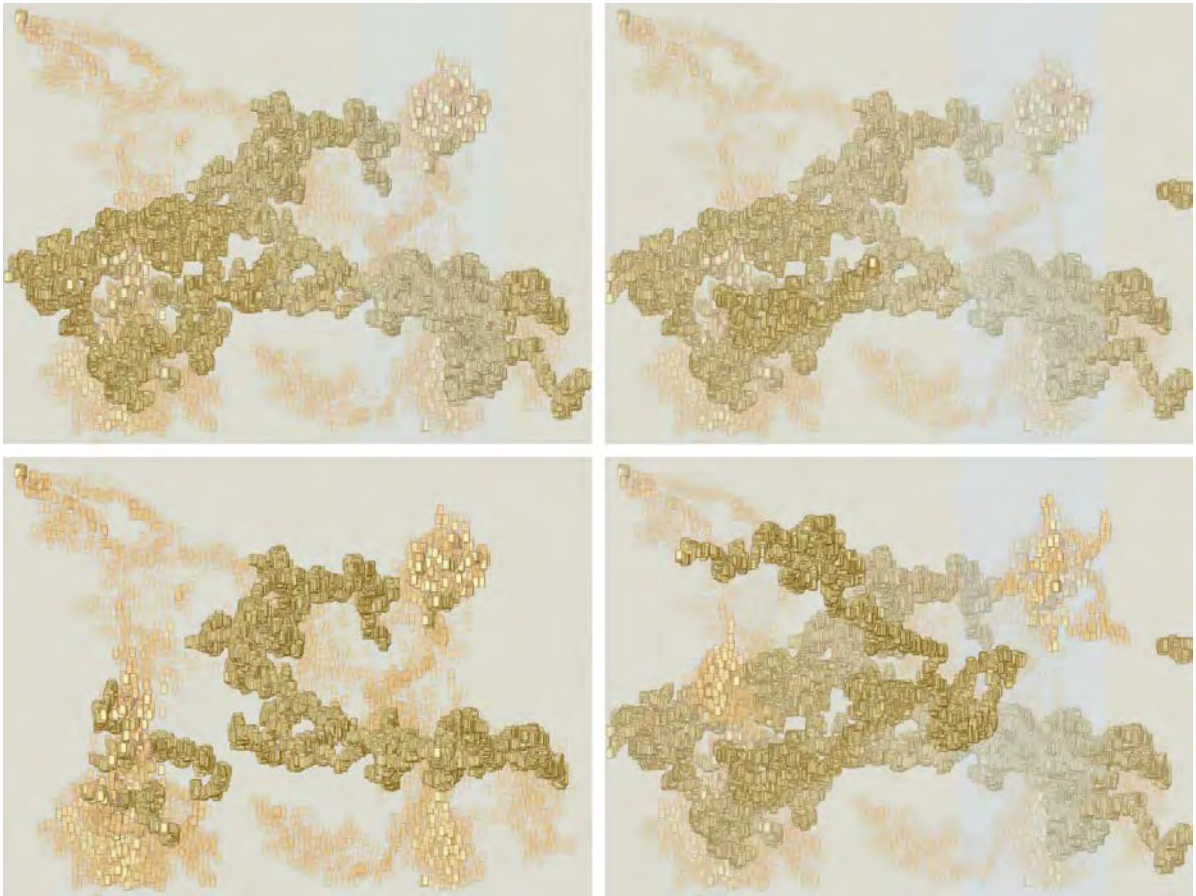


*Figure 2. Compositions sampled from the Visual Random Walker, version 8-5.*

*Figure 3. Compositions sampled from the Visual Random Walker, version 7-2*

(a) (b)

*Figure 4. Clusters of particles and matter in the cosmic space:*

(a) Jet in the Carina Nebula taken with Hubble's WFC3 detector – copyright: NASA, ESA, and A. Nota (STScI/ESA) (copyright: NASA, ESA, and A. Nota (STScI/ESA) (http://hubblesite.org/gallery/album/galaxy/pr2005035a/)

(b) "The intense outpouring of radiation from the central star cluster NGC 346 is sculpting the gas and dust in this region of space, located 210,000 light-years away in the Small Magellanic Cloud" – copyright: NASA, ESA, and A. Nota (STScI/ESA) (http://hubblesite.org/gallery/album/galaxy/pr2005035a/).

Starting from these general goals, the algorithm develops compositions on a continuous basis and in this sense it is a typical example of generative art. The visual output is of slightly unequal aesthetic value throughout the development process. This is due to the fact that the random walker moves in very small steps and the process of building structures in such small increments takes some time until new forms emerge. However, in time, the process always leads towards meaningful visual compositions.

The emerging forms are of such complexity as to make almost impossible the repetition of the emerging forms. This complexity is what makes possible the generation of new non-repetitive compositions on a continuous basis. However, although the development of forms through very small increments in hundreds of thousands or millions of steps may easily lead to visual overload, the visual fader module incorporated in the algorithm always resolves this problem by gradually sending in the far background the older complex form and refreshing the field where younger forms develop.
Considering these, the algorithm empowers the artist with the ability to work with a level of form complexity that cannot be achieved by human means alone and, therefore, providing a new platform for artistic exploration.

Some variations of the algorithm allow human aided development of the visual structures. The artist can introduce colour accents and can reposition the random walker. This allows the artist to intervene interactively and direct the process of structure formation in a drawing process based on the moving agent. Although this form of kinetic drawing is an important aspect of the algorithm, the present paper mostly focuses on the autonomous random walker as a generator of visual designs.

### 2.2. The Basic Algorithm

As mentioned in the introductory section, the visual constructor is an adaptation of the classical random walker algorithm with changes meant to produce meaningful visual output in the random walker's space, which, in our case, is the picture plane. The proposed system builds visual structures from traces left by a geometrical random walker. The algorithm is based on a classical discrete random walk in two dimensions [8, 1-4], [13, 39-58] and it is implemented with the Processing programming language [7], [8].

At each discrete moment in time, the agent may choose with equal probability to move in the positive or negative direction along the x or y axis. There is an equal probability distribution of chances to take a step in any one of the four directions. Because of the small step size and the even probability distribution, the agent moves at least for some time in a limited area and the traces of its random walk always cluster to some degree in that area creating the appearance of a larger complex form.

Starting from these basic elements of the algorithm, controlling the emerging designs requires the analysis of the correlations between the following aspects: (a) the geometric shape of the random walker; (b) the size and the proportional relationships between the geometric shape of the agent and the frame of reference; (c) the structure of the more complex forms resulting from the basic shape of the walker; (d) the distribution of forms within the pictorial field; (e) the texture, concentration, and contrast within the emerging forms and within the frame; (f) the illusion of depth. By controlling these aspects we aim to embed into the algorithm a generative system of visual organization for the emerging abstract designs. We discuss below how these aspects are handled in the visual constructor algorithm.

### 2.3. Building Form and Structure

The random walker algorithm continuously moves around the geometrical shape of the agent. We consider the basic shape of the agent to be the unit form from which the design is composed through various operations. Due to the intrinsic nature of the random walker algorithm, the most extensively applied operations to the unit form are translation in very small increments, repetition, overlapping and occlusion. All aspects of the emerging designs are depending on the results of these operations.

A number of geometric shapes were tested for the random walker, but the best visual results have been obtained with the simplest forms like ellipses, circles, squares or rectangles. This is because the shape of the random walker provides the basic unit from which larger forms are built through overlapping, repetition, irregular radiation, and gradation as the random walker moves around in small incremental steps.

The proportional relationship between the size of the frame of reference and the size of visual walker is important for the visual output. A number of tests showed that very small unit forms produce better visual results.

### 2.4. Creating Texture

The repetitions generate larger forms bearing a texturized appearance due to embedded repetitive traces of the geometric unit form. Several types of repetition occur as the walker moves around: repetition of size, repetition of colour and repetition of texture.

Considering that the unit form is small in size in the basic algorithm, we might expect that the multiple repetitions enumerated above would produce a rather uniform texture in the picture plane. However, depending on the extent to which the agent keeps moving in a given area, the resulting texture can be more or less spread out and more or less dense producing a certain degree of texture modulation that might bring interest in the composition.

### 2.5. Creating the Appearance Volume and Space

Although modulated texture alone may provide the basis for the emerging designs, the purpose of the algorithm is to base the design in forms with volumetric character and the entire composition to provide an overall feeling of depth. The spatial illusion is achieved by implementing a fading module working at local and global levels to create geometric and aerial perspective.

At local level, we can distance forms in depth by accompanying the repetition of the unit form with overlapping and occlusion at each step taken by the random walker. This creates the illusion that there is spatial distance between the repetitive unit forms and that the form that overlaps another comes closer to the viewer's eyes than the form that is partially covered. This system works if adequate correlation is ensured between the size of the unit form and the size of the random walker's step.

If the size of the random walker is larger than half of any of the height or width of the unit form, than overlapping cannot be achieved, in particular in the first phases of the random walker algorithm. In this situation, when the agent moves one step, this translates the form far enough from the previous position so that the form at the new location doesn't overlap with its previous trace. The two forms seem to be on the same flat surface of the picture plane and no illusion of distance in perspective is created.

Therefore, in order to create the illusion of depth, a condition is to keep the step size to a maximum value that is smaller than the minimum between the half of the width and the half of the height of the random walker. Satisfying this condition will ensure producing the feeling of depth through overlapping and occlusion of the unit form.
Aerial perspective al local level is obtained based on a certain degree of transparency of the unit forms. Overlaps with previous traces of the random walker often fade the traces left behind and make the more recent traces seem closer to the viewer.

At global level, the fading function is set into action by various interactions of the

random walker with the frame of reference. When such events occur, the fader will diminish contrast for all form generated up to the occurrence of the current event. New forms are drawn with much more contrast on top of the previous one creating the feeling of aerial perspective.
Apart from the role in creating aerial perspective, the fading modules has a role in diminishing the visual overload that unavoidably occurs through the development process.

### 2.6. Floating Structures

The compositions generated by the visual constructors have a general appearance of aquatic or fluid spaces populated by floating structures (see Figures 1-3, and 5). As mentioned in paragraph 2.1, this an expected result considering that the random walker algorithms are originated in studies of Brownian movement of particles in fluids.

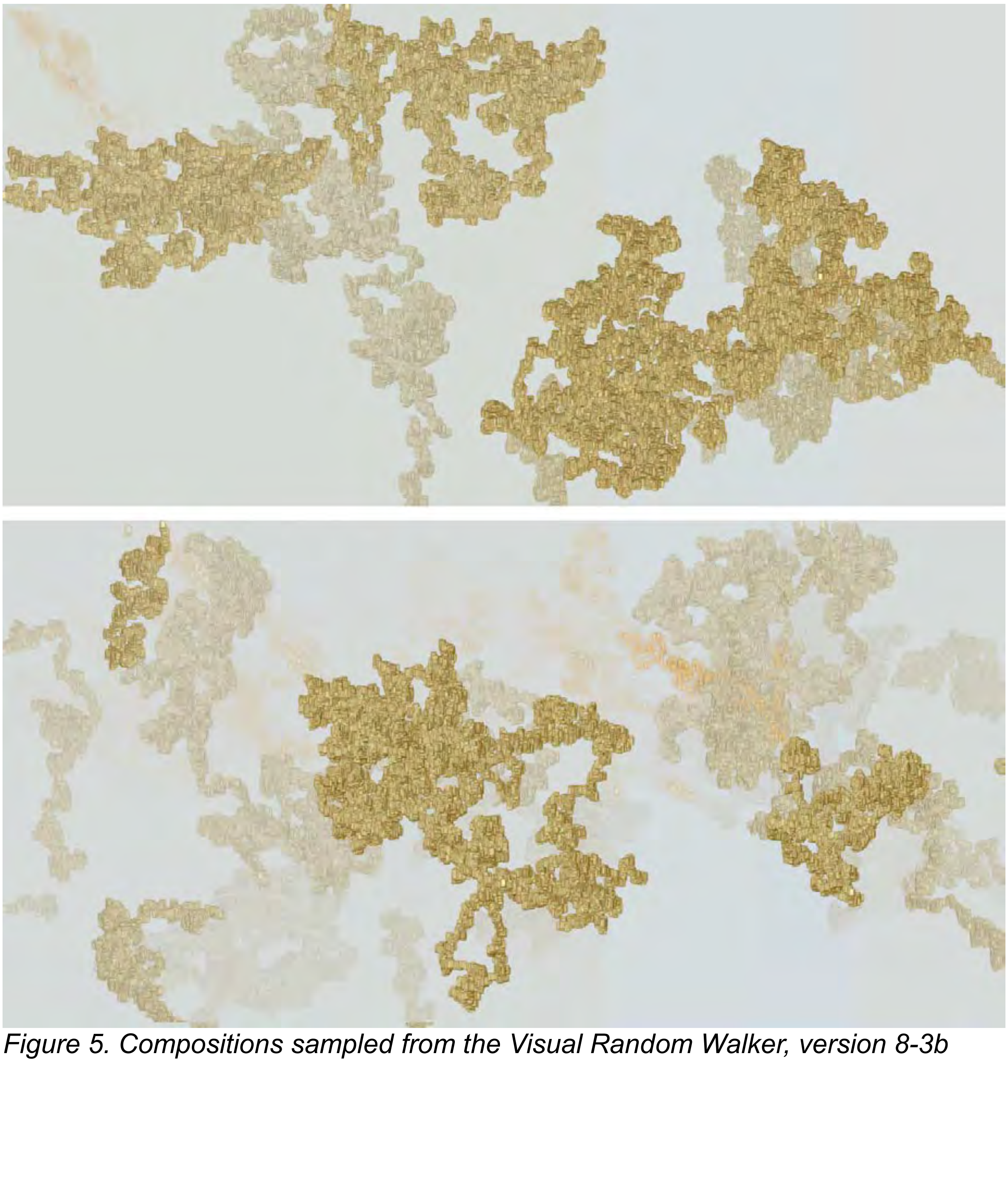


*Figure 5. Compositions sampled from the Visual Random Walker, version 8-3b*

This opens the possibility of further developments based on the implementation of agent interactions with various fields of visual tension in the picture plane [1] or by associating a physics engine to the algorithm so that the movement of the random walker is affected by such factors as gravitation, friction, and other simulations of natural forces.

## 3. The Artist and the Autonomous Visual Constructor

When discussing the autonomy of the Visual Constructor in the development process, the question of what is the role of the artist as a creator is naturally raised. Although this may provide the grounds for extensive analysis, we point out only several aspects that may clarify the problem in the case of the visual constructor algorithm presented in the current paper.

First, the visual constructor is created by the artist in a manner that allows comparison with the traditional artist using a medium to unexpected results. In the case of the visual constructor, the medium is the software and a classical algorithms that simulates some aspect of the real world: the Brownian movement of particles in fluids. The artist's adaptation of the algorithm is what makes the random walker a developer of visual designs.

The most significant aspect is that the artist is distanced from the creative process during the actual generation of the compositions. The system, once designed and tested, can autonomously produce a very large number of visual compositions which cannot be fully predicted and which are of extensive variety. The artist has an active role developing the concept of the artificial system and building the system in software. Once the system is launched, it works on its own.

Considering these, we conclude that we assist to a new emerging role of the artist in the creation process. The hand-eye coordination in the production of the work of art is removed. Instead, the actual production of the work is the result of an artificial system designed by artist. The artist becomes a system designer and the output, even in its unpredictable results, is the result of this design.

The proposed system also allows bringing back the role of hand-eye coordination and direct participation in the entire production of the artwork through the interactive version of the system.

The proposed system allows the co-existence of both models of the artist as system designer and the artist engaged in the entire production through kinetic drawing.

## 4. Conclusion

It is interesting to point out the emerging new forms of art production shifting the artist from the studio based environment into a software development process. The paper presents such a system providing a medium for the production of art where the creative process is fully preceding the effective development of the visual compositions, but also allows the flexibility to intervene in the composition development through direct interaction with the system.

## 5. References


[1] Arnheim, Rudolf. 1974. *Art and visual Perception. A Psychology of the Creative Eye.* The New Edition. ed. Berkeley, CA: University of California Press.

[2] Einstein, Albert. 1905. "On The Movement of Small Particles Suspended in Stationary Liquids Required by the Moleculae-Kinetic Theory of Heat." *Annalen der Physik* no. 17:549-560.

[3] Fishwick, Paul, ed. 2006. *Aesthetic Computing*. Cambridge, Massachusetts: MIT Press.

[4] Lawler, Gregory F., and Vlada Limic. 2010. *Random Walk: A Modern Introduction*. Cambridge, UK: Cambridge University Press.

[5] Nelson, Edward. 1967, 2001. *Dynamical Theories of Brownian Motion*. 2nd ed: Princeton University Press https://web.math.princeton.edu/~nelson/books/bmotion.pdf

[6] Reas, Casey and Ben Fry. 2007. *Processing. A Programming Handbook for Visual Designers.* Cambridge, MA: MIT Press.

[7] Reas, Casey and Chandler McWilliams. 2010. *Form + Code in Design, Art, and Architecture*. New York, NY: Princeton Architectural Press.

[8] Shiffman, Daniel. 2012. *The Nature of Code: Simulating Natural Systems with Processing.* 1st ed: The Nature of Code.

[9] Sims, Karl. 1991. "Artificial Evolution for Computer Graphics." *Computer Graphics* no. 25 (4):319-328.

[10] Sims, Karl. 1994. Evolving 3D Morphology and Behavior by Competition. In *Artificial Life IV Proceedings*, edited by R. Brooks and P. Maes. Cambridge, MA: MIT Press.

[11] Spitzer, Frank. 2001. *Principles of the Random Walk.* 2nd ed. New York, NY: Springer.

[12] Telcs, András. 2006. *The Art of Random Walks*. Berlin, Germany: Springer.

[13] Venegas-Andraca, Salvador Elías 2008. *Quantum Walks for Computer Scientists* Edited by Marco Lanzagorta and Jeffrey Uhlmann, *Synthesis Lectures on Quantum Computing*. San Rafael, CA Morgan & Claypool Publishers.

[14] Wong, Wucius. 1993. *Principles of Form and Design*: John Wiley & Sons.

**Daniel Bisig**
**Philippe Kocher**

# Early Investigations into Musical Applications of Time-Delayed Recurrent Networks

***Abstract:***

This publication presents the authors' preliminary investigations concerning the adaption of time-delayed recurrent networks into generative mechanisms for music creation. We argue that the dynamic properties of these networks renders them particularly attractive for the design of musical algorithms. The use of time-delays in a broad range of durations in combination with complex feedback mechanisms presents a system that unifies different aspects of algorithmic music creation in one single formalism. Not only do these networks present themselves as a means for sound synthesis, they are also able to generate rhythmical structures in different temporal scales.

As part of this research, the authors have developed and implemented different prototypes of network-based synthesis mechanisms. These prototypes are meant to serve as starting points not only for the assessment of the sonic capabilities of such networks but also for the identification of potential challenges concerning their integration into musical practice. The publication describes the algorithmic principles of these prototypes and provides an overview of some early acoustic results.

Based on this assessment, the publication addresses several challenges which lie beyond mere algorithmic issues and concern the adaptation of network-based synthesis systems for practical use. One category of challenges deals with the development of tools and strategies that assist musicians in the exploration of and experimentation with these highly non-linear synthesis techniques. We propose an automated evaluation mechanism that supports and guides the human search process by predicting the development of the sonic output for a given set of parameters. The second category of challenges deals with the provision of means that help musicians to acquire an intuitive understanding and appreciation of the generative principles that underly the synthesis methods. Here we argue in favour of a perception-driven form of comprehension that results from a tangible interaction with a physical interface whose affordances have been aligned with the algorithmic characteristics of the generative system.

***Topic: Sound Synthesis***

***Authors:***

***Daniel Bisig***
Zurich University of the Arts
Institute for Computer Music and Sound Technology
Switzerland
http://www.icst.net/

***Philippe Kocher***
Zurich University of the Arts
Institute for Computer Music and Sound Technology
Switzerland
http://www.icst.net/

***Contact:***
***daniel.bisig@zhdk.ch***

***Keywords:***
computer music, non-standard sound synthesis, recurrent time-delay networks

# Early Investigations into Musical Applications of Time-Delayed Recurrent Networks

**Dr. Daniel Bisig**
*Zurich University of the Arts*
*Institute for Computer Music and Sound Technology*
*Switzerland*
*http://www.icst.net/*
*e-mail: daniel.bisig@zhdk.ch*

**Philippe Kocher**
*Zurich University of the Arts*
*Institute for Computer Music and Sound Technology*
*Switzerland*
*http://www.icst.net/*
*e-mail: philippe.kocher@zhdk.ch*

## Abstract

This publication presents the authors' preliminary investigations concerning the adaptation of time-delayed recurrent networks into generative mechanisms for music creation. We argue that the dynamic properties of these networks renders them particularly attractive in the context of computer music. The use of time-delays in a broad range of durations in combination with complex feedback mechanisms presents a system that unifies different aspects of algorithmic music creation in one single formalism. Not only do these networks present themselves as a means for sound synthesis, they are also able to generate rhythmical structures in different temporal scales.

As part of this research, the authors have developed and implemented different prototypes of network-based synthesis mechanisms. These prototypes are meant to serve as starting points not only for the assessment of the sonic capabilities of such networks but also for the identification of potential challenges concerning their integration into musical practice. The publication describes the algorithmic principles of these prototypes and provides an overview of some early acoustic results.

Based on this assessment, the publication addresses several challenges which lie beyond mere algorithmic issues and concern the adaptation of network-based synthesis systems for practical use. One category of challenges deals with the development of tools and strategies that assist musicians in the exploration of and experimentation with these highly non-linear synthesis techniques. We propose an automated evaluation mechanism that supports and guides the human search process by predicting the development of the sonic output for a given set of parameters. The second category of challenges deals with the provision of means that help musicians to acquire an intuitive understanding and appreciation of the generative principles that underly the synthesis methods. Here we argue in favour of

a perception-driven form of comprehension that results from a tangible interaction with a physical interface whose affordances have been aligned with the algorithmic characteristics of the generative system.

## 1. Introduction

Feedback and delay mechanisms play an important role in computer music as techniques for digital audio signal processing and sound synthesis. Delay times in the range of a few samples are used for the implementation of digital filters. The combination of time-delay and feedback forms the basis for the design of recursive filters. These filters can be employed for the realization of highly pronounced and computationally efficient filtering effects. Techniques that operate with larger time-delays are typically employed to simulate phenomena of room acoustics such as reverberation or discrete echos. For the purpose of sound synthesis, the method of digital waveguide synthesis represents a classical physical modelling approach. This technique simulates the propagation of a sound wave through a physical medium. The time it takes for the sound wave to travel a certain distance is implemented as a delay line and the reflection of the wave at material boundaries is implemented as feedback.

Feedback and delay mechanisms also play an important role for the design of artificial neural networks. In time-delayed recurrent networks, the connections among neurons form cyclic graphs and durations for signal propagation are taken into account. Due to the fact that these networks possess an internal memory, they are capable of processing and learning non-static input patterns. Apart from these networks' role as powerful machine learning tools, their behaviour is also of great interest from a dynamical systems perspective. Contrary to classical feed forward networks, these networks often exhibit chaotic and complex patterns in their activity propagation. The vast majority of musical applications employ neural networks for analysis tasks and imitation-based approaches to musical composition, see for example [1, 2]. Others use the complex temporal dynamics of these networks as generative mechanism for algorithmic composition, see for example [4, 5]. There exists very little research concerning the adoption of recurrent neural networks as mechanisms for signal processing and sound synthesis. Ohya describes a sound synthesis method based on a recurrent network that consists of continuous-time and continuous-value neurons whose interconnections possess both weight and delay [6]. A second and somewhat more recent example describes a neural network-based synthesis system that consists of two neurons that exhibit mutual inhibition and lock their internal oscillations to the frequency of an input signal [3].

This publication is motivated by the desire to continue and expand the promising but seemingly neglected research that deals with the adaptation and application of time-delayed recurrent networks for algorithmic composition, sound synthesis and signal processing. In particular, we aim to combine time-delay feedback techniques from signal processing and artificial neural networks into unified generative algorithms for computer music. We believe that an extension of well established methods from digital signal processing with network-based forms of non-standard sound synthesis enables interesting sonic possibilities. Furthermore, a unified algorithmic system which can operate over a diverse range of temporal scales possesses great promise as a coherent mechanism for the creation of musical structures on both the level of musical composition and sound synthesis. Finally, the behavioural complexity that these methods inherit from their neural network counterparts can serve as a starting point for the creation of autonomous musical systems.

## 2. Prototypes

As part of a brief pre-project that was conducted prior to an application for a publicly funded research project, the authors have realised three prototypes that incorporate different time-delay feedback mechanisms. These prototypes served as early experimentation platforms and helped us to gain first insights concerning the musical potentials and pitfalls of these systems. In particular, they helped us to assess the following topics:

- software architecture requirements for the implementation of diverse time-delays and arbitrary recurrent network topologies
- integration of feedback stabilisation mechanisms
- generation of non-periodic network activity patterns
- impact of parameter changes on the networks' behaviour and sonic output
- characteristics and diversity of the networks' sonic output
- comprehensibility of relationships between network properties and sonic output

The three prototypes exhibit three different approaches to sound synthesis. (1.) An extension of digital waveguide synthesis, (2.) a continuous signal propagation network that employs a gate control mechanism, and (3.) a synthesis method which is inspired by spiking neural networks.

### 2.2 Prototype 1

The first prototype takes digital waveguide synthesis as starting point. It uses signal feedback and delay lines, but unlike standard forms of digital waveguide synthesis, the delays vary over time and they do so independently from one another (see figure 1). This approach does not try to approximate the sound of a musical instrument nor does it model an existing physical property.

This prototype has been implemented in the programming environments CSound, Supercollider and Max. Until now, only systems consisting of a rather small number of delay lines (up to 4) have been tested. The variable delay times range between one single sample and 0.1s and the values are stored in breakpoint functions which are interpolated during audio playback.

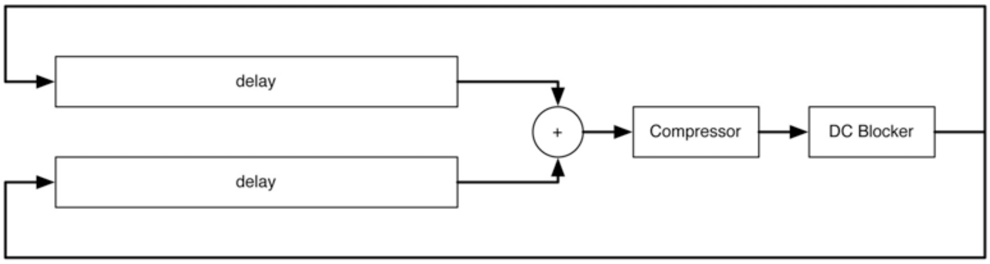



*Figure 1. Digital waveguide-based time-delayed feedback system. Two independent delay lines with a summed feedback.*

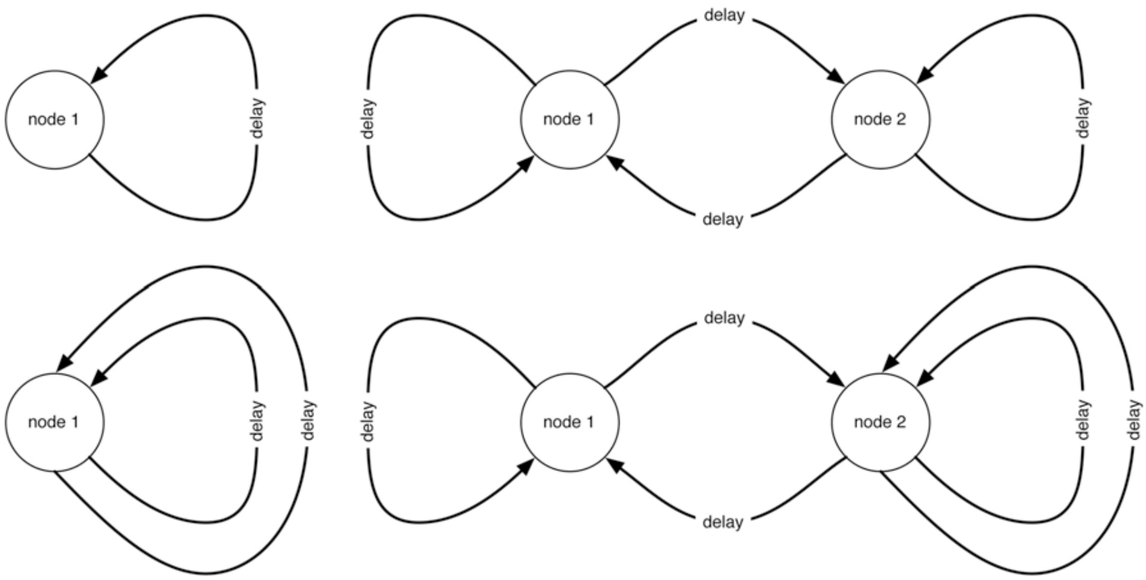



*Figure 2. Examples of recurrent network topologies employed for prototypes 2 and 3. From left to right and top to bottom: single neuron single connection (1n1c) network, two neuron four connection (2n4c) network, single neuron two connection (1n2c) network, two neuron five connection (2n5c) network.*

## 2.2 Prototype 2

This prototype consists of an audio signal graph in which gates and delay lines are connected (see examples in figure 2). At the nodes which act as gates, all incoming signals are summed and averaged by calculating the root mean square of the signals' amplitude (see figure 3). The gate opens if this average falls between a lower and upper threshold and the gate's responsivity is determined by an attack and decay time. These nodes and their gating behaviour are loosely inspired by neurons and their action potential threshold. Between the nodes, the signal is time-delayed, and, if desired, attenuated and low-pass filtered. The system is initially excited with a short audio signal, e.g. a brief tone or a noise burst.

The implementation of this prototype has been realised in the programming environments Max, Pure Data and SuperCollider. The scenarios tested so far consisted of only a small number of nodes (mostly one or two), and a larger number of recurrent and time-delayed connections. The parameters to control the behaviour of each node and connection are as follows:

- lower and upper thresholds to open the gate
- attack and decay time of the gate envelope
- signal propagation time delay
- signal attenuation factor
- cutoff frequency for low pass filter

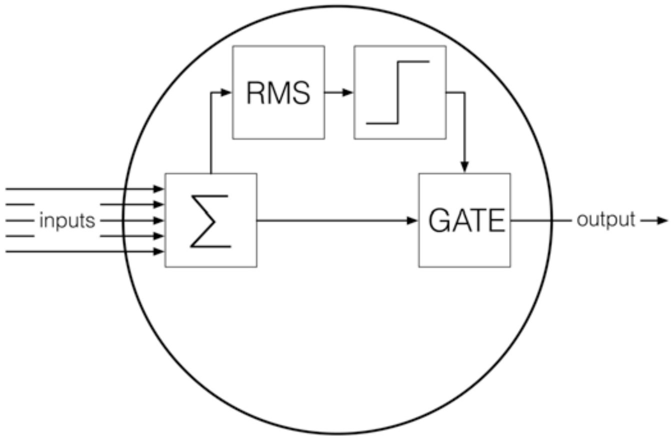



*Figure 3. Prototype 2 node characteristics. The boxes within the node represent from left to right: input signal summation, root mean square average, threshold function, gate with attack and decay time.*

**2.3 Prototype 3**

This prototype realises an audio signal propagation mechanism that resembles neuronal spiking. All audio signals that arrive at a neuron are summed together and subsequently passed through a sigmoid activation function in order to calculate the neuron's activity level. If this activity level is in between a lower and upper boundary, the neuron triggers a spike in the form of a sound grain and resets its activity level (see figure 4). The grain signal is time-delayed and attenuated when it travels across a neuronal connection.

The neural simulation and DSP engine have been implemented from scratch in C++. The software integrates the Jack audio routing library to connect neural activity to an audio hardware output. Any number of neurons can be rendered audible at the same time in this way. The network exposes a number of parameters to real-time control:

- signal content of audio grains
- amplitude envelope of audio grains
- slope of sigmoid activation function
- lower and upper activity thresholds for triggering audio grains

- amplitude of triggered audio grains
- duration of refractory period before triggering subsequent grains
- maximum number of overlapping grains
- signal propagation time delay
- signal attenuation factor

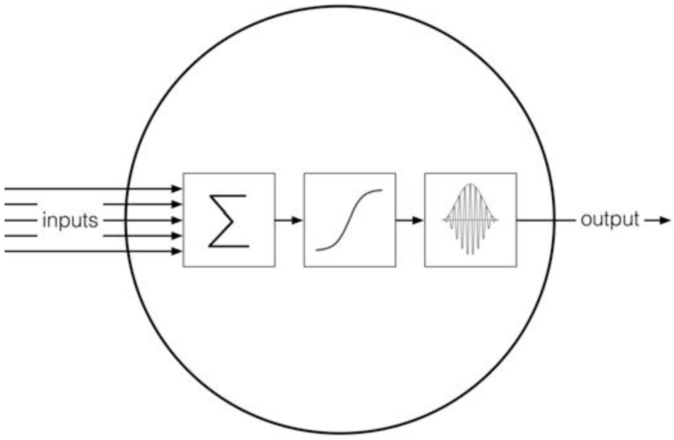



*Figure 4: Prototype 3 node characteristics. The boxes within the node represent from left to right: input signal summation, sigmoid activation function, signal grain generation.*

## 3. Results

### 3.1 Implementation, Software Architecture

Prototypes 1 and 2 have been implemented in an existing audio programming environment. In these cases, the general observation can be made that a graphical programming paradigm, as can be found in Max or Pure Data, is more suitable than text based environments such as Supercollider or CSound; since the visual interfaces of the former resemble flowcharts they are more readily able to represent the layout of a network.

Prototype 3 has been developed from scratch in C++. As expected, this approach significantly facilitates the close integration between network simulation and signal processing aspects of the software. Furthermore, it allows to overcome any constraints imposed by other software concerning the flexibility of the signal flow, in particular the usage of feedback at any point, and the application of arbitrary feedback times.

It has become clear that the computation of signal propagation within highly recurrent networks demands a different audio buffer update mechanism than is provided by most existing audio environments. For example, the custom software implementation, as realised for prototype 3, has allowed us to realise signal processing procedures that operate with heterogenous audio buffer sizes rather than a global uniform buffer size. This aspect forms an essential prerequisite for a computationally efficient implementation of arbitrary recurrent network topologies.

### 3.2 Network Dynamics

As a result of the recurrent network topologies, some of the systems described above are highly prone to enter runaway conditions, i.e. to blow up. In order to ensure that the systems remain stable, the amplitude of the signal has to be carefully kept under control.

In prototype 1, an automatic amplitude control (i.e. compressor) and a dc blocker are inserted into the signal flow before the signal is fed back into the delay lines. In prototype 2, the desired stability is achieved by setting the parameters for each node's gate function in such a way that the gate closes not only when the signal falls under a certain limit but also when the signal exceeds an upper threshold. In case of prototype 3, the signal spiking mechanism provides an inherent protection against runaway situations. Here, the neuronal activity level that can be reached by the network remains bounded due to the fact that the output signal, which consists of grains of fixed amplitude, entirely supersedes the input signal.

It has turned to be a non-trivial task to configure the networks, especially in prototypes 2 and 3, in such a way that they maintain activity over prolonged periods of time rather than to quickly die away. This behaviour is influenced by a number of mutually interdependent parameters, of which the most important ones are the minimum and maximum thresholds, the delay times, the gate attack and decay time in case of prototype 2 and the grain amplitude, maximum grain overlap and refractory period in case of prototype 3.

### 3.3 Sonic Characteristics

Tests with prototype 1 have shown that this type of network is able to easily produce a large variety of timbres and, because of the changing delay times which result in doppler shifts, different pitches and glissandos. In particular, by means of delay times that vary rapidly or over a large range of values, a richness of musical gestures can be produced. This quality is desirable from an artistic standpoint, but its complex dynamics is hardly predictable for the user. Experiments with different network topologies, i.e. more than two delay lines, have shown no essential changes to the sonic characteristics of the output. This raises the question under which conditions the network topology has a significant impact on the resulting sound.

The experiments conducted with prototype 2 started with networks consisting of a single node and an increasing number of time delayed feedback connections. Due to the large number of combinations of control parameters, a systematic evaluation of these systems under aesthetic or artistic criteria becomes unfeasible. For this reason, we conducted an explorative search for an "attractive" sets of parameters. It has been found that the choice of delay times has a significant impact on the musical quality of the output. Very small delay times are applied to achieve sonic continuity, as well as timbral effects of a strong comb filter quality, larger delay times produce rhythmic textures. The attack and decay times of the gate cause time lags which allow the signal to overshoot for a short period of time. The dynamics of this behaviour gives rise to pulsating rhythms in the sonic output.

With respect to prototype 3, sonic experiments have been conducted with audio grains that are 32 samples long and employ a hamming window as amplitude envelope. As was expected, regular periodic signals could easily be generated in case of the 1n1c and 1n2c networks by choosing a refractory period that exceeds the duration of a grain signal. By modifying the time delays, these periodic signals become audible either as rhythmic patterns or pitched sounds. On the other hand, the ease with which multiple levels of interleaved period patterns can be achieved by setting the refractory periods to a smaller value than the grain duration, constitutes a rather surprising result. These periodic patterns manifest as cyclically alternating intervals in pitch shifts and sound texture changes. These behaviours could be achieved for all tested network types. In case of the 1n2c and 2n4c networks, the aperiodic output signals that result from irrational ratios between signal propagation delays almost always give raise to sonically very diversified transition phases. In particular, the presence of multiple recurrent connections to a single neuron proved to be a very useful setup to obtain this kind of sonic result. In case of the more complicated 2n4c network on the other hand, the acoustically rewarding transition period is usually of very short duration and quickly approaches an invariable and noisy output. It seems clear, that the difficulty of designing a network with the aim of achieving a sonically interesting behaviour increases very rapidly as the network grows in size.

## 4. Discussion and Outlook

Based on these preliminary explorations into the sonic capabilities of time-delayed feedback networks, it is clear that these systems possess great musical potential but are at the same very challenging to work with. For a given network architecture, the anticipation of the sonic effects of parameter changes is difficult due to a number factors. (1.) The effects are often highly non-linear and mutually inter-dependent, (2.) they can differ considerably depending on the network's topology and its current state, (3.) they often not only affect the immediate audible results but also influence the long term sonic evolution of the network. Accordingly, these networks are particularly difficult to employ for purposes of musical improvisation and live experimentation. For the same reason, it is even more challenging to make musically informed decisions concerning the design of novel network architectures. Trial and error approaches to network design are time-consuming and likely very frustrating, in particular when dealing with larger networks than those presented in the prototype experimentation scenarios. Therefore, it is very important to establish design heuristics that are based on a basic understanding of the relationships between network properties and sonic output.

We believe that a systematic approach to the development of novel network-based generative algorithms should interrelate a thorough mathematical assessment of the networks' dynamic properties with a musical evaluation and classification of the networks' sonic output. Such a combined approach is instrumental in identifying promising network algorithms and for their subsequent adaptation and customization into generative algorithms for sound synthesis and composition.

In order to foster the musical usefulness of these networks, the aforementioned activities need to be complemented by research that specifically addresses issues relating to musical practice. This research should include the development of strategies and tools that assist musicians in exploring these systems and in acquiring an intuitive understanding of their underlying algorithmic principles. In that regard, we are currently planning to focus on the following aspects. (1.) The design and implementation of a semi-automated network evaluation system that guides musicians in their search for potentially interesting network configurations and behaviours. (2.) The development of physical interfaces that render network properties and behaviours accessible for tangible interaction and thereby help in the acquisition of an intuitive comprehension of this generative system. Both the guidance system and the tangible interfaces are meant to strike a balance between exposing the algorithmic principles of the networks' architectures and providing means for intuitive and perception-driven forms of interaction and musical experimentation.

The guidance system is intended to fulfill a dual function of predicting long term sonic developments and of searching for alternative network customizations that might exhibit musically interesting behaviours. The first functionality allows a musician to listen ahead of the current sonic output of a network and thereby helps to anticipate and influence the network's future musical development. The second functionality is likely to implement a local evolutionary search within the parametric and topological neighborhood of the currently employed network. Those alternative network architectures that best meet basic user-defined fitness criteria are then integrated into a constantly updated repertoire of networks that serve as promising candidates for further musical experimentation. By employing only low-level behavioural and acoustic criteria for the fitness function, the aesthetic evaluation of the musical output remains entirely up to human evaluation.

The research direction that deals with the development of physical interfaces is based on the premise, that a tangible interaction with a complex generative system helps musicians to acquire an understanding of how algorithmic principles and sonic output interrelate. The planned interface design is based on an approach that aligns perception-driven interaction with the topological and behavioural characteristics of network-based generative processes. For instance, the topological characteristics of networks lend themselves to a translation into spatial representations. In such a representation, the individual network nodes can appear as physical objects that individually emit sound and whose interconnectivity and time-delayed signal exchange mechanisms are represented by the spatial distances among each other. Such an installative setup not only renders the characteristics of the networks' acoustic signal propagation perceivable in a spatial manner, it also translates these characteristics into tangible affordances for an interactive manipulation of the network's architecture. By manually moving physical objects through space, a position tracking system can map these changes back into the network simulation in order to change the network's topology and signal propagation delays accordingly. We believe that such a mutually constituted relationship between a network-based generative system and its representation as tangible interface and installation links musical experimentation and engagement with perception-based forms of comprehension.

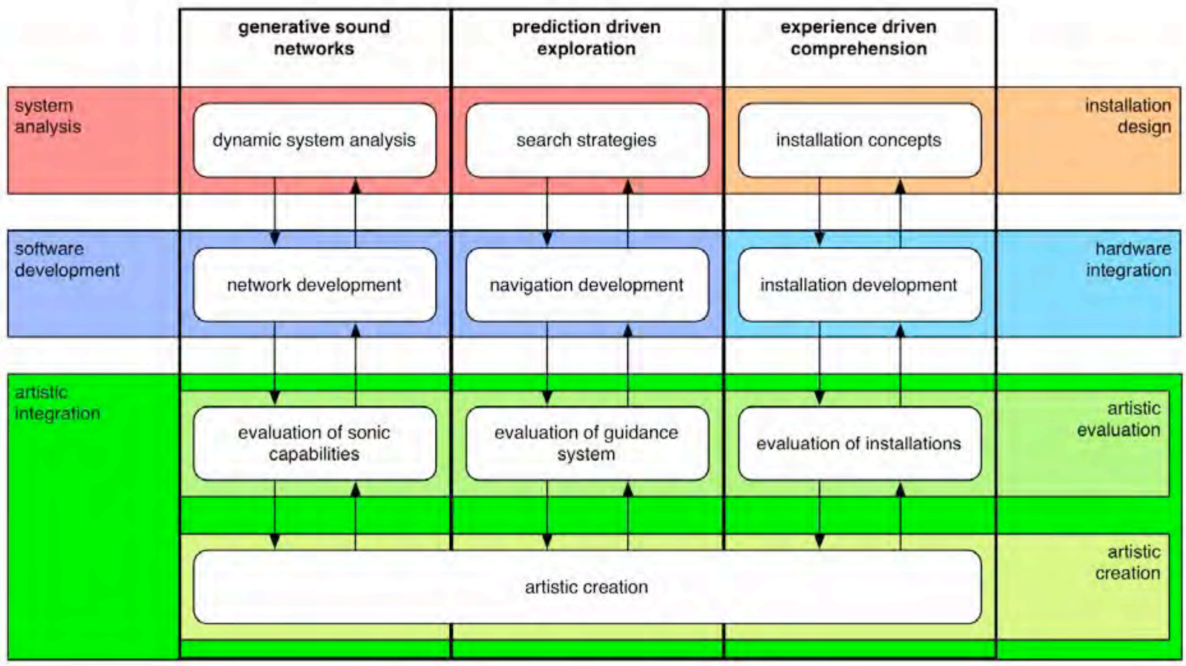



*Figure 6. Research strands. The research directions that are planned for the submitted project.*

Based on these aforementioned results and considerations, we have devised and submitted a proposal for a publicly funded research project. This proposal will run for the duration of two years and incorporates the previously discussed aspects into three main research strands (see figure 6). These research strands tightly integrate mathematical analysis and algorithmic developments with musical experimentation and evaluation. All activities converge into a residency program during which invited artists and musicians from the fields of algorithmic composition, electroacoustic performance and sound installation art will be able to adapt and integrate the project results into their own artistic creations.

We believe, that such an integrated approach which combines mathematical, engineering and musical expertise to address different aspects that pertain to musical uses of a complex system is essential for developing and transferring a novel generative system into artistic practice. Accordingly, we hope that this project can serve as inspiration for other research projects within generative art.

## 4. References

[1] Giuseppe Buzzanca. Artificial Neural Networks in Real-Life Applications, chapter Music and Neural Networks, pages 239–264. IGI Global, 2005.

[2] Douglas Eck and Juergen Schmidhuber. A first look at music composition using LSTM recurrent neural networks. Technical Report IDSIA-07-02, IDSIA, www.idsia.ch/techrep.html, March 2002.

[3] Alice Eldridge. Neural Oscillator Synthesis: generating adaptive signals with a continuous-time neural model. 2005.

[4] Hernán Kerlleñevich, Pablo Ernesto Riera, and Manuel Camilo Eguia. SANTIAGO - A Real-Time Biological Neural Network Environment for Generative Music Creation. In Applications of Evolutionary Computation, volume 6625 of Lecture Notes in Computer Science, pages 344–353. Springer Berlin Heidelberg, 2011.

[5] Kevin McCracken, John Matthias, and Eduardo Reck Miranda. Neurogranular synthesis: Granular synthesis controlled by a pulse-coupled network of spiking neurons. In EvoApplications (2), volume 6625 of Lecture Notes in Computer Science, pages 354–363. Springer, 2011.

[6] Kenichi Ohya. Sound Variations by Recurrent Neural Network Synthesis. In Proceedings of the International Computer Music Conference (ICMC), pages 280–283, Ann Arbor, MI, USA, 1998.

**Elif Belkis OKSUZ**

*Paper:* **Generating Through Allometry in Architecture: A design approach for relational morphogenesis**

***Topic: Architecture***

***Authors:***
***Elif Belkis OKSUZ***
Istanbul Technical University Faculty of Architecture

***Abstract:***
Morphology is one of the widely considered within different views in architectural and urban design. In this context, many biological terms and notions were adapted to architecture. One of them is called allometry, the study of scale and size relationship of growth in biology. Studies on allometric values in architectural design can be seen as early as Violette-le-Duc. Additionally, referring to D'Arcy Thompson's study "On Magnitude," many architects and planners have used this term in the metabolic and morphological studies on the existing buildings and the built environment. However, this study proposes a different view of allometry in architectural design. The study offers using allometric values not only on existing buildings or urban patterns but also on generating building forms and urban patterns.

Basicly, the intention of this study, comes from the supporting topological relations during morphogenesis, and considering these topological values as leading impacts during generation and formation process in architecture. Complex living systems, usually come from the organizations of different functions, forms or properties. Similar to living systems, emergence and growth of different parts depends on whole in architecture. Therefore, using allometric values would help to generate more efficient forms in building and urban scale. In this research, the allometry in morphogenetic design are offered to generate different urban patterns and building forms. When generating forms through allometry in the study, network topologies and spatial data structures are offered. Additionally, spatial data structures are used in octree and quadtree techniques. A quadtree structure based on a two-dimensional $2^{2n}$ grid system, considers both the parts and the whole system; and creates a hierarchical tree structure of the given data. The division of space is gathered through the position and the size of each component. An octree structure also works in the same rules but only in three-dimensional $2^{3n}$ cellular system. Both of these structures help to create an architectural form through hierarchical relationships of the given data. In this regard, it is expected to achieve a complex design forms through the topological relationships of different units and the environment by adapting allometry as geometrical and mathematical constraints to architecture.

*Fig1. The example of generating through allometry in building scale*

***References:***

[1] Elif Belkis Oksuz, "Morphogenetic Design through Network Topologies and Allometry in Architecture" MSc. Thesis in Architecture, Thesis Supervisor Prof.Dr.Gulen Cagdas, Istanbul Technical University,2013

[2] Philip J. Steadman, "Allometry and Built Form: Revisiting Ranko Bon's work with the Harvard Philiomorphs" Construction Management and Economics, 24:7, Routledge, London, p. 755-765, 2006

[3]Hanan Samet. Applications of Spatial Data Structures, University of Maryland, Addison-Wesley Publishing Company, US, 1993

***Contact:***
***elifb8807@gmail.com***

***Keywords:*** Allometry, Morphogenetic Design, Network Topologies, Spatial Data Structures.

# Generating through Allometry in Architecture: A design approach for relational morphogenesis

**Elif Belkıs ÖKSÜZ, MSc.** (PhD student)
*Istanbul Technical University, Faculty of Architecture, Istanbul, Turkey*
*elifb8807@gmail.com*

## Abstract

Morphology is one of the widely considered within different views in architectural and urban design. In this context, many biological terms and notions were adapted to architecture. One of them is called allometry, the study of scale and size relationship of growth in biology. Studies on allometric values in architectural design can be seen as early as Violett-le-Duc. Additionally, referring to D'Arcy Thompson's study "On Magnitude," many architects and planners have used this term in the metabolic and morphological studies on the existing buildings and the built environment. However, this study proposes a different view of allometry in architectural design. The study offers using allometric values not only on existing buildings or urban patterns but also on generating building forms and urban patterns. Basically, the intention of this study comes from the supporting topological relations during morphogenesis, and considering these topological values as leading impacts during generation and formation process in architecture. Complex living systems usually come from the organizations of different functions, forms or properties. Similar to living systems, emergence and growth of different parts depends on whole in architecture. Therefore, using allometric values would help to generate more efficient forms in building and urban scale. In this research, the allometry in morphogenetic design is offered to generate different urban patterns and building forms. When generating forms through allometry in the study, network topologies and spatial data structures are offered. Additionally, spatial data structures are used in octree and quadtree techniques. A quadtree structure based on a two-dimensional 22n grid system considers both the parts and the whole system; and creates a hierarchical tree structure of the given data. The division of space is gathered through the position and the size of each component. An octree structure also works in the same rules but only in three-dimensional 23n cellular system. Both of these structures help to create an architectural form through hierarchical relationships of the given data. In this regard, it is expected to achieve a complex design forms through the topological relationships of different units and the environment by adapting allometry as geometrical and mathematical constraints to architecture.

**Keywords:** Allometry, Morphogenetic Design, Network Topologies, Spatial Data Structures.

## 1. Introduction

Due to massive energy use and population growth, cities and buildings are expanding their boundaries and adapting to changes every day. The important facts of population growth and efficient design needs, have led us to develop different ideas and novel design strategies both in architecture and urban design. Yet, many of these remarkable ideas are developed through evolutionary design studies. In evolutionary design approaches, complexity of architectural forms and urban growth are likened to living organisms; and, their morphology and morphogenesis are widely considered within different strategies. In this regard, many biological terms and notions were adapted to architecture. More specifically, this paper focuses on one of these biological terms called allometry —the study of size and scale relationship of growth.

Although the impacts of size and scale relationship on form had been mentioned since Galileo Gallilei (1638), deeper studies of allometry in architecture were held in the late 20th century **[1]**. However, in most of these studies since then, allometry was discussed on existing buildings and urban patterns to calculate potentials of energy use or spatial organizations. In this study, considering the notion of allometry and its previous studies in architecture, the use of allometry is offered in a different view. The principles of allometry on form are examined through relational morphogenesis; and, evaluated in a morphogenetic design approach to generate architectural forms.

## 2. Allometry in architecture

As a biological term, allometry refers to "biological scaling, the change in organisms in relation to proportional changes in body size **[2]**." Even though, the word allometry was first introduced by Julian Huxley (1932), discourses on size and scale relationship of whole form and its parts can be seen as early as Galileo's period in literature (1638) **[1, 3, 4].**

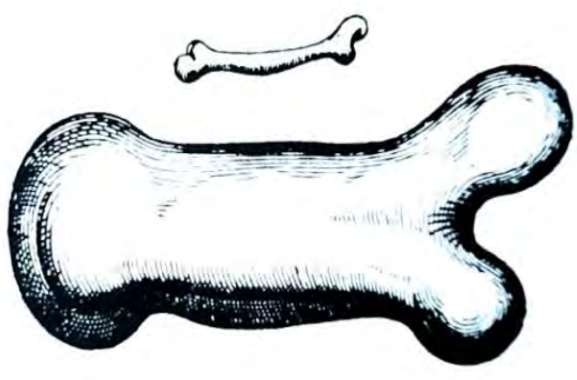


***Fig.1.*** *An example of different size of bones on different species by Galileo Galilei (1638); reproduced from Steadman (2008).*

Later, in architecture literature, similar discourses on size and scale relationship on buildings were *held by Viollett-le-Duc. Violett-le-Duc exampled this relationship within the following words: “In the art of architecture, it is not possible to establish the following formula; that 2 is to 4 as 200 is to 400; because if you can put a lintel 4 metres in length onto columns 2 metres high, you would not be able to put, on two columns of 200 metres in height, a lintel of 400 metres. To change scale, the architect must change the method (mode), and style consists precisely in choosing the method appropriate to the scale – using that word in its widest definition **[1, 5]**.”*

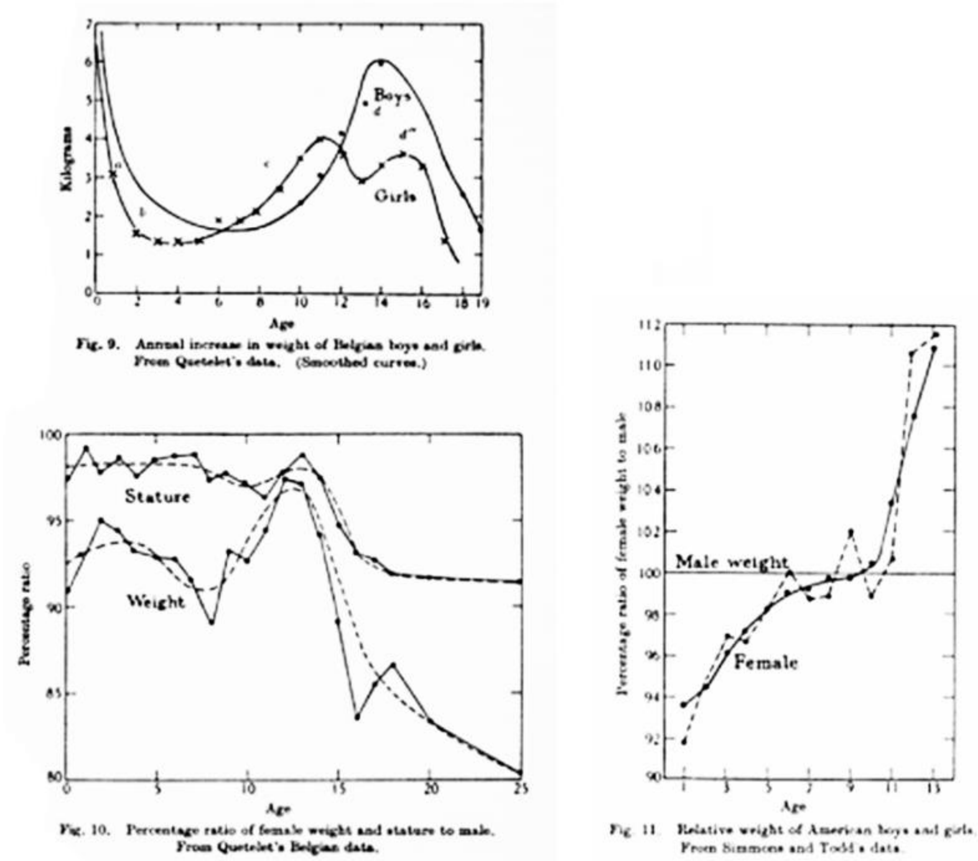



***Fig.2** Thompson’s (1917, 1971) comparison graphics on genders’ growth.*

Another inspirational study on size and scale proportion of form is mentioned in D’Arcy Thompson’s “On Growth and Form,” especially in "On Magnitude" chapter. The principles of today’s allometry in biology were derived from Thompson’s studies; in fact, his studies are still referenced in architecture and other design areas. In “On Magnitude” chapter, Thompson studied the progress of growth on boys and girls in several charts **[4]**.

Today, principles of allometry can be viewed in different ways. Besides comparing the proportions of different parts in growth of same species, allometric relations can be also discussed by comparing the proportion of similar parts of different species **[6, 7]**. For instance, growth of similar body parts of different species and growth of different body parts of one species can be examined through allometric relationships.

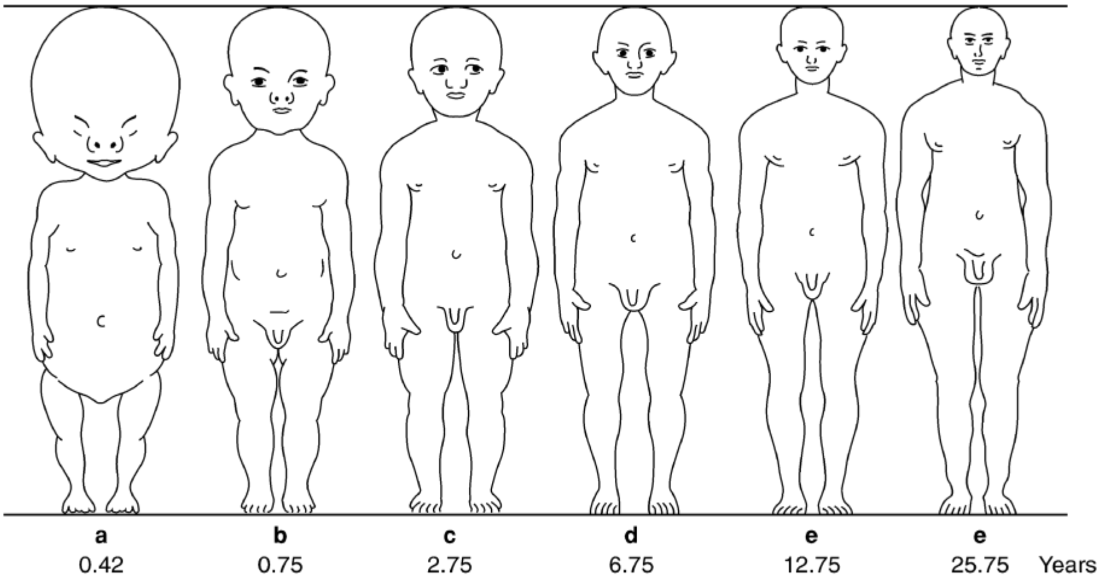



***Fig.3.*** *Growth of human in time C.M. Jackson, Morris's Human Anatomy, London 1915 and Growth, Yale 1928. Naroll and von Bertalanffy, 1973, p. 247; reproduced from Steadman, 2006*

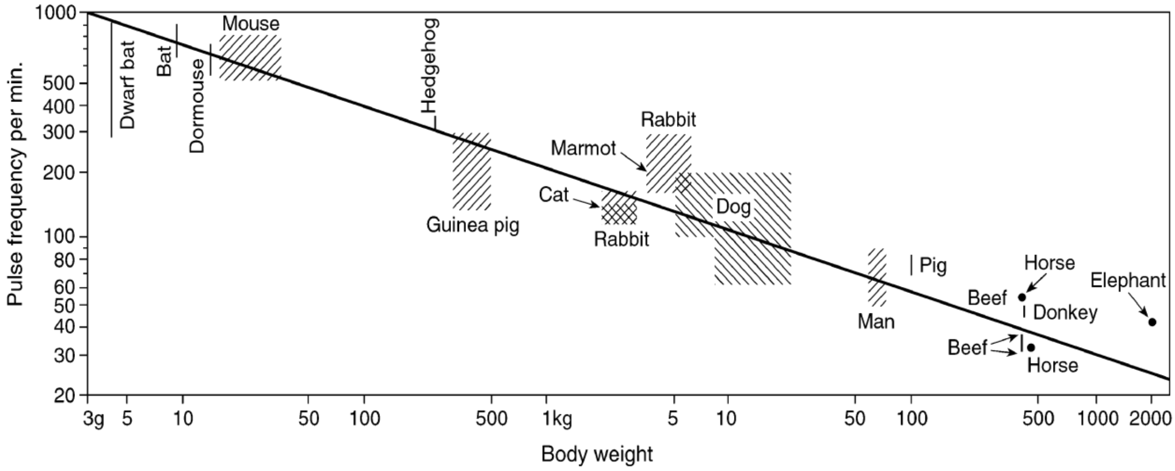



***Fig.4.*** *Growth of human in time C.M. Jackson, Morris's Human Anatomy, London 1915 and Growth, Yale 1928. Naroll and von Bertalanffy, 1973, p. 248; reproduced from Steadman, 2006*

However, Ranko Bon (1972) was the first who discussed allometry as the proportion of size and scale relationships of building form in architectural morphology [8]. His research was held on 20 different buildings with similar plans to reveal the allometric relation between building sizes and their spatial organizations. He proportioned the distances between rooms (ft) as topological relationships and their sizes ($ft^2$); then, compared the results in a logarithmic chart **[7-8]**. At the end, he achieved similar proportions in these 20 houses and mentioned this relationship as a positive allometry.

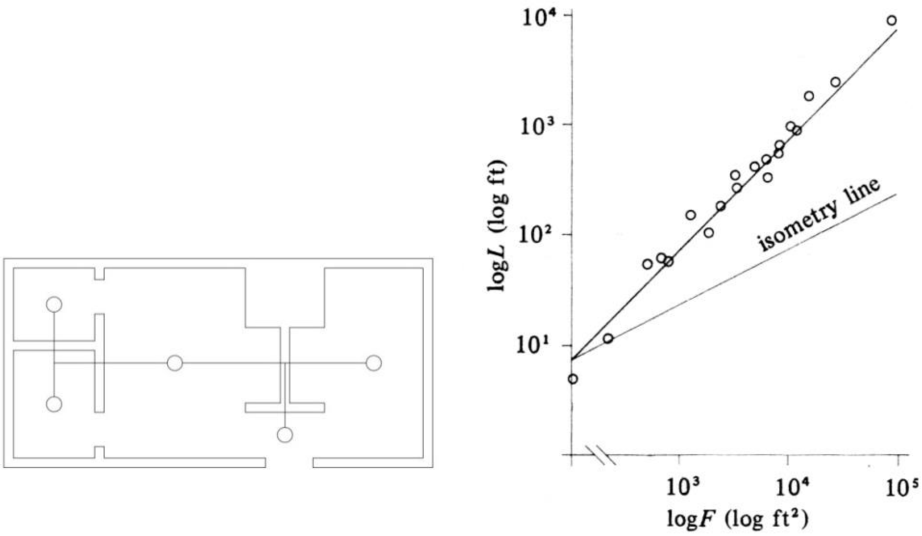



***Fig.5.*** *An example of size and organization comparison with its allometric table by Bon (1972); derived from Steadman (1983).*

Inspired by Bon's study and many other discourses on allometry in architecture, we aim to use same principles of allometry through relational morphogenesis on generating new forms in architecture **[10]**. Within this way, by supporting topological relations of parts within allometry, whole form can be generated in a more efficient way.

## 3. Evaluation of Allometry in Morphogenetic Design

As John Frazer (1995) mentioned in An Evolutionary Architecture, morphogenesis is probably the most deterministic stage of evolutionary design **[11]**. All the living systems in different scales are assembled to grow and organize depending on their functions, similarities and relativities **[10]**. Also, Steadman (2008) posits, “It was an important consequence of the ‘correlation of parts’ that functional relations would not only govern the necessary and simultaneous presence of various organs in systematic combination, but would also determine the proportions and dimensions of the overall shape of a creature… **[1]**.” Therefore, it is possible to say that during morphogenesis, each living unit organizes, breeds, or grows depending on their neighbors to serve the whole system. In this context, it is reasonable to compare the formation of human civilizations to morphogenesis of living systems in some ways. Especially, in architectural design, form is mostly achieved through the order and organization of each part depending on their contents, proportions and scale. Living forms emerge through these specific organizations such as size and scale relationships.

Using morphological factors like allometry in formation process would help to achieve efficient design solutions by supporting the organizations between whole form and its parts. As in living systems, allometric relations can be created or determined, and supported in the morphogenesis of built form. Adapting allometric values to design process can be contemplated as determinative facts in relational morphogenesis; and this would help to achieve relational morphogenesis of form. Consequently, relational morphogenesis would help to achieve efficient design solutions. Considering this fact, principles of allometry can be evaluated in architectural formation in many ways. Yet, one of the ways is to proportionate the topological relationships of spaces within their order (purpose of use). Kolarevic explains the benefits of topology in morphogenesis within these words: "The notion of topology has particular potentiality in architecture, as emphasis shifts away from particular forms of expression to relations that exist between and within an existing site and the proposed program **[12]**." In the next chapter, the implication of allometry on form is proposed within a digital design approach. Some of the digital design techniques and strategies are offered to adapt allometric notions to morphological process of design form.

## 4. Generating Forms through Allometry

### 4.1. The Implication of Allometry in Design by using Spatial Data Structures

To implicate the principles of allometry in architectural morphology, the structure of organization such as spatial use, structural use or other uses, should be acknowledged as whole and in its parts. Therefore, although parts of whole and their spatial relationships are predefined, their unexpected ways of organizations create a half-deterministic process. Within this way, top-down and bottom-up strategies will be used together in this allometric design approaches. As long as the relationships of design parts and their proportions in whole are described clearly either in mathematical or geometrical values, the implications of allometry can be applied by different techniques and strategies in digital media. In our study, to adapt the size and scale relationship in a morphogenesis of form, we offer to use octree design technique from spatial data structures.

Although there are several alternatives of octree technique in spatial data structures, in this case, we consider it in its simplest way. The principle of octree is simply explained by Hanan Samet as within these words: "We start with an image in the form of a cubical volume and recursively subdivide it into eight congruent disjoint cubes (octants) until blocks are obtained of a uniform color or a predetermined level of decomposition is reached **[13].**"

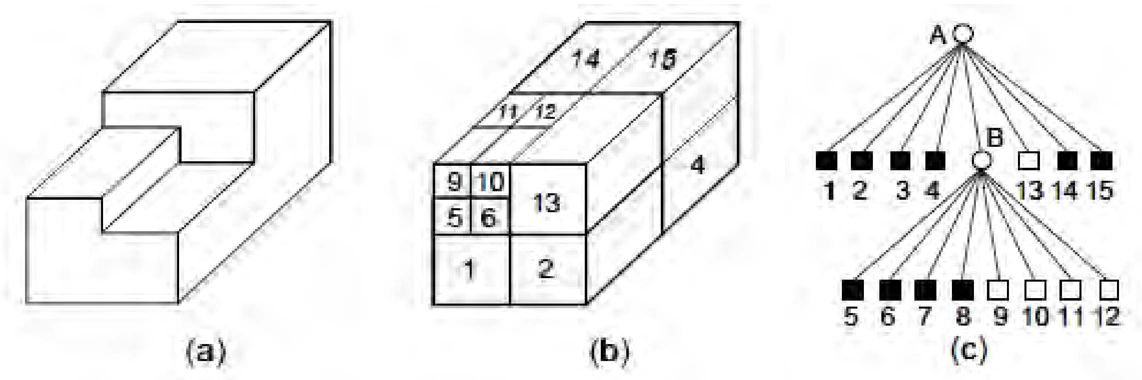



***Fig.6.*** *the decomposition of form by Octree structures from Samet (1995)*

The use of octree would allow creating new organizations and continuous patterns through defined topological relationships and adapting existing organizations. The applications of octree may change depending on the data type (point, line, volume) and their ways of use. In this case, octree technique will be used as point-based data structure; therefore, the points will provide the division of whole space into smaller parts. And, these points will be gathered through network topologies which would help and control the relationships and proportions of the whole system as a geometrical form. Network organizations of the parts are randomized to generate different alternatives by octree structures. The reason behind this approach is to design the structure of organization that supports the relationships and the proportions to design form which may lead the further organizations by simple applications.

### 4.2. A Building Block Design Trial on Relational Morphogenesis (Case Study)

When it comes to plan buildings forms and cities, there are many determining facts such as ecological, cultural, topographical, functional, vernacular and historical values and so on. Also, clearly it is not possible yet to convert each of them and use as a parameter of a building form in a digital design process. However, it is possible to create topological relationships among some of these values and adapt them to a morphogenetic process. Even initially predefining any of these structural, functional or programmatic relationships would help to control the formation of buildings in efficient way.

In this study, it is aimed to shape topological relations, which are predefined depending on their purpose or content in design progress, within allometric relations. In other words, a morphogenetic process is evaluated by order of space units (purpose of use) and their different network topologies as determining parameters of allometry. It is attempted to generate different architectural alternatives by supporting both spatial organization and user groups as parameters of allometry. For this case, allometric relations created by network topologies will be examined by generating urban block design alternatives. Therefore, the design progress starts with creating the structure of topological relationships their order in spatial organization and their proportions depending on its contents.

As a first step, initial points are created through grid structures to evaluate space efficiently in the given boundaries. The size of the grid is adjusted from the façade of existing buildings which are approximately 4 meters wide and 18 meters length (three to five story buildings).

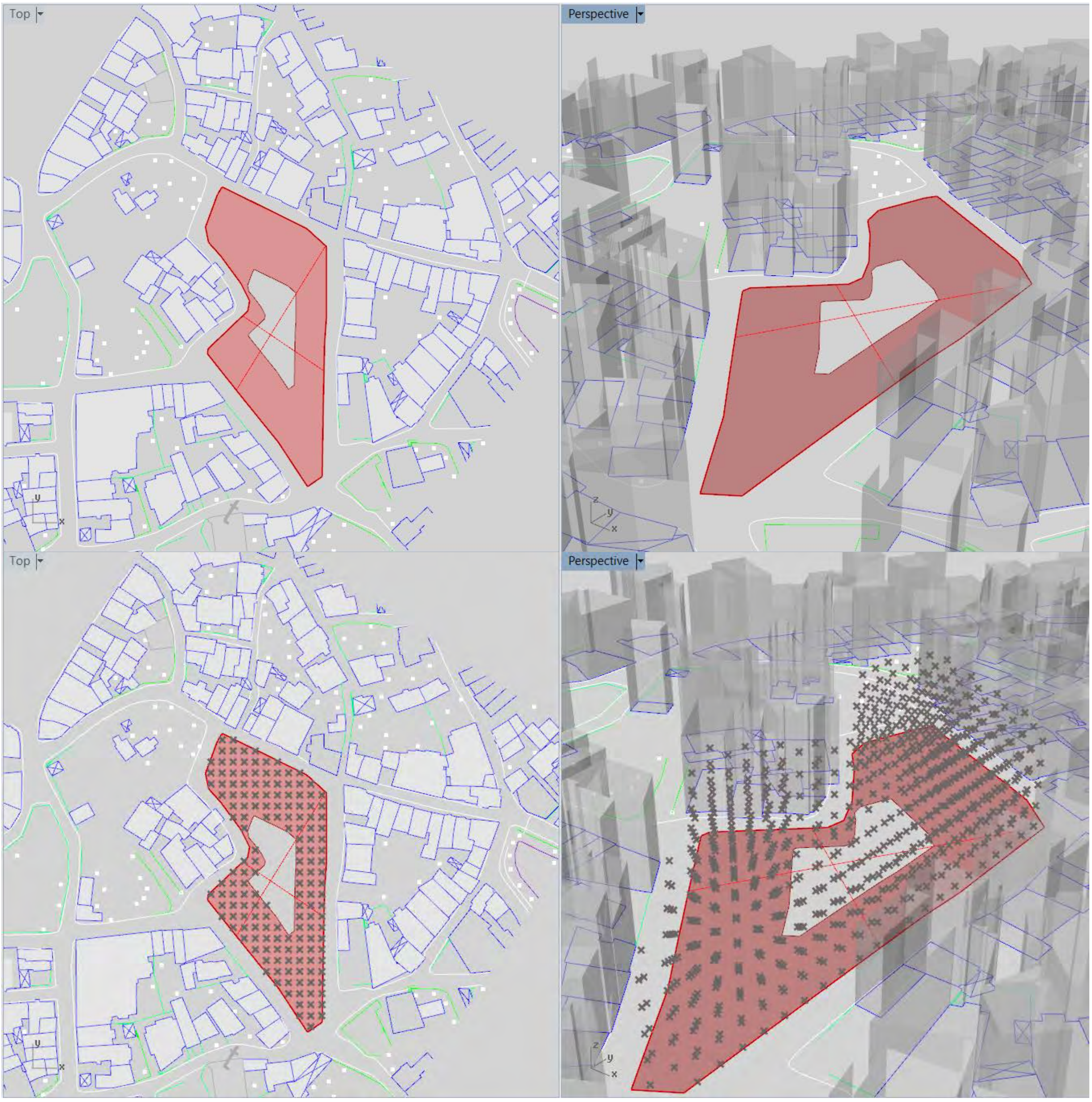



***Fig.7, 8.*** *Determination of boundaries, and creation of initial points for spatial organization*

After creating the initial points, in this situation the network points, first allometric relationship is determined for the emergence of networks. Geometrical and mathematical values (number of networks, length of networks…) of network lines are proportioned according to the predefined order for spatial unit. As it was mentioned before, while adapting allometric principles, parts of whole can be defined as any kind; as long as the order of their relationships is structured efficiently. Therefore, for this study the order of form and their relationships are structured upon their use.

In the design scenario, the order of parts is determined by relationships of green units, semi-public units and private units (housing, shopping units and gardens). Before, creating networks, the order of their emergence points are structured in the following way: 2/6 of points are semi-public units, 1/6 of points are open spaces and 3/6 of points are private units. Also, distances between points are defined by their function. Therefore, each unit can be created by their structured organization. The partition of points are shown in the following order: yellow points for shopping units, green points for open areas and purple points for housing units. Surely, the limitations for this process might be enhanced by more criteria; however, the more limitations may cause a more density of form.

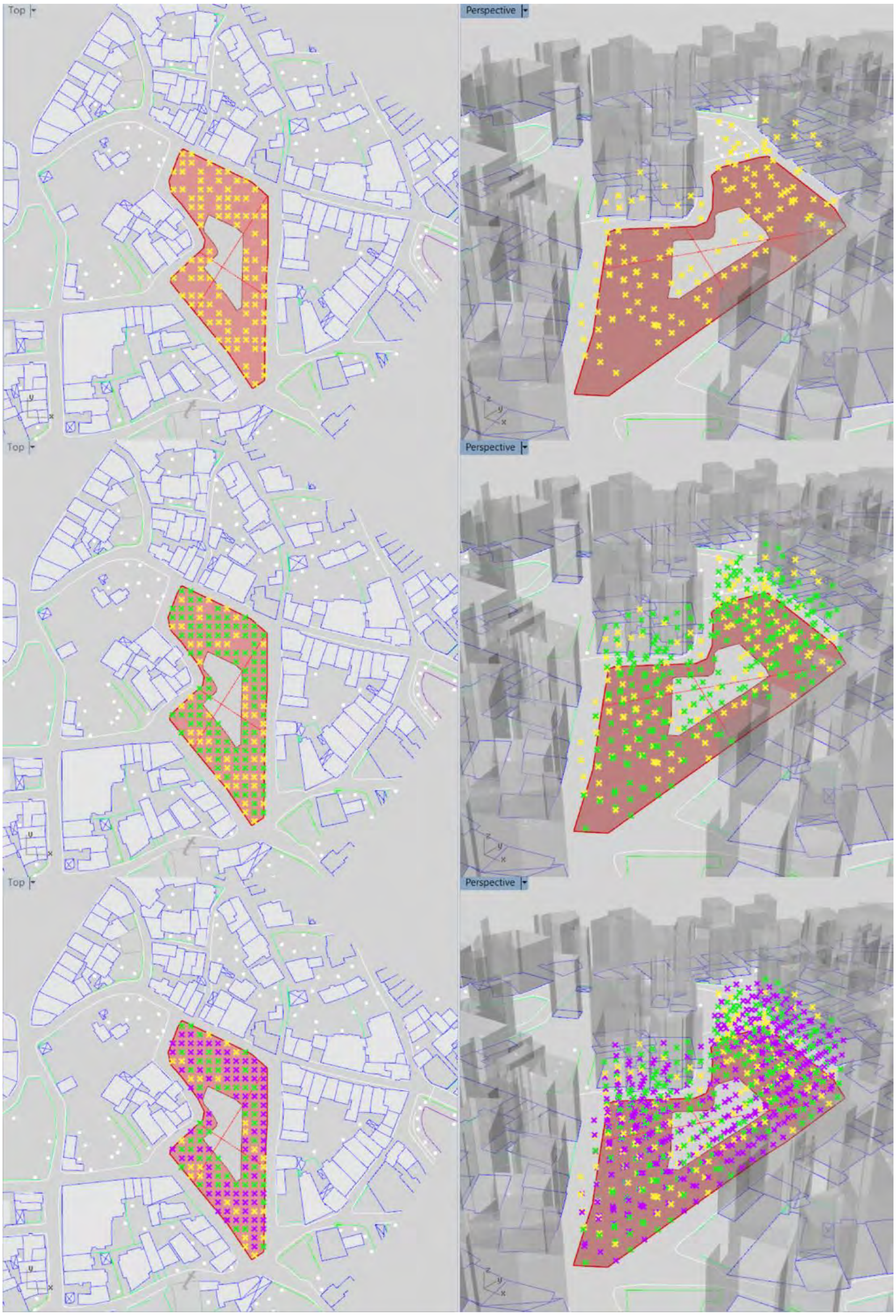



***Fig.9-11.*** *Selection and partition of network points by units' proportion*

After the specification of their distances and proportions, networks are created among these points. Within this way, emergence of each network would depend on their size and scale relationship; also, these determinations would help to create topological relationships of parts, and support the efficiency of space use. The impacts of proximity and their proportion on whole are defined similar to allometry in biology. The parameters of networks are defined in the following order: 1 connection and 28 meter distance for semi-public units, 1 connection and 8 meter distance for green units, and min 3 connections and 4 meter distance for private units. In this step, the organization of networks can be generated vastly to reach complex and satisfactory solution(s). One of the advantages of network organizations is that even with simple rules complexity can be efficiently created or controlled.

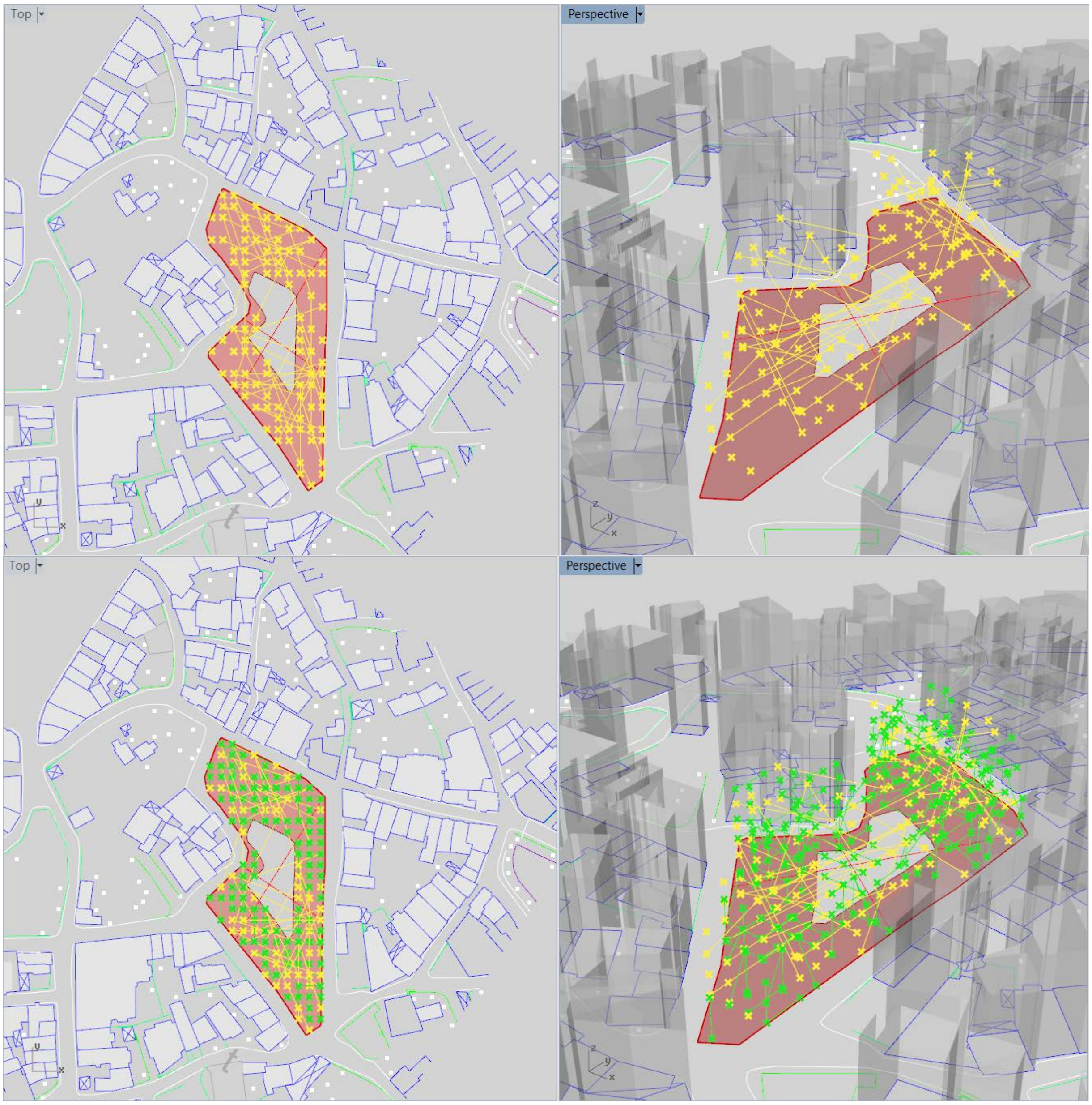



***Fig.12, 13.*** *Generation of network structures*

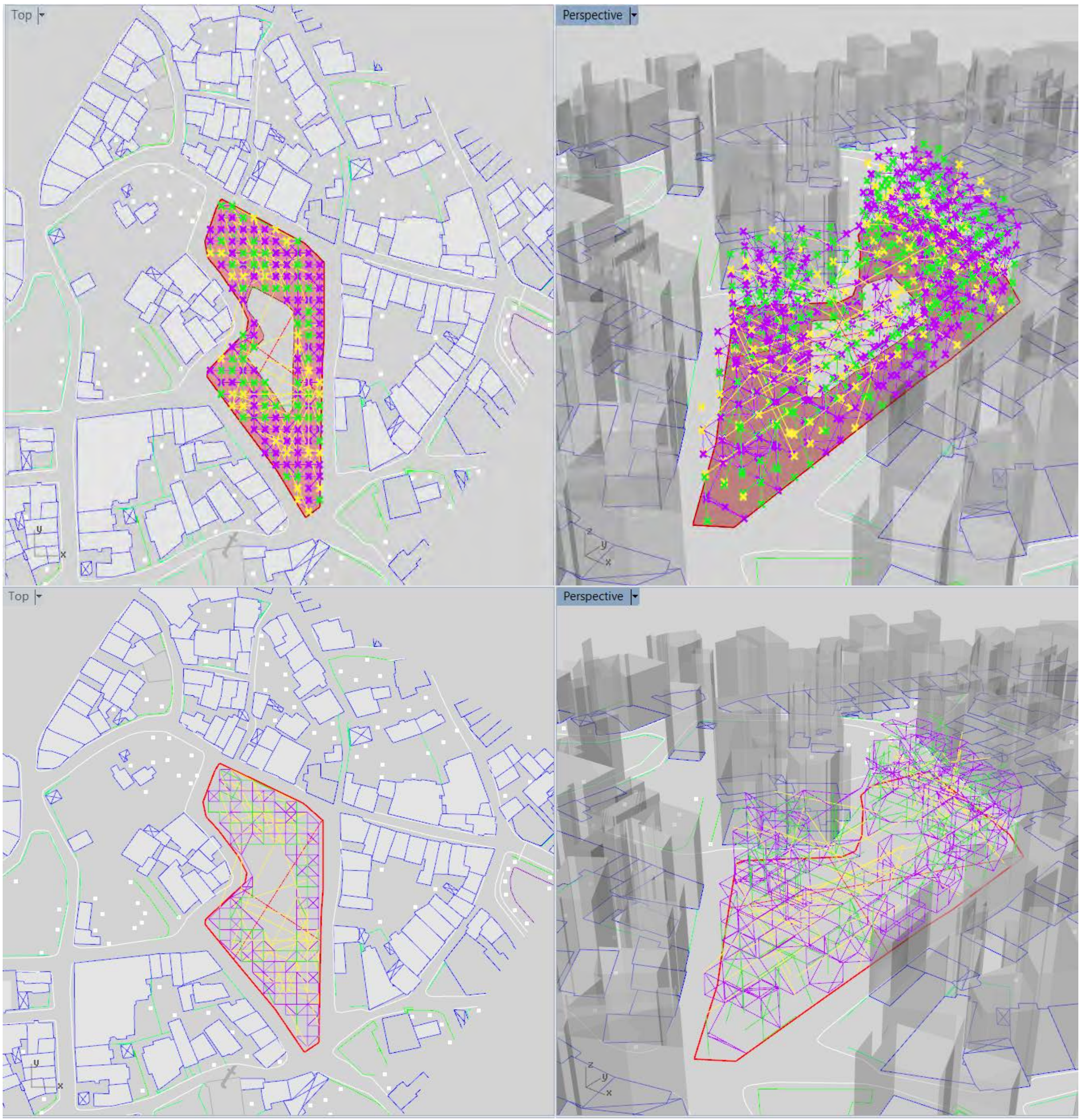



***Fig.14, 15.*** *Generation of network structures*

In the next part, octree technique is used for partition of each unit depending on their points' neighborhood relationship. Within this way, octree structures are used to control the different growth of each cell depending on relationships which provided by network organizations. Based on the network points' positions, points were collected in cubic volumes within specified numbers. Therefore, the sizes of spaces are achieved through proportions and relations among individual units in whole system. The maximum amount of points is determined 3 for each cubic volume. By merging all network points at once in octree technique, integrated spaces (volumes with more than one type of unit point) can be created. In this case, mixed use spaces can be created or controlled easily.

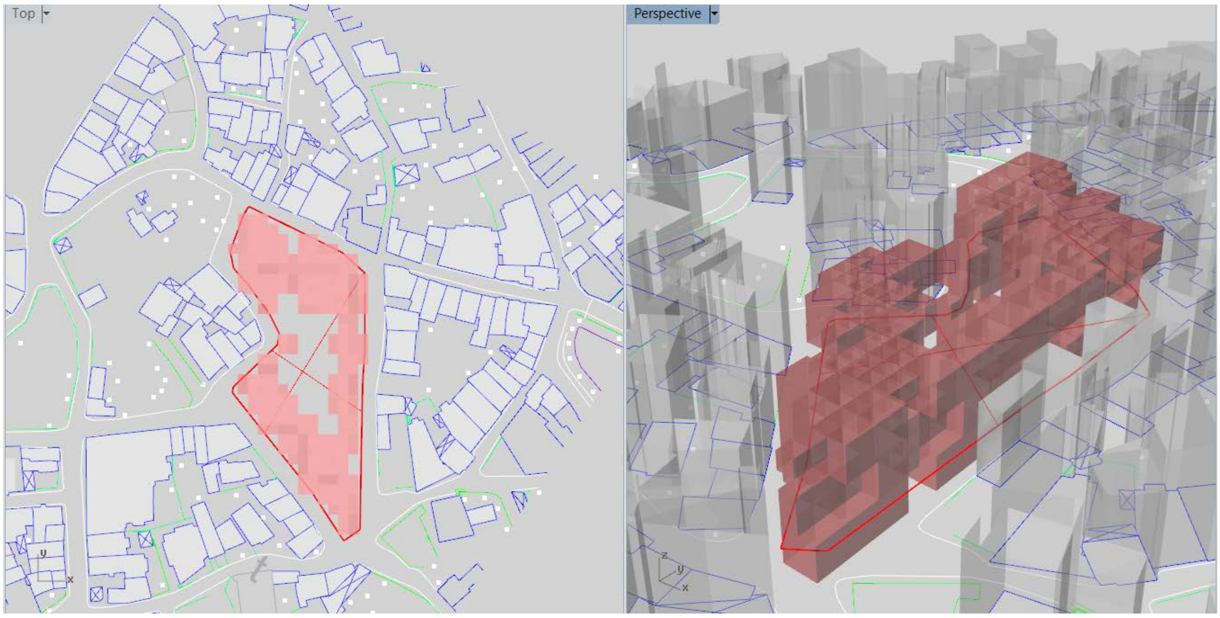


***Fig.16.*** *Generating proportion of units in whole through their relationships by Octree structures*

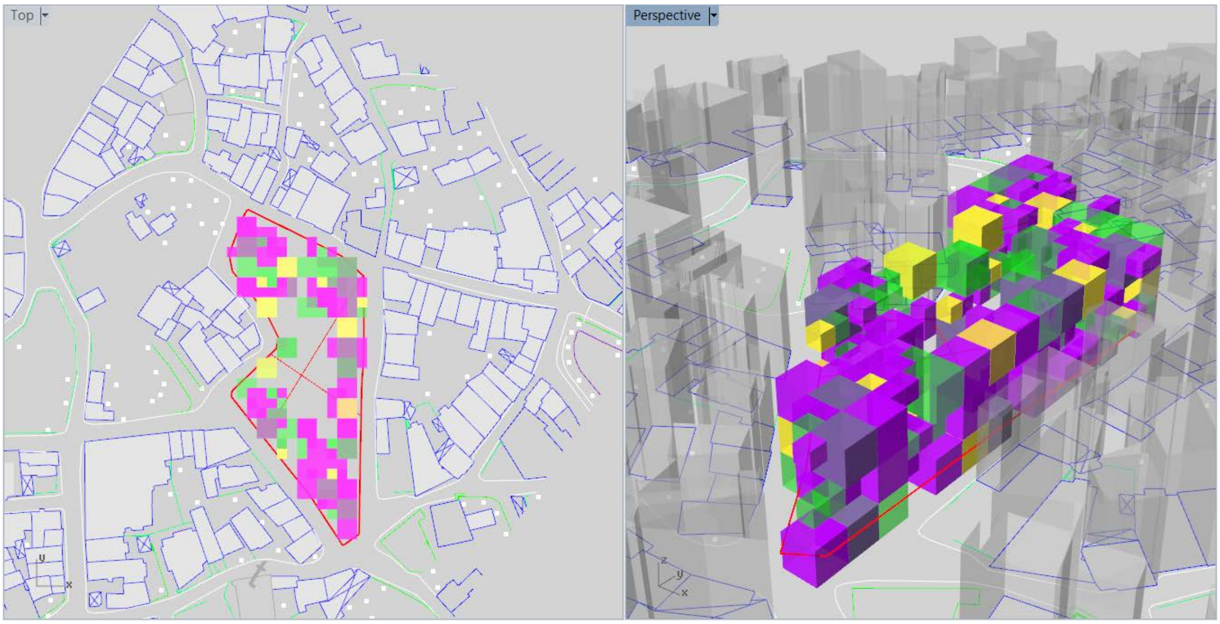


***Fig.17****. Determination the units' type by their point inclusion and final form*

At the end, redefinition of space units was held by finding the exact volume of each group of network points. By clustering specific amount of points in octree structures, mixed-use spaces (different combinations in volumes) can be created as in this example.

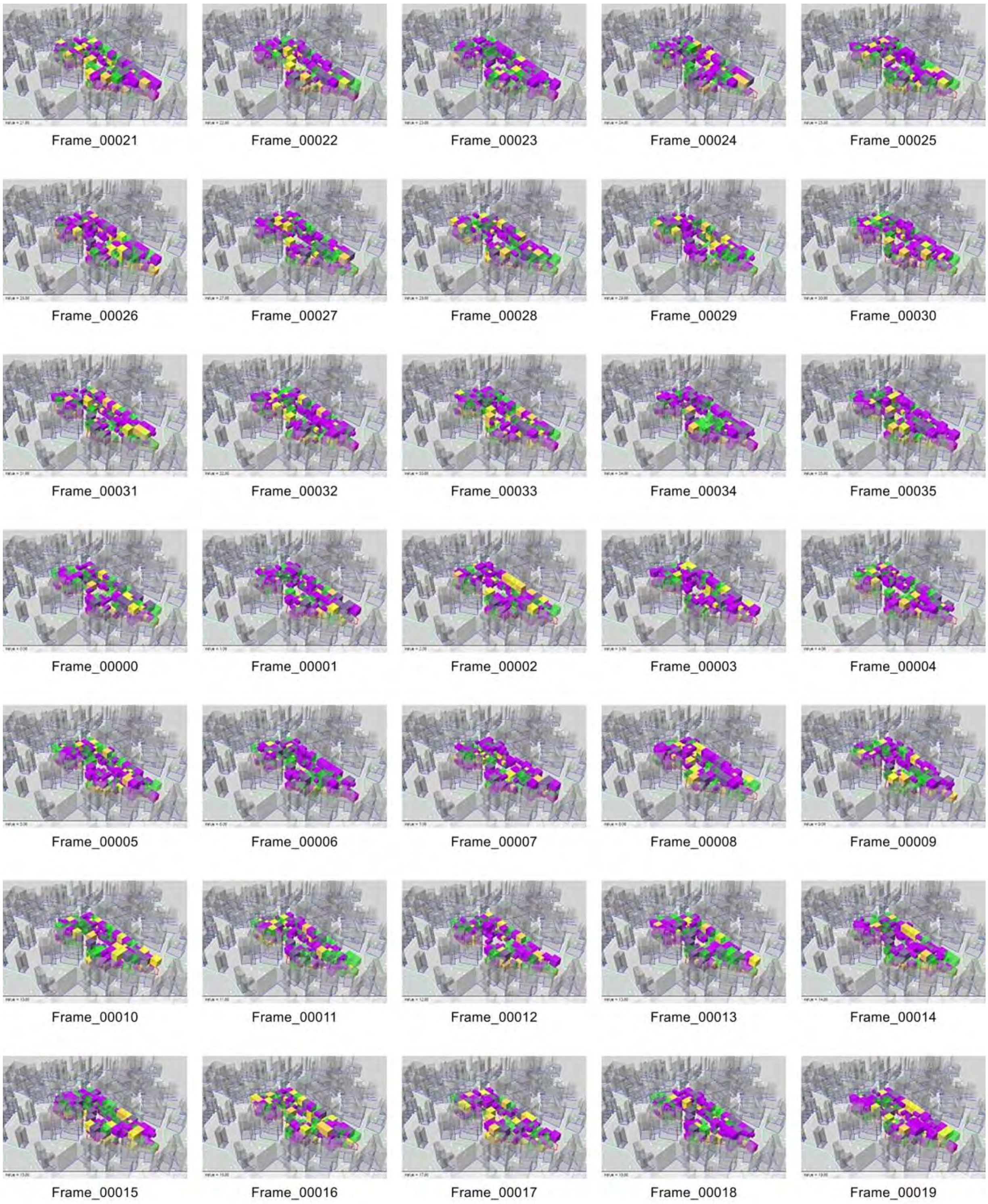



***Fig.18****. Generated alternatives by changing network topologies*

## 5. Conclusion

Adapting allometric principles to design morphogenesis can be considerably reckoned as a structuralist view in architecture. However, supporting any topological relationships and using their order as determinative facts of morphogenetic process would help to achieve satisfactory solutions easily. In fact, using allometry is one of the effective ways for that. Also, learning from the past organizations on existing buildings, new alternatives or continuity can be provided with this simple act. Even the smallest or simplest definition and limitation of any topological organization can be provided and controlled by networks as long as the relationships, scales and proportions between units are determined properly. In further studies, determining facts can be enhanced such as area of units, supported relationships, user types and so on. However, more network parameters might cause to reach very similar solutions at the end of the process. Within the same design strategy, networks can be applied and enhanced on existing buildings to create similar ones. By applying genetic algorithms and other evolutionary studies within this approach, it is possible to reach effective design alternatives in shorter time. For the future studies, it can be suggested that especially the use of genetic algorithms would help to eliminate and achieve the satisfactory results in shorter time.

**References:**

**[1]** Philip Steadman, “The Anatomical Analogy”, the Evolution of Designs Revised Edition, Routledge, Revised Edition, 2008, pp.31-53
**[2]** Definition of allometry:
(http://global.britannica.com/EBchecked/topic/1499967/allometry) accessed 24.10.2013
**[3]** Galileo Galilei, Discorsi e Dimostrazioni Matematiche Intorno a Due Nuove Scienze, Leiden, 1638; trans. H. Crew and A. de Salvio as Dialogues Concerning Two New Sciences, New York, 1914, p.2
**[4]** D’Arcy W. Thompson, “On Magnitude”, *On Growth and Form*, Abridged Edition, Cambridge University Press, Cambridge, UK, 1917, 1971
**[5]** E. E. Viollet-le-Duc, Dictionnaire Raisonné de l’Architecture Française, ‘Style’ vol. 8, p.483
**[6]** Philip Steadman, “Allometry and Built Form: Revisiting Ranko Bon’s Work with the Harvard Philomorphs”, Construction Management and Economics, 24, 2006, pp.755-765.
**[7]** L. von Bertalanffy, Theoretische Biologie Vol. II, Stoffwechsel, Wachstum, 2nd edn, Francke, Bern., 1973
**[8]** Philip Steadman, “Principles of Similitude” Architectural Morphology, Pion Ltd., UK, 1983
**[9]** Ranko Bon, 1973, “Allometry in the Topologic Structure of Architectural Spatial Systems,” *Ekistics*, 36 (215),pp. 270-276.
**[10]** Elif Belkis Oksuz, “Morphogenetic Design through Network Topologies and Allometry in Architecture” MSc. Thesis in Architecture, Thesis Supervisor: Prof.Dr.Gulen Cagdas, Istanbul Technical University, 2013
**[11]** John Frazer, “Introduction,” An Evolutionary Architecture, Architectural association Publications, Themes VII, 1995
**[12]** Branko Kolarevic, “Digital Morphogenesis”, Architecture in the Digital Age, Taylor &Francis, UK, 2003, pp.11-28
**[13]** Hanan Samet, Applications of Spatial Data Structures, University of Maryland, Addison-Wesley Publishing Company, US, 1995

**Enrica Colabella**

# Imaginative constrains for generative chain

**_Topic: Generative Chain_**

**_Author:_**
**_Enrica Colabella_**

Generative Design Lab, Politecnico di Milano University, Italy
www.generativedesig.com

**_References:_**

[1] Seamus Heaney "*Human Chain"* 2011 Faber&Faber

[2]Giovanni Pascoli *"Tutte le Poesie*", 2009, Newton&Compton

[3] Piero della Francesca, De prospectiva pingendi, a cura di G. Nicco Fasola, Firenze 1942.

***enrica.colabella@polimi.it***

**Abstract:**

*Quidquid recipitur ad modum recipientis recipitur*
*Anything perceived is perceived according to the way of who perceives*
*Aristotele / S.Agostino*

*Giovanni Pascoli and Seamus Heaney*

The first words of "Human chain" by Seamus Heaney are:
"After 'L'Aquilone' by Giovanni Pascoli (1855-1912)".
In this book Heaney dedicated to his granddaughter his last poem
*"A Kite for Aibhín"* :

Air from another life and time and place,
Pale blue heavenly air is supporting
A white wing beating high against the breeze…

Pascoli wrote::

un'aria d'altro luogo e d'altro mese
e d'altra vita: un'aria celestina
che regga molte bianche ali sospese...

In art a creative process works performing imaginative constrains able to generate chain. But how constrains can generate chain? With imagination, crossing times and spaces and connecting extraneous distant elements in ***a new generative vision***. The main tool is the performing of an interpretation on the significance, able to delineate *a new double resonant measure* as generative chain. As soon as the core of the new poem is structured as *a rhythm* in our mind, so we are able to follow the sound of our mother tongue generating a new poem in resonance with the precedent poem. This becomes as a *catalyst* able to generate a new imaginative chain. Following the concept of ***comprehensiveness*** delineated by Eliot we can discover imaginary constrains as connection from different times generating chain. Heaney:*Alphabets. Beowulf; so…*
The same process happens in all fields of art.
Piero della Francesca, *De Prospectiva dipingendi, I Trionfi* where are connected pictures and words following the Roman epigraphs.
Duality, Goethe *Poliritat*, 1805.
The contemporary use of random and data base in Markov chain.
***Unfunished:*** Michelangelo, *Giants*, *Pietà Rondanini*
M. Twain,*The Mysterious Stranger;* Dickens, *The Mystery of Edwin Drood*

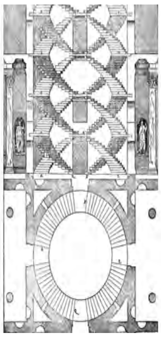
**_Keywords:_**
Imaginary, constraints, generative poetry, numbering, art, chain

# Imaginative constraints for generative chain

**Prof. Enrica Colabella**
*Generative Design Lab – Politecnico di Milano University*
*www.generativeart.com*
*e-mail: enrica.colabella@generativeart.com*

## Starting point:

This paper talks about the first result gained on the generative design approach for art configurations. The structure of this research is performed in a dual/double sound, following the concept of *Polaritat*, performed by Goethe [1]. The dual conjugation was in the structure of the Greek grammar. The dualism works in imitation of a natural code, performed in a double helical. *Image* to have a tetrahedron at whose basis we connect to each vertex the words: *imagination, thinking, memory* and on the top *intuition*. In a generative process we can cross from the significance from one word to another performing an helical double direction, one toward up, the other toward down. A great example of this process was designed by Leonardo at *Chambrod* for the staircase of the castle. This is a building with a double helical staircase, where as in a theatrical space, if two people start in climbing each one walking on one different part of the staircase, suddenly each one disappears to the vision of the other one. This is deeply in imitation of an art process by connecting the invisible to visible. The same happens also in St. Patrick well in *Orvieto* by Sangallo. But in this case the second staircase is dedicated to animals for bringing water.



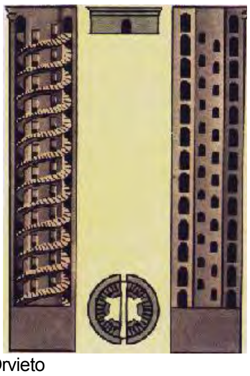



fig.1-2 Leonardo, Chambrod castle – Fig. 3-4 Sangallo, St. Patrick well in Orvieto

So the direction is *double* managed by intuition in performing appearance and suddenly disappearance between thinking, memory and imagination.
This process is performed also following the sentence by Aristotele, pursued by S. Agostino too**:**

*"Quidquid recipitur ad modum recipientis recipitur"*

*"Anything is perceived is perceived according to the way who perceives".*

So the *intuition/perception* can manage these two structures that we can schematize in: 1 . imaginative constraints - 2 . generative chain.

**1- Imaginative constraints for generative chain**

*Homage to Giovanni Pascoli and Seamus Heaney*

In his last book "*Human Chain"* [2] Seamus Heaney dedicated to his granddaughter his last poem " *A Kite for Aibhín"* [3]. The first line of this poem is: "***After*** *'L'Aquilone' by Giovanni Pascoli (1855-1912)".*

*"...Air from another life and time and place,*
*Pale blue heavenly air is supporting*
*A white wing beating high against the breeze…"*

Pascoli wrote:

*"…un'aria d'altro luogo e d'altro mese*
*e d'altra vita: un'aria celestina*
*che regga molte bianche ali sospese..."*

In art a creative process works performing imaginative constraints able to generate chain. But how constraints can generate chain? With imagination, crossing times and spaces and connecting extraneous distant elements in ***a new generative vision***. The main tool is the performing of an interpretation on the significance, able to delineate *a new double* ***resonant*** *measure* as generative chain. As soon as the core of the new poem is structured as *a rhythm* in our mind, so we are able to follow the sound of *our mother tongue* generating a new poem in resonance with the precedent poem. This becomes as a *catalyst* able to perform a new generative chain. In his talk for the Nobel prize in 1995 "*Crediting Poetry",* Heaney said: *"As poet I am inclined toward the search of a rhythm, in the sense that my effort is to submit me to the stability conferred by an order of musically satisfying sounds"*

Heaney defined his poem " *A Kite for Aibhín":*

*"A nice poem in the art of flying a kite. I remember that special*
*activity on a clear blue day and not so windy. Still the calm is*
*disturbed by an unforeseen gust of wind that causes the kite*
*to spiral upward and flutter down to get lodged in a tree. Unable*
*to dislodge the kite the string is cut and the kite is rising to heights unknown"*

Human chain is written in groups of 3 verses, *terzine* not rhymed, but still connected by assonances and rhythms in a meta-structure of metrics as an imaginative constraint [4].

Heaney said: *"For a poet the poetry is a way of putting himself in the world. My origins have been important because the emotional power transfers itself in the language and to me the world is always introduced in the form of **memory**. The artifice, the secret is in making it **to resurface** from the fund of the river".*

Heaney rediscovers in Pascoli a breath of his own language. In his mind resounds the common voices of English poets as "*Imaginist*". Pound defined this word and described his activity for poets as an effort *"to keep alive a certain group of advancing poets, to set the arts in their rightful place as a acknowledged guide and lamp of civilization".* In Heaney mind resounds the Pascoli voice as ***the direct talk***, in Pound definition. The *direct talk* we can discover especially in Heneay translation of the ending verses of *L'ultima passeggiata and of Myricae for:* ***"a momentary feeling of a conscience aperture toward a rebirth sense of time and place",*** *"a steering" toward "an unexpected conclusion. "* But above all Heaney rendered Pascoli English with his translation of his some poems. A translation intimately lived: ***"I have assumed the voice of another poet, I have spoken for intermediate person"*****.**

Heaney talks in an interview about a meeting been randomly born, at Urbino in 2001, with the verses of *The kite* recited by Gabriella Morisco, "*first to reveal the name of Pascoli known to me".* He hears ***an affinity***: "also I had written a poetry in which a kite appeared, located in a field of the rural Ulster", a family picture with his brothers, a Sunday in the years '40, with his father that launches *"in the air of the county of Derry a great kite manufactured in the house": "A Kite for Michael and Christopher"*. A poetry "*….. with the awareness that we have to be ready to run into the suffering in our life."*

*The kite strikes Heaney. He asks* ***a literal translation*** *to Morisco"….and while I was trying to render it in verses and I entered into the takings with the third rhyme,* ***I have gradually entered in a family world****, because the landscape remembered me a lot of the home ground of my same infancy", so "my composition was born from* ***a depth personal involvement."***

Morisco and Tony Oldcorn translate other poems for him, from *La cavallina storna* to *Digitale purpurea*. Heaney studies the biography and the work of Pascoli, fascinated from *"a persistent emotional tangle that confers in a big part of what he has written a surplus of urgency and an underground energy",* avoiding *"the abstractness*" and privileging ***"the things".***

Oldcorn asked in an interview Heaney if it was easy for him to translate Pascoli. He answered that: *"Among all, I have found easy to translate "La cavallina storna ", beloved for the content and for the verses"…… "they have a quality "enchanting….* ***the obsessive charm of a popular ballad*****"** and *"a sense of fatality and inevitability….. But it is always not easy to translate Pascoli."*

*"Do you believe to have made justice to the original texts?* ", Oldcorn asks him, in a conversation. *"It depends. I don't believe to have made justice to Digitale purpurea, because it is difficult to translate in terzine dantesche. Neither to Gelsomino notturno, for the difficulty to translate the 800 melodious Italian language in the thin modern English. In others, especially in L'ultima passeggiata, it seems me of yes because* ***I have rendered the tone pascoliano with my tone****. With the long poems as La cavallina storna, has helped me the fact that* ***they imitate the popular poetry****, that is* ***the classical form of the Irish ballad."***

These are the verses of *La cavallina storna*, that ends in this way:

*The horses now no longer munched their feed.*

*They slept and dreamt the whiteness of the road.*

*They didn't stomp the straw with heavy hooves.*

*They slept and dreamt of turning wheels in grooves.*

*In that deep silence my mother raised a finger.*

*She spoke a name… A great neigh rang in answer.*

Pascoli wrote:

*Ora, i cavalli non frangean la biada:*
*dormian sognando il bianco della strada.*
*La paglia non battean con l'unghie vuote:*
*dormian sognando il rullo delle ruote.*

*Mia madre alzò nel gran silenzio un dito:*
*disse un nome... Sonò alto un nitrito.*

It is repeated in the experience of Heaney translation with Pascoli the involvement among distant elements read on his friend table, his own table of job and peace.

**2- Performing aims as characters**

In ***a generative art process*** the main procedure is to identify a performing aim as a character. This character is able to delineate an unstable system between imaginary and real constraints. This moment is the starting up of an imaginary configuration as a possible iter of the process. As in real world we have more than one possibility in going ahead toward our aim for gaining the expression of our just default character. We have to put on our imaginative table the possibility that our memory for an association process is performing like the embryo of a possible configuration. In this moment we must choose and we have to configure the possibilities as categories. That means to fix the resonant evocations as a system with hierarchy. [5]
In poetry, it is not relevant the objective significant, the number of words and the punctuation of the first model of imitation.
*"I need of something that arouses or stimulates again* ***a memory for the inspiration*** - said Heaney, guest in Rome at the American Academy - *but my images inventory of my infancy is very far from my life as adult".*
May be, it is my interpretation, that Heaney attraction toward Pascoli poems *was also generate* following Pascoli imaginative sounds. In fact Pascoli is considered the most important *onomatopoeic* Italian poet. So in the translation of the sound from Italian to English the figurative words were a kind good help for *generative* chain.
The Pascoli poems are in the Heaney experience like *a constraint* able to generate an imaginative imitation at all original by following ***significance and sound*** as a natural code chain.
Imaginative constraints are able to delineate a process by discovering our own *codeness* as a paradigm of organization of our own ability in giving answers in art procedures. This is an open endless system. More we discover *connections and*

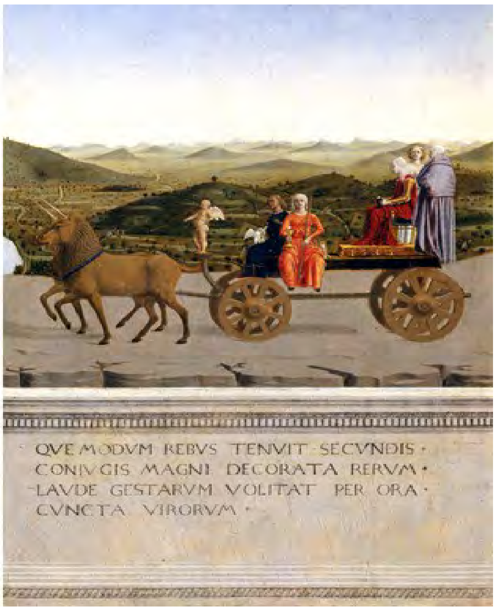
*distances*, more we are able to delineate the complexity to gain. ***Sound after sounds.***

### 3- *"Comprehensiveness"*

Following the concept of ***comprehensiveness*** delineated by Eliot we can discover imaginary constraints as connection from different times generating chain.
*"Every author that embodies such characteristics and is able to maintain a sort of equilibrium between tradition and personal expression, and, above all, each work that expresses in complex way the thematic and the feelings of each own epoch (that possesses, that is, "comprehensiveness") and that is remarkable in the same way in all the literatures, these could be defined classical".*
Words by Seamus Heaney in "*The meeting with the classical Greek and Latin".*
And more in '*Alphabets*' Heaney is found again as a child, reserved **to associate the form of the letters of the Greek alphabet to the familiar objects of his rural world**.

### 4- The point of view: Piero della Francesca [6],*"I Trionfi"* when imaginative constraints meet generative chain

*"Quelli che s'innamorano della pratica senza scienza sono come quei nocchieri che entrano in naviglio senza timone e senza bussola, che mai hanno certezza di dove si vadano. Sempre la pratica deve essere edificata sopra la buona teoria, della quale la prospettiva è guida e porta, "e senza questa nulla si va bene"*
*Leonardo da Vinci, Trattato della Pittura*
*"Those that fall in love themselves with some practice without science are as those helmsmen that enter shipping without rudder and without compass, so they ever have certainty of where are going. Always the practice must be built on the good theory, of which the perspective is guide and door, "and without this nothing is going right"*
*Leonardo da Vinci, Tractatus de Pictura*




The two painted scenes are the *recto* of the portraits of Federico da Montefeltro and of his wife Battista Sforza.

At the first scene we see the Angel crown the commander Federico.
The four figures sat on the wagon represent:
the Justice, the Prudence, the Fortitude and the Temperance.
The inscription of the parapet in low is a Latin writing as on the base of the Roman epigraphs, that wants to exalt the glory of the Duke:
*“It is brought in famous triumph that illustrious that the perennial fame of his virtues worthily celebrates as bearer of scepter equal to the greatest commanders."*
In the second scene the Duchess sits on the wagon, hauled by unicorns as sign of chastity, while she is reading a book of prayers.
The two figures close to her, are the Chastity and the Temperance, while the others two represent the Charity and the Faith.
Always in Latin, the writing celebrates her fame:
*"Who that maintained the moderation in the favorable circumstances flies on all the mouths of men being she decorated with the praise for the deeds of her great husband."*
The sentence is perhaps conjugated to the past for the fact of the death of Battista after the delivery, at 26 aged.
In this case, the writings have a commemorative value, for the reason that they want to exalt the qualities of *the two characters*.
They take back the tradition of the ancient Latin writings (epigraphs).
The words accompany therefore **the figurative text**, but **to the border**.

This 2 painters are a dual mirrored vision connected by an unicum ad continuum landscape. This is an incredible polarity representation, following imaginative constraints, that are painted as an Angel, figures, horses etc. The landscape is the generative chain, working *in an unicum ad continuum* in the 2 pictures.
Piero was the father of all artists from Renaissance until our days for generative artists. He was obsessed from his first age from *numbering*. Piero wrote *De prospective pingendi,* and aged, totally blind, he decided to dictate all his knowledge, as his last testament, to Luca Pacioli. But broking apparently *the chain* (truth is always winner) Pacioli decided to became a monk (they preserved all the ancient oral tradition about numbering) and to publish with his name *De Divina Proportione*, basic tool for the whole opera by Leonardo from *Codices to Gioconda* [7].

Orthographic projection of a tilted head (left), from Piero della Francesca's ***De Prospectiva Pingendi***, Book 3, folio 76v: Seen beside detail from 'Resurrection' circa 1460, by Piero della Francesca, Fresco, Museo Civico, Sansepolcro

***Try*** **to image yourself swimming in a calm sea of imagination. Your pleasure is in connecting several distant moments of your life full of soft odors and melodic sounds. Suddenly the weather changes. The wind become cold and strong, dissipating all your soft sweet remembering. In a just fast moment you became conscious of the distance for coming back to the sea edge. And as a lamp of a sudden storm, your legs become heavy and painful. It's panic. Fast, too fast for your conditions, you try to swim for coming back. As a river without bank, vain words are following down from your mouth. You leave your face in the cold water for darkening the panic and the pain of the body toward your mind. You are alone in the sea full of coldness and of darkness. Tears. A screeching of gull calls you back toward the light. Lightnings of light. In front of you, on the horizon toward the edge, there is a boat and a man, a back friendly, familiar. You feel yourself to be called strongly by name. *Your father's voice*. He turns toward your direction, his face: he is your father: his hand extend toward you, he picks up you with tenderness, he covers you and he embraces you as in your childhood. Suddenly it is produced a natural chain of blood and love.**

***"A song with art in jubilation"***

**So far from the global broken song of our waste land. But you can smile and look to the sky, *still today.* That's all.**

**5- Performing an idea**

When we perform an idea in the design of a generative art process we image an indefinite space in which we are defining the boundary. For activating this operative moment we can use words, geometries, algorithms, etc, in completely interchanging. Once we trace an embryo of limits for translating the abstract vision in a performing logical configuration, immediately we discover that our boundary constraints get an unlimited new near borders invisible from our mind until the new discovering.
So the fist site became the memory of our next discovering and so on.
This process between **memory and new discovering** we can call a generative chain process, able to work for connecting singularity to complexity as natural world.
In the case that our imagination is down and we are not able to perform any *idea /hypothesis* as staring up of our generative art process, another way of working is to use a *catalyst* as detonator of the process able to connect difference generating new assets. This is a very creative moment of *abduction (Pierce).* For great poets this invisible tool was able to configure their own time in their opera following the tradition of their culture, as a generative chain. As already said, Eliot called this process *"comprehensiveness"*.
Main condition for a poet and for all artists is to hear their art tradition voices, as chorus line of their singular voice. Especially if they are innovators. Tradition toward innovation.
There are a lot of people working in art in our time that use the definition of generative art for referring to processes that refer to Markov chain [8]. The structure of these processes is to predefine a set with algorithms of definitions of chance and not transformations in a memory process. By running in computers the program is able in performing randomly the sequence of the results by working directly on a prefixed database without any structure/paradigm of organization. We know that the

random is only configured for the numbering of the list of the results, being each result memory less. As Markov docet. In reality we know that each definition of change in the set configured is in solitude (we are alone when we are memory less) and it attends only its turn in the running process without any rules of harmony and symmetry following the Renaissance tradition. This because it is performed in an analytic way, in a very distant way (Markov defines his chains in 1906) from the complexity gained in our times in a lot of disciplines, *in mathematics and especially in logics, i.e. morphology, topology, fractals, hypothesis ad continuum*, etc.

## 6- Beowulf- Precedents and imaginary constraints: "*So*"

*A poet is born into allegiances to particular areas of places*
*and people, which he loves, sometimes against his will. But then he also*
*happens to belong to an increasingly accessible world.*
*James J. Montague*

*Heaney achieved no small measure of literary stardom with his translation of the Old English epic **Beowulf**. The poem begins as ambiguously as some great modernist works end: **So**. This is as "an audacious swing at in medias res". The epic tradition of beginning a tale in the middle of an action. Heaney' s so is a hard invocation to a reader; it begins the poem almost as though it were in the story core.*
*Heaney's translation took a widely under-read story and made in accessible again. The thousand-year-old saga appeared on many best-seller lists, on countless assigned reading curricula, and could be seen just as easily on public transport as **in a classroom**. It tells the story of a Beowulf, the future king who is called on by a neighboring ruler for help when a monster terrorizes his domain.*
*Heaney's translation has been so successful perhaps because, more than anything else, it reminds readers that literature does not necessarily exist in a vacuum, and is not **for few readers**. A poem survives 1000 years not by being unreadable, but maybe instead by finding an opportunity to present* itself again every so often before a new audience. Perhaps **the art of translation** comes in proving *that works of literature are not plastic, and there are translations that have been able to do this much, and **resuscitate a text** altogether.* [9]

## 7- Ending: *unfinished*

The list of *unfinished artworks* by great poets, painters, artists in several fields is really open. Always we discover a new one. Michelangelo, *Giants*, *Pietà Rondanini;* M. Twain,*The Mysterious Stranger;* Dickens, *The Mystery of Edwin Drood* ;Guido Reni, Turner, Camille Claudel and *so* on. There are a lot of different interpretation on the real deep motivation about this impressive act of paralysis in ending. But the most part of them is defined following an analytical vision. It might be that the significance was lived pure, in an embryo configuration, for reminding the infancy voices on the evidence of the not perfectible skin or page, as a mirroring of the human precariousness as unveiled ash. That is really more impressive, at all. An evident hidden will of *some imaginative constraints for generative chain.*

## 8- Giovanni Pascoli, *"Il fanciullino"* [10]

In verità la poesia è tal maraviglia che se voi fate ora una vera poesia, ella sarà della stessa qualità che una vera poesia di quattromila anni orsono. Come mai? Così: l'uomo impara a parlare tanto diverso o tanto meglio, di anno in anno, di secolo in secolo, di millennio in millennio; ma comincia con far gli stessi vagiti e guaiti in tutti i tempi e luoghi. La sostanza psichica è uguale nei fanciulli di tutti i popoli. Un fanciullo è fanciullo allo stesso modo da per tutto. E quindi, né c'è poesia arcadica, romantica, classica, né poesia italiana, greca, sanscrita; ma poesia soltanto, soltanto poesia, e...non poesia… …..Eccola in due parole. Un poeta emette un dolce canto. Per un secolo, o giù di lì, mille altri lo ripetono fiorettandolo e guastandolo; finché viene a noia. E allora un altro poeta fa risonare un altro bel canto. E per un secolo, o più o meno, mille altri ci fanno su *le loro variazioni*.

In truth, poetry is such a magnificence that if you now make a true poetry, it will be with the same quality of a true poetry of four thousand years ago. How does it happen? in this way: man learns to talk in so much different or so much better way, by year in year, by century in century, by millennium in millennium; but he starts with making the same wails and yelps in every times and places. The psychic substance is equal in the little boys of all the people. And therefore, there is not poetry arcadic, romantic, classical, neither Italian, Greek , Sanskritic poetry; but poetry only, only poetry, and... not poetry…….. here it is in two words. A poet expresses a sweet song. For one century, or down of there, thousand others repeat it flowering and spoiling it; until it comes to boredom. And then another poet makes to re-sing another beautiful song. And for one century, or more or less, thousand others do on it *their variations*.

### 8-1 An ending consideration

In a generative art process, after this investigation, we can affirm that the main condition for a *chain* for being defined *generative* is to be dual/***double,*** in one direction and in a double verse.

### References:

[1] J. W. Goethe:*"La morfologia delle piante";* 2008, Vb, Guanda
[2] S. Heaney,*"Catena umana";* 2011, Mi, Mondadori
[3] **http://www.poets.org/poet.php/prmPID/211**
[4] **http://digilander.libero.it/biblioego/BacHeaneyCatena.htm**
[5] C. Soddu, E. Colabella*: "Generative characters " ;* Mi, GA2013
[6] R. Longhi,*"Piero della Francesca"*;1980, Fi, Sansoni
[7] E. Battisti,*"Piero della Francesca";* 1992, Mi, Electa, A.Mondadori
[8] **http://en.wikipedia.org/wiki/Markov_chain**
[9] **http://entertainment.time.com/2013/08/30/an-appreciation-of-seamus-heaneys-translation-of-beowulf/#ixzz2kunbUwSo**
[10] G. Pascoli,*"Poesie e prose scelte"*a cura di C. Garboli; A.Mondadori,Mi 2002

**Jeffrey M. Morris**

*Paper:* **Collaborating with Machines: Hybrid Performances Allow a Different Perspective on Generative Art**

***Topic: Music***

***Authors:***
***Jeffrey M. Morris***
Texas A&M University, Department of Performance Studies
USA
perf.tamu.edu

***References:***
[1] Brian Ferneyhough, *Collected Writings*, ed. By James Boros and Richard Toop, Taylor & Francis, 1995
[2] David Rothenburg, "Get Out of Whatever Cage" in *Musicworks* 58, Spring 1994
[3] http://www.crackle.org

***Abstract:***
In the simplest view of generative art, an artist creates software, enabling it to make some aesthetic decisions on its own, and then sets it in motion, allowing the software to take over and generate the work we end up seeing. A purist might consider it cheating for the artist to intervene at any later stage. As an improviser and frequent participant in interdisciplinary collaborations with humans, I find the same thrill in collaboration with humans as I find when developing generative agents: the pleasant surprises of unexpected results I never would have thought of on my own. This has led me to explore a variety of possible collaborative relationships with my generative agents, and this has allowed me to reframe the simple view of generative art-making as one point on this spectrum of collaborative relationships.

Whereas in traditional art, the human artist is fully responsible for the pre-production and the final presentation of the work, the simplest view of generative art has the human artist responsible for pre-production and a machine (created by the artist) fully responsible for the final presentation. In actuality, the pre-production phase most often involves a feedback loop in which the artist constructs a system, sets it in motion, evaluates its output, and adjusts the system to behave differently. Some artists, like composer Brian Ferneyhough [1], have left the machine in the pre-production stage, using it only to produce raw material, and manually shaping it to create the final presentation. In contrast to the above models, works like John Cage's *Inlets (Improvisation II)*[2] and Michel Waisvisz's instrument the Kraakdoos (cracklebox)[3] have indeterminate (machine-dependant) decisions built into every performance, leaving the human performer to wrestle with the machine to mutually arrive at aesthetically pleasing results during the performance.

Examination of some of my compositions elucidates and expands this spectrum of possible relationships between human and machine in the final presentation of the work. These performances involve techniques such as complex feedback systems, live coding, physically and mentally strenuous performance conditions, and the "grain" of natural and social phenomena. In this framework, the traditional generative art model can be seen as one point in a rich spectrum of human-machine relationships, and this can pave the way for exploring new relationships. This also allows for reflections on the aesthetics of generative art: the authenticity of the machine's product and the effort of the artist and performer.

***Contact:***
***morris@tamu.edu***

***Keywords:***
Composition, improvisation, instrument design, aesthetics, authenticity, collaboration

# Collaborating with Machines: Hybrid Performances Allow a Different Perspective on Generative Art

**Jeffrey M. Morris, DMA**
*Department of Performance Studies, Texas A&M University,*
*College Station, Texas, USA*
*morrismusic.org*
*e-mail: morris@tamu.edu*

## Premise

In the simplest view of generative art, an artist creates software, enabling it to make some aesthetic decisions on its own, and then sets it in motion, allowing the software to take over and generate the work we end up seeing. [1] Artists who work with generative systems know this process involves a lot of trial and error before finally letting a system run on its own for the public to see. In many situations, an artist may take an editorial role and select, arrange, or adjust the output of the system before being viewed by the public.

As a musical improviser and frequent participant in interdisciplinary collaborations with humans, I find a similar thrill in collaboration with humans as I find when developing generative agents: the pleasant surprises of unexpected results I never would have thought of on my own. My preferred tool (for myself and for my students) is the Max graphic programming environment [2], because its real-time operation allows for programming development through *improvisation* (i.e., trying out “what ifs” as we think of them) instead of staged experimentation (i.e., write code, compile code, evaluate results, decide to keep or edit the code). Besides making it easier to discover fortuitous accidents, this improvisational process engages different mental processes. This trial-and-error stage is worth discussing in the context of creating generative art, but as demonstrated in the simple model above, it is easy to overlook.

Many of my musical creations highlight the trial-and-error stage of the process by putting it *on centre stage*: composing environments in which computer and human performers collaborate on stage to realize a musical performance. This has led me to explore a variety of possible collaborative relationships with my generative agents, and this has allowed me to reframe the simple view of generative art-making as one point on this spectrum of collaborative relationships.

## 1. The Production Process as Collaboration

In traditional composition, a composer writes all the notes and a performer plays all the notes. Up to a certain level of ability, the performer acts as a music playback system, hopefully a “high fidelity” one. However, we readily recognize that the best performers bring their own influences to the composition and somehow make the performance unique and more rewarding than a simple high fidelity reproduction of the composition: outstanding performers are celebrated for the nonlinearities they introduce. They add substance to the performance and somehow make it something more than what the composer created alone.

The twentieth century saw many examples of indeterminacy used in musical compositions, in which more demands were placed on performers to make creative decisions before the composition could become complete and ready to play, more than simply providing an expressive interpretation of fixed notes. Works like these might be placed along a continuum of substance contributed by the composer or the performer.

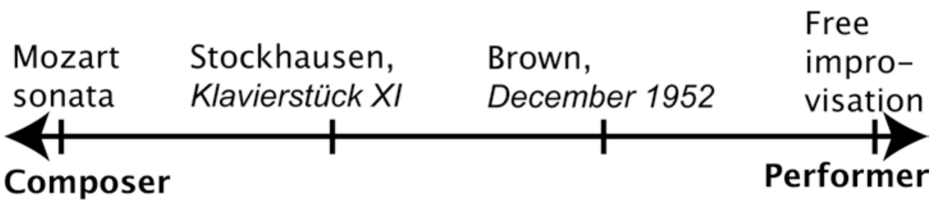



*Figure 1. Continuum of relative substance contributed by the composer and performer for a few example musical works. [3,4]*

This framework makes a clear distinction between pre-production (the role of the composer) and presentation (the role of the performer). In traditional art forms, the human artist is fully responsible for the pre-production and the final presentation of the work. The simple view of generative art has the human artist responsible for pre-production and a machine (created by the artist) fully responsible for the final presentation. In actuality, the pre-production phase most often involves a feedback loop in which the artist constructs a system, sets it in motion, evaluates its output, and adjusts the system to behave differently. Some artists, like composer Brian Ferneyhough [5], have left the machine in the pre-production stage, using it only to produce raw material, and manually shaping it to create the final presentation. In situations like this, the workflow of the pre-production stage becomes complicated to trace. So, let us consider works in which creative decisions are made by both human and machine in a more easily defined space: on-stage during live performance.

John Cage’s composition *Inlets* [6,7] instructs performers to hold and tip water-filled conch shells, which will cause them to produce very sparse gurgling sounds. However, while a shell won’t gurgle until the performer tips it, the performer cannot force the gurgle to happen at any particular instant. There is a degree of randomness built into the instrument. Michel Waisvisz’s instrument the Kraakdoos (“cracklebox”)

[8] is a simple yet complex instrument based on an amplifier circuit in a feedback loop with six body contacts for the performer to complete the circuit (with artistically-valuable infidelities) by completing the circuit with his or her own skin (by lightly touching the pads). Both *Inlets* and the Kraakdoos bring indeterminate (machine-dependant) decisions built into every performance, leaving the human performer to wrestle with the machine to mutually arrive at aesthetically pleasing results during the performance. They are like the indeterminate compositions described above. However, these works allow us to limit our focus to onstage events during performance, and they draw distinctions between human and machine, instead of pre-production and presentation.

So, let us combine these ideas and consider generative art in terms of the human instrument builder and the randomness of the machine, live on stage in performance.

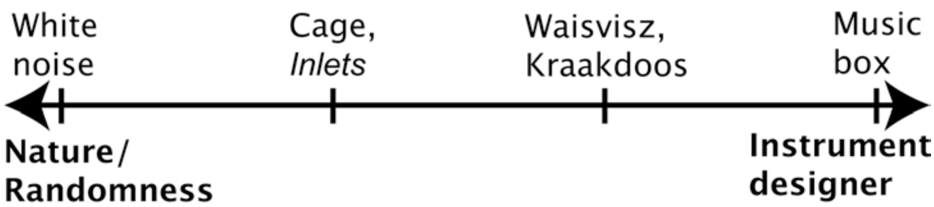



*Figure 2. Continuum of relative substance contributed to a performance by the instrument designer and by nature or pseudorandom processes.*

This diagram requires some discussion before moving on. Clearly we can't equate every musical instrument designer with composers. In this diagram, "instrument" refers to a music-creating machine with an increasing degree of determinacy toward realizing *one* musical performance, one "composition," as a music box does. When we normally think of musical instruments, we think of "universal" or "neutral" ones capable of playing (seemingly) any composition, for example a piano. In this discussion, however, we are considering substance contributed to a single, specific performance, and the makers of traditional (neutral) instruments don't contribute much substance to the realization of specific performances. (The influence of neutral instruments is worthy of considering, but at another time.)

## 2. Cheating and When We Care About It

We have been discussing *substance*, and I mean this in the ontological sense: what makes an artwork a "work" in the first place, what factors/roles contributed to its identity as a work, and how substantial that identity is. [9] This allows us to examine situations when a human artist designs a machine, sets it in motion to produce results, and then intervenes/edits those results before presentation: is this cheating? Well, it *can't* be cheating unless someone has broken rules. A generative art purist might consider it cheating for the artist to intervene at any later stage, but it can't be "cheating" as such. It might be *lying*, if the artist falsely suggests that the public is seeing the unadulterated output of an algorithm, but this is subject to the way a work is presented and the context outside the work itself.

I believe we would tend to agree that while it may not be fruitful to consider whether a practice is cheating, an unadulterated generative work has more substance. That fact makes the work more special, in a way akin to Walter Benjamin's idea of *aura*. [10] We feel differently about a work when we know it was created with certain notable constraints. Be it more authentic, rare, or impressive, the substance of the work is somehow increased in our minds. Therefore, aside from discussions of cheating or dishonesty, the substance of a generative work can be lessened by editorial intervention by its human creator.

What we can learn from this discussion is that this kind of integrity, authenticity, etc.—however you want to name it—is something we care about. *That* in turn means it is something that can be manipulated as an expressive element in an artwork, building and resolving tension to shape the experience.

## 3. Example Performances

The following is a brief discussion of generative performances of mine that allows us to apply the frameworks laid out above: live performances that explore relationships between human and machine creators and expressively exploit issues of substance. These performances relate to the category called Live Algorithms [for Music] as defined by Blackwell and Young, [11] except that discussions of live algorithms typically place more emphasis on the machine's ability to hear and understand the human performers, whereas my works explore a variety of relationships between human and machine and favour the simplest form of machine listening/cognition that would be effective for each performance situation—this often means that the machine isn't "hearing" or "understanding" the human in ways like the human is hearing and understanding the machine. I believe this ends up contributing to the substance and discussion-worthiness of the works in the end.

### 3.1 *Elektro* and *Tappatappatappa*

In 2005, I created an automated live sampling environment for solo cello titled *Zur Elektrodynamik bewegter Cellisten* ("*Elektro*" for short). Even though it is a non-traditional composition (on which we won't focus in detail here), I composed it using the traditional model described above: I created the composition in cycles of trial and error, then delivered it to the cellist to perform. During this trial-and-error stage, however, I made a quite fortuitous accidental discovery that ended up yielding a distinct generative performance I ended up titling *Tappatappatappa*.

The nature of *Elektro* is that it does not contain any sounds of its own to play. It captures sound from the soloist, folds it upon itself into intricate counterpoint (via various applications of digital delays), and reintroduces the transformed material to the performance, allowing the human performer to respond in turn. With regard to Blackwell and Young's machine listening, the software only tracks the amplitude envelope of the soloist, allowing the software to opt to play in tandem with the soloist, invert the envelope so that it may trade off with the soloist, delay the envelope so that it echoes the soloist, or ignore the envelope so it seems independent of the soloist.

During the trial-and-error stage of creating *Elektro*, there were several times in which I needed to provide a simple input sound in order to confirm that the software was processing and responding to the sound as I intended. The simplest way to do this was to tap on the internal microphone on my laptop and listen to the results through its internal speakers. Since the microphone was very near the left internal speaker, feedback loops would easily form during these tests. While this was inconsequential to developing *Elektro*, it made clear to me that this system was vibrant and ready to sing in its own voice if allowed to do so—that is the performance I call *Tappatappatappa*, using the same software as *Elektro* but with a feedback loop instead of a soloist.

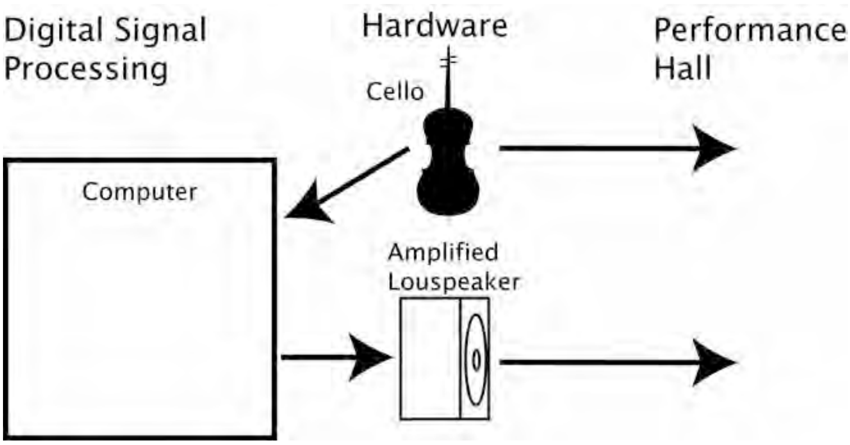



*Figure 3. Configuration for Elektro.*

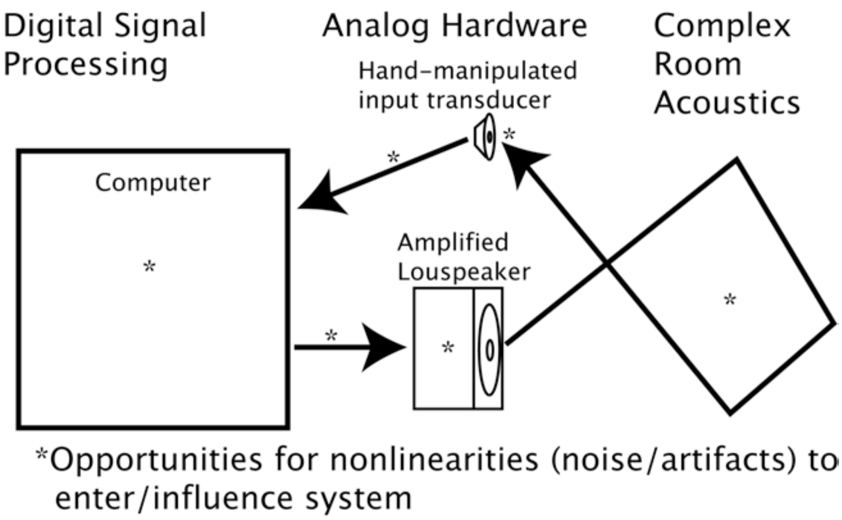



*Figure 4. Configuration for Tappatappatappa.*

In *Tappatappatappa*, the human performer is only able to guide/coax/steer the emerging voice of the complex feedback system. This system has digital, analog, and acoustic stages, and each stage introduces its own nonlinearities that end up creating the sound heard in performance. It is an emergent beast and the human is merely its tamer (hardly its master). The human performer is only able to:

1. Make small changes to the length of the acoustic portion of the feedback loop by moving the input transducer around in space,

2. Introduce small sounds into the system by tapping or stroking the input transducer, as if providing a grain of sand to allow pearls to form, and

3. Trigger the software to move on to its next selected mode of behaviour and musical structure at a specific moment (the software will ordinarily change modes on its own; when the performer triggers a change, he or she cannot specify what mode to change to, only that the change occur “now”).

*Tappatappatappa* can be thought of as a musical instrument, but one in which its own computation becomes the resulting sound: a *computation instrument*. [12] The beauty (if harsh) of this instrument’s voice may be explained by Stephen Wolfram’s principle of computational equivalence: “…almost all processes that are not obviously simple can be viewed as computations of equivalent sophistication.” [13] Wolfram goes on to suggest that processes humans perceive as complex or beautiful are perceived that way because the processes themselves are as sophisticated as the humans perceiving them. Such systems make it, as Gary Flake puts it, “easy to forget that the rules are really in place.” [14]

The substance of this piece lies in the facts that it includes sounds I don’t know how to make any other way, its results are highly unpredictable (risky, even), and its results are unique to the current performance situation: the room acoustics, and the sounds currently resonating in the system. In performance it bears resemblance to the “human editor” model of pre-production in that the human performer has a form of “veto power,” but it turns the power structure upside down: the human is at the mercy of the machine.

### 3.2 *A Treatise on the Æsthetic of Efforte*

*Treatise* (for short) also places the human performer in a precarious position, but this time it is strenuous both physically and mentally. In its essence, it is a live coding environment for MIDI-controlled Yamaha Disklavier piano. To this, the environment adds an requirement for “breath control.” The performer must blow into a microphone producing noise in seven frequency bands in order to fill seven corresponding virtual bellows that scale the volume of any note triggered as if they were real bellows powering a reed or pipe organ. This not only adds the mental strain of maintaining this unusual form of volume control, but it creates the physical strain of producing so much wind motion, and doing so puts the performer in an unusual (sometimes light-headed) mental states.

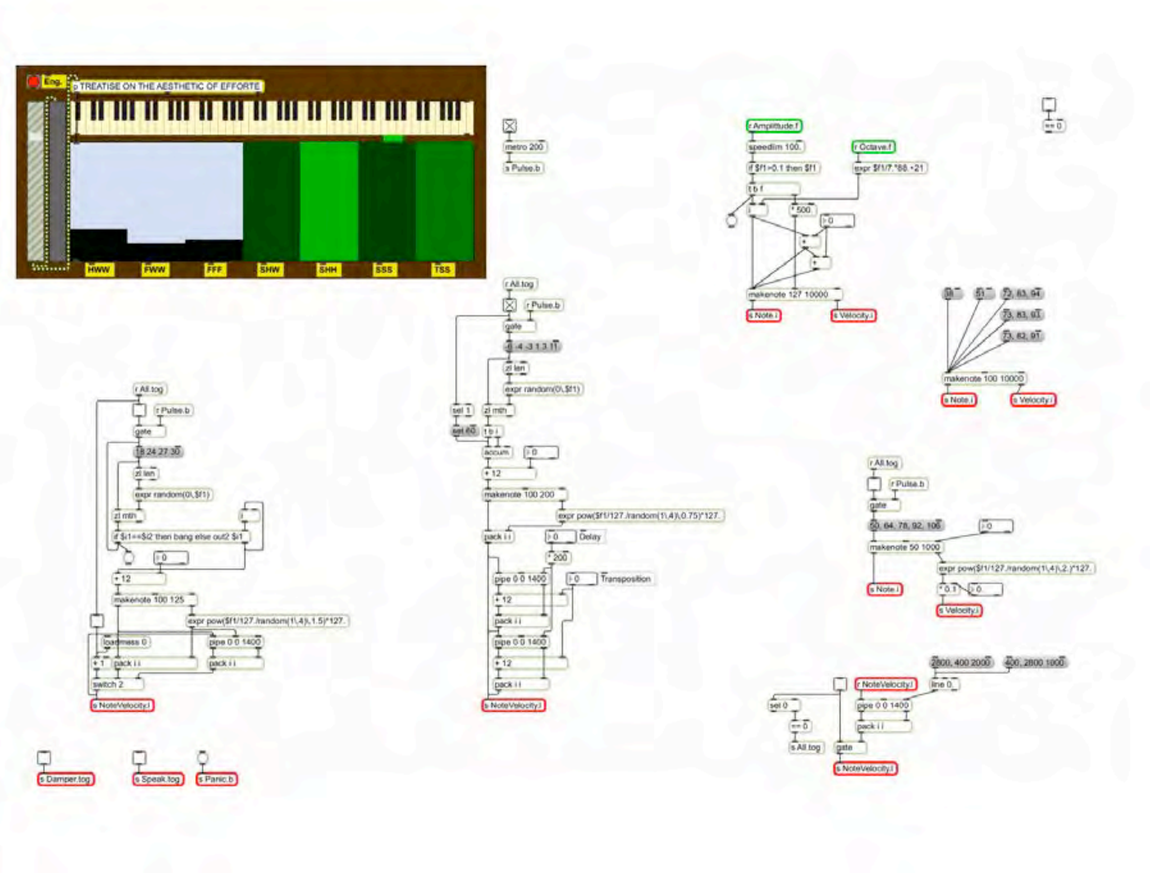


*Figure 5. Performance screen for* Treatise*. The virtual bellows are reflected in the upper left corner. The rest of the screen is open for live coding of MIDI instructions during performance (in Max).*

In this piece, it is almost as if the human is the one that is prepared and then let loose to see what comes out instead of the human letting the algorithm run free. The substance of the piece lies partly in the fact of this precarious situation of the performer and also in the specialness of the creative decisions the performer makes while in this state: under pressure, strained to certain limits, and a bit dizzy.

### 3.3 *The Collected Works of Ferin Martino as Conjured by Your Presence*

Ferin Martino is the human-like name I gave to a piano-playing algorithm I created. When presented as an interactive art installation, the algorithm proceeds in making piano-playing decisions on its own, but its decisions are disrupted by the input from a camera focused on the visitors. Simple frame differencing and mass calculations yield a single value corresponding to the amount of movement in front of the camera, and this value shapes the activity level of the note-making decision processes in the algorithm. This means that increasing or decreasing motion in front of the camera disrupts the music the algorithm would have played on its own. Because it builds structure by recombining material from its short-term memory, a single disruption can cause the music to spin off in a new direction very quickly. Because the algorithm regularly changes its modes of response to input (in decidedly unsophisticated ways despite their complex results), spending some time with the installation evokes a sense of a playful character on the part of the software. At times it may accompany motion in literal cartoon-like ways, at other times it may provide sensitive accompaniments to complement the motion it sees, and at other times it may seem to ignore the motion.


*Figure 6. The frame-differencing camera view of Ferin Martino that disrupts the piano-playing algorithm as it performs. Here, the viewer has just waved his hand around in the area between himself and the camera, so that area appears the brightest.*

In contrast to the last two pieces discussed, *Ferin* does not involve danger of failure, but its specialness does derive from a similar phenomenon. Once you have observed the work, it has necessarily changed, and so the true "complete works" of Ferin Martino are something one can never truly hear. After spending time with it, you may begin to question whether you caused the musical gesture just played or if it was a coincidence. The risk involved here is the precious tenuousness of your understanding of the relationship between the machine and the human contributions. It is delicate and ephemeral. Authenticity is ungraspable, washed away by the viewer's own observation of it.

# 4. Conclusion: Posthuman Performance as an Analytical Platform

## 4.1 Asking Questions

McCormack, et al [15] ask, “What new kinds of art does the computer enable?” Besides processing previously unimagined amounts of data and structure, let us not forget that doing so quickly also means the ability to do some of that work in real time. Besides the convenience of quick results, this means we gain the opportunity to see these structures played out as performances, these processes applied as improvisations, and we in turn gain the opportunity to engage them with our improvisational mindsets, not just the mindsets of incremental experimentation. This facility allows our tools to step up to the level of being our collaborators, and it allows for us to analyze them as such. McCormack, et al also ask what generative art can teach us about creativity and about art. I believe real-time collaboration with our algorithms will be an invaluable platform for us to learn those lessons.

In his imagined conversation on the topic, Galanter [1] asks, “Isn’t generative art about the issue of authorship?” and proceeds to assure us that generative art tools are independent of the meaning an artist may wish to convey. I agree, but I hasten to point out that generative art is special in its ability to illuminate issues of authorship, and as shown above, it can manipulate our sense of those issues (authenticity, presence, causality, etc.) as an expressive element in an artwork.

Galanter’s question is so pertinent because of our acute sensitivity to issues authorship, or more broadly, authenticity. In a chapter analyzing virtuality in art, I have proposed a framework in which we examine an artwork in terms of where and why the mental model it builds eventually fails. [16] In one kind of work, the mental model “fails” the human viewer, causing the viewer to “pop out” of the world the work has tried to evoke. Sometimes this is an opportunity for one to ask oneself why the work existed, to reflect on a second level of meaning, for example, “Why would someone mass produce prints of soup cans and put them in galleries?” In another kind of work, the human “fails” the model, meaning that some part of the viewer’s abilities, sensibilities, disposition, or habits of self control have broken the aesthetic experience. (In an extreme example, “This performance artist is naked, bleeding, and freezing—we have to stop the performance and get her medical attention.”)

This moment of popping out gives one a chance to see oneself *seeing* the work, to notice how and what it made one think and perhaps learn something about oneself in the process. In situations like that, we get a chance to glimpse ourselves from the outside.

## 4.2 Posthuman Performance

Galanter [1] also ponders, “Is generative art modern or post-modern?” and explains that it is ideologically neutral. Again, I agree, but I hasten to raise a point at the opportunity. Aside from that discussion (pitting modernist science against postmodernist humanities), it may be more fruitful to consider generative art in the ways in which is it *posthuman*, not meaning against or abandoning the human, but the ways in which it evokes perspectives *outside* the human. Works like these can be called posthuman because the influence of nonhuman elements upon creative decisions is overt—this is a more objective assertion than discussions of [post]modernist aesthetics. These works lend themselves to analysis in posthuman terms. [17]

In this paper, I have examined generative art not as a solution to the problem of defining creativity or art itself, but to show that hybrid performance can be a platform to let us reflect on those things in order to better understand them and apply that understanding to traditional forms of art. Collaborative generative performance situations like these give us ways to step outside ourselves, to see *seeing*, hear *hearing*, create *creating* and watch it unfold, partly as a third party. They allow us to view the *human* from the outside—this unique perspective offered by posthuman art is easy to overlook with minds curious to know the future of art. This allows us to begin to notice the more subtle but significant influences of technology on human creativity as we examine more traditional forms of art and ask, "Which artworks are indeed purely human after all?"

## References


1. Galanter, P. 2003. What is Generative Art? Complexity theory as a context for art theory. *International Conference on Generative Art.* Milan, Italy: Generative Design Lab, Milan Polytechnic.
2. Cycling74. Max. Computer software application. www.cycling74.com [accessed 10 November, 2013].
3. Stockhausen, K. 1956. *Klavierstück XI*. London: Universal Edition.
4. Brown, E. 1952/1954. *December 1952*. In *Folio and 4 Systems*. G. Schirmer.
5. Ferneyhough, B. 1995. *Collected Writings*. Boros, J. and Toop, R. eds. Taylor & Francis.
6. Cage, J. 1977. *Inlets*. Edition Peters.
7. Rothenburg, D. 1994. "Get Out of Whatever Cage." *Musicworks* 58.
8. Waisvisz, M. Kraakdoos. Electronic musical instrument. www.crackle.org [accessed 10 November, 2013].
9. Morris, J. 2009. Ontological Substance and Meaning in Live Electroacoustic Music. *Computer Music Modeling and Retrieval: Genesis of Meaning in Sound and Music*. Kronland-Martinet, R. et al, eds. Berlin: Springer Verlag.
10. Benjamin, W. 1936/1969. The Work of Art in the Age of Mechanical Reproduction. *Illuminations: Essays and Reflections*. Arendt, H., ed. Schocken.
11. Blackwell, T. and Young, M. 2005. Live Algorithms. *Artificial Intelligence and Simulation of Behaviour Quarterly* 122: 7-9.
12. Morris, J. 2008. Embracing a Mediat[is]ed Modernity: An Approach to Exploring Humanity in Posthuman Music. *Performance Paradigm*, v. 4.
13. Wolfram, S. 2002. *A New Kind of Science*. Wolfram Media. www.wolframscience.com/nksonline [accessed 10 November, 2013]. 716–717.
14. Flake, G. 1998. *The Computational Beauty of Nature: Computer Explorations of Fractals, Chaos, Complex Systems, and Adaptation*. MIT Press. 11.
15. McCormack, J., et al. 2012. Ten Questions Concerning Generative Computer

Art. *Leonardo* (to appear, accepted July 2012). MIT Press. Extended version at http://jonmccormack.info/~jonmc/sa//wp-content/uploads/2012/10/TenQuestionsV3.pdf [accessed 10 November, 2013].
16. Morris, J. Humanness, Elevated Through its Disappearance. 2011. *Meta-Plasticity in Virtual Worlds: Aesthetics and Semantics Concepts*. Mura, G. ed. Hershey, Pennsylvania: IGI Global. 116.
17. Gomoll, L. Posthuman Performance. 2011. *Total Art*. 1:1.

**Jon M. R. Corbett**

# *Apophenia and Celestial bodies: Ancient origins of the pixel*

***Topic: Art History***

***Author:***
***Jon M. R. Corbett***
University of British Columbia, Department of Creative Studies
Canada,
ok.ubc.ca

***References:***
[1] John H. Rogers, "*Origins of the ancient constellations*", Journal of the British Astronomical Association, 1998

[2] Laura U. Marks, "*Enfoldment and Infinity: An Islamic Genealogy of New Media Art.*" Cambridge, MA: MIT Press, 2010

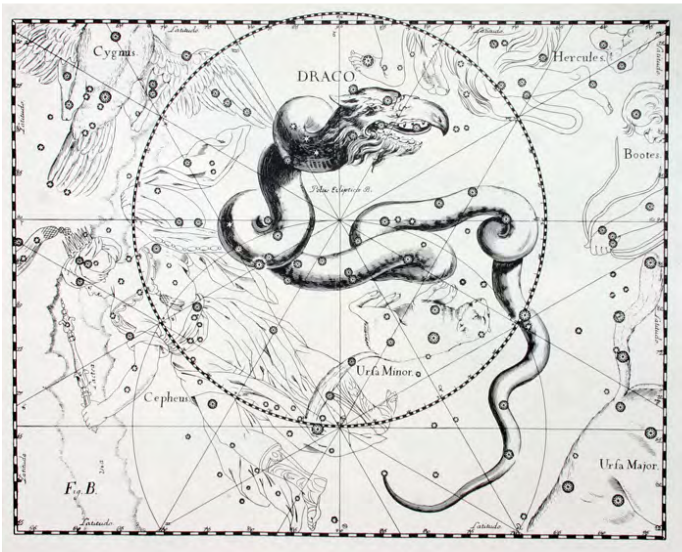
[3] Richard F. Lyon, "*A brief history of 'pixel'.*" Electronic Imaging 2006. International Society for Optics and Photonics, 2006.

***Abstract:***
Despite popular perception, the pixel, the smallest visible element used in digital expression, actually has a history that goes farther back than most of us realize. Although, contemporary generative art has evolved from the coalescence of artistic practices and technology, it is the added innate function of the human brain to form meaningful imagery from a variety of visual stimuli that has provided the primary environment in which the pixel is employed.

Though a pixel can be viewed merely as a container for smaller digital elements (for example RGB color values), it is the smallest visible component a viewer interacts with in the digital world. It is the role of the pixels in a collection to provide the viewer with the necessary information required to create a meaningful image. The human brain has an incredible capacity to link, reference, and formulate meaningful structures from visual information even where the stimuli is limited, selective, random or meaningless. This is a phenomenon known as apophenia.

Utilizing apophenia as the vehicle for exploration, this paper will trace the trajectory of pixel evolution from Bronze Age Mesopotamia (~1500 BC) through the early 20th century. The purpose of this investigation is to not only establish the greater history of the pixel in image construction, but to provide a greater context for understanding the inherent modes of human perception and how these ideas interact with, inform, and alter our experiences with works of generative art.

*Example: Draco (constellation) by Johannes Hevelius, 1690, illustrates the human capacity to generate meaningful imagery from a collection of random 'celestial pixels'*




***Contact:***
[***j.corbett@ubc.ca***](mailto:j.corbett@ubc.ca)
[***joncorbett@live.ca***](mailto:joncorbett@live.ca)

***Keywords: pixel, apophenia, perception, art history, celestial***

# Pixels from Heaven: Apophenia and the Ancient History of the Pixel

**Jon M. R. Corbett, BFA**
*Department of Creative Studies*
*University of British Columbia, Canada*
*email: joncorbett@live.ca*

## Abstract

Despite popular perception, the pixel, the smallest visible element used in digital expression, has a history that goes farther back than most of us realize. While contemporary generative art has evolved from the coalescence of artistic practices and technology, it is the human brain's ability to create comprehensible imagery from a variety of visual stimuli that provides the primary environment in which the pixel is employed.

Although a pixel can be considered simply as a container for smaller digital elements, it is the smallest visible component a viewer interacts with in the digital world. The role of pixels in a collection is to provide a viewer with the necessary information required to create a meaningful image. The human brain has an incredible capacity to link, reference, and formulate coherent structures from visual information even in cases where the stimuli are limited, selective, random or meaningless. This phenomenon is known as apophenia.

Utilizing apophenia as the vehicle for exploration, this paper will trace the trajectory of pixel evolution from Bronze Age Mesopotamia (~1500 BCE) through the early 20th century. The purpose behind this investigation is to not only establish the greater history of the pixel in image construction, but also to provide a greater context for understanding the inherent modes of perception and how these ideas interact with, inform, and alter our experiences with works of generative art.

## Introduction

Over the past four thousand years, the imagery found and generated within mediums as varied as the heavens, paintings, television and computers all share a common component – the pixel. It is the minutest and simplest element in any image. The definition of pixel or picture element varies in interpretation based on the context of the media or apparatus used, but in all contexts it is the smallest controllable visual component in a given display space. As such, it has played an extraordinary role in the advancement of image representation, information transmission, color theory, and even the development of a unique pixel aesthetic in the digital art world and traditional art practice.

In this paper I will discuss how the modern pixel and its related aesthetical characteristics were founded in ancient celestial apophenia, and further, how the role and use of the pixel has evolved through both traditional and technological art forms. Additionally, I will provide a short historical survey of artwork illustrating the evolution of the pixel-aesthetic, and how this foundation is being utilized in modern generative art practices. Finally, I will explore the future of the pixel as an essential artistic tool in the digital arena of visual art production.

## Ancient History of the Pixel

### Mesopotamia (~1500 BCE)

Given that nearly every image is merely a composition of points, lines, and planes [1], the pixel theoretically is evident in nearly all forms of visual art. The key characteristics of the pixel are: one, that we usually observe it as an illuminated point, and two, that a series of pixels are required for the formation of an identifiable image. Similarly, these two characteristics are present in the celestial identification of the constellations. Understanding that stellar constellations are illuminated points forming meaningful images on a night sky is an important step in relating how images are formed within our minds, and how we use these points to transmit information. One of the fundamental roles of a pixel beyond its contribution to an image's make-up is its ability to relay information. Whether it is the red, green, and blue values in our digital displays or the location of the North Pole, the pixel serves several functions. Sky-maps used in ancient Mesopotamia and the Mediterranean around 3200 BCE were mnemonics primarily used for time and calendar keeping, navigation, and farming [2]. Despite this, it was the physical documentation of the first zodiac constellations in Mesopotamia around 1500 BCE where the first pixels received life in recorded form; these images were the most likely source for the Greek classical constellation maps of the sky found around the 5th century BCE [3].

### Greece and Rome (~500 BCE to ~200 CE)

*Figure 1. Aion, god of time with Zodiac (detail). Central part of a great floor mosaic from a Roman villa. ca. 200–250 CE.*

As constellations developed and sky-maps became more uniform, the Greeks developed a more formal set of 48 constellations from the various traditions, including images of the zodiac [4]. However, images of the zodiac were not restricted to the sky, artistic development during this period found their way into mosaics. The mosaic is a large image composed of smaller particles, whether they are pebbles or colored glass, and mosaic tradition is one of the earliest examples of pixelated art (Figure 1). Ancient mosaics were not typically rigidly aligned, nor were they structured in the gridded formation of our modern digital displays, but they did provide the creative foundation that the digital mosaic of the 20th century would eventually build upon.

**Iran (1000 CE)**

In terms of pixel-related characteristics, the next evolution of the pixel/point occurs in the 9th century CE when the concepts of atomism found in Islamic art and architecture coincided with our modern application of the pixel. Whether the elaborate construction of *muaqarnas* domes or the Islamic calligraphy built on the standardized element of an individual square or rhomboid, media theorist and artist Laura Marks establishes that these characteristics form “a strong parallel in computer-based media that makes it impossible to know the relationship between pixel-based image and underlying software” [5]. This theoretical framework is also evident in Kandinsky’s distinction of the line as merely a collection of connected points [1], yet another reflection of how constellations are representative of spatially distributed pixels in the sky connected through the apophenic capabilities of the human mind.

## Modern History of the Pixel

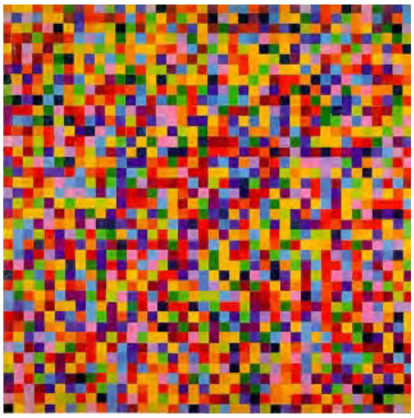
**Traditional Art Media**

There is a paradox that exists in the visual arts when discussing the pixel as an artistic component of art production; it is a paradox born of synchronicity. The pixel in the modern sense is a digital element, used far more often in technology than in the traditional art world. However, the evolutionary trajectory of the electronic pixel coincides with the development of divisionism (also referred to as *chromoluminarism*) in painting. Because these two mediums evolved relatively independently up until the 1960s, I believe it is more practical to investigate them individually.

From an art world perspective, the origins of the modern pixel aesthetic emerged with Georges Seurat and Paul Signac in the 1870s. Their creation of pointillism is heavily reliant upon the concept of divisionism – a style of painting that relies on the optical mixing of separated individual dots or patches of color [6-7]. The breaking apart of the picture into individual components was a vital step not only in the theory of color and optics, but was instrumental in the development of abstraction and a rethinking of what composes a picture. Divisionism, therefore, was at the forefront of a deconstructionist movement in the art world that included other art forms like cubism, fauvism, and Dadaism. In addition to this separation of an image's components, the use of systematic and mechanical instruments also came into popular use with artists. One of the most common tools early artists utilized was the grid, not just as a guide but as a formal construction element and critical visual component. An early example of imagery produced with a grid and separated color or tonal elements can be found in the work of Jean Arp and Sophie Taeuber. For example, "*Duo Collage*" (Figure 2), despite being Dadaist in its construction, is inseparable from the "historical context of mechanization that […] gave rise to [its] creation" [8]. In this way, the grid further pushed art imagery towards a foundation that is shared with digital media. Over the past hundred years artists have been exploring the grid and solid color segregation in numerous ways, one of the best examples of this early form of the pixel aesthetic can be found in the work of Ellsworth Kelly.

The deconstruction/construction and abstraction of color and the diagrammatic has become a very prominent feature in modern art – from early artists like Piet Mondrian to contemporary artists like Chuck Close. The use of the gridded element frame or cell is as firmly rooted in contemporary artistic practice as it is in the current digital world. Perhaps one of the earliest artists to create artwork that utilized both the grid and solid color blocks is Ellsworth Kelly. In Figure 3, Kelly's arrangement of random color swatches is so visually related to 8-bit computer graphics that it is hard to believe this work was created close to 40 years before computer graphics were utilized in an artistic manner. It is the deconstruction and abstraction of traditional artistic elements and the greater use of mechanical tools and systemic approaches to art creation that has allowed artists to develop a unique aesthetic that is now further enhanced by the digital world. In fact, it is this diagrammatic abstraction that Buchloh describes as being…

*"the one variety […] that explicitly recognizes externally pre-existing systems of spatio-temporal quantification or schemata of statistical data collection as the necessary and primary matrices determining a pictorial/compositional order […] And while the diagrammatic would most likely operate in tandem with these other matrices, it would be sufficiently differentiated to be recognizable as a distinct episteme within the highly differentiated gamut of non-representational painting."* [9]



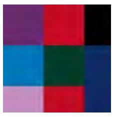
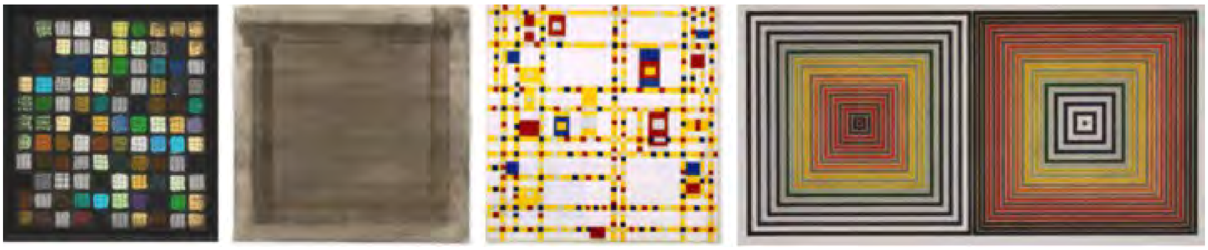


*Figure 2.* *Figure 3.* *Figure 4.*

*Figure 2. Jean Arp and Sophie Taeuber. Duo Collage. 1918.*
*Figure 3. Ellsworth Kelly. Spectrum Colors Arranged by Chance III. 1951.*
*Figure 4. Gerhard Richter. 4900 Colors: Version V, Plate 9 of 10. 2007, Fondation Louis-Vuitton pour la création, Paris.*

With respect to Gerhard Richter's "4900 Colours" (Figure 4), Buchloh's discussion exemplifies what makes Richter's presentation different from Kelly's. At the same time his observation can easily be extended to digital art and more specifically the pixel-aesthetic. Richter's "4900 Colours" are panels of isolated color blocks that appear to be random, but his color arrangement is actually determined by computer prior to being rendered in enamel and plastic. This work could have easily been produced digitally, as the final visual exhibition is very demonstrative of the pixelized world common to low resolution digital imagery. Richter's use of the computer as a tool to assist the random assignment of each color's location makes this work rather ironic when considering that the end result is not just facilitated by a computer, but is itself visually representative of the digital world. From Arp to Richter this short survey of how the pixel aesthetic has evolved in modern art is only a small selection of a much larger history of artists (including Joseph Albers, Agnes Martin, Piet Mondrian, and Frank Stella – see figure 5) who explored the distinctive realm of the diagrammatic that gave rise to an aesthetic that bridges traditional art with our new technological age. This is an important aspect in understanding the role that traditional art plays in this new aesthetic and is essential knowledge to consider as we look at the evolution of the digital pixel and the way these two seemingly separate disciplines have amalgamated into one unique aesthetic movement.



**a.** **b.** **c.** **d.**

*Figure 5.* ***a*** *– Josef Albers. Gitterbild (Lattice Picture, Also Known as Grid Mounted). 1921, Tim Nighswander/Art Resource, NY;* ***b*** *– Agnes Martin. Wood I. 1963, Gift of Sally and Wynn Kramarsky, The Museum of Modern Art, New York;*
***c*** *– Piet Mondrian. Broadway Boogie Woogie. 1943, The Museum of Modern Art, New York;* ***d*** *– Frank Stella. Double Gray Scramble. 1973. Gemini G.E.L., Los Angeles, Museum of Modern Art, NY.*

**Digital Art Media**

Although the term 'pixel' has only been a part of our modern lexicon since the 1960s [10], its conceptual origin coincides with Seurat's development of pointillism. The "*bildpunkte*—literally picture points" [10], was used by German photographer

Hermann Vogel in the 1870s, and was first described in print in Paul Napkow's German patent for the "*Elektrisches Teleskop1*", the first electromechanical television, in 1884 [11]. Even though these two conceptual frameworks would not come together until several decades later, I believe it is important to note that the modern pixel was actually developed synchronously with pointillism/divisionism and abstraction and is not an invention of the modern computer age. The continued deconstruction and abstraction of the picture in the visual arts early in the 20th century was a crucial step to the future marriage of the *dot* as an artistic device in digital media. Digital art as we know it today is actually the result of over a hundred years of creative exploration and innovation in both the art world and technology. It is worth noting that the introduction of divisionism thrust the painted *pixel* into existence through deconstruction whereas *bildpunkte* is a component required for the construction of an image in a new electronic medium. The pixel is typically considered to be "the smallest single component of a digital image," but it's true definition is very much subject to the context in which it is used. Although "aesthetic theories suitable […] for computer art [were] still in their infancy" [12] in the 1970s, without the development of these theories the use of the pixel as an artistic device would not have evolved into a core component of the contemporary visual aesthetic now intrinsic to digital and new media art. The modern pixel aesthetic in pre-computer art is composed of three unique properties that are shared by its modern digital sibling. Those properties are founded in the science and mathematics of optics (including color and perception), geometry, and the mechanization of art making processes. But in order for the age of computers to be brought into the realm of art making there must be an accepted legitimacy by the art world. The birth and evolution of most art movements are typically not experienced in real-time. That is to say, in order for a new art movement to become instituted within a culture it requires time for it to be reviewed, studied, and critiqued before it can be embraced or legitimized. I assert that the pixel aesthetic in art practice has incubated sufficiently to be recognized as a legitimate artistic movement in its own right. Baumann observes that success in the art world generally relies on three factors: a change in cultural opportunity space, the institutionalization of resources and practices, and a legitimating ideology [13].

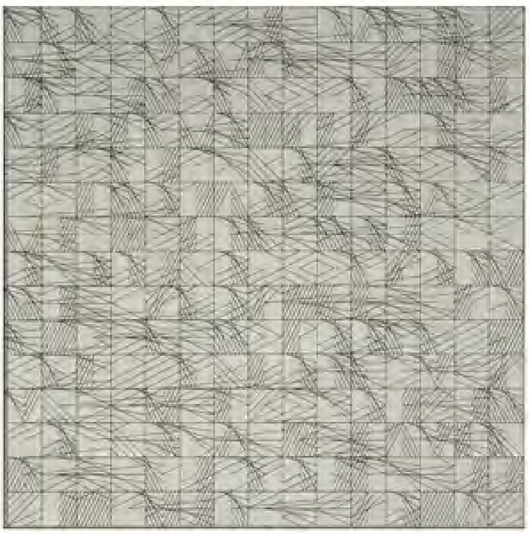


*Figure 6. Vera Molnár. Untitled. 1969, Musée National D'Art Moderne Centre Georges Pompidou, Paris.*

Hindrances to creative research must be overcome and a space free from the social-psychological connotations associated to conventional aesthetics [14] would be required in order for a new environment of digital art to get a foothold. The rapid development of early computing technologies proved to be an ideal opportunity space, while artists and computer scientists alike provided the experimentation that laid the groundwork for the institutionalization and ideology of this new aesthetic. Dietrich also goes on to say that it is the computer's non-humanness that can free art from the influences of the current art community, but unfortunately, the "art critics who pointed out the cool and mechanical look of the first results of computer art did not grasp the implications of this concept" [14]. One of the earliest pioneers of digital computer art was Vera Molnár (figure 6). Her computer-generated works in the late 1960s had produced forms that had previously not been observed in nature or in art institutions up to that time [14]. Much like Kelly and Richter, Molnár's early computer works make use of an aleatory approach to image placement, which contains the diagrammatic language at the heart of the pixel aesthetic and gives her work a similarly mechanized attractiveness to that of the early abstractionists. As the 1960s ushered in a new age of technology, there was a creation of many new arenas for artists to explore, still primarily based in electro-mechanical and analog based systems. It was the ability of the computer to replicate and perform routine programmable functions that was significant in the advancement of the computer as a viable artistic tool. As computer technology moved to digital based frameworks, the role of graphics and visual output truly came to the forefront and defined what the pixel aesthetic is today.

## Survey of apophenia and the modern pixel in generative art

Now that a historical foundation is established, we can begin to explore how these seemingly separate histories, media, and formats have amalgamated to bring forth a unique and appealing visual language. Before I discuss the pixel's significance within generative art it is necessary to establish the criteria that make this particular aesthetic different from the multitude of practices that digital art is comprised of. Digital art has taken on many forms over the years. There are numerous subtypes of digital art; some examples include digital painting, photo manipulation, and music visualization. Generative art, one of these subtypes, is itself an umbrella for numerous sub-forms, and the use of apophenia/pareidolia and the visual experience of pixel data is inextricably tied to one-another. When we talk about pixels and pixel aesthetics we generally leap immediately to raster-based imagery as opposed to vector-based imagery, allowing the visual representations to retain their blocky grid-like nature. Therefore, the use of smoothing and/or interpolation filters is often discouraged especially when scaling is introduced. Further, we can combine this particular characteristic of the pixel with the psychological phenomena of pareidolia, a form of apophenia often related to the observation of familiar, recognizable objects in disassociated contexts, especially facial features in things such as clouds or rock formations. Using the pixel as the vehicle we are able to explore how generative art is affected by our human perceptions and the rudimentary formation of the digital image. One additional theory that is also applicable is Arthur Koestler's notion of the *holon* [15]. A holon is described as something that is both *a part* and simultaneously *a whole*. The pixel is one of these holonic components, that is itself a single unit composed of smaller parts (binary data or color related values) that can exist on its own while simultaneously being a member of a larger collection of pixels that form an image.

One of the earliest artworks that satisfy these criteria is found in Leon Harmon's scientific exploration of perception and visual information [16]. When Harmon's study of image perception is viewed in conjunction with psychological studies of how color and patterns impact visual imagery [17-19], we see exactly how Harmon's research works within the context of pareidolia (Figure 7). In a sense, Harmon's digital exploration of how little information is needed to make a recognizable image is very much related to the minimal information we require to generate images from our stars. As a result of this exploration, the division, abstraction, and minimalization of the image to its most important components has most likely made Harmon the father of the modern photographic/digital mosaic.

The photographic mosaic is an art form that was introduced into the mainstream art world in the mid-1990s, and was made popular by computer scientists like Adam Finkelstein. In 1994, Finkelstein and Sandy Farrier created a mosaic of John F. Kennedy (Figure 8) from image segments of Marilyn Monroe. Since this time, there have been numerous computer scientists and artists alike that have developed processes and algorithms that attempt to optimally suggest the best arrangement of a subset of images to create a photo-mosaic, including several computer applications made for consumers that have moved the practice from the lab and studio into the average computer user's home. What makes photo-mosaics especially pertinent to this survey is that each 'pixel' of the larger image is represented by an entirely separate image. In this regard, the holon is explicit and consideration of the individual components is as critical as viewing the entire constructed image. However, it is the prevalence of this style of pixel-selection artwork that has become so accessible to the general public that, to some extent, has diluted the underlying creative process through its automation. The popularity of digital image mosaics has provided the entire population the ability to create incredible imagery with little to no artistic or technological background. However, without this particular mode of pixel-oriented construction I do not believe that the pixel would have continued to flourish and remain intrinsic to digital expression as it has. Photo-mosaics can be considered semi-generative (or pseudo-generative) in the sense that a finite subset of random image 'pieces' can be combined in a multitude of arrangements to produce many different images. If one were to create a mosaic image of randomly assigned smaller images then at some point recognizable images will inevitably become discernible.

*Figure 7. Leon Harmon Mona Lisa, 1973. Scientific American, New York, NY.*

*Figure 8. Adam Finkelstein and Sandy Farrier Jfk-Mm. 1994. Xerox PARC Algorithmic Art Show, Palo Alto, CA*

The idea that random objects can eventually construct meaningful images is exactly what Phil McCarthy's *Pareidoloop* does. *Pareidoloop* is a generative art application that combines genetic programming techniques with facial recognition software to randomly layer countless polygons upon one another until an identifiable face is generated (Figure 9). These portraits are fictional characters from the digital world, yet they are sometimes identifiable as individuals from our own reality. This is an intriguing concept that not only have we managed to create a face from random data, but an identifiable personality as well. As McCarthy points out, it is interesting how many of these portraits resemble old photographs of Einstein [20].

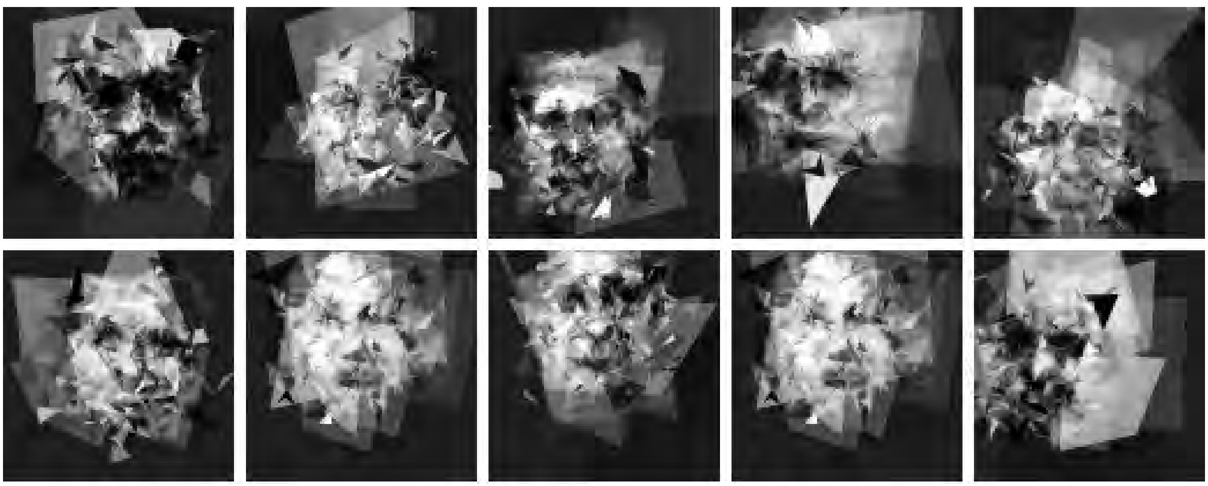


*Figure 9. Phil McCarthy. Pareidoloop (portraits generated by Jon Corbett). October 12, 2013.*

Our pareidolic tendency towards the heavens is ever evident today. Returning my focus back to our cosmos, I would like to draw attention to the modern convention of naming our celestial bodies, for example “Crab Nebula”, “Fireworks Galaxy”, and “The Witch’s Broom Nebula”. Their obvious inspirations from earthly objects leads to a theoretical exploration of celestial art generation. Artist Chris Keegan has produced pareidolic photo manipulations from deep space imagery taken by the Hubble Telescope. Keegan’s images give us a glimpse of what our universe could generate (Figure 10), and by extension demonstrate an opportunity for possible exploration in a generative art context.

Conceptually, both McCarthy’s and Keegan’s explorations are a look at where this evolutionary process of the pixel has arrived at; further, it begs the question, *what is next?*

Perhaps the next step is to move our apophenic predisposition into a three dimensional space with spatially distributed pixels. Perhaps putting ourselves *within* the heavens is the next step, not only visually seeking imagery, but experiencing the imagery as environment. Immersion in a three-dimensional light sculpture (like Squidsoup’s *Submergence* [21]) would be able to facilitate such an environment if the images produced through its apparatus were filled with floating fields of generated clouds.

**a.** **b.**

*Figure 10. Chris Keegan.* ***a*** *– Butterfly. 2010;* ***b*** *– Black Body. 2010.*

## Conclusion

The combination of our apophenial nature and our compulsion to format imagery with blocks of information have recorded origins dating back thousands of years, from the star patterns used to navigate our planet, to the recognizable yet fictional characters found within the algorithms of modern computing. The role of pixel is crucial, whether we consider or are even aware of the historical context of its birth. The pixel, as the single most important element in a generative artist's toolbox, combined with the endless possibilities that perception affords, opens up an entire universe for future exploration.

## References

[1] Kandinsky, Wassily. "Point and Line to Plane (1926)." *Kandinsky: Complete Writings on Art* (1947): 527–699.

[2] Rogers, John H. "Origins of the Ancient Constellations: I. The Mesopotamian Traditions." *Journal of the British Astronomical Association* 108 (1998): 9–28.

[3] Gurshtein, Alexander A. "The Origins of the Constellations." *American scientist* 85.3 (1997): 264–273.

[4] Rogers, John H. "Origins of the Ancient Constellations: II. The Mediterranean Traditions." *Journal of the British Astronomical Association* 108 (1998): 79–89.

[5] Marks, Laura U. *Enfoldment and Infinity: An Islamic Genealogy of New Media Art*. MIT Press Cambridge, MA, 2010. 189-218.

[6] Greene, Vivien. *Divisionism, Neo-Impressionism: Arcadia & Anarchy*. Guggenheim Museum Publications, 2007.

[7] Homer, William Innes. "Seurat and the Science of Painting." (1964).

[8] Robertson, Eric. *Arp: Painter, Poet, Sculptor*. Yale University Press, 2006.

[9] Buchloh, Benjamin H.D. "The Diagram and the Colour Chip: Gerhard Richter's 4900 Colours." *Gerhard Richter 4900 Colours: Version II*. Eds. Larner, Melissa, Rebecca Morrill and Sam Phillips. Ostfildern, DE: Hatje Cantz Verlag, 2008. 61-71.

[10] Lyon, Richard F. "A Brief History Of'pixel'." *Electronic Imaging 2006*. International Society for Optics and Photonics, 2006. 606901–606901–15.

[11] Nipkow, P. "German Patent No. 30105." *Published Jan* 15 (1884).

[12] Franke, HW. "Computers and Visual Art." *Leonardo* (1971): 331-38.

[13] Baumann, Shyon. "A General Theory of Artistic Legitimation: How Art Worlds Are like Social Movements." *Poetics* 35.1 (2007): 47–65.

[14] Dietrich, Frank. "Visual Intelligence: The First Decade of Computer Art (1965-1975)." *Leonardo* 19.2 (1986): 159-69.

[15] Koestler, Arthur. "The Ghost in the Machine." (1968)

[16] Harmon, Leon D. "The Recognition of Faces." *Scientific American* 1973: 70-82.

[17] Ishihara, Shinobu. *The Series of Plates Designed as Tests for Colour-Blindness*. Kanehara & Company, 1936

[18] Gombrich, Ernst Hans. *Art and Illusion: A Study in the Psychology of Pictorial Representation*. Vol. 5: Phaidon London, 1977. Print.

[19] Cave, Carolyn Backer, Preston R Bost, and Ronald E Cobb. "Effects of Color and Pattern on Implicit and Explicit Picture Memory." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 22.3 (1996): 639.
[20] https://twitter.com/phl/status/225289119645966337
[21] http://www.oceanoflight.net/blog/projects/submergence-2013/

**K. Moraes Zarzar, M. Shah**

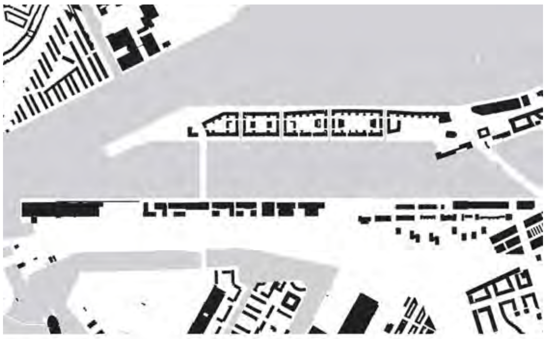
*Paper:* **Generative Design Mechanism: City as a Physical Construct, An analysis of the urban context within post-war housing in Amsterdam - Java Island**

***Topic: Architecture***

***Research group: Urban Design Research Lab, Cardiff Metropolitan University, Wales UK:***
***Authors:***
***Dr. M. Shah. PhD***
mshah@cardiffmet.ac.uk
***Dr. K. Moraes Zarzar, PhD***
karinazarzar@gmail.com
www.karinazarzar.com
***ir. Joëll Thepen***
jthepen@gmail.com
***Julie Heyde, architect***
j.heyde@criss-crossing.com
***Lauren Havel, architect***
l.havel@criss-crossing.com

***References:***
[1] Komossa, S. (Ed.) et al., "*Atlas of the Dutch Urban* Block", Thoth, Bussum, 2005
[2]De Kool, D. et al., "*De Monumentale Stad" Plan Zuid Amsterdam H. P. Berlage*", http://daviddekool.nl
[3]Fraenkel, Francis F., H.P. Berlage's plan for the southern extension of Amsterdam, Canaletto, Alphen aan den Rijn, 1976

***Abstract:***
In this present paper, we would like to postulate that the generative design mechanism is intrinsically experiential within architectural and urban design sensibility. Our current research focuses on the comparative study of past 17 century urban planning solution as a set of formal structures and geometrical patterns that can provide the logic and future direction as the possible complete immersion of architectural forms within urban configurations.
This paper shows a brief analysis of the urban configuration of the Java Island in comparison to the Ring Canals and Amsterdam South.
The key questions that we hope to address include: to what extent the past medieval as well as Renaissance planning solutions were used in the geometric patterns for the urban configurations in Java Island and in what extend they help in creating an identity of the place with important social, economic and specifically health implications for the communities in question as well as reinforcing the identity of the city in which they belong.
We were able to conduct this initial research with the support of the Seed Fund Award 2013 provided by the Cardiff Metropolitan University.



NIEUWE SITUATIE

*Image of Java Island, plan*

*Image of Java Island*

***Contact:*** ***karinazarzar@gmail.com***

***Keywords:*** urban planning, geometry, identity, precedent, health

# Generative Design Mechanism: City as a Physical Construct, An analysis of the urban context within post-war housing in Amsterdam - Java Island

**Dr. K. Moraes Zarzar, dipl.arch, MTD, PhD**
*Zarzar ArchLab, The Hague, The Netherlands*
*www.karinazarzar.com*
*karinazarzar@gmail.com*

**Dr. M. Shah, PhD**
*Urban Design Research Lab, Cardiff Metropolitan University, Wales UK*
*mshah@cardiffmet.ac.uk*

**ir. Joëll Thepen,** *AECO STUDIO, The Nederlands*
**Julie Heyde, architect,** *Atelier Criss-Crossing Paris , France*
**Lauren Havel, architect,** *Atelier Criss-Crossing Paris , France*

## Premise

In this present article, we would like to postulate that the 'generative' design mechanism is intrinsically experiential within architectural and urban design sensibility. Our current research focuses on the critical analysis of the 17th century urban planning solutions as a set of formal structures and geometrical patterns that can provide the logic and future direction of the possible complete immersion of architectural forms within urban configurations.

This article provides an initial analysis and overview of the urban configuration of Java Island in comparison with the Ring of Canals and Amsterdam South.

The key questions that we hope to address include: to what extent do the Renaissance up to early to early 20th century planning solution such as the Ring of Canals and Amsterdam South were simulated in the urban configurations of Java Island (1995-96)); and to what extent do these help in defining the identity of the place as well as reinforcing the identity of the city in which they belong.

We were able to conduct this initial research with the support of the Seed Fund Award 2013 provided by the Cardiff Metropolitan University.

## 1. Introduction

In a way this paper follows the line of inquiry that is briefly touched upon by Komossa and Meyer [1] in their introductory essay to the Atlas of the Dutch Urban Block. They argue that most contemporary research done on cities, and structural units of the urban maps, proceeds from the assumption that with the modern movement, there has been an inseparable split between the classic and modern city and that not infrequently the loss of urbanity and urban qualities is connected with this break.

Having said this they argue that in the case of Amsterdam this is only partially true and that there is a great deal of continuity from the 17th century ring canals to recent projects such as the GWL terrain in Amsterdam.

Historically Amsterdam's Ring of Canals and Amsterdam South provide an excellent example of a 'generative design' mechanism that is intrinsically experiential within its context and urban sensibility. The key questions that we hope to address are: to what extent do the Renaissance up to early to early 20th century planning solution such as the Ring of Canals and Amsterdam South were simulated the urban configurations of Java Island (1995-96)); and to what extend do these help in defining the identity of the place as well as reinforcing the identity of the city in which they belong.

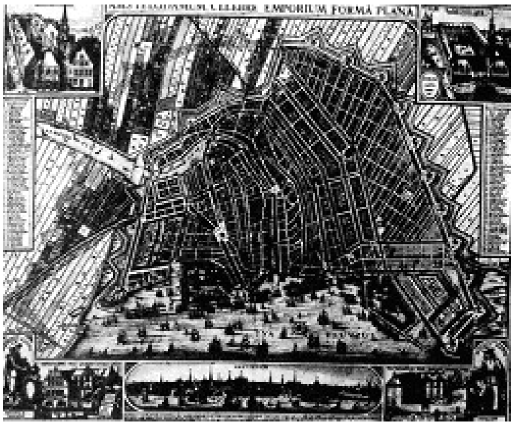
## 2. Ring of Canals [1]

The Ring of Canals

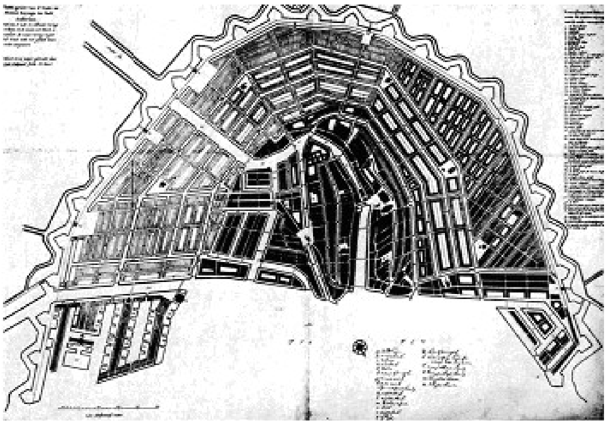
In his essay on the ring canals, Meyer [1] observes that in this case the urban block cannot be considered the generator of the urban plan. Since in the case of the Ring of Canals, the land was divided according to the drainage of water and was aligned with those of the farm land. Thus the streets were set out first and the 'inbetween/leftover' was subdivided into lots by the developers over time, in accordance to the need of the specific buyers. This created an instance where the size of lots vary dramatically from large expansive lots to some exceptionally narrow ones – thus providing a unique quality to the city with very pronounced variations in the width of the facades of the buildings, as compared to the height. This provided a gradual built up of an urban block that was mixed used, pedestrian oriented, sustainable and most importantly with a spatial flexibility that allowed it to remain intact over the past centuries, despite continued interventions and reconfiguration.

Here the public and private spaces were inherently distinguishable and ever-present. According to Han Meier, the urban block, as we know now, "was born" when individuals begun to buy in the Ring of Canals, more lots to build them for rent. Then the buildings were built at once and were similar in form and function. We think that he meant that once we can see the whole as an (urban) object, the resultant 'block' becomes distinguishable such as in Amsterdam South.

Introduced in the 17th century the Ring of Canals were a completely new urban intervention, based on the model of the 'ideal city' that was projected in concentrated rings around the existing city – thereby connecting the suburb of early 17th century with the main historical center of the city.



City expansion showing ring of canals, 1st phase and projected 2nd phase, circa 1625



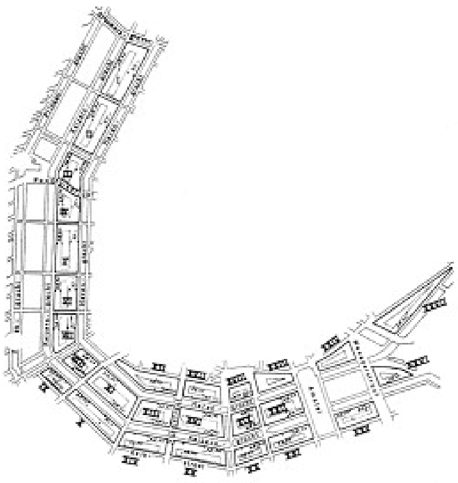
Map of the 'old and new works of the city of Amsterdam' by D. Stalpaert 1662

Expansion of 1662, the final phase of ring of canals

It took almost 200 years for the ring canals to be realized in what can be considered to be its current spatial configuration. Space was created for housing for the rich, the less well to do and the craftsmen.

### 2.1 Function:

The Ring of Canals was primarily a large scale expansion, that was only made possible as the city's administrators had the right legal instruments at their disposal, for instance for the expropriation of land. Moreover among the important considerations in planning the expansion were the construction of new fortifications, water management and making the new areas accessible, the subdivision of the area into saleable lots, and the establishment of Keuren (Keur in this sense in Dutch is normally translated as by-laws, but at this period refers to both the urban block and the regulation for construction which were connected with them).



Overview of the keur blocks, map from the building ordinances of the City of Amsterdam

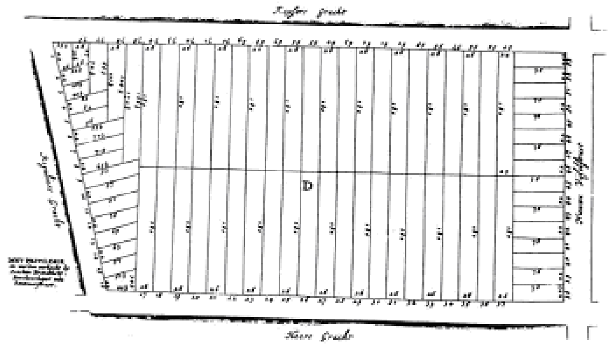
In the early days after 1616, the canals lots were mostly developed and sold as houses and possible workshops by the carpenters, masons and the ironmongers. Over the years and particularly during the first building boom after the 1625, the canals lots became more up market and were reserved for merchants who both lived and worked there. It was only after the second building boom of 1658 that houses were built for purely residential purposes. The new large houses built in the second part of the canal belt as well as the lifestyle which went with them, was modelled on the Dutch version of the classic country house or' villa' developed around 1640 developed by the first generation of Dutch architects: Jacob van Campen, Pieter Post and Philips Vingboons.

At present the Ring of Canals includes town houses, dwelling over shops and double residences. Most dwellings consist of 3-8 room built structures. There are generally private gardens and services in the block which include:, workshops in the basement, storage and commerce, coach houses, stables and shops.

### 2.2 Grid:

Detail of the parcellation of 1614 is an excellent example of identifying the grid that was in place in the ring canal from the outset. This is further substantiated by the uniformity of the size of the block which remains to the present day; 100 x 150 m.

The average number of dwelling is 84 and dwelling size remains within the confines of 105m2 -795 m2.

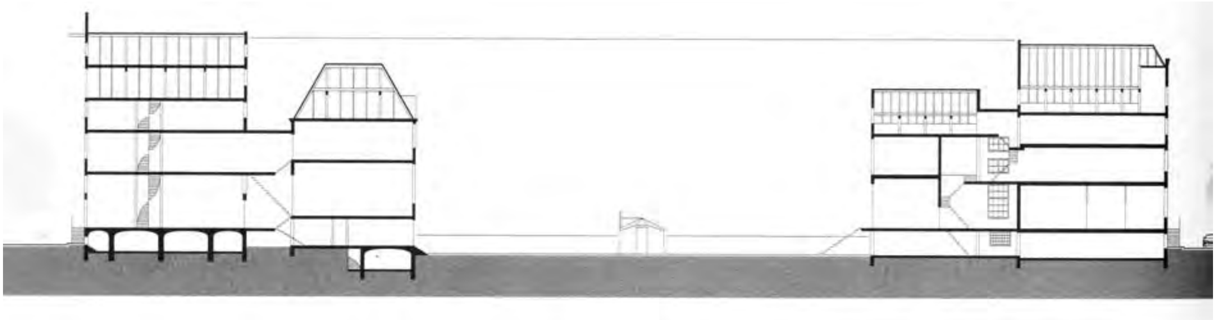


Detail of the parcellation of 1614.

**2.3 Block characteristics:**

As noted in the detail of the parcellation of 1614, originally the canal plots were of fixed and regular dimensions for instance 30feet wide and 190 feet deep. Although these parcels were sold individually, multiple lots next to each other were regularly purchased by the same individual. This meant that either a wider structure was built or several smaller houses were built. The lot width therefore could vary between 5.75 meters and 14.75 meters. The lots could also vary from being 55 meter deep including the pavement in front in comparison to the average house being 30 meters deep. During the late 17th century the ‘garden house’ with a maximum height of 12ft and depth of 15ft was also introduced as part of this build up lot. Building deep into the parcel was made possible by the introduction of the lightwell – first introduced within the extensions of the existing house at the front of the property but later after 17th century it was incorporated into the original design.  The lower ground floor of the lot was generally used for commercial and enterprise usage. The main building or dwelling included upon entrance a long corridor that led to the highpoint of the spatial layout of, the salon or the staircase.


Recent drawing of the façades of keur block VII along the Herengracht



General Cross_section

In older type of merchant residences, the front room was called the comptoir and was often used as an office. The wider section of the front corridor close to the front door could be used as the storage space for goods and samples of merchandize. There is generally a small stair located at the front of the house, where this entry and the corridor meet. This was the original stair of the house, which became less common in later residential dwellings after the commercial aspects were no longer active.

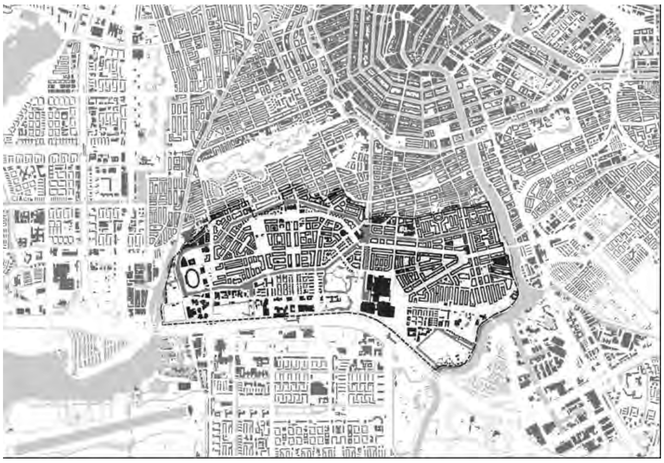
Proceeding along the corridor towards the rear of the house, one ascends several steps and ultimately comes into the salon. It occupied the full width of the house and over looked the garden. It was the most representative space of the house. By raising the salon slightly above the level of the bel-etage of the front house, it was possible to situate the kitchen under it, on the same level as the garden. The cellar under the light well and salon were part of the dwelling; even after the 1700 the cellars under the front of the dwelling were intended for rental.

The dwelling program thus incorporated the residential and commercial, the public and the private within a single specification of the urban residential lot. Here the lot equally represented the mixed used multitasking elements so common and rampant with the block itself. This was a unique and practical solution within the confined of very rigid parameters - thereby making it equally pertinent and applicable within the 20th and 21st century sensibility of the ring canal.

**2.3 Final comments:**

The Ring of Canals in a way introduced a new sense of identity within the city, here the mixed-used urban blocks with the added complexity of pedestrian paths overlapping with an array of land and water based transportations created a new city dynamics. The public and the private realm of the blocks although well demarcated and pre-eminently consistent in its presence over the centuries remained very much part of a single urban identity. Although initially it was the merchant class and the bourgeois that defined the new realm of the city, this moneyed class was in many cases replaced by the downtrodden and extremely poor families. Within the span of the four centuries, despite the ups and downs within its social status, the poor, the bourgeois and the odd foreign nationals all encompassed the main element of this city’s sense of identity and rationale.

## 3. Amsterdam South [1] [2] [4]:



Map of Amsterdam showing Amsterdam South

The extension designed by Berlage in 1917 is located at the South of Amsterdam in land exppropriated by the municipality. Amsterdam South has an interesting location: the Berlage Bridge connects the district with the center. Amsterdam South is not too close to the center, avoiding the crowded center, and not too far, which makes it possible to reach the center by common modes of transportation such as the bicycle.

Berlage made two urban plans for the South part of Amsterdam, the first being in 1905 and the second in 1917. The first plan was accepted by the municipality; however, it was only built in the area nearby earlier expansions closer to the center of the city.

Berlage was influenced by theoreticians, in particular by Camilo Sitte's picturesque view of the city and his preference to medieval cities as stated in Sitte's "*De Stadtebau nach seinen Kunsterichen Grundsatzen*" from 1889. However, when he was designing the second plan, he took some distance from Sitte's approach, probably by recognizing the need for a more pragmatic line serving the program of a modern city.

It was not that he could not see the beauty of the medieval center and of the Ring of Canals; in fact he appreciated very much the Herensgracht in its perspectives and picturesque façades. But, according to Berlage, as the ring became bigger in diameter, the perspective lines didn't provide the same effect and the individual houses all together became chaotic. Also to make expansions following the line of the rings would make a very monotonous city. Taking this into account, he realized that the Baroque street pattern with broad avenues and straight lines would solve many of the then present problems such as transit in the streets. Berlage was however aware that the Dutch culture was more close to the picturesque than to the monumental.

Therefore the second plan presented two dialectic concepts into work, Camilo Sitte's picturesque and Albert Erich Brinkmann's "monumental" as stated in Brinkmann's "Platz und Monument" from 1908. Berlage put the two concepts together creating a monumental structure (symmetry, axes and a high density allowing for the plan of compact urban blocks) while allowing the picturesque for the detail, being the ideal style the one provided by the architects of the Amsterdam School such as Michiel de Klerk, Piet Kramer and Johan van der Mey.

Beside theoretical approaches, Berlage, a syncretist mind, also analyzed urban plans and diagrams such as, respectively, Howard's Garden City and Haussmann's plan for Paris. It is often cited that Berlage referred to the garden city in his Amsterdam South plan, in particular showing his pedestrian routes with abundant number of trees as well as the Block courtyard. In what concerns Haussmann as a precedent in Berlage's plan. One may see more differences than similarities [4]. First, Berlage's plan didn't limit itself to the design of boulevards, but also to streets, squares and courtyards. Their objectives were also very different from one another. While Berlage wanted to solve housing problems for the working class, Haussmann intended to "save" the bourgeois society from the risk of a revolution. Beside aesthetical reasons, the wide streets allowed for the interference of military troops if the people, living in great poorness, decided to revolt against the richer classes.

The land where Berlage planned involving nowadays Apollobuurt and Rivierenbuurt was expropriated what allowed for great freedom in particular in comparison with his colleagues who were responsible for earlier expansions [4]. Berlage only had to take the following issues into account:

1. The 3 water ways
2. The railway dike which forms the limits on the South side of the plan
3. The plan of a road connecting the new district with the old city
4. The plan of a canal that would connect the 3 waterways

**3.1 Function:**

The district was idealized to solve the housing problem of the work class. Amsterdam South plan is divided into two parts: the Apollobuurt and Stadionbuurt aimed at upper classes and the Rivierenbuurt, focusing on the middle class. The Berlage Bridge was meant as the entrance to the district from the city center. Numerous urban blocks had shops and offices to serve the whole district in low scale. Amsterdam South shows a kind of segregation concerning religion, culture and politic such as at the De Dageraad block. This block was built by the socialist housing association of the same name. The block was designed by Michiel de Klerk and Piet L. Kramer (not only the façades but the apartment layout as well) with council subsides to house workers of the socialist party [3].


De Dageraad

**3.2 Grid:**

From the 19th century urbanism, a need has arisen to wider street profiles. Berlage asserted that the geometric plan was more suitable for the transport in a modern cityand could be also, aesthetically speaking, of great beauty. He used a right angle grid with some star form radiation. The streets were ornate by rows of trees and many pedestrian roots what show a reminiscence to the Garden Citiy diagrams of Howard.

The monumentality of the district can be felt by the combination of the broad streets and the urban blocks which show austerity due to their materials, height (maximum of four levels), its symmetry and axes.

**3.3 Block Characteristics:**

In contrast to the Ring of Canals, the urban blocks in Amsterdam South were constructed as one object. The corners of the blocks were embellished giving an accent on the intersections.

Facades:

The “schoonheidscommissie” (beauty commission, group of people who judge the quality of the architectural production in The Netherlands) had a great influence in what the buildings would look like. This commission praised to a morphological consistency deciding about roof heights, shapes and accents. The “schoonheidscommissie” even decided about the style, selecting those architects belonging to the Amsterdam School. They aimed to façade unit and therefore the materials and style was a main concern [4].

The facades of the building blocks were built with the most used material in The Netherlands: the bricks and were not designed as individual house facades but as a whole. The façade had a double function, on the one hand giving privacy to the inhabitants and on the other hand, giving form and character to the streets and squares. Here one may find Sitte’s influence who asserted that facades should be designed as the walls of the streets and squares. The façades were in fact designed independent of the house layouts making them, later, unsuitable to new comfort standards of for example light and subject to modifications [5].

Access:

There are three types of access to the urban block: first, a series of doors (sometimes 6 doors) each giving access to an individual apartment. The social importance of this private access to outside world has reminiscence of the villa, the house of the rich which has access to the public space through their own door. A second type is called the “*Haagse Port*” which reduces the number of main doors by bringing together access to up floors through a staircase. On the first floor, there is a subdivision; there are main doors for the inhabitants of first floor and other doors to access the staircase of upper floors. The third type is the “portiek” which is a collective staircase for all floors. Collective stair cases are often accentuated elements on the façade.

Courtyard:

The courtyard is the heart of the urban block which is often cited as an interpretation of principles found in Howard's Garden City. However, the importance of the courtyard as a centre of every-day life depends of the apartment layout. Some apartment layouts emphasized more than the others the relationship between living-room and dining room with this green heart. For example, one of the wide spread type in Amsterdam South has the living-room and diner room interconnecting the courtyard with the public space, here, courtyard and street have the hierarchy. However, the diner-room on the side of the courtyard was often used as one extra bedroom.

Most apartment-layouts did not have bathrooms. Later, when bathrooms were introduced into the layout of each apartment, the new layout often "turns around" interrupting the relationship between the apartment and the courtyard. The new layout had the living-room and diner-room only facing the street and the douche in the center of the apartment.

In Spangen, Rotterdam, the architect J.J.P. Oud in the 1920's decided to emphasize the relationship living room and dining -room with the courtyard, placing the bedrooms on the street side making the courtyard, visually, the real heart of the block as well as well as the collective space used by all residents of the block.

### 3.4 Amsterdam South versus the Ring of Canals:

Monumental in structure and picturesque in detail. Amsterdam South does not follow the structure of the medieval city or the ring of canals. However, it keeps few similarities in function (shops under and living above) and access to the apartments of the blocks which had their individual door towards the public space.

Amsterdam South is the result of a syncretist mind which recollected elements of different plans and theories. Its main difference with the ring of canals is that the urban block of Amsterdam South is designed as one element, while the "blocks" of the ring of canals were built through 200 years. Also, the grid of the ring of canals were determined by the drainage canals being the left overs built. In the case of Amsterdam South the canals were not determinants for the size of the urban blocks. The South plan had few constraints such as the waterways and the canal mentioned above.

Other differences are to be seen in the form of type and construction. So the blocks of Amsterdam South has apartments stapled on each other and are standardized to facilitate its construction by the housing associations. In contrast, the houses in the medieval center are done by private initiative, its dimensions depending of the owner necessities and with many variations within the type (shops, office, living areas). Constructed by individual parties, its form can be translated as the unity in variety.

Amsterdam South did not reinforce the identity of the old centre of Amsterdam, but created new possibilities. Its success is to be noticed in the way that contemporaneous extensions show diverse elements recalled from this plan as we may see in Java Island and in IJburg. The district still has its attractiveness, and, though interventions were carried out, it continuously attracts people to live in the area. Part of its attractiveness is surely due to the proximity to the centre for bikers, the presence of many lines of public transport and parks.

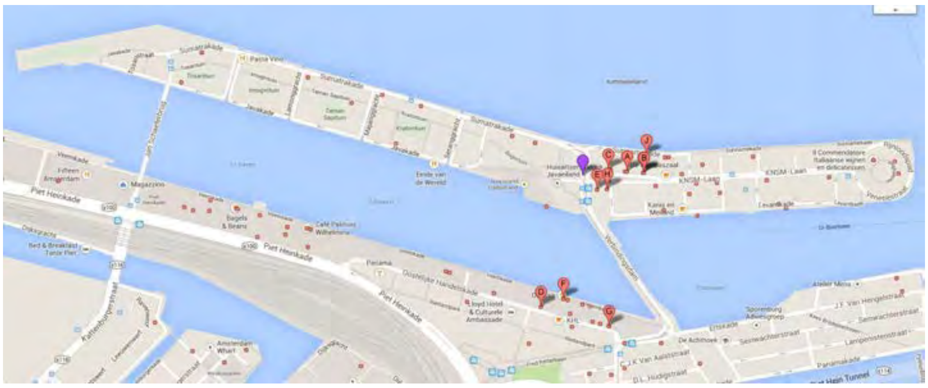
## 4. Java Island [1]:

View of the South

Java Island was planned by Sjoerd Soeters and it is located at the Eastern Harbour District of Amsterdam. It was built from 1995 to 1996. Java Island can be easily reached by car. Due to its proximity it can also be easily reached by bicycle or by foot.

### 4.1 Function:

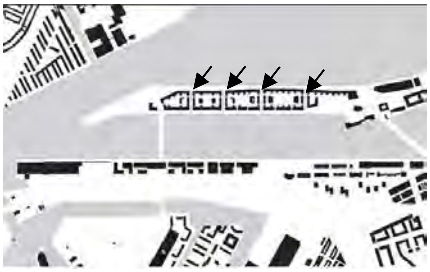
Java Island is a residential district. It was developed together with other artificial islands to solve or at least diminish the shortage of houses in Amsterdam. Java Island is linked to the KNSM Island in its Eastern side on the Azart Square (Azartplein) where shops, facilities and public transport are situated. Also from Azart Square one may cross the bridge towards mainland where immediately after the bridge one may find several cafés, shops and supermarkets.



Shops and facilities

**4.2 Grid:**

Java Island is an artificial Island which measure 130m wide by 1200m. It is connected to the old city of Amsterdam via two bridges. The grid seems to be determined by the concept of the 5 rooms which creates an internal route for pedestrians and bikers. This island is cut by 4 canals. Perpendicular to the four canals, on the North and on the South of the island one can find a car road, being the one in the South local and interrupted by intervals, so that only bikers and pedestrians can walk the whole quay area.



Canal streets

**4.3 Block Characteristics:**

In the courtyards

Soeters' Java seems to be generated by the concept of the block and not by the streets. The buildings that compose Soeters' blocks differed from each other like in the Ring of canals. Contrary to the ring of canals, the blocks were divided regularly according to a modular rule. This similarity (variety) and difference (regularity) created an estrangement which one may feel when crossing the bridge to "enter" Java.

Facades on the South

Soeters planned 5 Blocks accommodating 3 living environments: dwellings along the quays, dwellings along the canals and dwellings in the interior of the blocks. Dwellings on the quays could be divided in 2 living environments, because living on the North of the Island is considerably distinct from living on the South side. The buildings follows the same modular structure (5 x 5.4m per building with its entrance from courtyard or quays in the middle where one also find the elevators) on both quays, but the dwellings along the North Quay have their living rooms facing the courtyard what give them a complete different experience of space in comparison with the apartments facing the South quay, the IJ and city (most living rooms of apartments in Amsterdam South also faces the street). Modular bays which is not found in the ring of canals.

The buildings on the quays have some similarities with the medieval part of Amsterdam, the ring of canals and even Berlage's Amsterdam South. However the precedents are defamiliarized when applied in Java Island.

For example, from the ring of canals, Soeters recollected the variation of buildings that composes the block while from Amsterdam South he applied the modular bays.

In the four canals that cross the island there are great similarity in the urban level with the ring of canals. So dwellings directly reach the public space via a small set of steps, typical element of the houses of the ring of canals. There are also houses instead of apartments and the façades are all differing from each other. However, the width does not vary; the size of each house is 4.5m and the height is from 4 to 5 storeys. The façades are different from each other and each canal has a recombination of some of the 19 projects designed by young architects.

Facades on the canals / detail: entrances

The courtyard is an element present in the whole city; however, here Soeters turns it public. The courtyards houses gardens and are connected to each other by a route only for pedestrians and bicycles protected from the cold Northern wind. This route brings one inside the courtyards making one fill in and out the block reinforcing the idea of the block.

### 4.4 Java Island versus Amsterdam South and the Ring of Canals

Contrary to Amsterdam South, where the whole block often belongs to a cultural, political or economic group, in Java Island, the buildings, which composed the blocks, are the ones which are made for one cultural or economic group. In other words, each building in Java was meant for people with the same cultural background and aspirations.

In Java Island, there is a recombined and often defamiliarized use of precedents which create an identity of the place and reinforce the identity of the city. The proximity of the district to the center of the city favours the integration of the part with the whole, while the pedestrian route linking the 5 rooms favours the identity of the place.

However, Java Island often seems to be a montage of various (defamiliarized) scenarios of Amsterdam wrapped up with the idea of the block and the canals which is probably caused by a weaken integration between the urban planner and architects.

## 5 Insights

The article discusses two plans, the Ring of Canals and Amsterdam South, which seem to have powerful generative design strength and their hypothetical influence in the planning of Java Island.

The Ring of Canals introduced a generative design element that went beyond its physical design sensibility – it defined a new sense of identity and life style for its residents – irrespective of their social standing and time frame. It provided a generative design element that encompassed both the urban and architectural elements within its array of design solutions.

Thus the ‘urban block’ as quite randomly introduced within the Ring of Canals, generated a series of design directions for the current and future expansion of the city. The most prominent being the use of the courtyard as a central node that connected the urban and the architectural, the public and the private space, particularly in the case of Java Island.

Amsterdam South is the result of a syncretist approach. It recollected elements of different plans and theories. Though keeping some details of the Ring of Canals, it is an unprecedented development in the city. Its main difference with the Ring of Canals is that the urban block of Amsterdam South is designed as one element, while the “blocks” of the ring of canals were built through 200 years; the urban blocks and streets of Amsterdam South were also not determined by the drainage of waters.

It belongs to different time in history and is provided to solve the problems for housing for the working class. Its monumental plan and picturesque blocks express a new kind of identity for this working class which was becoming emancipated.

Both plans provides an identity of the place however, the Ring of Canals reinforces the identity of the existence city in a stronger way then Amsterdam South. Now almost a 100 years after the construction of this district, it seems though not to be possible to discard it from the city. It is part of the history of the city and of the numerous movements, connecting the 19th century city plan with the modern city. We believe that Amsterdam South, despite its almost abstract use of precedents, is a successful intervention in its relatedness to the identity of the city's history and identity.

Java Island absorbs both plans, not always in a successful way. In the case of the Java Island despite at times the 'literal' replication of urban block and building typologies presented, there is an acute sense of chaos; of, at certain instances, a loss of essence that these very design elements were able to provide in the city centre. This seems to be the result of, on the one hand, the amount of rules governing the architectural design (the quays South side of the Island), and on the other hand due to an uprising of the architects against the rules of the game (see the architecture of the 4 canals). It would do no justice to the plan if we did not mention the successes of the plan, such as the opening of the blocks and its interconnection by a route for pedestrians and bikers turning the former collective into public space. This route is the strongest element of identity of the place.

Having said that it can be argued that both Berlage and Soeters in their later planning interventions introduced a series of innovative new dimensions to this city, however their interventions primarily iterated within and through the nodes of the courtyard centred design sensibility – thus generating a design sensibility that connected the past with what was considered their 'present or contemporary' sensibility, along with the expansions and interventions that continue to be practiced today.

## 3. References

[1] With exception of the conclusion of the section, most historical facts found in this section were collected: In: Komossa, S. (Ed.) et al., "Atlas of the Dutch Urban Block", Thoth, Bussum, 2005

[2] Fraenkel, Francis F., H.P. Berlage's plan for the southern extension of Amsterdam, Canaletto, Alphen aan den Rijn, 1976

[3] Architecture Guide, http://www.architectureguide.nl/project/list_projects_of_architect/arc_id

[4] With exception of the conclusion of the section, most historical facts found in this section were collected in De Kool, D. et al., "De Monumentale Stad, Fragment II:, Plan Zuid Amsterdam, H. P. Berlage", http://daviddekool.nl

[5] Sitte, Camillo. 1889. De Stadtebau nach seinen Kunsterichen Grundsatzen (City Planning according to Artistic Principles). In: Camillo Sitte: The Birth of Modern City Planning. By: George R. Collins and Christianne Crasemann Collins. Mineola, New York: Dover Publications, Inc., 1986

**María de Lourdes Zambrano Ruiz**

# *Random Mathematical Approach in Architecture design Process.*

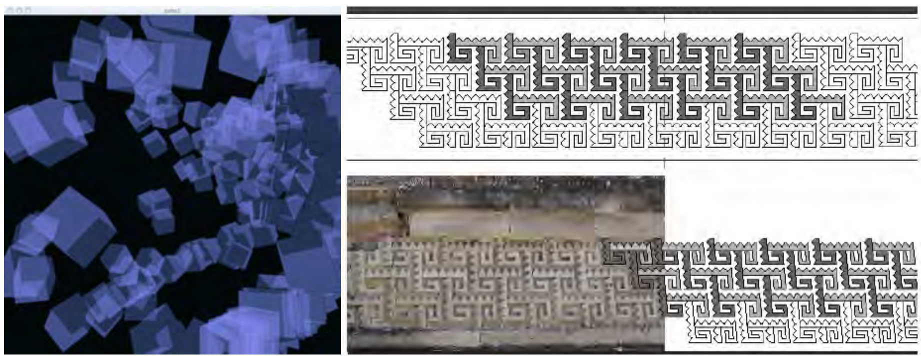
***Abstract:***

The actual issue about design process with link between Random Mathematics and design envelopes has a historical support in geometry on the frieze and panels design, express in mesoamerican architecture. The main idea is argued in mathematics and geometry with relation to arts and design of mesoamerican buildings. The mesoamerican civilizations like Mixteco-Zapoteco, Maya, Totonaca and others, are developed with methodology in their building process.. The mathematic term is geometry in symmetry operations for friezze and plans. The symmetry operation has a link with Randomness, however the symmetry operation has order and design pattern, instead of Random mathematics not or not as raises as the symmetry operation, but the fact is that the link is setting with infinite and finite models (for example like the image below shows).

Actually, we can see that the studies of Random Mathematics have many applications, especially on computer programs, for example Computer-aided design, the image below is a example of this. The block shapes are drawing by computer programming language randomly way and it's a finite model (but it could be infinite), the next image shows a development of pattern design on Mitla Facades with finite models, but with a chance to be infinite models.

There are many applications about Monte Carlo method on Design and visuals: "*…efficient in solving coupled integral differential equations of radiation fields and energy transport, and thus these methods have been used in global illumination computations that produce photo-realistic images of virtual 3D models, with applications in video games, architecture, design, computer generated films, and cinematic special effects.*" (Szirmay-Kalos)

The hypothesis could be planted with this idea and others with Monte Carlo methods on Engineering and Design.



*The firs image is produced by the processing programm, the next of is a design of facades in Mitla, Oaxaca.*

***Topic: Architecture***

***Authors: María de Lourdes Zambrano Ruiz***
Autonomous University of Chiapas, Department of Architecture
México
www.unach.mx

***References:***

[1] ^ Third Workshop on Monte Carlo Methods, Jun Liu, Professor of Statistics, Harvard University

[2] García-Salgado Tomás, Teoría del Diseño Arquitectónico, México, TGS-UNAM, 2007.

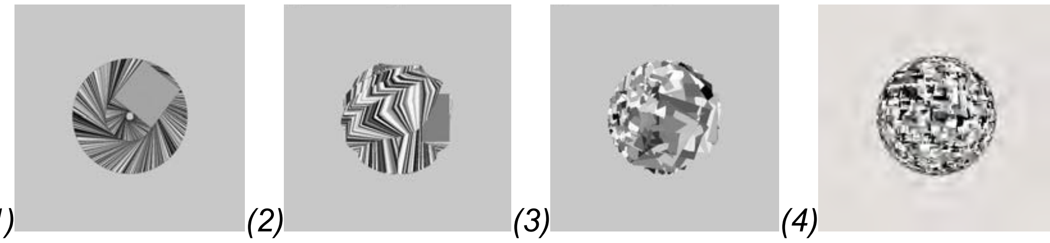
[3] Szirmay-Kalos, László (2008). Monte Carlo Methods in Global Illumination - Photo-realistic Rendering with Randomization. VDM Verlag Dr. Mueller e.K..

***Contact:***
***luluzambrano.arq21@gmail.com***

***Keywords:***
Randomness, Symmetry Operation, Finite Models, Infinite Models, Mitla, Oaxaca, randomly, Monte Carlo methods

# Mathematical Approach
# In Architecture design Process
# A Historical View, from Mitla, Oaxaca

**Prof. M.L. Zambrano**
*University Autonomous of Chiapas, Architecture Faculty*
*e-mail: luluzambrano.arq21@gmail.com*



*(1) (2) (3) (4)*

**Figure 1.***Cubic transformations of images with a geometric dynamic behaviour, through programming language. The image (1) and (4) represent a simple process to draw shapes in 2D and 3D, created by computational language. Quadrangle to cube shapes has the same pattern to draw the 2D and 3D figure: circle and sphere.*

## Abstract

Approach to mathematics, arts, computational programs and architecture was developed in the last century. A lot of research in Geometry, mathematics and Architecture show a complex geometries structures. The link between Mathematics and design was developed in Mexico. It has a historical background in geometry and design process in architecture, for example the frieze and panels design, especially in Mesoamerican architecture and specifically in Mitla, Oaxaca. The Mesoamerican design concepts like Mixteco, Zapoteco, Maya, Totonaca and others are developed with methodology on the symmetries conception. The mathematic term is symmetry operations for frieze and plans, and study is the discrete symmetries, whole numbers finite or infinite associated with the geometric pattern integrated in the design of a facade.

## 1. Introduction

The approach to the mathematical language to generate design in the facades is known by few. Consequently, little is studied about this term and about the symmetry operations in the architecture and the study of the discreet mathematics in the process of design, of a finite and infinite, organized and random way. The beginning of the mathematics with operations of discreet symmetries in design process has historical base in Mitla.

This study will be established in three parts. In the first one, I willexplain the historical base, in the second and third part I will focus on the current base in the study and on the link of the geometry, the programs and exposition of experimentation across programs of design and generation of the forms.

The main idea originates from the study of an organized sequence through symmetry operations surrounding buildings with friezes and background in order to create random chaos pattern that can be observed in the series of images above ( from 1 to 5).

*"Symmetry is a general concept in mathematics; broadly speaking, a symmetry preserves a certain property (e.g., geometric similarity) of an object under some operation applied to the object. This notion of invariance is formalized in an elegant branch of mathematics called group theory. In the context of geometry, we will consider geometric transformations as the symmetry operations, such as reflections, translations, rotations, or combinations thereof*."[1][1]

As a matter of fact, we can see that the studies of Randomness Mathematics have many applications, especially in computer-aided programs. The block shapes are drawnwith computer programming in a random way using a finite model (but it could be infinite as well). It is visible in development of pattern design on Mitla Facades with finite models, where infinite models may be used too.

There are many applications about Monte Carlo method on Design and visuals: "*… efficient in solving coupled integral differential equations of radiation fields and energy transport, and thus these methods have been used in global illumination computations that produce photo-realistic images of virtual 3D models, with applications in video games, architecture, design, computer generated films, and cinematic special effects*." [2]

The hypothesis could be planted with this idea using Monte Carlo methods on Engineering and Design.

## 2. A Historical View. Mitla'sSymmetry Architecture.

The esthetical development of the cultures in the ancient Mexico tackles their central subject matter in the study of the geometry and mathematics. Nowadays, it is observed and expressed in the facades of the buildings, especially in Mitla. The analysis derives from the link between the current knowledge of the geometry and the Mesoamerican architecture.

### a) Mitla, Oaxaca

The city of Mitla has an area of 48 000 m². It is located in the town of San Pablo Villa of Mitla, in oriental limit of the central valley of Oaxaca (Vale of Tlacolula). Its geographical references are: 16 ° 55 ' of north latitude and 96 ° 24 ' longitude west. Literature shows that city of Mitla was inhabited in the year 500 B.C. (its first constructions date back to 200 A.D.) by the Zapoteca culture. It is quite probable that Mitla, in its initial stage,developed an exact geometry in composition and construction of its buildings, and in the course of the time it was perfected. At present, in the diverse friezes in its facades this knowledge is appreciated.

Apparently, 17 symmetry operations are studied for background, grouped by families, which can contain: reflections, slid reflections, rotations and, in all the cases, translations. Also, seven operations have been studied for friezes, they are not designed to generate extensive planes neither to develop frames, and only they contain reflections, rotations and horizontal translations.

Mitla, has complex panels in its design, the image of the figure 2 shows the possible development of the design when tends to be infinite.

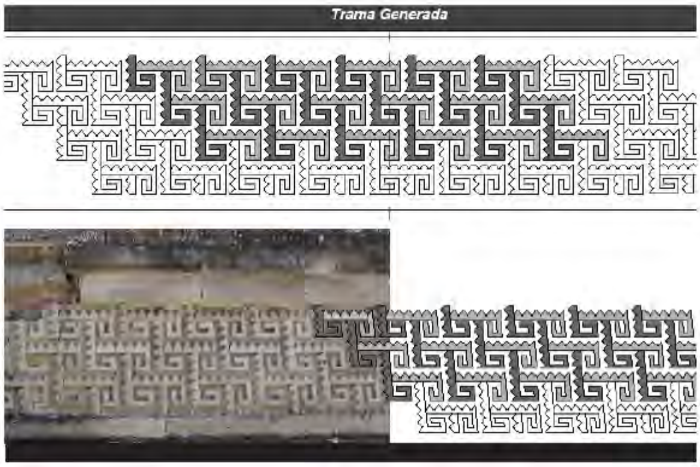



**Figure 2.** *Part of the east facade, Church group in Mitla. This image shows graphically a discreet symmetry, when the design of the motive in the panel tends to be infinite.*

The study of the friezes in Mitla is sustained in the idea that its architects were very advanced in process design, mathematics, geometry, and they had a highly developed visual perception.Moreover, they were applying beginning of proportion, harmony and symmetry in the configuration of its buildings and city. In the Mitla's architecture, the structures contain front's panels of friezes that show the beginning of a long way for this study: from construction system, design perception to scientific process.

**b) Analysis Procedure**

As a first approach to this topic was discussed two of the important features that presentedthe design of the friezes and the setting of thefacades: shafts of composition and the angles. The findings in the precision of the laying, disposition and job in each of its panels were surprising. In many of the cases the composition axes were coming closer to angles of thirty (30), forty five (45), sixty (60), ninety (90) and one hundred and eighty (180)degrees, and the disposition of these axes was generating geometric patterns like the square, rectangle, rhomb, triangle, parallelograms. On this matter, it is possible to state that the builders of this city handled geometric beginning or at least there was an attempt of approach, and not only that. They were probably applying such a complex way, generating movements in background and bands, where rotations existed as well as slides. Nevertheless, not in all the cases movement was happening in the background.In majority of cases, it can be noted that horizontal movements, rotations, reflections, but not vertical development with diagonalmovements.

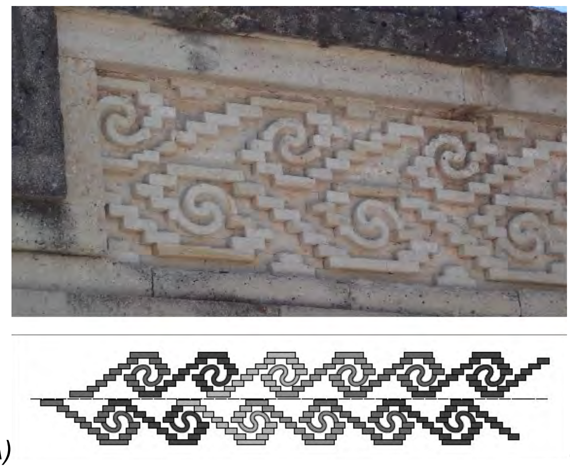
The friezes are built with parts of stone (in different cases) cut and modulated, willing, and summered in bands (see figure 3); however, there are carved friezes, located always in the lintels, waging a hollow.

For the design of panel there must have been some method of experimentation and prior stroke in site. The stroke on site could have been done by system of threads or natural fiber (as a system of wires). If the architects of Mitla based its delivery system on a pilot program before, they probably worked on a replica of the dashboard in stone, which enabled it to have a test run before the work and thus achieve greater accuracy in the final result.

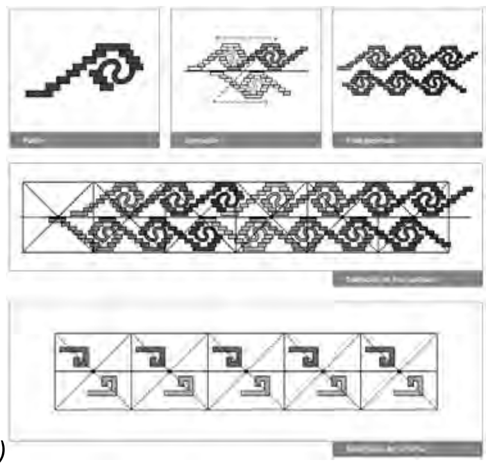
**Figure 3.** *The accommodation of parts is arranged in bands, cut into modules.*

If we take a pattern and apply the operation that corresponds with its transformation and then start with a basic design of element (is better if it is not a non symmetry design), we have the symmetry created by the transformations (Figure 4 A and B).

As a second step, we will take into account that all the patterns have a frieze of symmetry horizontal movement; once we create a basic unit that contains all the properties (other symmetries), we can move it in both directions. As a part of design process on facades, we take a basic pattern and reflect on a vertical line. It is recommended that you choose a close line but not the one that intersects your original item. And now there are two parts in your basic design: the original item and mirror image (see figure 5 (C) and (D).



*(A)*



*(B)*

**Figure 4.** *In both images (A) and (B) one can observe the process of the classification of the marbles in one of the panels into buildings of Mitla. With the same procedure, each and every one of the panes in the architecture of Mitla, were classified. It should be noted that some of the special panels show differences in their design.*

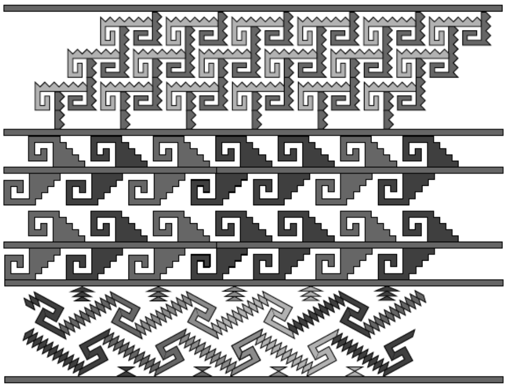
*(C)*

*(D)*


**Figure 5.***In images (C) and (D)the intention of the design is executed in background. It is an interesting process because it was a step closer to develop frames by plans.*

The evidence about 3D manipulated in Mitla's geometry is clear, however, we don't have specific evidence about 2D conception in every motive design, like plans or drawings.

The art and science transcended to other cultures of ancient Mexico as for example the Mayan culture, particularly Uxmal and Yaxchilán. These operations can be seen in the buildings, known as the quadrangle of the nuns in Uxmal (Yucatan) and the Palace of Yaxchilán (Chiapas).

## 3. Constructive Procedure

As mention above, the first approach to this topic was already discussed, two other important features that presented the design of the friezes and the setting of the facades are: shafts of composition and the angles.For example, in the picture below, it is shown that the parts are cut and embedded (approximately in the angles of 30, 60, 90 and 45 degrees). The frieze has axes of composition where they will be placing each of the parts; it is necessary to point out that the design of a same frieze has variations that are presented in another frieze of the same reason.

Taking up the theme of the approximation of the angles, some parts do not match in axles to accurate angles, these are at the top ready with a part number in 3 and 4(See Figure 7 E and F).

However, there is a geometric concordance between the parts. These are placed on distances and dimensions provided. This allows the implementation of the operation of symmetry in frieze and the formation of the entire design of motifs. Another observation that I would like to stress is that there is a transition between the band and frieze in the background, thus generating a scheme in frieze. Axis vary between lines 16, 17, 13 and 24, depending on the composition of frieze.

However, they are more frequentin the 16th line, where possibly there is a relation to the final design of the boarder.

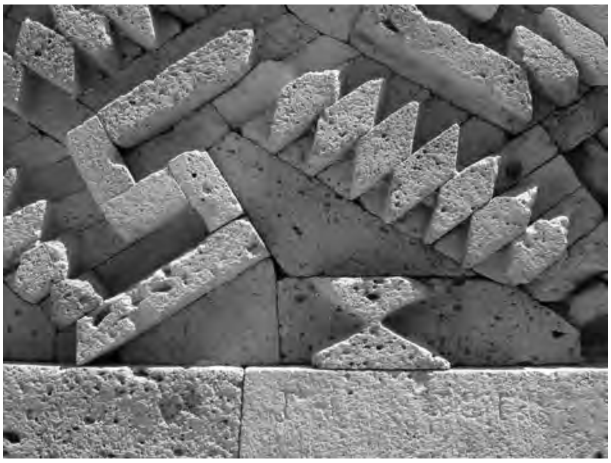
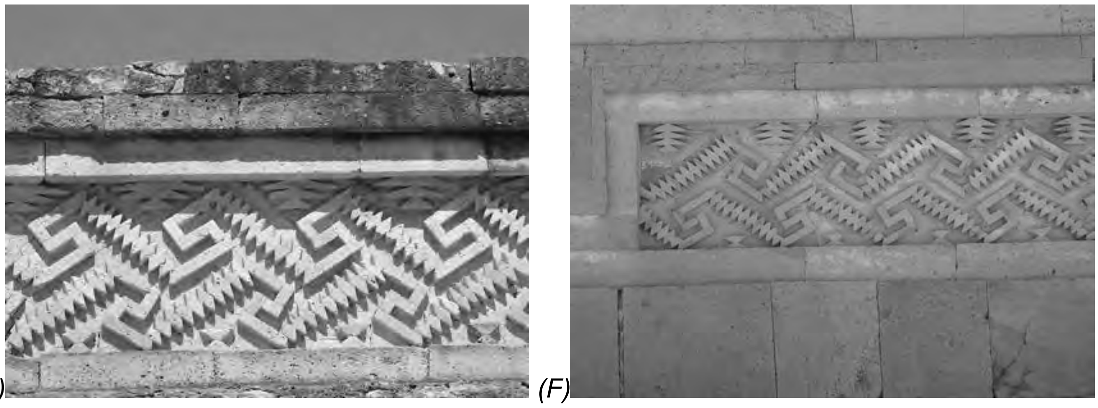


**Figure 6.** *We can see the disposition arrange little pieces of stone block with a specific cut with angles approximate to 90º, 30º*



*(E)* *(F)*

**Figure 7.***The design of this panel with the motif of the "serpent" is another variation in the arrangement .The important detail is the number of elements. In the picture above, there are 4 triangles while in the photograph below we have only 3.correspond to the building of the columns and the group of the church respectively.*

The friezes not only show geometric principles of composition in band but they also portray a development in all background, a dual band and many of them show a transition between frieze and the background.

The foregoing description derives from the classification of the marbles in their designs for grounds, following an order based on groupings or on families. With this the study of the operations of symmetry in frieze it will be crucial to create a better interpretation of the geometric analysis of each one of the reasons prepared in facades .It is important to note that the classification of the marbles will be based on scientific research of the operations of symmetry, i.e. the majority of The fretworks present the operation of symmetry to friezes ‘tg’, some simultaneous dual-band , others to a single , and even are the principle of flat symmetry classification called ‘*pg*’.

To analyze the constructive system of structures it is necessary to know the type of material with which it is built. These structures were built with material taken from the region: stone quarry as can be seen in the photos

On the other hand, the task of pasteparts in some areas of the structures required the use of some kind of a primitive mortar.It was generally a mixture of mud with prickly pear( *'Baba de Nopal'* cactus) according to the oral tradition ; however, in site it can be seen in a few parts that mortar. For columns and other elements monolithic, the builders used the carved stone or chisel.

Some hypothesis suggest the use of the system to cover wooden base and a system of beams facts with a material similar to the species of a bamboo. At present, there is a room covered with this materialwhichproves this hypothesis (figure 8). However, the analysis of the space, reduced in size to the width, suggests that walls have been covered with the same material as well.

**Figure 8.** *Hypothesis of room cover suggests a permanent material versus imperishable material*

In most of the parts of the wall base they were trying to pressure the pieces of stone to configure the design the all wall; in many cases, the structures are available for an item that helped this accommodation to pressure from the parts, as can be seen in the photos above, in a few parts although there are parties are united with the kind of mortar manufacturing.

By observation and by the analysis on the site, you can infer that the structural system of the buildings was based on columns and decorated beams, what can only be seen in the interior of the tombs. It is possible that the foundation consisted of a system of rollers where heavy structure rested, a kind of procedure that developed a dynamic system in a seismic zone. The pillars were carved with jade stones or glass (according to oral tradition) that as discussed before, served as part of the foundations and also bore the cover of the rooms.

It is very likely that a system of drainage in the architectural ensemble of Mitla was developed, since in the buildings there is a drainage system organized by a few holes oriented toward the south-west, with the implication that by gravity and slope water returned to the stream.

This slope invested (term that designates the type of system) is a feature of the Yucatanhas buildings, especially in Uxmal. The profiles retract inward at the base of the wall, and are projected above the three friezes above, each more outgoing than the lower one. This seems to be an optical correction. In addition to resetting the force of the vertical lines in a block long and low, it allows the light reflected by the earth bathe the wall from the bottom; the result of this perception is that it produces an illusion of depth, in both the provision of the fretworks makes in a given time, the sun set to the work piece between figure and background (when you change the orientation of the lighting changes to Visual reading of the friezes on the facade).

## 4. Approach the Study on Mitla's Motif with QMCA[2]

As an important tool of analysis of the Mitla's motif we can use The Quasi-Monte Carlo method, with Stanford 3D Scanning, in recently years QMCA it have been used for scanners and surface reconstruction algorithms: *"Many researchers, however, do not have access to scanning facilities or dense polygonal models. The purpose of this repository is to make some range data and detailed reconstructions available to the public"*[3][3]

The researches of applications of QMCA are developed in arts and other 3D examples. It is suitable for open surfaces, and compares with others methods based on surface reconstruction.If analyze part by part the stripes in the symmetries of Mitla and as part of a basic pattern, breaks down, and then go piece-by-piece forming a complex system of design, we will have a possible application in the use of the QMCA.

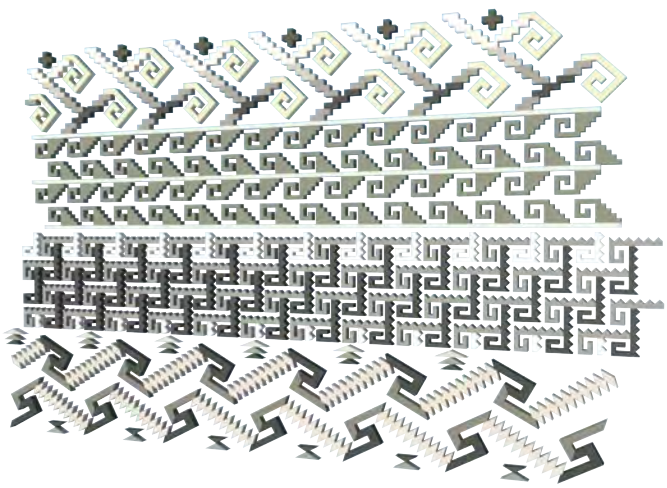
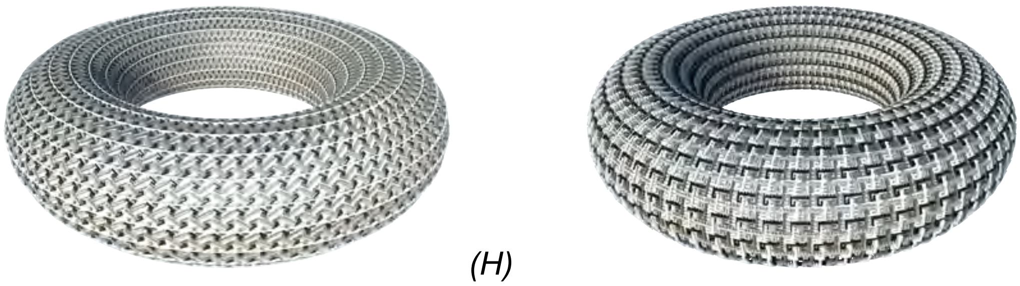


**Figure 10.** 3D Model about the complete background design composed with the friezes bands.

There are many methods to explore 3D spaces and the possibility to make transformations by spaces with symmetries, for example Mitra's studies about symmetry in design architecture, (see figure 9)show: *The surface of the model is sampled uniformly with average sample spacing h. The user parameter h determines the scale of the smallest symmetric elements that we want to detect. For every sample point we compute a local signature that compactly encodes local geometric properties at that point that are invariant under transformations of the specific* *transformation space under consideration. Sample points with similar signatures are paired and a canonical transformation that maps one sample to the other is computed and refined using local registration methods."*… "*If a shape contains symmetries or repetitive structures, then the estimated transformations exhibit specific accumulation patterns when mapped to a suitable transformation space. These patterns can be extracted using cluster in methods and grid fitting techniques. While the method of [Mitra et al. 2006] is mostly concerned with pairwise symmetries, the structure discovery method of [Pauly et al. 2008] in addition analyses the spatial relations among different symmetries. The underlying formulation is based on theory of transformation groups and thus allows a rigorous mathematical treatment of the concept of structural regularity"* [4].

If we know about the procedure of their construction we can use it to design a model with the approximate measures in 3D and 2D to make transformations or, explore the possibilities in the management of the finite shapes, such as explore the symmetries of frieze into three-dimensional models such as the Torus, (see figure 9)



*(G)* *(H)*

**Figure 9.** *Overlapping the strips with design of the friezes at Mitla within the torus. The horizontal and vertical limits are closed.*

## 5. Conclusion

The study of geometry, mathematics and its possible applications through computer programs allow us to understand and progress toward the design process in architecture linked with the history of ancient civilizations and the ones that are already missing. The study of the operations of symmetry in the architecture of Mitla binds us the knowledge of the geometry with the architecture and provides the tools for designing facades, floors applicable to architectural projects. It provides mathematical principles that an architect should know for the design of objects with precise geometry. The mathematical principles bring us closer to explore ways by means of computer programs and invite us to reflect on the history of those ancient civilizations that possessed these processes of design without the use of technology.

The scientific breakthrough that these Mesoamerican civilizations achieved through its knowledge expressed in the design of its architecture by means of mathematics, geometry explored and used for its architecture.

It should be noted that the exploration still continues, since the scientific and artistic knowledge, extends to other Mesoamerican cultures. This analysis may provide the necessary tools for the design methods in the architecture (not only in the configuration of the walls and floors, but also in plant design architectural) driving a repertoire of possibilities in the symmetries of these, and also rescue this architecture.

## 6. Acknowledgements

Professor Thomas Garcia Salgado for letting me work on his book Theory of Architectural Design, which supports the research of this article. To each and every one of the people who spend their time on advising me: Paul Rosell in the Mathematics Institute, Carlos Villareal and Carlos L. Nataren Institute of Physics at the UNAM. As well as for revision and correction of the text by Professor Rafał Czyżewski and the last images modelling by my assistant José Luis López Maza.

## 7. Notes

1 Symmetry in 3D Geometry: Extraction and Applications, Niloy J. Mitra, UCL

2 Professor Yu-Shen Liu call QMCA, that one method is based on the Monte Carlo integration and counts the number of intersection points between point sets and a set of straight lines. Russel E. Caflischsaid that "Monte Carlo is one of the most versatile and widely used numerical methods… Monte Carlo quadrature is attained using quasi-random
(also called low-discrepancy) sequences, which are a deterministic alternative to random or pseudo-random sequences. The points in a quasi-random sequence are correlated to provide greater uniformity"
3http://graphics.stanford.edu/data/3Dscanrep/. October 25 th 2013

## References

[1] MITRA, N. J., GUIBAS, L. J., AND PAULY, M. 2006.Partial and approximate symmetry detection for 3D geometry. ACM Trans. Graph. 25, 3, 560–568.
[2] SZIRMAY-KALOS, László (2008). Monte Carlo Methods in Global Illumination - Photo-realistic Rendering with Randomization. VDM VerlagDr. Mueller e.K
[3] YU-SHEN LIUA, Jun-HaiYonga, HuiZhanga, Dong-Ming Yanc, Jia-Guang Sun, A quasi-Monte Carlo method for computing areasof point-sampled surfaces. April 2005
[4] NILOY J. Mitra, Mark Pauly, Symmetry for Architectural Design, ACM Trans.
[5] GARCIA Salgado T. Theory of Architectural Design, TGS/ FA-UNAM, 2007 pp.127

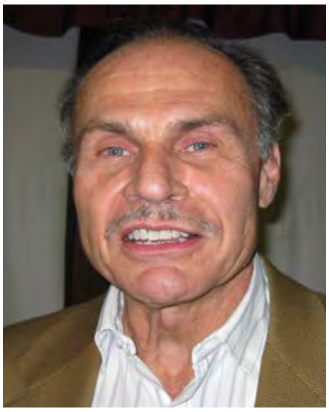
## Autor

Architect by Faculty of Architecture, UNAM in 2007. She obtained the Master degree with Honorific Mention in the year 2009 by the Postgraduate Course in the same faculty. Assistant Researcher N3 by CONACYT conducted their professional practices in Government Institution. Has teaching experience for more than 5 years in universities such as UNAM (Mexico city) UNACH (Chiapas). In the professional field has exercised its work in the projection area for preserve Heritage Building. Currently. She is Professor in the Faculty of Architecture from the University Autonomous of Chiapas. Coordinator Committee of Vigilance Heritage Built by the Chiapas Architects College.

3

**Nikolaus Bezruczko**

*Paper:* **Generative art simplifies psychometrics of artistic judgment aptitude**

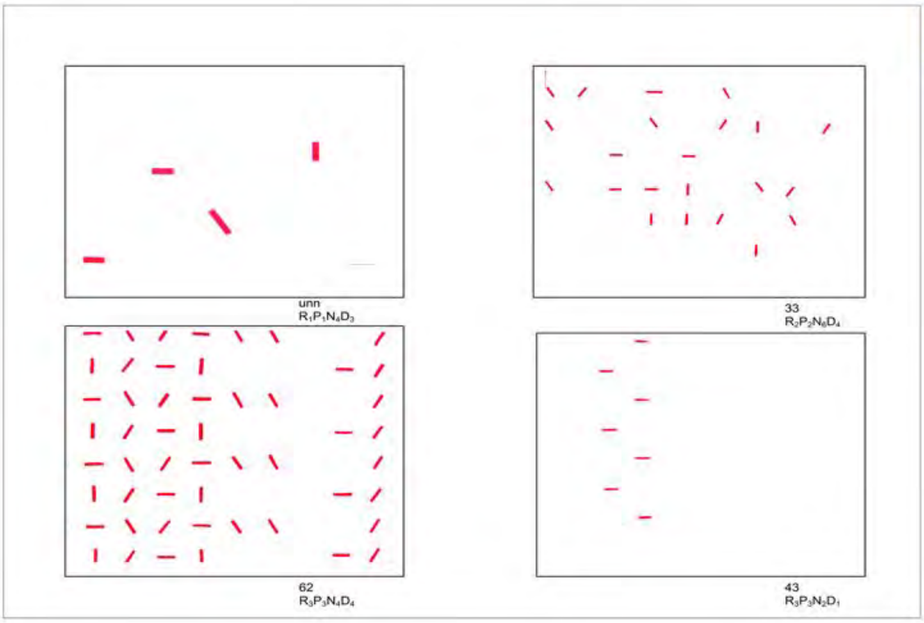


***Topic: Generative art and psychometrics***

***Authors:***
***Nikolaus Bezruczko***
Measurement and Evaluation, Consulting, Chicago, USA

***References:***
[1] Fechner, *Vorschule der aesthetik.* Leipzig: Breitkopf , 1876.
[2] Birkhoff, *Aesthetic measure*. Cambridge: Harvard University Press, 1933.
[3] Attneave, Stochastic composition processes. *Journal of Aesthetics and art Criticism, 17*, 1959.
[4] Bezruczko and Schroeder, Artistic *Judgment III: Artist validation*, Technical Report , Chicago: Johnson O'Connor Research Foundation.
[5] Bezruczko, Measuring Artistic Judgment Aptitude, *Journal of Applied Measurement,* in press, 2013.

***Abstract:*** Artistic judgment is widely appreciated across broad domains of Western civilization. Moreover, social researchers have studied its occurrence as aptitude for over 100 years. Unfortunately, complexities associated with objective images and validation has made artistic judgment aptitude measurement virtually intractable. This presentation will describe advances measuring artistic judgment aptitude using generative art. Many researchers have studied artistic judgment. Fechner [1] first conducted empirical studies in 19th century. Birkhoff [2] followed with mathematical studies and emphasized influence of order and complexity on artistic judgment preference. Other 20th century researchers investigated preference for controlled visual images and confirmed differences between artists and nonartists. Attneave's [3] research led to understanding that nonartists and artists fundamentally differ in sensitivity to redundancy (order). Present research continues contemporary empirical trend by demonstrating a stochastic algorithm that objectively manipulates order and complexity in visual images. Physical images were rendered in a Neoplastic style, and their effectiveness for measuring artistic judgment aptitude was validated with professional artists (*N* = 66) from several American cities [4]. This research will describe an artistic judgment information processing model, procedure for image production, collection of field observations, empirical analysis with a probabilistic Rasch model, and evidence for a psychometric construct. Finally, an algorithm developed at 1-layer will be generalized to n-layers of visual arts information. [5]



*Images produced by a stochastic algorithm with generative properties. They have been psychometrically validated with professional artists and laypersons for measuring artistic judgment aptitude.*

***Contact:****Nbezruczko @msn.com*

***Keywords:*** Artistic judgment aptitude, Rule based art, Automatic item generation, psychometrics, Rasch model

# Generative Art Simplifies Psychometrics of Artistic Judgment Aptitude

**Dr. Nikolaus Bezruczko, PhD**
*Measurement and Evaluation Consulting,*
*Chicago, USA*
*nbezruczko@msn.com.*

## Abstract

An Important educational function in advanced Western economies is development of human talent both for efficient organizational management, as well as individual self-realization and personal satisfaction. Toward these goals, human aptitude measurement is instrumental to efficient use of rare human resources. Many cognitive capacities such as spatial, verbal, and intellectual reasoning are psychometrically evaluated, and their results have implications for pedagogy, career planning, and occupational counselling. Not surprisingly, artistic judgment aptitude is among those human capacities with both individual and cultural implications. Artistic expression to an important degree defines cultural development and is widely acknowledged to influence quality of life. Moreover, artistic expression contributes to perceptions of personal well-being, as well as transcendent states of spirituality and insight. Despite its enormous importance, artistic judgment aptitude measurement typically faces several challenges that have stymied practical development of objective measurement technology.

AJ aptitude measurement is problematic because theoretical knowledge is fragmented, literally scattered across more than a century of social research and most of it too fragmented for practical aptitude test development. Landmark 19th century studies established feasibility of inferring artistic judgment from visual preferences, and early 20th century researchers continued these studies. Dominant statistical factors that influence visual preference judgments were identified, and their relations to artistic judgment were investigated. However, practical artistic judgment aptitude measurement never became widely accepted nor supported by empirical validation studies.

A purpose of this report is to describe contribution of generative art methodology to improvement of artistic judgment aptitude measurement. A generative algorithm was developed that implemented statistical factors to produce visual images with explicit parameters capable of distinguishing between professional artists and nonartists. Developmental studies were also conducted to investigate aptitude origins of these preference differences. Application of generative art to image development addressed long standing objectivity and validity problems measuring artistic judgment aptitude.

An algorithmic information processing model was developed that manipulated syntactic complexity and redundancy in abstract images. Then empirical preference studies were conducted to examine differences between professional artists and nonartists. These results established both theoretical validity for an image construction model, as well as predictive validity of score implications. Then after several years of operational use, abstract generative images were followed by

production of controlled figurative images. In this report, brief historical background is presented of artistic judgment beginning with Fechner's 19th century landmark studies, then problems are summarized that plagued artistic judgment aptitude measurement for much of 20th century. Finally, a solution is presented that, first, models artistic judgment in a complex, sequential and recursive information processing structure. Then image decoding is isolated in the syntactic component of this model. Professional artists and nonartists are believed to process visual information differently, and an algorithm was developed to generate visual images that distinguish between them. Results are summarized in this report of empirical studies of these images.

## 1. Introduction

### 1.1 Philosophical orientation

Unlike traditional aesthetic studies, which strive for philosophical insight and understanding, artistic judgment (AJ) aptitude measurement is dedicated to practical humanistic goals with a prominent emphasis on objective, valid, and reproducible knowledge. AJ differs significantly from general aesthetic studies in social research by a conspicuous emphasis on professional artists and artistic values. Then this knowledge is implemented to solve practical issues of form, beauty, and function.

Visual arts are widely recognized to represent a humanistic accomplishment, and they typically define the civilization achieved by a people. Many commentators, for example, consider the arts and philosophy of ancient Greece to represent pinnacle of Western civilization. At a practical level, AJ is implemented every day in a broad range of activities and endeavours, and its prevalence tends to improve quality of life and personal states of being. Pervasive influence of AJ on practical affairs suggest aptitude research should present important benefits to students, teachers, counsellors, and parents. AJ aptitude, in fact, is instrumental toward success and productivity in many occupations and careers such as graphic arts, architecture, textiles, industrial design, cosmetology, dentistry, photography, and this list seems endless. Virtually any activity that requires visual appraisal is likely to benefit from AJ aptitude.

Unfortunately, objective AJ aptitude measures have been extraordinarily difficult to develop. Over 125 years of empirical AJ research has led to conceptual fragmentation and relatively minor consolidation of knowledge. Unlike most other aptitudes, artistic aptitude development and AJ in particular is closely associated with culture and social values, which is typically influenced by visual arts training and experience. This context for AJ complicates psychometric construct validation. A further obstacle to gaining practical knowledge about AJ aptitude is synthetic, controlled visual images are commonly rejected on artistic grounds. Consequently, scientific penetration of artistic phenomenon in general has been extraordinarily difficult.

Psychometrics emphasize statistical methods for identifying human mental capacities such as attitudes, opinions, achievement and ability, as well as broad range of mental aptitudes. Unlike traditional mental capacities, however, AJ aptitude presents special challenges in terms of construct development, artistic validation, as well as formulation of objective visual images that function as standard test items.

Conceptualization of AJ aptitude as a distinct entity subject to empirical relations can be traced to Eysenck's psychometric studies, which identified two prominent factors in visual preference judgments of artists and nonartists for geometric polygons [1]. Eysenck referred to them as "T" and "K". Eysenck conceptualized T as a general "taste" factor that describes sensitivity of laypersons to aesthetic differences that is trainable and related to education and arts experiences but with a substantial genetic component. Eysenck frequently compared T to an IQ factor in context of the arts.

The K factor differs from a common factor by distinguishing between professional artists and nonartists. Instead of representing a common construct, K represents fundamental *differences* between visual sensitivities of artists and laypersons. The K factor assumes AJ is a special talent not widely distributed among general population. A constellation of personality characteristics have been associated with artistic talent, and Eysenck went on to identify personality and aesthetic sensitivity of artists and nonartists [44]. A general goal since Eysenck's research has been to develop methods for identifying those persons with AJ talent, which has led to a hypothesis of a "latent trait" with explicit psychometric properties.

### 1.2 Generative art and psychometrics

Purpose of this report is to describe an implementation of generative art that simplifies AJ aptitude measurement by solving several problems associated with producing objective AJ images and their validation. A comprehensive review of the social research literature does not show another similar application of generative art to psychometrics. Therefore, advances reported here should be of interest to both artists and social researchers.

A basic conception in generative art is stochastic principles can release a visual image without direct manipulation of an artist [45]. Substantial advances in generative art are based on this idea, and this report describes its solution of following psychometric problems:

- Production of objective visual images independent of artistic intervention, which minimizes influence of style and arts background on visual preference.
- Inexpensive and convenient replication of visual images.
- Manipulation of image layers to probe fundamental perceptual process.
- Generative art frees art making from spontaneous inspiration of creative production.

Generative art provides capacity to examine discrete aspects of a very complicated process and manipulate those aspects relevant to some particular question. In doing so, generative art is clarifying the humanistic foundation of visual arts expression and emphasizing its implications for human affairs. In consequence, generative art has opened the door for future studies of AJ aptitude.

### 1.3 Aesthetic versus artistic judgment

Aesthetic studies address conceptions of beauty and their functions in human affairs, which contrast sharply with AJ aptitude emphasis on individual differences and practical, objective methods to identify these differences.

The term aesthetics is a broad concept that “encompasses the perception, production, and response to art, as well as interactions with objects and scenes that evoke an intense feeling, often of pleasure [2].” In contrast AJ is a complex neuropsychological capacity that differs across persons, yet is only one among several prominent aptitudes necessary for artistic productions.

Not surprisingly, differences between aesthetics and AJ have profound implications, which are summarized by the following:

- Historical antecedents differ significantly. Aesthetics has ancient philosophical origins. AJ arguably was initiated by Fechner’s 19th century studies followed by Eysenck's 20th century research.
- AJ is predominantly a practical matter of identifying a human difference.
- Aptitude emphasizes distinctions between artists and non-artists. Aesthetics tends to emphasize overall questions of beauty and “states of being”.
- Aptitude has much stronger emphasis on validity both as an artificial construct and subsequent interpretation of implications.
- Aptitude seeks to establish exact limits of knowledge and understanding.
- AJ aptitude is an explicit construction of scientific knowledge.

Narrow concentration of AJ aptitude on measurement of individual differences contrasts with broad, sweeping concerns of aesthetics on sensitivity and development, response and reaction, as well as expressiveness and communication. Aesthetics seeks an understanding of the sources of inspiration and crystallization of expression, while AJ emphasizes only objective human differences.

## 2. Scientific foundations: 19th and 20th centuries

### 2.1 Historical background

AJ preference studies have an unusually prominent history in modern social research. Beginning in 19th century, several empirical traditions including psychophysics, educational testing, psychobiology, information theory, and experimental psychology have examined AJ preference with controlled visual stimuli. Fechner [3, 4] first studied preference for Golden Section, which is a proportional aspect of visual preference prominent in visual arts theory since antiquity. Fechner's foundational work generalized Weber's earlier mathematical work with physical sensation and established a corresponding relationship between visual stimuli and subjective preferences. One consequence of Fechner’s advances is utilization of visual preference as indicative of perceptual processing, an empirical methodology that has become established in AJ research.

Birkhoff [5] conducted mathematical studies and concluded complexity and order are objective image properties that influence visual preference. He asserted AJ in particular occurs during a succession of discrete processing stages, a forerunner of contemporary information theory. In his model, complexity and order maintain functional relations with visual preference, and he proposed the model:

$$M = O/C$$

where M is an artistic measure that is a function of order and complexity. This means in any image, artistic value is always greatest when order is maximized relative to complexity. At any level of complexity, an increase in order will increase overall aesthetic value. Berkhoff 's algorithm for complexity and order remains a topic of interest among mathematical researchers [46].

Eysenck followed Birkhoff's work with extensive factor analytic studies of visual preference for polygons that found significant differences between artists and nonartists. Eysenck [1, 6] called the main factor "T", a general Taste factor. Another factor that he called "K" is bipolar and distinguishes between artists and nonartists. Like Birkhoff, Eysenck identified complexity to be a key influence on visual preference. Control subjects expressed significantly higher preference for more complex polygons [7, 8]. Eysenck hypothesized fundamental genetic differences between artists and nonartists in visual perception, neurological function, and perceptual sensitivity. Unfortunately, Eysenck's contributions were only based on ordinal score correlations and weak true score methods which ultimately would undermine his effort to measure artistic judgment. In fact, a test derived from Eysenck's T, the Visual Aesthetic Sensitivity Test (VAST), tends to be unreliable [9, 10].

Finally, Berlyne [11, 12] extended idea of information processing stages and proposed several levels, namely, syntactic, semantic, expressive, and cultural that convey artistic information. Although empirical studies have not yet demonstrated information extraction from these stages, complex art likely requires sequential, as well as recursive processing before arts-related cognition concludes. Berlyne's emphasis on syntactic information would have special importance for contemporary advances. Syntactic information involves physical configuration of visual elements in an object or pattern and is fundamentally related to balance and layout design.

Social researchers have shown an enduring interest in Berlyne's research because he found image complexity to follow a curvilinear preference function. He reported visual preference for image complexity monotonically increases until reaching a maximum, and then preference steadily declines. Unfortunately, his studies did not include professional artists, and social researchers incorrectly concluded that preference for complexity indicates higher AJ. Contemporary social researchers, in fact, are surprised to learn that Berlyne's complexity function is *inversely* to related AJ, when samples include professional artists. In fact, complexity affects professional artists and nonartists differently. Inadequate sampling and overgeneralization of results has led to confusion concerning complexity and AJ that continues to muddle empirical aesthetic research. Martindale commented extensively on confusion and inconsistency surrounding Berlyne's research [13].

Fechner, Birkoff, and Eysenck are largely unappreciated in social research for an innovative line of inquiry that established a new way of looking at subjective experiences. They challenged historical conflicts between traditional physical science and social research and demonstrated perceptual preferences, subjective appraisals, and statistical order can lead to empirical knowledge. These accomplishments now establish a foundation for virtually all significant empirical work measuring AJ aptitude. Their advances, arguably, have established a standard for all social research and provides an important perspective on future studies.

## 3. Contemporary research

### 3.1 Stochastic image models

Twentieth century progress toward measuring AJ was substantial but incomplete because following problems could not be solved.

- Uncontrolled influences on visual preference contaminated AJ aptitude measurement.
- Artistic quality of controlled images for AJ aptitude testing was unacceptable.
- Test validation was inadequate because aptitude researchers neglected to distinguish between artists and nonartists.

Two significant advances facilitated implementation of generative art in AJ aptitude measurement. First, Attneave [14, 15, 16] described role of complexity and redundancy on visual preference, and speculated artists have highly sensitized visual receptors that may be easily stimulated by subtle redundancy features in complex patterns. He speculated nonartists may be less sensitive to redundancy and less able to simplify complex fields. Consequently, his research led to speculation that a discriminative perceptual mechanism distinguishes between artists and nonartists. Second major development was Noll's computer demonstration that generative art could have strong aesthetic properties [17, 18]. Noll was first American to apply computer technology to construct objective visual images, which led to broader mainstream recognition of stochastic influences on visual art.

### 3.2 Information theory and perceptual models

Visual stimuli consist of many information sources that in some cumulative manner influence visual preference [11, 12]. Viewers are believed to extract information during image scanning and relay it to specialized neuron receptors where neurological processing reassembles a meaningful gestalt or percept. A key mechanism in this process is image decomposition and information extraction. Information theory proposes extraction is governed by several principles such as uncertainty, amount of information, organization, and coherence. In simplest model, Platt [19] proposed separating aesthetic information into formal and stylistic information levels, while Moles [20] proposed a more complex system that simultaneously superimposes qualitatively independent information levels on an image during perception. He emphasized that "each level conveys its own unique message and possesses specific rules of organization" [20, p. 474]. Moles advanced conceptual foundations further by proposing a hierarchical information processing system in which artistic perception is decomposed into independent qualitative levels then reconstructed during cognition. Perceptual sensitivity and capacity are key differences he proposed between artists and nonartists. He emphasized prominence of semantic information represented by cultural conditions such as religion or government on visual preference. Finally, Berlyne proposed expressive and syntactic levels [11, 12], during perceptual processing. Expressive level transmits some personal aspect of artist, while syntactic information is physical configuration of visual elements in an object or pattern. Influence of this approach can be found in contemporary research [21, 22, 23].

### 3.3 Professional artists, contemporary art, and perceptual models

Interest in role of chance on image production was not restricted to 19th and 20th century science and technology. Professional artists since Picasso have been deconstructing visual images, and Mondrian emphasized structural organization of paintings without explicit figurative content. “De Stijl” and neoplasticism were an early 20th century art movement dedicated to foundational aesthetic principles [24]. Figure 1 presents several 20th century examples of 20th century contemporary art that integrated random principles into their production. By 1950s, professional artists such as Kelly were explicitly implementing stochastic mechanisms in visual art. For example, in *Spectrum Colors Arranged by Chance I to VIII*, Kelly, an American artist, completed a series of collages by using numbered slips of paper, which were indexed with specific colors. He then used one of eighteen different hues, which were randomly assigned to locations on a grid 40 inches by 40 inches. Moreover, he used a different stochastic process in each of eight collages. Kelly appears to have been first professional artist to implement probabilistic modes systematically in art.

Kazimir Malevich, *Eight Red Rectangles*, 1915

Theo van Doesburg, C*omposition VII (The Three Graces)* 1917

Ellsworth Kelly, *Arranged by Chance*, 1951

Ellsworth Kelly, *Spectrum Colors Red and White*, 1952

Figure 1. Ellsworth Kelly used numbered slips of paper, which were assigned by chance to a grid pattern in his paintings.

### 3.4 Problems and challenges

While substantial 19th and 20th century knowledge accumulated about AJ, aptitude testing remained relatively primitive because AJ is both a shared, cultural experience, as well as genetic aptitude expression. Not surprisingly, intensity of this interdependency stymied virtually all efforts to separate AJ into objective and subjective aspects. Not until 1980s, when Johnson O'Connor Research Foundation (JOCRF) undertook a major initiative to develop an AJ construct for occupational and vocational counselling was an algorithm developed to construct objective images. JOCRF's strategy was to diminish costs of traditionally painted artwork and improve predictive validity by developing an objective image model based on information theory. Then a generative algorithm was developed to produce test images. Definitive validation by professional artists followed, which rationalized test design and image template development.

AJ aptitude measurement has faced stubborn challenges. For example, close relations between artistic judgment and social context undermine objectivity necessary for valid measurement. Other problems included generally weak artistic judgment criteria, as well as inadequate validation samples. In general, synthetic images were typically rejected on artistic grounds.

Theoretical fragmentation also inhibited AJ aptitude measurement. For example, AJ image processing is complex, and even simple images present an enormous amount of information to viewers. Early interest in proportions, then investigations of image characteristics, that influence visual preference, and emergence of information processing theories have not led to theoretical consolidation. Consolidation of AJ research across traditional disciplines (psychology, cognitive science, information processing, and experimental psychology), as well as more recent neuro-imaging studies has not occurred. Not surprisingly, fragmented and incommensurable conceptual perspectives, as well as inconsistent empirical interpretations has inhibited coherent AJ construct development.

### 3.5 Contemporary AJ aptitude testing

AJ aptitude testing with generative test images is currently conducted in JOCRF testing offices, which is located in several American urban centers. JOCRF has been developing aptitude tests since 1920s and is the largest aptitude testing organization in USA. Until 1980s, JOCRF based AJ testing upon visual appraisal of stimuli with controlled proportions, which was never widely endorsed within JOCRF nor by professional artists in general. Consequently, JOCRF undertook a major initiative to develop a new AJ test construct based on contemporary scientific knowledge of AJ perceptual processing, stochastic generative models, and visual arts theory. Visual Designs Test (VDT) is a product of this research and an example of generative art implementation, which substantially improved AJ aptitude measurement [25].

## 4. AJ aptitude measurement theory

### 4.1 AJ construct

First, AJ needed a plausible but comprehensive aptitude construct with hereditary antecedents that interact with experience and education. Then some aspect of overt human behavior needed to be identified that reveals AJ aptitude and is related to a wide range of artistic activities. These considerations led to a construct based on visual preference for "physical elements organized in space". Visual preference is logically fundamental to all artistic expression and both visual preferences and spatial abilities are linked to substantial prior AJ research. An emphasis on preference also simplifies the immense complexity of AJ by excluding physical production, appreciation, and training. The following sections describe a preference construct that was elaborated by advances in contemporary behavioral science.

Twentieth century information theory and experimental aesthetics provided a theoretical context for hypothesizing AJ as a specialized cognitive processing aptitude. This fundamentally new approach to AJ aptitude exploited following principles about human perception, aesthetic preference, and physical objects:

1. Artistic judgment is based on systematic perceptual processes. Humans, for example, implement a scanning process that decomposes visual stimulation into discrete information levels, and then simultaneously reconstructs them into personally relevant meaning. This process is sensitive to feature attributes such as contours, colors, textures, and complexity, which interact with experience and knowledge, as well as linguistic and conceptual cues.

2. Objects and patterns have objective properties that are independent of human perception and a basis for their artistic valuation. These properties conform to physical laws and have psychological effects that are expected to remain stable and consistent over time.

3. Neurological sensitivity to visual information varies among persons and is largely innate. Persons with artistic aptitude are expected to be more sensitive to visual stimulation. Innate sensitivity differences to arts-related stimulation between artists and nonartists are the foundation for an aptitude approach to AJ.

4. Given a visual choice between meaningless alternatives, artists prefer less-complex designs. (Artist preference between meaningful alternatives is profoundly more difficult to describe.) Moreover, preference for less-complex designs also appears to have stable aptitude properties [8, 26]. Other physical features that distinguish artists from nonartists such as symmetry, balance, and proportion, as well as information properties such as novelty, interestingness, and pleasingness appear mediated by culture and socioeconomic status [8].

### 4.2 AJ processing model

A provisional AJ perceptual processing model was formulated for this research to guide theory development and instrument construction, which is presented briefly below. AJ preference was hypothetically modelled in an information processing structure divided in several stages that were defined by specific extractions of syntactic, semantic, stylistic, and expressive information. This model revisited theoretical considerations initially proposed by Berlyne [11], but integrated insights from contemporary perspectives [21, 22]. Unfortunately, these contemporary models tend to emphasize aesthetic aspects not immediately relevant to practical aptitude measurement. Moreover, contemporary aesthetic processing models are not generally validated by both nonartists and professional artists, which limits their usefulness for aptitude measurement. Consequently, an artistic judgment processing model was specifically developed for present research that emphasized differences between artists and nonartists, which is presented in Figure 2.

Figure 2 presents an overall perceptual processing structure of components and stages developed specifically for AJ measurement [43]. Image processing in this structure involves decomposition into memory registers, recursive separation of visual information into cognitive and affective components, and a stage of critical evaluation and artistic judgment. This process then enters a stage of image reconstitution mediated by personal affect, which concludes in an overall cognitive judgment concerning meaning and comprehension. Simultaneous with overall processing is dynamic within image processing that emphasizes collative image properties such as complexity and redundancy, which distinguish between professional artists and nonartists. While comprehensive artistic cognition is deliberative and recursive, contemporary studies agree preference for complexity occurs almost instantly during initial encoding [27, 28]. In other words, syntactic structure of images is specifically isolated in this processing model, and preference values are assigned very early independent of overall information saturation of any given image.

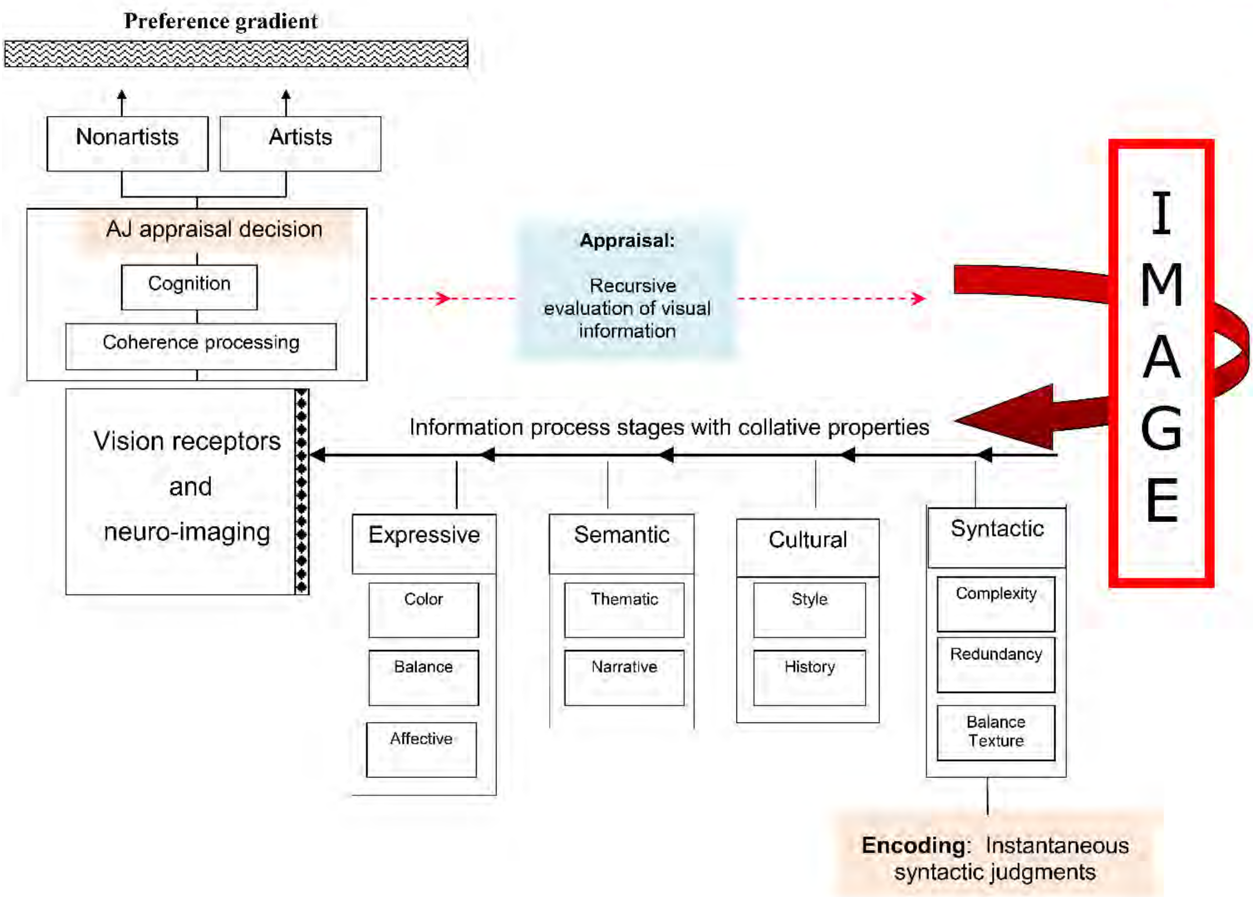



Figure 2. Information processing model of artistic judgment

According to this aptitude model, artistic perceptual sensitivity should lead artists to be less tolerant of complex images with low structure (high complexity and low redundancy, which are images consisting mainly of random visual noise. Consistent with empirical research, artists will prefer less preference for random complexity than nonartists. Likewise, artists should express higher preference for complex, coherent, syntactically balanced visual images independent of meaningfulness.

## 5.0 AJ image development

### 5.1 AJ test design strategy

An AJ aptitude test goal was to establish an objective visual preference gradient based on images that systematically varied along theoretically significant design features. These design features should distinguish between visual preferences of artists and nonartists. To reach this goal, a research plan was developed that a) hypothesized an empirical AJ visual preference model based on published research, b) formulated a strategy to isolate visual preference judgments, then, c) developed a theoretical construct amenable to practical implementation. In this context, an image construction model was developed to manipulate images that would separate artists and nonartists on a visual preference gradient.

Following sections describe empirical AJ methodology that was implemented.

- isolation of syntactic attributes in visual images
- operational definition of complexity and redundancy with an objective, rule-based algorithm
- statistical manipulation of complexity and redundancy in image models
- collection of visual preferences from professional artists
- adaptation of image model specifications for figurative images

### 5.2 AJ image components

Prior studies had identified complexity and redundancy as "radical" influences on item difficulty, which should influence visual preference. Neurological sensitivity has long been considered instrumental to significant preference differences between artists and nonartists [16]. These principles were represented in an image model by operationally defining both complexity and redundancy in the following algorithm:

$$(C_e C_t) R_p$$

which was implemented across 1-layer of image processing levels, where each level has rank in an overall hierarchy, and:

$e$ = $n$ of elements and $n$ takes values 2, 4, and 8

$t$ = types of elements and ranges from 1 to 4

$p$ = $n$ of panels $p$ and n takes values from 1, 2, and 4 which leads to images of 0%, 50%, and 100% redundancy, respectively. Figure 3 presents complexity and redundancy components in a VDT image model.

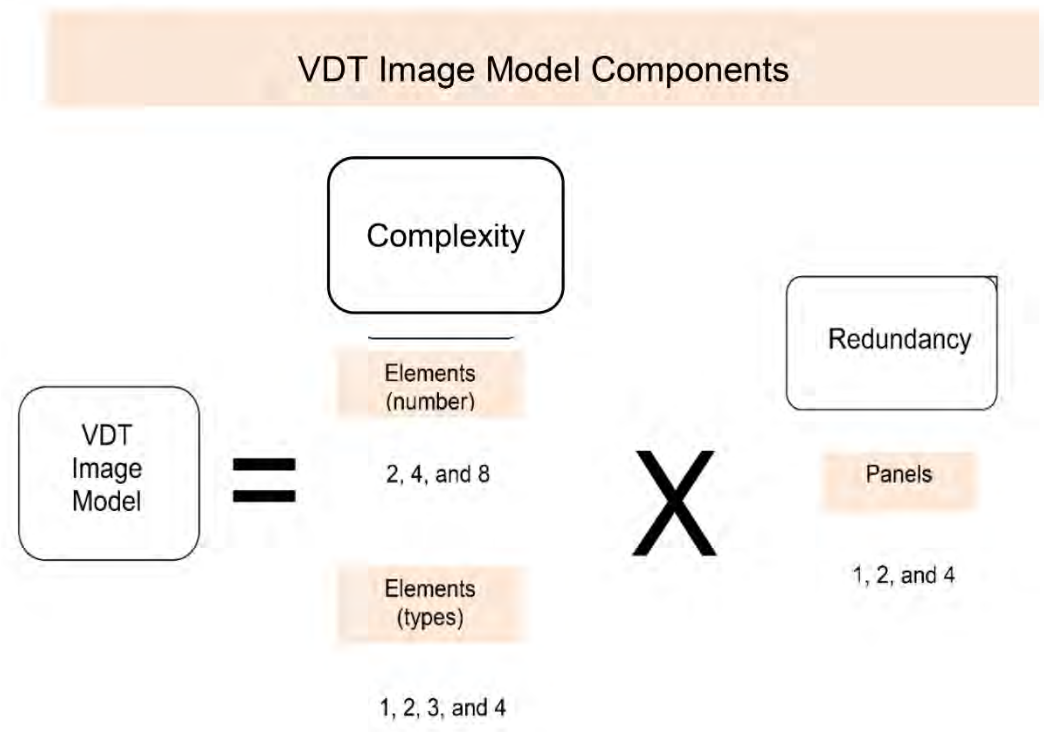



Figure 3. VDT image model components

**5.3 Objective test images**

Separating cultural, stylistic, and historical criteria that influence AJ has been a long standing obstacle to social researchers. A related problem was establishing an objective artistic standard for evaluating personal visual preferences. Complicating psychometric test development, AJ is emphasized in visual arts education and professional training, which contaminates validation procedures. In addition, a common perception of laypersons is visual arts function outside scientific boundaries hence AJ testing is impossible to conduct [29, 30]. Consequently, empirical studies that purport to be objective about AJ tend to raise profound suspicions among artists, and altogether, these conditions fundamentally undermine conventional validation procedures. While talent is widely associated with AJ, forces described above largely prevented aptitude testing advances for most of 20th century.

Generative art played an instrumental role in breaking through methodological impasse of AJ aptitude testing. An algorithm for producing objective images virtually eliminated influence of arts training and background on visual preference. This image model manipulated key predictors of visual preference, which was coded in image templates, which then were field tested. Moreover, this image model was based on theoretical principles, which provided strong support for construct validity. These images were also broadly endorsed by a substantial sample of professional artists, and validation studies distinguished between artists and nonartists [36].

Development of a response mechanism was initially problematic. A response mechanism represents that aspect of human behaviour related to target performance. Mental ability testing in general emphasizes human performance in an educational or training context because a purpose of mental testing is to assess effectiveness of that training. Unfortunately, traditional approaches to ability and achievement contextualized by training and education weakens validity foundations for aptitude measurement. In contrast, AJ aptitude testing emphasizes instrumental role of a "latent trait" on human behaviour independent of education or training context but necessary for successful occupational or professional performance. In other words, an AJ aptitude test does not infer what examinees can do artistically, but rather their visual inclinations independent of training. In fact, visual preferences are typically considered an expression of personal taste and presumably less dependent on formal education or art training.

### 5.4 Image template construction

VDT test model consists of a single image model, which is defined by a range of complexity and redundancy attribute values. Any generated template is only a "snapshot" of image possibilities and has virtual capacity to generate images limited only by physical constraints. Several procedural steps were completed to produce images. First, a physical cell structure was specified, and an item construction algorithm, which manipulated complexity and redundancy, was implemented with a stochastic procedure to assign design elements. Images from this procedure were submitted to field testing to establish parameter values. Based on image model specifications presented above, a single image generator produced 96 templates, which was limited only by dimensional constraints of the physical cell structure. Figure 4 presents VDT construction specifications for item templates. Figure 5 presents sample isomorphs corresponding to templates produced by this procedure.

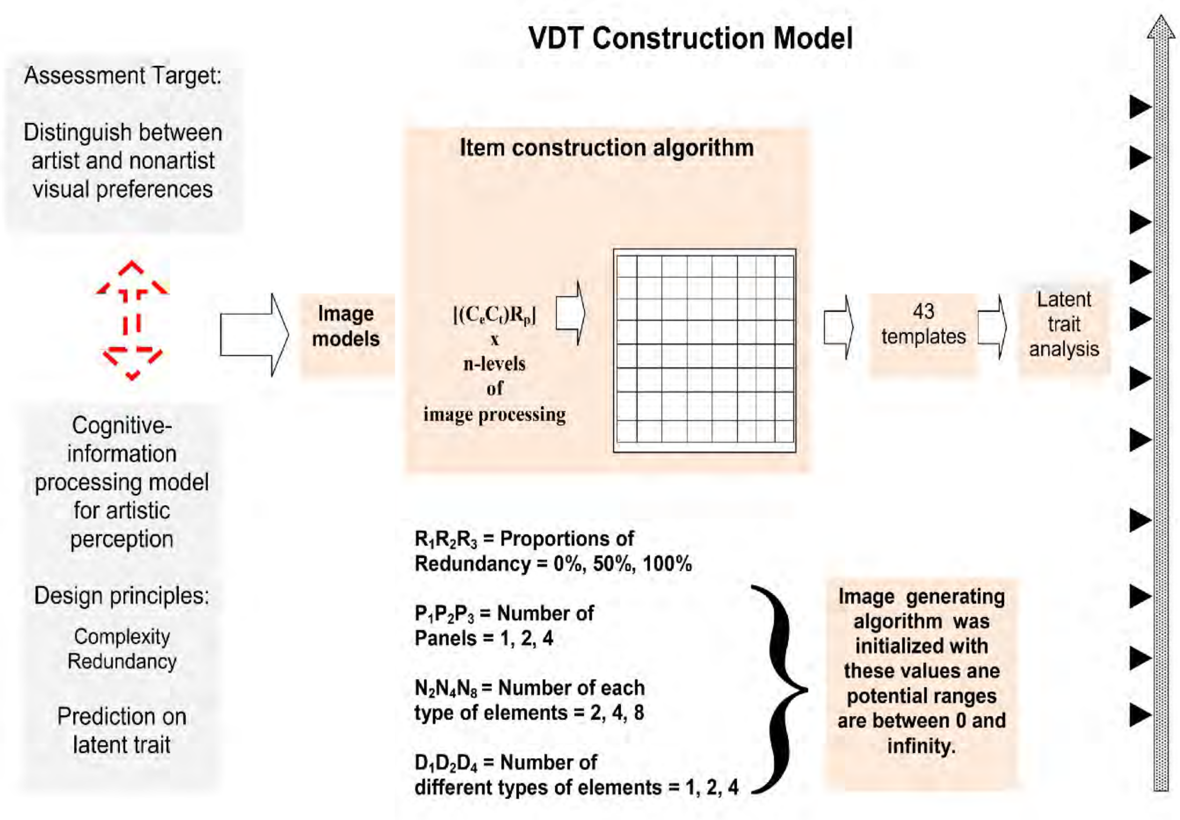



Figure 4. VDT rule-based image construction model

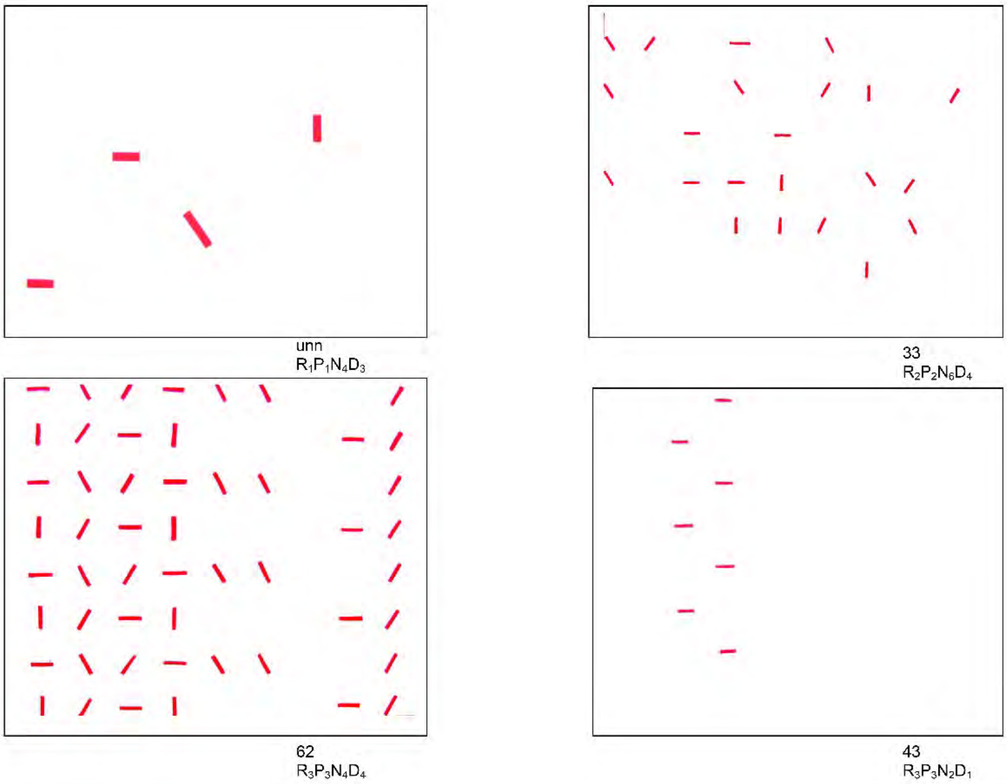



Figure 5. VDT sample isomorphs from a generative algorithm

A rule-based method was developed for objective image construction. Rule-based methods were originally developed for intelligence and achievement testing [31, 32]. This adaptation to AJ judgment aptitude integrates Eysenk's K factor with several ideas from experimental aesthetics and information theory. Together, they establish an image model, which operationally defines a visual preference construct with linear measurement properties. Subsequent studies would examine professional artist validation and aptitude status of this construct in developmental research [40].

A key innovation was a generative statistical algorithm that manipulated complexity and order (redundancy) separately in visual designs [33, 34, 35, and 36]. Based on Attneave's stochastic composition process (1957, 1959), this algorithm included a stochastic component that systematically manipulated only complexity and order (redundancy), and randomly assigned image elements to a design grid. This procedure reduces visual art to syntactic information expressed in stark abstract designs of black, white, and red. Using this algorithm and an incomplete factorial design in which 3 levels of 3 complexity factors were crossed with 3 levels of a redundancy factor [33], 84 pairs of images that contrasted higher and lower complexity levels were constructed. Visual preferences between image pairs were collected from several JOCRF examinee samples, and their responses were dichotomously scored to exploit Eysenck's research indicating artists prefer less-complex designs. Conventional psychometric analyses then identified two prominent factors that were called Simplicity and Uniformity [9, 25]. Original 84 items were reduced to 35 forced-choice items (Simplicity = 22 items and Uniformity = 13 items) and published as Visual Designs Test (VDT) [9].

## 6. Migration to figurative images

**6.1 Background**

Although VDT abstract consists of statistical images generated by an algorithm, they mimic minimalist images similar to contemporary neoplasticism, and professional artists in a validation study soundly endorsed their aesthetic value (*N*=66). Artist de-briefing interviews after the professional artist validation study revealed their interest in stochastic images, and artists from this sample frequently identified specific aspects of VDT abstract images that influenced their preference in presented image pairs.

In order to broaden validity foundations beyond minimal, nonrepresentational, abstract images, a study was conducted of examinee preference for more traditional, representational art. Of particular interest was comparability of visual preference for abstract images based on the VDT algorithm versus images that included semantic, expressive, and stylistic information. Are abstract and figurative images equally valid for evaluating AJ aptitude? In order to address this question, VDT generative algorithm was adapted for production of authentic figurative paintings.

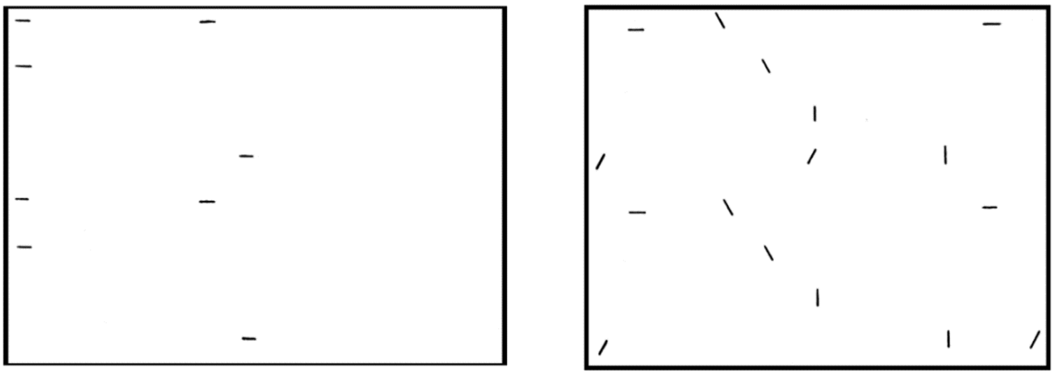
Not surprisingly, VDT generalization to figurative images raised enormous challenges. VDT abstract is a 1-layer image model, while figurative images in general consist of *n*-layers that are likely saturated with semantic, expressive, cultural, and syntactic information. Information density of figurative would obviously be much higher, and interactions would be expected across levels. This challenge is described below [37].

> The goal of the *n*-layer model is to generate items by manipulating a relatively large number of elements at two or more layers in a parent model. . . . unlike the 1-layer model where manipulations are constrained to a linear set of generative operations using a small number of elements [37].

Figure 6 presents both VDT abstract and figurative images, which contrasts syntactic structure between a single layer abstract image and a profoundly more complex figurative image. VDT abstract images are direct products of a generative algorithm, which systematically alters syntactic properties of complexity and redundancy. The challenge is to produce figurative images, which maintain comparable syntactic properties with VDT abstract images but also include levels of artistic information defined by content, style, expressiveness, and color.

Validity of any comparison between abstract and figurative images would depend on some convincing demonstration the cognitive-perceptual model that was supported during visual judgments of VDT abstract also applies to visual appraisal of figurative images. Consequently, figurative images were needed that would provide variation of syntactic properties within figurative images. In other words, several versions of figurative images would be needed which would present subtle complexity manipulations. In this manner, not only would comparability be established but validity of underlying perceptual mechanism could be evaluated to further extend the VDT cognitive model.

Abstract



Figurative

Figure 6. VDT migration to figurative images

Strategy to address this goal emphasized reproducing syntactic structure of specific VDT abstract images in figurative paintings during their production. Then producing iterations of the paintings with specific complexity manipulations.

Collaborating with a professional artist, figurative images were painted across five visual art styles (Fauvism, Post-Impressionist, Surrealism, Renaissance, and Baroque), which are presented in Figure 7. Three styles, Fauvism, Renaissance, and Baroque are representational, while Surrealism and Post-Impressionism paintings are nonrepresentational. Painted in oil or acrylic on canvas, they were especially created to reflect complexity and redundancy of several VDT abstract images. Each figurative image was painted four times to reflect complexity and redundancy levels of abstract images.

Figurative production of each style was staged in three separate sessions. During first painting session, the artist created five paintings independent of VDT abstract images, which established an artist baseline for each style. Then each painting was manipulated to represent proportional relations between complexity and redundancy in an abstract image. Artist then manipulated three separate complexity levels.

**Fauvism**

**Renaissance**

**Baroque**

Figurative images were painted in a variety of styles in order to examine preference by style interactions within context of complexity manipulations. Artist controlled complexity in each style by imposing a ratio of complexity to redundancy on each painting. This ratio was systematically manipulated across four paintings. During this procedure, artist maintained thematic coherence across entire set of complexity manipulations.

**Post-Impressionism**

**Surrealism**

Figure 7. Figurative styles were manipulated with a generative procedure.

Through this procedure, syntactic structure of VDT abstract images was systematically reproduced in figurative paintings.

Following steps summarize production of figurative paintings. First, the artist identified proportional relations between complexity and redundancy in five artist-preferred VDT abstract images. Professional artist preference for these images had been established in previous JOCRF field studies. Consequently, the artist established a formula -- one part complexity to one half redundancy, that is, 1:.5, then created paintings on canvases in five styles described above. This ratio, 1:.5, was reproduced in Post-Impressionist, Surrealism, Renaissance, and Baroque paintings. A fifth painting, Fauvist in style, presented complexity and redundancy in a 1 to 1 relation. These paintings established a syntactic baseline.

Figure 8 presents four VDT abstract images of differing complexity generated from an algorithm. Professional artist first reproduced proportional relations of complexity and redundancy in a Post-Impressionist figurative painting. Next, the artist

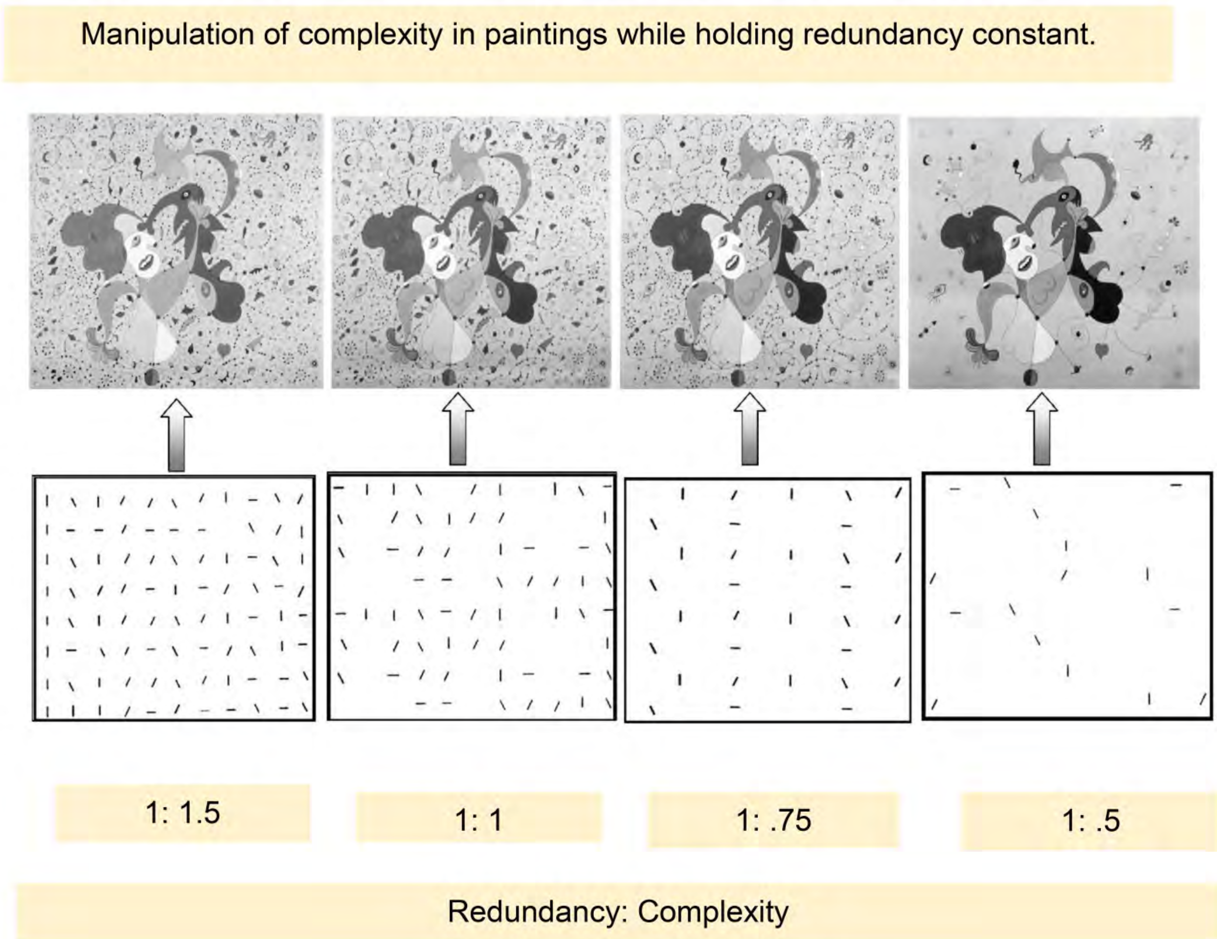



Figure 8. Manipulation of complexity in a Post-Impressionist painting was directly linked to generative algorithm for abstract images.

reproduced each painting three times but discretely increased complexity incrementally. Each reproduction was a step higher in complexity, while stylistic coherence was carefully maintained. Redundancy was not explicitly manipulated and remained fixed across paintings.

Following this procedure, an artist-preferred figurative image was paired with each complexity manipulation for each style. In other words, ffigurative images with syntactic properties highly preferred by professional artists were paired with a more complex painting. Finally, images were photographed, printed, and 20 image pairs bound into test booklets [38]). A complete set of paintings from this study are presented in an appendix. Then visual preferences were collected for both abstract and figurative images. A statistical comparison of these results is presented in sections below.

## 7. VDT Empirical Summary

### 7.1 Empirical calibration, measurement analysis

Early published reports describe VDT construct development with approximately 1,500 examinees from JOCRF testing offices [35]. Following expression presents the linear measurement model that was implemented to transform ordinal preferences scored for conformity with professional artist preference to a linear scale. Every response was coded either 0 or 1 depending on agreement with professional artists.

$$\Pi_{nix} = \frac{\exp \sum_{j=0}^{x} (\beta_n - \delta_{ij})}{\sum_{k=0}^{m_i} \exp \sum_{j=0}^{k} (\beta_n - \delta_{ij})]}$$

$x = 0, 1, \ldots m_i$

where $\delta_{i0} = 0$ so that $\exp \sum_{j=0}^{0} (\beta_n - \delta_{ij}) = 0$ and

$\exp \sum_{j=0}^{0} (\beta_n - \delta_{ij}) = 1$. $X$ is count of completed steps.

Numerator contains only difficulties of completed steps, $\delta_{i1}, \delta_{i2}, \ldots \delta_{ix.}$ Denominator is sum of $m_i + 1$ possible numerators.

### 7.2 Item response (preference) analysis

Several empirical criteria are examined to establish psychometric quality of visual preference judgments. For example, consistency between image difficulty defined by agreement with professional artists and examinee preference propensity is needed to establish basic order between images and examinees. Some examinees showed a high propensity to agree with artist judgment, while others did not. Then statistical reproducibility of an image hierarchy that results from preference judgments needed verification, which established predictive foundations. Figure 9 presents response category parameters after VDT abstract images were presented to JOCRF examinees. Vertical axis presents probability of agreeing with professional artists, while horizontal axis is a linear scale that represents image difficulty. Probability of an examinee responding in a category (0=disagree with professional artist or 1=agree with professional artist) depends on difficulty of specific images and examinee preference propensity. For example, probability of an examinee with low preference propensity, approximately -1 logits, agreeing with an image of moderate difficulty, 0.0 logits is very unlikely, while probability of disagreeing is close to .8. These results show highly ordered relations between images and preferences.

```
+----------------------------------------------------------+
|CATEGORY   OBSERVED|OBSVD SAMPLE|INFIT OUTFIT| COHERENCE|
|LABEL SCORE COUNT %|AVRGE EXPECT|  MNSQ  MNSQ| M->C C->M|
|-------------------+------------+------------+----------|
|  0   0    2651  55|  -.70  -.70|   .99  1.03|  71%  76%| 0
|  1   1    2201  45|   .32   .32|   .99  1.02|  68%  62%| 1
+----------------------------------------------------------+
AVERAGE MEASURE is mean of measures in category.
```

```
        DICHOTOMOUS CURVES
P      ++--------------+--------------+--------------+--------------++
R  1.0 +                                                             +
O      |                                                             |
B      |0                                                           1|
A      | 000000                                               111111 |
B   .8 +       00000                                     11111       +
I      |            0000                             1111            |
L      |                0000                     1111                |
I      |                    000               111                    |
T   .6 +                       000         111                       +
Y      |                          000   111                          |
    .5 +                             ***                             +
O      |                          111   000                          |
F   .4 +                       111         000                       +
       |                    111               000                    |
R      |                1111                     0000                |
E      |            1111                             0000            |
S   .2 +       11111                                     00000       +
P      | 111111                                               000000 |
O      |1                                                           0|
N      |                                                             |
S   .0 +                                                             +
E      ++--------------+--------------+--------------+--------------++
       -2             -1              0              1              2
                       PERSON [MINUS] ITEM MEASURE
```

Figure 9. VDT response categories

### 7.3 Abstract items

In first of several studies, several hundred JOCRF nonartist examinees rated "attractiveness" of two sets of 45 VDT abstract images on a scale of 1 to 5. A Rasch model rating scale analysis found VDT images operationally to define a construct ranging from more-complex to less-complex. Figure 10 presents the image hierarchy. The higher rated, more-complex images are along the low end and lower rated, less-complex images are along upper portion. These preliminary results established coherence among ratings for images that only differed in complexity.

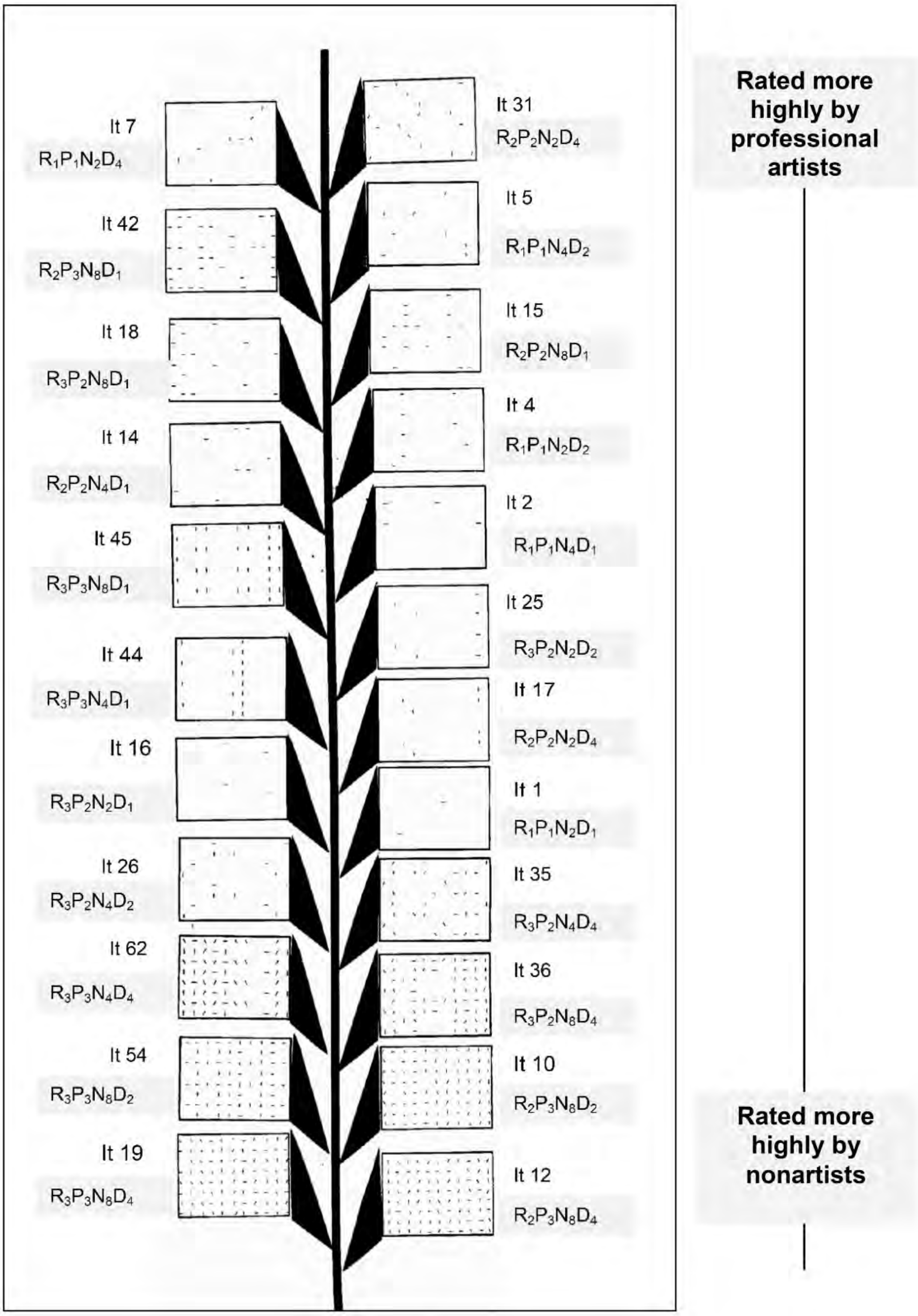



Figure 10. VDT abstract image hierarchy. Images lower on this higher hierarchy are rated higher by nonarts.

In a second study, images of contrasting complexity were paired and presented to examinees. Then principle components analysis was conducted of preferences, which identified to two prominent preference factors, Simplicity and Uniformity [9].

They were formulated into separate scales: Simplicity (22 items) and Uniformity scales (13 items), respectively. VDT Simplicity presents design pairs that differ in complexity defined by variety and frequency of elements. Uniformity pairs also differ in complexity but are defined by element dispersion and spatial orientation.

In general, image calibration with a Rasch model replicated a linear hierarchy presented in Figure 10. Fit, residual, and construct validity analyses are summarized in published reports [39]. Further studies collected visual preferences from professional artists for Simplicity and Uniformity scales and found their locations to differ significantly from nonartists. Nonartists fell significantly lower along the Simplicity construct than professional artists, while professional artists tended to cluster above a defined scale threshold [36, 41]. This image hierarchy, which consistently shows high psychometric reliability (>.90), and VDT abstract images has been in operational use in JOCRF testing offices for over 20 years.

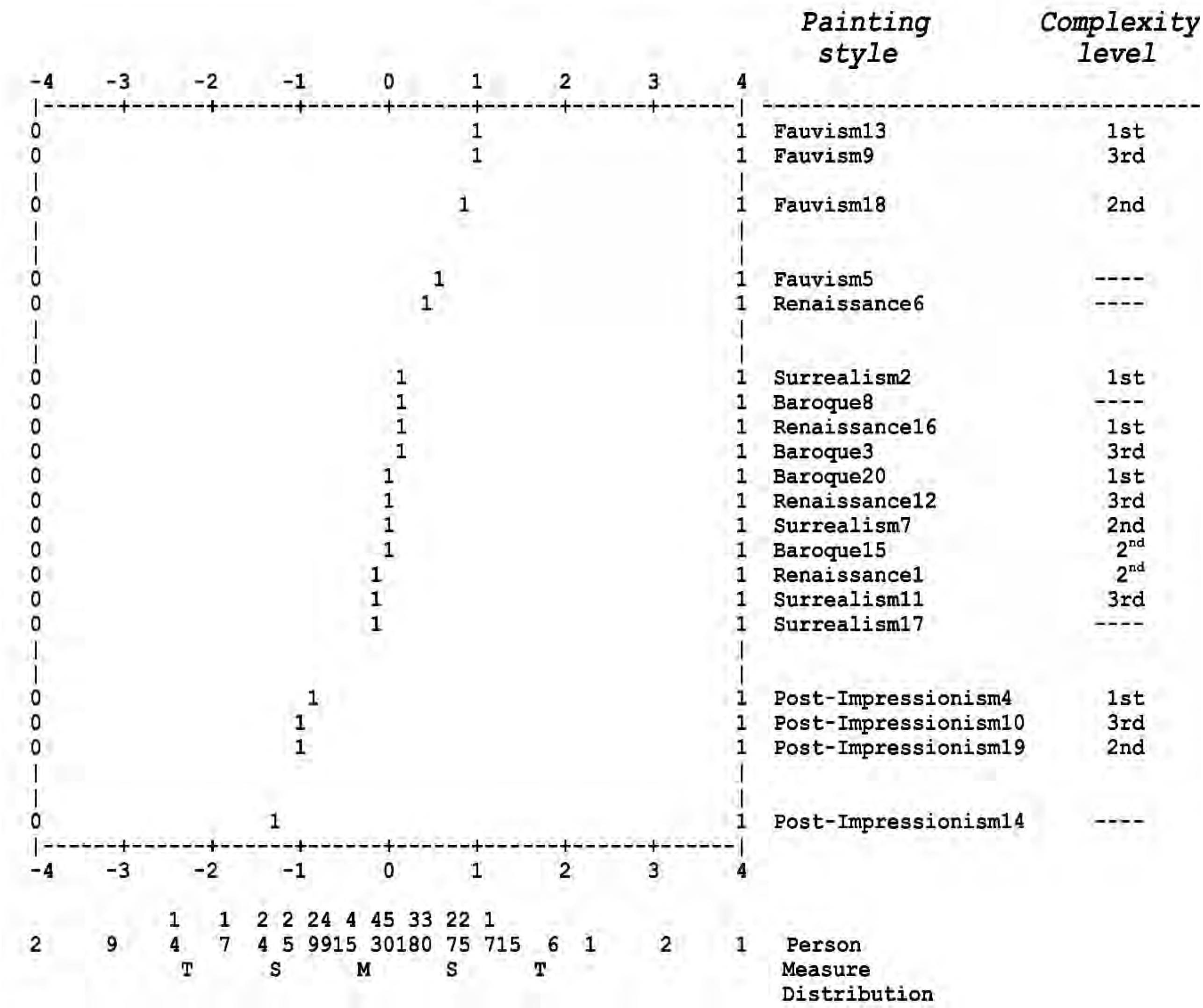
**7.4 Figurative items**

After conclusion of VDT abstract validation, questions began to mount about comparability of AJ aptitude measurement based on VDT abstract versus figurative images. Consequently, a study was conducted to examine their similarities and clarify their differences.

Two sets of images were prepared for this study. First, thirty-four pairs of VDT abstract images organized on basis of results from professional artist validation were printed in booklets. Then VDT figurative images were similarly organized and printed in booklets. VDT figurative image pairs consist of 20 pairs of traditional paintings in five styles: Fauvism, Renaissance, Baroque, Surrealism, and Post-Impressionism that were specifically painted for this research according to a procedure described in preceding sections of this report.

Both abstract and figurative image pairs were presented to a JOCRF client sample with the question, "Which do you prefer?" Professional artist preference in each pair was keyed correct and responses were analysed with a probabilistic dichotomous Rasch model [42]. Figure 11 presents a calibrated hierarchy of figurative images based on this sample.

Vertical arrangement of paintings in Figure 11 indicates difficulty of agreeing with professional artist judgment. “Complexity level” indicates amount of complexity artist added to a painting. The “3rd“ level, for example, indicates highest complexity in each style. According to these results, four complexity levels of Post-Impressionist paintings were presented to examinees, and all were relatively easy for these examinees to agree with professional artists. In contrast, examinee preference was least similar to professional artists for Fauvist style paintings, which is located at top of hierarchy. Nonartist agreement with professional artists for Surrealism, Renaissance, and Baroque styles ranged between these extremes.




Note. N = 462 examinees.

Figure 11. VDT figurative image hierarchy. Within a style, each painting is identical except for a complexity manipulation. Higher complexity level indicates incrementally higher complexity level.

Another pattern appears within this distribution of agreement with professional artists. Within Post-Impressionism, Surrealism, and Fauvism, the image with least complexity, surprisingly, was most consistent with professional artist preferences. In other words, when lowest complexity level paintings, which are indicated by "----" in Figure 11, were presented in pairs, nonartists tended to agree with professional artists more than when alternative pairs were presented. In contrast, lowest complexity level paintings in Baroque and Renaissance show least agreement between nonartists and professional artists. Preference for figurative images in mid-range are close to chance, which suggests that both Post-Impressionist and Fauvist styles could be highly effective in an AJ scale of figurative images. In general, these results, as expected, show complex interactions among style, content, and syntax.

**7.5 Construct validity studies**

Construct validity of the hierarchy was consistent with theoretical expectations, that is, visual preference higher on the construct map is systematically linked to shifting syntactic structure of complexity and redundancy objectively manipulated during template production. VDT reliabilities are typically high (>.90). Construct validity has been statistically examined by regressing item difficulties on design components ($C_1$, $C_2$, $R_1$, $C_2XR_1$), which found $R^2$ = .79 corrected for attenuation.

Conventional psychometric studies have consistently shown VDT internal structure and reliability to be high (> .90), and empirical studies support convergent, divergent, and professional artist validity [9, 35, 36, 41]. Developmental implications of Simplicity and Uniformity were also investigated by JOCRF and Chicago Public Schools with school children [32]. Cross-cultural robustness of Simplicity and Uniformity was supported by studies with inner-city Chicago and Portuguese school children [26]. These results are interesting as cross cultural comparisons found virtually identical scores.

In addition to studies described above, theoretical validity was investigated of the hierarchal image structure that was obtained after raw scores were transformed to linear measures. In this statistical procedure, VDT abstract calibrations were regressed on orthogonally coded item components of complexity and redundancy (number of panels, number of total elements in panel, number of element types in panel, and interaction of element types and redundancy). Results showed systematic relations between item components and logits difficulties to account for almost 80 percent of preference variance ($R^2$ = .79; $F$ = 56.59, $P$ < .001). These results support hypothesized relation between visual preference and complexity.

More recent studies have examined convergence of high scores on career selection. This research examined relations between VDT abstract scores and arts-related career choices in a data base of over 10,000 JOCRF examines. These results found significant positive correlations between VDT abstract and career choices. Examinees with arts-related occupational backgrounds expressed preferences for VDT abstract images that were significantly correlated with professional artists.

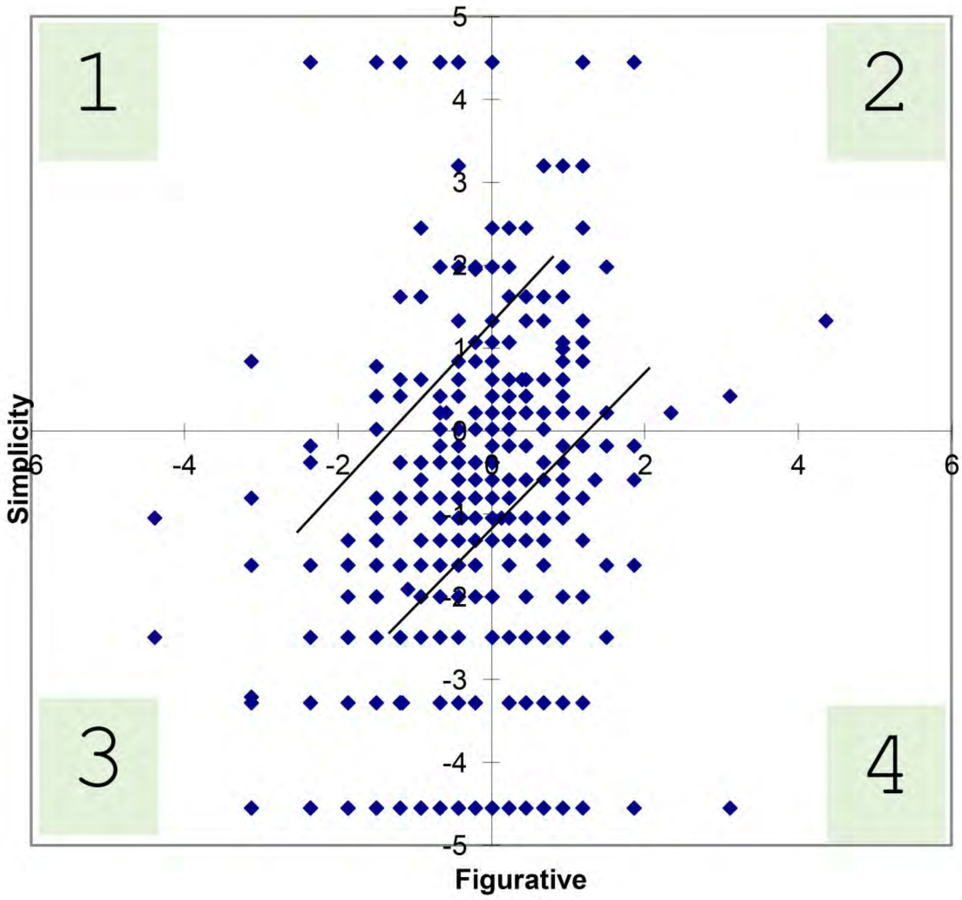
### 7.6 Professional artist validation

VDT artist validation was conducted with a sample of professional artists from across a range of artistic media in three metropolitan areas: New York City (4), New Orleans (17), and Chicago (41). Their ages ranged from 19 to 75 years (Mn = 40.9, SD = 13.1) with a median of 39 years. About 60 percent were females. All artists were actively engaged in design and production of visual artworks (*N*=66). Simplicity and Uniformity items were administered to both groups. Difference between nonartists and professional artists was statistically significant, and sstandardized difference was .44 SD units. Details of that study were published [36]. A separate follow-up validation study was conducted with VDT figurative images using abstract image calibrations obtained from professional artists in VDT abstract validation.

### 7.7 Comparability of Abstract and Figurative constructs

Construction of a figurative scale with syntactic properties derived directly from abstract images generated from a rule based algorithm raises questions about comparability of preference judgments. Do examines with high AJ aptitude measures based on abstract preference judgments also receive high measures on a figurative construct? Likewise, are AJ aptitude measures interchangeable between abstract and figurative scales? In order to address these questions and others, abstract and figurative examinee measures were statistically correlated and those results appear in Figure 12. Raw scores in this plot have been transformed to linear person measures (logits) for VDT abstract and figurative scales, respectively.

As expected, figurative images full of semantic content, stylistic variation, and complex expressiveness introduced considerable unexpected variability into the VDT preference model. These results suggest the simple VDT complexity model is less effective when images are not random patterns. Meaningfulness and content become prominent in figurative images, and coherence and style influence visual preference. Yet, despite these complications, significant positive correlation was obtained between abstract and figurative examinee measures. Corrected for attenuation, this correlation was over .40, which establishes empirical foundations for generalizing the VDT abstract algorithm to synthetic production of rule-based figurative images. This correlation would be expected to be even higher if professional artists had been included in this sample.




N = 435 nonartist adult examinees.

Figure 12. Correlation of examinee linear measures on both abstract and figurative constructs. Examinees in quadrant 4 showed much higher agreement with professional artists when images were figurative. Examinees in quadrant 1 agreed more with professional artists when images were abstract.

Three results presented by this plot based on nonartists are especially important. First, most examinees who were in middle of abstract aptitude distribution are also in middle of figurative distribution. Their AJ sensitivity does not appear to interact with image content, that is, abstract versus representational content. However, these results show two subsets of examinees that substantially distort relations between abstract and figurative measures. First, a group of examines with very low Simplicity measures, showed much higher agreement with professional artists when presented figurative images, which is very surprising. Second, another examinee group showed very high Simplicity measures, yet they showed very low agreement with professional artists when presented figurative images. In general, VDT figurative results show strengths and weaknesses of the AJ aptitude processing model.

## 8. Discussion

### 8.1 Complexity

Despite over 125 years of empirical research, confusion about complexity, visual preference, and visual arts continues to muddle AJ discussions. In this research, complexity was defined by a simple criterion of frequency. Number of elements, types of elements, and their frequency contributed to higher complexity. Redundancy was controlled by constraints on the stochastic generator. More importantly, this simple model for manipulating complexity was supported by relations with professional artist preference. Image variation based on this definition of complexity led to significant differences between professional artists and nonartists. Much confusion in contemporary literature about complexity and redundancy is related to empirical and philosophical studies that neglect to consider differences between professional artists and nonartists.

### 8.2 Generative art and psychometric image models

An issue of contemporary importance concerns role of generative art in cognitive processing models, which was central to this research. Generative art was instrumental to establishing a cognitive-perceptual image model that was successfully validated by professional artists. Consequently, precise contribution of generative art to this advance is a question of some interest.

A cognitive item model usually requires several preparatory steps before producing items for a test design. VDT and its implementation of generative art required following steps:

1. *Assessment target.* Declare an explicit assessment target, which in this research was AJ aptitude.
2. *Review literature.* Identify empirical and philosophical literature related to assessment target. For example social research is replete with studies that examine influences on AJ – criteria that influence AJ. While complexity and redundancy were selected for this research, alternatives such as expressiveness and coherence could easily have been just as effective.
3. *Establish empirical relations*. Relations between empirical criteria and assessment target establishes an “idea”, which acquires dynamic function. In other words, idea of criteria and target must establish functional interdependence.

4. *Empirical verification.* Design an experiment that demonstrates your idea (criteria and target ) is empirically related to test performance. For example, demonstrate variation of image complexity or some other criterion such as expressiveness, or coherence is empirically related to AJ.
5. *Formalize images*. Develop separate images that demonstrate inter-relations of criteria and target.
6. *Construct development.* Identify thresholds that indicate qualitative contours and transitions across purported linear construct.
7. *Parameterization*. Collect field data to identify parameter values. Rasch measurement model was applied for this purpose in this research.

These steps complete a process of conceptualization, construct formulation, and measurement parameterization, which occurs during psychometric construction of any idea. Present research differs because a generative mechanism was added to the process, which increased consistency of preference responses and increased clarity of validation. By linking image construction, which is defined by explicit criteria of complexity and redundancy to a generative stochastic algorithm, a background field was created in images that was irrelevant to the dynamic function presented in the cognitive-preference model. Implementing the generative stochastic algorithm effectively eliminated visual background from interfering with targeted preference.

## References

[1] Eysenck, H. J. (1941). Type factors in aesthetic judgments. *British Journal of Psychology, 31,* 262-270.
[2] Chatterjee, A. (2011). Neuroaesthetics: A coming of age story. *Journal of Cognitive Neuroscience*, *23*, 53-62.
[3] Fechner, G. T. (1865). Weber die Fragen des Golden Schnitts. *Archiv. f. d. Zeichenenden Kuenste* (Nauman-Weigel), *11*, 100-112.
[4] Fechner, G. T. (1876). *Vorschule der aesthetik.* Leipzig: Breitkopf and Hartel.
[5] Birkhoff, G. D. (1933). *Aesthetic measure*. Cambridge, MA: Harvard University Press.
[6] Eysenck, H. J. (1940). The general factor in aesthetic judgments. *British Journal of Psychology, 3,* 94-102.
[7] Eysenck, H. J. (1968). An experimental study of aesthetic preference for polygonal figures. *Journal of General Psychology, 79*, 3-17.
[8] Eysenck, H. J., and Castle, M. (1970). Training in art as a factor in the determination of preference judgements for polygons. *British Journal of Psychology, 61*, 65-81.
[9] Bezruczko, N., and Schroeder, D. H. (1989). *Technical Report 1989-2. Artistic Judgment Project I: Internal-structure analyses.* Chicago: Johnson O'Connor Research Foundation, Inc.
[10] Bezruczko, N., and Schroeder, D. H. (2002) *Statistical Bulletin: Artistic Judgment: Figurative Pilot.* Chicago: Johnson O'Connor Research Foundation, Inc.
[11] Berlyne, D. E. (1971). *Aesthetics and psychobiology.* New York: Appleton-Century-Crofts.
[12] Berlyne, D. E. (1974*). Studies in the new experimental aesthetics: Steps toward an objective psychology of aesthetic appreciation*. Washington, DC: Hemisphere.
[13] Martindale, C., Moore, K., and Borkum, J. (1990). Aesthetic preference: Anomalous findings for Berlyne's psychobiological theory. *American Journal of Psychology, 103*, 53-80.
[14] Attneave, F. (1954). Some informational aspects of visual perception. *Psychological review, 61*, 183–193.
[15] Attneave, F. (1957). Physical determinants of the judged complexity of shapes. *Journal of Experimental Psychology, 53,* 221-226.
[16] Attneave, F. (1959). Stochastic composition processes. *Journal of Aesthetics and art Criticism, 17*, 503-510.
[17] Noll, A. M. (1966). Human or machine: A subjective comparison of Piet Mondrian's "Composition with Lines" (1917) and a computer-generated picture. *The Psychological Record, 16*, 1-10.
[18] Noll, A. M. (1972). Effects of artistic training on aesthetic preferences for pseudo-random computer-generated patterns. *The Psychological Record, 22*, 449-462.
[19] Platt, J. R. (1961). Beauty: Pattern and change. In D. W. Fiske and S. Maddi, (Eds.), *Functions of varied experience.* Homewood, Illinois: The Dorsey Press.
[20] Moles, A. (1958). *Information theory and esthetic perception*. Urbana, IL: University of Illinois Press. Originally published as *Theorie de l'information et perception esthetique* by Flammarian and Cie.
[21] Leder, H., Belke, B., Oeberst, A., and Augustin, D. (2004). A model of aesthetic appreciation and aesthetic judgments. *British Journal of Psychology, 95*, 489–508.
[22] Leder, H. (2013). Next Steps in Neuroaesthetics: Which processes and processing stages to study? *Psychology of Aesthetics, Creativity, and the Arts , 7,*

27–37.
[23] Schmidhuber, J. (1997). Low-complexity art. *Leonardo, 30*, 97-103.
[24] Ichijo, A., Hayami, Y., Takyo, S., and Niimi, T. S. R. (1998). *De Stijl 1917-1932: Art and Environment of Neoplasticism*. Toyko: Kawade Shobo Shinsha.
[25] Bezruczko, N., and Schroeder, D. H. (1987). *Visual Designs Test: Abstract.* Chicago: Johnson O'Connor Research Foundation, Inc.
[26] Bezruczko, N., and Fróis, J. P. (2011). Comparison of several artistic judgment aptitude dimensions between children in Chicago and Lisbon. *Visual Arts Research*, *37*, 1-15.
[27] Lindgaard, G., Fernandes, G., Dudek, C., and Brown, J. (2006). Attention web designers: You have 50 milliseconds to make a good first impression! *Behaviour & information technology*, *25*, 115-126.
[28] Tuch, A. N., Presslaber, E. E., Stöcklin, M., Opwis, K., and Bargas-Avila, J. A. (2012). The role of visual complexity and prototypicality regarding first impression of websites: Working towards understanding aesthetic judgments. *International Journal of Human-Computer Studies, 70,* 794–811.
[29] Dickie, G. (1962). Is psychology relevant to aesthetics? *Philosophical Review, 71*, 285-302.
[30] Reber, R. (2008). Art and its experience: Can empirical psychology help assess artistic value? *Leonardo, 41*, 367-372.
[31] Embretson, S., and Gorin, J. (2001). Improving construct validity with cognitive psychology principles. *Journal of Educational Measurement*, *38*, 343-368.
[32] Hornke, L. F., and Habon, M. W. (1986). Rule-based item bank construction and evaluation within the linear logistic framework. *Applied Psychological Measurement, 10*, 369-380.
[33] Bezruczko, N. (1989). *Research Memorandum 1989-3. Item specifications for 84 forced-choice VDT items.* Chicago: Johnson O'Connor Research Foundation, Inc.
[34] Bezruczko, N. (1990). *Construction and validation of a scale for Eysenck's K factor.* Presented at Eleventh International Colloquium on Empirical Aesthetics, Budapest, Hungary.
[35] Bezruczko, N., and Schroeder, D. H. (1990). *Artistic Judgment Project II: Construct validation* (Technical Report 1990-1). Chicago: Johnson O'Connor Research Foundation. (ERIC No. 017 064)
[36] Bezruczko, N., and Schroeder, D. H. (1991). *Artistic Judgment Project III: Artist validation* (Technical Report 1991-1). Chicago: Johnson O'Connor Research Foundation.
[37] Gierl, M. J., Lai, H., and Breithaupt, K. (2012, April). Methods for creating and evaluating the item model structure used in automatic item generation. Paper presented at the Annual Meeting of the National Council on Measurement in Education, Vancouver, BC, Canada.
[38] Bezruczko, N., Borgognoni Vimercati, A., and Callipari, P. (2000). Visual *Designs Test: Figurative Pilot Edition.* Rome, Italy: Courage Press.
[39] Bezruczko, N. (2002). A multi-factor Rasch scale for artistic judgment. *Journal of Applied Measurement, 4,* 360-399.
[40] Bezruczko, N., and Schroeder, D. H. (1995). Development of visual preferences in art-trained and non-art-trained schoolchildren*. Genetic, Social, and General Psychology Monographs, 122*, 179-196.
[41] Bezruczko, N., and Schroeder, D. H. (1994). Differences in visual preferences and cognitive aptitudes of professional artists and nonartists. *Empirical Studies of*

*the Arts, 12*, 19-39.
[42] Wright, B. D., and Stone, M. H. (1979). *Best Test Design.* Chicago: MESA Press.
[43] Bezruczko, N. (2014). Automatic Item Generation Implemented for Measuring Artistic Judgment Aptitude. *Journal of Applied Measurement,* (in press).
{44} Eysenck, H. J. (1972). Personal preferences, aesthetic sensitivity and personality in trained and untrained subjects. *Journal of Psychology, 40*, 544-557.
[45] Galanter, P. (2003). What is Generative Art? Complexity theory as a context for art theory. In GA2003–6th Generative Art Conference, Milan.
[46] den Heijer, E., and Eiben, A. E. (2010, July). Using aesthetic measures to evolve art (pp. 1-8). In *Evolutionary Computation (CEC),* 2010 IEEE Congress.

Appendix

VDT

Figurative Images

(Figurative syntax assigned by generative algorithm)

1-A

1-B

2-A

2-B

3-A

3-B

4-A

4-B

5-A

5-B

6-A

6-B


7-A


7-B


8-A


8-B

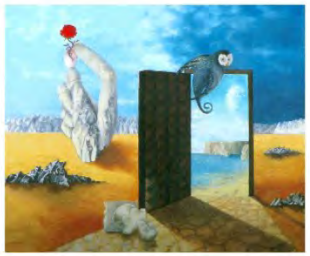

9-A


9-B


10-A


10-B


11-A


11-B


12-A


12-B


13-A


13-B


14-A

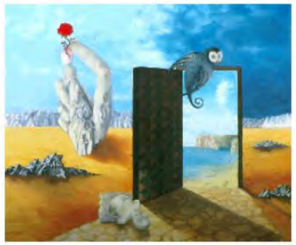

14-B


15-A


15-B


16-A


16-B


17-A


17-B


18-A


18-B

19-A

19-B

20-A

20-B

**Philip Galanter**

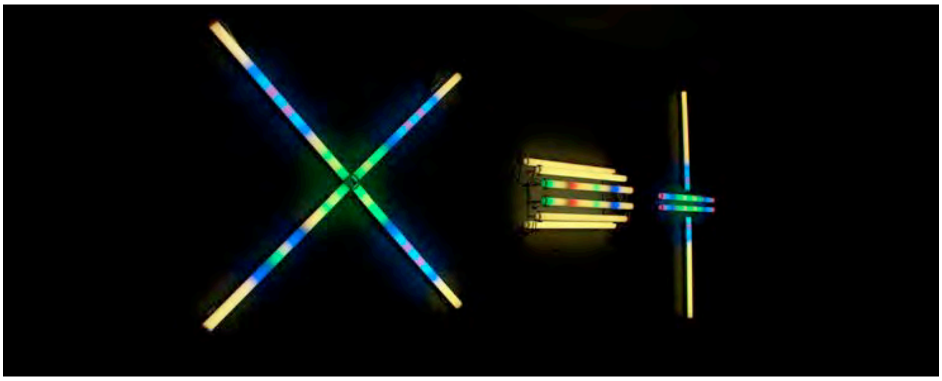
*Paper:* **XEPA: color and pattern algorithms for intelligent light sculptures**

*Topic:* ***Fine Art***

***Authors:***
***Philip Galanter***
Texas A&M University
Department of Visualization
USA
http://www.viz.tamu.edu/

***References:***
[1] Galanter, P., Computational aesthetic evaluation: past and future, in Computers and creativity, J. McCormack and M. d'Inverno, Editors. 2012, Springer: Berlin.
[2] http://philipgalanter.com

***Abstract:***
Over the years generative artists have created art using systems such as genetic algorithms, reaction diffusion systems, cellular automata, artificial life, deterministic chaos, fractals, and Lindenmayer systems. While these systems can offer a seemingly unending stream of visuals and sound, they typically do so without discrimination, and they lack any self-critical functionality. This is most apparent in genetic or evolutionary systems where the fitness function is frequently not automated, and is simply the artist making manual interactive choices.
Computational aesthetic evaluation remains an unsolved problem. Only when computer-based systems are both generative and self-critical will they be worthy of consideration as being truly creative.
XEPA is the name of both the art project and individual intelligent sculptures that display animated colored light and produce music and sound. XEPA is an acronym for "XEPA Emerging Performance Artist." Each XEPA "watches" the others (via data radio) and modifies its own aesthetic behaviour to create a collaborative improvisational performance. In doing so each XEPA independently evaluates the aesthetics of the other sculptures, infers a theme or mood being attempted, and then modifies its own aesthetics to better reinforce that theme. Each performance is unique, and a wide variety of themes and moods can be explored.
After a system overview, some of the algorithms used in XEPA for color scheme selection and pattern generation are presented. In particular attention is given to the creation of "painterly" color palettes, complex patterns, and emergent synchronization.



*Three XEPAs in alpha testing during software development*

***Contact: email***

***Keywords:***
Computational aesthetic evaluation, physical computing, sculpture, cellular automata, emergence, complexity

# XEPA: Color And Pattern Algorithms For Intelligent Light Sculptures

**Philip Galanter, MFA, BA**
*Department of Visualization, Texas A&M University, College Station Texas, USA*
*philipgalanter.com*
*e-mail: galanter@viz.tamu.edu*

## Premise

Over the years generative artists have created art using systems such as genetic algorithms, reaction diffusion systems, cellular automata, artificial life, deterministic chaos, fractals, and Lindenmayer systems. While these systems can offer a seemingly unending stream of visuals and sound, they typically do so without discrimination, and they lack any self-critical functionality. This is most apparent in genetic or evolutionary systems where the fitness function is frequently not automated, and is simply the artist making manual interactive choices.

Computational aesthetic evaluation remains an unsolved problem. Only when computer-based systems are both generative and self-critical will they be worthy of consideration as being truly creative.

XEPA is the name of both the art project and individual intelligent sculptures that display animated colored light and produce music and sound. XEPA is an acronym for “XEPA Emerging Performance Artist.” Each XEPA “watches” the others (via data radio) and modifies its own aesthetic behaviour to create a collaborative improvisational performance. In doing so each XEPA independently evaluates the aesthetics of the other sculptures, infers a theme or mood being attempted, and then modifies its own aesthetics to better reinforce that theme. Each performance is unique, and a wide variety of themes and moods can be explored.

After a system overview, some of the algorithms used in XEPA for color scheme selection and pattern generation are presented. In particular attention is given to the creation of “painterly” color palettes, complex patterns, and emergent synchronization.

## 1. Generative Art as a Way of Making Art

In a now decade old paper I offered what has come to be the most widely cited definition of generative art to date.

> Generative art refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art. [1]

The key element in generative art is the use of an external system to which the artist cedes partial or total subsequent control. Under the general rubric of complexity science various systems, and various kinds of systems, have been studied, compared, contrasted, and mathematically and computationally modelled. An abstract understanding of systems that spans the physical, biological, and social sciences is beginning to emerge. And it is these very systems that are being used as state-of-the-art generative systems by artists.

Things we think of as complex systems defy simple description and easy prediction. Many would agree that the most complex systems we encounter are other living things. And life requires a mix of order and disorder; order to maintain integrity and survival; and disorder to allow flexibility and adaptation. It was this kind of intuition that lead physicists Murray Gell-Mann and Seth Lloyd to suggest the notion of effective complexity. As illustrated in figure 1 Shannon's information complexity increases with disorder, but effective complexity peaks where there is a mix of order and disorder. [2, 3]

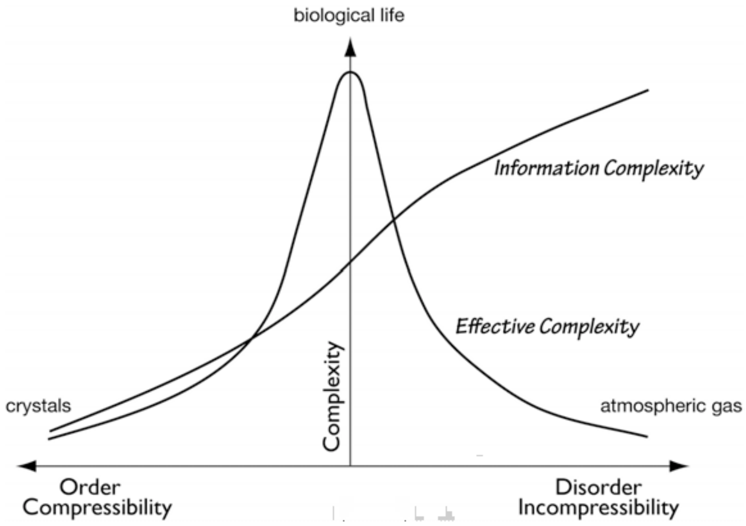



*Figure 1 – Effective complexity increases in systems that combine order and disorder*

This notion of effective complexity can be used to classify the various systems used in generative art. This is illustrated in figure 2.

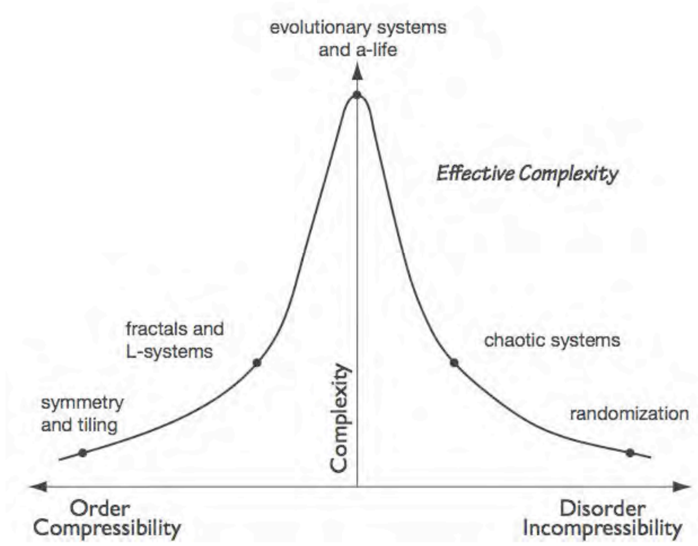



*Figure 2 - Generative systems organized by effective complexity*

## 1.1 Generative Art and Computational Aesthetic Evaluation

Artists exercise critical aesthetic judgment in all phases of their work. Aesthetic evaluation comes into play when studying other artists, while applying micro-decisions while creating a piece, in learning from a newly created piece prior to beginning the next piece, and so on. It also comes into play when trying to categorize art as to genre or movement.

Most generative art systems don't involve aesthetic evaluation. While the various systems noted above can provide an apparently endless stream of forms, images, sounds, and so on, selection of results and direction of the systems is left to the manual intervention of the human artist/operator. Where the generative system does have a form of normative aesthetics it is most typically in the form of purely forward generation, and are not applied retrospectively providing a kind of back propagation of error measures or other form of feedback.

Many writers such as Boden emphasize that novelty is a necessary but insufficient criteria for creativity. Creativity also carries with it the implication that the results are useful or otherwise of value. To fully qualify as creative artists computers will have to at least combine generative systems with computational aesthetic evaluation. [4]

This problem is perhaps most acutely felt in the realm of evolutionary art systems. When genetic algorithms and other evolutionary approaches are applied to industrial applications a key element is the fitness function. For example, the genotype for an electronic circuit can be fed to circuit simulation software. The phenotype, i.e. the circuit, is then tested virtually with a span of inputs and the resulting outputs. These can then be scored with a fitness function that weights the parts count, ease of construction, price of components, conformity to input/output specifications, power consumption, and so on. Because the evolutionary process is completely automated optimal solutions can be rapidly approximated by allowing gene pools with many dozens of competitors evolving for hundreds of generations.

The problem for generative artists using evolutionary systems is that we don't know how to create general robust aesthetic fitness functions. Outside of some narrow automated attempts, the typical solution involves putting the artist in the loop and manually scoring each new phenotype. This places a severe upper limit on both the size of the gene pool and the number of generations that can be run. This has been referred to as "the fitness bottleneck." [5]

While it is true that computational aesthetic evaluation remains a fundamentally unsolved problem, it is not for lack of trying. [6] There have been attempts to measure or define aesthetics in terms of relatively simple formulas, but all have been found to be inadequate and problematic. The mathematician George David Birkhoff suggested the formula M=C/O where M is the measure of aesthetic effectiveness, O is the degree of order, and C is the degree of complexity. While the specifics of his proposal were almost immediately disproved in empirical studies, he was one of the first to identify complexity and order relationships as being key, and was also the first to claim a formula rooted in neurology. [7]

The Golden Ratio φ, an irrational constant approximately equal to 1.618, and the related Fibonacci series have been said to generate proportions of optimal aesthetic value. This has been contested and arguably debunked by writers such as Livio in reputed examples such as the Great Pyramids, the Parthenon, the Mona Lisa, compositions by Mozart, and Mondrian's late paintings. [8]

Somewhat more successful has been Machado and Cardoso's adaptation of Birkhoff's aesthetic measure in their NEvAr system. [9] NEvAr generates images using an approach first introduced by Sims called evolving expressions. [10] Three mathematical expressions are used to calculate pixel values for the red, blue, and green image channels. The set of math expressions operates as a genotype that can reproduce with mutation and crossover operations. Machado and Cardoso evaluate the aesthetics of these images as a ratio of image complexity and perceptual complexity. To implement this as an automatic fitness function the degree to which an image resists jpeg compression is considered image complexity, and the degree to which it resists fractal compression is considered perceptual complexity. They reported surprisingly good imaging results but to date there is no particular evidence that this approach generalizes to other kinds of images.

A number of generative artists have observed that success in the realm of computational aesthetic evaluation is unlikely until psychological and neurological research suggests models of how aesthetics in humans works. While a complete robust model is probably many years away, some tantalizing research has been offered.

Rudolf Arnheim applied the principles of gestalt psychology to aesthetic perception, and in doing so established the notion of aesthetic perception as cognition. Many see this as suggesting that aesthetic perception can be modelled computationally.

Unfortunately Arnheim's theory of aesthetics is much more descriptive than normative. Direct application to computational aesthetic evaluation is not obvious and would likely require breakthroughs in computer vision well beyond the current horizon.

Daniel E. Berlyne has offered the concept of arousal potential and its relationship to hedonic response. Arousal potential is a quantitative property of stimulus patterns to arouse the nervous system. He proposes that hedonic response is the result of separate and distinct reward and aversion systems. The reward and aversion systems activate in proportion to the number of neurons stimulated, and the number of neurons responding will increase as a Gaussian cumulative distribution. Berlyne further proposes that the reward system requires less arousal potential exposure to activate, but that when activated the aversion system will produce a larger response.

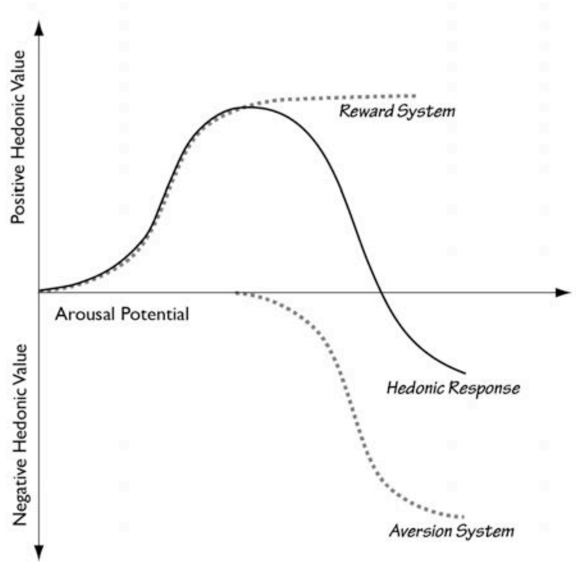



*Figure 3 - Arousal potential as the summation of two Gaussian cumulative distributions*

From this point of view art works of only moderate information complexity maximise the hedonic response. This is consistent with the artistic notion that audiences respond best to works that are not so ordered as to be boring, and not so disordered so as to be chaotic. An alternate interpretation would be that this response echoes effective complexity, and that the human nervous system is optimized for the processing of life forms in the natural living world.

Colin Martindale developed a (natural) neural network model of aesthetic perception dynamics he referred to as prototypicality. Martindale suggests that neurons form nodes that accept, process, and pass on stimulation from lower to higher levels of cognition. Low level processing tends to be ignored, and high level semantic nodes encoding for meaning have the greatest strength in determining preference. [11, 12]

Nodes are described as specialised recognition units connected in an excitatory manner to nodes corresponding to superordinate categories. Nodes at the same level, however, will have a lateral inhibitory effect. The result is that nodes encoding for similar stimuli will be physically closer together than unrelated nodes thus creating semantic fields. As a result the overall nervous system is optimally activated when presented an unambiguous stimulus that matches a prototypically specific and strong path up the neural hierarchy. Preference is then determined by the extent to which a particular stimulus is typical of its class. The obvious suggestion is that computational aesthetic evaluation is a strong candidate for an artificial neural networks approach. However, the fact that the human brain includes approximately $10^{15}$ neural connections should give us pause as to how daunting a project that might turn out to be.

## 2. XEPA and Experiments in Computational Aesthetic Evaluation

XEPA is an art project that, among other things, introduces a platform for experiments in computational aesthetic evaluation. The project is fundamentally artistic in motivation, however, and no pretense of controlled scientific research is implied. There is, however, an engineering aspect to the work. At the time this paper was written XEPA had just reached an alpha-stage of development. The hardware design and software possibilities are versatile enough that a number of approaches will be possible in the future, and those described here are just a beginning.

Each XEPA is a light sculpture that can display animated colored light sequences as well as high fidelity sound/music. In addition each XEPA "watches" and "listens" to the other XEPAs, and then attempts to change its own performance so as to fit in better and improve the aesthetics of the group performance. Each performance lasts a minute or two, and each performance is a unique improvisation different than the rest.

### 2.1 XEPA Hardware Design

As light sculptures each XEPA is constructed using four to eight one meter length tubes. XEPAs can be wall mounted, free standing, or suspended sculptures. Different installations may have differing numbers of XEPAs of different designs. Each light sculpture tube is a milky white diffuser with 16 RGB LED lighting units inside acting as 16 pixels. Each pixel is individually addressable as a 24-bit color using the lighting industry DMX control protocol.

Sound is produced using a single studio quality monitor with built-in amplification. A typical speaker of this kind is the Genelec 1029A. Because a given XEPA acts as a performer or instrumentalist rather than an ensemble, a single speaker rather than a stereo pair is appropriate. Various XEPAs will produce sound simultaneously and mix in the air not unlike a band using acoustic instruments.

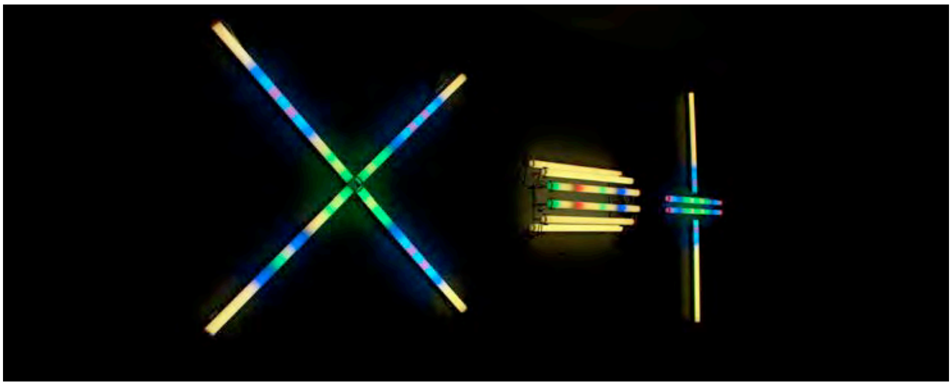


*Figure 4 – Three wall mounted XEPAs, each about 6 feet tall*

Each XEPA uses three inexpensive processors. An Arduino Mega 2560 is used for high-level observation and decision making. The Mega 2560 is an open source hardware platform using an ATmega2560 microcontroller chip with 256 KB of flash memory for code, 8 KB of SRAM for variable memory, and 4 KB of EEPROM for non-volatile storage not requiring frequent updates, and 4 UARTS that assist with serial communications.

An Arduino Leonardo is used for real-time DMX communications used to control the LED tube animation. Also an open source hardware platform, the Leonardo uses an ATmega32u4 microcontroller chip with 32 KB of flash memory for code, 2.5 KB of SRAM for variable memory, and 1 KB of EEPROM, and 1 UART for serial communications.

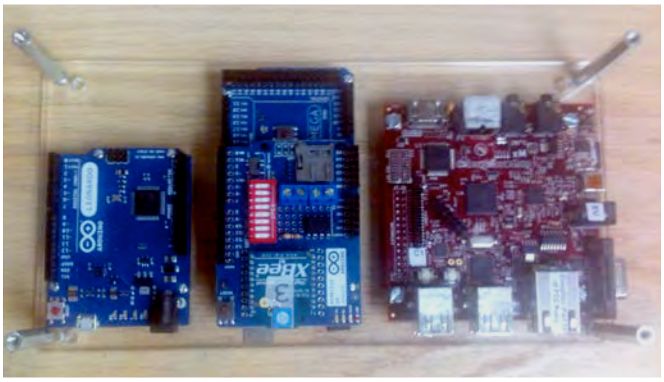


*Figure 5 – XEPA “Brain” without front acrylic cover and processor interconnects*

The third processor is an open source hardware single-board computer produced by Texas Instruments called the BeagleBoard. The BeagleBoard-xM used by each XEPA uses a TI DM3730 Processor running at 1 GHz with an ARM Cortex-A8 core. The BeagleBoard has 512 MB of RAM for both code and data, and boots from a 4 GB microSD memory card. The BeagleBoard is designed to be a complete single board computer and includes DVI-D video output, USB interfaces, and so on. However, XEPA uses the BeagleBoard as a sound engine for real-time high fidelity music synthesis, and only requires the built-in audio output hardware, and a USB port for serial-over-USB data communications.

All three boards are mounted on laser-cut clear sheet acrylic enclosures that can either stand freely or be wall mounted. The enclosures are open and clear to present the “XEPA Brain” as a deconstructed demystified element.

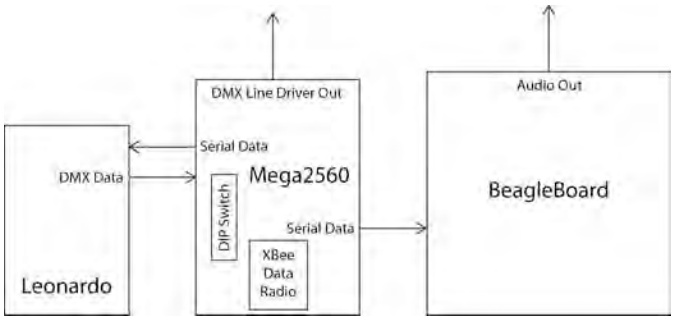



*Figure 6 – XEPA “Brain” interconnection design*

Figure 6 gives some details as to how the three processor boards work together. The Mega 2560 has an extra “shield” board for additional circuitry I designed. It provides an XBee data radio to broadcast very short messages announcing what the XEPA is doing, and picks up broadcast messages from other XEPAs to “view” and “hear” what they are doing. The XBee data is transparently presented to the Arduino software as serial data. There is also an 8-bit DIP switch that can be used to assign the XEPA a unique ID number, or to set various debug modes. The shield also provides a small line driver circuit used to convert the +5 volt data from the Leonardo to the balanced signal required by DMX. Not shown is a microSD memory card reader that can be used in the future.

As previously noted the Mega 2560 takes care of all higher level functionality including “watching” other XEPAs, executing aesthetic evaluation, and deciding what light animation and sound phrases will be performed. At regular intervals related to the rhythm and tempo of the performance the Mega 2560 sends short commands to the Leonardo and BeagleBoard. The Leonardo reacts to each message by executing an animation sequence, and the BeagleBoard reacts to each message by generating a sound phrase in real-time.

## 2.2 XEPA Software Design

XEPAs create a performance by executing light animation and sound phrases. At the beginning of each phrase a given XEPA sends out a message that merely describes what that XEPA is doing. In principle it is as if each XEPA is watching all the others. There are no “commands” telling each XEPA what to do. Each XEPA decides for itself which of the other XEPAs it should adapt to based on their coarse behavior.

The XEPA algorithms have been heavily influenced by lessons learned from my personal experience as an improvisational musician and performance artist, as well as ideas noted in the previous section on computational aesthetic evaluation.

One lesson is that our perceptual cognition will meet an improvised performance more than half way. As Arnheim discovered our gestalt mechanisms will “fill in” and otherwise structure our perception to maximize clarity in experience. Each XEPA’s performance can only be evaluated in the context of the choices of all the other performers.

Another lesson is that the audience wants to be surprised, but the audience doesn’t want to be left behind by a performance too unpredictable to follow. This is not unlike Berlyne’s concept of arousal potential and the notion that our perceptual processing is tuned for high effective complexity.

A third, and perhaps most important, lesson is that micro-aesthetic decisions by themselves don’t matter nearly as much as the contribution they make to a clear high-level semantic impression. This is similar to Martindale’s notion of prototypicality where low-level sensations result in successful aesthetics when they resonate with a unified abstraction at a high level of cognition.

XEPA is designed to execute effective improvisations that never repeat. XEPA is not, at this time, intended to be a system that learns aesthetics other than being “taught” by tables of aesthetic correspondences provided by the artist. In other words the current project is to build a system that can gainfully use what it has been force-fed. It’s entirely possible that future work can integrate machine learning.

The visual component can include a large number of color palettes, animation sequences, tempos, rhythms, fades, flashes, pulses, and so on in all possible combinations. In the current implementation most of the patterns are generated using cellular automata in a way that elaborates on my previous pieces RGBCA #1 (2010) and RGBCA #2 (2010). Where the earlier pieces strictly assigned an automaton to each of the 3 additive primary colors (red, green, blue), XEPA can use an arbitrary number of automata combined and mapped into arbitrary color schemes.

The sound component includes harmonies, scales, finite but large sets of melodies of fixed length, timbres, and so on also in all possible combinations. The cross product of the audible and visual possibilities further exponentiates the media space.

A hierarchical model inspired by Martindale is used to gain leverage over this combinatorial explosion. A set of high level semantic fields are invented called themes. Each theme is a suggestive phrase such as “artic zone” or “house on fire” or “spring life.” For each of these every color palette, scale, animation sequence, and so on is given a weight based on artistic intuition. For example, a palette of blues and whites would be given a large weight for the theme “artic zone”, while a palette of reds and yellows would be given a low weight for that particular theme. While this is a combinatorial burden, it’s not at all impossible for twenty or so themes.

In performance each XEPA independently executes table-driven computational aesthetic evaluation of the other XEPAs, and then adapts its own performance. Each follows this general algorithm:

- Whenever a new packet is received from another XEPA
    - Time-stamp the packet for possible later synchronization
    - Compare the packet (genotype) to the weights for each theme generating an error score (fitness score) for each
- At the end of a phrase compare your error score to the error scores of the other XEPAs
    - If there are lower error scores use a Monte Carlo technique to select the genotype of another XEPA
    - Apply crossover to the current genotype using the selected genotype
    - Synchronize with the selected XEPA

XEPAs initialized in random states will execute this quasi-evolutionary system in a loosely coupled manner. Over time the performing XEPAs will converge on a coherent theme.

## 3.0 How XEPA implements “painterly” color palettes

In previous light sculptures I’ve noted a dominance of cool colors and a lack of strong yellows and oranges. In LED pieces yellow is typically created by mixing a red LED and a green LED. The balance of these two light sources is delicate, and it can be difficult to get a yellow without a green or orange tint.

In fact my informal survey of generative works that create color palettes reveals a similar dominance of cool blues, greens, and violets, and fewer warm reds, oranges, and yellows, and especially a lack of subtle steps between. Light pieces in particular lack a painterly use of color and will over-emphasize the harsh additive secondary colors magenta and cyan.

This is all primarily due to the use of the additive RGB color system and the resultant spacing of colors around the color wheel. The typical RYB subtractive system used to describe color mixing in paints spreads the warm colors further around the color wheel.

It’s interesting to note that if one uses the HSV color mode in either Adobe Photoshop™ or the Processing programming language, or virtually any other digital color application, one will get the cool color dominant spacing seen in the RGB color wheel. The upshot of this is that if hues are selected “randomly” one gets more cool colors than warm colors. The difference between the two is clearly shown in figure 7 and figure 8.

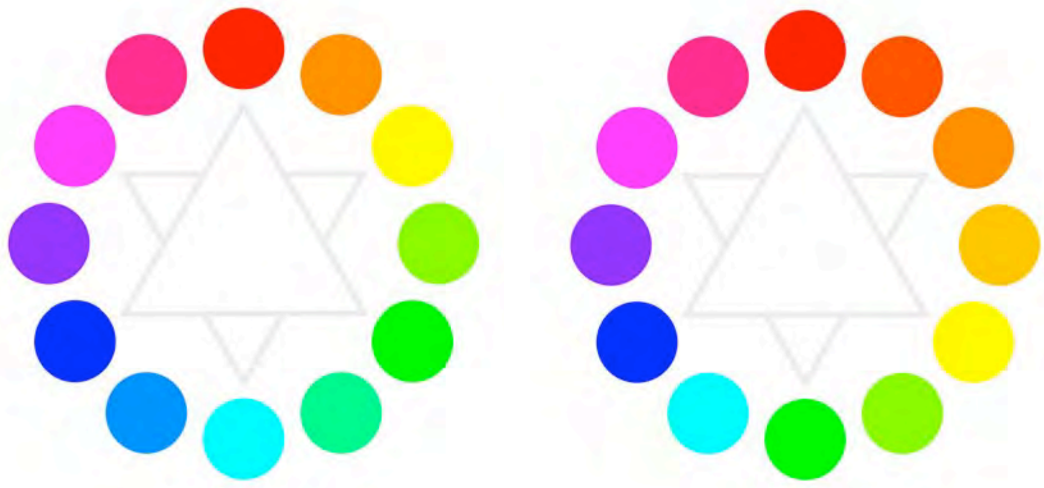


*Figure 7 – The additive RGB system (left) versus the subtractive RYB system (right)*

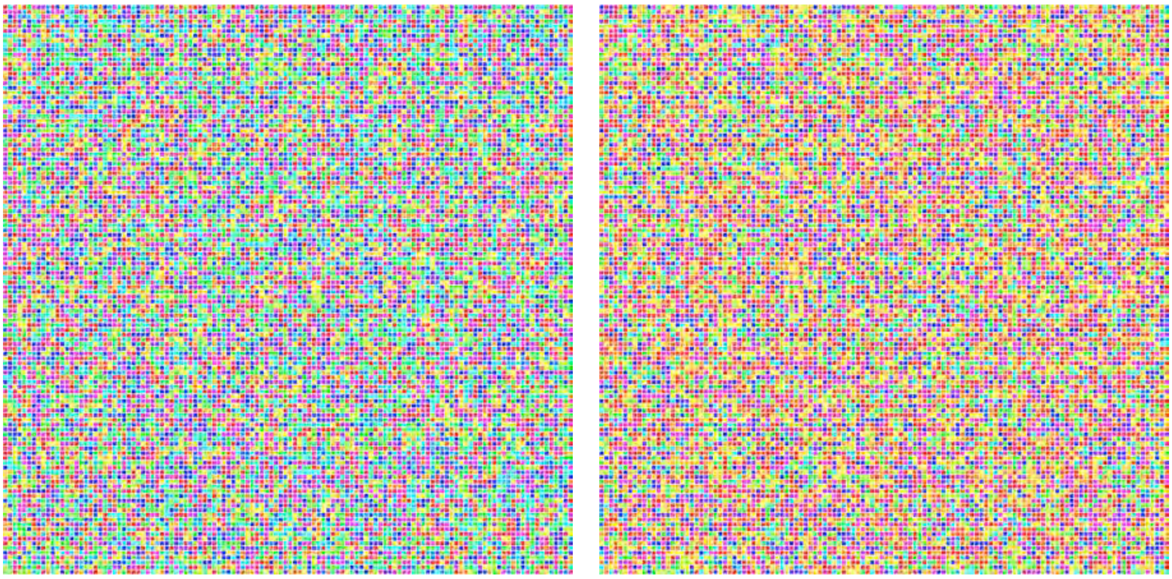


*Figure 8 – Random RGB colors (left) versus Random RYB colors (right)*

In order to achieve a more even handed balance of warm and cool colors, and to encourage painterly color palettes, XEPA does all of its color calculations and representations using a RYB color system. Those colors are converted into the device specific RGB values needed by the lighting fixtures late in the process at the device driver level. In other words XEPA uses a RYB system.

But in order to achieve a more painterly look the RYB system one would get simply by interpolating primary and secondary color values has been modified a bit by eye.

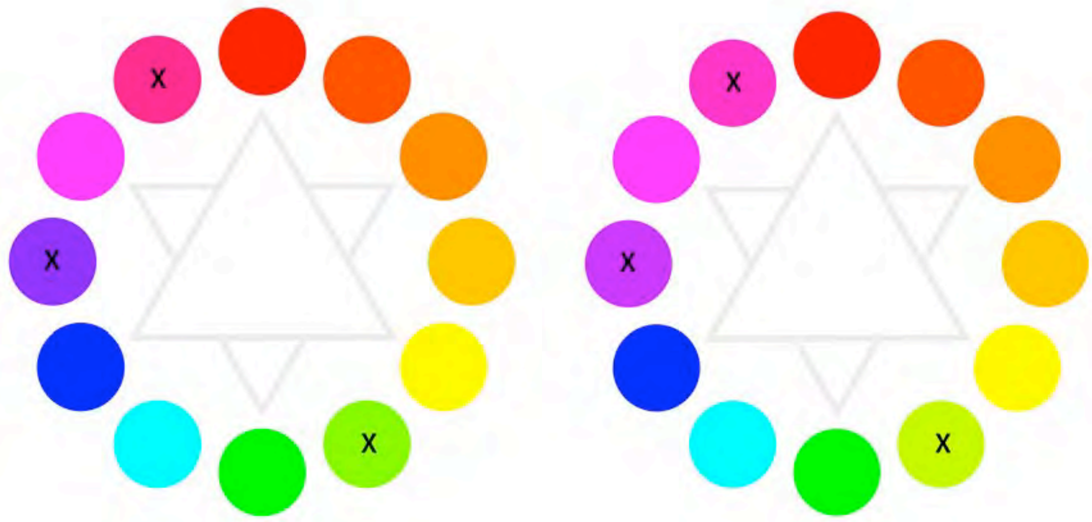



*Figure 9 – The RYB system (left) versus the RYB Plus system (right)*

In XEPA the color system is defined by the 12 primary, secondary, and tertiary colors. Hues in between those colors are calculated by linear interpolation. To my eye the color spacing of three of the tertiary colors are subjectively too biased to one side. These have been manually adjusted to move red-violet half again towards violet, green-yellow half again towards yellow, and blue-violet half again towards violet. I believe this helps all 12 colors to claim a distinct place in the color semantic space. I've named this color system RYB Plus.

It's important to note that the spacing around the color wheel does more than just balance cool and warm colors in the case of random selection. Perhaps more importantly it has a significant impact on the generation of color schemes using color harmony, i.e. relative spacing on the color wheel. This is where the aspect of creating a painterly palette comes to the fore.

The impact on color schemes is demonstrated in figure 10 (3 colors evenly spaced around the color wheel) and figure 11 (4 colors evenly spaced around the color wheel).

The details of the RGB, RYB, and RYB Plus systems are shown in the final figures.

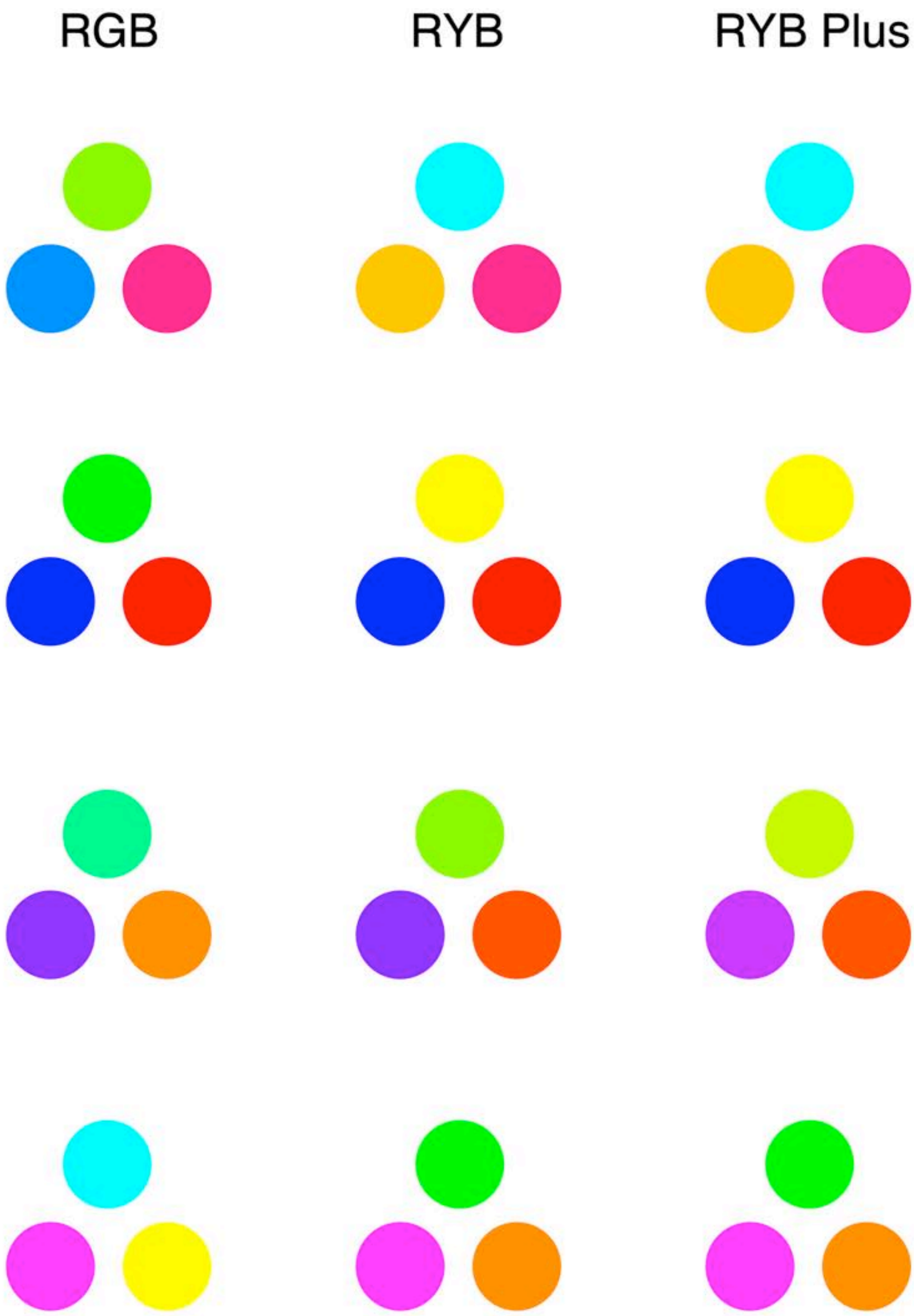



*Figure 10 – A comparison of triadic color schemes in the three color systems*

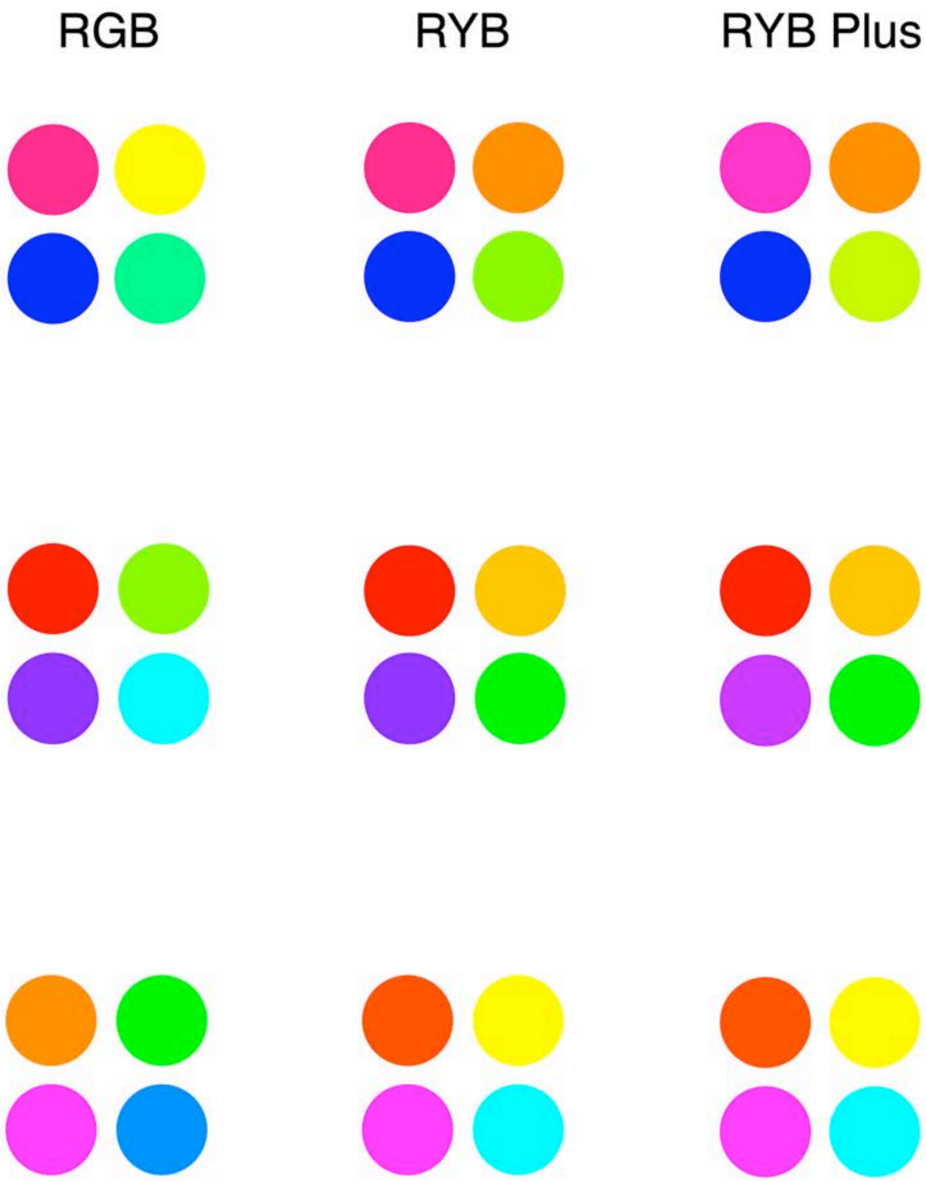



*Figure 11 – A comparison of tetradic color schemes in the three color systems*


*Figure 12 – How RYB and RYB Plus are mapped into RGB in the device driver*

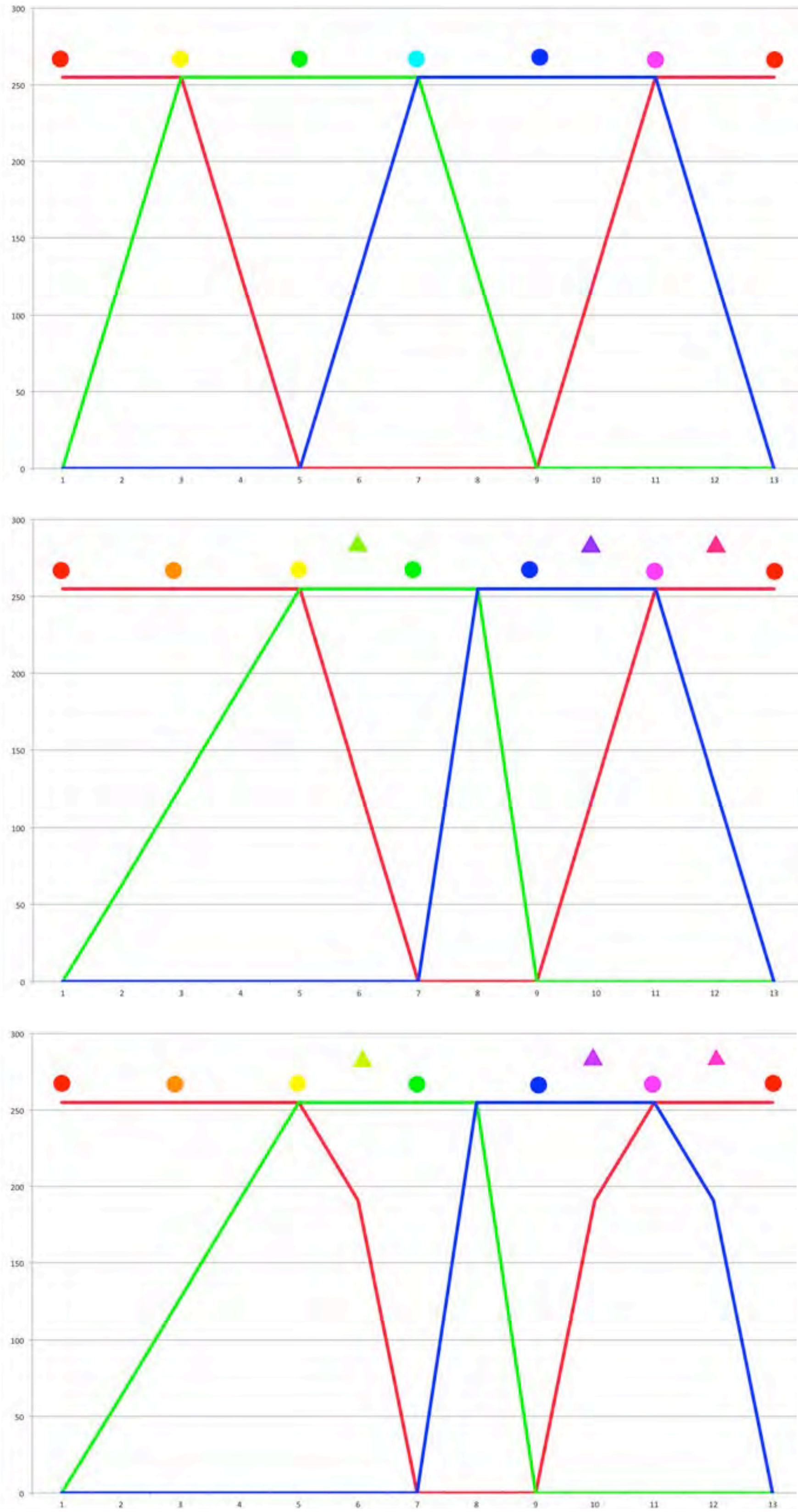


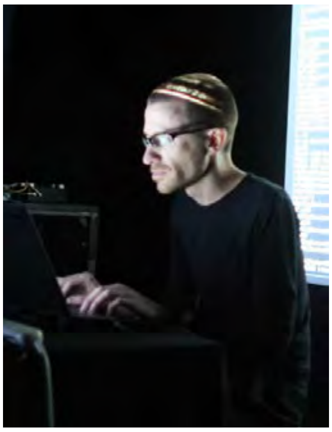
*Figure 13 – Interpolation of RGB values for the RGB (top), RYB (middle), and RYB Plus (bottom) systems*

## References


1. Galanter, P. *What is Generative Art? Complexity theory as a context for art theory*. in *International Conference on Generative Art*. 2003. Milan, Italy: Generative Design Lab, Milan Polytechnic.
2. Gell-Mann, M., *What is complexity?* Complexity – John Whiley and Sons, 1995. **1**(1): p. 16-19.
3. Shannon, C.E., *A mathematical theory of communication.* The Bell System Technical Journal, 1948. **27**(3): p. 379--423.
4. Boden, M.A., *The creative mind : myths and mechanisms*. 2nd ed. 2004, London ; New York: Routledge. xiii, 344 p.
5. Todd, P.M. and G.M. Werner, *Frankensteinian Methods for Evolutionary Music Composition*, in *Musical networks: Parallel distributed perception and performance*, N. Griffith and P.M. Todd, Editors. 1998, MIT Press/Bradford Books: Cambridge, MA.
6. Galanter, P., *Computational Aesthetic Evaluation: Past and Future*, in *Computers and Creativity*, J. McCormack and M. d'Inverno, Editors. 2012, Springer: Berlin.
7. Birkhoff, G.D., *Aesthetic measure*. 1933, Cambridge, Mass.,: Harvard University Press. xii, 1 p., 2 l., 3-225, 1 p.
8. Livio, M., *The golden ratio : the story of phi, the world's most astonishing number*. 1st trade pbk. ed. 2003, New York: Broadway Books. viii, 294 p.
9. Machado, P. and A. Cardoso, *All the Truth About NEvAr.* Applied Intelligence, 2002. **16**(2): p. 101-118.
10. Sims, K., *Artificial Evolution For Computer-Graphics.* Siggraph 91 Conference Proceedings, 1991. **25**: p. 319-328.
11. Martindale, C., *Relationship of preference judgements to typicality, novelty, and mere exposure.* Empirical Studies of the Arts, 1988. **6**(1): p. 79-96.
12. 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: Amityville, N.Y. p. 181-194.

**Renick Bell**

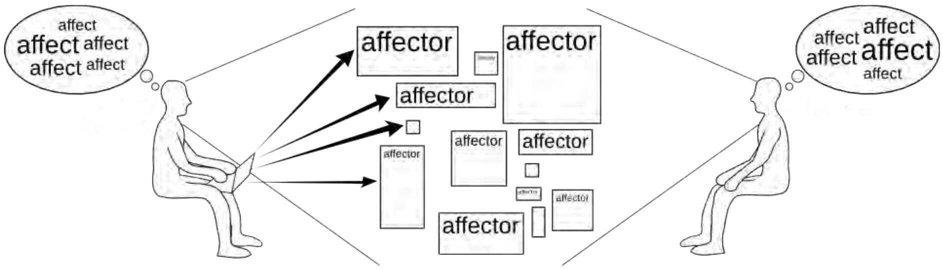
*Paper:* **Pragmatically Judging Generators**



***Topic: Music, Aesthetics***

***Author:***
***Renick Bell***
Tama Art University,
Tokyo, Japan
www.tamabi.ac.jp

***Abstract:***
Galanter defines generative art as art practice employing systems with some degree of autonomy to produce art works [4]. Brown describes live coding as a method for interacting with generative processes, clearly demonstrating its membership in the set of generative art practices [2]. McCormack, Bown et al. ask what characterises good generative art and draw attention to the processes involved as a determining factor for such evaluations [5]. The extent to which the generative aspect of live coding influences the aesthetic evaluation of such a performance can be examined using a pragmatic aesthetic framework. Such a framework, based Dewey's concept of an art experience [3], has been described by Bell [1]. Identifying the position of generative processes in the broader context of a live coding performance containing other important features may reveal some directions for aesthetic evaluations of generative processes in other domains. Through this pragmatic approach, improved experiences of live coding and other generative art works can be achieved.




*An illustration of live coding as an art experience.*

***References:***
[1] R. Bell, "Towards Useful Aesthetic Evaluations of Live Coding," in Proc. of the Int. Computer Music Conf., 2013.
[2] A.R. Brown and A. Sorensen, "Interacting with Generative Music through Live Coding," Cont. Music Review, vol. 28, no. 1, 2009.
[3] J. Dewey, Art as Experience. Perigee Trade, 2005.
[4] P. Galanter, "What is generative art?...," in GA2003 – 6th Generative Art Conference, 2003.
[5] J. McCormack, O. Bown, et al., "Ten Questions Concerning Generative Computer Art," Leonardo, Feb. 2013.

***Contact:***
***renick@gmail.com***

***Keywords:***
aesthetics, evaluation, live coding, pragmatism

# Pragmatically Judging Generators

**Renick Bell**
*Tama Art University, Tokyo, Japan*
*http://renickbell.net*
*e-mail: renick@gmail.com*

## Abstract

Galanter defines generative art as art practice employing systems with some degree of autonomy to produce art works [13]. Brown describes live coding as a method for interacting with generative processes, clearly demonstrating its membership in the set of generative art practices [5]. McCormack, Bown et. al. ask what characterises good generative art and draw attention to the processes involved as being a determining factor for such evaluations [14]. The extent to which the generative aspect of live coding influences the aesthetic evaluation of such a performance can be examined using a pragmatic aesthetic framework. Such a framework, based Dewey's concept of an art experience [12], has been described by Bell [1]. Through this pragmatic approach, improved experiences of live coding and other generative art works can be achieved. Identifying the position of generative processes in the broader context of a live coding performance containing other important features and how they are evaluated may reveal some directions for pragmatic aesthetic evaluations of generative processes in other domains.

## 1. Introduction

This paper briefly describes live coding as a form of generative art. It then describes a pragmatic aesthetic framework which is a revision of the aesthetic theory of John Dewey, the American pragmatist. That is followed by a summary of his theory of valuation. The paper then analyzes generative art and live coding in terms of the revised aesthetic theory. That approach is used first to discuss a section of a paper by McCormack, Bown, et. al. asking questions about "what characterises good generative art" [14]. It is then used in response to a critical analysis of the generative aspects of live coding written by Brown and Sorensen.

## 2. Live Coding as Generative Art

This paper defines live coding as the interactive control of algorithmic processes through programming activity, a definition derived from Brown, Collins, and Ward [4, 7, 18]. This paper will not consider programming in front of others as a tutorial or make a distinction between public performances and solitary coding. The relationship between this definition and generative art is made clear below.

The definition of generative art from Galanter is:

> “Generative art refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art.” [13]

Though McLean and Wiggins write that live coding differs from generative art in that "generative art is output by programs unmodified during execution," [15], Galanter does not expect complete autonomy from generative art processes, just that the artist relinquishes at least partial control to the generative system.

Brown describes live coding as a method for interacting with generative processes, plainly classifying it as a member of the set of generative art practices [5]:

> “generative music in an expansive sense, where substantial musical outputs are produced by an algorithm... It is the ability to harness generative material that allows live coding performers to participate in a new kind of performance where they exercise indirect, or meta, control over the creation of their music.” [5:3]

Brown describes the performer's position as:

> “The performer is directly embedded within the algorithmic process and is free to guide and directly manipulate the unfolding of processes over time. The generative process exists on two levels, the playing out of the algorithmic potential of the code and the unfolding of the algorithmic opportunities and structural pathways held in the mind of the performer.” [5:7]

Another paper predating the Brown reference above "[advocates] the humanisation of generative music" [18:246]. That humanisation does not preclude the inclusion of live coding as a type of generative art.

Soddu's definition gets at the practical consequences of generative art: "construction of dynamic complex systems able to generate endless variations." [17] Live coding seems to fit this description well. This leads towards consideration of the aesthetics of generative processes in live coding, about which Collins writes that "... generative music is best appreciated when studied closely, when run many times..." and further asks "At a live concert, is generative music a music that says this time is special, now is privileged?" [6:71] These aesthetic questions are considered below.

## 3. Pragmatic Aesthetic Evaluation

The extent to which the generative aspect of live coding influences the aesthetic evaluation of such a performance can be examined using a pragmatic aesthetic framework. Such a framework, based on the pragmatic philosopher John Dewey's concept of art as experience [12], has been described by Bell [1]. With the intent of improving Dewey's theory, it has been revised by Shusterman [16] for general aesthetics and by McCarthy and Wright to explain interaction with technology [19].

This author presented a revision in [1] and a summary in [3]. Further revisions appeared in [2]. This version contains some additional minor revisions.

## 4. A Revised Pragmatic Aesthetic Theory

An affect is an emotional state. An affectee is a person experiencing affects in an interaction with affectors. An affector is a percept that stimulates affects in an affectee. A work of art is an affector which in some way was created, organized, or manipulated with the intention of it being an affector. A person involved with the creation or arrangement of an affector is an artist.

An art experience is the experience of affects in an affectee as the result of the affectee's interaction with a network of a potentially infinite number of affectors, with at least one of those affectors being a work of art. The affectors in the network influence each other and function directly or indirectly to stimulate affects in the affectee. The art experience is the experience of those affectors either simultaneously or in sequence. Changing the network of affectors changes the nature of the experience.

## 5. Dewey's Theory of Valuation

Dewey wrote a considerable amount of material on valuation. His theory of valuation can be summarized as follows. This summary first appeared in [2], but it contains minor revisions.

Value cannot be assigned in a disinterested manner [10]. Value is assigned to an experience according to the context of the experience (including but not limited to the culture it takes place in [10]). Such judgments are always in flux and susceptible to revision based on newly obtained experience.

The value of something derives from how well it suits the achievement of an individual's intentions and the consequences of achieving those ends through those means. The object of an appraisal is also evaluated while considering its consequences with respect to other intentions held by the individual [10].

Everything of value is instrumental in nature. Valuations themselves are instrumental for future valuations and action [9]. Every end is in turn a means for another intention in a continuous stream of experience. Valuations are used to control the stream of an individual's experience [11].

Relating this theory of valuation to the revised aesthetic theory above, it can be said that the value of an affector is connected to the value of an art experience in which it is involved. The value of an art experience is determined by the affects experienced [1] and how well those affects and the other consequences of the experience and its affectors suit the intentions of the affectee [2].

Simple steps for analyzing an experience through this theory are presented in [2].

## 6. Pragmatic Aesthetic Evaluation of Live Coding

It is useful to consider some aspects of live coding with regards to this theory.

Live coding has many affectors, such as the rhythm and timbre of the output sound, the sound diffusion system, the performance space, the contents of the projection, the programming language and tools used, and so on [1]. An important affector which is felt indirectly in every case and directly perceived in others is abstraction [3]. Generative processes are included in this network of affectors. A more complete exposition of affectors in live coding can be found in [1].

There are also many types of affectees. One simple classification groups them according to three criteria: whether or not they are programmers, musicians, or fans of live coding [1]. When experiencing generators, an awareness of a generator's role in a performance (or lack of it) and the affectee's knowledge modulate that experience.

Live coders possess a large variety of intentions, and the intentions of some can differ or even be in opposition to the intentions of others [2]. When evaluating generators, evaluation depends on the intention of the performer or the audience.

## 7. Breaking Down Generators into Component Affectors

Generative processes in an art experience have many aspects. In other words, they are compound affectors constituted of many affectors, including:

- the origin of underlying algorithm(s)
- the characteristics of the algorithm(s)
- a mapping of the algorithm to one or more synthesizers (audio in the case of live coding, but a visual or other synthesizer in other fields)
- the design of the internals of the process
- the implementation of the internals of the process, including its efficiency or elegance
- the design of the interface to the process
- the notation in code to express the process
- the degree to which the process has been abstracted and parameterized
- user interaction with the generative process
- the manner in which the generative process fits with other affectors involved in the experience

The necessity of considering all of these affectors in relation to the other affectors experienced follows from the theory above. This is supported by Cox, McLean, and Ward, who write that code should be evaluated both from its appearance as text and in the experience of it running [8].

## 8. What Makes Generative Art Good?

McCormack, Bown et. al. present a list of ten questions about generative art. One of those questions asks what characterises good generative art [14]. A dialogue providing answers to their questions through use of the theory above shows how it can be applied and might achieve the "more critical understanding of generative art" they say is needed. A selection from their questions and this author's responses follow, with comments related to live coding added.

> “Why is generative art in need of special quality criteria?” [14:9]

Proper consideration of the role of the generative process in the experience is needed. Because a generative process is a compound affector, consideration of all of its components is also necessary. It is also necessary to ask to what degree the affectee is aware of the generative affector and its components.

> “Is it better considered alongside other current practices?" [14:9]

Experiences exist in relation to one another. Past experiences influence present ones. In addition, generative elements appear alongside non-generative elements in every case, and the two have influence on one another. For example, in live coding sometimes audio samples are triggered as a result of a generative process. While the triggering is the result of the generative process, the audio may result from sound design efforts that may or may not rely on generative techniques. In the case that they do not, the practice of creating generative processes is being considered in conjunction with the practice of sound design. Thinking critically about the relationship between these two seems useful.

> “Consider two important properties that differentiate generative art from other practices. The first is that the primary artistic intent in generative art is expressed in the generative process. This process is what the artist creates, and as such should arguably be the subject of scrutiny in appreciation of what it produces.” [14:9]

This seems unnecessary. First, it may be difficult to define a "primary artistic intent" in some cases. Artists frequently possess a variety of intentions. In [2], a variety of intentions possessed by live coders is presented. It may be hard in many cases to choose just one as primary, and it is not certain that doing so is necessary or makes the work any better. For example, eating a meal at a fancy restaurant serves a practical intention of satisfying hunger, and it may also work towards various aesthetic intentions, such as enjoying exquisite flavors, appreciating an environment, engaging in stimulating conversation with friends, and so on.

Further, it seems conceivable that a generative technique might be used as a means towards an end that the artist gives higher priority. For example, consider a live coder whose primary artistic intent is making an audience dance. In this case, the intent to use generative processes is subservient to the primary intention of stimulating and maintaining a full and energetic dance floor.

Using a generative process is just one tool that an artist has for producing a work, along with a collection of other tools. An artist should have the freedom to select appropriate tools in every circumstance. It does seem appropriate, however, that the generative process and its output figure in the evaluation of the work as affector and consequently in the evaluation of the total experience.

> "Secondly, the way this process is interpreted or realised is also the locus of artistic intent, and is intimately intertwined with the first property. The basis of all generative art resides in its engagement with process. So the locus of artistic intent should include the motivations, design and realisation of the process..." [14:9]

While the generative process may or may not be the center of the artist's activity, this point recognizes that the generative process is actually a compound of several factors. Each factor plays a role in evaluation of the generative process and an experience of it.

> "Put simply, the "generative" and "art" parts are inseparable. Process in generative art should be considered the primary medium of creative expression, implying that the exclusive or predominant use of creative software or processes designed by others in one's generative practice is problematic." [14:9]

Calling the use of tools from others problematic is too strong. The total experience should be judged. For example, the use of a standard algorithm but mapped in an original way should still be able to cause affects of admiration of originality, surprise or novelty, or other positive affects. There seems to be no reason that employment of a generative process designed originally by someone else could not be used by another artist. It can be thought of as jazz sax players playing saxes that someone else has manufactured, or singers making use of songs from composers other than the singers themselves. The fact that a painter has not manufactured the paint in her painting is rarely a reason to evaluate the experience of the painting poorly.

> "Understanding an algorithm's subtlety or originality opens a fuller appreciation of the eloquence of a generative work. But this is a significant problem for most audiences, reinforced by focussing on the surface aesthetics of the art object as is often seen in computational generative art, where the computational process is rarely directly perceptible." [14:10]

Collins also notes this problem [6:69]. Any art experience is taken differently by different affectees. Knowledge of an area closely related to an affector changes the experience, but it is too much to ask that every affectee have working knowledge of all aspects of each affector. It is better to accept the knowledge that an affectee brings to the experience and allow that background to give them an authentic experience, even if it is a different experience from an affectee who is an expert. An artist can reveal the generative aspects of an art work, and that transparency can be good as long as it is in harmony with the intentions of the affectee (such as the artist). Providing enough information so that the audience can understand the generative process could be an intention of the artist, but it does not seem to be necessary. Collins suggests good program notes to increase the functioning of generative processes as an affector for audiences [6:68].

Games are one example of an artwork that has generative aspects which are not the main focus of the piece and in which the generative aspects only function indirectly in the experience of affectees. Live coding works similarly for affectees with relatively less knowledge of the means of live coding but possessing intentions such as immersion in electronic music or dancing.

## 9. Pragmatic Aesthetic Evaluation of Generators in Live Coding

Brown and Sorensen provide a detailed account of their experience with generators in live coding in [5]. Some discussion of those points follows.

> "... the way in which an algorithm is represented can impact upon its utility for the live coder. [5:6]

This certainly seems true. The artist experiences that representation directly, and other affectees in the audience it may experience it directly if that representation appears in the projection or experience it indirectly through its influence on the output sound or projection contents.

> "The description length and complexity of an algorithm plays a large factor in its appropriateness for live coding. Algorithms such as neural networks, evolutionary algorithms, agent based systems, and analytic systems are all affected by issues of description complexity. The longer the description of the algorithm, the more time will pass writing the code in which the programmer is unable to pay attention to other aspects of a performance." [5:7]

It may then be advisable to use the generators in a generalized sense, meaning already abstracted and available as functions, and code around the parameterized aspects of the generator. The ability to code a generator from scratch could be one intention of a live coder, making this an important point. However, other intentions can make the approach of using an abstracted generator as a library function very effective. While the way that a process is implemented can be factor, it is not always the case that the implementation is the most pertinent affector for an affectee. In many experiences it can be almost invisible.

> "When programmers make a decision to abstract code away into a library, an abstract entity which can only be accessed as a 'black-box', the ramification is that they no longer have the ability to directly manipulate the algorithmic description." [5]

Parameterization might mitigate this problem. A higher-level function can take functions as parameters, in which case some structure is fixed but other structure can be controlled by the programmer in a live setting. The general framework can be coded in advance, leaving a key component to be coded in a performance or to be selected from a body of pre-coded components. It also depends on how the library is accessed, since in some cases that code may still be malleable.

The flexibility of abstractions and code in this way appears as an affector for affectees with programming knowledge, and the resulting affects again are determined partially by intention.

> “Many grammars, pattern matching and analysis systems require a substantial amount of look-ahead for decision making and also often require the generation and scheduling of material into the medium to distant future. We have found these types of algorithms to be not very valuable in practice as they limit our ability to affectively respond to other concurrent processes, input devices and, most importantly, fellow performers.” [5:8]

It seems that some of these processes could be run as if they were non-realtime, that is given their targets in advance and allowed to generate their data silently. Once their output has been generated, the performer can select from or edit it. That data can used by another process. Naturally it would be less responsive to real-time interaction, but it may still be useful. Still, the opinion that Brown and Sorensen express reflects their unique experience of those algorithms. Others may find that such limits are impulses to other creative activity, leading to positive affects.

> “we have identified a set of algorithms that we have found particularly valuable... [including] probability, linear and higher order polynomials, periodic functions and modular arithmetic, set and graph theory, and recursion and iteration.” [5:8]

Here, Brown and Sorensen describe their positive experience with various techniques. It is worth noting that some affectees may lack necessary awareness that such techniques are being used for these affectors to work directly, though their results are certainly felt indirectly.

> “Many simple processes, such as repetition, can become tedious, while others, such as randomness, can seem featureless and uninteresting... This balancing of control and surprise is a constant challenge for generative sound artists and our experience suggests that at present it is better handled by the performer than by some computational ‘agent.’” [5:10]

Brown and Sorensen further describe their experience with various types of generators. It does seem that others might feel differently. Artworks which have been valued highly by many in the past have relied heavily on both repetition (Alvin Lucier's "I am sitting in a room.", for example) and randomness (such as Marcel Duchamp's "Three Standard Stoppages"). This shows the variablity of experience, partly due to the framing of that experience and differing intention.

Brown and Sorensen write that "generative processes should be:"

- "succinct and quick to type"
- "widely applicable to a variety of musical circumstances"

- "computationally efficient allowing real-time evaluation"
- "responsive and adaptive by minimising future commitments"
- "modifiable through the exposure of appropriate parameters" [5:1]

Brown and Sorensen derive actionable criteria from evaluating their experience, which seems productive.

The matter of being succint is up to the notation representing the generative process, rather than particularly being a factor of the generative process itself. Naturally, the larger the number of parameters that that abstraction requires can influence the amount of typing, but even one abstraction with a given number of parameters can be represented notationally in various ways, some of which are more concise than others. This relates directly to their last item, which is unavoidably in conflict with the first point. However, their point is correct in that frequently good abstractions are parameterized well to achieve maximum generality. This leads to their second point.

The width of application is also up to the performer. A generative process which is specific though frequently used may not require application to other cases in order to be evaluated positively. Proper parameterization will increase generality, but some abstractions may still remain fairly specific in their use-cases, which may still not be a factor which would cause a negative evaluation.

Modularity can reduce the commitment required to a generative process. If the process generates data that is in turn read and rendered by another process, then the user simply has to change what the rendering process refers to for its data. This could refer to the commitment required in the generation of the data itself. The need to change the direction of a particular generative process can be reduced if the processes are flexible enough to be discarded freely and instantiated in abundance, or so on. It is likely, though, that only the performer is likely to directly experience these affectors.

It is important to remember that generators can lead to a change in our intentions. Though a generative process may be conceived with a particular goal in mind, after becoming familiar with its output, intentions can change. What may have be imagined as a simple and boring test may be later considered to have interesting output, while an implementation of a generator that perfectly expresses the intention it was begun with may turn out not to have interesting output, causing a change of intentions.

## 9. Conclusions

Identifying the position of generative processes in the broader context of a live coding performance containing other important features may reveal some directions for aesthetic evaluations of generative processes in other domains. Through this pragmatic approach, improved experiences of live coding and other generative art works can be achieved.

## 10. Acknowledgements

I would like to thank Professors Akihiro Kubota and Yoshiharu Hamada at Tama Art University for research support.

## 11. References

[1] R. Bell, “Towards Useful Aesthetic Evaluations of Live Coding,” in Proceedings of the International Computer Music Conference, 2013.

[2] R. Bell, “Considering Interaction in Live Coding through a Pragmatic Aesthetic Theory,” in Proceedings of SI13, NTU/ADM Symposium on Sound and Interactivity, Nanyang Technological University, Singapore: , 2013.

[3] R. Bell, “Pragmatic Aesthetic Evaluation of Abstractions for Live Coding,” The Japanese Society for Sonic Arts, 2013 [Online]. Available: http://www.jssa.info/doku.php?id=journal017

[4] A.R. Brown, “Code jamming,” M/C, vol. 9, no. 6, 2007.

[5] A.R. Brown and A. Sorensen, “Interacting with Generative Music through Live Coding,” Contemporary Music Review, vol. 28, no. 1, pp. 17–29, 2009 [Online]. Available: http://www.tandfonline.com/doi/abs/10.1080/07494460802663991. [Accessed: 15-Sep-2013]

[6] N. Collins, “Generative Music and Laptop Performance,” Contemporary Music Review, vol. 22, no. 4, pp. 67–79, 2003 [Online]. Available: http://www.tandfonline.com/doi/abs/10.1080/0749446032000156919. [Accessed: 15-Sep-2013]

[7] N. Collins, “Live Coding of Consequence,” Leonardo, vol. 44, no. 3, pp. 207–211, 2011.

[8] G. Cox, A. McLean, and A. Ward, “The aesthetics of generative code,” in Proc. of Generative Art, 2001.

[9] J. Dewey, “Valuation and experimental knowledge,” The Philosophical Review, vol. 31, no. 4, pp. 325–351, 1922.

[10] J. Dewey, “Theory of valuation.” International Encyclopedia of Unified Science, 1939.

[11] J. Dewey, Experience and nature, vol. 1. DoverPublications. com, 1958.

[12] J. Dewey, Art as Experience. Perigee Trade, 2005.

[13] P. Galanter, “What is generative art? Complexity theory as a context for art theory,” in In GA2003 – 6th Generative Art Conference, 2003.

[14] J. McCormack, O. Bown, A. Dorin, J. McCabe, G. Monro, and M. Whitelaw, “Ten Questions Concerning Generative Computer Art,” Leonardo, feb 2013 [Online]. Available: http://dx.doi.org/10.1162/LEON_a_00533. [Accessed: 15-Sep-2013]

[15] A. McLean and G. Wiggins, “Live coding towards computational creativity,” in Proceedings of the International Conference on Computational Creativity, 2010, pp. 175–179.

[16] R. Shusterman, Performing live: Aesthetic alternatives for the ends of art. Cornell University Press, 2000.

[17] C. Soddu, “Generative Art International Conference.” 2013 [Online]. Available: http://www.generativeart.com/. [Accessed: 16-Nov-2013]

[18] A. Ward, J. Rohrhuber, F. Olofsson, A. McLean, D. Griffiths, N. Collins, and A. Alexander, “Live algorithm programming and a temporary organisation for its promotion,” in Proceedings of the README Software Art Conference, 2004.

[19] P. Wright and J. McCarthy, Technology as experience. MIT Press, 2004.

**Silvija Ozola**

*Paper:*
**SYNTHESIS OF NATURE AND ART IN LATVIAN CITIES**

***Abstract:*** Natural environment of the Baltic seashore became a dwelling place for the people who settled there. A new functional environment was established by changing water and greenery systems and by creating architectural structures. The first towns in Latvia were set up in the 13th and 14th centuries. Design and structural layout of building was affected by presence of the hydrological basin – the sea, rivers and lakes, as well as masses of plantations. Planning composition of settlements was formed according to the characteristics of the relief - lowlands and hills, and other natural elements.
On the 18th November, 1918 the independent Latvian Republic was proclaimed. Approach to urban development changed. Nature elements began to be included in the architectonic spatial structure of the cities. Pieces of art enriched the cultural environment. Synthesis of nature and art create harmonious environment and contribute to development of diverse planning and spatial compositions and their originality in Latvian cities. Sculptural works have enriched the coastal landscape of the Baltic Sea in Liepāja, the river and lake sceneries in Cēsis, Talsi and plantation structures in Baldone, Līgatne, giving artistic expressiveness and identity to the urban environment.

***Topic: Architecture***

***Author:***
***Silvija Ozola***
Riga Technical university
Liepaja branch
Latvia

***References:***
[http://magneticcc.wordress.com/talsi-marta/](http://magneticcc.wordress.com/talsi-marta/)

*City Talsi in Latvia*

***Contact:***
***ozola.silvija@inbox.lv***

***Keywords:*** City, composition, harmony, identity, nature elements, structure, synthesis

# SYNTHESIS OF NATURE AND ART IN LATVIAN CITIES

**Silvija Ozola**

Riga Technical university

**Summary**

Natural environment of the Baltic seashore became a dwelling place for the people who settled there. A new functional environment was established by changing water and greenery systems and by creating architectural structures. The first towns in Latvia were set up in the 13th and 14th centuries. Design and structural layout of building was affected by presence of the hydrological basin – the sea, rivers and lakes, as well as masses of plantations. Planning composition of settlements was formed according to the characteristics of the relief - lowlands and hills, and other natural elements.

On the 18th November, 1918 the independent Latvian Republic was proclaimed. Approach to urban development changed. Nature elements began to be included in the architectonic spatial structure of the cities. Pieces of art enriched the cultural environment. Synthesis of nature and art create harmonious environment and contribute to development of diverse planning and spatial compositions and their originality in Latvian cities. Sculptural works have enriched the coastal landscape of the Baltic Sea in Liepāja, the river and lake sceneries in Cēsis, Talsi and plantation structures in Baldone, Līgatne, giving artistic expressiveness and identity to the urban environment.

The harmonious environment in Latvian cities, created by interaction of nature and art, can enrich our experience in creativity to find new and innovative solutions to urban development.

**Keywords**: city, structure, nature elements, synthesis, composition, identity, harmony

## Introduction

Culture and art conforms the identity of territorially limited Latvian state and numerically small nation’s self-assurance at epoch of globalization. Natural landscape with unique coloring and simple beauty is the national treasure of Latvia. Traditions of Latvian environment creation are founding in the rural and urban housing development, but nature, architecture and artistic design creates the landscape of contemporary urban environment.

**Nature elements in housing and urban planning**

Since olden times Baltic nations formed an organic intimacy with nature, what manifested in mental rituals and folklore, as well as in construction and transformation of the surrounding. At Latvian territory people of Baltic families formed settlements included by a wooden fence. Taking care for the safety, fortified housing began to establish at hill forts choosing natural mounds, moraine ridge tops or hills on confluence sites of rivers. An essential prerequisite for construction site selection was suitability of surrounding land for farming and vicinity, as well as hunting-rich forests in the proximity of settlement. Population growth and fortified settlements became too narrow. At lowlands to arterial roads and near water began to arrange enclosed settlements, which planning reflected individuality of relief. Perfect natural sense of site selection and organization of urban spatial structures, as well as attitude to the environment, efficient use of natural materials and landscape individualities settlements appropriated functional purposefulness and original beauty.

The ancient Curonians and Semigallians built one building for dwelling, but in case of need, they built besides residential building one after another without advance planning small houses for each function. Country estate planning developed and countryside intimacy expressed oneself. Originally just around the dwelling house, but later around the all building complex was built fence. The combination of country estates was irregular – several villages were located close together, but elsewhere houses were built in a row one after another. On the seashore of Baltic Sea from Palanga to Kolka and along Gulf of Riga to Salaca River close to neighboring unmatched groups of six, eight or ten houses formed hamlets inhabited by the Livonians – they historically were rooted in the Finnish traditions and differed from Lithuanian and German hamlets where streets were built. Enclosed complexes of houses or farmsteads formed greater or lesser hamlets and it became dominant type of residence place in Latvian territory.

Figure 1 Fortified residence in the natural environment – Turaida's castle near Sigulda [I-1]

In Latvian territory since the 13th century began to build stone fortresses (Figure 1). The first cities were founded in the 14th century. Rural residential buildings were gradually transformed and adapted to urban conditions – formed a little story building was connected with the natural environment. In cities of Western region of Latvia as Durbe, Ventspils, Kuldiga, Bauska, Jelgava, Aizpute, Liepaja and Piltene, as well as small villages Talsi, Grobina, Tukums residential houses with a tripartite plan started to built. They had a fireplace area in the central part and two lobbies: one in the front of the house, where was the main entrance, and another with an entrance to the courtyard and garden. Pass-through residential building layout helped to link the city's architectural space with the natural environment. Residential houses with a tripartite plan were placed on either sides of road or street with the side facade towards carriageway. Wooden structures and people cultivated greenery became a characteristic feature of the landscape of Latvian towns.

## Greeneries in Latvian urban planning

At the first half of the 19th century in Latvian cities began to arrange of the first public gardens, but a few decades later, urbanization and railway traffic facilitated emergence of industrial sites. Natural areas in urban environment declined, and nature landscape was supplemented by human cultivated plantations. Cities focused on functional issues, urban environment improvement, and greenery system formation. Public parks, boulevards, and squares became an integral part of urban amenities.

In Tsarist Russia health resorts developed and the interests of the guest took into account. Summer cottages, hotels and luxurious houses and verandas were decorated with openwork, woodcarvings, balconies, metal forging grids. Treatment, recreation and entertainment were the main interests underlying the concept of a health resort. In Rīgas Jūrmala, Liepāja and other health resorts a significant role was assigned to parks and greeneries. In 1899, the Seaside Park was designed and on the seacoast of the Baltic Sea arranged on. The extensive territory of the public park was divided into several functional zones, such as the active recreation zone with tennis courts, playgrounds and quiet zones. In varied landscape the fountain and sundial were included. The health resort stimulates the development of Liepaja's planning and in forming of urban landscape greenery was used. In 1911, Rose Square became a symbol of Liepaja (Figure 2).

Figure 2 Nature elements in urban environment – Rose Square in Liepaja. 1911. [PK]

**Urban aesthetics**

At the turn of the 19th and the 20th century the first Latvian sculptors declared itself and development of Latvian professional sculpture began. The first creative efforts of Latvian professional sculpture were linked with easel-sculpture. Little by little a framework of genre was opened and language of forms was developed. The first professional Latvian sculptors mastered the artistic education, learning Russian and European sculpture heritage. In Paris, Gustavs Šķilters (1874–1954) and Teodors Zaļkalns (1876–1972) attended a studio of prominent French sculptor François-Auguste-René Rodin (1840–1917) on Montparnasse Boulevard, where emerging sculptors gathered from different countries. Direct contact with the French masters of sculpture and their creative works left a great meaning on the first Latvian sculptors' creative self-expression and led to research into the nature, as well as improvement of the art of interpretation. In 1907, Zaļkalns went to Italy where he learned Italian Renaissance and contemporary art. Zaļkalns lived in Florence for two years and attended several other Northern Italian cities too. The artist's impressions and experience helped to master stone sculpture – granite as the material did verbosity and detail, but contributed to the certainty of composition and shape [1].

In start-up phase of mass culture at the beginning of the 20th century Art Nouveau and a new concept of spatial placement developed. Accordingly aesthetics of corresponding epoch and professional art requirements the folk art heritage began to purposefully use. Urban environment came to the attention of the artistic and synthesis of architecture and art began significant. Latvian monumental sculpture flourished, encouraging sculptors' interest in person [1].

On 18th November of 1918, the independent Latvian Republic was proclaimed and understanding of urban aesthetics changed. Much attention was focused on sculpture and architectural solutions for interfacing with the natural elements, such as sulfur springs (Figure 3), relief (Figure 4), waters (Figure 5), natural stands of trees and cultivated plantations. National culture revival in twenties and thirties of the 20th century granted Latvian professional sculpture democratic orientation. After the 1934th of 15 May coup former Prime Minister Kārlis Ulmanis (1877–1942) came to power and established an authoritarian regime and nationalism became the ideological component. In urban environment folk expressions monuments was included (Figure 6 and 7) to increase people's national consciousness and to achieve a common goals.

Figure 3. St Mara sculpture at the sulfur spring in Baldone's health resort. 1930ies. [PK]

Figure 4. Cēsis Castle Park stairs. 1935. Authors: artist Jānis Rozenbergs (1900–1966), sculptor R. Āboltiņš and Kārlis Jansons (1896–1969). (Photo by R. Sīmanis, around 1940) [PK]

Figure 5. Cēsis Castle Park pond landscape with stairs, which extends to the surface of water. 1935. [PK]

Figure 6. Monument to the Liberators of Jelgava. Unveiled on June 21st, 1932. Author: sculptor Kārlis Jansons. [PK]

Figure 7. Rēzekne Symbol – monument "United for Latvia" or "Latgalian Māra". The first unveiled on September 8, 1939. Authors: Leons Tomašickis (1904–1996) and sculptor Kārlis Jansons. Restored by the sculptor Andrejs Jansons. [PK]

## Semantic message of architecture and art

On August 5th of 1940, Latvia was incorporated in the Union of Soviet Socialist Republics. In isolation on Western cultural ideology socialism architecture was formed. Its motto was: “Socialist in content and form rational”. In 1957, the Communist Party of Soviet Union and the Soviet government adopted a resolution “On the housing development in the USSR” creating the basis for construction industrialization.

Primitive architectonic forms were included in urban environment and population resulted in negative emotions. In the seventies of the $20^{th}$ century, international modernism grew into the late phase and in cities began to pay more attention to the protection of nature elements and historical architecture. In industrial conditions it was not an easy task, but in urban environment the nature landscape significance increased [2].

Figure 8. Monument to the dead fishermen and seafarers in Liepāja. 1976. Authors: sculptor Alberts Terpilovskis (1922–2002), architect Gunārs Asaris. [I-2]

Figure 9. Memorial in Priekule. 1974.–1984. Authors: Pārsla Zaļkalne, architects Artūrs Zoldners, Elmārs Salguss, dendrology Aivars Lasis. [PK]

Diverse spatial structure caused emotion in people. Elementary functional qualities guaranteed a comfort, are not only to initiate a dialogue with space. In the seventies of the $20^{th}$ century, postmodern architecture was characteristic formal expressions of diversity gain and compositional technique complexity. In spatial environment sought to bring wider image system was created special symbols (Figure 8) and metaphors, as well as accentuated the semantic nature of spatial forms, to promote with definite idea and creating of spatial environment saturated with thinking [2].

Postmodern space does not made simple, but always hid himself some surprises organized through a variety of means of expression. Motto “ideas justifying everything" cleared the way for complete compositions' liberation and the most spacious interpretation of technical and artistic tools. Development process of new ritual traditions was promoted [2]. In Liepaja a wide path with luxurious greenery leads to architectural ensemble with concrete stairs on the shore of Baltic Sea.

Life shape elements for postmodern symbolism were used. In Liepaja at the closing of Kurmaja Prospectus the monument to the dead fishermen and seafarers on ten meters high concrete podium sheathed with dolomite plates was set up. Five meters high Mother-vernacular statue symbolizes mother, wife, daughter, bride, waiting to return to their dear comes in from the sea. In Priekule Memorial of Warrior's Cemetery twelve meters high Mother-vernacular and child statue was positioned in the center of the ensemble (Figure 9). Postmodernism awarded the seclusion room. Surrounding plantations gave an intimacy to Priekule Memorial of Warrior's Cemetery composition forming by vertical and horizontal elements.

In the eighties of the 20th century, in Jelgavkalns near Sigulda, where ancient Libyan camp was situated, the sacred landscape by symbolic sculptures (Figure 11, 12, 13) was formed. On June 7th of 1985, Folksong Hill with emotionally-based sculptures by sculptor Indulis Ojars Ranka was opened. Congruence of stone statues and nature embodies the beauty and wisdom, as well as loving attitude towards nature expressed in Latvian folk songs. In Turaida past encounters with the present. On July 1st of 1990, Songs Garden was opened. Sinuous trails linked Songs Garden with Folksong Hill to create a unified ensemble – Folksong Park (Figure 10), informed about accumulated heritage of intangible culture and value system based in traditional Latvian folk wisdom.

Figure 10. Latvian Folksong Park in Turaida, near Sigulda. 1985. Authors: Director of the Sigulda Regional Studies Museum Anna Jurkāne, sculptor Indulis Ojārs Ranka, architects Jānis Rozentāls, Ilgvars Batrags. [I-3]

Folksong Park near the Castle is a place for discovery of Latvian folk vitality secrets, as well as for exploring folk song meanings and wisdom to feel majestic beauty of nature and to draw energy. In 1996, Folksong Hill with twenty-six sculptures was included in the list of World's Sculpture Garden and Parks (Washington).

Figure 11, 12, 13. Folksong Park. Sculptures "Song's Father", "Thinker", "Spīdola" [I-4]

**Synthesis of nature and art in urban environment – ensign of Latvian culture**

On May 4th of 1990, Latvia re-declared national sovereignty. In the renewed Latvian Republic attitude to historical and cultural values was changed. Started at the first half of 20th century spatial making traditions was continued.

In Latvian regional architecture dominate the intimate humanitarian dimension, and spatial relationships are very significant. Latvian landscape made up with an amazing sense of harmony sorted elements, such as the lines of gentle hills with dark contours of the horizon, birch groves, fir or pine forests, which include white zig-zag paths, meadows and fields with small house clusters with gardens. Landscaping or architectural context determine the scale of building compositions, but in modern urban environment requirements of the economy dictate forms of industrial buildings and the scale of super-large three-dimensional structures. Sense of proportion determines human attitude to regional expression in art and architecture [2].

Contemporary environmental forms are varied: open space interspersed with enclosed or semi-enclosed spaces, because the ability to perceive is different. In Latvian cities relief and location of planning elements influenced architectural and spatial structure. Open space created by water and greenery system promote health, communicative and recreational function, as well as affected the artistic expressiveness of the urban landscape. Over the centuries established centers of towns Kandava, Sabile, Kuldiga, Talsi now perfectly adapt in landscape (Figure 14). In the 1930s the inhabitants of Talsi decided to make a memorial site for freedom fighters of Latvia by unveiling the monument “Koklētājs” by Kārlis Zemdega. In the 19th century at one of the nine hills Ķēniņkalns (Kilg’s Hill) a park was established, but in autumn of 1996 a monument “Koklētājs” was mounted. Witnesses of the past gets a unique attraction in interaction with the surrounding landscape (Figure 15).

Figure 14. Costal panorama of Talsu Lake. [I-5]

Figure 15. Monument “Koklētājs” – a dedication to fallen heroes of Latvian War of Independence. 1930ies. Authors: sculptor Kārlis Zemdega (1894–1963), monument minted sculptor Vilnis Titāns (1944–2006). 1996. [I-6]

Nature and building interaction encourages the search for artistically innovative solutions to create harmonious environment. Cultural environment enrich with art works (Figure 16).

Figure 16. Sculpture on Rīgas Jūrmala Beach – Majori. 1995. Sculptor Jānis Bārda. [I-7]

Synthesis of landscape and art promotes development of varied planning and original spatial compositions in Latvian cities. Silhouette and plastic construction of building is information the most intensive and emotional the most active components of spatial environment. Artificial spatial-shaped silhouette is read as a contrast on natural landscape or the sky background.

Plastic construction of the object is revealed most vividly in chiaroscuros, heterogeneity and dynamics of spatial structure [2]. Eastern Latvia's Center of Creative Services "Zeimuļs" (Figure 17) is situated near hill fort with Livonia weather ruins. The shape of this complex is created as sculpture with attuned to relief and it provides semantic message. This complex was nominated for the final of Latvian Architectural 2012th show the best job.

Figure 17. Eastern Latvia's Center of Creative Services "Zeimuļs" in Rezekne. Authors: SIA SAALS architects Rasa Kalniņa and Māris Krūmiņš. 2012. [PK]

## Conclusions

1. Aesthetics of Latvian urban environment formed in a long period of time at presence of nature. Searching for harmony, people in self-generated living environment, according era aesthetic requirements, for accentuate of the most important places and nature elements artworks chosen.

2. National political system affected the choice of artistic means to express semantic message. In the presence of natural elements for expression of certain ideas and creating information-intensive space symbolic images and the subject artworks were used. Buildings acquired message to the appropriate composition, silhouette and plastic construction, aspiring to achieve synthesis of landscape and art.

## References


1. Latviešu tēlotāja māksla. 1860–1940. Rīga: Zinātne, 1986. (In Latvian)
2. Strautmanis I. Reģionālās arhitektūras formveides valoda. Rīga: Rīgas Tehniskā universitāte, 1992. (In Latvian)


## Materials from collections

PK – Postcards from Silvia Ozola's collection

## Internet resources


I-1 https://www.google.co.uk (10.11.2013)

I-2 http://www.inyourpocket.com/latvia/liepaja/sightseeing/places-of-interest/Monument-to-Mariner-Lost-at-Sea_6675v (10.11.2013)

I-3 http://wikimapia.org/16581887/lv/Dainu-kalns {10.11.2013}

I-4 http://wikimapia.org/16581887/Dainu-kalns-hill-Folksongs-hill (10.11.2013)

I-5 http://www.magneticcc.worldress.com/talsi-marta/ (10.11.2013)

I-6 http://www.talsi24.lv/par_pilset/64/384/862 (10.11.2013)

I-7 http://www.agoda.com/family-house-majori/hotel/jurmala-lv.html (10.11.2013)

**Tatsuo Unemi**

*Installation:* **Non-stop Evolutionary Art You are Embedded in**

***Topic: Interactive Installation***

***Authors:***
***Tatsuo Unemi***
Soka University,
Department of Information Systems Science
Japan
www.intlab.soka.ac.jp/~unemi/

***References:***
[1] Tatsuo Unemi, "*A Fully Automated Evolutionary Art*", GA2012, Lucca, Italy, 2012
[2] Tatsuo Unemi, "*Synthesis of Sound Effects for Generative Animation*", GA2012, Lucca, Italy, 2012

***Abstract:***
In a similar mechanism as the huge variations of complex organisms appeared and disappeared on the earth through the evolutionary process for billions of years, it is possible to organize a process of non-stop development in the computer to produce unpredictable complex patterns, utilizing a technique of evolutionary computation. This visually interactive installation is one of the extended variations of author's previous work entitled *fully automated evolutionary art* [1]. It continuously produces abstract images and animations by a type of evolutionary computation based on a minimum gap of generational changes and combination of computational aesthetic measures as the fitness criteria. It was purely autonomous without any effect from the outside, the author extended it using Kinect® camera to embed the visitors' figure in the visual output. The information captured by the camera does not affect to the evolutionary process, but it changes the audio output because the process of sound synthesis is based on the features extracted from the visual output [2].
This is the shallowest connection between the production process and the action of visitors, but it's more enjoyable than the oneway effect where the visitors are just observing the production. And, it is the start point toward deeper interaction and mixture between the life in the machine and the life in the nature.

*Example: Image visual output.*

***Contact:***
***unemi@iss.soka.ac.jp***

***Keywords:***
Evolutionary art, visual interaction, interactive installation, automatic art

# Non-stop Evolutionary Art You are Embedded in

**Prof. T. Unemi, BEng, MEng, DEng.**
*Department of Information Systems Science, Soka University, Hachioji, Japan*
*www.intlab.soka.ac.jp/~unemi/*
*e-mail: unemi@iss.soka.ac.jp*

## Premise

To extend an evolutionary art to be interactive with visitors, we introduced a mechanism to mix the visitor's image captured by the live camera and the image produced by the automated evolutionary process. This is the shallowest connection between the production process and the action of visitors, but it's more enjoyable than the one-way effect where the visitors are just observing the production. It is a start point toward deeper interaction and mixture between the life in the machine and the life in the nature.

## 1. Introduction

In a similar mechanism as the huge variations of complex organisms have appeared and disappeared on the earth through the evolutionary process for billions of years, it is possible to organize a process of non-stop development in the computer to produce unpredictable complex patterns, utilizing a technique of evolutionary computation. Evolutionary art is one of the generative approaches to produce interesting complex patterns inspired from the evolutionary process of natural organisms. The framework of Interactive Evolutionary Computing has been used by several number of artists and researchers in order to generate these kinds of patterns that fit with human's preferences, just similarly to the breeding process of ornamental plants and pet animals following a type of aesthetic criteria. This method is obviously based on a type of cooperative mechanism between man and machine, where a human is always taking a necessary role for creation.

On the other hand, owing to the recent improvement of image processing technology in both software and hardware, the automated production of similar type of patterns became possible. This visually interactive installation is one of the extended variations of author's previous work entitled fully automated evolutionary art [1]. It continuously produces abstract images and animations by a type of evolutionary computation based on a minimum gap of generational changes and combination of computational aesthetic measures as the fitness criteria. It was purely autonomous without any effect from the outside. We have received many times of comments from the visitors that it would be more interesting and playful if it could have a type of visual interaction with visitors. These comments should be agreed considering from our experience with flocking orchestra [2] and identity-SA [3] that are installations of visually interactive swarm utilizing a live camera and generating sounds. The visual feedback easily and effectively attracts the visitors of wide generations from the elementary school kids to elder persons if the response is quick enough. Even though the information captured by the camera does not affect to the evolutionary process, it is effective if it changes the result visuals. At the same time, the audio output is also affected because the process of sound synthesis is based on the features extracted from the visual output [4].

There are several types of possible methods to mix these two images. Our approach introduced here is relatively simple but effective enough to attract visitors**.**

## 2. Mixing Methods

SBArt is using functional expression as the genotype that maps a coordinate in the spatiotemporal space to a color value in the HSB (hue, saturation and brightness) color space. Each of the frame images of animation is rendered with *x* and *y* coordinates and the same value for the time variable *t* for each pixel. The visitor's real time image captured by the live camera is usually a distribution of color values in a two-dimensional lattice. There are several possible methods to combine the generated image and the captured image, but we need to design a method to make it easy for visitors to recognize both images in the display at same time. One of the easiest methods is to calculate the average color value between values extracted from corresponding position in the two images for each pixel, but it is uninteresting because mutual affection is too obvious. It is easy for visitors to separately recognize each of the original images as shown in Figure 1.

Another method to keep the color combination of the generated image is to shift the time value by the brightness, or another scalar measure, extracted from the captured image. Figure 2 shows a sample result image. This method provides an effective mixture of two different images in different features, the color distribution from generated image and shape from captured image. However, it doesn’t seem suitable because the smooth gradation typically drawn in expression-based evolutionary art has gone from the result image due to a spatial noise in the background part of camera input.

To achieve the requirement that it should present both features of evolutionary art and recognizable visitors figure, we introduced a method to eliminate the effect of camera image from the part of background by extracting the part of visitor’s body. It is not difficult by using a simple method to take a difference of pre-recorded background image and the current captured image, if the background of the installation environment is stable, that means nothing moving behind the visitors and no fluctuation happens at the lighting condition. To adapt to an unstable environment, we introduced a Kinect® camera instead of ordinary web camera to use depth, distance between a camera and an object, but not the brightness. Kinect® is a trademark owned by Microsoft Corporation®. Adjusting the threshold depth to distinguish the object and the background, it is easy to extract the visitor’s figure from the captured image. Figure 3 shows a typical example of the result image processed by this method. Only the depth values shorter than the adjustable threshold value affect the mixing process with the generated image.

SBArt, itself, has two types of alternative modes to embed external images and movies, namely deformation and discoloration [5]. These methods are also available to introduce a type of interactivity by using camera image as the external one. However the disadvantage is difficulty on calculation of the fitness value for each candidate in the evolutionary process. Though the evaluation should be processed on the image mixed with the captured image, the selection must be done before displaying it to the visitor. Some minutes of delay between capture and display is unavoidable. Considering an expected staying time of visitors, the time delay should be shorter than ten seconds or so, to make them aware of the interactivity.


*Figure 1. A simple mixture of generated image and captured image by taking the average color values for each pixel*.

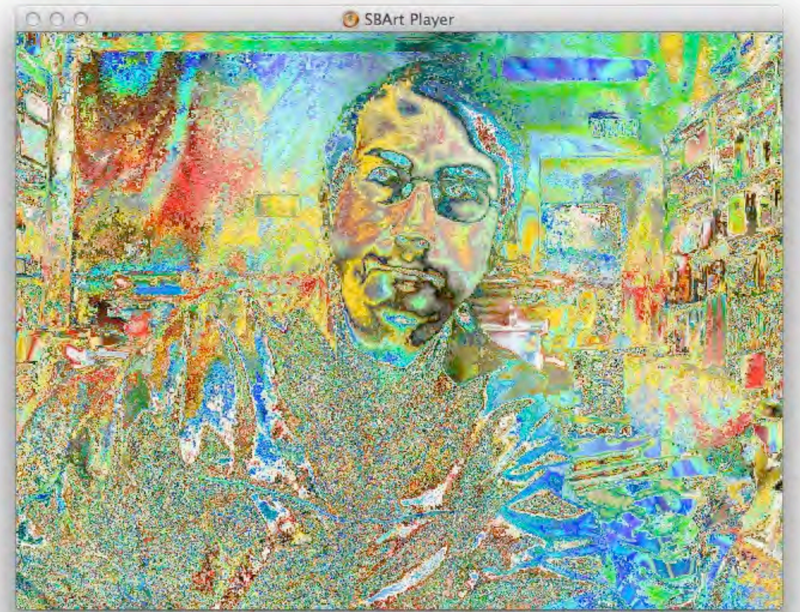



*Figure 2. Shifting the value of time variable t by the brightness of captured image for each pixel*.

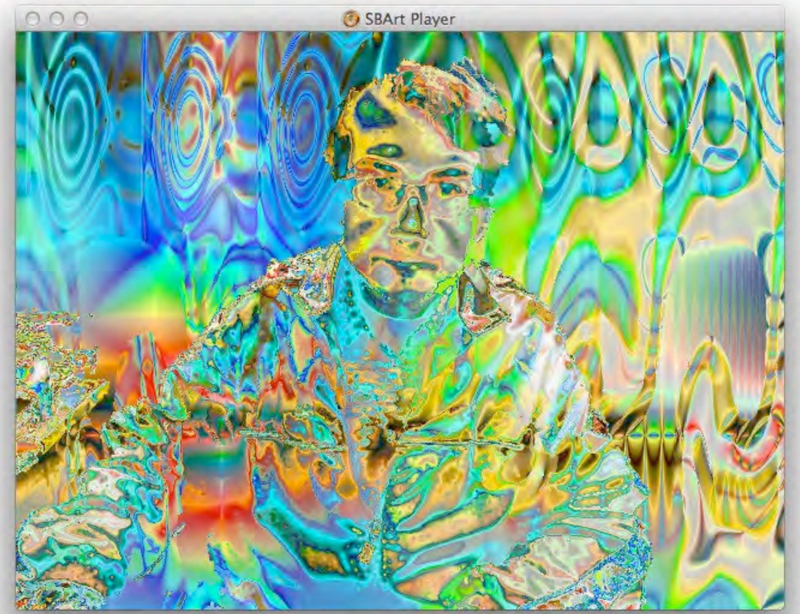



*Figure 3. Mixing visitor's figure with generated image using Kinect® camera.*

## 3. Implementation

The latest version of SBArt is using compiled code of each genotype to render the image that enable to utilize hi-speed parallel processing by graphics processing unit. Owing to this extension, it achieved the real time rendering of smooth animation faster than 24 frames per second [6]. To continue to take this advantage, we designed a modification process of shader code in order to embed a captured image. A new argument was added to the main function of fragment shader to which the image sampler for the depth values is assigned, and a new code was inserted to modify the time value *t*. Figure 4 is an example of modification of shader code, where the extended parts are indicated in bold face with underlines. The depth values greater than the threshold value are replaced with zeros before it forms a sampler object from camera input.

Because this extension doesn't affect the evolutionary process but only in the rendering process for display, we implemented this functionality in the player module but not in the evolving side. Figure 5 illustrates the system configuration of computers, devices and software modules. The player module receives a source fragment of shader code from the evolution module, and then modifies it to be applicable to the mixing process described above. This module was extended to capture the distribution of depth values by Kinect® camera and feed the data in a form of sampler object to the compiled code.

The controller module for Kinect® is written in C language utilizing an open source software library named *freenect* by OpenKinect project [7].

Original code:
```
kernel vec4 individual01(float T, float width, float height){
  float t=T*-2.018997+0.769912;
```

```
  vec2 p=(destCoord()/vec2(height,height)*2.-vec2(width/height,1.))*...;
  vec3 v=((power(abs((-(vec3(t,p.x,p.y)))-(cnst(t,vec3(-0.375667,...
  ...
  return vec4(v,1.);
)
```

Modified code:

```
kernel vec4 individual01(float T, float width, float height, sampler cmr){
  vec4 C=sample(cmr,destCoord());
  float t=(T+(C.x+C.y+C.z)/3.-.5)*-2.018997+0.769912;
  vec2 p=(destCoord()/vec2(height,height)*2.-vec2(width/height,1.))*...;
  vec3 v=((power(abs((-(vec3(t,p.x,p.y)))-(cnst(t,vec3(-0.375667,...
  ...
  return vec4(v,1.);
)
```

*Figure 4. An example of shader code modification.*

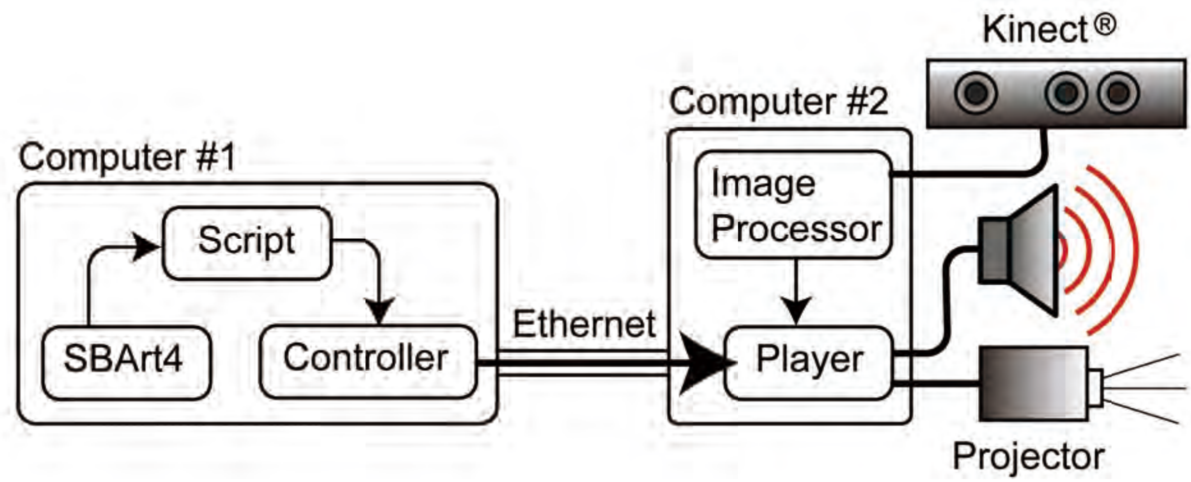



*Figure 5. Configuration of computers, audio visual devices and software modules.*

## 4. Concluding Remarks

We implemented a new functionality for visual interaction between a generative image and a captured image in the display module of *fully automated evolutionary art*. This is the shallowest connection between the production process and the action of visitors, but it's more enjoyable than the one-way effect where the visitors are just observing the production. There are a number of the other places into which we can introduce some type of interaction, such as selection of the set of functions for genotype, parameters in the evolutionary process, projection methods for final visuals, and so on. We hope the installation design described here will be one of the start points toward deeper interaction and mixture between the life in the machine and the life in the nature.

## References

[1] Tatsuo Unemi, “SBArt4 for an Automatic Evolutionary Art,” Proceedings of the IEEE World Congress on Computational Intelligence (WCCI 2012 - IEEE CEC 2012), pp. 2014-2021, June 10-15, Brisbane, QLD, Australia, 2012.

[2] Tatsuo Unemi and Daniel Bisig, “Flocking Orchestra - to play a type of generative music by interaction between human and flocking agents.” in C. Soddu ed. Proceedings of the eighth Generative Art Conference, Milan, Italy, December 15-17, pp. 19-21, 2005.

[3] Tatsuo Unemi and Daniel Bisig, “Identity SA - an interactive swarm-based animation with a deformed reflection.” in C. Soddu ed. Proceedings of the 10th Generative Art Conference, Milan, Italy, pp. 269-279, 2007.

[4] Tatsuo Unemi, “Synthesis of sound effects for generative animation,” in C. Soddu ed. Proceedings of the 15th Generative Art Conference, pp. 364-376, December 10-13, Lucca, Italy, 2012.

[5] Tatsuo Unemi, “SBART 2.4: an IEC Tool for Creating 2D Images, Movies, and Collage,” *Leonardo*, Vol. 35, No. 2, pp. 171, 189-191, MIT Press, 2002.

[6] Tatsuo Unemi, “SBArt4 - Breeding Abstract Animations in Realtime,” Proceedings of the IEEE World Congress on Computational Intelligence (WCCI 2010 - IEEE CEC 2010), pp. 4004-4009, July 18-23, Barcelona, Spain, 2010.

[7] OpenKinect, http://openkinect.org , 2011-2013.

**Val Tsourikov**

*Paper*: **Architecture of Self Learning A.I. Platform for Generative Art**

***Topic: Architecture***

***Authors:***
***Val Tsourikov***
Predizo LLC
www.predizo.com

***References:***
[1]Tsourikov, V.,at al, (2000). "Document semantic analysis with knowledge creativity capability" U.S. Patent number 6,167,370.
[2] Galanter, P. (2012) "Computational Aesthetic Evaluation: Steps Towards Machine Creativity.
www.generativeart.com

***Abstract:***

The process of creation novelty includes two main phases: generation of many concepts and selection of the concepts that are novel and promising. These two phases are present in any type of creative process: in art, music, mathematics, technical inventions, fashion design.

We propose the architecture of A.I. platform, which can be customized for particular domain. The platform includes following modules: open knowledge base, generator of new structures, semantic distance measurer, trend detector, evaluator of degree of novelty of generated concepts, morphological space builder for promising concepts.

Open knowledge base is semantic by nature and consists of two parts: first part includes basic structures partially filled with content to represent most important existing domain knowledge (relations between colours, geometric figures, images), second part contains structures with high degree of abstraction and limited content.
Generator of new concepts includes several algorithms: combinatorial, genetic, analogical reasoning. Novelty evaluator uses semantic distance to decide how novel the new concept is.

The purpose of morphological space builder is to quickly develop new promising concept by building N-dimensional space of many possible modifications of basic concept.

For example, if generator of new structures created semi-transparent white cube with black ball oscillating inside the cube, and experts like it, then shape, colour and oscillating frequency of the ball, as well as shape and colour of the cube will be replaced by many possible options to find the best combinations, i.e. morphological space of the created artefact will be built.

Problem of concepts selection. Evaluation of new concepts generated by A.I. software, is not a trivial task. We suggest to use semantic distance to choose revolutionary concepts and automatic trend analysis for selection of new concepts that may belong to existing or forming trends.

***Contact:***
***valerymt@gmail.com***

***A.I. platform, semantic distance, trend detector***

# Architecture of Self Learning A.I. Platform for Generative Art and Films

Dr. Val M.Tsourikov,
Predizo LLC, Minsk, Belarus www.predizo.com
email: valerymt@gmail.com

## 1. Automatic generation of content as mega-trend

We define mega-trend as phenomenon that has three main features: high and lasting demand determined by fundamental society needs; existence of infrastructure to distribute products or services; technology reached critical point from which it can be used by masses. Let's do quick analysis of automatic content generation.

Content creation is a fundamental feature of human civilization: visual art, books, music, photographs, movies are being created with accelerated rate. Success of social networks as content sharing platforms proves, that content remains in high demand. Easy access to the Internet became a norm, i.e. infrastructure for content distribution exists and is available almost everywhere. A.I. technology for content creation is on the rise (semantic text analysis, natural language processing, voice synthesis, machine learning). Intelligent systems more and more often are used to solve practical problems.

In some areas modern A.I. systems are able to find creative solutions that are better than similar results found by human experts. In 1997 Deep Blue computer defeated G.Kasparov, the most ingenious chess player of all times. Interesting to note, that same year Boston based Invention Machine Corporation launched A.I. software IM-Phenomenon which was able to generate novel solutions of technical problems, in fact acting as an artificial inventor. IM-Phenomenon later was included in more broad software technology now called Goldfire Innovator [1], which is widely used by high-tech companies. Fast progress in generative art and music [2] also supports the idea that society is facing new mega trend – automatic content creation in many different areas.

Because all major components of mega-trend are ready, it's possible to develop A.I. platform for automatic content generation to be used not only by art professionals but also by normal internet users.

## 2. Main features of A.I. platform for automatic content generation

There are two objectives of the project:

a)to design and implement web-based Artificial Intelligence platform to enable easy access to tools of generative art and movies;

b) to create collaborative environment for people who want to create novel art and movies, that have value for end users and can successfully compete with traditional technologies of creating art and movies.

Key concepts of the platform:

- automation of all three main phases of creative process (novel idea generation, evaluation of new ideas, learning of new things, including trends detection in user preferences);
- adaptive nature of the platform, determined by machine learning and predictive analytics algorithms;
- pragmatic output of the platform – generated art and movies will be distributed to end users as products, which have aesthetic value.

Conceptually, the platform is similar to A.I. systems for creativity automation, developed earlier in space research, technical innovations [3] and financial engineering [4].

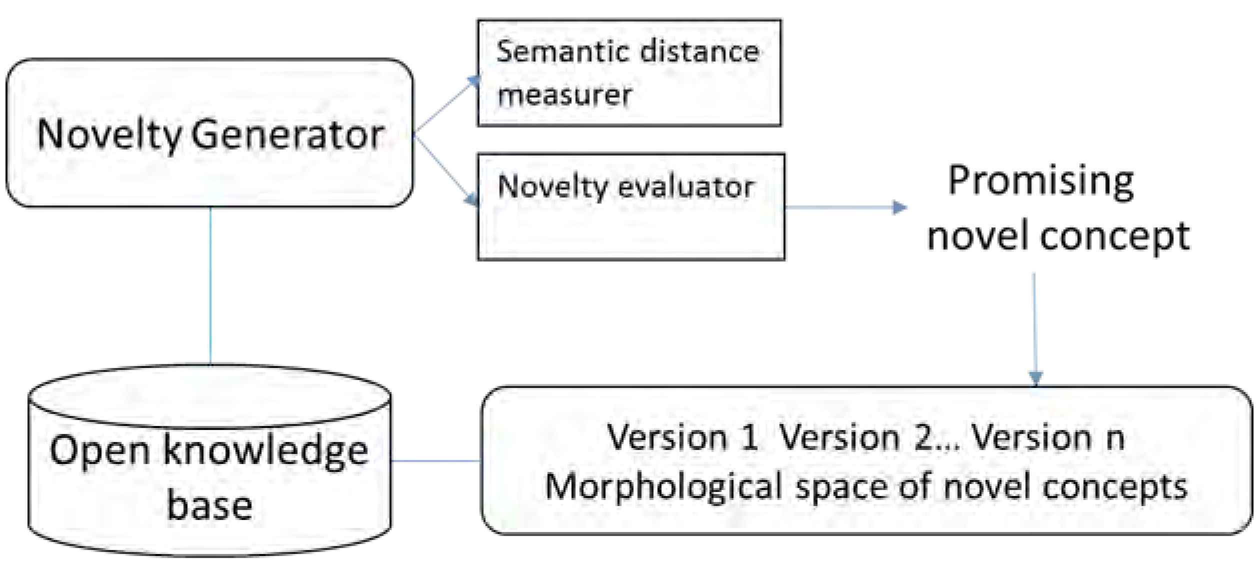



*Figure 1 – Architecture of A.I. platform*

The architecture of A.I. platform can be customized for particular domain. The platform includes following modules, as shown in Figure 1 :

- open knowledge base of abstract structures and shells,
- novelty generator of new structures and concepts,
- semantic distance measurer,
- trend detector of user preferences,
- evaluator of degree of novelty of generated concepts,
- morphological space builder for promising concepts.

Open knowledge base contains basic graphical structures, shells, music themes and abstract movie scripts. The knowledge base can be updated by platform developers or by end users.

Generator of new visual structures, texts, scenes and scripts acts as a composer of novelty. It constantly creates novel artefacts by using built-in knowledge bases, new trends discovered on the internet, and inputs from platform users. There are several algorithms involved in generation of novelty in this important module. Machine learning, trend analysis, inputs from users and predictive analytics help find promising directions in search for novelty and increase probability of creation valuable results.

Semantic distance measurer calculates semantic distance of newly generated structure or text and sends results to evaluator of novelty of generated concepts to determine formal coefficient, which shows how far new structure is from known concepts.

Trend detector uses semantic analysis and statistical machine learning algorithms to find evidence of trends being formed in sentiment, tastes in art, music and preferences in films. Data from this module is used to control computational process in generator of novelty module. Trend detector processes databases of social networks, online communities, clubs and other places where general users and domain experts express their opinions on art, movies and music.

Morphological space builder for promising concepts takes most innovative and practically feasible concept and generates all possible permutations of the concept, thus creating many versions of original idea. Main objective of this phase is to let end users to observe the entire universe of possible versions of novel concept at once and chose the most interesting candidates for further development.

The A.I. platform includes several universal modules, which can be used in all areas – from generative music to movies. For example, combinatorial intelligence, genetic algorithms, semantic processors [5], Bayesian networks, ant colony optimization and fuzzy logic can be applied to any domain.

Customizable modules have knowledge bases created by domain experts and later by platform users. Knowledge base for generative art will have different structure vs. knowledge base for generative films.

## 3. Methods of Novelty Generation

There will be two types of novelty generation approaches: analogy-based methods to generate art, music and movies that remain within boundaries of existing paradigms; and revolutionary methods which may help create new style in art or movies.

Direct analogy. This simple but practically very useful method uses replacement of objects or operations in entire system (graphical image, movie scenario) without changing the basic structure of initial system. For example, in movie script direct analogy means that conflict between two adult characters may be used to describe similar conflict between two teenagers, or slightly modified conflict between adults. Structure of the conflict remains the same, but it is moved to different time, culture, place or social group.
Direct analogy algorithms sits on the top of all major abstract structures of visual scenes, scripts, dialogues.

Automatic creation of movie script from novel, short story, discussions on message boards, social network activity. Modern semantic processors are able to create meaningful summaries of texts, which will be used to generate movie scripts.

Interactive novelty generation. To make sure that novel ideas created on the platform have pragmatic value, human users will be involved as active participants in generative process. Computer creates novel idea, users approve or reject it; depending on user votes, the algorithm will take different path in search for novelty.

Pattern and scene recognition. Users load photographs, drawings, videos to the platform; pattern and scene recognition software finds most promising patterns or scenes and starts generative art or film algorithms to create novel content.

Introduction of new technology that will enable generation of novelty. For example, BCI (brain computer interface) may help create new forms of art, like direct emotional contact between artist and the audience. Combination of A.I., nanotechnology and synthetic life may lead to creation of self-controlled art-objects, which are alive and intelligent.
3d printing is rapidly changing the way art is created. The role of A.I. platform in this

case is to bring together new disruptive technologies, generative algorithms and users to quickly realize potential of BCI, synthetic life and similar revolutionary breakthroughs in science and technology [6].

The platform users will have an opportunity to apply many other methods of novelty creation, which have being developed in generative art, music and films.

If users see value in novel idea, concept or script generated by the platform, they will have an opportunity to refine original result by using special module of amplifiers of positive effects of new idea.

## 4. Collaboration

The platform will have feature rich environment for creative collaboration between artists, actors, script writers, musicians and managers. The concept of online film production network is not new, several of them exist today. What is new - and this is really critical difference – the layer of Artificial Intelligence between human users of the platform (Fig. 2).
A.I. tools make production of content (art, music, movies) much faster, cheaper and with higher probability of success (determined by predictive analytics and trend analysis). Intelligent generative technologies do not have internal cultural constraints, hence they may find unusual combinations of building blocks that human creators tend to miss.

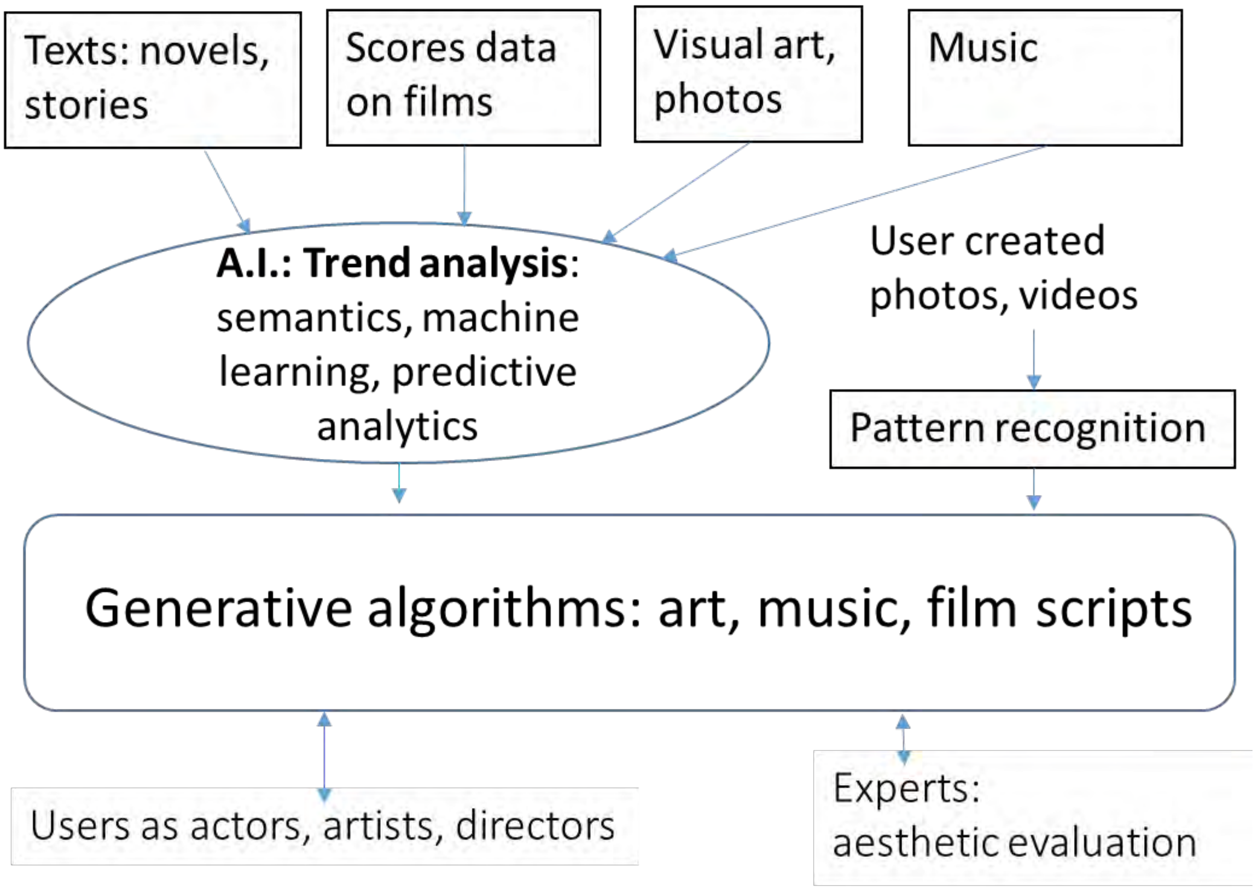


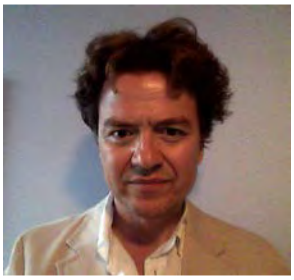

*Figure 2 – Collaboration between users, experts and generative system*

## References

1. Tsourikov, V. Inventive Machine: second generation. AI and Society, 1993, 7(1): p. 62-77.
2. McCormack, J., d'Inverno, M. (editors). Computers and Creativity. 2012, Springer, 430 p.
3. Tsourikov, V. Invention Machine Project. Journal of TRIZ (in Russian), 1991, 2(1), p.17-34.
4. Tsourikov, V., at al., A.I. system for automatic synthesis of trading technologies and portfolios for investment funds. In International Conference on Artificial Intelligence. 2008, p. 275-279. Las Vegas.
5. Tsourikov, V.,at al, Document semantic analysis with knowledge creativity capability, 2000. U.S. Patent number 6,167,370.
6. Galanter, P. Generative art after computers. In International Conference on Generative Art. 2012. Milan, Italy: Generative Design Lab, Milan Polytechnic.

**Yiannis Papadopoulos**

*Paper-Installation:* **AN EVOLVING MUSICAL PAINTING ON THE BOUNDARY BETWEEN PERMANENCE AND CHANGE**



***Topic: Audio-Visual Generative Art***

***Authors:***

***Yiannis Papadopoulos***
***David Parker***
***Martin Walker***
***Emma-Jane Alexander***
University of Hull
http://www2.hull.ac.uk/science/computer_science.aspx

***Roberto Bono***
ARTeUTILe
http://www.arteutile.net/

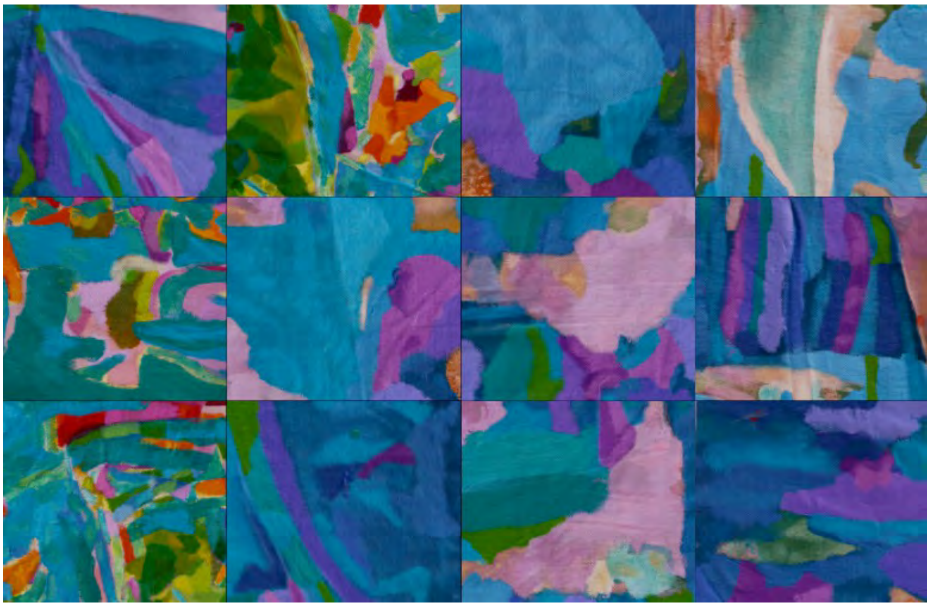
***Andrea Alberti***
http://www.erjn.it/alberti

***Bob Salmieri***
http://www.milagroacustico.net

***Abstract:*** Works of art, whether representational or abstract, are typically fixed in time by the artist and remain permanent thereafter. In this work, we depart from this model by defining the "art object" as a multi-dimensional artistic design landscape that can be eternally travelled each time in a different and unique way using computers.

Roberto Bono has painted 12 double-sided abstract panels which, when put together in a 4x3 lattice, create an abstract painting. The number of paintings that could be produced potentially by rotating, flipping or repositioning the twelve panels are in the order of quintillions. One could imagine these paintings as points in a vast artistic landscape that can be explored in the form of a random and unique each time slideshow or by using evolutionary algorithms that start from arbitrary positions within this landscape and move towards those paintings in which the transition of colours between panels has been optimally harmonised. Musicians Alberti and Salmieri have added base music to match the ambience of this visual landscape and accompanying harmonic sounds to individual panels which when played together create variants of the same piece as the audio and visual design spaces of this evolving musical painting are being explored simultaneously.

There is a pervasive feeling of "everything changes and stays the same" in the experience of this art. Indeed, this work can be seen as an experiment on the edge between movement and stillness, stability and instability, permanence and change. This is a boundary that is both intriguing and fascinating and one that has been the subject of deeply significant philosophical and artistic work in the past, from the elegant theories of Zeno of Elea, Heraclitus of Ephesus and Hegel to the beauty of the artistic works by Myron of Eleutherae, Leonardo and Vermeer. Journeys through this musical painting can be experienced at `generativeart.net.dcs.hull.ac.uk`



***Contact:y.i.papadopoulos@hull.ac.uk***

***Keywords:*** musical painting, evolutionary audio-visual art, philosophy in art

# An Evolving Musical Painting on the Boundary Between Permanence and Change

**Yiannis Papadopoulos*, David Parker, Martin Walker, Emma-Jane Alexander**
*Department of Computer Science, University of Hull, United Kingdom*
*http://www2.hull.ac.uk/science/computer_science.aspx*

*with artists*

**Roberto Bono** *(www.arteutile.net)* **Andrea Alberti (***www.erjn.it/alberti)* **Roberto Salmieri** *(www.milagroacustico.net)*

**contact author email: y.i.papadopoulos@hull.ac.uk*

## Abstract

This paper discusses an evolving musical painting that bridges manual and generative art. The painting is neither a still image, nor a fixed sequence of images and sounds; it is instead an audio-visual design space defined by artists and explored by computers — a vast landscape of musical panels through which a different visual and musical journey is taken each time the artwork is experienced. The painting is part of a portfolio of hybrid art in which panels and painted sculptures are virtualised, enhanced with music, and explored through technology. In this paper, we discuss the conception, birth, and possible future of this art project.

## Main

This art project was conceived during a dinner party in discussions between the authors very much in the same way that many literary, artistic and philosophical works were conceived in ancient Greek symposia (συμπόσιον — a drinking party in Greek).

Roberto Bono is an abstract painter who experiments with double-sided paintings and panels that can be joined together in different ways, creating a three dimensional space that crosses the boundary between painting and sculpture. On this occasion, he had painted 12 double-sided abstract panels which, when put together in a 4x3 lattice, form an abstract composition. Figure 1 shows an example of such a painting. Upon viewing this work, it occurred to Yiannis that the number of paintings that could potentially be produced by rotating, flipping or repositioning these twelve square panels is surprisingly large — in the order of quintillions, in fact.

It was calculated that a slide show that displays each painting for a minute would last longer than the age of Universe. At this point, awed by the magnitude of this realisation, our imaginations took over.

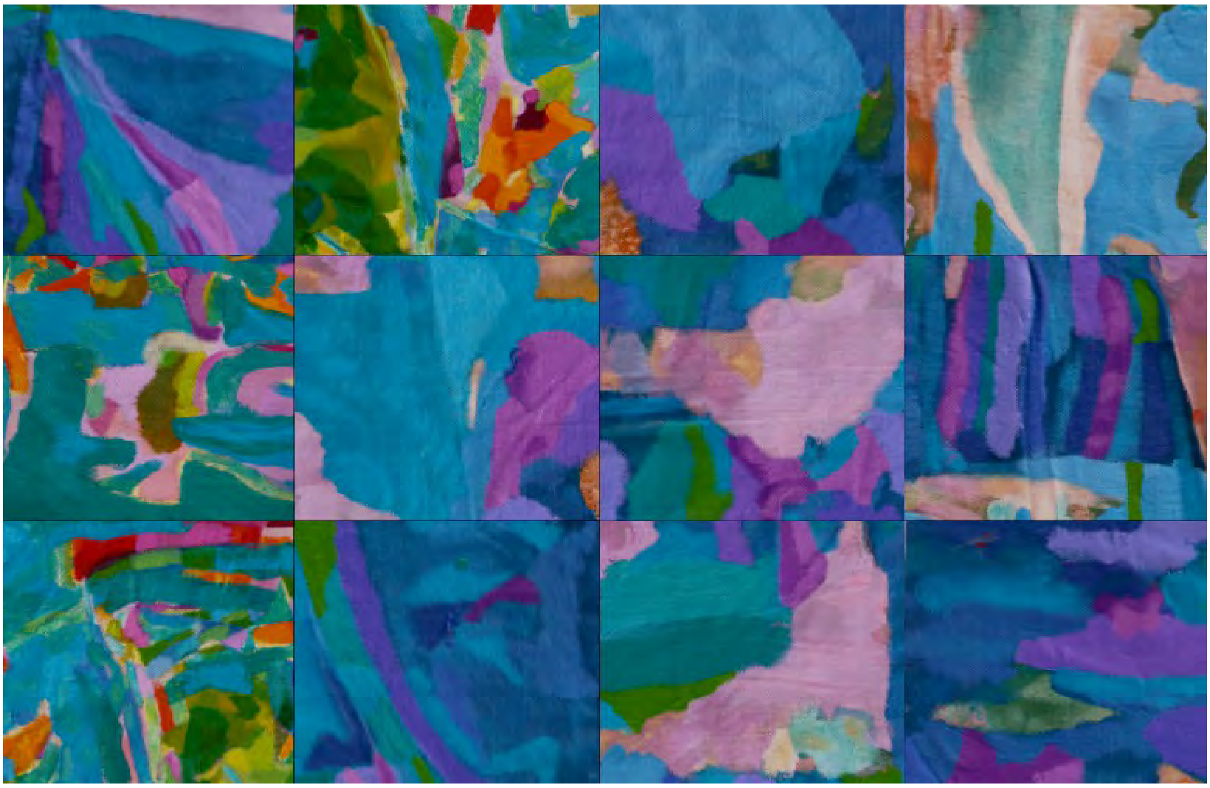


Figure 1: A 4x3 configuration of panels creating an abstract painting

Yiannis imagined these many potential paintings as points in a vast artistic landscape, like wild flowers in a Mediterranean field in the spring. Roberto's paintings are bright and colourful, so the metaphor of the flower meadow was effortlessly evoked and worked well as a concept to inspire this art project. Like flowers in this meadow, the paintings that could be put together from Roberto's panels are similar looking, but also individual in pattern, shape, and composition, each one worthwhile admiring in its own right but also aesthetically pleasing to see collectively as a group. Figure 2 illustrates the concept of a landscape of paintings potentially created by the many different combinations of panels.

It is interesting to observe that this vast artistic landscape is one of unrealised possibility; it contains many paintings that have the *potential* to exist, but only if their exact configuration should be discovered. Aristotle was the first to use an artistic analogy for illustrating the relationship between potential and actual [1]. He famously observed that a beautiful marble statue already exists in "potentiality" within a block of stone, but awaits for the sculptor to bring it out in "actuality". Similarly, the artistic vistas defined by Roberto's panels exist in potentiality, but need a transformative tool to bring them out into the actual world so that the aesthetics of these paintings can be appreciated. And what better tool for such a transformation than a computer?

Thus inspired, we digitised these images and created a system that renders the panels in 4x3 configurations, each of which creates a unique painting.

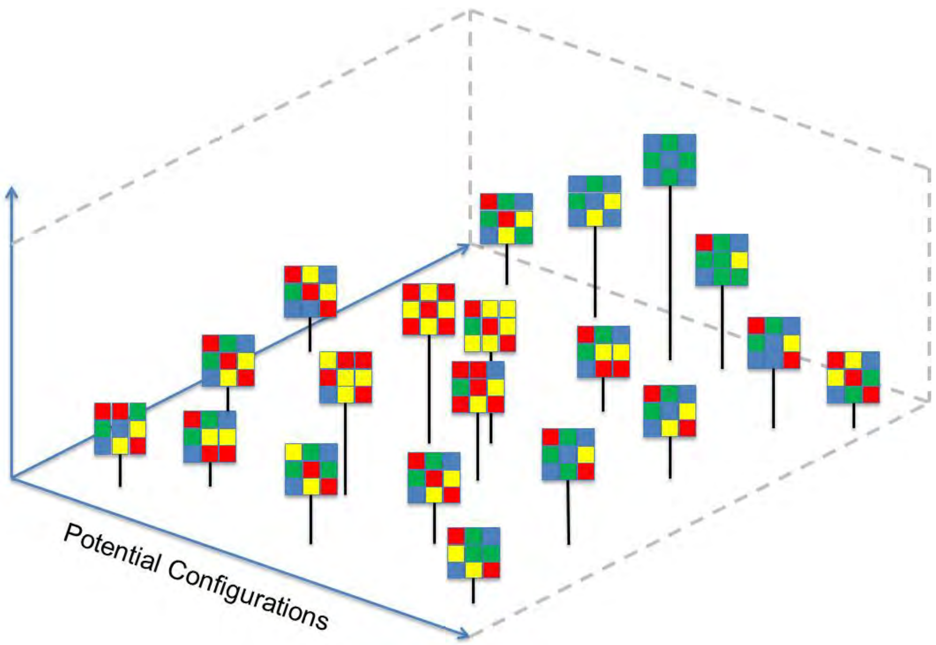



Figure 2: Design space — potential configurations of panels in paintings

In this system, such configurations can be formed manually by a person moving around panels, flipping them, or rotating them, or it can be done automatically by the computer itself and displayed on screen. The latter method allows viewers of the art to experience a computer generated slideshow of paintings that are taken, one by one, out of the potential landscape and brought into actuality. Because of the vast number of possible paintings that can be generated, the chances of seeing the same painting twice are far, far lower than the odds of ever winning any lottery. Thus every new painting is likely to be unique, never viewed before and probably never to be viewed again — a fleeting glimpse into an immeasurable and unexplored artistic realm.

Using the flower meadow metaphor, we could say that a slide show of such paintings unfolding in time is the equivalent of a trip through a real meadow wherein a bee flies from one flower to another. In the case of this art project, this trip is in reality a voyage through a *design space* — the set of all possible designs that can be created from a number of individual elements — and it is randomised so that a viewer always takes a different and unique path through this artistic design landscape.

Then sometime later, on a balmy summer evening spent reminiscing about childhoods in the Greek islands and the ancient landscapes of Sicily — and encouraged by a few glasses of Assyrtiko of Santorini and Greco di Tufo, it occurred to us that a landscape is never quiet. Instead, it is alive with subtle, ambient, but always-changing sounds: the songs of birds and the chattering of cicadas, the whispering of trees, the gentle splash of the sea, sometimes the sound of tolling winds meandering through narrow streets — everywhere one can hear the ever-present voice of nature. So we gave the silent artistic landscapes of this project a voice of their own.

Musicians Roberto Salmieri and Andrea Alberti wrote two compositions for two different sets of Roberto's panels. They added background music to match the ambience of the visual landscape and provided each individual panel with accompanying harmonic sounds. When played together, and in rhythmic sequence, this creates an enormous number of variants of the same piece of music. In this way, the audio and visual design spaces of these ever-changing musical paintings are being explored simultaneously, with a different sequence of images and a unique musical piece created during each journey.

Further inspiration for this project came from our interest in evolutionary biology and the way its principles can be applied to evolve not only biological life, but also technological systems. In theory, the brain — i.e., the instrument of human reasoning — is itself the result of an interesting evolutionary voyage through the potentialities that are inherent within the near-limitless design space defined by matter. Humanity, for example, can be seen as the result of a particular path through this space where chemical reactions at low levels and then mutations and recombination of genetic material has gradually given rise to a species with reasoning ability. Imagine taking all the atoms composing the DNA of a human being and throwing them in the air: out of the innumerable possible patterns they may form, there is one that gives rise to intelligent life in the form we know it. Evolution can thus be seen as nothing more than a search — random, but still guided by natural selection — within the design space of organic matter, with the potential to lead to results such as intelligent life.

This evolutionary thinking can also be applied to artistic design spaces. It occurred to us that one option for the exploration of Roberto's painting would be to use evolutionary algorithms that could start from arbitrary starting points within the landscape of paintings and, over the course of many generations, evolve towards the most aesthetically-pleasing regions of the landscape. We chose to define this aesthetic ideal as those paintings in which the transition of colours between panels is optimally harmonised to be as smooth and gentle as possible. In other words, those paintings most likely to evolve further are those in which the colours and patterns at the borders of adjoining panels are most similar. In our computer implementation, we achieve this by measuring the difference between the colours of the pixels along the boundaries of the panels and then trying to minimise that difference.

One can visualise this concept by thinking of the artistic landscape not as being flat, but rather as one that has hills and valleys; the higher the hill, the greater the level of harmonisation between panels in a painting, and the deeper the valley, the greater the level of contrast between the panels. In this type of landscape, paintings lie in valleys and on hills, and the higher one goes, the closer one is to the harmonious ideal. On each hill, we describe the painting that occupies the peak as a *local optimum*: it is the most harmonious painting in its neighbourhood. Perhaps this is a configuration where the painting has been harmonised with regards to a particular colour. Globally, there is also one hill — or mountain — that is taller than all the others, and at its peak is a painting that is *globally optimal*: it has the greatest harmonisation value in the entire landscape. The concept is illustrated in Figure 3.

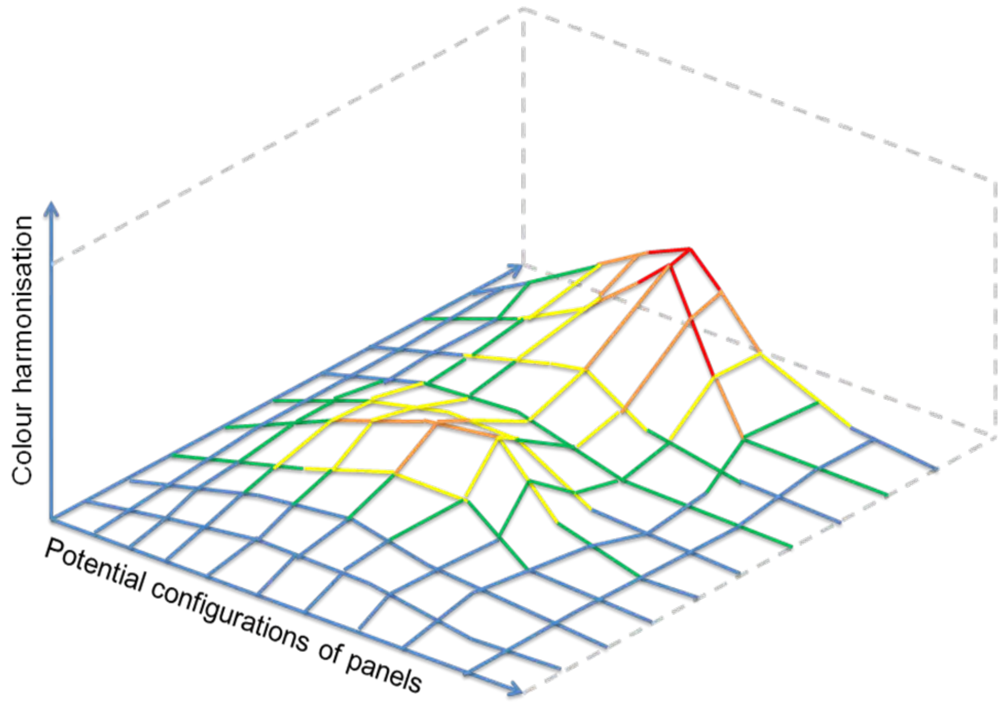



Figure 3: Landscape of paintings with different degrees of colour harmonisation between panels

The evolutionary algorithm we have developed to journey towards the peaks of such landscapes (based on [2]) first creates a random population of paintings by selecting panels and placing them in random positions in the 4x3 lattice. It then evaluates the harmony between panels of each individual painting in this population by calculating the colour difference between the pixels near all edges; we represent this as a Cartesian distance in a three-dimensional colour space. It selects the most harmonised paintings (thus emulating natural selection) and "breeds" those paintings by applying a *crossover operation* to each pair; this produces a new "child" painting that has attributes of both parents — in other words, some panels will be in the same position as one parent, and the rest will be in the same position as the other parent. In addition, to add a further random element, we also create a few *mutations*, which are paintings with one or more randomly altered panels.

The result is a new, improved population of paintings — and thus we move to explore a new, higher region in the landscape. The process is then repeated and the most harmonious painting of each population is displayed in the slideshow. Generation after generation, improved paintings that lie closer to the peaks of the artistic landscape are conjured out of potentiality into the actual world and displayed, while, in parallel, the musical script that corresponds to this journey is being dynamically composed and played.

Manual, randomised, and evolutionary journeys through two evolving musical paintings can be experienced online at **generativeart.net.dcs.hull.ac.uk**. Visual instances of the two paintings are shown in Figures 4 and 5 respectively.

Figure 4: Still instance of an evolving musical painting — Visual artwork by Roberto Bono, Music by Andrea Alberti

There is a pervasive feeling of “everything changes and everything stays the same” in the experience of this art. Indeed, this work can be seen as an experiment on the edge between movement and stillness, stability and instability, permanence and change. This is a boundary that is both intriguing and fascinating, and one that has been the subject of deeply significant philosophical and artistic work in the past. This work includes the thought experiments of Zeno of Elea arguing the implausibility of motion; the philosophy of Heraclitus of Ephesus and Georg Wilhelm Friedrich Hegel, who saw perpetual motion as the essence of nature and history; and the artistic works by Myron of Eleutherae, Leonardo Da Vinci, and Vermeer, who so beautifully and enigmatically captured physical and emotional motion within the absolute stillness of marble or canvas.

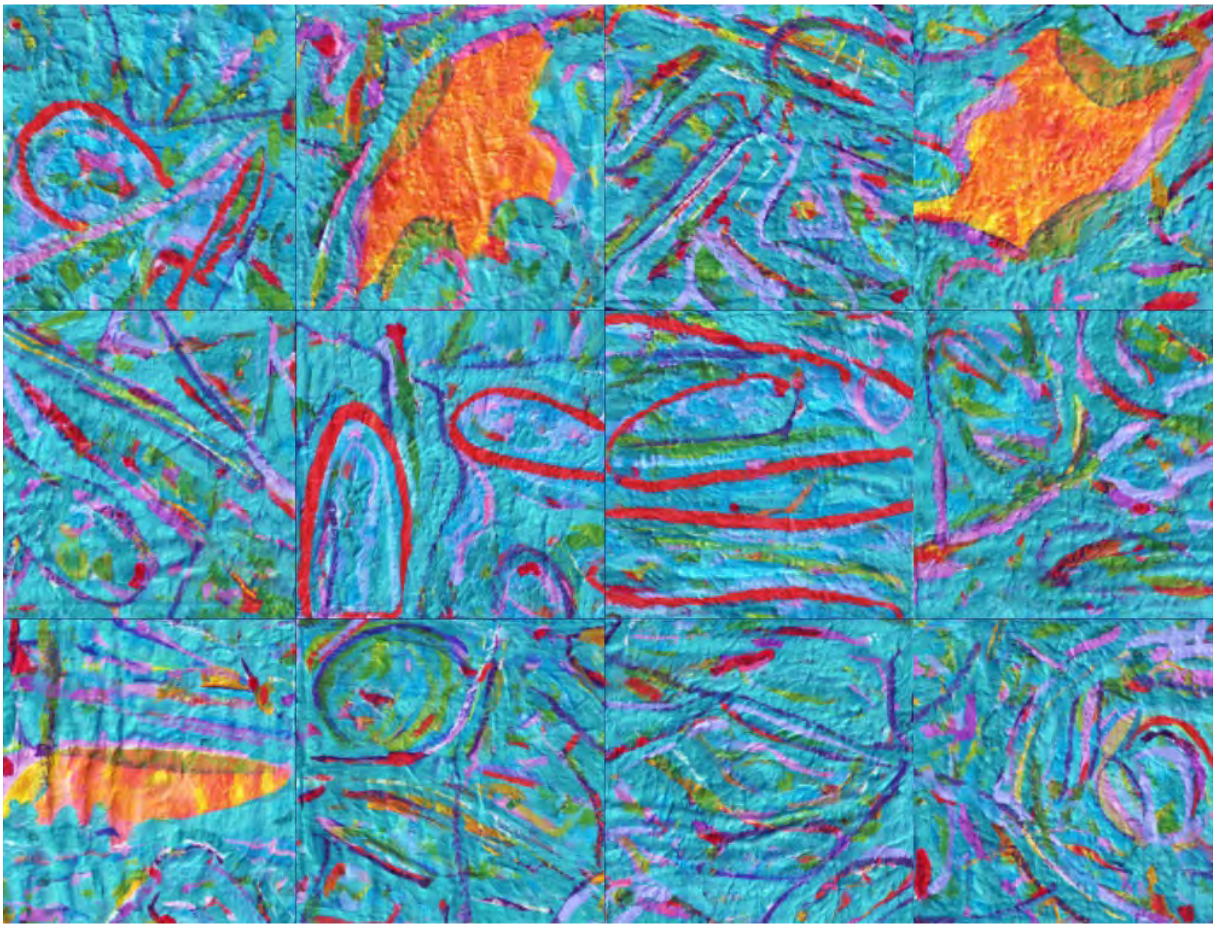


Figure 5: Still instance of an evolving musical painting — Visual artwork by Roberto Bono, Music by Roberto Salmieri

We like to think that there is both artistic merit and potentially useful practical applications in this art project. For example, informal feedback by clinicians who have experienced this artwork — and also from patients who have seen this in public presentations — suggests that it can have a therapeutic effect, e.g. on people with long term conditions like autism, tinnitus, or dementia. We are currently planning research together with clinicians to test this hypothesis. We have also planned a series of musical painting sculptures to take the work into three dimensions, including a musical art sphere and a painted Möbius strip; these can be virtualised and enhanced through technology to create interesting art works which, beyond their artistic merit, can also provide case studies for art therapy. Much of this work could also evolve into a form of educational or artistic game in the future.

## References

1. Aristotle, Physics Book III (Γ; 200b-208a), in "Aristotle Physics" translation by Robin Waterfield, Oxford University Press, ISBN 978-0-19-954028-0

2. Tate, D.M. and Smith A. E., 1994. A genetic approach to the quadratic assignment problem. Computers and Operations Research. 22, pp.73-83.

*Zeynep Bacınoğlu and Ömer Halil Çavuşoğlu*

(Paper): **EXPLORING THE POTENTIALS OF NATURE INSPIRED APPROACHES IN ARCHITECTURAL DESIGN THROUGH COMPUTATIONAL MODELS OF SEED GROWTH**

***Topic: Architecture***

***Authors:***
***Zeynep Bacınoğlu****
***Ömer Çavuşoğlu****
***Sema Alaçam****
* ITU, Graduate School of University of Science Engineering and Technology, Department of Informatics, Architectural Design Computing Grad. Prog.
www.mimarliktabilisim.itu.edu.tr

***References:***
[1] http://news.bbc.co.uk/2/hi/8473316.stm
[2] Scheurer, F., Getting Complexity Organised: Using Self-Organisation in Architectural Construction, Automation in Construction 16(1), pp. 78-85, 2007.

***Abstract:***
The use of nature as a source of inspiration is a well established concept in architecture. The past few decades have seen computational approaches that have brought out new ways of thinking during the architectural design process. The observation of living organisms and natural systems have inspired novel computational models such as cellular automata, L-systems and genetic algorithms and refined simulations of growth patterns in nature and swarm behavior. Even more recently, designers have developed unique approaches in their exploratory process that have gone beyond replicating natural systems through predefined approaches, instead analysing these systems as processes and as ecosystems that consist of complex interactions. Two notable instances of the latter approach have been the way that the growth of slime mold, viewed as a process has provided information to Tokyo Rail designers[1] and the way the growth process of trees has been used as an ecosystem metaphor in the design of the Groningen Stadsbalkon[2]. In this paper, we discuss the potential of nature inspired design processes in idea generation and form finding in the architectural design process, through a series of experiments based on the computability of seed growth.
The experimental setup consists of square glass mats of width 8cm, at top which cress and arugula seeds are placed. The growth of these seeds is photographed and videotaped from above . This data is then converted into a matrix based definition system and used in the Processing. The experiment is repeated with different amounts of seeds. We use the overlaid matrix system to abstract out the co-ordination of the germinated seeds, the direction of the growth process and the denseness of growth. We then analyze the correlation between the number of seeds used and these parameters.

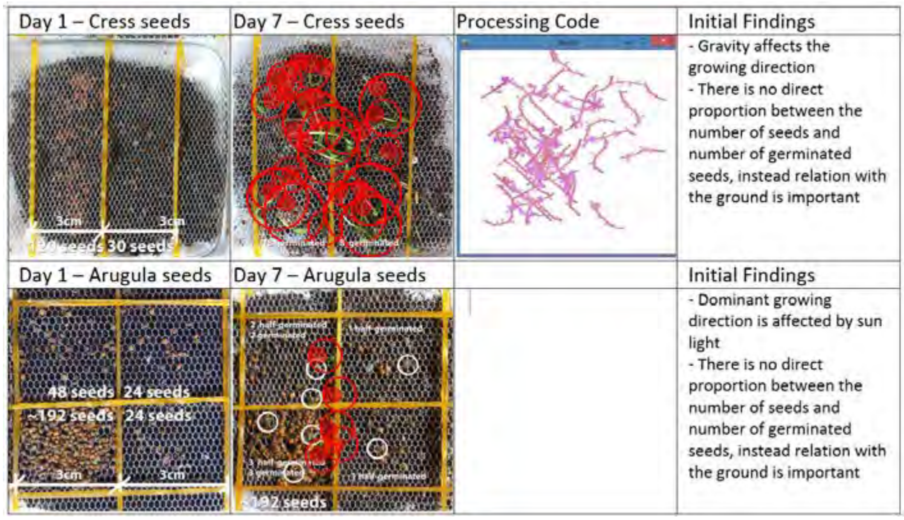


*Figure: Growing process of different seeds*

***Contact:***
***zeynepbacinoglu@gmail.com***

***Keywords:*** Nature inspired design, computability, growth process, form finding, biomimetics

# Exploring the Potential of Nature Inspired Processes in Architecture through Computational Models of Seed Growth

**Res. Assist. Saadet Zeynep Bacınoğlu[1], Res. Assist. Ömer Halil Çavuşoğlu[2], Res. Assist. Sema Alaçam[3]**

[1,2,3] *Graduate School of Science, Engineering and Technology, Department of Informatics, Architectural Design Computing Graduate Program, Istanbul Technical University, Istanbul, Turkey*
*www.mimarliktabilisim.itu.edu.tr*
[1]*zeynepbacinoglu@gmail.com*, [2]*posta@omercavusoglu.com*, [3]*alacams@itu.edu.tr*

## Abstract

The use of nature as a source of inspiration is a well-established concept in architecture. The past few decades have seen computational approaches that have brought out new ways of approaching the architectural design process. Designers have developed unique approaches in their exploratory process that have gone beyond replicating natural systems through predefined approaches, instead analysing these systems as processes and as ecosystems that consist of complex interactions. In this paper, we discuss the potential of nature inspired design processes in idea generation and form finding during the architectural design process, through a series of experiments based on the modelling and computability of seed growth.

## 1. Introduction

*"For artists communication with nature remains the most essential condition. The artist is human; himself nature, part of nature within natural space" (Paul Klee, 1953:7, first edition in 1925).*

We aim to discuss that how Nature becomes a source of intuition and it provides a layout for generating design ideas. Our approach to considering Nature as a layout for design is related to Deleuze's notion of the "plane of becoming" which considers all of life as a process of becoming, instead of a singular imitation or analogy [2] .The term 'Nature' refers to the organic and inorganic entities and beings in a broader sense. In this paper, however, when we mention "Nature inspired" design approaches, we limit ourselves to living organisms.

The observation of living organisms and Natural systems has inspired numerous approaches such as Voronoi Diagrams [3], Cellular Automata [4], Evolutionary Computing [5], Fractals [6], Evolutionary Programming [7], L-systems [8], Genetic Algorithms [9], Swarm Behaviour [10], among others. There has however been a lag of a few decades in the adoption of these Nature inspired computational approaches in architectural discourse [11- 16]. The successful adoption of such approaches in architectural design is a subtle and challenging problem. Improperly done, they carry the risk of becoming a collection of concrete methods that are isolated and context free. Simpleminded adoptions could lead to boilerplate techniques that are merely used for the purposes of routine design. However, Nature inspired computational approaches have the potential to bring novelty to the discourse of architectural design, if we regard these as a way of thinking and reasoning; in Deleuze and Guattari's words, as a generative way of being and becoming [2]. In other words, Nature can be regarded as a 'counterpoint', constituting the relationships between different planes, forming compounds of sensations and blocs, which together determine 'becoming'. As Ballantyne proposes, *"...it is not just these determinate melodic compounds, however, that constitute nature; an infinite symphonic plane of composition"* [17].

We argue that direct observation of Nature, together with Roudavski's notion of 'reverse engineering' [18], is crucial for architects to gain an intuitive experience for Nature inspired computational approaches. Direct observation of Nature is important in terms of the dialogue between the designer and the above referenced computational processes. Dialogue between designer and Nature promotes diverse actions such as abstraction, conceptualization, exploration and calculation. This encounter makes possible design thinking in terms of a reflection-action' [19] or a 'seeing -calculation' cycle [20]. It has been argued that direct experiments on the complex mechanism of plant morphogenesis are difficult and time consuming, which is why developmental biologists have come to increasingly rely on mathematical and computational models [18]. We believe however, that this time consuming activity of direct experimentation on plant morphogenesis is highly important for architects; as Snodgrass and Coyne remark "Creativity is not matter. It is open-ended, wasteful and often misses the mark" [21].

In this paper, we aim to investigate the potential of nature inspired design processes in idea generation and form finding during the architectural design process. In Section 2, we discuss a few distinctive architectural examples and design approaches which deal with nature either as a process or as an ecosystem consisting of complex interactions. In Section 3, we present our own explorations based on a series of experiments on the dynamics of seed growth.

## 2. From Form Towards Formation: Computability of the Flux

*"By extension, the meaning of a concept depends on a context (or the horizon) within which it occurs; but this context is made up of the concepts to the concepts to which it gives meaning" [21].*

Abstraction is the way of differentiating within an existing context and constituting new ones. While looking at Nature, the action of abstracting might occur at different levels; one may abstract analogically, metaphorically, conceptually, geometrically or formally. Each assumption translates existing meanings into a new context and therefore creates new meanings in new contexts. The richness of the domain of initial assumptions and incidental actions influence the fruitfulness of idea generation in architectural design process. First published in 1925 in a booklet for Bauhaus students, Klee’s drawing of the point process is shown in *Figure 1.a-e* [1].

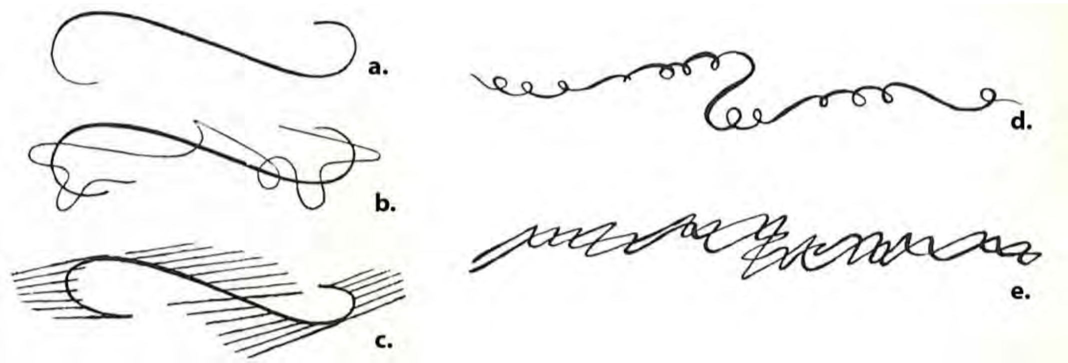



*Figure 1.a: An Active walk by a point agent; Figure 1.b – 1.c: “The same line accompanied by complementary forms”; Figure 1d: “Same line circumscribing itself”; Figure 1.e: Two lines moving around an imaginary main line” [1].*

Hanlon defines five composition rules in architecture, shown in Figure 2.a-2.e [22]. The same static image can be represented via different concepts such as a numeric representation consisting of 3 major and 2 minor lobs (Figure 2.a), as an angular division (Figure 2b). In Figure 2.c we see proportional comparison; Figure 2.d involves a triple hierarchy and the fifth one incorporates orthogonal orientation [22]. **In addition to** Hanlon’s representations, we have added a further ten possible ways of abstraction (Figure 2.f- Figure 2.o).

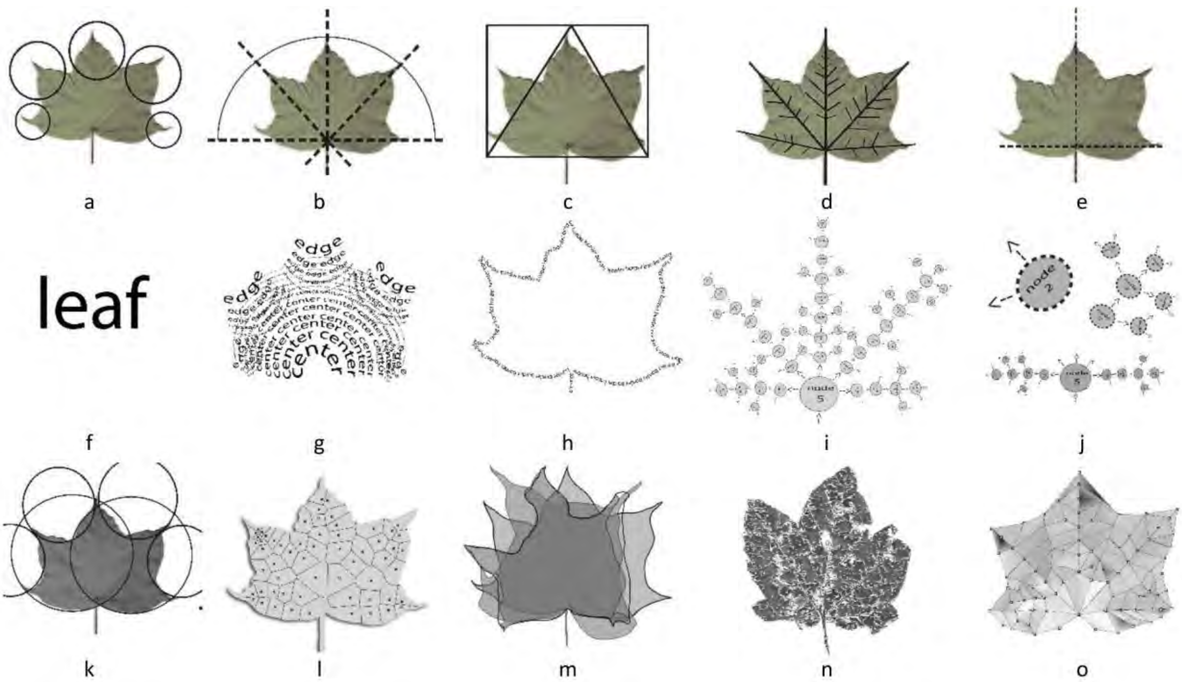



*Figure 2.a-2.e: Redrawn of Hanlon’s diagrams [22].Figure 2.f: Verbal expression, Figure 2.g: Conceptual representation, Figure 2h: Contour; Figure 2.i: Branching; Figure 2.j: Self-similarity; Figure 2.k: Geometric abstractions via reading negative; Figure 2.l: Voronoi diagrams; Figure 2.m: Process of drying; Figure 2.n: Deterioration; Figure 2.o: Triangulated mesh.*

Dealing with natural processes as a formation, Thompson [23] describes the dynamics of growth and physical processes, not only as initial geometric representations but also as a set of transformation rules *(Figure 3.a and 5.b).*

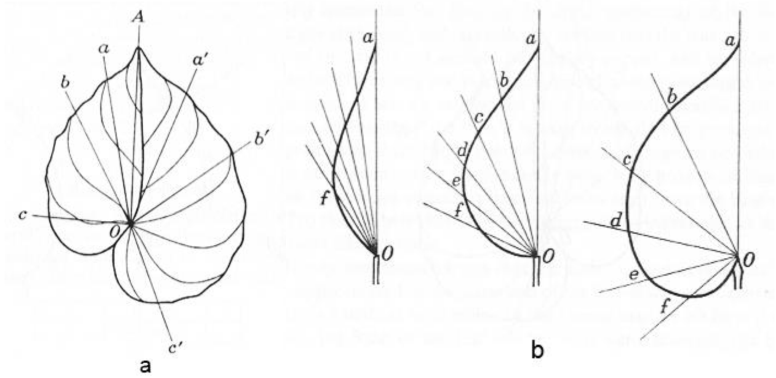



*Figure 3.a-b: Growth of a leaf of Begonia Daedalea [23].*

Thompson [23] conceives form not as a given, but as a product of dynamic forces that are shaped by flows of energy and stages of growth; he demonstrates new working methods for understanding the influence of physical forces on the environment *(Figure 4.a-c).*

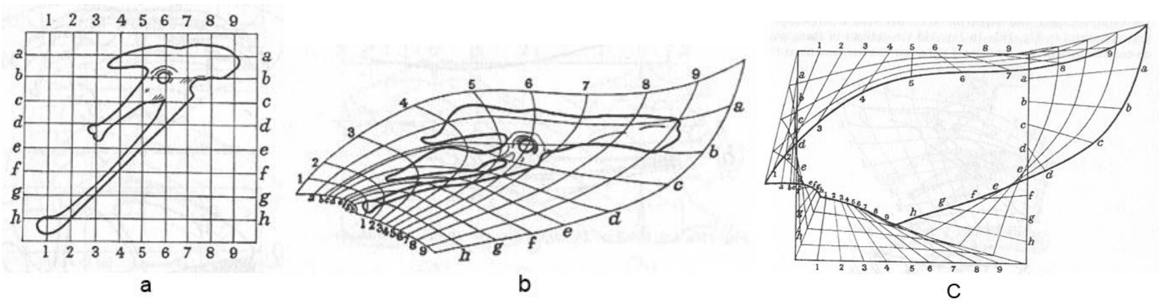
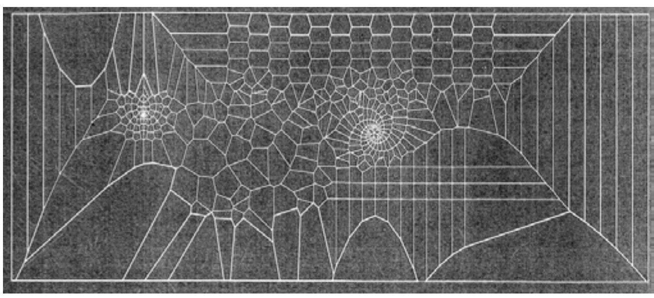



*Figure 4.a-c: Method of coordinate, digitation of morphological transformation [23].*



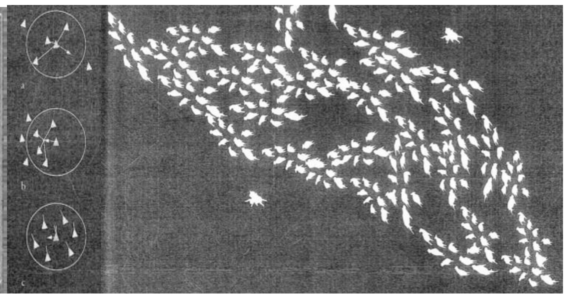


*Figure 5: "Tiling" [24]. Figure 6: "Recipe for tiling, cracking, flocking, blending, weaving, packing, spiralling" [24].*

Aranda and Lasch merge observations of biological processes with algorithmic design thinking by creating flexible and adaptable representations of formation which take into account responses to outer forces [24]. They claim that these representations of formation are both adequate to "liquefy the form organisations" and "create the potential for crystallization" [24]. For instance, they describe how natural phenomena such as the flocking rule can simulate crowd behaviour *(Figure 5)*.

In another celebrated example, the Groningen Stadsbalkon project, metaphoric abstraction is integrated with the earlier phases of design process to develop a digital analysis tool [13, 25]. The Stadsbalkon project utilized the metaphor of the “Column forest” in the form finding process; the columns are assumed as particles of a swarm system which is understood to be able to grow, shrink, split or die [13]. Each particle then tries to grow, constrained by the interaction with other columns(particles) located in its neighbourhood [13].

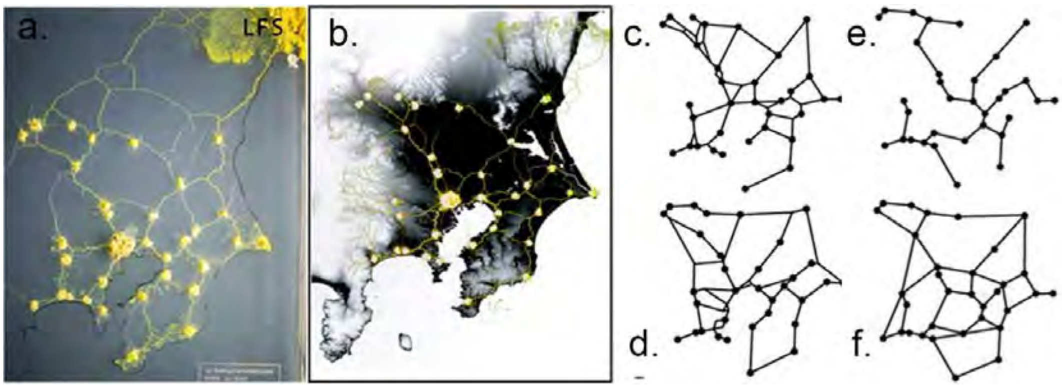


*Figure 7.a-f: Slime Mold dispersion and its computational model[26].*

A biologically inspired mathematical model was developed for the Tokyo Railway system based on the complex growth mechanism of slime mold. Slime mold grows and spreads as an interconnected network in its foraging strategy to discover new resources[26-28]. As shown in *Figure 7.a-f*, an experimental setup in which a plate covered with gel, representing the Kanto region, along with food sources representing cities to be connected to Tokyo was used[26]. The slime mold spreads in search of food and the pattern of growth was used as input in the design process. Beyond some differences in relation with the geographic features such as reduction of mountains and lakes, the ubiquitous character of a transport network was translated from the experimental model into the design model [26], from one domain to another.

Apart from taking nature into consideration as a process or as an ecosystem consisting of complex interactions, there has been some recent research [29-31] on alternative computational processes supporting the generation of form, based on the interaction between material and environment. Oxman approaches ‘form’ as a result of the matching between material parameters and their corresponding environmental constraints [29] (a derivative of natural behavioural formation) Kotnik and Weinststock use the potential of material properties for unfolding a generative logic of form finding in their projects [31]. They integrate the adaptation of the form and the distribution of material in response to the forces acting upon them. However, Menges states “even in design computation, materiality is still conceived as a passive property of form rather than as an active form generator. But unlike CAD, the underlying logic of computational design offers the possibility of synthesising virtual form generation and physical materialisation in architectural design” [30]. Menges actuates material information in exploratory computational design processes through the example of performative wood works shaped by the information of fiber density and direction[30].

## 3. Case Study: Computational Models of Seed Growth

### 3.1 Methodology

We started our experiment setup with six different seed alternatives and observed their growth for one week. Next, we updated our environmental setup with cress and arugula seeds and prepared a new set up by controlling the number of seeds in order to observe the effect of a change in density *(Figure 8).* We measured the growth numerically as well as through diagrams, sketches and time based photography. We decided to use a matrix based definition and then repeated the same experiment with the seeds lined up in a 2D matrix. We used the overlaid matrix system to abstract out the co-ordination of the germinated seeds, the direction of the growth process and the density of growth. We then analyzed the correlation between the number of seeds used and the utilized parameters and visualized and analyzed the data we collected.

### 3.2 Constraint of Experimental Study

The experimental setup consists of physical, time and media constraints, which we related to the captured data. As a physical contraint square glass mats of width 8cm were used, atop which cress and arugula seeds were placed. The growth of these seeds was photographed and videotaped from above every 4 minutes. The same experiment was repeated with different setups such as randomly distributed seeds sequentially 200-600-3000 in each mat *(Figure 8.a-c)*; matrix ordered in 6x6-8x8-12x12 and 3x3-6x6- 9x9 (Figure 9.a-c). We observed each growth process for 7 days.

*Figure 8.a-b-c: Image of cress and arugula seeds sequentially belonging 2nd day, 4th day and 7th day after germination.*

*Figure 9.a-b-c: 2nd, 4th and 7th day of cress (above) and arugula (below) seeds which are located in a matrix of 6x6; 8x8 and 12x12 seeds.*

### 3.3 Observations and Findings

We prepared an experiment setup with cress and arugula seeds and observed their germination process for 7 days. To achieve coherent information, we repeated the experiment under the same conditions, but with different seed types and density to measure how germination, growth and interaction of the seed were affected. In our experimental setup we encountered new and unexpected phenomena, notably a circular movement pattern as well as complex behaviour of seeds. In Coyne's words, we "played" with our findings in a computational environment and benefited from them as an initial context.

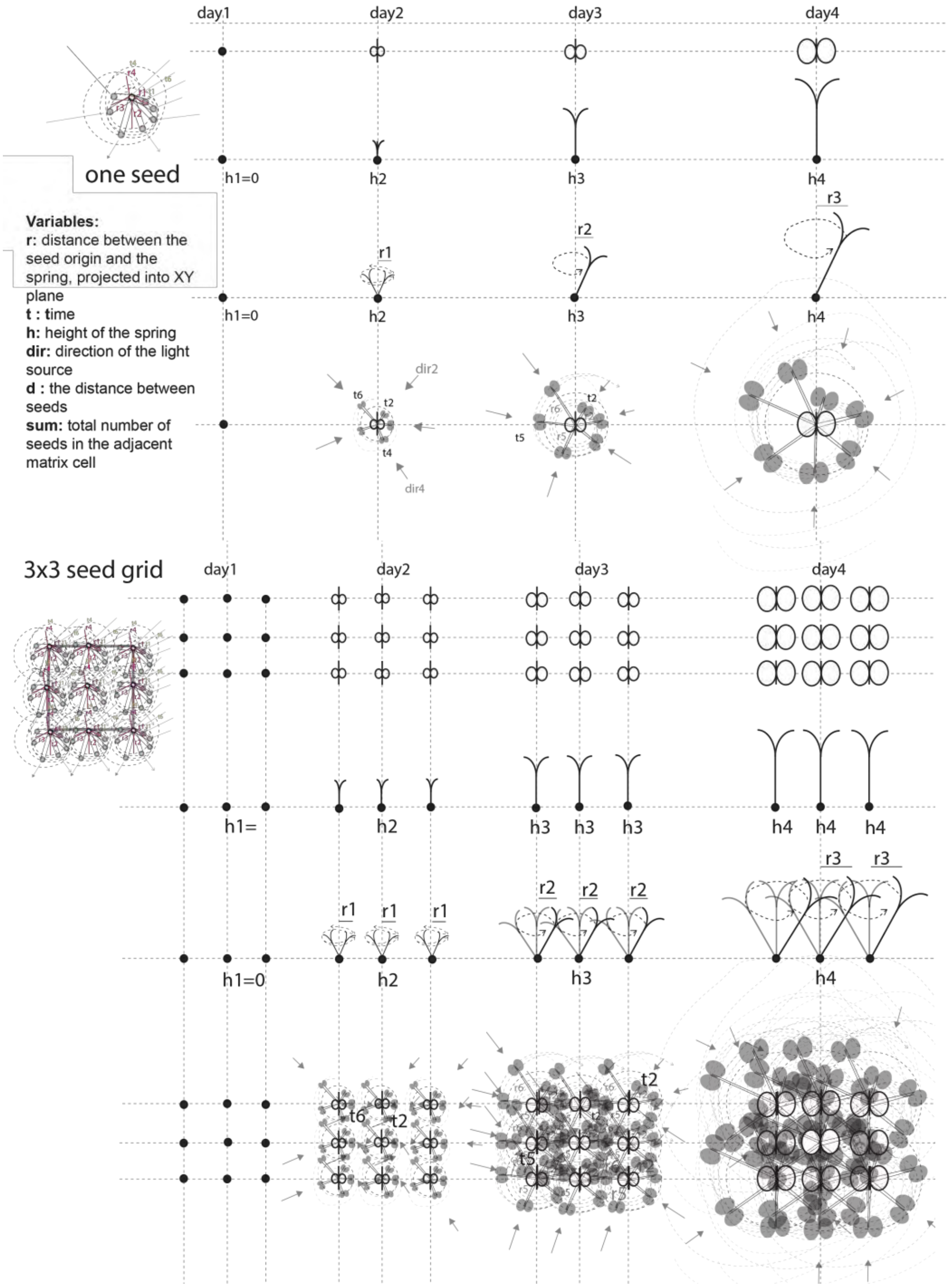



*Figure 10: Illustration of growing process of arugula seeds*

### 3.4 Computational Models

### 3.4.1 Grid Deformation

Each value in the two dimensional matrix represents information about one seed's growth condition (as explained in Section 3.2). First we applied existing values as an increment dependent on a coefficient variable. We assumed that whenever one seed starts to grow, it requires more area. We decided to represent this situation as a repulsion force that translates the neighbour meshes. This translation was calculated in both horizontal and vertical directions *(Figure 12).* The coordinate of the meshes was reorganised proportionally with the values defined in the 2D arrays (*Figure 11 and Figure 12)* .The translation rules, defined in Figure 12, are applied to the data file (.txt) which consists of seeds' germination situation.

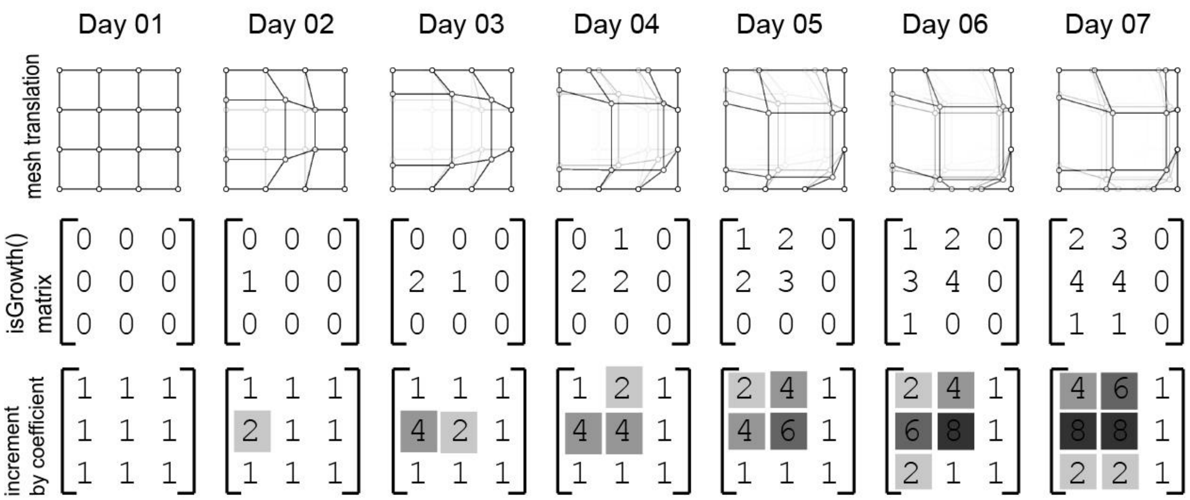



*Figure 11: Time Based Grid Deformation Through Mesh Translation*

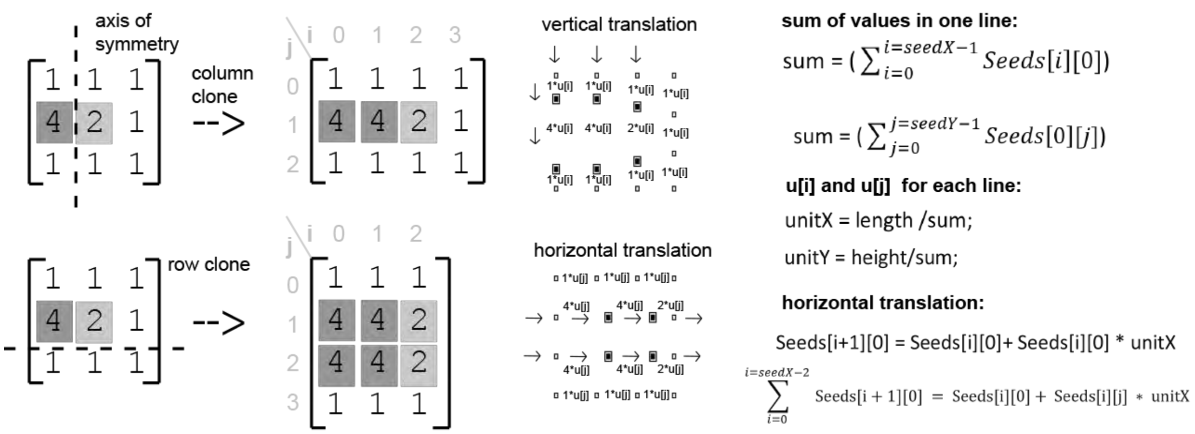



*Figure 12: Translation rules*

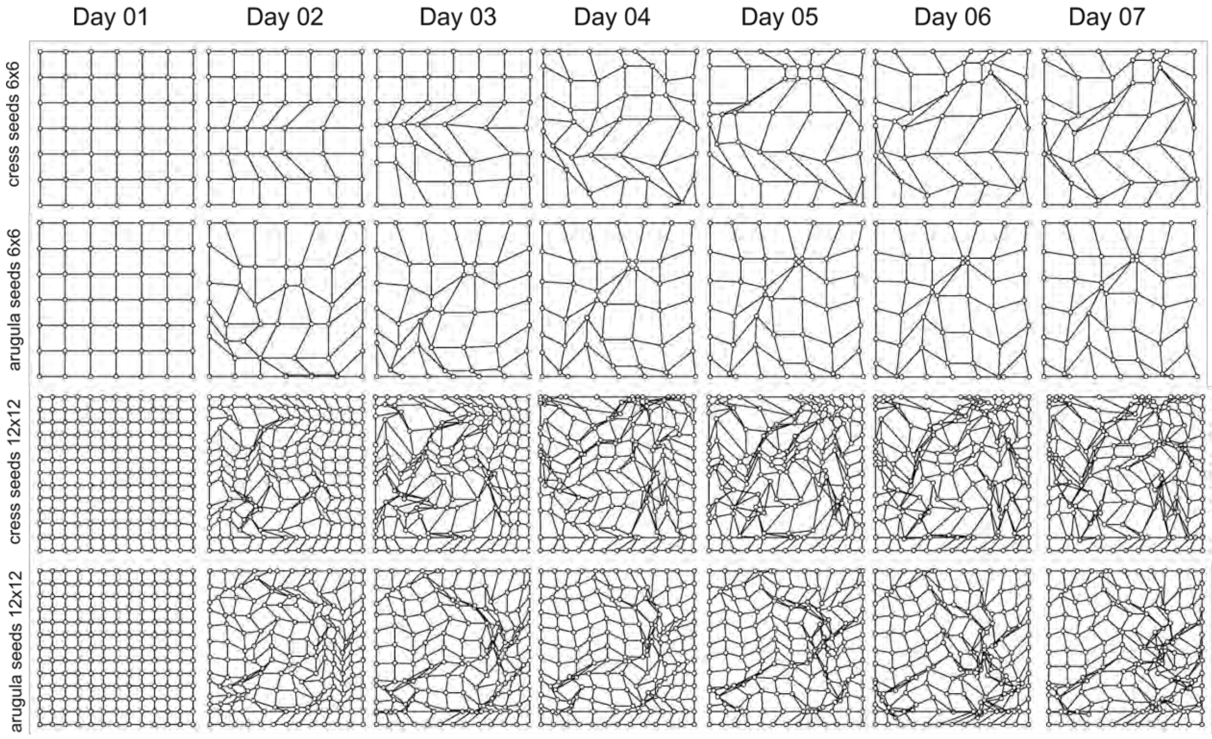


*Figure 13: Time Based Grid Deformation through Mesh Translation*

### 3.4.2 Object Based Modelling

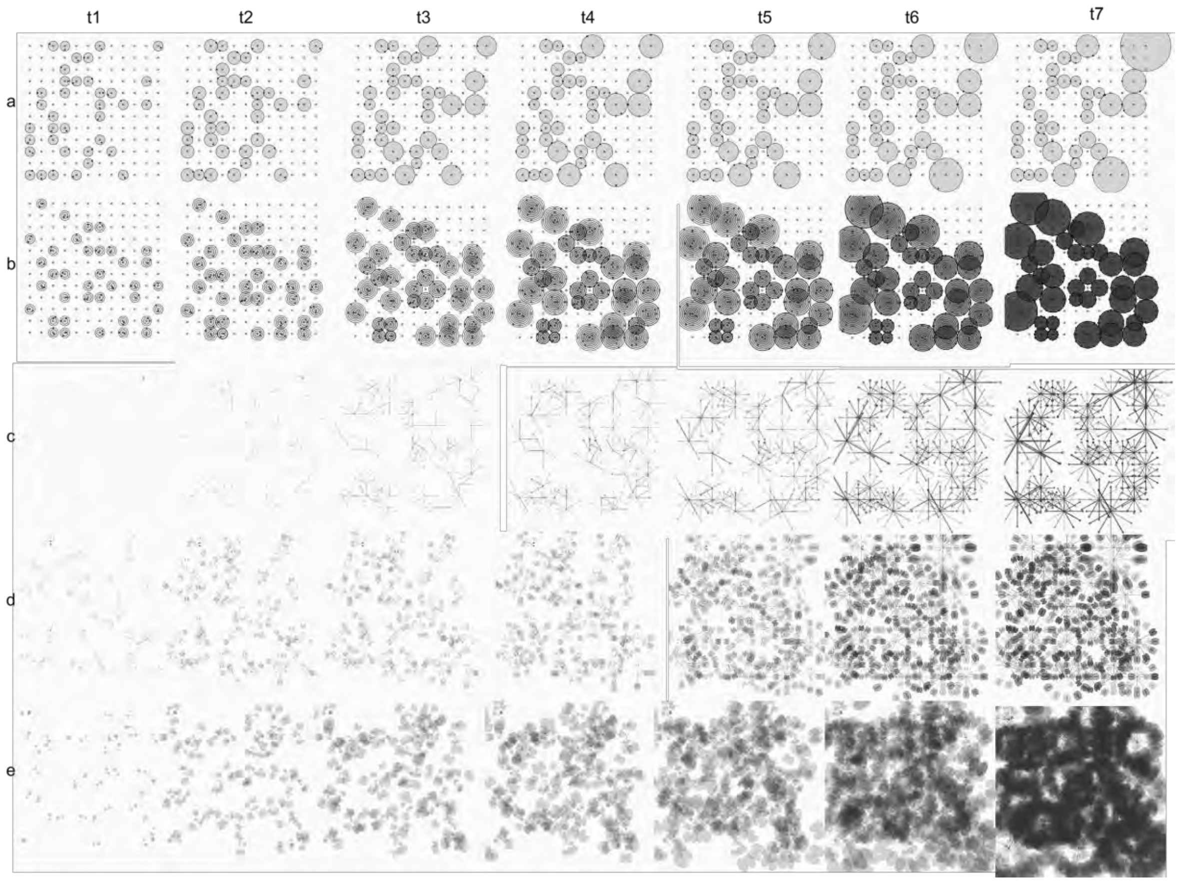


*Figure 14: Alternative representations for the simulation process of seed growth*

We defined each seed as an object with specific properties and functions in Processing environment. Each seed is considered to be able to “grow()”, sprout()” , “moveCircular()” and they are also expected to control the distance and intersection condition via “collisionControl()” function and “display()” the defined images . The same class definition is used in the alternatives shown in *Figure 14*. The initial coordinates of the seeds are assumed as fixed points and the springs make circular movement. The number of the seeds (s), whether overlaps are allowed or not and the density of germination are the variables that can be changed easily.

## 4. Discussion

In this paper, our goal is to indicate the potential of directly observing living organisms and using these observations as inspiration during the form finding and idea generation stages in nature inspired computational design approaches. Instead of merely using clearly defined existing Nature inspired methods, we argue that while observing Natural processes it is important to explore relations intuitively and constitute new ones through the observed context with a subjective vocabulary and subjective assumptions. Therefore, the cycle of observation, abstraction, constitution of assumptions and translation of the observed data into digital media provides a reflective, explorative and interpretative experience. In other words, Nature becomes a source of intuition and provides a layout for generating design ideas; such interaction with Nature may be considered, in effect, a way of thinking. With this in mind, we tried to explore the principles of seed growing process through a case study.

A seed exists both as an entity and as an element of an ecosystem which exhibits complex interactions. While growing, a sprout interacts not only with other sprouts, but also with the soil, the source of light and the density around itself. When we reconsider these ways of becoming through new analogies and metaphors, we encounter novelties that enhance our understanding of the original process. For example, when we model the requirement of area for growth by the seed as a repulsive force that affects the grid system, the representation of forces constitutes a topological folding which can be used further as a layout for spatial diagrams or evolution processes in an urban setting in terms of population increase.

## 5. Acknowledgement

We would like to thank Prof. Gülen Çağdaş, for encouraging us to explore both theory and practice of generative systems and evolutionary architecture. We would like also thank Mohan Ravichandran for his feedback.

## 6. References

1. Klee, P. (1960) Padagogica Sketchbook, Translated by: Sibyl Moholy-Nagy, : Praeger Publishers, New York. *(First published 1925 and edited by Walter Gropius and Laszlo Moholy-Nagy)* (page: 16-17).

2. Lampert, J. (2006) Deleuze and Guattari's Philosophy of History (1st edition), Bloomsbury Academic.

3. Voronoi, G. (1908) Nouvelles applications des paramètres continus à la théorie des formes quadratiques. *Journal für die Reine und Angewandte Mathematik* 133: 97–178. doi:10.1515/crll.1908.133.97

4. Neumann, J., (1951), *The general and logical theory of automata*, in L.A. Jeffress, ed., Cerebral Mechanisms in Behavior – The Hixon Symposium, John Wiley & Sons, New York, pp. 1–31.

5. Barricelli, N.A. (1954) "Esempi numerici di processi di evoluzione". Methodos: 45–68

6. Mandelbrot, B. (1967) How Long Is the Coast of Britain? Statistical Self-Similarity and Fractional Dimension. Science, New Series 156 3775 (May 5, 1967): 636-638

7. Fogel, L. J., Owens, A. J., and Walsh, M. J. (1966) Artificial Intelligence Through Simulated Evolution. Wiley.

8. Lindenmayer, A. (1968) Mathematical models for cellular interaction in development. In: J. Theoret. *Biolog*y. 18. 1968, p.280-315

9. Holland, J.H.(1975) Adaption in Natural and Artificial Systems, University of Michigan Press, Ann Arbor, MI.

10. Reynolds, C.W. (1987) Flocks, herds and schools: A distributed behavioral model. *Computer Graphics* 21 (4): 25–34.doi:10.1145/37401.37406. ISBN 0-89791-227-6.

11. Frazer, J. (1995) *An Evolutionary Architecture*. London: Architectural Association.

12. Lynn, G. (2000) Greg Lynn: Embryological Houses, *AD: Contemporary Processes in Architecture*, 70:3, 26-35.

13. Scheurer, F. (2003) The Groningen Twister: An experiment in applied generative design, Paper presented at the Generative Arts 2003 Conference, Italy.

14. Hensel, M., Menges, A. and Weinstock, M. (2004) *Emergence: Morphogenetic Design Strategies*, Wiley, London, 2004.

15. Hensel, M. (2006) Computing Self-Organisation: Environmentally Sensitive Growth Modelling,*Techniques and Technologies in Morphogenetic Design*. *AD Architectural Design* Vol. 76, 2.

16. Hensel, M., Menges, A. and Weinstock, M. (2010) Emergent Technologies and Design Towards a biological Paradigm for Architecture. London: Routledge

17. Ballantyne, A. (2007) *Deleuze and Guattari for Architects*, Routledge, New York. (page: 48 )

18. Roudavski, S. (2009) Towards Morphogenesis in Architecture. *International Journal of Architectural Computing*, 7(3), (pp . 345-374).

19. Schon, D (1983) *The Reflective Practitioner*, Basic Books, New York.

20. Stiny, G. (2006) *Shape, Talking about Seeing and Doing*. MIT Press.

21. Snodgrass, A., Coyne, R. (2006) *Interpretation in Architecture: Design As A Way of Thinking*, London: Routledge. (page: 25)

22. Hanlon, D. (2009) *Compositions in Architecture*. New Jersey, John Wiley & Sons, Inc. (page:5)

23. Thompson, D W., (1992) On Growth and Form. Dover reprint of 1942 2nd ed. (1st ed., 1917). ISBN 0-486-67135-6 (page: 279-280).

24. Aranda B., Lasch C. (2005) Pamphlet Architecture 27: Toolin, Princeton Architectural Press. (pages: 77 and 65).

25. Scheurer, F. (2007) Getting Complexity Organised: Using Self-Organisation in Architectural Construction, *Automation in Construction* 16(1), 78-85.

26. Tero, A., Takagi, S., Saisuga, T., Ito, K., Bebber, D.P., Fricker, M.D., Yumiki, K., Kobayashi, R., Nakagaki, T. ( 2010) Rules for Biologically Inspired Adaptive Network Design, *Science* 22, Vol. 327, No. 5964, pp. 439-442.

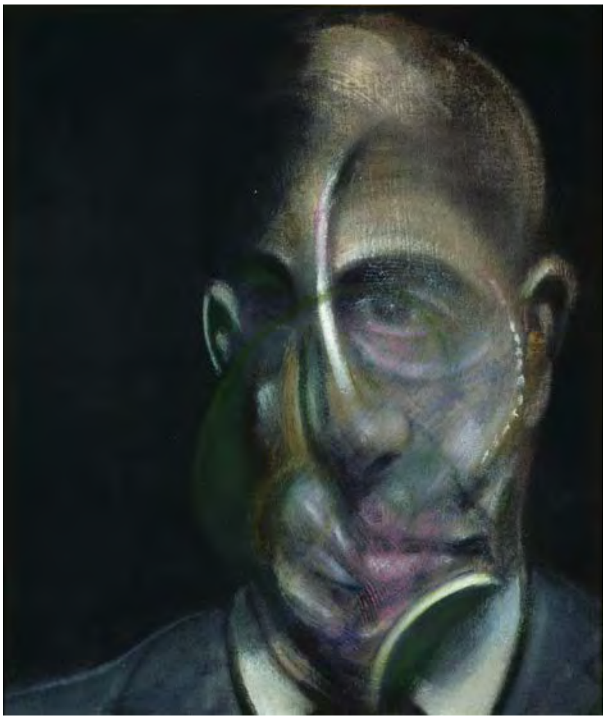
27. Bebber, D., Hynes, J., Darrah, P., Boddy, L., Fricker, M. (2007) Biological Solutions to Transport Network Design, Proc. Roy. Soc., Lond. B 274 2307- 2315. doi: 10.1098/rspb.2007. 0459.

28. Nakagaki, T., Kobayashi, R., Nishiura, Y., Ueda, T. (2004), Obtaining Multiple Separate Food Sources: Behavioural Intelligence in the Physarum Plasmodium, Proc. Roy. Soc. London, B271, 2305-2310

29. Oxman, N. (2010). Material Based Design Computation, Doctoral Thesis, MIT, Cambridge, MA.

30. Menges, A. (2012) Material Resourcefulness, AD: Material Computation, *Architectural Design* Vol. 216, 34.

31. Kotnik, T., Weinstock, M. (2012) Material, Form and Force, AD: Material Computation, Architectural *Design* Vol. 216, 104.

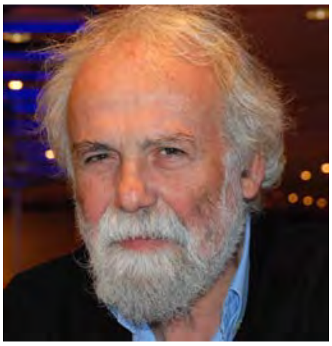


Francis Bacon, self portrait 1971 and portrait of Michel Leiris 1976

# *POSTERS, ARTWORKS, INSTALLATIONS*

**Celestino Soddu**

# *Artworks:* D'APRES FRANCIS BACON



***Topic: Generative Art***

***Celestino Soddu***
Generative Design Lab
Politecnico di Milano
generativedesign.com

***References:***

[1]C.Soddu, "Recognizability of designer imprinting in Generative Artwork", GA99 proceedings, 1999
C. Soddu, "Argenia, Art's Idea as Generative Code", in 2000 GECCO proceedings, Las Vegas, Nevada, 2000
[2]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
[3]C.Soddu, "New Naturality: a Generative approach to Art and Design", Leonardo Magazine 35, MIT press, July 2002
[4]C.Soddu, "Perspective, a Visionary Process: The Main Generative Road for Crossing Dimensions" in Nexus Network Journal: Volume 12, Issue 1, Springer Publisher, New York, 2010

In 1996 I done my generative artwork "D'apres Picasso", by constructing a generative device able to produce endless variations of woman portraits. I made that artwork referring to my interpretation of Picasso portraits as Picasso made his portraits by referring to the African 3D statues and to Velasquez.

For this GA conference I tried to perform my interpretation of the portraits of Francis Bacon. Mainly to his self-portraits.

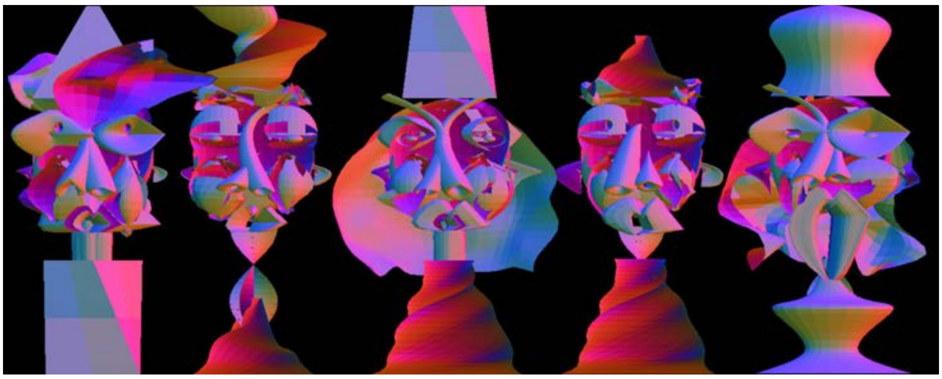
I chose Francis Bacon because he made his portraits by interpreting the Van Gogh portraits and, one more time, the portraits of Velasquez.

And for another important reason: Francis Bacon was, in the seventies of last century, the only artist that we can call a figurative artist able to propose an incredible and strongly recognizable artworks production. With an incontestable identity.

Being figurative and being strongly recognizable are, in my opinion, the two characters of a generative approach to visual Art that I most appreciate.

My generative artwork "D'apres Francis Bacon" works by evolving my interpretation of the 2D images of these portraits into 3D events. The movement from 2D into 3D is performed as reverse perspective. When the process works on a reverse perspective, it needs a subjective interpretation. But not only. It defines a possible contamination among different 3D events and their reciprocal intersection and interaction, trying to produce results that have the feeling inspired by these portraits.

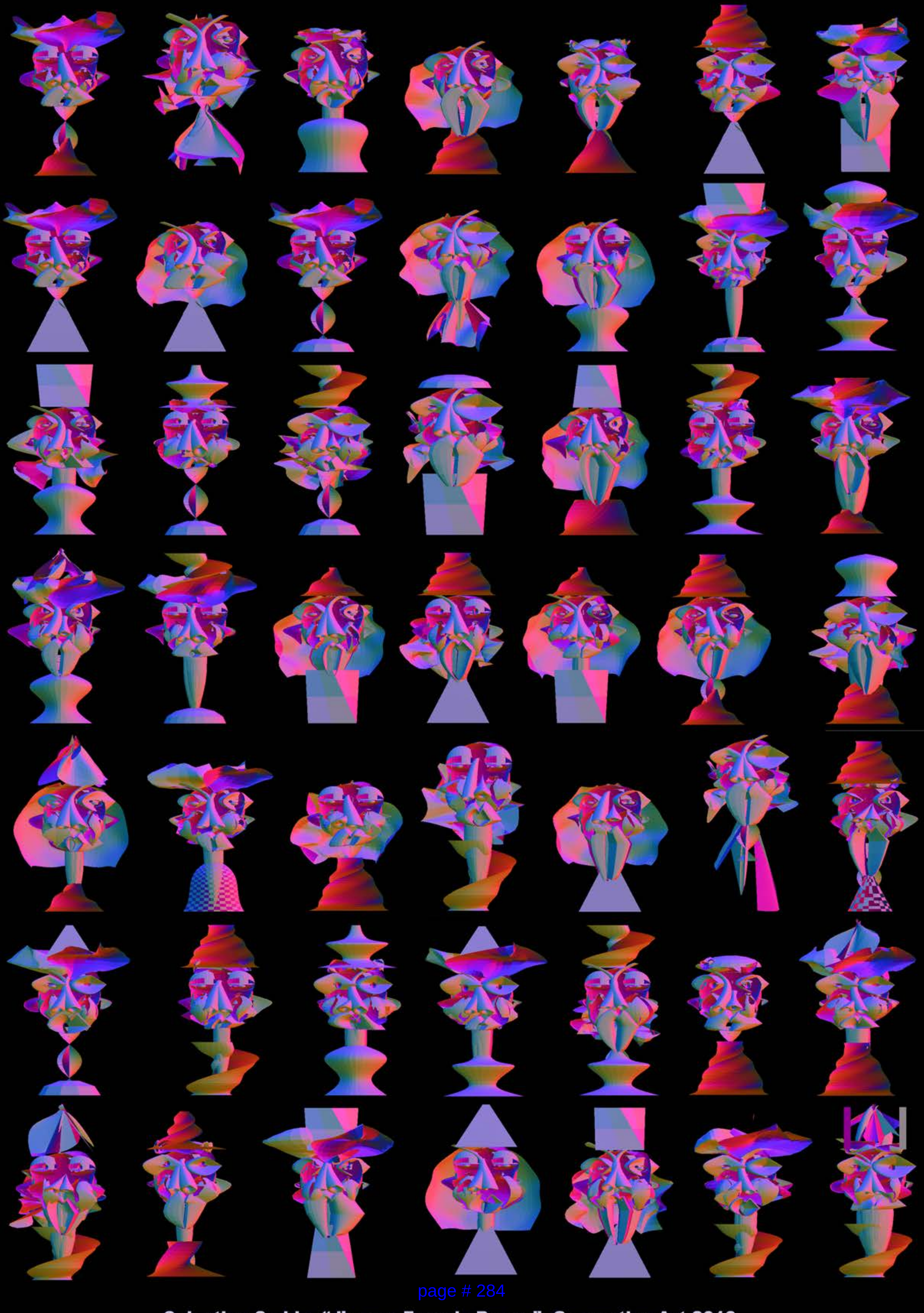
The aim was to arrive to a sequence of possible variations where each portraits is strongly identifiable as a possible interpretation of Francis Bacon portraits. But this is clear only in a first step. More, each generated portraits could be strongly identifiable as belonging to my artist vision.



*Five portraits of "D'apres Francis Bacon" by Celestino Soddu*

***Contact: email***
***Celestino@soddu.it***

***Keywords:***
Generative, Art, Identity, Figurative, Interpretation, Portraits





Celestino Soddu, “d’apres Francis Bacon”, Generative Art 2013

**Chin-En kEiTH Soo**

*Installation :*

# Type Brighter

**Topic:** Interactive Art

**Authors:**
**Chin-En kEiTH Soo**
Lecturer Computer Graphic Design
Department of Computer Science
Faculty of Computing and Mathematical Science
University of Waikato

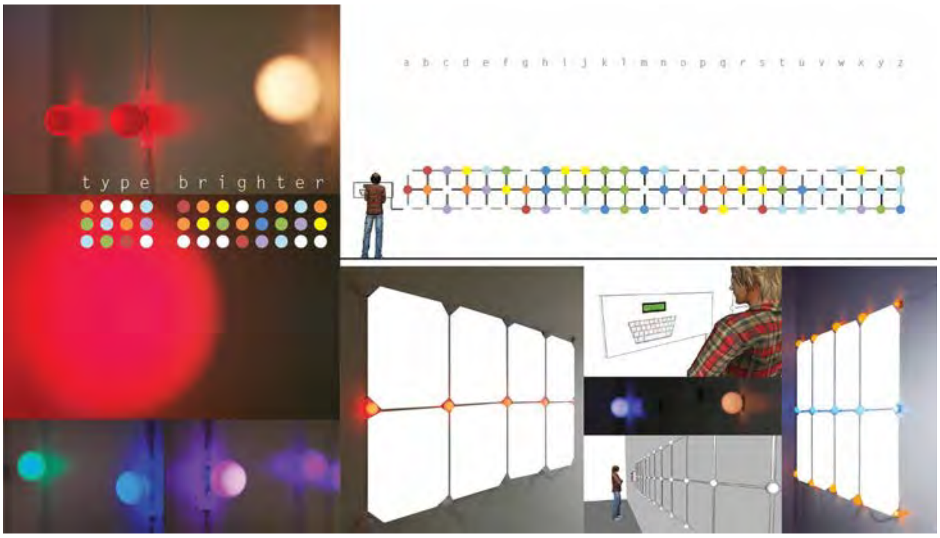
http://cgd.waikato.ac.nz/staff/keith

[http://www.waikato.ac.nz/research/expertise/staff/ChinEnKeithSoo.shtml](http://www.waikato.ac.nz/research/expertise/staff/ChinEnKeithSoo.shtml)

**Abstract:**

Type Brighter is intended as a new way of reading the alphabet. Shape, colour and pattern create memorable sequences based on characteristics of the letterform. By utilizing colour and repetition, readability is promoted. Each letter of the English alphabet is assigned a colour and positions, resulting in a full set of unique patterns. The user types using the keyboard, and the corresponding lights are shown on the light board. The simplicity of colour makes Type Brighter an alternative to more complicated communications such as mores code, and the use of pattern creates memorable sequences of colour. User can also experience the change of ambience, while the moving colour type projects an abstract story using light.

Type Brighter aims to create a new visual language through light. Colour, shape and pattern are strong visual elements, and when combined create a memorable experience. Colour serves an important part of our everyday lives and is easily distinguishable in all situations, making Type Brighter effective in a range of applications.

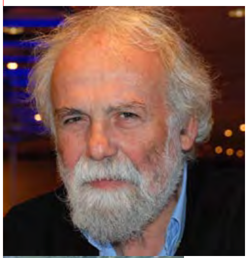



**Contact:**
ceks@waikato.ac.nz

**Keywords:**
Colour, Interactive, Light, Typography

**Celestino Soddu**
**Enrica Colabella**

## Generative characters in a Generative Design process



***Topic:Teaching Generative Design***

***Author:***
***Celestino Soddu***
***Enrica Colabella***
Generative Design Lab, Politecnico di Milano University, Italy
generativedesign.com

***References:***
[[1]C.Soddu, “L'immagine non euclidea“, Gangemi publisher, 1987
[2]C.Soddu, “Citta' Aleatorie“, Masson Publisher. 1989
[3]C.Soddu, E.Colabella, “Il progetto ambientale di morfogenesi“, Progetto Leonardo Publisher 1992
[4]C.Soddu, “Milan, Visionary Variations”, Gangemi publisher, Rome 2005
“Title”, Publisher, Where, Year
[5]Seamus Heaney, Beowulf: A New Verse Translation Bilingual Edition,2000 Paperback

***Abstract:***
Following the methodology fixed in our quoted books it is shown the experience of the **generative design approach** with the students from all the world at the Master School of Design of Politecnico di Milano University. The starting point for each student is to engage a process by using the trilogy *Memory/Thinking/Imagination* for performing the main aim of the generative process as **a character**.
This trilogy works following an helical direction in double verse. The **generative character** is discovered by fixing 3 words as ***attributes,*** also in contrast between them in significance. In this way the character performs an instability of the system delineating a first not linearity. Students choose attributes from an imaginary world of singular reference
It is activated in the generative process *a dualism*, as *Goethe* fixed in *Polaritat,* 1805, that *gains* students in working in a **transformation process** of elements. These are connected *imaginatively* with attributes. The next step is the core of the process.
Using a ***catalyst*** (images, sounds, poems etc.) each student interprets it by a process of ***abduction*** (*Pierce)* able to catch the impression fixing it in a first sketch as an embryo of a performing idea/code. In this first hypothesis are fixed the aim/attributes. ***So*** students have just delineated a paradigm/code able to perform a control act in the generative results. As in nature code works.
*So* is a deductive moment. It refers to the incipit of *Beowulf* by *Seamus Heaney* ; that is the translation of the epic English romance after one thousand of years. This for the simple reason that we can use the word generative in a correct way only if we are connected to the past time, as the great poet Heaney gave us a so incredible example. Putting the fixed characters in the first idea structured as an embryo of paradigm is like to translate the past (catalyst) into a new configuration performed as ***generative chain.*** These are expressed by choosing from singular cultural references a ***motto***, as expression of a popular voice in ***mother tongue***.
The first part of the works of students( they stay in the middle of course) is shown in GA exhibition in vertical format A4 as fragments connected each to the others in evocation of the old film material in our digital time.

Students:
ANSELMO NISHINO CAROLINA, AVILA CINTHIA, BALDASSARI GIULIA, BOWMAN LINDA, CASIRAGHI ALICE, DEMBINSKA KAJA, FERRARIO LUCA FILIPPO FEDERICO, FORMICA GIULIA, GATTO DANIELE, GAVERINA LUCA, GIUSSANI MATTEO, HASAN DANIEL JACOBSEN, HENRIKSEN THEODOR ANDREAS AAS, HONG SOYOUNG, HU ZHIYUAN, IKONOMI LEONIDHA, IMBRIANI LUCA, KAN SEMIHA, KANG ZIIWON, KARIMIPOUR KATAYOON, KOZAWSKA ALEKSANDRA, LICHTENAUER CAMILA, MISUND BJARTE ANDREAS, OLIVEIRA CARLA SOFIA, PAM VERHOEF, PANTELAIOU SOFIA-EVAGGELIA, PRESTHOLT EIVIND, PUCHALT FERRET CLAUDIA, RIVA RODOLFO, SAPORITI MARCO, SHAHENAZ HEGAZY, SCIASCIA ALESSIO, SOARES CARNEVALE ITO DANIEL, TAYSEIR FATHIA, YU JIABI, ZHONG WANPING

***Contact: genlab@polimi.it***

***Keywords: Generative, Characters, Chains, Design, Art, catalist, paradigm, code, variations***

**Daniela Sirbu**

*Artwork/ Installation:* **An Abstract Constructor of Visual Dynamics**

***Topic: Interactive Art***

***Authors:***
***Daniela Sirbu***
University of Lethbridge, Faculty of Fine Arts, Department of New Media
Canada
http://www.uleth.ca/finearts/new-media

***References:***
[1] Arnheim, Rudolf. 1974. *Art and Visual Perception*. Los Angeles, CA: University of California Press.
[2] Reas, Casey and Ben Fry. 2007. *Processing. A Programming Handbook for Visual Designers.* Cambridge, MA: MIT Press.
[3] Shiffman, Daniel. 2012. *The Nature of Code: Simulating Natural Systems with Processing*. The Nature of Code 1st ed.

***Abstract:***
Based on a simple geometric module, the Abstract Constructor explores the pictorial space interacting with the hidden perceptual field of the framework and builds new self-generating structures from transparent traces left along its own paths.
The movements of the Abstract Constructor blend layers of continuous, but random paths, which are occasionally fractured by jumps geared towards several attractors in the visual field. The path fractures can be auto generated or can be initiated through interactions with the viewer. As the Abstract Constructor moves within the visual field and repeatedly revisits its previous paths, the older paths are covered by newer layers of transparent traces creating a sense of depth.
The latest visited attractors create dominant centres of interest in the composition through increased trace density with stronger contrasts of texture, light-dark, foreground-background, and colour.
This artwork/installation piece includes a series of nine printouts sampled from the Abstract Constructor's compositions and a digital diptych of active generative panels that allow the user to interact life with the Abstract Constructor.

*Digital diptych with active Abstract Constructor panels (screenshot)*

daniela.sirbu@uleth.ca

***Keywords:*** generative art, artificial creativity, processing.

# An Abstract Constructor of Visual Dynamics

**Daniela Sirbu, Associate Professor**
*Department of New Media, University of Lethbridge, Canada*
www.uleth.ca/westgrid/vr/contact.html
*e-mail: daniela.sirbu@uleth.ca*

**Abstract**

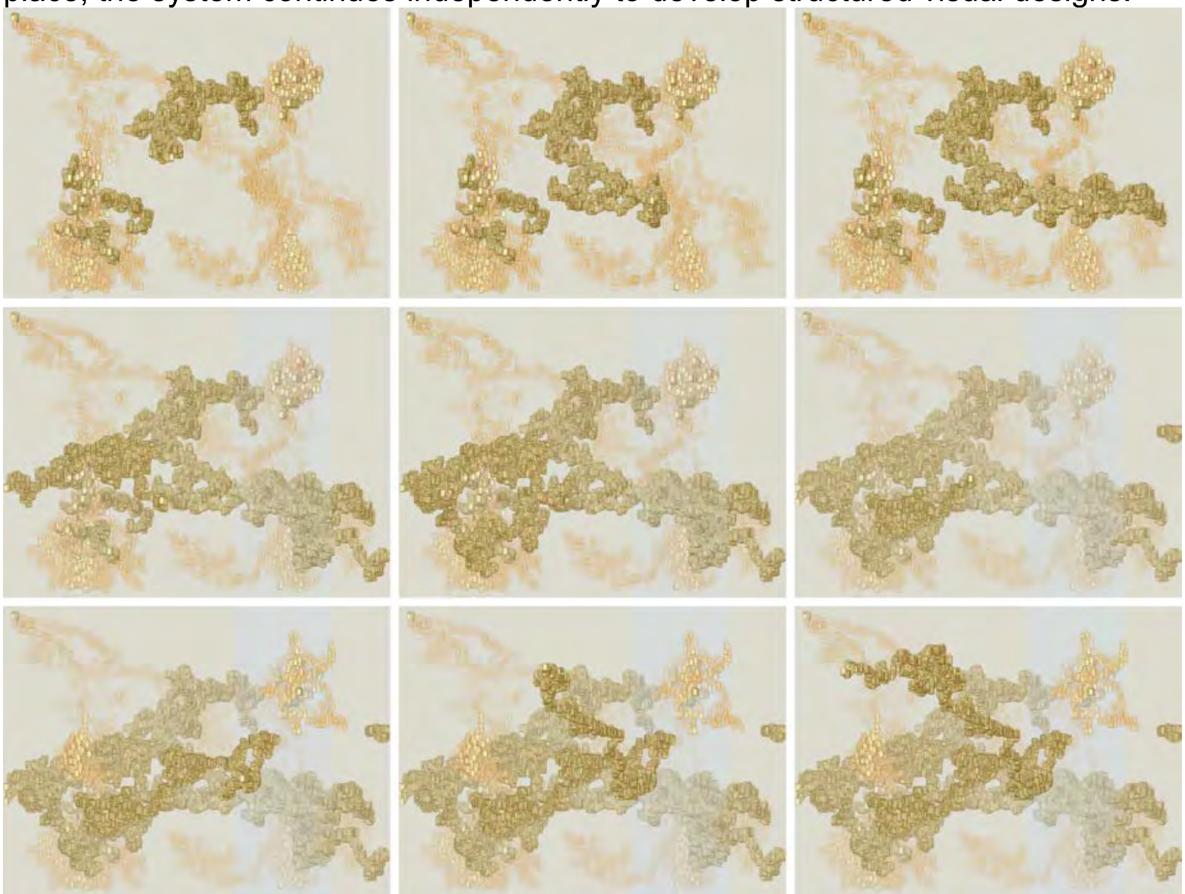
Based on a simple geometric module, the Abstract Constructor explores the pictorial space interacting with the hidden perceptual field of the framework and builds new self-generating structures from transparent traces left along its own paths.

*Title: Wandering. Digital diptych with active Abstract Constructor panels (screenshots). Sampled from the Visual Random Walker, version 7-2.*

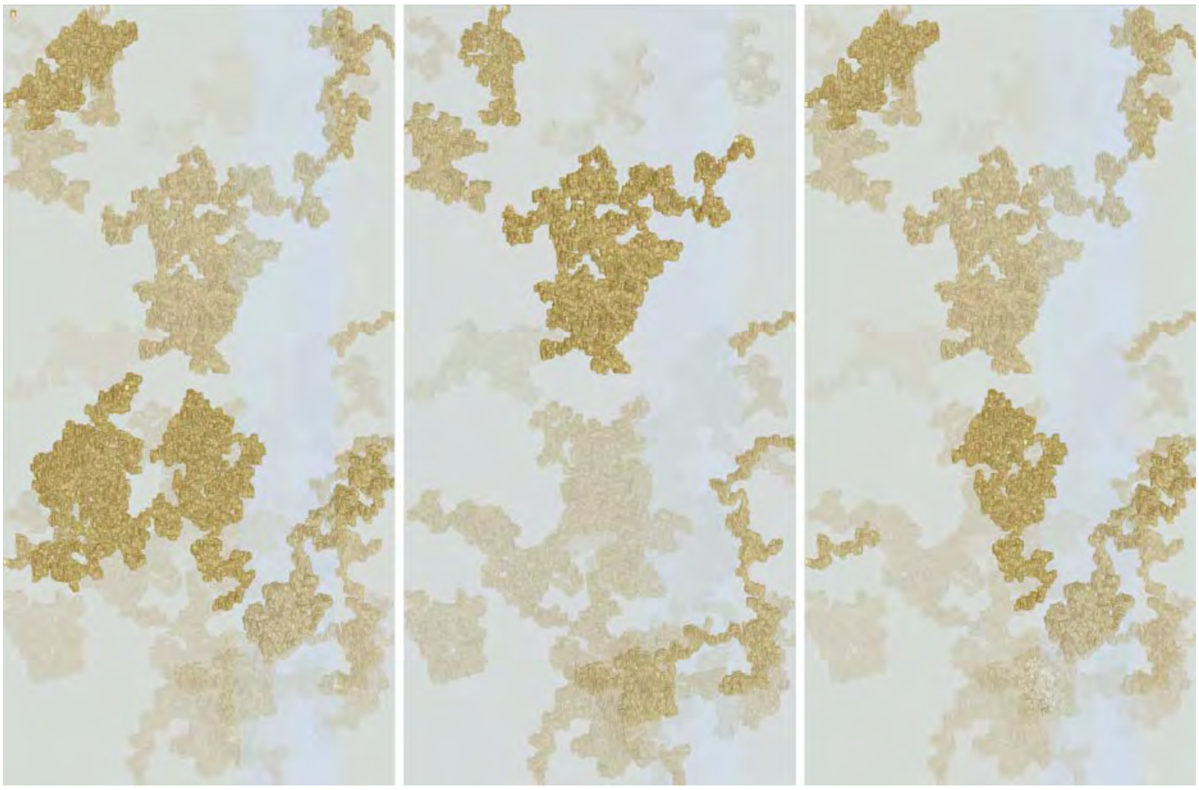
The movements of the Abstract Constructor blend layers of continuous random paths, which are occasionally fractured by jumps directed towards several attractors in the visual field. The path fractures can be auto generated or can be initiated through interactions with the viewer. As the Abstract Constructor moves within the visual field and repeatedly revisits its previous paths, the older paths are covered by newer layers of transparent traces creating a sense of depth.

The latest visited attractors create dominant centres of interest in the composition through increased trace density with stronger contrasts of texture, light-dark, foreground-background, and colour.

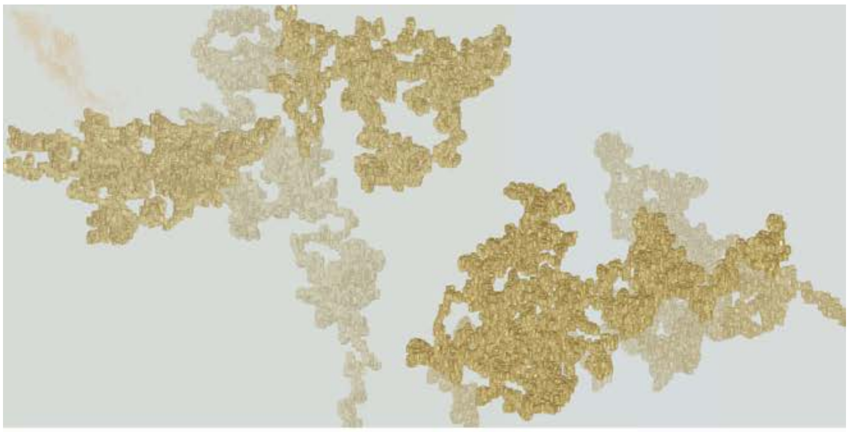
This artwork/installation piece includes a series of nine digital printouts sampled from the Abstract Constructor's compositions and a digital diptych of active generative panels that allow the user to interact life with the Abstract Constructor
This *Wandering* digital diptych is an interactive version of the Visual Random Walker. The interaction allows a form of kinetic drawing with the system continuously building structures and the viewer interfering directly with the random walker to introduce colour accents, control the positioning of the seed for structure building, control the density and spread of the structures, or actively combine drawing with the structure generating as an intimate part of the drawing process. When no interactions take place, the system continues independently to develop structured visual designs.

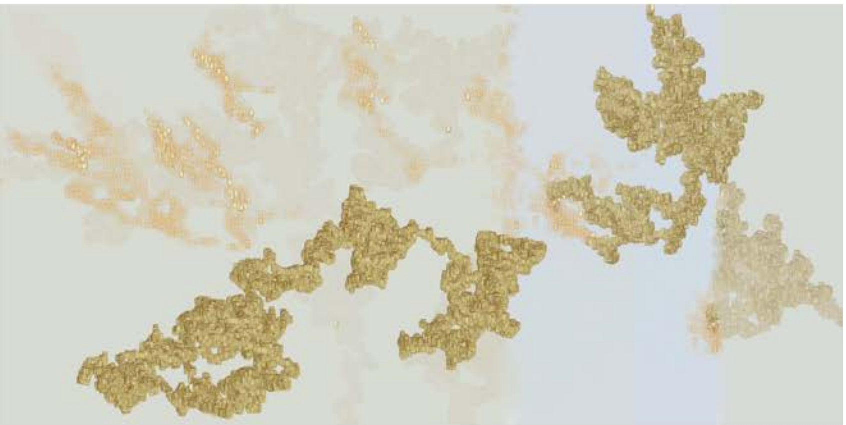


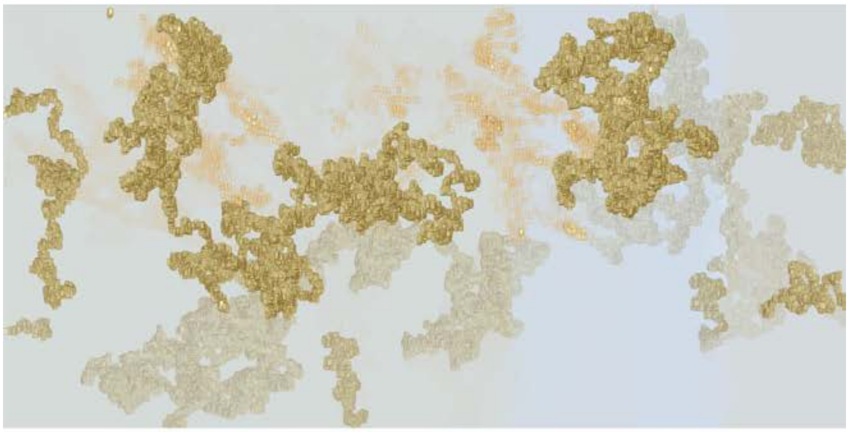
*Title: Wandering Constructor I. Composition series sampled from the Visual Random Walker, version 8-5. Unique digital prints – mounted.*

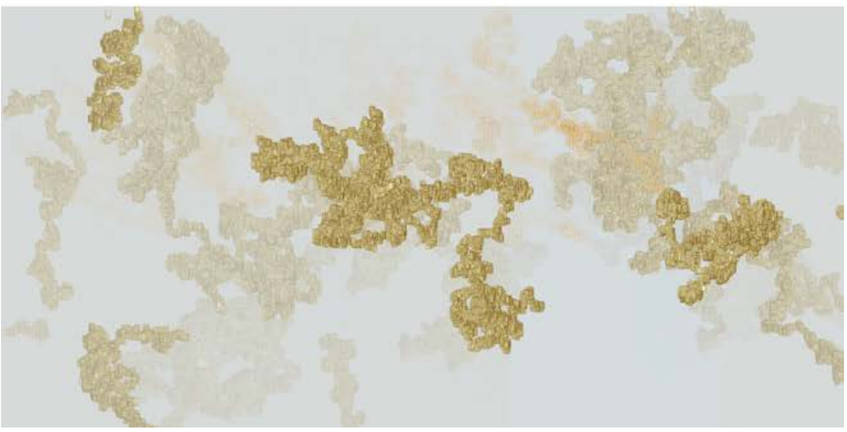


*Title: Wandering Constructor II. Composition series sampled from the Visual Random Walker, version 8-6. Unique printouts. Unique digital prints – mounted.*









*Title: Wandering Constructor III. Composition series from the Visual Random Walker, version 8-6. Unique digital prints – mounted.*

## 1. References

[1] Arnheim, Rudolf. 1974. Art and Visual Perception. Los Angeles, CA: University of California Press.

[2] Reas, Casey and Ben Fry. 2007. Processing. A Programming Handbook for Visual Designers. Cambridge, MA: MIT Press.

[3] Shiffman, Daniel. 2012. The Nature of Code: Simulating Natural Systems with Processing. The Nature of Code 1st ed.

**Hector Rodriguez**

*Video Installation:* **THEOREM 8**

**Topic: computational cinema**

**Authors:**
**Hector Rodriguez**
**[**www.concept-script.com**]**

Run Run Shaw Creative Media Centre, City University of Hong Kong

***Abstract:***
Theorem 8 is a 3-channel video projection installation exploring the intersection of art and mathematics. It is made using a custom software that decomposes every frame in a movie using a fixed database of frames from another movie.

The project is based on the mathematical concept of orthogonal decomposition. The idea is to select a fixed set of frames from one movie and then allow every frame in another movie to make a shadow projection onto each of those frames. (The concept of a shadow is based on the mathematical idea of a vector projection). Every frame in the second movie is decomposed onto those various changing shadows.

By mixing the different shadow projections, it is possible to achieve an approximate reconstruction of the current frame in the first movie.

The 3-channel installation setup shows the original movie, Godard's *Alphaville*, and its reconstruction in the center image. Its shadow projection onto 72 frames is shown on the left and the right screens. The frames are taken from the (never completed) film *Witch's Cradle*, directed by Maya Deren in collaboration with Marcel Duchamp.

**Technical details as well as a non-technical video documentation, can be found here:**

http://theorem8.concept-script.com

***Contact:***
***smhect@cityu.edu.hk***

***Keywords:***
Computational Cinema, Art, Mathematics

# Theorem 8

**Dr. Hector Rodriguez, PhD**
*School of Creative Media, City University of Hong Kong*
*http://www.concept-script.com/*
*Email: smhect@cityu.edu.hk*

**Prof. Felipe Cucker, PhD.**
*Department of Mathematics, City University of Hong Kong*
*Email: macucker@cityu.edu.hk.*

**Abstract**
This paper explains the concept and technical process of the work *Theorem 8*. This project is a 3-channel video projection installation exploring the intersection of art and mathematics, specially the concept of orthogonal decomposition.

## 1. Introduction

**Theorem 8** is a 3-channel video projection installation exploring the intersection of art and mathematics. It is made using a custom software that decomposes every frame in a movie using a fixed database of frames from another movie. The decomposition is based on the mathematical concept of orthogonal decomposition. The title, *Theorem 8*, refers to the orthogonal decomposition theorem, which concerns the idea of an object in a higher-dimensional space projecting shadows onto a lower dimensional space.

## 2. Technical description

This technical description assumes some basic familiarity with elementary ideas in linear algebra, such as the concepts of a vector, a vector space, and linear independence. It is meant for the technically inclined reader who wishes a more in-depth account of the artistic procedure employed in the making of *Theorem 8*. The first section explains the basic terminology, while the second section details the actual procedure used to generate the images in the installation.

### 2.1 Background Notions

A frame is a set of n x m pixels, where n and m are the width and height of the image. A movie is a sequence of frames.

Associated with every frame f in movie M is a function $B_f(x,y)$ whose inputs are the screen coordinates of a specific pixel and whose output is a floating point number in the range (0,1), the “brightness” or “value” of that pixel.

A frame f can also be described as a vector in $R^{n \times m}$ whose (y * m + x)th component is given by $B_f(x,y)$. In other words, the vector is an array containing the values of every pixel in f. They are sequentially ordered, so that the values of the pixels in the first row are followed by those of the pixels in the second row, and so on.

We take the set F of all frames of n x m pixels as a vector space, equipped with the two basic operations of vector addition and scalar multiplication. The operation of vector addition takes two vectors and outputs a new vector formed by adding corresponding entries in each input vector. The operation of scalar multiplication takes a floating-point number and a vector and outputs a new vector formed by multiplying each component of the input vector by the input number.

If F is to be a proper a vector space, it must be closed under the operations of vector addition and scalar multiplication. Frames must be allowed to contain values in the range $(-\infty, +\infty)$. This requirement poses a problem for any pixel-based visualization. In particular, how will negative values be visualized, since there is no such thing as a pixel with negative brightness? The solution adopted here, for visualization purposes only, is that any number $> 1$ will be set to 1 and any number $< 0$ to 0. All computations will otherwise be performed on the actual values. Recognizing that this solution is inelegant, the artist experimented with other possibilities, but the current option gives the most arresting visual result and so was selected because of aesthetic considerations.

We endow vector space F with a dot product, an operation whose inputs are two vectors and whose output is a single number. Given two input vectors, its dot product is obtained by multiplying every pair of corresponding entries and adding the results together. The expression $<u_1, u_2>$ will denote the dot product of vectors $u_1$ and $u_2$.

The concept of a dot product is important, because it can be used to define what it means for two vectors to be perpendicular to one another. Two vectors $u_1$ and $u_2$ in some vector space V are orthogonal (or perpendicular) if and only if $<u_1, u_2> = 0$. The "size" or "length" of a vector u, written $\| u \|$, is given by

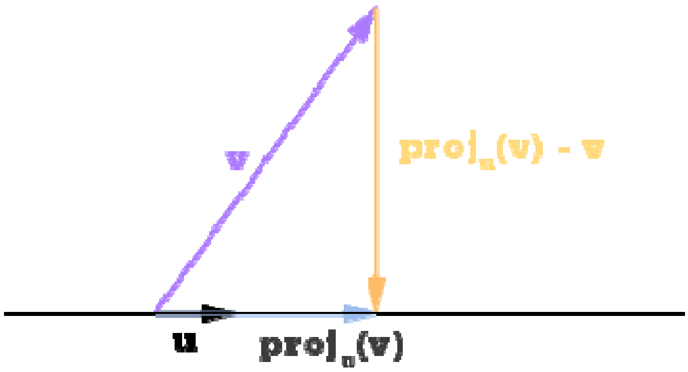
$$\|u\| = \sqrt{< u, u >}$$

We now come to the key ideas at the heart of this project:

Given a vector u in F, the orthogonal projection of vector v in F onto u is defined as

$$P_u(v) = \left(\frac{< v, u >}{\|u\|^2}\right)u$$

We will also say that $P_u$ (v) is the *shadow* cast by v on u, or the component of v in the direction of u.




Given a set U = {$u_1$, $u_2$, ...., $u_k$} of linearly independent vectors, the *decomposition* $v_u$ of vector v with respect to U is the set of shadows cast by v on every vector in U. The *reconstruction* of v with respect to U is the sum of the shadows cast by v on every vector in U. (The reconstruction is a linear combination or weighted sum of the vectors in U whose coefficients or weights depend on the projections of v onto the vectors in U). Note that every reconstruction is an approximation; it is not necessarily true that v = $v_u$. The larger the size of U, the better the reconstruction.

In this project, the vectors in U will not only be linearly independent but also orthonormal. A nonempty subset S of vector space V is orthonormal if the vectors in S are of unit length and pairwise orthogonal. There is a technique, known as the Gram Schmidt procedure, which takes a set S of linearly independent vectors and outputs a set of orthonormal vectors with the same size (as well as the same span) as S.

### 2.2. The procedure

This section details the procedure that generates the 3-channel video projection.

Select two movies $M_1$ and $M_2$:

$M_1$ = *Alphaville* (Jean-Luc Godard, 1965)

$M_2$ = *Witch's Cradle* (Maya Deren, with Marcel Duchamp, 1943).

Choose at random a set G of 72 linearly independent frames from $M_2$ and then apply the Gram Schmidt procedure to G, thus generating a set of orthonormal vectors ("the database").

For every frame f in $M_1$, compute the shadow cast by f onto every vector in the database as well as the reconstruction of f with respect to the database.

Display every frame f in $M_1$ next to its reconstruction in the center image.

Display the shadows cast by f on every vector in the database on the right and left images. The following is a view of the right screen.

The following is a view of the 3-screens.

### 3. The chosen footage

The 3-channel installation setup shows the original movie, Godard's *Alphaville*, and its reconstruction in the center image. Its shadow projection onto 72 frames is shown on the left and the right screens. The frames are taken from the (never completed) film *Witch's Cradle*, directed by Maya Deren in collaboration with Marcel Duchamp. The two films were selected because their filmmakers used light and shadow as dramatic elements. Moreover, Godard can be seen a response to the rise of cybernetics and information technologies, while Deren and Duchamp were interested in abstract mathematical spaces. This project is also an artistic response to information technologies and mathematical abstraction. The artist aims to show how mathematical concepts, such as the idea of a vector space and an orthogonal decomposition, can be treated as artistic resources for the generation of unprecedented moving images.

A video documentation, as well as detailed setup instructions, can be found in the project's web site:

http://www.concept-script.com/theorem8/index.html#

## Acknowledgments

This work was produced at the School of Creative Media of the City University of Hong Kong and the Department of Cinema Studies of New York University (NYU). The artist and technical director of the project was Hector Rodriguez. All programming was done by Philip Kretschmann and Hector Rodriguez. The mathematical advisor to the project was Felipe Cucker. The artist would like to express his deep appreciation to Prof. Richard Allen, Chair of the Department Cinema Studies of NYU.

**Jeanne Criscola**

*Artworks:* **Cook the Recipe**

***Topic:***
***Pattern and Poetry***

***Author:***
**Jeanne Criscola**
Southern Connecticut
State University
Art Department
New Haven, CT USA
www.jeannecriscila.net

***References:***
[1] www.processing.org

[2]
http://www.ubu.com/vp/

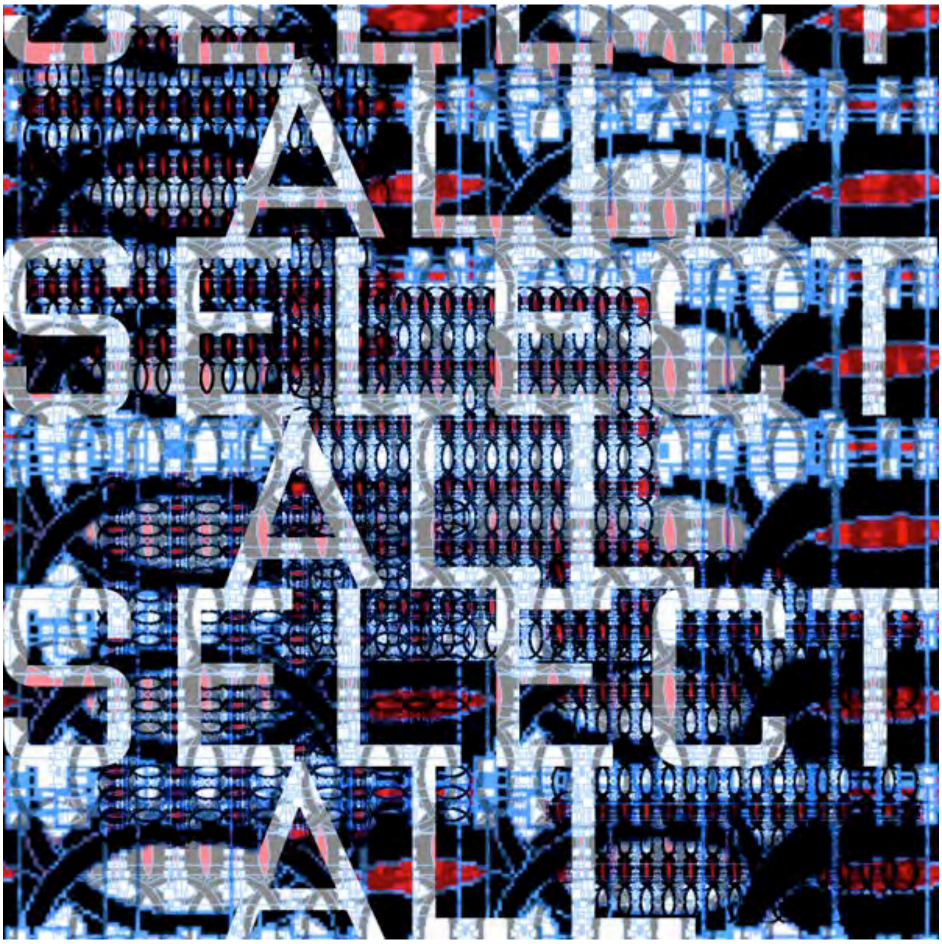
[3]
http://ww3.rediscov.com/sacknerarchives/Welcome.aspx

***Abstract:***

The blending of language and pattern through generative means reveals unique expressions where words form a poetic pattern and patterns form a visual language. Composed as a series of 10 visualizations, these visual poems[2,3] are studies in meta meaning.

Implementing the Processing application software[1], patterns are created, captured, layered, and multiplied in a fractal manner. A similar process is applied to words in each work on paper using capture, layering, and duplicating. Words are drawn by chance using a very simple and direct method—by randomly opening a dictionary to a spread and using one's finger to pick a word.

Using integration methods akin to cooking, a finite number of ingredients, each in a particular quantity, are brought into play. Cooking time and the sequence in which the ingredients are incorporated, determine the precise actions and the ultimate outcome. The moment of finalization is arrived at once it meets one's satisfaction.




*Example: "Select All"*

***Contact:***
jcriscola@gmail.com

***Keywords:***
Visual poetry, generative pattern, interface drawing

**Jeffrey M. Morris**

*Installation:* **The Collected Solo Piano Works of Ferin Martino, as Conjured by Your Presence**

***Topic: Music***

***Authors:***
***Jeffrey M. Morris***
Texas A&M University, Department of Performance Studies
USA
perf.tamu.edu

***References:***
[1] Umberto Eco, *The Open Work*, trans. Anna Cancogni, Harvard University Press, USA, 1962/1989
[2] http://www.morrismusic.org/2011/the-collected-solo-piano-works-of-ferin-martino-as-conjured-by-your-presence

***Abstract:***
This is an interactive art installation using a piano-playing computer algorithm that generates music reminiscent of early twentieth century expressionist composers like Arnold Schönberg. Since it is capable of generating its own œvre, I gave the software a human-like name, Ferin Martino. In this installation, motion of the viewers (seen by the computer's video camera) disrupts the flow of the music created. This creates a situation that lets us reflect on the ontological nature of music: this music cannot be heard without the audience causing changes in the composition. By extension, it offers a chance to reflect on the way that any composer's music only has its existence in the minds of its audiences, and that the modes of it existence may be as diverse as its listeners. This is an idea suggested by literary theorist Umberto Eco in *The Open Work* [1].
This work consists entirely of software and can generate new material practically indefinitely. The fact that the code fits on one screen indicates the elegance of the approach to generating endless music with pleasing results.
A sample recording is available at reference [2].

Technical requirements: 1) Computer with webcam and either 2A) Yamaha Disklavier piano and MIDI interface or 2B) amplifier and speaker. The composer can provide 1 and 2B if necessary.

*Example: Motion as detected by the software, to disrupt the flow of music*

***Contact:***
***morris@tamu.edu***

***Keywords:***
Improvisation, interaction, piano, authenticity, aesthetics

**Linda Chiu-han LAI**

*Algorithmic 3-channel video installation (combinatorial narrative):*
**DOOR GAMES WINDOW FRAMES: NEAR DRAMA**

***Topic: Generative Cinema***

***Authors:***
***Linda C.H. LAI (artist)***
School of Creative Media, the City University of Hong Kong, Hong Kong
www.scm.cityu.edu.hk/people/faculty/associate-professor/lai-chiu-han-linda/ OR http://sweb.cityu.edu.hk/smllai

***Philip Kretschmann*** (Programmer)
***Hector Rodriguez*** (Programming Consultant)

***References:***

***Abstract:***
This work is an automated multiple-window installation exploring mannerisms and **formulaic structures in Hong Kong film melodrama** from the 1960s. It consists of a database of about **500 movie clips**. In the form of a 3-channel projection, the **automated drama** explores the mannerism and formulaic structures of 11 such films. From the viewpoint of contemporary cinema, the frequent closing and opening of windows and doors to introduce a new scene is redundant, a residue of the traditional box-like theatre'a treatment of space. But for this project, I have turned such door and window movements literally into a unique propeller of drama. As punctuations as well for emotive shifts, the **combinatorial game** I play with these clips constructs **micro-narrative movements**. The 'near dramas' resulting from the game are not prescribed, but rather programmed for open meanings as filmic elements freely align and combine based on **preset algorithmic rules**. As such, this work explores the use of technology and generative thinking in the practice of visual ethnography, a domain of anthropology. Rather than excavating, I argue that **generative thinking** directs us to both the **hiddenness and potentiality in image analysis**, thus an **experimental form of anthropological research**.
This work highlights an **internal self-generative logic**. A computer program was written to apply principles of self-organization to 500 carefully selected movie clips. Each clip is assigned a number, each digital representing a value, including which of the 11 movies it is from, duration, types of shot size and so on, together forming the grammar of **visual musicality**. **Combinatorial justaposition** and alignment within each of the three image discourses occur in THREE movements (phases), each operating upon a different set of rules to achieve its own visual music. The 3 consecutive movements are currently timed to finish in about 20 minutes and will recycle automatically.
Video demo:
(1) https://vimeo.com/35050069
(2) https://vimeo.com/48866866 // Full Documentation: http://lindalai-floatingsite.com/content/interactive/interactive/NearDrama/index.html

***Contact:***
smllai@cityu.edu.hk
(SMLLAI…)

***Keywords:***
Combinatorial narrative, algorithmic cinema, melodrama mannerism, multi-channel projection, automatic video clip alignment, a library of 500 video segments

# DOOR GAMES WINDOW FRAMES: NEAR DRAMA

## Generative Cinema

## Algorithmic 3-channel projection│Combinatorial narrative

*generated from a data library of 500+ short video clips*

**Dr. Linda C. H. Lai**
*School of Creative Media, the City University of Hong Kong*
*http://www.scm.cityu.edu.hk/people/faculty/associate-professor/lai-chiu-han-linda/*
*e-mail: smllai@cityu.edu.hk (SMLLAI-at-cityu.edu.hk)*

Research Assistant: Terence Chan (Chan Kwan-ho)
Programmer: Philip Kretschmann
Programming Consultant: Dr. Hector Rodriguez

## Premise

***Keywords:***
Combinatorial narrative, algorithmic cinema, melodrama mannerism, multi-channel projection, automatic clip alignment, film analysis as artistic creation, digital archive

## 1. Film analysis through artistic creation: art as research

<*Door Games Window Frames: Near Drama*> is a generative art piece comprising of action sequences of open-ended drama based on a database of movie fragments extracted from Hong Kong (HK) Cantonese thrillers and melodramas from the 1960s. In the form of a 3-channel projection, the automated drama explores the mannerism and formulaic structures in 11 HK oldies.

**1.1 Deploying mannerism: from unperfected montage to dramatic potentials**

Works in commercial cinema are by and large nicknamed genre films, indicating the power of formulaic treatment of character relation and event development. While studying a dozen of HK Cantonese genre films from the 1960s, I was mesmerized by the frequent closing and opening of windows and doors that function as the lead to new scenes and actions. From contemporary cinema's viewpoint, such devices are redundant, a residue of theatre, or a weak view of montage. The doors and windows in these HK oldies are nonetheless a unique propeller of drama. In <*Near Drama*>, I turn door/window movements literally into punctuations for emotive shifts.

**1.2 Micro-narrativity → Open work → Infinite dramaticity**

In <*Near Drama*>*, v*iewers will see two of HK's most popular male stars in the 1960s – Xie Xian (Tse Yin, father of Nicolas Tse) and Zhang Ying (Cheung Ying) – in varied personae – as well as the best known female stars' close-up facial performance. As an example of algorithmic database cinema, the piece's **micro-narrative evolvement** is not prescribed, but programmed for open meanings as the dramatic elements, such as an object, a hand, an expression or a door, freely align and combine based on a few set rules. Here, the standard story-based narrative shifts to a recurring trajectory of dynamics created by juxtaposing shots of varied sizes, varied intra-frame motions and speeds and differential contents. Imagine the entire work to be a collage of signifiers of pathetic drama that do not amount to any comprehensible plot line. *"Near drama"* is indeed the core concept: actions and human interaction are evolving as if something significant is about to occur, but not quite there yet, and the combinatorial machine takes the viewer away (back) into dizzying blends of motions.

## 2. What's in the clips?

### 2.1 Constructing '"near drama"

Visitors will see the same few faces repeated throughout the work – yet in different costumes and posturing, and variegated class background, as mentioned in the last session. This work thus explores "micro-narrative meanings," that is, to explore the free open meanings of individual elements – an object, a gesture, the banging of doors and windows – as well as the permutations of the meanings of each fragment as they combine with what comes before and after them in the ever-evolving image discourse. In this way, this combinatorial machine works against the conventional audience expectation as the fragments of images are never finally subjugated to a story-line to complete narrative comprehension. There could have been no end to this piece of automated 3-window drama, except that a black picture that says 'the end' will be attached to a few chosen clips so that it will appear at irregular intervals to give visitors a sense of a break or a breathing space.

### 2.2 Liberating the fragments: low-level study

There is no scored music. The work has a minimalist soundscape, comprising mainly the sound of doors closing and closing in some scenes, at times banging, sighs, yawns and murmurs, utterances of names of female characters, or a fragment of a spoken dialogue. Every now and then, a tiny fragment of a typical programmed music for tragedies would pop up. Like the case of the image track, the accumulation, distribution and juxtaposition of emotive intensity take over plot delivery in the sound track. The method of fragmentation and isolated of fragments from narrative comprehension is the artist's effort to further discover the low-level elements that comprise grand family drama and thrillers that have shaped the imagination of a generation of everyday movie-goers.

## 3. Technical specifications

All clips are tagged manually. In this version, we have simplified the analysis by giving each clip an <u>index</u>. For example, a clip indexed “0.30221” refers to the following:

1st digit = Film // [0-7]
2nd digit (1st decimal digit) = Duration [seconds] // Added decimal indicates the exceptions of clips over 1 digit range, eg. N. NN. NNNN instead of N.NNNNNN
3rd digit = Size of Shot // [0-4] 0-MS 1-MCU 2-FS 3-CU 4-TB
4th digit = Narrative Punctuation // [0-6] 0-Door 1-Drama 2-Window 3-Outdoor/Garden/Balcony 4-Object 5-Text 6-Corridor
5th Digit = Speed // [0-2] 0-S 1-M 2-F
6th Digit = Sound // [1-2] 1-No 2-Yes

| | Film | Duration | Size of Shot | Facial Expression | Narrative Punctuation | Actor | Dynamics | Content | Notes | Sound | Index |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | MS | Neutral | Window | XP | M | Picking up knife | | | 0.10211 |
| 2 | 1 | 3 | MS | Sudden | Window | XP, ZY | F | Turn and point at | | | 0.30221 |
| 3 | 1 | 1 | MS | Surprise | Window | XP | F | Woman run | | | 0.10221 |
| 4 | 1 | 3 | MCU | Angry | Window | XP, ZY | F | Hold knife and argue | | | 0.31221 |
| 5 | 1 | 3 | MS | Neutral | Drama | XP, ZY | M | Bed night play | | | 0.30111 |
| 6 | 1 | 9 | MS | / | Drama | / | S | Curtain sunshine | | | 0.90101 |
| 7 | 1 | 6 | CU | Curious | Window | ZY | M | Man look door | | | 0.63211 |
| 8 | 1 | 8 | MS | Hidden | Door | XP, ZY | S | Man behind woman think | | | 0.80001 |
| 9 | 1 | 4 | MS | Staring | Door | XP, ZY | M | Man look woman left | | | 0.40011 |
| 10 | 1 | 2 | CU | Shock | Door | ZY | M | Man shock | | | 0.23011 |
| 11 | 1 | 4 | MS | Neutral | Drama | ZY | M | Man with tie | | | 0.40111 |
| 12 | 1 | 8 | FS | / | Outdoor | / | M | Car passing | | | 0.82311 |

Work display: a 3-channel projection: 1230mm (h) x 1600mm (w) per screen

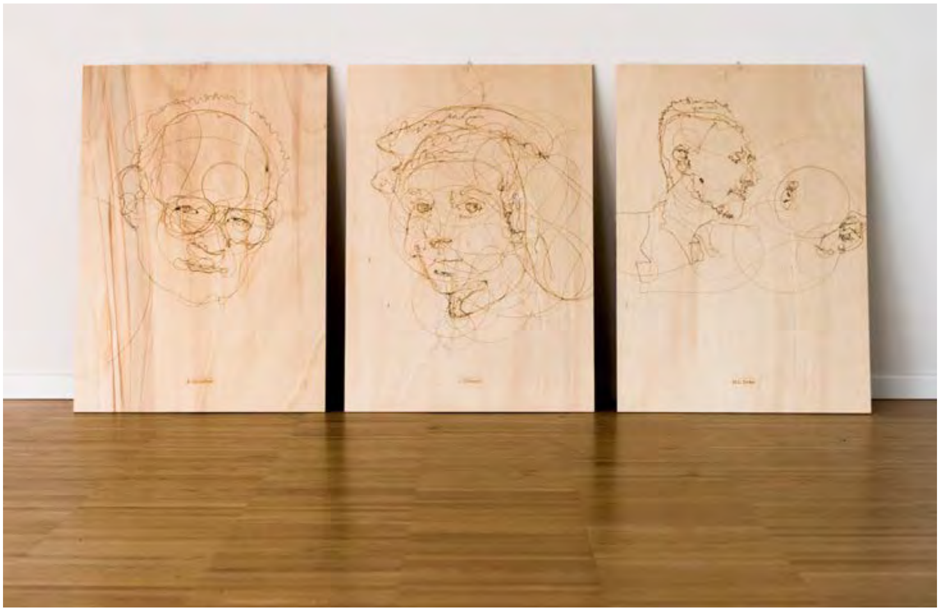

This work is an application written in Processing 1.5.1. Java runtime environment should be installed on the computer.

**Matteo Moretti**

*Artworks:* **Cornu Portrait**

***Abstract:***
Cornu portraits is a “homage” to the pioneers, mathematician and artists that researched on the relation between math, art and nature.
They inspired thousands of people, artists and my personal research on generative design. A passion born during Univeristy time, after attending a conference with B. Mandelbrot abouth “The fractal geometry of Nature”. Cornu portraits is a series of portraits, based on a parametric algorithm (Cornu algorithm) that generates endless variants of the same subject. After the generation of hundreds of results, I chose one and laser engraved on a wood panel, from digital to the real world, on an irregular surface, to celebrate the uniqueness of the generative process.

In this first chapter, I portraited M.C. Escher, L. Fibonacci and B.Mandelbrot.



***Topic: Architecture***

***Authors:***
***Matteo Moretti***
***Free University of Bozen Bolzano***
[www.unibz.it](www.unibz.it)

***References:***
[1] http://portfolio.matteomoretti.com/?commercial=cornu-portraits

[2] http://franzmagazine.com/2012/09/07/rosengarten-festa-per-un-distretto-creativo-della-citta-di-bolzano/

***Contact:***
***matmoretti@unibz.it***

***Keywords:***
Cornu Spirals, Generative art, Portrait, pioneers

**Maurizio Turlon**

# *Artworks:* **An experience of Generative Painting**

***Topic: Generative Painting***

***Author:***
***Maurizio Turlon***
Artist and physicist

***References:***
www.maurizioturlon.it

***Abstract:***

The aim of the installation is to illustrate an experience in creating works of generative painting devoted to the link between art and science.

The author has developed a non-commercial software that allows to create, manage and display shapes (hyperstructures) defined in spaces with an arbitrary number of dimensions (nD hyperspaces). Over time, he gradually refined and enriched the software, with the management of sounds and chromo-evolutionary structures, orienting it to become an instrument for the creation of works that can be placed in the context of generative art.

Author's generative painting works are the result of a frozen "chromatic trace" starting from a geometric (*Fig. 1*), functional (*Fig. 2*) or table-arranged mathematical structure in predetermined or random motion within a nD hyperspace. The typical result is a bitmap file that is reproduced on canvas, plexiglass or other medium.

The generative software is able to manage hyperstructures covering several physic-mathematical topics (oscillating systems, polytopes, multivalue logics, ...) and is integrated with author's special routines that permit to work with arbitrary-length integers for scientific or artistic purposes. In addition, the software allows a complete and accurate chromatic control of the creation governed by the definition of the initial conditions.

The end result is a generative painting with deterministic or non-deterministic character. Sight-worthy are the artworks showing 2D dynamic-optical effects on matte canvas which are generally visible only in 3D installation with overlay surfaces (*Fig. 3*).

*Fig. 1: 4D Hypersphere*

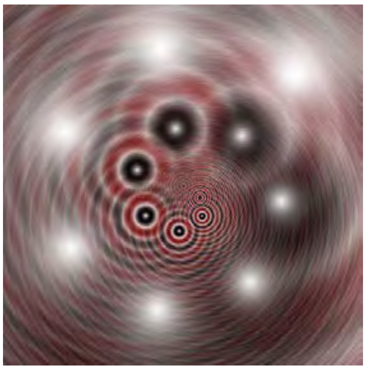


*Fig.2: 2D Oscillating system*

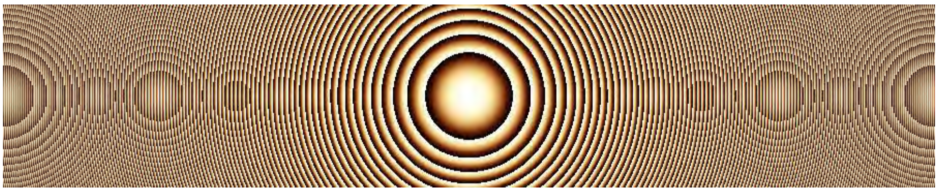


*Fig. 3: Particular of a 2D dynamic-optical modulation*

***Contact:***
maurizio.turlon@alice.it

***Keywords:***
generative painting, hyperspace, hyperstructures, hypersphere, oscillating systems, dynamic-optical effects

# An experience of Generative Painting

**Dr. Maurizio Turlon**
*www.maurizioturlon.it*
*e-mail: maurizio.turlon@alice.it*

## Abstract

*Fig. 1 - Chromatic trace*

The aim of the paper is to illustrate the potential of the software developed by the author in creating generative painting artworks . The creations can be deterministic or non-deterministic and are essentially pictorial images defined in multidimensional spaces. The development of the paper provides a brief description of the basic elements of the generation technique with notes on software's capability to create sounds and react to external inputs.

## Introduction

The main feature of the software is the ability to create, manage and display shapes (*hyperstructures*) defined in spaces with an arbitrary number of dimensions (*hyperspaces*). The hyperstructures can have mathematical or table-arranged origin and are free to move within the hyperspace according to functional or random-perturbative inputs. The major elements of the hyperstructure are associated with colour-dynamical components responsible for generating an image (*chromatic trace*) that can be frozen in any state (*Fig. 1*). Optionally, you can establish a link between the colour component and a sound component that is uniquely dependent on the geometric and dynamic properties of the hyperstructure. The typical generative action results in the creation of BMP, WAV and AVI files.

## General aspects

Conceptual elements and techniques used to achieve the above results have a number of features inspired by elements of physics and mathematics.

### Chromatic field and sonorities

In analogy with the physical concepts of scalar or vector field, a *chromatic field* is a region of the hyperspace where point-by-point is defined a colour. Within the field, the point of a hyperstructure that occupies a given position necessarily assumes a given univocal colour. Introducing an appropriate mathematical law, as well as you can associate a colour to a point so you can associate a sound to a colour and therefore associate a sound to a point. As a result of the limitations imposed by the representations of colours and sounds (RGB, MIDI, ...), the correspondences between points, colours and sounds are not necessarily bijective.

### Primary chromatism

If you simply consider the one-dimensional space, the set of chromatically definable positions can be represented by the set of points of a straight line. Four points of the line are remarkable: *origin*, *antiorigin* (or point at infinity assumed unique), *unity* and *antiunity*. Once arbitrarily assigned colours to the remarkable points, the introduction of an appropriate functional law allows you to assign a univocal colour to all points of the straight line (*Fig. 2*). By extending these criteria to the hyperspace, the chromatic field is defined as soon as, for each dimension, you assign the colours to unity and antiunity and choose the two colours for origin and antiorigin. Once you have completed the chromatic initialization, each point (*vertex*) of the hyperstructure can be linked to a univocal colour (*primary chromatism*) that depends exclusively on vertex position.


*Fig. 2 - Primary chromatism*

### Secondary chromatism

Under the constraints of the primary chromatism, you can also handle the aspect of other interstructural elements (*edges*, *surfaces*, ...). This process is accomplished by introducing functional laws capable of constructing combined colour effects between vertices, edges and surfaces (*secondary chromatism*). The results may have evolutionary character thanks to integrated support codes based on physics and mathematics (wave effects from oscillating systems, compositional effects from multivalue logics, ...). The set of previous choices completely define all the preliminary elements of the hyperstructure (*skeleton*). The skeleton can take a very different appearance depending on the primary and secondary chromatism (*Fig. 3*).

*Fig. 3 - Skeletons*

**nD dimensionality**

The software is designed to realize hyperstructures defined within spaces of arbitrary dimensions (*n*D hyperspace). However, due to various limitations (power system, user interface, …), the maximum number of spatial dimensions handled is thirty-two (32D hyperspace). The main managed structures are of type
- geometric (polytopes, hyperspheres, ...)
- logical (multivalue logics, fuzzy logic, ...)
- functional (real or complex functions, scalar or vector fields,...)
- table-arranged (XLS or MDB external data, internal data, …)
- miscellaneous (reticular structures with constrains, ...).

Due to the long execution times, some features are currently limited to 2D or 3D hyperspaces.

**Structural dynamism**

Once defined the chromatic field and the hyperstructure, you can virtually move the skeleton within the hyperspace according to standard modes (zoom, rotational views, ...) or parser managed modes (parametric functions, special functions, …). With similar methodologies to those introduced in physics to describe dynamical systems (absolute and relative motion, center of mass, ...), the software enables each points of the skeleton to move around the origin of the chromatic field or around another special point (*center of structure*). The center of structure is hyperstructure dependent and can be managed by internal or external inputs. The types of functional movement achievable are potentially limitless and can have *deterministic*, *semideterministic* or random character. In particular, the use of the term “deterministic” highlights the ability to target the generation results through the definition of the initial conditions. In contrast, the use of the term "semideterministic" underlines the ability of the software to take autonomous decisions, based on pre-coded rules, in the face of internal or external random events. The setting result of colour and dynamic parameters is to generate a chromatic trace that can be displayed, frozen and memorized in any state.

## Operating elements

The generation activity is supported by a VB programming code that integrates several features and permits internal and external inputs.

### Support codes

To optimize the management of the structural dynamism, the software makes extensive use of hyperstructural-dependent parsers. At the same time, in order to achieve colours with nuances and details (harmonic gradations, logical-chromatic compositions, ...), the software allows you to manage arbitrary-length integers without approximations. Moreover, the realization of a powerful code to design oscillating systems enabled you to generate special chromatic effects and to support the integrated management of sound waves.

### Sound-colour dynamism

The software allows you to dynamically create musical notes that uniquely depend on chromatism, geometry and position of the skeleton in the hyperspace. These musical notes can be built using the standard external media (MIDI, ...) or the internal code designed to handle sound waves and oscillating systems. By combining the versatility of structural dynamism with the ability to associate points, colours and sounds, you get the effect of a skeleton that changes its colours and plays musical notes during its construction or a movement (*sound-colour dynamism*).

### Supporting files

The typical storage mode of the chromatic trace is the creation of BMP files. These files can be generated and memorized during a cycle with the consequent possibility of creating sequential frames for video installations. When the sound-colour dynamism is enabled, the software allows you to create WAV files. As images and sounds are generated simultaneously, you can integrate the two memorization types and dynamically create AVI files.

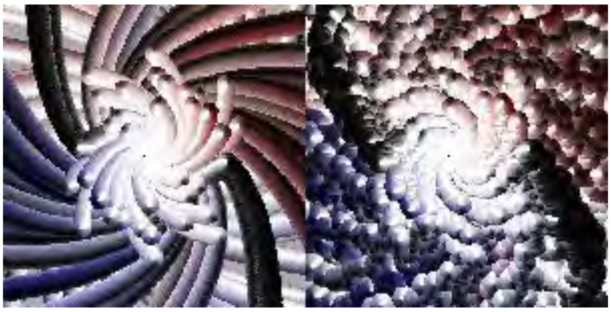


*Fig. 4 - Structural dynamism*

## Interactive aspects

The software allows you to define and change the structural dynamism with internal or external input parameters. These parameters can be random or not perfectly controllable (*random-perturbative parameters*) and consequently generate unpredictable skeletons (*Fig. 4*). As the typical activity consists in the generation of dynamic skeletons inside a loop, the consequence of using random-perturbative parameters is to get results with non-deterministic character. The internal input parameterization is typically assigned to customizable functions accepting cyclic or random variables with or without the use of parsers. The external input parameterization is currently limited to activities related to the use of a mouse or a microphone. Mouse parameterization is managed with or without the use of parsers, while microphone parameterization is handled exclusively with parsers. The results of activities involving the mouse can be addressed while those involving the microphone are generally unpredictable.

## Artistic aspects

The software has features strictly devoted to the generative painting and features of more general use in the context of the generative art.

### Pictorial capabilities

Operational options allow you to achieve a variety of results that can be associated to different painting styles. This is true in deterministic case and is even more accentuated in semideterministic or random cases. The vertices and the other interstructural elements (edges, center of structure, …) are represented in separate and independent order and have the ability to take autonomous and complex shapes (bands, paths, …). Particularly significant is the opportunity to consider the hyperstructure itself as a brush that can dynamically change shape and chromatism in response to internal or external inputs.

### Sound capabilities

The sound-colour dynamism is an important feature of the software and is supported by the presence of code that handles oscillating systems and sound waves. A particular result of this integration is the creation of arbitrary musical scales starting from musical notes defined uniquely in terms of abstract compositions of oscillators.

### Sound-pictorial generations

Combining the pictorial and sound capabilities with the interactive aspects related to external microphone inputs, the software allows you to realize random hyperstructural generations capable of self-sustaining. This is justified by a cyclic generation sequence (start→point→colour→sound→perturbative input→start→…. ) and is supported by parser-manageable functions.

## Conclusions

The synthetic elements presented above, let you guess the versatility of the software developed by the author in creating generative painting artworks. Particularly important is the ability to realize, with deeply different painting styles, chromatic traces inspired by the intrinsic beauty of complex mathematical shapes. Finally, the dynamic association between points, colours and sounds, integrated by interactive capabilities, highlights the potential of the software in the direction of audio-visual installations with a variety of applications in the context of generative art.

**Jamy Sheridan**
**Zlata Baum**

Artwork: **Two Views of 90 Seconds of Attention**

**Topic: Generative Art**

**Authors:**

**Jamy Sheridan**
MICA
Animation
USA
www.mica.edu
jamysheridan.com

**Zlata Baum**
MICA
MFAST
USA
www.mica.edu
zlatabaum.com

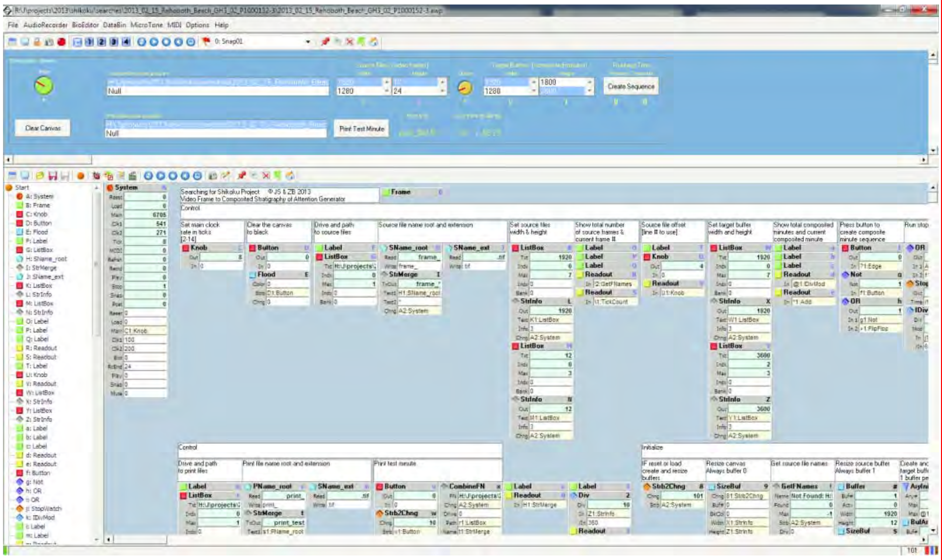
www.generativeart.com

**Abstract:**
Two Views of 90 Seconds of Attention is a product of Sheridan and Baum's ongoing Searching for Shikoku project which is currently exploring 'stratigraphies of attention'; static maps of time and change per se that act as low dimensional analogs of the many perceptual filtering and ideological accretion processes inherent in human consciousness and culture. The two images are generated from two different views of 90 seconds of DSLR video data using Sheridan's generative compositing system created using John Dunn's ArtWonk4 algorithmic art software.

**Images:**

*90 Seconds of Attention: View One*

*90 Seconds of Attention: View Two*



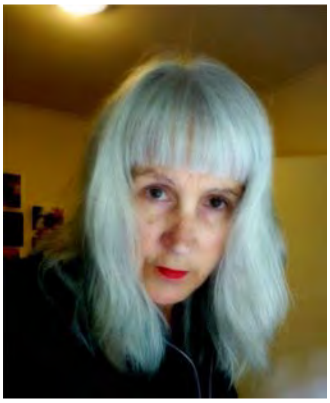
*Screenshot of ArtWonk4 code used to generate composited images*

**Contact:**
**jamysheridan@fastmail.us**

**Keywords:**
ArtWonk, Stratigraphy, Time, Attention, Composite image

**Julie Clarke**

artworks:
**Night Sports**



***Abstract:***
The photographs are the product of the generative approach in that, although my original intention was to simply photograph people playing in the floodlit park at night, my camera's internal function automatically adjusted the exposure, which resulted in the distant figures being captured in what looks like slow motion. By using Photoshop I selected the body/ies of the people in the original photographs to highlight the section I found most compelling since they are simultaneously represented as depicting movement as well as stasis. If generative art is made with autonomous systems (computer and digital apparatus) and depends largely on the intervention of a non-human agent then these photographs may be considered generative, since a certain amount of chance determined the outcome, which includes the colour saturation of the yellow, high intensity artificial lights used to flood the park.. The images relate to early Futurism and the concepts of future, speed, technology and the fact that the world is in constant movement. More importantly, the photographs acutely reveal that it is only the mechanical eye (not the human eye) that can capture exquisite, minute, human velocity. This too relates to generative or emergent art because of the image's reference to repetition, complexity, (dis)order and the sometimes ambiguity of content such as that created in this photograph below, in which there was no dog and yet there appears to be one.

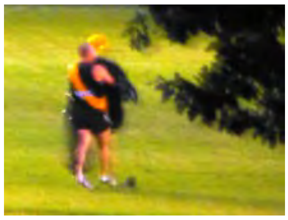
***Topic: Art***

***Author:***

***Julie Clarke***
***Screen and Cultural Studies***
***Culture and Communication***
***The University of Melbourne***





***Contact:***
*jjclarke@unimelb.edu.au*

***Keywords: Emergent behaviour, night sports, future, speed, stasis, velocity.***

| | |
|---|---|
| **Robert Spahr** | *Poster:* **Data Loss Cruft (Corruption)** |

***Topic: Computational Art and Glitch***

***Author:***
***Robert Spahr***

Southern Illinois University Carbondale, Department of Cinema & Photography
Illinois, USA
www.robertspahr.com

***References:***
[1] www.whitehouse.gov
[2] www.thebureauinvestigates.com/category/projects/drones/
[3] www.robertspahr.com

Since 2003, I make art from the digital leftovers produced by the main stream media as well as the digital leftovers we create as individuals left behind on social networking sites, and scattered across the web. I write automated computer programs that collect these digital leftovers by scraping them from the web, and remixing them into a digital collage. I call this work 'Cruft', which is a computer hacker term defined as an unpleasant substance; excess; superfluous junk; and redundant or superseded computer code.
Computer code downloads a recent photo from the Whitehouse.gov website as well as a report published by The Bureau of Investigative Journalism listing U.S. covert drone war casualty estimates. The text file of casualty estimates is literally inserted into the binary code of The White House photo. The drone war information becomes hidden from view, but corrupts the image producing visual distortion often referred to as a glitch. This Cruft **re-generates** a new image by altering the data, displaying the corruption and reminding us of it's origin.

*Dataloss Cruft 19-23-13 @15:22* *www.robertspahr.com/work/dataloss/*

***Contact:***
***rob@robertspahr.com***

***Keywords:*** CRUFT, generative, glitch, computational art, net.art, drone warfare, obama, corruption

**Anna Ursyn**

*Artworks* **: Variations**

**Topic: Art**

***Authors:***
***Anna Ursyn***
University of Northern Colorado
School of Art and Design
Country USA
www.Ursyn.com

***References:***
[1] Anna Ursyn, "Perceptions of Knowledge Visualization: Explaining Concepts through Meaningful Images" Publisher, IGI-Global, 2013

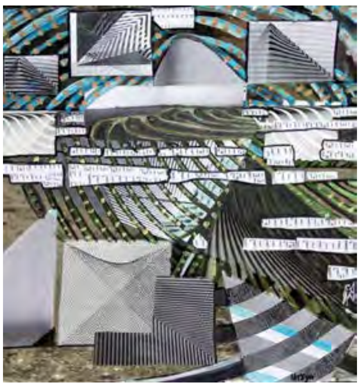
[2] Anna Ursyn, Computational Solutions for Knowledge, Art and Entertainment: Information Exchange Beyond Text", IGI-Global, 2013

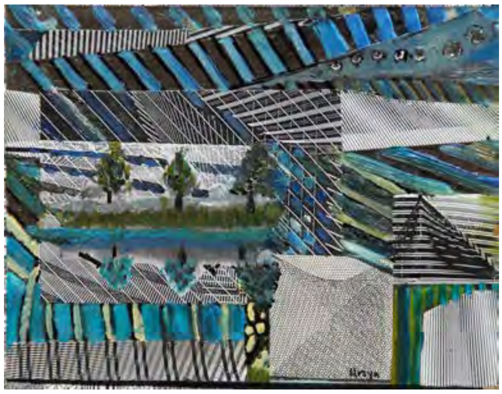
***Abstract:***

In my works, natural order infuses several levels of both worlds: some determined by man and some determined by nature. It guides our understanding of big data sets related to network analysis, whether we employ physical analogies of the data, render the data graphically, or interact in real time. Acutely aware of natural order that infuses both worlds, I examine what technological and human worlds have in common. My task is to juxtapose the regularity of nature with man's constructions, both physical and intellectual. The digital factor of all these media creates even more opportunities for the contemporary art.

Generative art results in precise images with perfect lines that follow premeditated transformations. Through the use of software I can recycle drawings along with generative shapes and patterns. I transform algorithmic images into physical constructions. Free of details images became synthetic expression of the figure.

Processes in nature and events in technology inspire my images. Such processes also support my instruction in computer art and graphics, where students learn to create artwork inspired by science and demonstrate what they understand of scientific concepts.





***Contact: email ursyn@unco.edu***

***Keywords: Natural Order, Computer Art Graphics, Knowledge Visualization***

**Daniel C. Howe**

*Artwork:* **Transformations: generative images scripted in Photoshop (a series of digital prints).**

*__Artworks:__*
**Transformations: generative images scripted in Photoshop (a series of digital prints).**

*__Authors:__*
*__Daniel C. Howe__*
City University
School of Creative Media

http://www.scm.cityu.edu.hk/

*__Abstract:__*
This series of procedural experiments in textual and visual language explores the theme of 'transformation', as both an artistic strategy and as a metaphor for human engagement with technology. The works leverage ExtendScript, Adobe's JavaScript scripting engine, to transform inputs (texts, images, dictionaries) into novel generative outputs.

*From 'Women' (series) by Daniel C. Howe, digital prints* (50x70cm) *on canvas, 2012*

*From 'Wreckage' (series) by Daniel C. Howe, digital prints* (50x70cm) *on canvas, 2012*

…

*__Contact:__*
*__danihowe@cityu.edu.hk__*

*__Keywords:__*
Transformation, generative, photoshop, extendscript, javascript

**Massimo Gasperini**

## Spirals from a board

*Topic: Art*

***In memory of:***

***Massimo Gasperini 1945-2013***

and his participation to the last three GAConferences

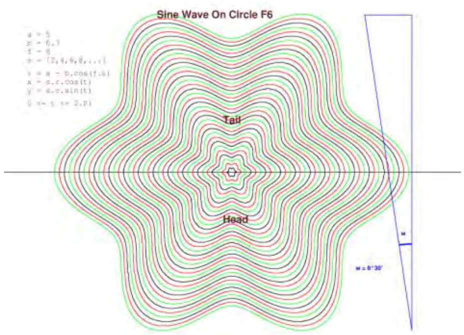
www.despiramirabilis.com

Massimo Gasperini was a Generative Sculptor and Jazz player. He died unexpectedly this year. He participated to the last GA Conferences with his artworks. So, for remembering him, two sculptures of his production are presented in this exhibition.

***from his abstract of GA2012:***

"Bowl from a board" is an old technique used by woodworkers: you cut concentric circles on a wooden board at a bevel angle, and stacking them up you get a bowl. Remarkably, if you use wedges instead of boards you get a logarithmic spiral.

Massimo wrote software to draw the outlines of the segments to be cut on the wedge. These segments are not only circles, but ellipses and other curves like sine curves and fourth grade functions.




Changing the parameters of the curves and the angle of the wedge he obtained countless 3D surfaces. These wood sculptures were sections of these surfaces, which can have negative or positive curvatures.

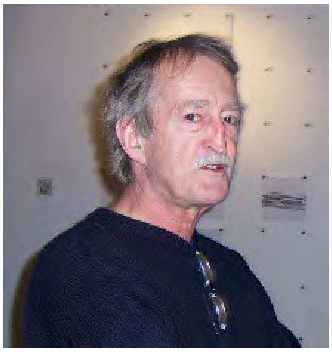
"Curds' Evolution" and "Third report from Gerico"

***Contact his son: marco.gasperini@libero.it***

***Keywords:*** logarithmic spiral, wood sculpture, mathematical art

**Paul S. Coates**

## In Memory of Paul Coates



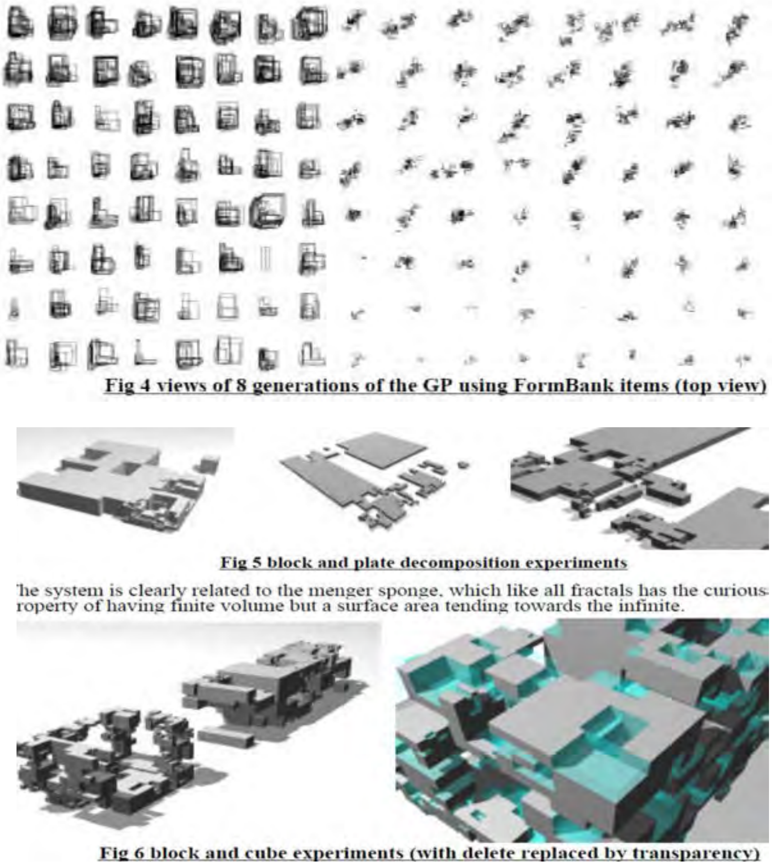
***Topic: Architecture***

***In Memory of***
***Paul Coates***
***1945-2013***

***and his participation to several GA Conferences, starting from the second, GA'99***

Paul Coates, after initially teaching at Liverpool Polytechnic, he developed his main body of research into computer design systems at the University of East London where he founded the MSc Computing & Design in 1991 and where he continued to teach until 2011.
Here, he refined his work on many artificial-life (AL) and intelligence (AI) methods for architectural design, which inspired research around the world and laid the foundations for many developments and academic courses in architectural computing to this day. In 2009 he received the Excellence for Innovative Research award by the Association for Computer Aided Design in Architecture (ACADIA).
Coates' work was not quite finished. But a generation of students and colleagues are carrying on his legacy. Over the last ten years, former students have begun implementing his thinking into the industry context where live projects and design methodologies are starting to translate his research into reality.

*Some images from his paper at GA2001*




***Keywords:*** computer design architecture

Francis Bacon, repainting Velasquez and portrait of Lucien Freud

# *LIVE PERFORMANCES*

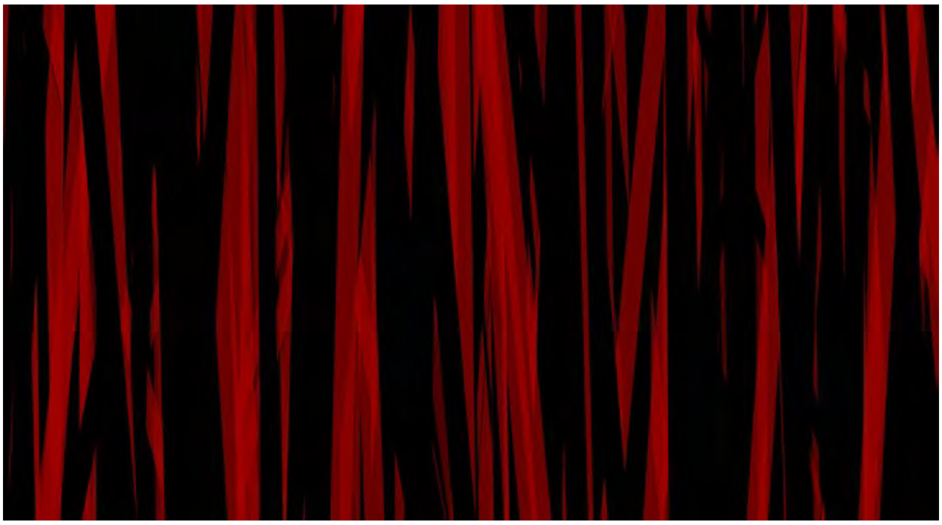
| | |
|---|---|
| **Enrico Zimuel** | *Live Performance:* **Random cuts** |

***Topic: Generative Art, Cellular Automata, Music,***

***Authors:***
***Enrico "Catodo" Zimuel***
Independent artist
Turin (Italy)
www.catodo.net

***Abstract:***

The cut as constructive or destructive act. Using a custom software, based on a generative algorithm produced by the author, this live performance shows the ambivalence of the cut as constructive and destructive act. The performer uses a parametric software, based on a cellular automata algorithm, to generates video and audio. The images are produced with random lines (cuts) drawn on the screen (projector) with different sizes and colors. To represent the destructive cuts, the algorithm draws black lines to simulate a delete action, overwriting the previous shapes. A live video is produced with this simple idea.
At the same time, the performer produces sounds using the same parameter of the visual algorithm, manipulating a sound synthesizer, produced by the author.
The idea of this live performance comes from a generative art work presented by the author in [1]. In this previous work, the generation of the sounds was not included.



*Example: extract of the video "Random Cuts" [1]*

***References:***
[1] E. Zimuel, "*Random Cuts*", *http://vimeo.com/61521947*, Extract from the exhibition *Sul filo della Lama*, Scarperia (Firenze), 2013

***Contact:***
***e.zimuel@gmail.com***

***Keywords:***
Audiovisual performance, evolutionary computation, abstract animation, cellular automata, electronic music

**Jeffrey M. Morris**

*Live Performance:* **Tappatappatappa**

***Topic: Music***

***Authors:***
***Jeffrey M. Morris***
Texas A&M University,
Department of
Performance Studies
USA
perf.tamu.edu

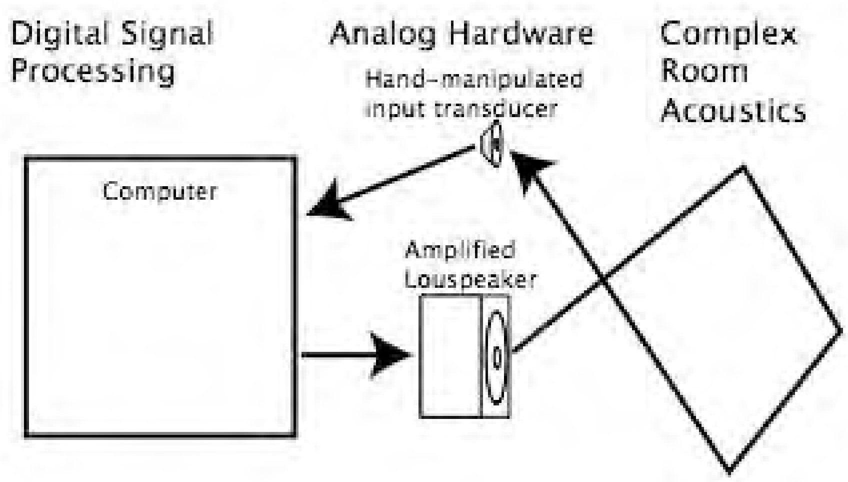
***References:***
[1]
http://www.morrismusic.org/2006/bellingham-electronic-arts-festival
[2]
http://www.morrismusic.org/2011/tappatappatappa

***Abstract:***
*Tappatappatappa* is a performance for improvising computer in a complex feedback system, merely guided by a human performer. Discovered while creating a generative agent for a live sampling composition for solo cello, *Tappatappatappa* uses its own output as its input, in a complex feedback loop including three stages: digital signal processing (constantly changing according to its own algorithms), the complex acoustics of the performance space, and the analog input and output hardware.

The human performer is only able to shape the performance in one of three ways: 1) introducing small sounds to the system by tapping or scraping the input transducer (a cone speaker used as a dynamic microphone) that can coax the voice of the system to bloom like a pearl around a grain of sand, 2) a few limited commands to the software, mainly like a conductor, calling for new actions to happen (but the details of the resulting actions are decided by the software), or 3) moving the input transducer around in the performance space, allowing new acoustic modes to resonate or damping resonances by pressing on the transducer.

The result is the emergent voice of the complex multimodal system itself, with the human performer limited to the role of sometimes-conductor, sometimes-animal tamer, grasping at invisible resonant modes illuminated by the feedback system. Recording examples are at references [1] and [2].

Requirements: Stereo PA and space/power onstage for performer with laptop.



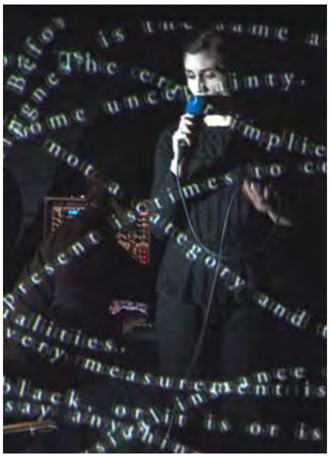

*Example: Digital, analog, and acoustic stages of the feedback loop.*

***Contact:***
***morris@tamu.edu***

***Keywords:***
Feedback, improvisation, aesthetics, emergence, DSP

**INIRE**

*Live Performance:* ***Subsensorial Transmission***



***Topic: Art***

***Authors:***
**INIRE**

**Krzysztof Pawlik**
**Małgorzata Dancewicz**

***www.inire.net***

***References:***
***http://vimeo.com/36210942***
***http://vimeo.com/36229280***
***http://vimeo.com/36210274***

*Subsensorial Transmission* is – from the one part the fascination of the human mind, its depth and possibilities that lies still unexplored, although strongly researched – on the other, fear of losing uniqueness of listening, seeing, feeling and understanding art. The main project issue is the question about measuring beauty and it's impact factor.

The form of the performance, inspired by the structure and activity of the brain and mind, is constructed of non-figurative generated and synthesized images and sounds, reffering to the nerve and glial cells shapes and juxtaposed with the sounds and voices of the performers.

Dimension of visual and aural perception, art message as pure feeling, perception without context and interpratation – is it still possible to conceive?

The most important compositional element of the performance is active, semiotically uninvolved common presence of the sender and receiver in common aesthetic experience.

Project was supported by

Adam Mickiewicz Institute
CULTURE.PL

***Contact:***
***dancewicz@wp.pl***
***+48 505 057 027***

***Keywords:***
audiovisual performance, field recording,neuroesthetic,

**Marco Cardini**

*Live stereoscopic painting – Stereoscopic Artworks:*
**TITLE: Nocturn**

***Topic: Stereoscopic Painting - Informational Art.***

***Author:***

***painting and music***

***Marco Cardini***

*Facebook: Marco Cardini*
*www.marcocardini.com*

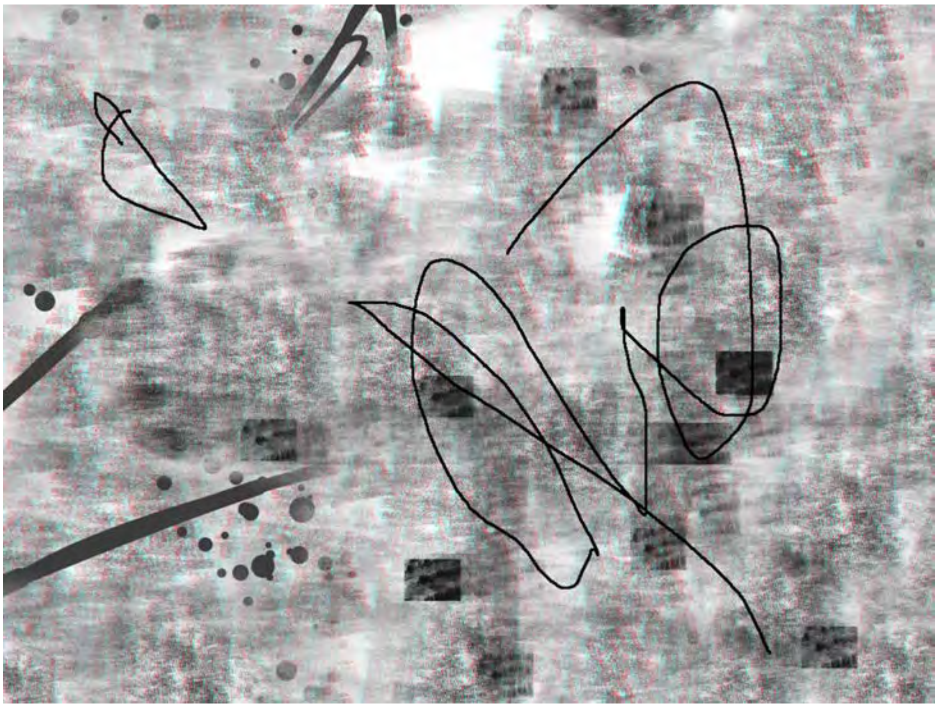
**References:**

Software PAGe MMM, (Painting by Aerial Gesture)
Realized by ComputerART Lab ISTI – A.Faedo C.N.R. Pisa IT

***Abstract:***

schema sistema PAGe

The painting in real time with stereoscopic 3D digital brusche, allows you to create multi-dimensional space of visual perception. Realigning the pixels of brusche with cyan and red optical filters, it is possible to compose multiple levels of perception visible in space. The PAGe MMM system consists of a program which allows the realization of visual/sound digital works of art executed in realtime under the control of the gesture of the performer.

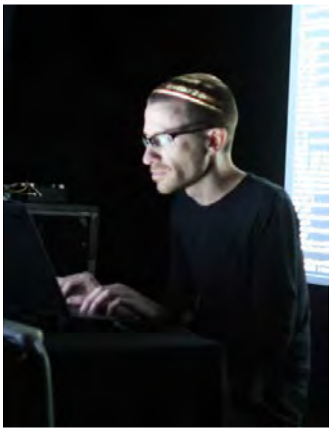


*pittorecibernetico@gmail.com*

*Keywords:* Light Painting, 3D painting, Stelle 3D, Digital painting 3D, immagini 3D.

**Renick Bell**

# *Live Performance:* **IMPROVISATION**



***Abstract:***
Using a custom live coding system on a laptop, between 15 minutes and one hour (according to the organizer's scheduling of the concert) of improvised programming generates percussive music played through a sound system with ample bass. That coding is projected on the largest possible screen. The improvisation flows through distinct sections and employs thousands of audio samples. It emphasizes generative rhythms and variation of event density. For some examples, see [1,2].

A library called Conductive [3], written by Bell to solve the problem of time-constraints in live coding, triggers a software sampler. In the performance, that and other prepared code is loaded into an editor and edited. New code is entered, and code is sent to an interpreter to be run. Doing so, Bell manages multiple concurrent processes that spawn events, including the number of processes, the type of events those processes spawn, and other parameters.

A live coding performance consists of a network of potential percepts like rhythms, timbres, event density, rate of change, programming libraries, projection contents, and performance space. Software abstractions can be directly perceived or indirectly felt through their influence on other percepts. Chief among these abstractions are those which represent generative processes. Audiences are made aware of the generative processes, their representations in code, and their output. Encountering this set of percepts makes an art experience, as described by John Dewey [4,5].

*Bell doing a live coding performance in Graz, Austria in May 2013.*

***Topic: Music***

***Authors:***
***Renick Bell***
Tama Art University,
Tokyo, Japan
www.tamabi.ac.jp

***References:***

[1] http://www.youtube.com/watch?v=1hskIYnal_o
[2] https://soundcloud.com/renick/renick-bell-live-coding-at
[3] R. Bell, "An Approach to Live Algorithmic Composition using Conductive," in Proceedings of LAC 2013, 2013.
[4] R. Bell, "Towards Useful Aesthetic Evaluations of Live Coding," in Proceedings of the International Computer Music Conference, 2013.
[5] J. Dewey, Art as Experience. Perigee Trade, 2005.

***Contact:***
***renick@gmail.com***

***Keywords:***
live coding, algorithmic composition, generated rhythms, algorave

printed in Milan the 28th of December 2013
ISBN 978-88-96610-25-1

# GA2013

XVI Generative Art conference
La Triennale di Milano, Italy
organized by Celestino Soddu and Enrica Colabella
Generative Design Lab
Politecnico di Milano

Domus Argenia Publisher
ISBN 978 88 96610 25 1

www.generativeart.com