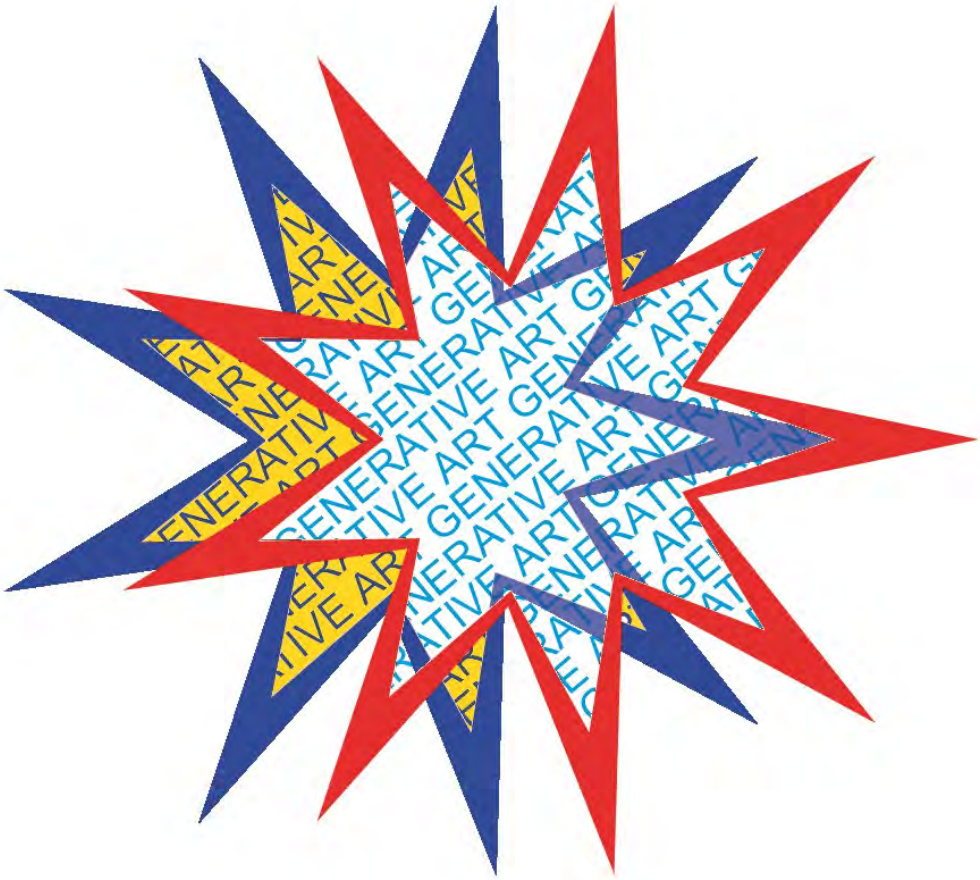
XX GENERATIVE ART 2017

proceedings of
XX Generative Art conference

edited by
Celestino Soddu
Enrica Colabella



GENERATIVE ART 2017

GA2017, XX International Conference

Ravenna, 13, 14, 15 Dec. 2017 at Biblioteca Classense and MAR, Museum of Art

Proceedings

Edited by Celestino Soddu and Enrica Colabella

Generative Design Lab, Politecnico di Milano University, Italy
Argenia Ass. Roma, Italy

The book contains the papers, installations, artworks and live performances presented at XX Generative Art conference in Ravenna, Italy.

In the 1st cover, a generated Mosaic-Architecture, a generative study on the futuring Identity of Ravenna. The architectures are generated by Celestino Soddu, designing, with his own Argenia software, a possible artificial DNA of Ravenna.

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Ravenna, Ultima Cena, Sant'Apollinare Nuovo

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Opening

Firstly our thanks to Ravenna, to MAR, the museum of art, and Classense Library that hosting our XX Generative Art conference and particularly to the Director Maurizio Tarantino and his collaborators Marta Zocchi and Francesca Boschetti.
Twenty years ago, the first Generative Art conference took place in Politecnico di Milano University with a great enthusiasm and open mind for different and new fields of Art and Science.
Now Generative Art is well known all over the world with very interesting open doors in Art toward the complexity of our time, also with really different intents and significances. Frequently people call GA all the digital art and, often, it has been used to propose a creative approach based on random and not on the interpretative creation of logical complex processes for generating artworks.
During these two decades of Generative Art conferences, several papers and artworks delineated many different possibilities and characteristics of Generative art, by finding specifications, convergences, and interchanges. And our meeting was really a space for discussions and knowledge. We are really grateful to artists, scientists and researchers that participated in these GA conferences and discussions with their enthusiasm and knowledge.
Since our first studies on complex intelligent systems, we tried to follow the Renaissance vision with the close relationship between Art and Science, which was strongly emerging since the first Generative Art conference twenty years ago.
Since the first GA conferences, we identified a bridge from past toward the future for gaining a quality open toward complexity in Generative Art processes. This is the basic structure for gaining answers to new questions that is the main role of an artist. We hope that this approach can connect also different visions for gaining as a river aesthetic quality of our time toward the sea.
The future can hold us the surprise of not being so fascinated by technology as a novelty but to find humanistic interest in a new approach, where technology is only the tool for enhancing own creativity, uniqueness, and ability to a logical interpretation of future. As it is happening in the scientific research, as medicine, where advanced technology is used for focused approaches to uniqueness and diversity.
It would be interesting to discuss and evaluate together how we would like Generative Art in the next future. Where we would like to continue in meeting generative artists who find the possibility of building their own generative tools and we would like to think to an advanced technology that opens to different contents and that enhances the creative potential of everyone. In a world where identity, expressed and amplified through Generative Art, is appreciated as an increasing subjective identity, as an expanding knowledge of the world.

Celestino Soddu and Enrica Colabella
Chairs of Generative Art conferences

PAPERS

Designing Generative Art.
Mosaic concept, Creativity, and Idea in Generative Design
(Paper and artworks)
Topic: (Generative Art approach, architectural design)

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How to Design a Generating Event. I would like to take advantage of the fact that we are in Ravenna, the capital of the mosaic, to make some considerations on my approach to generative art. As the mosaic involves, as parallel fields, the small scale of each tile and the large scale of the image, so my generative approach works simultaneously on the small and the large scale.
This parallelism and strong correlation between detail and total space have always been one of my creative matrices, even in my oil paintings of the 1960s/1980s.
Since 1985, in my generative works, the progressive transformations of the basic elements and the spatial evolution of the whole space have always been intimately connected and were made through the same algorithms that mirrored my vision of architecture.
It was therefore easy, this year, to perform, for this meeting in Ravenna, the generation of mosaic-architectures able to focus a possibility to reinforce Ravenna's in-process identity with this strong relationship between mosaic, architecture and the urban space.
These generated architectures are, however, a three-dimensional mosaic. Every single tile is a three-dimensional event able to spatially reflect the light becoming an integral part of the total architectural image. This interchange between 3D events at small and large scale lights up a recognizable identity and, in my intentions, is strongly representative of futuring Ravenna identity.

2 Oil Paintings, NYC Guggenheim Museum and NYC Brodway/5th ave, C.Soddu 1985 - Mosaic Architectures for Ravenna Identity in front of MAR - 4 Mosaic-Architectures details C.Soddu 2017

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Keywords: mosaic, generative approach, architecture

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[1] www.generativedesign.com
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Designing Generative Art.
Mosaic concept, Creativity, and Idea in Generative Design

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The ancient harbor of Ravenna

Abstract

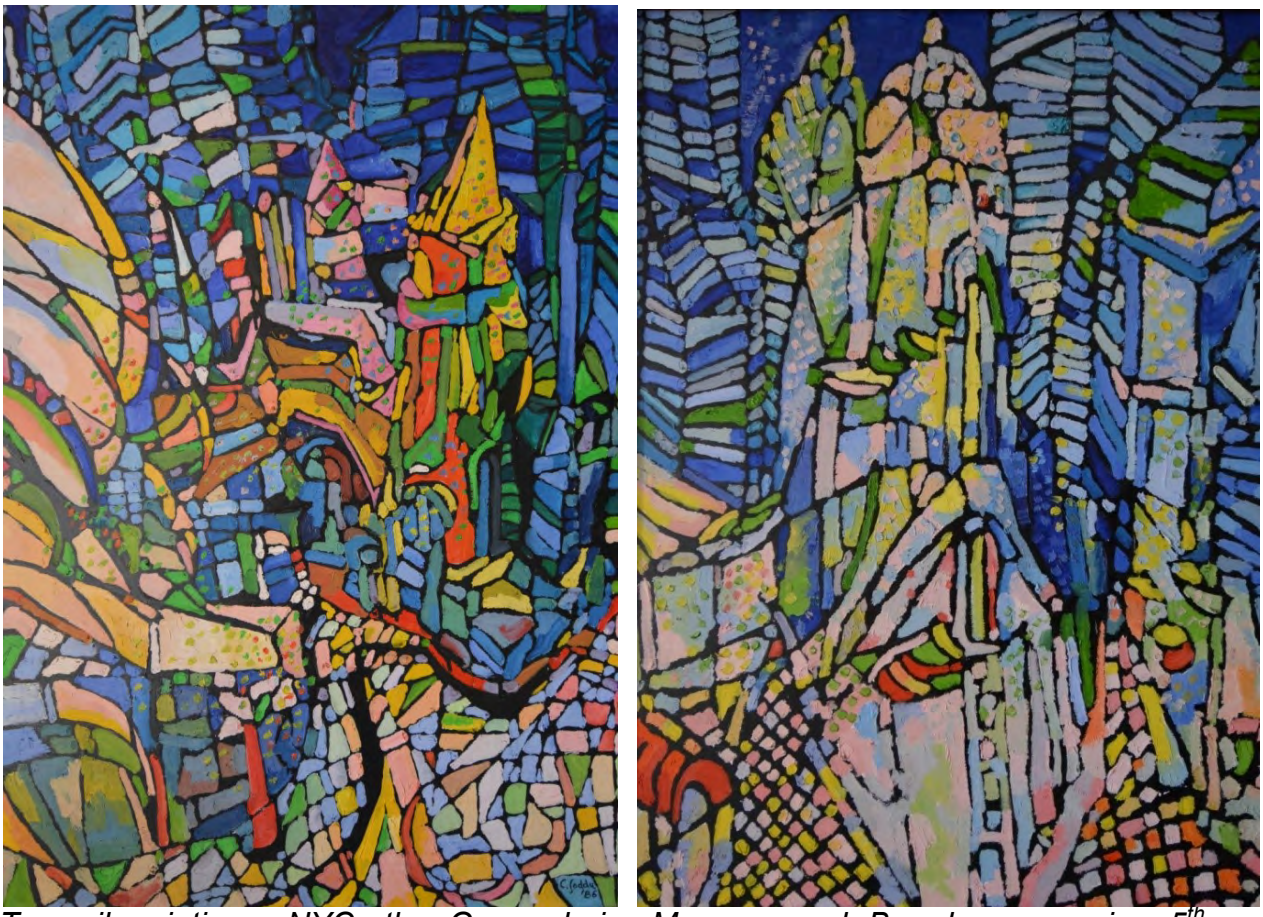
We are in Ravenna and I would like to suggest some reflections on the generative approach starting from the art of mosaic. Also in relation to my last work about the urban identity of Ravenna, I like to face the Generative Architectural Design to the mosaic structure. The occasion is the XX Generative Art conference and the aim of my last generative work was to make Ravenna more Ravenna than before focusing the mosaic structure of futuring architectures.

The relationship is that the structure of the mosaic tiles as ***repeated parts in variations*** and the structure of the set doesn't belong only to the mosaic feature but also focus the characteristics and organizational structure of my creative work since the sixties. This structural feature is explicitly present in my oil painting works since the sixties as well as in the structure of my generative approach to architecture, art, design, and music that I developed since the eighties.

The pictorial approach was to represent the single tile as a plan element that was born from a brush stroke. But it was performed by transforming its geometry as related to the three-dimensional spatial structure of the whole event.
Each basic rectangle was represented, after a transformation in a circular field, as a curved element, circular point, and so on, by maintaining, on one side, its basic element

identity, that is achievable with a unique and un-repeatable brush strokes and, on the other side, by strongly alluding to its role in the entire space of the set. The shape of the element and its color/light indicated both the uniqueness of the event and its layout in three-dimensional space.

The geometric control system of the totality has always been, since the early years of my creative activity, strongly ***oriented towards the non-Euclidean representations of the 3D space where it was possible to identify multiple observation points with progressive dynamic rotations*** but also multiple vanishing points of single bundles of parallel lines.



Two oil paintings, NYC, the Guggenheim Museum and Broadway crossing 5th ave. C.Soddu 1986. The like-mosaic structure and the curved space representation is explicit and it is a constant of my work.

The geometric arrangement of the tiles and the geometric arrangement of the totality are therefore two aspects of the same idea developed with different geometric logic. The aim is to establish a relationship between the two dimensions of the painting and the three dimensions of the space. This happens through different geometric transformations: in the tiles through the transformation and the ***progressive characterization*** of the base rectangle, the brushstroke; in the totality through the ***curvature of the space*** represented to pursue the progressive dynamics of the vision that can ***wrap the space around the observer***.

In the sixties I was a jazz player and this creative approach is performed like a jam session. The fragmented structure of small-scale elements is the rhythm of the piece ever changing and with no repetition. A mix of drums and bass that cannot be understood as an

accompaniment but an essential part of the music. It's not a case that, in the sixties, I played not only the clarinet but also the contrabass. **The rhythm is a continue interpretation of the theme, structured with subsequent variations.** My main reference was the Modern Jazz quartet where the drums of Connie Kay and the bass of Percy Heath play with a sequence of "generative" variations, ever unpredictable, and had the same importance as John Lewis and Milt Jackson variations. Looking at my oil paintings of that period, as the image of Guggenheim museum in NYC, the structure is the same and the spirals of the museum of Frank Lloyd Wright is like a solo of Coltrane playing with the Modern Jazz Quartet. Or I followed this vision when painting it.
But Music and painting are not my main field of expression. I am an architect and music and two-dimensional images are only paradigms of my space vision.

My generative approach

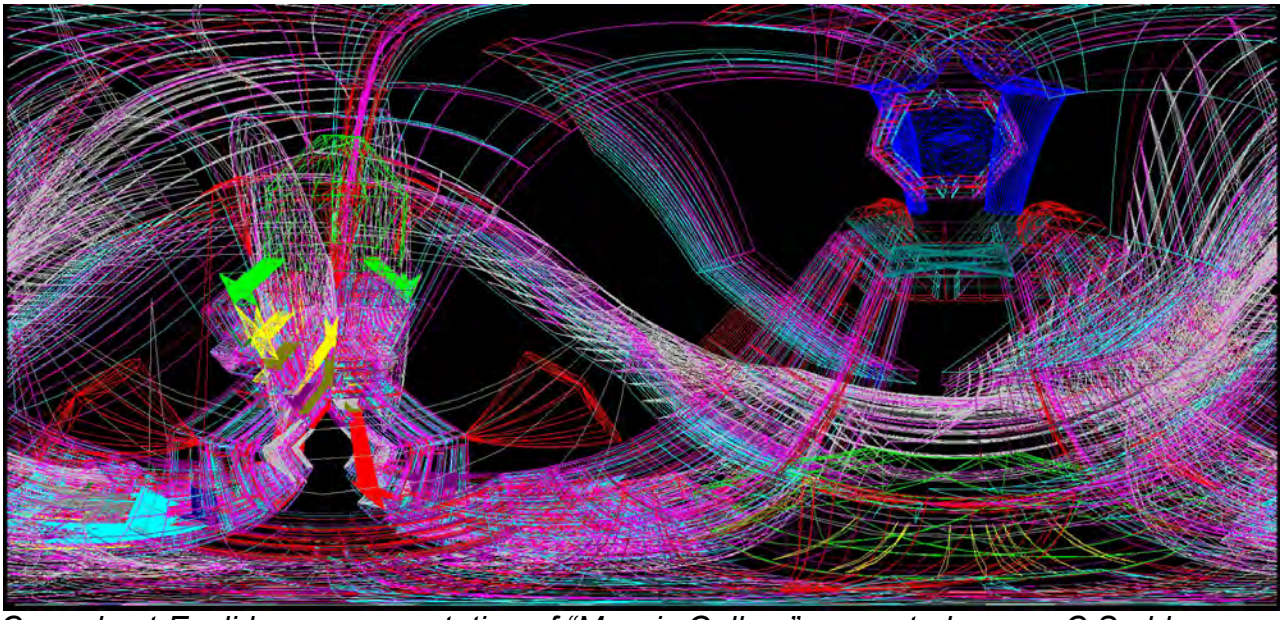
In the early eighties, I defined my aim: representing my vision in architecture with codes, following the Renaissance cultural approach: art and science together as a logical interpretation of existing and possible worlds. This changed my design approach from forming to transforming, from shapes to processes, from drawings to algorithms. But I didn't change the structure of my creativity that continues to follow the structure of mosaic: rhythm, riffs, and melody.
This approach had a chance: ***the possibility to directly design my vision, my idea of architecture and Ideal cities before carrying out any possible result, together with the possibility to directly managing the complexity***. The Idea is performed by constructing something like an artificial DNA, a generative code able to generate endless variations of 3D models of cities and architectures, all characterized by my vision but all different, unique and unpredictable, as in Nature.
Each code is one of my operative interpretation of my favorite cities, able to perform a character. Altogether the codes are a system, like a logical labyrinth, able to generate a sequence of events belonging to my vision. Each generated species of cities is identifiable and recognizable as belonging to a peculiar Idea, an interpretation of the Past.
As DNA in Nature, these generative codes are executable logical processes able to manage subsequent transformations toward the complexity. If the base is the interpretation of the Past, as I am doing now for Ravenna, the codes can perform the progressive transformations toward the Future. (www.futuringpast.com) This is the second aim of my work: ***designing the Identity of architectures and cities***. The Generative Codes identify and manage each city identity, each Ideal City, as transforming process toward the Future.
The results are sequences of architectures, objects, and cities all different, really complex and recognizable as belonging to my architectural and urban vision. They are not simple images but fully performed 3D models, with exterior and interior spaces and fully performed 3D details. Each generated file is ready to be printed with 3D printers.

Mosaic and generative approach

The experiences in music and oil painting were an important starting point for my generative approach because they helped me in a progressive acquiring geometric complexity and strong recognizable characters. The recognition of details, their strong rhythmical unpredictable sequence, and their progressive generation was kept alive going from a brushstroke to a generated 3d "tile" event. The connection system of the totality remains in its multiple relationships structures. The paradigm representing the idea through a complex topological structure that appears, often, curved was made by using

anamorphic prospective representations.

This curvature, this anamorphic bending of right lines was, and is, really important for me because of its strong ability to join the entire space around the observer, and constructing a geometry directly interacting with him. ***The bending space was, for me, one of the generative tools for joining the rhythm and the melody***. The waves of the rhythm create the interface between “tiles” and their flowing into unique events.



Curved not-Euclidean representation of “Mosaic Gallery” generated space. C.Soddu

In my generative approach to architecture, ***the tiles became three-dimensional events***. From the single triangle, that is the basic event in the construction of a three-dimensional space, the tile becomes a volume that assumes the shape resulting from a spatial transformation oriented to being part of the whole generated space, but also from an orientation that defines its character and peculiarity.

The ***geometric control system of the totality***, starting from a topological paradigm of an architectural space, ***is performed as a geometric transformation-deformation system*** that abandons the Cartesian orthogonal grid for systems that reconnect the parallel bundles of curves, and dynamically find the possibility of complex topologies.
These ***topological paradigms and transforming not-Euclidean systems*** are not constructed in static shapes but build in a reference system for the progressive generation of architectures that explicitly refer to my performing design concept before it has come into the formal choice.

Bending the space topology

Of course, in these transformations of the original Cartesian design, the structure of basic relationships remains fundamental, although the progressive interconnections generated by space folds increase the topological wealth of the architectural space event. This creates and improves the relationships and interfaces between the parties.
Following that the details can be able to assume importance and character. My references were the Middle Ages images of cities, the Renaissance and, above all, the Baroque, ending to my main master, Gaudi.

For the Baroque, particularly, this paradigm of geometric transformations was born from my interpretation of Borromini that, in his work, used the transformation of the classical geometric structures by performing new spatial relations systems. These transformations did not change the classical geometric canons but integrated them with new relationships that were originated from the curvature of the architectural space.
Details drawn by Borromini are curved events able to fix and act a progressive construction following a spatial concept and improving the character of his architectural vision.

What I did, building the generation of contemporary baroque spaces, was born from the rereading and interpretations of these progressive transformations, these curves of the Cartesian pattern of the paradigm that Borromini had begun to use.

My further experimentations went ahead because the generative approach, with the possibility of experimenting with multiple geometric algorithms and their possible mutual contamination, gave me the possibility of controlling the complexity of possible variations. It was, for me, the only possibility of reviving Baroque thought in contemporary time. The Baroque thought, in my interpretation, is never a casual approach to the forms but a conscious approach to the potential of geometric structures and of innovative spatial topologies. This progressive approach gives the possibility to explain an idea of complex-recognizable architecture.

In the same years, I went ahead experimenting a generative music approach by constructing my software “musicablu”. This is structured with the same vision. The results are based on my interpretation of “my favorite things”: Coltrane, Modern Jazz Quartet, the Bach Fugues variations and Beatles sequence of harmonies that I interpreted as spatial moving, an increasing variation from an accord to another sliding from a fixed tonality to a dynamic harmonic sequence.

Ravenna experiments

In the experiment I did for Ravenna in these months starting from the ancient images of this city as peculiar paradigm, I tried to develop this generative approach from detail to totality with the aim to construct elements for the identity of Ravenna. Or, at least, discovering how increasing and communicating this identity could be possible through generative architectures that I call Mosiac-Architectures.

Mosaics are very important for Ravenna. The greatest difficulty in finding the mosaic as a feature of the architecture, therefore of the spatiality of events, is that the mosaic is naturally highly readable on a small scale. More, this becomes only a surface treatment in the scale of the building. My first attempts were developed by inserting mosaics into the generated surfaces and volumes but this was not a feature of architectural and urban identity, it did not seem enough to strongly identify Ravenna. In other words, Ravenna, with such architectures, did not increase its own identity and recognisability, as it was in my vision. Especially when we considered not only the detail scale but the urban scale.

Two generated “Mosaic Galleries” in front of MAR, Ravenna. C.Soddu 2017.

A generative idea *ad hoc* and, following, a generative focused technique was needed to build the recognizability that I was searching for. A creative path able to unveil the character based on my interpretation of Ravenna's urban identity and able to represent this idea.

Two mirroring variations of Mosaic Galleries in Piazza del Popolo, Ravenna. CS2017

There are many references to the use of mosaics in the characterization of architecture. In addition to the Byzantine mosaics, my favorite one is the use of mosaics in Gaudi's architectures that I always considered one of my reference masters for my architecture. I found in these mosaics the same relationship between rhythms, riffs and melody variations that performs my creative approach.

Details of mosaic-architectures designed for Ravenna. Generated "galleries" C.Soddu 2017.

But my idea of architecture is based on ***a three-dimensional space identity running progressively from details to the whole*** building. For me, ***the mosaic is a set of events whose diversity and identity is based on a strongly three-dimensional relationship with space***. So, after several attempts, I chose a different but allusive way to of *unveiling the potential identity Ravenna*. I chose to create algorithms that perform the individual tiles so that they are sensitive to their location and spatial orientation. At the same time, I followed the concept of the mutual importance of rhythms, riffs and exceptional sequences in performing the space. I have done that for fitting my vision of architecture.

To achieve that I worked on the ***morphogenetic definition of each 3D tile***. I built three-dimensional events based on the orientation of each face of the skin surfaces by using the normals, that are the spatial orientation of each face. Every single event is therefore

generated to be sensitive to light and thus to communicate its orientation. Each "tile", precisely because of the space-light relationship that is highlighted, is such that it can improve, as mosaic do, the relationship between detail and the whole, and to the possibility of being, even visually, identifiable and able to characterize the whole building. These "tiles" become an important part of the urban context in which they are inserted.
I privileged the relationship between geometry and light on geometry and color. In architecture, the relationship between geometry and light has strongly characterized the history of Italian architecture, much more than, for example, the relationship between geometry and color, which has strongly characterized other cultural identities.
My final images seem to be, I know, a little dark. But the shadows are essential to communicate the space structure. I like Caravaggio for the smell of infinite space around the lighted images, also if I like Giotto too, with no shadows, for his strong visionary way to show his medieval cities by using non-linear sequences of dynamic points of view. (the book “L’immagine non Euclidea”, C.Soddu, Gangemi Publ. 1986)

Two mirroring generated mosaic-architectures with a central paradigm in the Ravenna downtown. C.Soddu 2017.

Following the importance of shadows, the mosaic tiles I have created in my architectures do not have the color as a characterizing element. It is the light that always colors the tiles differently and, through the refractions, defines the orientation and the space relationship with the whole. And this, in the architectural image, does not only involve detail, as if it was to read the color of each tile, but also involves the larger architectural and urban image, just because the tiles amplify the role of the same light in the communication of the

architectural space event, even on an urban scale.

Generated mosaic-architectures in the downtown of Ravenna. C.Soddu 2017.

Mosaic and Generative Design

My opinion is that this type of approach reinforces an important aspect of Generative Design. ***The generative approach expresses a possibility that characterizes and distinguishes it: the possibility of setting up a personal tool capable of reflecting and amplifying the subjective idea, the design creativity of each artist***.
The generative approach, building tools (algorithms) in harmony with one's own creativity, amplifies the identity of the artworks, and also, for the artist, **the knowledge of himself and his vision**.
Building own instrument, own algorithms, each artist builds his visionary vision, his uniqueness.

Surely, without a generative, logical and operational approach, I could never build so complex architectures and so close to the idea I had in mind. But the idea was on the basis of the operational technical path to reach it.

Two mirroring variations of generated architectures in Ravenna downtown. C.Soddu 2017

Idea, Creativity in Generative Design

The idea. Each generative approach must be based on an idea. Performing a new idea is really difficult if we use commercial tools and not tools built on ad hoc. Each artist, along with the idea, also creates the technique to perform it. And generative art follows and amplify this possibility.
In this, it is clear that generative design is not only a technology, a casual search tool for capturing forms, as many people often tend to consider it today. ***Generative Design is a project approach that can enhance own creativity, own designer identity***, the character of own being an architect. It's like having a large team of architects working for us, each of which develops possible variations of every detail and every overall layout. A group of draftsmen designs that think like you and that produces infinite variations of your idea. And we are sure that variations are the best way to communicate an idea. As Bach has taught us with his Fugues.

Generated artificial isle in front of Ravenna, C.Soddu 2017

Two generated mirroring variations of a tower in the ancient harbor of Ravenna. C.Soddu 2017

Mosaic-architecture in Piazza del Popolo, Ravenna. Variation 3. C.Soddu 2017

But this idea must exist. It cannot be derived from the tools, even by generative software created by others. It must be expressed a priori and pursued in developing the algorithms, transformation logic, topologies, and space bends that represent this idea before it becomes an achievable three-dimensional architecture.

Using advanced and sophisticated tools does not make everyone an architect, or an artist, or a musician. Instruments and technologies are not capable of turning a man without ideas into a genius. They only amplify his limits, which is explicit, above all, in the lack of character and in the impossibility of recognizing his works among others.

The recognition of an artwork is in fact directly linked to the presence of an idea. Using advanced tools, we only can easily pass from idea to its executive representation, or even to a result, in a very short time.

Mosaic-architecture in Piazza del Popolo, Ravenna. Variation 4. C.Soddu 2017

Generative Art is the art, understood as skill, to build processes capable of generating results representing the vision of an artist. The artwork is the generative process.

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All books are for free download at www.artscience-ebookshop.com

Two mirroring generated Mosaic Architectures in the ancient harbor of Ravenna, C.Soddu 2017

AESTHETIC-ORIENTED GENERATION OF ARCHITECTONIC OBJECTS WITH THE USE OF EVOLUTIONARY PROGRAMMING *(Paper)*

Topic: Architecture

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Abstract
The process of architecture design involves self-expression of the architect, which results in artistic values added to the designed object. Author's creativity correlates with viewer's aesthetic experiences and it seems necessary to put some dose of human imagination into the project to obtain emotional response. An architectonic object, as any other piece of art, takes part in the dialogue with other artifacts and refers to cultural and historical context.
Therefore, the task put before automatic design of architecture is very difficult. At the moment, it is not possible for artificial intelligence to imitate human way of thinking during the design process, and none computer program is equipped with the knowledge about the world that is available for even the least talented architect. However, there is plenty of evidence that objects created by people are not the only ones appreciated by them for highly functional and aesthetic values. Products of evolution – living organisms – disregard human culture but anyways have the power to inspire many artists. They still are perceived as beautiful and harmonic by people, who themselves are a product of evolution as well. Evolutionary programming gives a chance to imitate to some degree the biological processes in order to obtain optimal solutions.
This paper aims to present a method of aesthetic-oriented generation of architectonic objects with the use of evolutionary programming. Because aesthetic evaluation of architectonic objects is associated with visual perception, it seems a suitable solution to use human perception model for the purpose of automatic design and automatic assessment of generated models. The proposed method is based on the Biederman's visual perception model, in which object recognition is assumed to be performed by investigation of components' shape and relation between them. Biederman has distinguished around forty basic components that majority of objects are composed of. They are called geons (geometric icons) and differ between each other by so-called non-accidental properties, i.e., properties that are easy to notice independently on the point of view: axis type, cross-section shape, symmetry, and change of cross section size
.In our approach geons are used as components to build architectonic objects prototypes. Each prototype has its structural representation in the form of graph, where nodes denote geons, while edges describe spatial relations between them. During the process of evolution, the prototype graphs – genotypes – are modified in the result of mutation and crossover. In result, after each step of evolution, a new generation of 3D models (phenotypes) is rendered. Evaluation is performed on the basis of Birkhoff's aesthetic measure adapted for 3D solids by means of the fitness function, which is supposed to prefer objects with higher aesthetic value. Symmetrical, harmonic forms with optimal equilibrium are preferred, however, some elements of chaos, that make the shape more interesting, may occur. Such selection imitates natural environment and therefore enables to generate objects related to organic forms appreciated by people.

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Keywords: aesthetic measure, automatic design of architecture, artificial creativity

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Aesthetic-Oriented Generation of Architectonic Objects with the Use of Evolutionary Programming

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Abstract

This aim of this paper is to present an aesthetic oriented evolutionary approach to design. The paper deals with creative design process which is characterized by the variability of design structure. Genotypes of architectonic objects are represented by graphs. Aesthetic evaluation of the objects is based on Biederman's visual perception model. Phenotypes represent configurations of Biederman's basic components essential for visual perception. The approach is illustrated by examples of phenotypes preferred by the fitness function with encoded aesthetic evaluation mechanism.

1. Introduction

The process of architecture design involves self-expression of the architect, which results in artistic values added to the designed object. Author's creativity corelates with viewer's aesthetic experiences and it seems necessary to put some dose of human imagination into the project to obtain emotional response. An architectonic object, as any other piece of art, takes part in the dialogue with other artifacts and refers to cultural and historical context. Therefore, the task put before automatic design of architecture is very difficult. At the moment, it is not possible for artificial intelligence to imitate human way of thinking during the design process, and none computer program is equipped with the knowledge about the world that is available for even the least talented architect. However, there is plenty of evidence that objects created by people are not the only ones appreciated by them for high functional and aesthetic values. Products of evolution – living organisms – disregard human culture and do not fit into definition of art, still they are perceived as beautiful and harmonic by people, who themselves are a product of evolution as well. Evolutionary programming gives a chance to imitate to some degree the biological processes in order to obtain optimal solutions.

This paper aims to present a method of aesthetic-oriented generation of architectonic objects prototypes with the use of evolutionary programming. The proposed method is based on Biederman's visual perception model, in which object recognition is assumed to be performed by investigation of components' shape and relation between them. Because aesthetic evaluation of architectonic objects is associated with visual perception, it seems a suitable solution to use human perception model for the purpose of automatic design and automatic assessment of generated models. In our approach, architectonic objects

prototypes are generated as configurations of some basic solids. Each prototype has its structural representation in the form of graph, where nodes denote components, while edges describe spatial relations between them. In genetic algorithms considered in this paper all prototypes are represented in two forms: in an encoded form of genotypes and in the decoded form of phenotypes. During the process of evolution, the prototype graphs – genotypes – are modified in the result of mutation and crossover. After each step of evolution a new generation of 3D models (phenotypes) is rendered.

The paper is organized as follows: First, the Recognition-by-Components perception model is explained and phenotypes of architectonic objects are presented as configurations of elementary shapes. Then, the structural representation of objects is proposed in the form of graph, which constitutes genotype for the evolutionary algorithm. Further sections contain the mutation and crossover operators, as well as the selection function, which is supposed to prefer objects with higher aesthetic value. Evaluation is performed by the fitness function basing on Birkhoff's aesthetic measure for polygons adapted for 3D solids. Symmetrical, harmonic forms with optimal equilibrium are preferred, however some elements of chaos, that make the shape more interesting, may occur. Such selection imitates natural environment and therefore enables to generate objects related to organic forms appreciated by people. The next section presents examples of the algorithm's performance, and, finally, some conclusion is made.

2. Phenotype

Aesthetic value of an architectonic object is not easy to represent for the purpose of computational design. We do not know how exactly aesthetic evaluation is performed by a human brain and whether it is possible to imitate this process by a computer. Because aesthetic evaluation is related to perception, it seems a promising solution to use a visual perception model in order to assess quality of a phenotype in an evolutionary algorithm focused on aesthetic values. One of two main perception theories – the view-independent model – appears to be more appropriate for this task. It assumes that object recognition is performed by division of a perceived figure into basic components and investigation of their shape and relations between each other. Contrary, the view-dependent model concentrates on recognition based on memorized views of an object – identification occurs when the most similar view is found. Although probably both models take part in human perception, the first one seems more useful for the purpose of computational design. We have decided to use an alphabet of elementary shapes to construct phenotypes of architectonic objects. This will enable the fitness function to analyse their properties and relations to other components, which may be a step forward finding computational analogues of hard-to-define elements of beauty – order, harmony, rhythm, coherence, etc.

2.1 Recognition-By-Components

The view-independent perception model was proposed by Marr [1] and further developed by Biederman [2] in his Recognition-By-Components theory (RBC), who described a set of

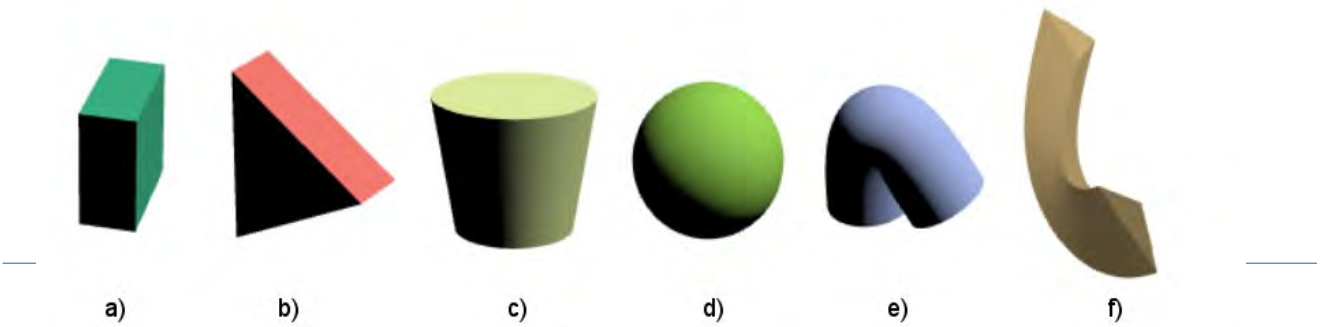

Figure 1. Geons

elementary shapes that most objects are divided into during the recognition process. These elements – so called geons – are characterized by lack of sharp concavities and can be described by some non-accidental properties, i.e., properties that are easy to recognize independently on the point of view. The most important of them are: cross section edges, which can be straight or curved, cross section symmetry (none, vertical, or vertical and rotational), cross section size change (constant, contract, or expand and contract), and axis type, which is straight or curved. These attributes are perceived by us with high accuracy even when a shape is partially covered or laid at an angle. Non-accidental properties define a type of geon – e.g. a prism or a cone – while exact parameters of a solid, like size or curvature of an axis, are specified by metric attributes. Metric properties take longer time to process and perception of them is prone to errors. For instance, it is quite easy to say that a solid's cross section is symmetrical and round, but its diameter length is difficult to assess. Combining possible values of non-accidental attributes results in 36 geon types. Exemplary geons are presented in Figure 1. Shapes in a), b), c) and d) are characterized by straight axis type, while the axis of e) and f) is curved. Cross section edges are curved in case of c), d) and e), and straight in a), b), f). Cross section symmetry of a), c), d) and e) is both vertical and rotational, b) is vertically symmetrical and f) can be characterized by lack of symmetry. The cross section contracts in c), expands and contracts in d), while in the rest of solids its size remains constant.

RBC theory describes also relations between geons. Again, the relation type can be recognized independently on the point of view. Biederman distinguished two main non-accidental relations: an end-to-end relation presented in Figure 2., and an end-to-side relation shown in Figure 3. The end-to-end relation takes place when two neighbouring geons contain a common surface, while the end-to-side relation occurs when a surface of one solid is attached to the larger surface of the second one. For the purpose of architecture design we propose also an overlap relation, illustrated in

Figure 2. End-to-end

Figure 3. End-to-side

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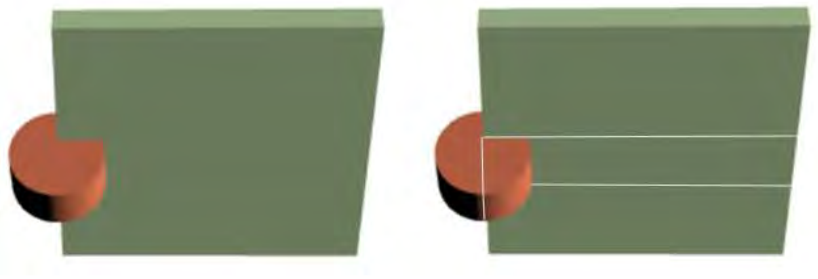

Figure 4. Overlap

Figure 4. The overlap relation enables construction of complex objects with the use of few geons and is based on assumption that human eye can identify a geon even when it is partially covered by another solid. In case of lack of the overlap relation, the object from Figure 4. must have been divided into five geons. Assumption that the components may overlap reduces the number of geons to two.

The proposed evolutionary algorithm builds phenotypes of architectonic objects from geons. Our approach assumes that in most cases aesthetic evaluation is based on non-accidental properties, i.e., only geon types are taken into account, disregarding metric information. Therefore, the most important part of the phenotype description are non-accidental attributes and relation types, although metric parameters are of course necessary to visualize a designed object.

3. Genotype

Figure 5. Phenotype

Evolutionary algorithm acts on the basis of genotypes - representations of phenotypes - to reproduce, mutate and select individuals [5] [7]. The proposed approach uses composite graphs [4] for structural representation of phenotypes introduced in the previous section. Composite graphs are directed graphs with nodes containing a set of bonds. Graph edges are attached to bonds. The presented genotype graphs contain nodes representing geons. Each node is described by two groups of attributes: non-accidental properties and metric parameters. Node bonds represent types of geon's surfaces and their number varies depending on the cross section shape. Figure 6. presents a graph structure of a phenotype in Figure 5. The phenotype consists of two overlapping geons. In the graph each of them is represented by two nodes connected by an edge labeled “overlap”. Each node contains a set of attributes (for clarity, only the non-accidental ones are listed), and a set of numbered bonds: no. 1 representing a top basis of a solid, no. 2 - a bottom basis, and no. 3 – a side surface.

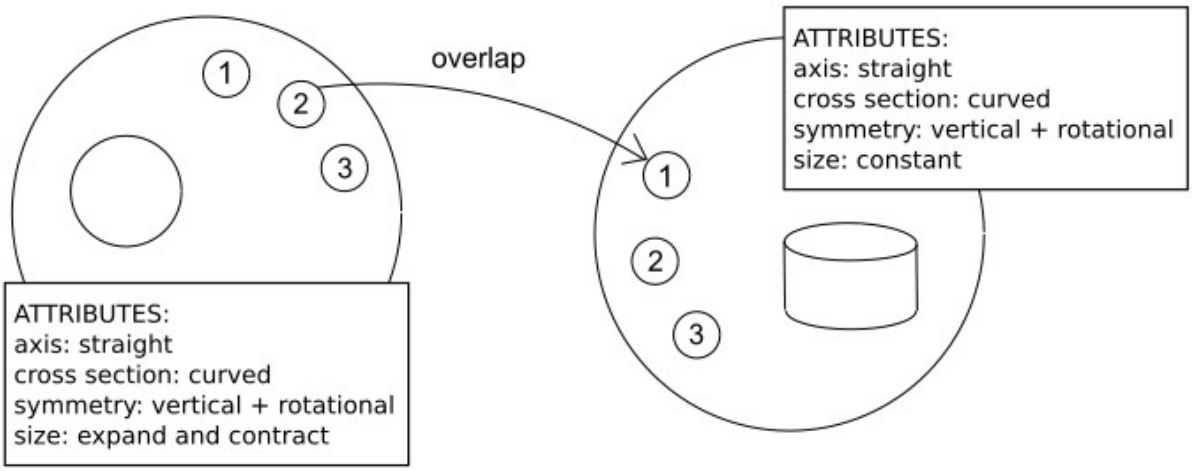

Figure 6. Genotype

4. Genetic operators

Genotypes are modified by means of two genetic operators: crossover and mutation. The way in which these genetic operators are defined strongly depends on the type of genotypes used in a given application. In this paper structures of architectonic objects are represented by means of graphs as genotypes. This representation of genotypes forces new interesting extensions of genetic operators.

4.1 Crossover

The crossover operator is called the major computational engine of genetic algorithms [6]. This operator enables reproduction. Selected individuals are randomly paired and on the basis of their genotypes new individuals are created. Crossover operator for binary strings divides parental genotypes at a given position and exchanges corresponding sub-strings. Applying the crossover operator to the nonstandard pair of genotypes in the form of graphs requires establishing, firstly, their sub-graphs that would be exchanged, and secondly, rules of embedding each of these sub-graphs in another parental genotype.
The presented alghoritm tries to divide a genotype graph into two subgraphs, each of them containing at least one node representing a geon located on the ground (a ground geon), which is indicated by a metric attribute defining location of its bottom basis. In case of only one ground geon in the structure, the second subgraph is a null graph containing no nodes. All the edges between obtained subgraphs are removed. All the other edges remain the same, unless there is a node connected to two ground geon nodes from different subgraphs. In that case, it is randomly allocated to one of the subgraph. After division, the first subgraph of the first graph is merged with the second subgraph of the second graph and the second subgraph of the first graph is merged with the first subgraph of the second graph. An edge representing an end-to-side relation is added between the ground geon nodes in order to provide a consistent object. Phenotype sketches in Figure [nr] illustrate the process of reproduction: in a) the selected individuals are divided into two parts each, in b) two new individuals are created by merging the obtained parts.

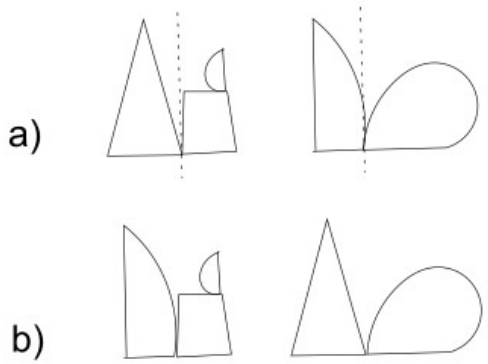

Figure 7. Crossover

4.2 Mutation

In order to introduce new features to the population, the evolutionary alghoritm uses a mutation operator.The mutation operator for a binary string allows flipping bit at a given location of the string. The two following types of this second genetic operator can be applied to graphs: structural mutation which allows to modify graph structures (deleting and adding nodes), and attribute mutation for modifying values of attributes.
In this paper the both types of mutation are proposed, extended by modification of a relation type.
Genotypes of random individuals are slightly modified by changing a value of a random attribute or a random relation type, or by adding a random node. Beneficial mutations have a chance to be copied into the next generations. Sketches in Figure 8 present examples of mutation: a) – modification of a non-accidental attribute value, b) – modification of a metric attribute, and c) – modification of a relation type.

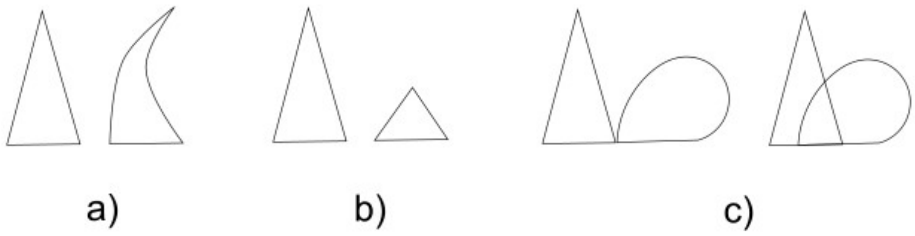

Figure 8. Mutation

5. Selection

During the process of selection the most adequate individuals are chosen for reproduction. Fitness function evaluates to what degree each phenotype fulfills aesthetic criteria of an architectonic object. The evaluation is performed on the basis of Birkhoff aesthetic measure for polygons adapted for 3D solids [3]. Human sense of aesthetics correlates with our urge for gathering information about environment, which is an evolutionary formed strategy that helps to survive. New information is valued provided that it is comprehensible. Therefore, presence of some kind of order increases aesthetic quality of an object, however highly ordered structure may not deliver enough information, as it can be too predictable. It is essential then to ensure optimal balance between the new and the

ordered. Our attempt to obtain this goal is to construct a fitness function that rewards the following:

1. every relation of order, i.e., symmetry and alignment to the same plane,
2. every geon in a relation of order,
3. every geon type, provided that the number of geon types does not exceed a critical value,
4. equillibrium.

In result of the first condition, objects with more different relations of order are preferred, which enables novelty, as not every geon of the solid is arranged in the same way as the others. The second condition values relations containing high number of geons, which decreases chaos. The third condition ensures diversity of components and at the same time prevents confusion, inevitable when an object consists of too many different elements. Finally, the fourth condition concerns both aesthetic and functional requirement of architectonic object and enables to obtain a prototype that is possible to be built. Sketches in Figure 9 present individuals preffered by the fitness function according to the described rules, respectively a) – the first rule, b) – the second one, c) – the third one, and d) – the fourth rule.

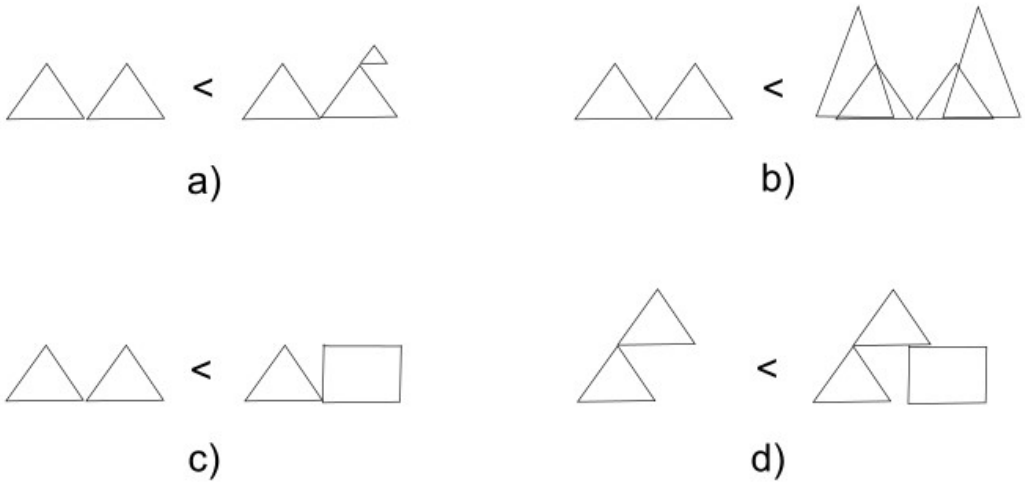

Figure 9. Selection

6. Examples

The proposed alghoritm starts with generating random population of individuals, each of them consisting of no more than three geons. After that, the evaluation is performed by the fitness function and individuals with highest scores are chosen for reproduction, while the rest of them is destroyed. The chosen individuals are randomly paired. Each pair produces two children with the use of the crossover operator. In random cases the mutation operator modifies the child. The new population is created from the reproducing pairs and their children, and the whole process starts again. The number of iterations, the size of initial population and the number of selected individuals are defined by the user.

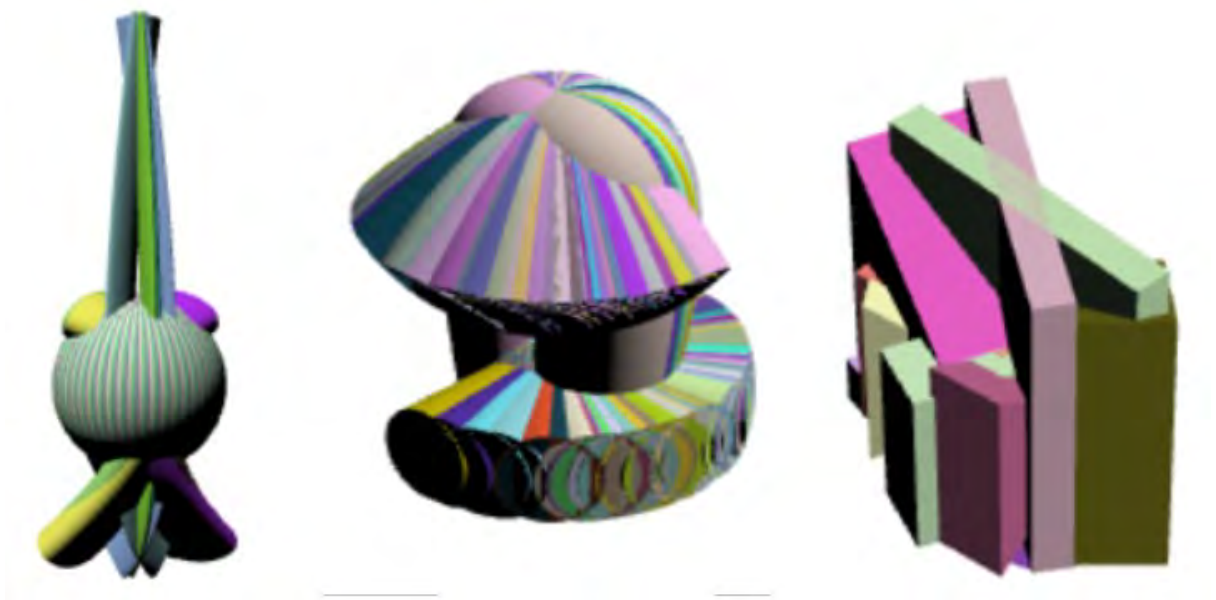

Figure 10. Examples of phenotypes

The alghoritm is designed to generate phenotypes which are well balanced, with some relations of order (like symmetry or alignment to the same plane) and the limited number of geons. Figure 10. presents some phenotypes preferred by the fitness function.

7. Conclusion

The aim of this paper is to present a new approach to aesthetic-oriented creative design. A genetic algorithm as a part of a digital tool has been proposed in the
creative design process. Evolutionary process has been used to stimulate the creativity of the designer and to suggest optimal solutions with regard to the defined aesthetic measure. Aesthetic evaluation mechanism for architectonic object prototypes has been encoded in the fitness function.

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Computer algorithm classified artwork for generative design
Topic: (Computer, Art, Design)

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The work of detecting artwork by art scholars is a very complicated task. It gets much more complicated when it is done by computer algorithms. In the past studies, researchers have tried to do the manner of detecting forms analysis based on such software such as the WND-CHARM without man's intervention. This software was initially used for molecular biological analyses applied based on comprehensive set of numerical descriptors. Numerical descriptors are formed for image contents features that reflect many aspects of visual contents such as shape, edge, statistical distribution of pixel intensity, fractal feature, and polynomial descriptors are decomposition of the image.

By converting quality to quantity by the software, qualitative artwork can be divided into a range of numbers with basic meanings and, ultimately, numbers will compare in quantitative systems the qualitative cases. Numerical values derived from artwork can be considered as biological genes, which, according to the principles of genetic science, result in human distinctions. These genes contain qualitative information that is visualized by the creation of artwork. In the present research, the art of NegarGari as one of the most important forms of painting in Iran will be analyzed.A dataset of 660 NegarGari is chosen for analysis by WND-CHARM in respect to their visual contents. Datasets belong to different periods of the Persian Islamic dynasties.

Three experiments were designed for this study to automatically determine similarities in images. Thereafter, data were converted to codes to be comparable with each other by computer. Finally, the classification of artworks was done by computer based on the resultant similarities. Moreover, the similarity exploration was done in respect to different art schools, genre of painting, and painters.

Experimental results showed that automatic computer analysis can group painters by their artistic movements, and provide a map of similarities and influential links that is largely in agreement with the analysis of art historians. These results demonstrated that machine vision and algorithms are able to mimic complex cognitive tasks of the human perception of visual art, and can be used to measure and quantify visual similarities between paintings, painters, and schools of art.The research has shown that the algorithm analysis is able to translate the qualitative artworks to quantitative ones. The Generative art is based on algorithmic principles so in the future of this kind of research, we can achieve of a new kind of generative art derived from artwork. Meanwhile, by these numerical values we can find the artworks belonging to a same family but distinguished from the previous works of art.

The 3 experiments were designed for this study to find the similarities between paintings of different Persian Islamic dynasties and determine similarity of their artistic style; also computer will find the similarities between the different art schools, genres of painting and painters. In the following section, we will describe the dataset, the method of images analysis and at the end; the graphs will demonstrate the results of experiments.

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Key words: Computer analyses, Art history, Persian paintings, Generative algorithm

Computer algorithm classified artwork for generative design

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Abstract:

The work of detecting artwork by art scholars is a very complicated task. It gets much more complicated when it is done by computer algorithms. In the past studies, researchers have tried to do the manner of detecting forms analysis based on such software such as the WND-CHARM without man's intervention. This software was initially used for molecular biological analyses applied based on comprehensive set of numerical descriptors. Numerical descriptors are formed for image contents features that reflect many aspects of visual contents such as shape, edge, statistical distribution of pixel intensity, fractal feature, and polynomial descriptors are decomposition of the image.
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In the present study, a dataset of 660 NegarGari are chosen for analysis by WND-CHARM in respect to their visual contents. Datasets belong to different periods of the Persian Islamic dynasties. Three experiments were designed for this study to automatically determine similarities in images. Thereafter, data were converted to codes to be comparable with each other by computer. Finally, the classification of artworks was done by computer based on the resultant similarities. Moreover, the similarity exploration was

done in respect to different art schools, genre of painting, and painters. Experimental results showed that automatic computer analysis can group painters by their artistic movements, and provide a map of similarities and influential links that is largely in agreement with the analysis of art historians. These results demonstrated that machine vision and algorithms are able to mimic complex cognitive tasks of the human perception of visual art, and can be used to measure and quantify visual similarities between paintings, painters, and schools of art.
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The effort made in this study does not mean that human intervention is completely eliminated but in the first stage, i.e. the selection of works of art, this intervention prevails. The purpose of this research is to examine the computer's ability to recognize artwork and finding out how algorithms automatically determine paintings similarities and classified them based on their similarity that is broadly in agreement of art historians.
The 3 experiments were designed for this study to find the similarities between paintings of different Persian Islamic dynasties and determine similarity of their artistic style; also computer will find the similarities between the different art schools, genres of painting and painters. In the following section, we will describe the dataset, the method of images analysis and at the end; the graphs will demonstrate the results of experiments.

Image dataset

The Muslim conquest of Persia, also known as the Arab conquest of Iran, led to the end of the Sasanian Empire. The Muslims took over the provinces of Persia one by one and eventually conquered the whole Empire.[1]
One of the visual cultural heritages is painting[1] that changed through the ages. The religious view of Muslim has had a strong impact on Persian painting that called NegarGari[2], it is extremely difficult to study the early Islamic NegarGari in Iran, and the main two problems are: [13]

1. the figurative painting was forbidden in Islamic manner therefor NegarGari was not popular in society and was merely used for designed books in small size[3]
2. the other one is not accessible images for early period because most of them are damaged

Meanwhile, for this study only a few Persian Islamic dynasties were chosen because of the most existence images such as Umayyad Dynasty, Abbasid Dynasty, Seljuq Dynasty, Mongol Dynasty, Timurid Dynasty, Safavid Dynasty, Afsharid-Zand dynasty, Qajar Dynasty and Pahlavi Dynasty. [1]

In previous study[4] the source of the images were from various on-line sources using basic internet queries, to ensure that the computer analysis will be based on the visual content, if the sources been the same, some artifact and source-specific features might be effected the computer analysis.
The online source of NegarGari are little and the most of them are valuable non accessible antique artwork and have been kept in personal collection or galleries, for this reason we tried to use other sources like photography images and scanned files.

[1] toward an aesthetic of Persian painting
[2] NegarGari is verb and Negareh is noun
[3] the study of painting and the art of the book
[4] Computer analysis

We tried not to use all the images for one collection from one sources, because if all collection of one Dynasty were from online web site and the collection of other Dynasty was from the scanned file, the similarities of the source can lead to severely biased results we tried to all the images being in their original condition preserving the original aspect ratio.[5]

For computer analysis, all the images must be in normalized size, for analyzing the western European paintings all dataset was normalized to 640,000 pixels,[6]As previously mentioned, Persian's NegarGari are smaller than western European paintings therefor all dataset normalized to 1024*876 almost about 800.000 pixels.[5]

It was expected that uses the sampling method to make the analysis more meaningful for comparing similarities[7] and for each experiment the specific number of images used but about the less number of Persian's NegarGari and the unknown ones in this paper we use censes instead of sampling method, at least the dataset includes 660 NegarGari representing 61 known painters chosen. By senses in each run the number of images that randomly selected to determine the Fisher discriminant scores of the features was different, and the number of repeated experiment was different too.

Image analysis method

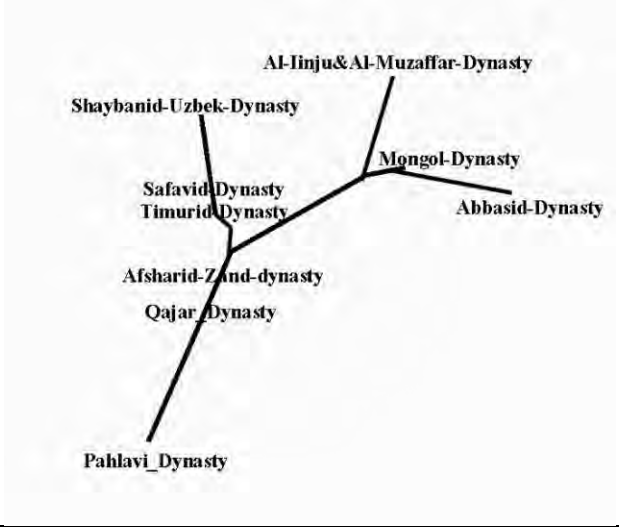
The image analysis method is based on the WND-CHARM scheme [7], which was originally developed for biomedical image analysis [3]. The CHARM [8-9] set of numerical image content descriptors is a comprehensive set of 4027 features that reflect very many aspects of the visual content such as shapes (Euler number, Otsu binary object statistics), textures (Haralick, Tamura), edges (Prewitt gradient statistics), colours [6], statistical distribution of the pixel intensities (Multiscale histograms, first four moments), fractal features [13], and polynomial decomposition of the image (Chebyshev statistics). These content descriptors are described more thoroughly in [7-8-9-10]. This scheme of numerical image content descriptors was originally developed of complex morphological analysis of biomedical imaging, but was also found useful for the analysis of visual art [10-13].
An important feature of the set of numerical image content descriptors is that the colour descriptors are based on a first step of classifying each pixel into one of 10 colour classes based on a fuzzy logic model that mimics the human intuition of colours [6]. This transformation to basic colour classes ensures that further analysis of the colour information is not sensitive to specific pigments that were not available to some of the classical painters in the dataset, or to the condition and restoration of some of the older paintings used in this study.
Once numerical image content descriptors are computed, each feature is assigned with a Fisher discriminant score, as defined by Equation 1 where Wf is the weight assigned to the feature f, Tf is the mean of the values of feature f in the entire dataset, Tf,c is the mean of the values of feature f in the class c, and f,c is the variance of feature f in the images of class c. Fisher discriminant scores can be conceptualized by the variance of the values of a certain feature across the image dataset, divided by the mean of the variances of that

[5] Computer analysis
[6] Computer analysis
[7] [Shamir, 2008; Shamir et al. 2008; Shamir et al. 2009; Shamir et al. 2010]

feature within the classes.
Then, the image features are ranked by their Fisher discriminant scores, and the 50% of the image features with the lower Fisher scores are rejected. The distance dI,P between each image I to each painter P is then measured by using Weighted Nearest Distance method, with the Fisher scores used as weights [8] as defined by Equation.[2]

Experiments results

WND-CHARM method was used for computer analysis of the Persian NegarGari. 5 experiments were designed to find the similarities of Muslim Iranian dynasties, art schools, painters and the similarities of painters by Portrait genre and the phylogenies generated for Muslim Iranian dynasties and the art schools are shown in Figures 1 to 5, respectively Portrait genre and the number of human figures in Figure 6 to 10.
Experiment 1 was designed to find the similarity of Muslim Iranian dynasties, the dataset of 651 images was participate in experiment and the figure 1 shows, the phylogeny reflecting the result. This experiment was done once and the number of training images was 25 for each dynasty. In this experiment, only the certain numbers of dynasties that have at least 25 paintings participate in experiment and the other dynasties did not shown in phylogeny because of the less number of their painting like Umayyad- Dynasty and Seljuq-Dynasty. As the figure shows, dynasties from early time are placed in the upper part of the phylogeny, while dynasties from late time are clustered in the lower part. It is noticeable that the computer was able to correctly cluster dynasties that belong in the same century, and placed these clusters on the graph in a fashion that is largely in agreement with the analysis of historians.



The figure1: reflecting the similarities between Muslim Iranian dynasties

In experiment 2 the metadata is art school and the dataset of 660 images from 18 art schools was participate in experiment, this experiment repeated 4 times with different training images and featured used. First of all 22 images was used for training and the% of feature was 0, in second experiment number of training image was the same but the 15% of feature was used, in the third one number of feature was the same but 35 images was used for training and in the last experiment, number of training image was the same but the 30% of feature was used. Figure 2 to 6 shows, the phylogeny that reflecting similarity of art schools.

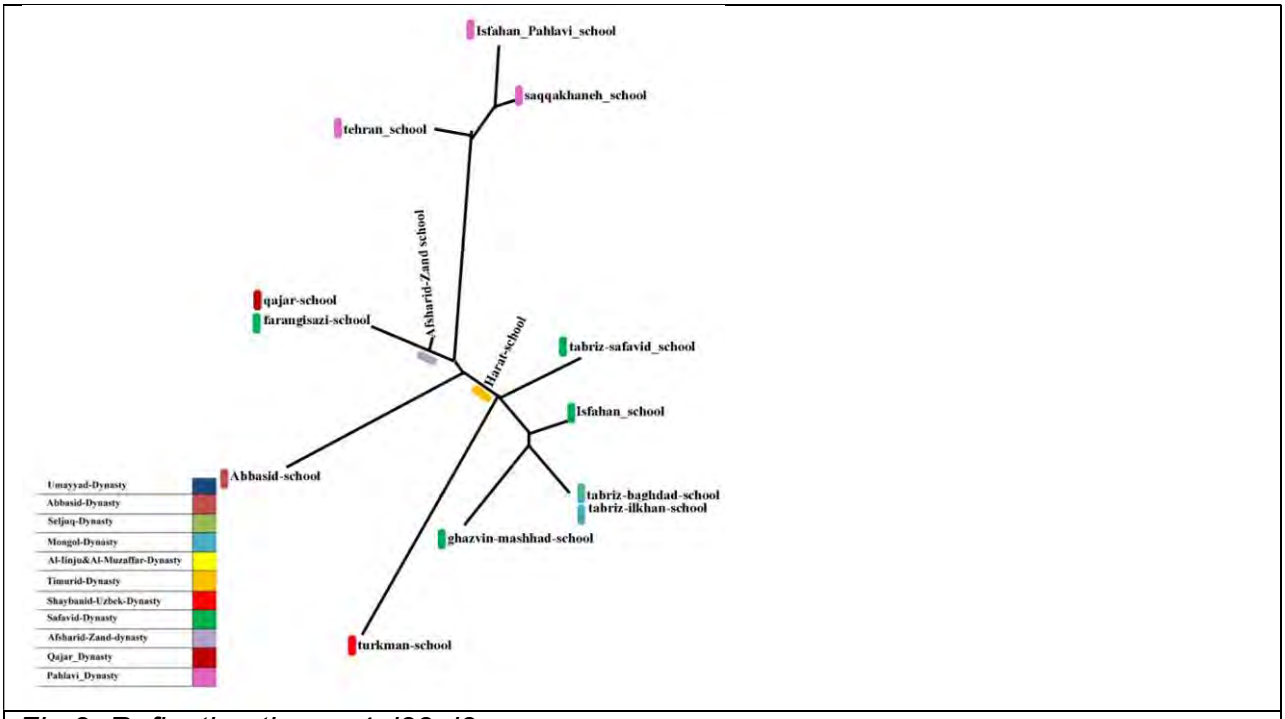


Fig 2. Reflecting theexp4_i22_j2

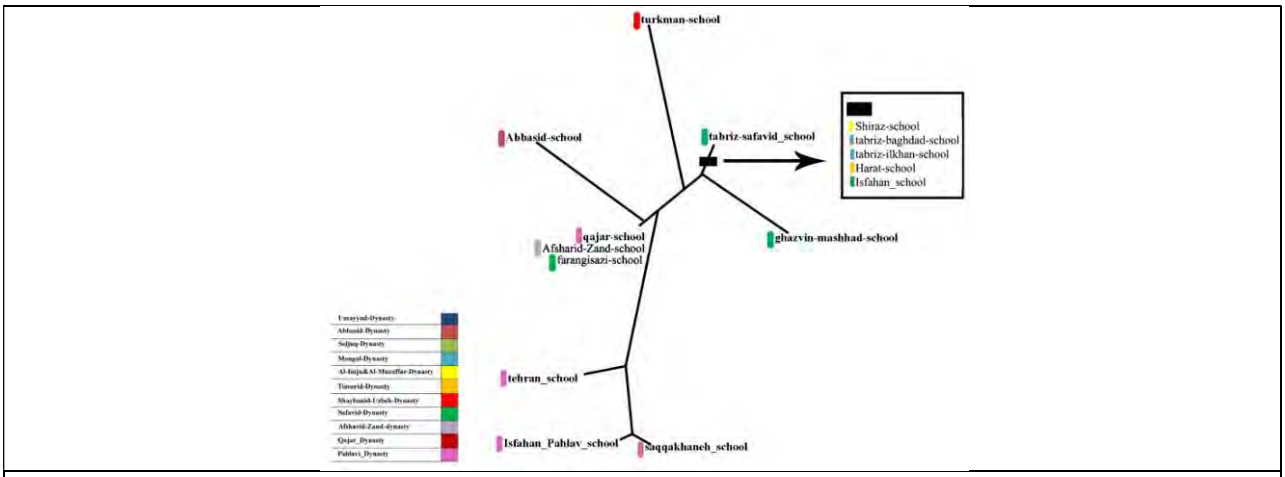


Fig 3. Reflecting the similarities between art schools exp4_i22_j2_f15

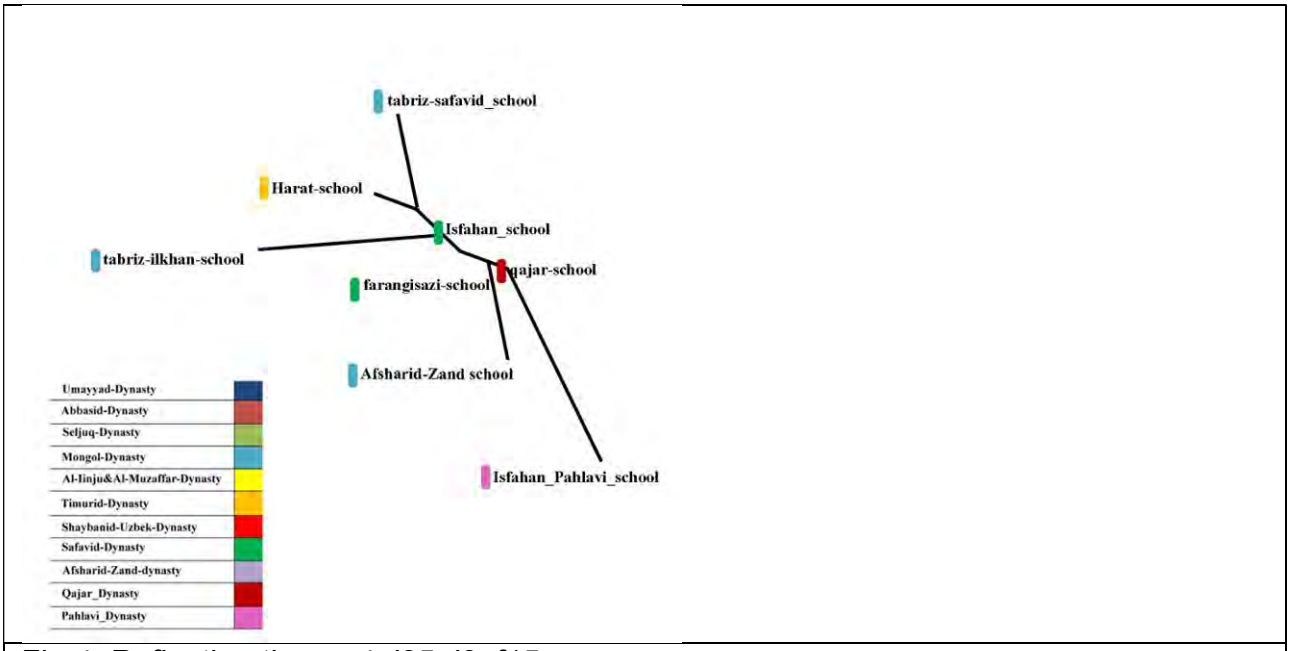


Fig 4. Reflecting theexp4_i35_j2_f15

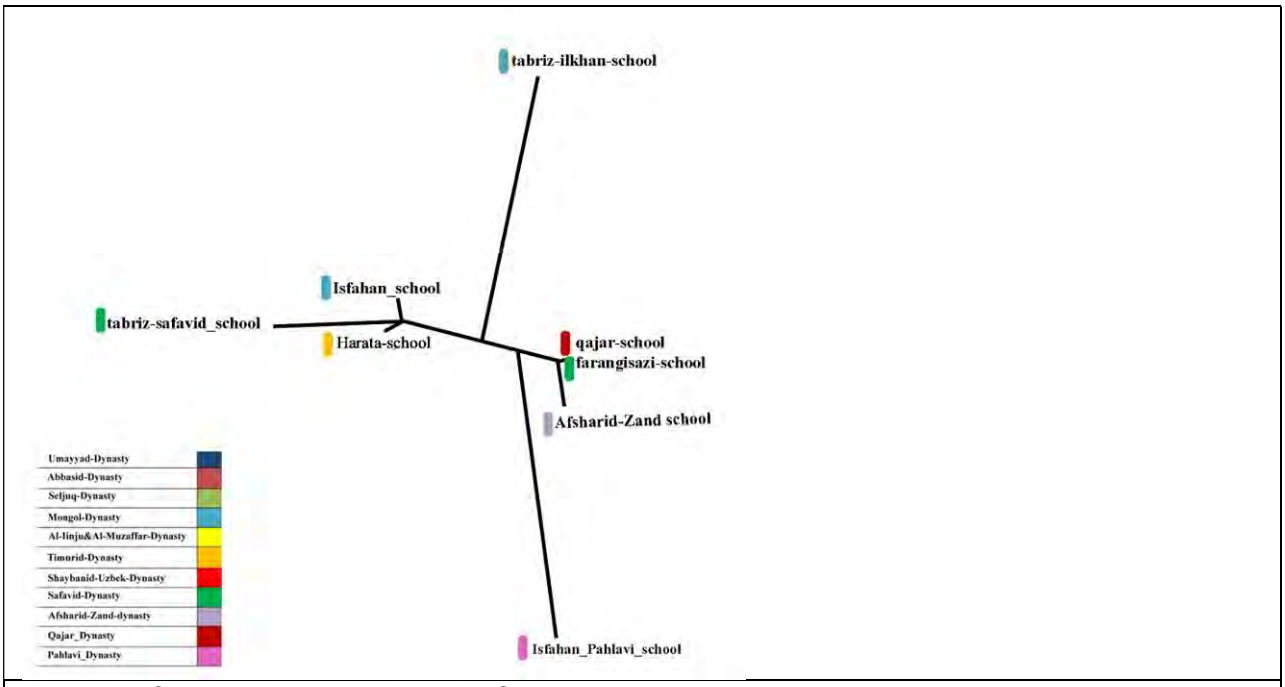


Fig 5. Reflecting theexp4_i35_j2_f30

Experiment 3 was designed to find the similarity of the 61 known painters, for this reason, 25% of the numerical content descriptors used and the experiment was repeated 99 times such that in each run different images were randomly allocated to training and test sets, the experiment was done two times, first of all the number of training images was 12 for each painter, therefor only 8 painters that have at least 12 painting are shown in figure 6. The lower part of the phylogeny features painters from Pahlavi dynasties, while the upper part includes Behzad and Siyah_ghalam from Timurid dynasty. Muhammad_ghafari_kamalolmolk and Gholer_aghasi are painters belong to Qajar and

Pahlavi dynasty, but they are placed next to painters from Timurid dynasty and Abolhasan_ghafari_sanieolmolk is a painter belongs to Qajar dynasty but he is placed next to painters from Pahlavi dynasties.

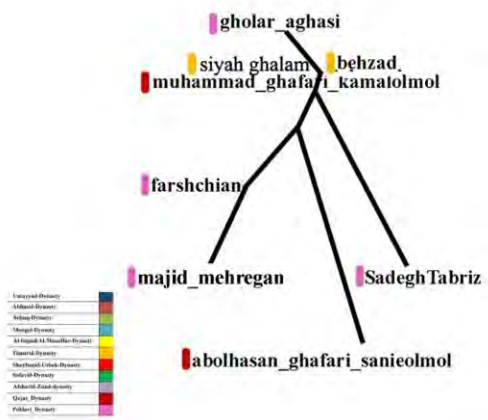


Fig 6. EX3 Reflecting the similarity of 61 known painters with 12 training images

Second of all the number of training images was 15 therefor only 7 painters that have at least 15 painting are shown in figure 7, the lower part of the phylogeny features painters from Pahlavi dynasties, while the upper part includes Timurid painter, Behzad and Siyah_ghalam. Muhammad_ghafari_kamalolmolk is a painter belongs to Qajar dynasty, but he is placed next to the painters from Pahlavi dynasty and Abolhasan_ghafari_sanieolmolk is placed in the farthest way from Muhammad_ghafari_kamalolmolk. The result shows that when the numbers of training images raise, the accuracy of the result are more in agreement with art historian.

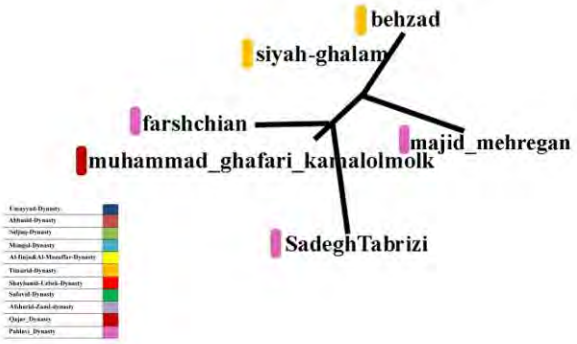


Fig 7.EX3 EX3 Reflecting the similarity of 61 known painters with 15 training images

Experiment 4 was designed to find the similarity of the 31 known painters that have works of portrait genre. The experiment was done three times, in each run, the experiment was repeated 20 times. First 15% of the numerical content descriptors were used and the training images were 7 for each painter therefor only 12 painters that have at least 7 paintings are shown in figure 8, at the left side of the painter from Pahlavi dynasty are places together and Muhammad_ghafari_kamalolmolk the painter of Qajar dynasty is again placed next to the painters from Pahlavi dynasty and Abolhasan_ghafari_sanieolmolk is placed in the farthest away from him, other painter are not satisfactory placed.

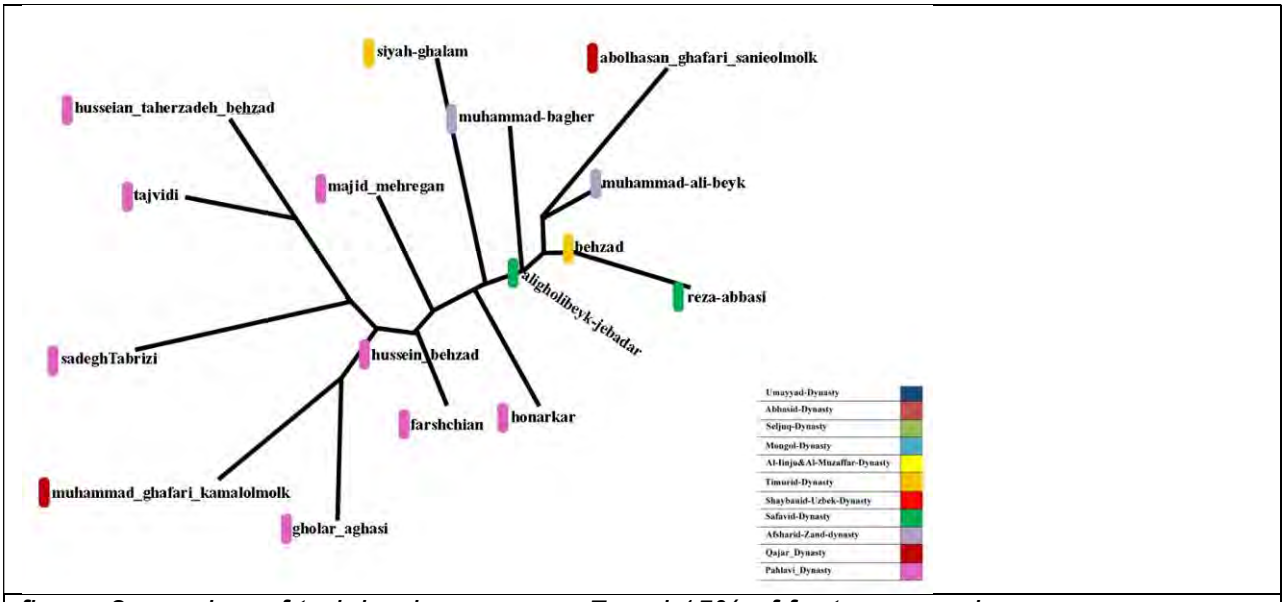


figure 8: number of training images was 7 and 15% of features used was

Secondly, the number of training images was raised to 9 and the results were mostly the same as the previous analyse.

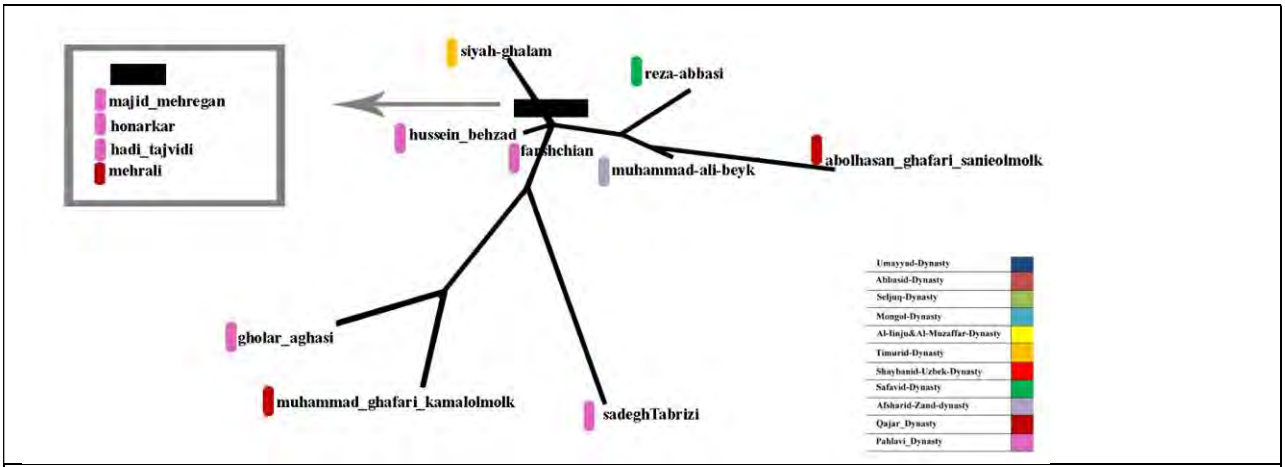


Fig 9. number of training images was 9 training images and 15% of features used

At last, when the numerical content descriptors was raised the results were satisfactory, upper part of the graph includes Pahlavi painter Muhammad_ghafari_kamalolmolk the painter of Qajar dynasty is again placed next to the painters from Pahlavi. In the middle part of the phylogeny, the pair of Timurid painter was show together; Behzad and Siyah_ghalam. Reza Abbasi and aligholibeyk-jebadar painters from Safavid dynasty are close to Timurid painters in agreement of art historian and

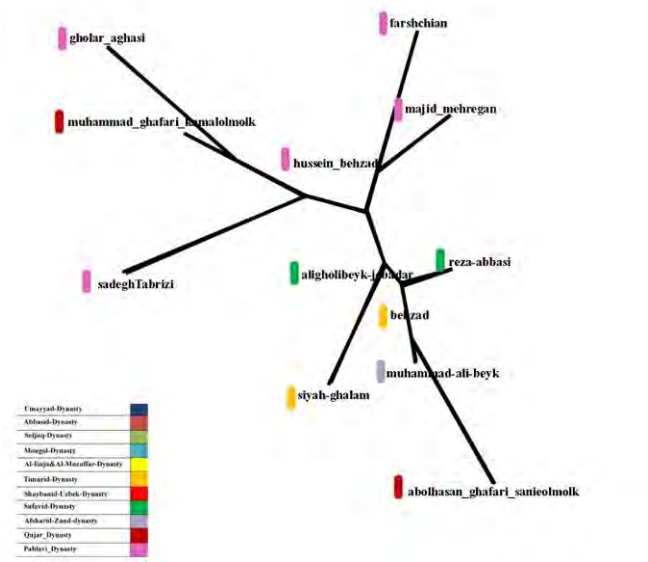


Fig 10. EX4Reflecting the similarity of the 31 known painters that have portrait genre with 9 training images and 30% of features used

It is noticeable that in all graphs from experiment 4, the computer was able to correctly cluster most of the painter from same dynasty, for example: all painters from Pahlavi dynasty are placed in fashion that is largely in agreement with art history, and the pair of Timurid painter was show together; Behzad and Siyah_ghalam But there is some exception like Muhammad_ghafari_kamalolmolk that is not belong in Pahlavi dynasty but is placed in the farthest away from Abolhasan_ghafari_sanieolmolk, this result show that Pahlavi painters are inspired by Kamolmolk and the Saniolmolk was far away the modern era.

Conclusion

By converting quality to quantity by the software, qualitative artwork can be divided into a range of numbers with basic meanings and, ultimately, numbers will compare in quantitative systems the qualitative cases. Numerical values derived from artwork can be considered as biological genes, which, according to the principles of genetic science, result in human distinctions. These genes contain qualitative information that is visualized by the creation of artwork. In the present research, the art of NegarGari as one of the most important forms of painting in Iran will be analyzed.

The Iranian NegarGari with its long history has always been considered an empty art free of fundamental changes during different periods. Therefore, with the research done, it is understood that not only this art is not based on the same traditions, but also has many changes in its own nature.

The research has shown that the algorithm analysis is capable of translating qualitative artworks to quantitative ones. By comparing the quantitative comparison of the qualitative works, it is possible to open the way for the recognition of artwork with higher precision and refrain from individual decisions and human interventions. This research is just the beginning of the acquisition of generative artworks based on algorithmic principles. So that

by these numerical values we can find the artworks belonging to a same family but distinguished from the previous works of art.
The process followed in the present research is based on biological analysis software that has been used for many years to understand biological distinctions. But this can be reflected in the philosophical debates, and indeed it is the biological and phenomenological analysis of generative and non-generative artworks. The view of Gilles Deleuze as one of the new philosophers who founded the foundations of his philosophy on scientific principles. Biology as a science that first approaches the problem of life as a systematic and cognitive approach is Deleuze's defining tool. He defines the potential teachings that have the same pre-existing qualities and practical implications in the organism of the universe by genetic science and as a form of difference. Deleuze can be considered as the master-mind of the phenomenological studies in the future of this research.

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Fractal Beings

Topic: Art

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Abstract
Fractals have always existed since the beginning of time. We have known them since the work of Benoit Mandelbrot [1]. They were first used to create beautiful images and especially to serve as a good tool to simulate nature.
In physical cosmology, fractal cosmology is a set of minority cosmological theories which state that the distribution of matter in the Universe, or the structure of the universe itself, is a fractal across a wide range of scales. More generally, it relates to the usage or appearance of fractals in the study of the universe and matter [2].
Fractals thus appear to be present at all scales of the universe, both for galaxies and black holes, but also at the microscopic level. They are well compatible with the theories of relativity and those of quantum physics.
In this publication, we postulate the hypothesis that fractals are still much more than that, and that they are also directly related to any form of life, plant, animal, human and certainly others.
The Fractal Beings are the continuation of the series of creative artificial beings, begun in 2005 with the Painting Beings, and in which we meet over the years Cinema Beings, Sculpt Beings, Quantum Beings, etc. [3] [4].
The Fractal Beings are thus an artistic representation of virtual beings, which are in line with the works of Mandelbrot, Nassim Haramein [5], Karen French [6], and many other scientific authors.

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Key words: Fractal, Artificial Life, Quantum Computing, Genetic Algorithm

Main References:

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Fractal Beings

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Abstract

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In physical cosmology fractal cosmology is a set of minority cosmological theories which state that the distribution of matter in the Universe, or the structure of the universe itself, is a fractal across a wide range of scales. More generally, it relates to the usage or appearance of fractals in the study of the universe and matter [2].
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Art Beings

The series of Art Beings was initiated in 2002, on the simple principle of considering populations to be artificial as organic matter of a digital work. It is all along the series, to create evolutionary ecosystems, based on the use of genetic algorithms.
These evolve populations of virtual entities, which can be pixels (2D), vertices (3D), animation frames (4D), and so on.
This work of Research and Creation aims to explore new ways of creation, by mixing the principles of artificial life, with those of digital creation.
These sets of creations are based on a number of fundamental concepts, including that of symmetry, present on many scales in nature [7], [8], [9].
Many "artist and researchers" have been studying this type of track for some time, such as Den Heijer who is interested in the aesthetic measurement of such creations [10], or Di Paola [11], who tries to see how these processes Algorithms can be related to human

creativity.
The use of evolutionary algorithms in creation is very well described by Philip Galanter [12], one of the world's leading specialists in Generative Art, as well as by Matthew Lewis [13], author of a founding paper on this topic .

Plant & Light Beings

The first creations were articulated around the light and the plants, as it can seem natural, in a creation of world.
Plant Beings and Light Beings are based on the evolution of L-Systems, which are algorithms particularly well suited to the digital world of plants. [14].

Light & Plant Beings. © Alain Lioret . 2004

Painting Beings

The following series was much more evolved, with the appearance in 2005 of Painting Beings. These beings are simply sets of self-organized pixels that make up painting in a 3D space. It is about dynamic painting, in movement, whose principle rests on a genetic algorithm which makes evolve the various populations of pixels,

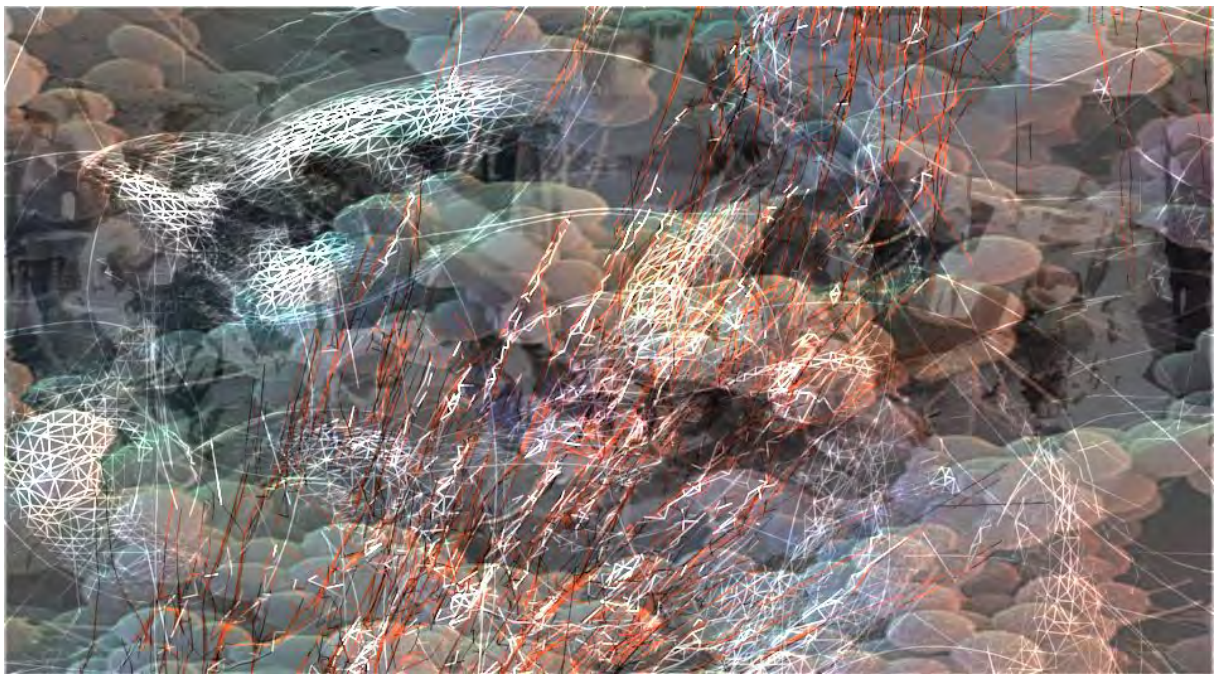
constituents of the created images. [15]

Painting Beings. © Alain Lioret . 2006

Cinema Beings

The following series follow the same pattern, but extend the concepts to other spaces of creation: the Sculpt Beings, for the modeling of Mesh in 3D, the Cinema Beings which form a more complex ecosystem, combining various types of Beings, like the Cut Beings for editing (according to the principles of Eisenstein in particular), Painting Beings for 2D images, Sculpt Beings for 3D creations, Sound Beings for sounds, etc. [16]

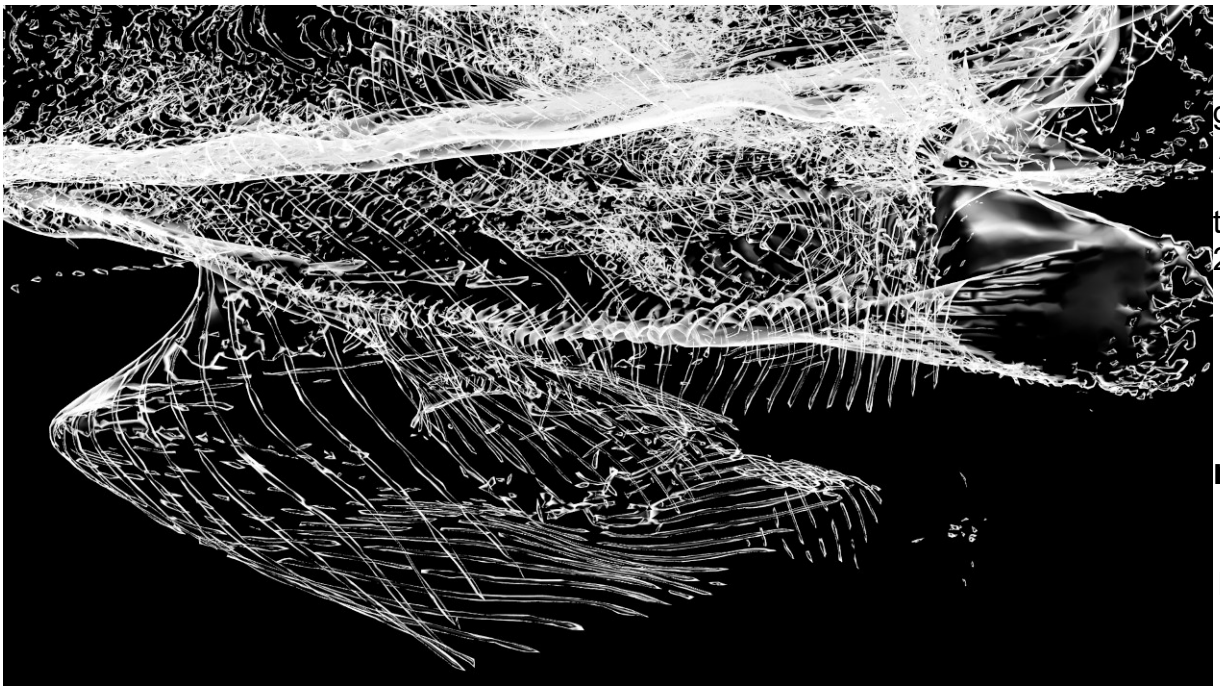
The different Beings (creator beings) that make up the virtual universe of what is called here the "Cinema Beings" can be considered as the equivalent of particles of the work of art (as would be the point on a drawing, the grain in a sculpture, the image in a film, etc.) [17] [18]. One can imagine that these are the living particles of the work of art thus created.



Cinema Beings. © Alain Lioret . 2011

Quantum Beings

It is therefore a natural logic that led this work towards the exploration of two new types of Beings, more related to the physical world around us, and which have their place in this series of evolutionary works: the Quantum Beings and the Fractal Beings.
The Quantum Beings (also called the Time Beings), behave like quantum particles, with most of the characteristics of this type of particles (which are also waves), and in particular the gift of ubiquity, the quantum entanglement, teleportation, etc.
The use of quantum algorithms, while the quantum computer does not yet exist, is particularly interesting. This allows you to explore even a little further new worlds of creation. [19], [20], [21].



Quantum Beings. © Alain Liorent. 2014

Fractal Beings

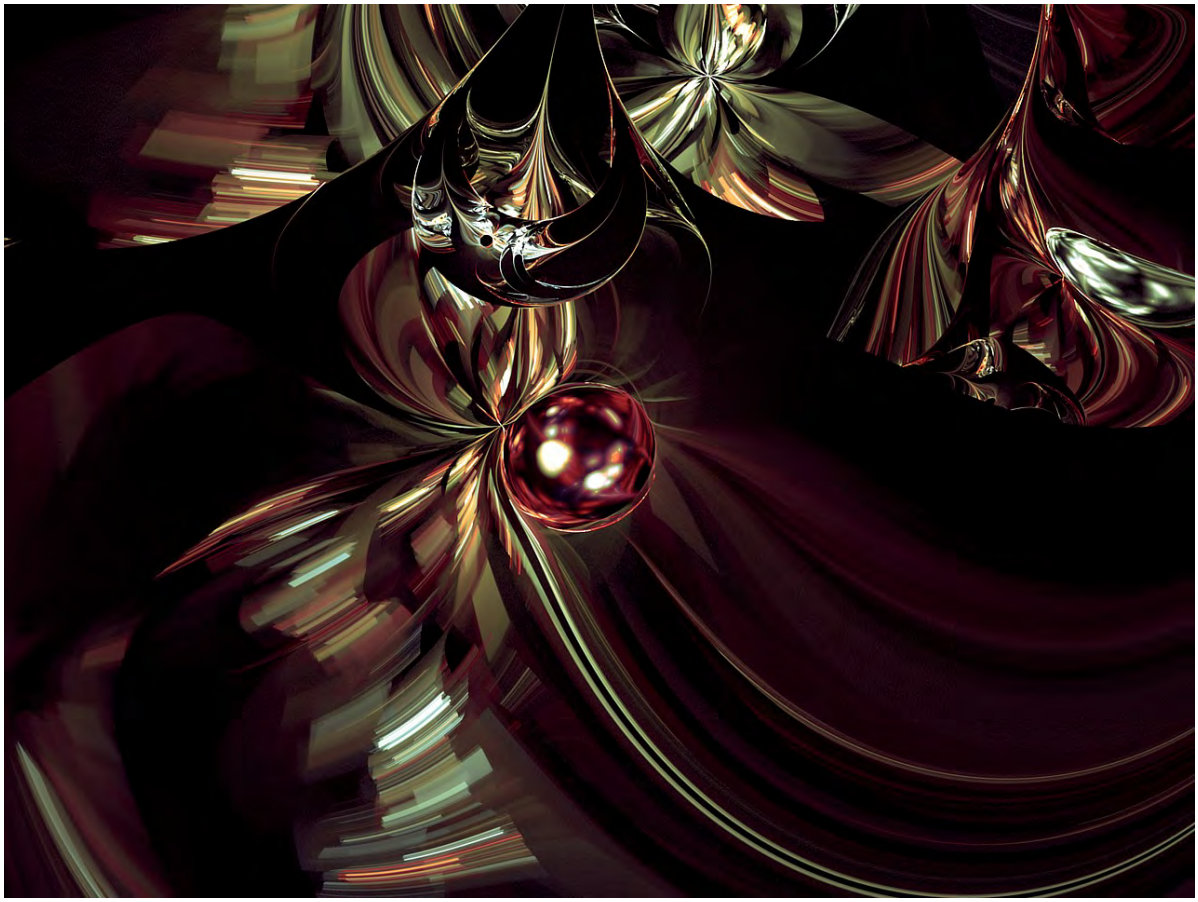
The Fractal Beings, the last born of the series, (and there, we loop in a certain way on the beginning of the series, at the beginning, created with L-Systems), are created starting from the evolution of fractal creations (therefore recursive and with levels of self similarity).

It is important to note here the importance of some recent works that show that fractals have a primordial place in the universe.
We have here two important tracks, which revolve around fractal cosmology and the first recently discovered fractal beings. Many scientific writers have postulated that the universe as a whole was fractal in structure. Luciano Pietronero [2] who was one of the first to do so, but also Andrei Linde [25], Laurent Nottale [26], and the excellent work of the French mathematician Alain Connes [27] and authors like Yurij Baryshev and Pekka Teerikorpi [28]

A recent discovery by Cuthill and Morris mentions some strange living organisms: it is the Rangeomorphs [29]. Rangeomorph fronds characterize the late Ediacaran Period (575–541 Ma), representing some of the earliest large organisms. However, their extraordinary branching morphology differs from all other organisms and has proved highly enigmatic. This reveals an adaptive radiation of fractal morphologies which maximized body surface area, consistent with diffusive nutrient uptake (osmotrophy). Rangeomorphs were adaptively optimal for the low-competition, high-nutrient conditions of Ediacaran oceans. With the Cambrian explosion in animal diversity (from 541 Ma), fundamental changes in ecological and geochemical conditions led to their extinction.

Another major work is proposed by Tim Palmer [30]. He propose a new hypothesis about the nature of physical reality at its most primitive level. The hypothesis is framed in terms of invariance, a concept that forms the very bedrock of physics. Specifically, the Invariant Set Hypothesis proposes that states of physical reality are precisely those belonging to a non-computable fractal subset of state space, invariant under the action of some subordinate deterministic causal dynamics. The Invariant Set Hypothesis provides a geometric framework for a new perspective on quantum physics.
The work around Fractal Beings is made following these research. The evolution

capacities of Fractal Beings are variable (see all the articles described in reference for more details). Each time, these abilities are based on rules or artistic references (which can be images, objects, films, the golden ratio, the Fibonacci series, etc.).
The images created for this work are based on Fractal Beings. Models are created using 3D objects. The genetic algorithm thus seeks to explore the infinite world of fractals to create images (in a 3D space), which try to appear according to innovative methods and new ways of creation (use of genetic algorithms). [22].
The idea is quite simple: we explore the world of fractals (and especially those based on the formulas of MandelBulb and IFS systems). These formulas now classic in the world of fractals, are here coupled with the use of a genetic algorithm that allows to play with the various parameters, and to explore original creations.

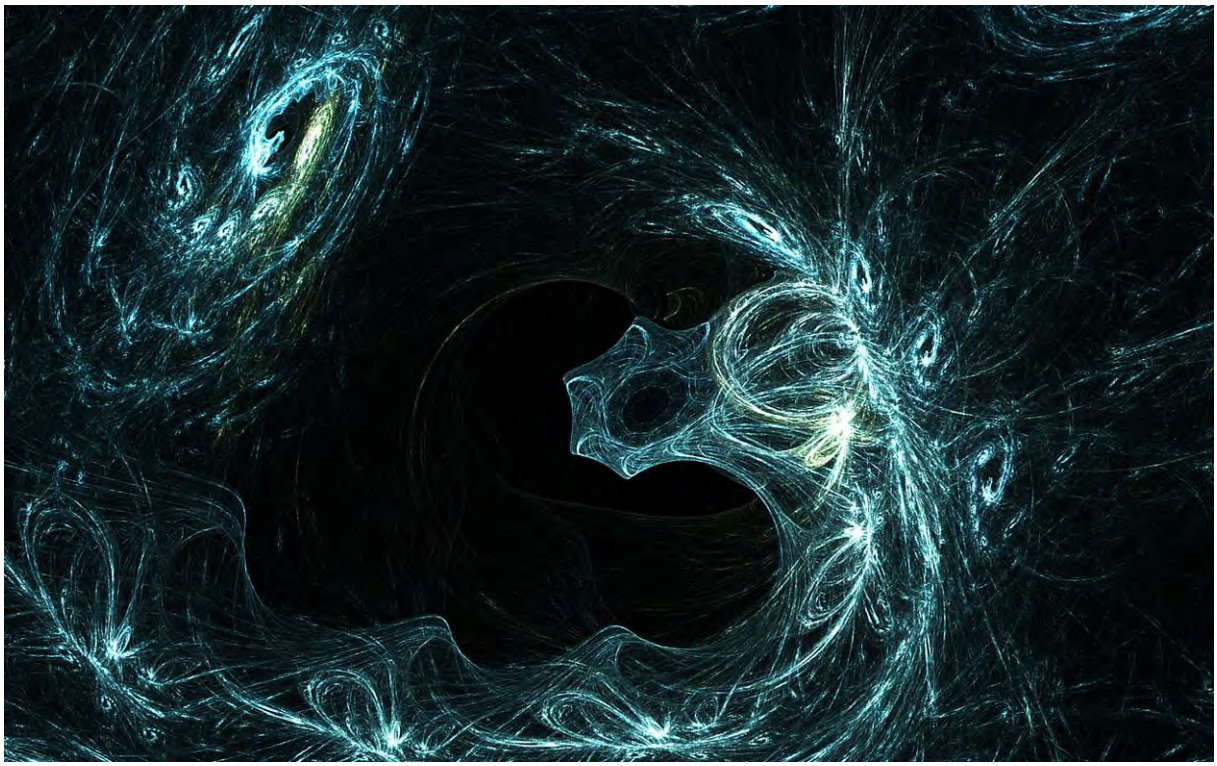


Fractal Beings. © Alain Lioret . 2017

Infinite Artistic Explorations

The use of fractals is overall very surprising. It would seem that the fractals, discovered in 1975 by Benoît Mandelbrot, are still far from having delivered all their secrets.
Thus, we know that fractals can very well model mountains, clouds, trees, plants, pulmonary systems or blood vessels, etc.
Almost everything that exists in nature, everything that is not built by man. They are therefore an interesting model of the visible aspects of Nature.
What about the invisible? What are the other fractals? What are today considered just as beautiful and abstract? Questions that remain open and require many other experiments.

Recent research on fractals joins some older ones, and all converge on an Art of Nature, on the edge of the Arts and Sciences axis. [23], [24]. A particularly rich field for the artist interested in the advances of science.



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Fractal Beings. © Alain Lioret . 2017

***TongArk*: a Human-Machine Ensemble**
Paper

Topic: *Music*

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Abstract
This work explains a software agent that applies the musical task of accompaniment. The author investigates computer system possibilities in creating and transforming musical material under artistic and procedural circumstances built on some perception and analysis of a sound realization of the creative concept, and the external manifestation of emotions by a human agent.

Software reveals the interactive duet “human / software agents” in which the latter perceives the part performed by the human agent, and makes an ambient sound in its own musical part using the genetic algorithm. The human agent controls the software agent’s performance by means of some change in emotions shown on the face.

The software agent estimates the affective state of the human performer using face recognition to generate accompaniment. Every single change of any affective state is reflected in updating the timbre and reverberation characteristics used by a computer system of sound elements as well as in transforming the sounding in all of the software agent’s part.

Researches on peculiarities of the correlation between sounds of a definite pitch and/or timbre and the affective states caused by them together with the listening tests carried out within the framework of this project – all these made possible to develop a structure of the correlation between the key emotions and frequency and space parameters of sound.

The system design combines Affective Computing, GAs, and machine listening. This article describes the algorithmic processes of the system and presents the creation of two music pieces. Details of the work and possibilities for future work are given.

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Key words: human-machine interaction, emotion recognition, genetic algorithm

Main References:

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TongArk: a Human-Machine Ensemble

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Introduction

The incentive motivation for creating the *TongArk* project is the need for real-time communication between the human agent and the software agent when the former performs his/her part on the piano. Obviously, any professional pianist often uses not only his/her hands but both feet as well pressing and releasing the soft and sustain pedals, accordingly. In this way, special gestures used to communicate with a software agent turn out to be rather awkward, and the use of various sensors may cause some discomfort. Consequently, the affective states expressed on the face may become one of the idle but effective communication media.

In the music practice, a face expression is sometimes an extremely efficient communication medium. This is especially evident in the work of symphony orchestra conductors who always make use of mimicry to convey their intentions to the performing orchestra more efficiently (see Figure 1).

Happiness: 33.83614
Surprise: 31.34216
Sadness: 16.31085
Anger: 11.42576

Anger: 47.07011
Surprise: 46.28304
Disgust: 2.401005
Fear: 1.618385

Happiness: 79.60812
Surprise: 8.475149
Neutral: 4.814065
Anger: 3.797681

Anger: 44.04148
Neutral: 41.06308
Surprise: 10.36321
Disgust: 2.973584

Figure 1. Conductors' emotions identified by Microsoft Emotion API (four most probable affective states in the list of eight, with the "weight" of each corresponding emotion)

Certainly, in the performing art (by pianists, violinists, flautists, etc.) conveying intense emotions by face is more than an exception as this communication medium is optional, often excessive and even improper in the ensemble playing. Nevertheless, while correlating with the software agent this way of communication is likely to become an advantageous process of interaction.

Emotion recognition also makes a computational system manage the software agent's part during the creation of a musical composition (Winters, Hattwick and Wanderley 2013). Nowadays, face recognition is becoming increasingly prevalent as a controller because neural network algorithms and their software realizations are growing up rapidly and getting much faster and precise than ever before. By using face recognition (with Microsoft Cognitive Services (MCS) Emotion API) and the genetic algorithm, the *TongArk* project explores a real-time composition where a human performance leads to the software agent's response.

Preparatory Work

The key feature of the *TongArk* generative process is emotion recognition that controls the frequency range of current timbres and the reverberation type in the software agent's part. The sound equalization is based on a correlation between emotion characteristics and the pitch and dynamics of the sound. According to some researches (Chau, Mo and Horner 2014, 2016; Chau, Wu and Horner 2014; Wu, Horner and Lee 2014), specific emotions are caused by sounds of some specific frequency and dynamic ranges. In our case, it is important that such correlation would also appear between emotions and complex sounds in the tempered twelve-tone system. The above-mentioned researches state ten emotional categories (Happy, Sad, Heroic, Scary, Comic, Shy, Romantic, Mysterious, Angry, and Calm), but only three of them correlate with the Emotion API list of emotions (Happy – Happiness, Sad – Sadness, Angry – Anger). Therefore, a listening test has been developed to include the other five emotions from Emotion API (Contempt, Fear, Disgust, Surprise, and Neutral).

Twenty-two professional musicians, both teachers and students of the sound engineering faculty took part in the test. For this, piano sounds from the Native Instruments Akoustik Piano VST library were recorded in the range from C1 to C8. The test results gave a pitch range for the above-stated five emotions as shown in Figure 2.

Emotion	Pitch Range
Happiness	C5 – C7
Sadness	C1 – C8
Contempt	C1 – C6
Fear	C1–B1, C7–B7
Disgust	C4– C6
Surprise	C5 – C8
Anger	C1 – C3
Neutral	C4 – C8

Figure 2. Pitch range of the Emotion API list of emotions

Another example of the correlation between emotions and sounds are effects of the reverberation time on the emotional characteristics (Mo, Wu and Horner 2015). In order to correlate the reverberation characteristics with the Emotion API list of emotions, there was developed another listening test. In this test, there were 24 reverberation presets (using FMOD DSPs) with three different timbres. The same group of listeners chose the most appropriate reverb type for each emotion as shown in Figure 3.

Emotion	Reverberation Preset
Happiness	AUDITORIUM
Sadness	CONCERT HALL
Contempt	HANGAR
Fear	QUARRY
Disgust	OFF
Surprise	STONE CORRIDOR

Anger	UNDERWATER
Neutral	GENERIC

Figure 3. Correlation between the Emotion API list of emotions and FMOD sound library's reverberation presets

Implementation

The implementation is in C# using the Exocortex.DSP library[1] for FFT and NAudio library[2] for sound input. A snapshot from a web-camera is taken at regular intervals and then passed to the MCS cloud using Emotion API. The human agent's audio output signal is transmitted directly to a PC and simultaneously recorded, both as a wave stream from the microphone and MIDI messages. The sound engine is written using FMOD sound library[3] while the generative algorithm mostly uses its DSP (low-pass and high-pass filters) together with reverberation presets. The same library is employed for the pre-prepared sound playback.

The human agent's sound is captured from the microphone, and after FFT its spectrum (bands amplitude values) becomes a fitness function of the genetic algorithm (Miranda and Biles 2007). Therefore, the software agent's performance is never the same as the human performance but it always tries to achieve and/or copy it. In addition, all sounds are considered to be "neutral" outside any emotional context.

In the FFT output there is an array of complex numbers, each of them containing an amplitude value for a definite spectral band. Out of this array there are selected some amplitude values of those frequencies which fit the sounds of an equally tempered scale. As a result, there is an array of 84 amplitudes from C1 (32.703 Hz) to B7 (3951.044 Hz) which becomes a fitness function of the genetic algorithm. The population consists of 1000 members, each of them representing a volume values array of every downloaded sound element (one value per sound element making 84 values in all). While launching the program all the arrays are initialized with zeroes. Subsequently, the population runs phases of the two-point crossover and mutation with the pre-determined probability of event. For instance, the 0.8 pre-determined parameter of the crossover means the crossover occurring among 80% members. The parameters of the crossover and mutation are defined independently at the initialization and may change during the performance. It is also possible to define a mutation step which determines how smoothly or suddenly the mutation occurs. The speed of approximation to the fitness function standard is determined by the frequency of the epoch alternation as well (in the present project, the optimal quantity turns out to be 5 to 50 epochs per second). However, since the fitness function gets renewed frequently the selection process continues until the human agent's sounding breaks for a long time. If that is the case, the fitness function becomes an array of zero values. This makes the genetic algorithm create generations that would exactly fit the fitness function.

During the performance process, Emotion API returns the list of eight emotions (happiness, fear, disgust, etc.) with their "probabilities" or "weights" in every specific time interval (in the predetermined range of 1 second to 5 minutes). Therefore, when the human agent changes an emotion on his/her face and the software detects this, the list of emotions and their "weights" also change. Immediately, another group of sounds smoothly replaces the current group. At the same time, the software agent is making a real-time

transformation of each sound using low-pass and high-pass filters, and the reverberation type changes globally in the software agent's part as shown in Figure 4.

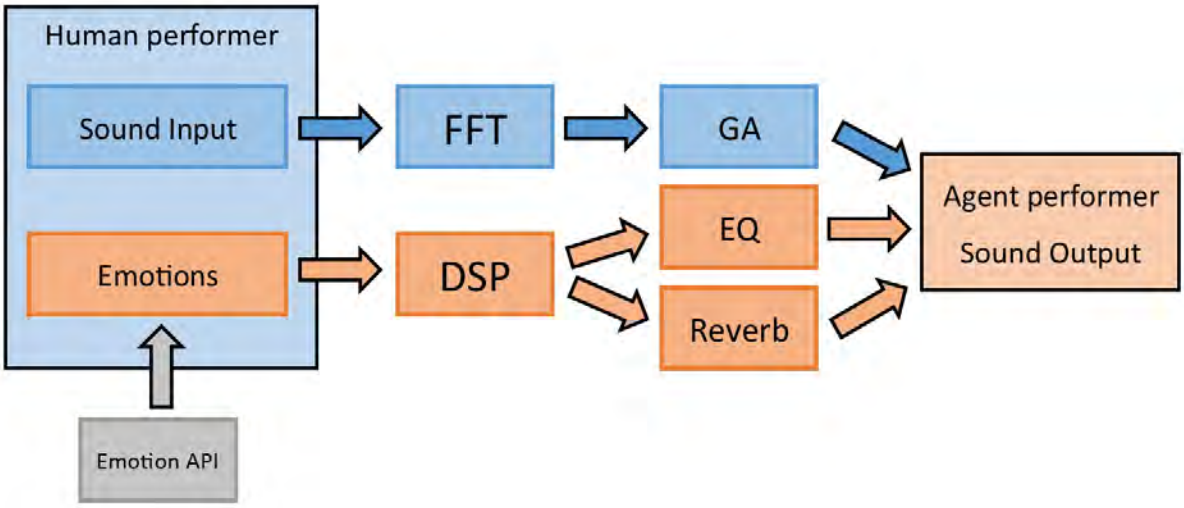
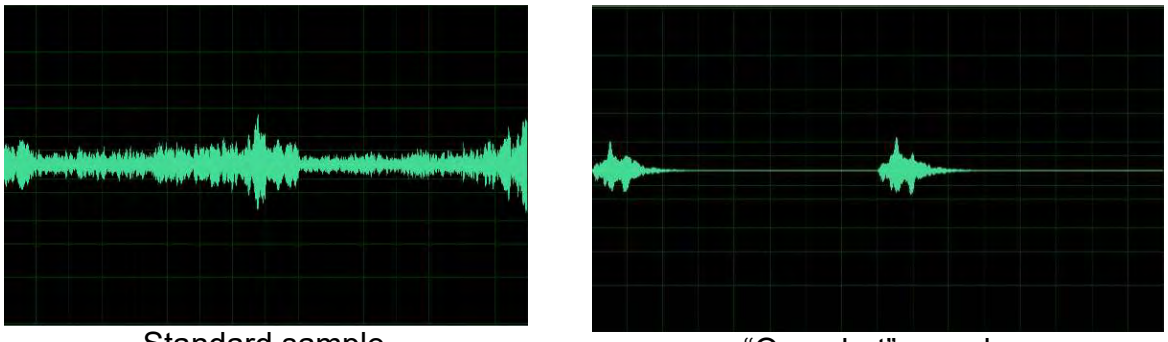


Figure 4. Scheme of the generative process

Demonstration

BigDukkaRiver[4] and *Ngauruhoe*[5] are examples of the system in action. For both compositions there were created four groups of sound samples. In the second composition, samples from one of the groups were "one-shot" samples (see Figure 5).



Standard sample "One-shot" sample

Figure 5. Standard and "one-shot" samples

All of the sound elements within one group are equal in their duration. In order to avoid the resulting monotony in the software agent's part, the sound elements are reproduced with some delay one from another (randomly from 50 ms to 1 sec). The application of such methods to one-shot samples in combination with changes in volume determined by the genetic algorithm often result in generating interesting rhythmic structures.

Each group contained 84 sounds of some particular timbre in the tempered twelve-tone system (C1-B7). Sounds from different groups randomly filled the array of 84 sounds which was to be active at some predetermined time. The pre-prepared sounds were made using Camel Audio Alchemy and Steinberg HALionOne VSTs, the timbre of the piano was Native Instruments Akoustik Piano (Concert Grand D).

In the project, the human agent played the digital piano, and the sound stream was transformed in the array of amplitudes by the FFT function (the FFT window size is 4096 samples, the sample rate is 44100 Hz). This array became a fitness function of the genetic algorithm, and the result of each epoch controlled the volume of each sound in the software agent's part. The genetic algorithm implementation uses different parameters of the crossover and mutation as shown in Figure 6.

Composition	Epochs (qty per second)	Cross-over (0 to 1)	Mutation (0 to 1)
BigDukkaRiver	20	0.5	0.7
Ngauruhoe	6	0.3	0.8

Figure 6. Genetic algorithm settings for the musical pieces

For the reverberation type, only the emotion with the highest percentage of recognition is used. The “Neutral” emotion is ignored, keeping the previous settings active. In the final sound mix, the Great Hall reverberation was added to the human agent's part.

Future Work

The development of *TongArk* is ongoing. Some future work may include such improvements as acoustic recording, live performance and creating a system for numerous performers (both human and software agents). Today, the main problem is Emotion API itself, at least until significant improvements in the Oxford project are made. The main issue is that emotion recognition is first quite unstable and, second, it gives a result with some evident latency. A low quality of recognition forces the human agent to tense facial muscles and even grimace occasionally. Emotion API defines many facial expressions as the Neutral emotion regardless the human agent's actual emotions at that point of time. This motivates to use or develop another neural network and train it to recognize different expressions of a particular performer more precisely and in detail.

Notes

[1] http://www.exocortex.org/dsp
[2] http://naudio.codeplex.com
[3] http://fmod.org
[4] http://www.soundworlds.net/media/BigDukkaRiver.wav
[5] http://www.soundworlds.net/media/Ngauruhoe.wav

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Flight: A Scene of Escape

Topic: Agent Driven Narrative

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Keywords: generative art, emergent narrative, simulation, genetic algorithm, evolutionary art

Abstract
This paper describes the attempt to construct the emergent narrative, *Flight,* which tells the story of a series of departures, movements, or escapes across an abstracted map or terrain. An evolving group of entities drifts across an arrangement of boundaries while competing for the reader's attention. Entities can render several categories of text to the screen, each of which are affected by elements and boundaries in the terrain. The internal design of entities allows them to evolve through collision with terrain elements as well as boundary events. Complex narrative conditions emerge as agents move toward their spatial goals.

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Narrative In 'Maps of a Future War: Flight'

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Abstract

This paper describes the attempt to construct the emergent narrative, Flight, which tells the story of a series of departures, movements, or escapes across an abstracted map or terrain. An evolving group of entities drifts across an arrangement of boundaries while competing for the reader's attention. Entities can render several categories of text to the screen, each of which are affected by elements and boundaries in the terrain. The internal design of entities allows them to evolve through collision with terrain elements as well as boundary events. Complex narrative conditions emerge as agents move toward their spatial goals.

Keywords

generative art, computational narrative, genetic algorithms, narrative,

Introduction

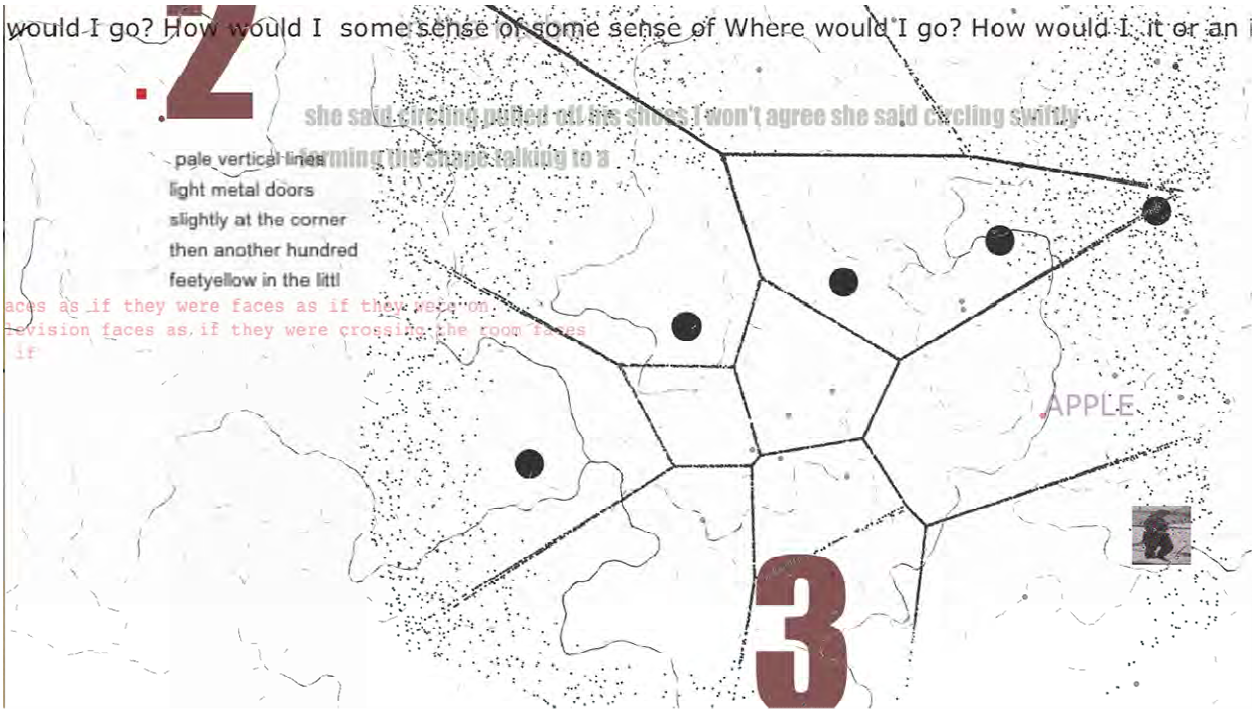
Recently I began work on a digital project comprised of a series of artist's maps meant to describe social, financial, and political precursors to military conflict. *Flight*' is a screen-based digital artwork, one of the generative art works in the speculative series '*Maps of a Future War*'. For this artist's map, a system of agents, signals, and boundaries interact in a digital environment to produce a fragmented story about migration, or accounts of flight from conflict, poverty, danger, injustice, or oppression. The story is advanced through the use of genetic computation on text blocks that are allowed to drift across regions, boundaries, graphic elements, and area textures. These narrative blocks, or text agents, can sense signals from other map elements, and pick up traces or evolve according to elements from their surrounding boundaries or their larger regional environments. Texts are computed and then tested for coherence to a group of predetermined or 'written' state rules which can be viewed as the system's narrative phases and which in turn affect certain types of organization in the world narrative. Each of the maps in the series is intended as a fragment of a larger, non-coherent narrative. In keeping with plasticity of the theme, and with skepticism as to the ability of a linear narrative to represent a story that consists imaginatively as a dynamic situation, the agent texts within each map were initially conceived as evolving assertions which would arise from movement across terrains and the shifts in system processes.

There are several motivations underlying a work of this type. The first is the creative aim of showing that satisfying and 'writerly' narratives can operate as dynamic systems, texts that are nonlinear and emergent as opposed to causal and progressive. The second, more technical idea, is that of continuing experiments [2] [3] [5] [7] in the application of genetic algorithms to narrative environments. The goal in writing each map's 'story' or 'account' was to build a generative process for the development of a story whose sum meaning might exhibit a kind of organization or pattern that would reach beyond the events described in any single thread of discourse within a fictional story world. Overall, the *Maps* project is a work of nine interrelated story worlds, each a visual art work consisting of text agents, a signal system, boundaries, regions, animations, and other graphic elements.

The whole work, and even the work involved in the creation of the single map *Flight*, is larger than the scope of this paper. The goal of this paper is to describe the construction of the generative system used to construct narrative, so what follows is not a comprehensive design document detailing all elements of *Flight* or of the series, *'Maps of a Future War'*, but an outline of the features of one part of this project's design for agent led narrative, identifying key structures of the agents themselves, the system's overall narrative states, and the resulting forms, behaviors, patterns, or actions of the story.

This description starts by listing the overall narrative phases of this segment of the project and then goes on to describe the composition of the individual agents in *Flight*, their identify key features (forms) and behaviours (actions) and the way those forms and behaviors are encoded as data strings similar to genes. Using genetic algorithms, these narrative 'genes' are then evolved to other identities helping the story system as a whole cycle through a series of predetermined or written narrative states. The results are then demonstrated as a dynamic story as generated by the map *Flight*. Though

genetically evolved, all subsequent instantiations and narrative states derive from the initial narrative archive.



Maps of a Future War: Map #3 Flight (2017)

1. Instantiation as Representation

In *Flight*, the idea of narrative state is used to model the central conflict of the story, while short texts, sentences, and fragments, which can be thought of as instantiations of those states, are the fictional representation of conflict on screen.

Narrative states in *Flight* were based on readings that described the erosion of political solutions to conflict [9]. Compared to the real world, the structure of *Flight* is very simple, limited to five contexts,
fifteen states, and the resulting transitions, as shown in Figure 1. *Flight* uses these symbolic narrative

states and text instantiations to tell stories of people in transit and to model situations that are dynamic and interrelated. In addition, instantiations are influenced by the specifics of their phase, location, and history as calculated by the digital environment.

Maps of a Future War: Map #3 Flight
Figure 1. Narrative Contexts, States, and Transitions

History	Sociology	Clausewitz	Justice	Politics
blur aggressor and defenders	erase human causes of class, race, etc	judge all sides as equally guilty	repress critics	point out complexity
is History < 0.6?	is Sociology < 0.6	is Strategy >0.6?	is Justice < 0.6?	is Politics <0.3?
↓	↓	↓	↓	↓
erase sequential memory	accept the account of the aggressor	assign blame equally	point out wrongs of the victims	dismiss preventative strategies
is History < 0.3?	is Sociology < 0.6?	is Strategy >0.3?	is Justice >0.3?	is Politics ↓ >0.3?
↓	↓	↓	↓	↓
consciousness of the instant	military groups replace political groups	condemn all parties	punish the innocent and the guilty	point out the failure of politics

Figure 1. *Maps of a Future War: Map #3 : Flight* Narrative Contexts, States, and Transitions.

Starting from these states and transitions, text agents in *Flight* drift across regions, collide with boundaries, and update

according to chance, proximity, and context. However, these instantiations are expected to change through genetic replication and mutation, thereby developing in unanticipated ways.
The intent is to move the system forward towards an exploration of unanticipated states that are explicitly dependent on the historical evolution of the map's lifecycle and to give text agents the ability to create instantiations that represent emergent states, or narrative conditions that are not programmed or anticipated by the map's initial model.

2. Narrative Design of Agents

In *Flight*, text agents produce instantiations of the story, acting as the narrators of the world. Each agent has a set of internal states and behavioral rules, as well as a string or pattern of 'DNA' that describes their starting context and identity. As described in Figure 2., some aspects of an agent's state is fixed for the agent's lifetime while other aspects are expected to change through interaction with the environment, replication, or mutation. In the model below, the agent's context, font, and color are fixed for life while it's attributes for location, observation, belief, and action are expected to evolve with the narrative system. Movements, evolution, state changes, and the resulting shifts in instantiation depend on the state of the environment and genetic computation.

Maps of a Future War: Map #3 Flight
Figure 2.. Agent Design

Context
History
Narrative State
Region

Signals/Sensors (Inputs)
Instantiation (Outputs) ← DNA ← Genes ← Computation
Movement (Outputs)
Appearance (Outputs)
Signals/Sensors (Outputs)

Figure 2. *Maps of a Future War: Map #3 : Flight* Agent Design

Text instantiations produced by agents are formed in three sections: observation, belief, and action, and are computed via a genetic algorithm from a population of solution fragments that depend on that agent's situation in the world, its narrative state in the map, and its genetic identity. For example, a text agent may sense change based on the reception of a signal from the environment. That agent will then generate a set of possible instantiation solutions and assemble a text based on that text's coherence with the current narrative state. Figure 3. shows an instantiation plan for text fragments.

Maps of a Future War: Map #3 Flight
Figure 3. Instantiation Plan

Instantiation ← DNA ← Genes ← Computation
↓
(Observation Belief Action)

Figure 3. *Maps of a Future War: Map #3 : Flight* Instantiation Plan

The relationship of observation, belief and action in agent instantiations is the basis for the emergence of new narrative states. Each instantiation of observation and action has equal probability of presenting new instantiations, while changes in belief are slightly more difficult to achieve. Figure 4. shows a possible instantiation set for an agent over several iterations. In turn, the environment can receive signals from agents, and serve as a feedback medium responsive to agent evolution.

Maps of a Future War: Map #3 Flight
Figure 4. Instantiation Plan

Signals/Sensors (Inputs)
↓
Instantiation ← DNA ← Genes ← Computation
↓
(Observation Belief Action)

Figure 4. *Maps of a Future War: Map #3 : Flight* Instantiation Plan

3. Rules of the World

Finally, there are rules for agent behavior on the map. An example of a behavior rule for an agent might be: Find the region of least conflict and move in that direction. These rules are classified in three groups: agent to environment, agent to agent, and environment to environment, controlled by the map's event/signal system, and computed as state coherence during replication. They are meant to express the overall narrative state of the map, and to couple agents to the world at large. Examples of world rules for a single agent in a predefined narrative state are listed in Figure 5.

Maps of a Future War: Map #3 Flight
Figure 5. Sample World Rules

Narrative State	Region Rule	Boundary Rule	Agent to Agent Rule	Agent Rule
consciousness of the instant	increase observation	increase action	increase action	weaken belief
military groups replace political groups	increase action	increase observation	increase action	increase belief
punish the innocent and the guilty	decrease observation	increase belief	increase action	increase action

Figure 5. *Maps of a Future War: Map #3 : Flight* Sample World Rules

As described earlier, the construction of instantiations depends on the assembly of three component text fragments categorized as observations, beliefs, and actions and assigned to the current narrative state. That is, each narrative state has an archive of possible text solutions per component. A component's judged distance from the narrative state is termed the agent's coherence weight. Coherence value of each component is calculated during selection when a final instantiation is chosen as story.

4. Using an Evolutionary Approach to Assemble Instantiations

4.1 Genetic codes

From this archive of text components, *Flight* determines an initial or parent population of agent instantiations which in turn define the map's opening narrative state. *Flight* then uses an evolutionary approach to create story [5]. Using a 'DNA' string which contains nine 'genes', three for each of the component text fragments (observation, belief, and action) and which is meant to index the characteristics of that agent's component text blocks, each agent assembles enough text components to achieve two possible parent instantiations. These parent texts then undergo two evolutionary routines (crossover, mutation), and are then assigned an instantiation weight based on their dominant component. Figure 6. illustrates an example gene and the calculation of its component index.

Maps of a Future War: Map #3 Flight
Figure 6. Example Component Assembly

DNA (random (0,1))	0.23	0.42	0.17	0.34	0.78	0.41	0.50	0.03	0.21
Environmental Signals	0.45	0.33	0.67	0.21	0.33	0.42	0.54	0.10	0.72

(assigned)			
Component Index (without mutation)	norm(0.23 + 0.42 + 0.17) + (0.45 + 0.33+ 0.67) *0.25) = 0.42	norm(0.34 + 0.78 + 0.41) + ((0.21 + 0.33 + 0.42)*0.25) = 0.47	norm (0.50 + 0.03 + 0.21) + ((0.54 + 0.10 + 0.72) * 0.25) = 0.28

* norm() =(value - min) /(max - min)

Figure 6. *Maps of a Future War: Map #3 : Flight* Example Component Assembly

4.2 Genetic operators

Flight uses two genetic operators, mutation and crossover, to evolve instantiations:

Mutation

Mutation is an operation to change the ith index in the in the chromosome code. For example, Figure 7. demonstrates a parent chromosome mutating one 'gene' in the fourth DNA index which would manifest as a component text mutation from Group 5 to Group 1.

Crossover

Crossover intermixes the existing DNA strings to population to create new indices. In this initial version of *Flight*, only single point crossover is used. A dividing point is selected from one of the three component block (observation, belief, action) and the transfer of data is applied. Figure 8. shows a crossover at the action component. The child instantiation inherits its action index from Parent B, while retaining its observation and belief indices from Parent A.

Maps of a Future War: Map #3 Flight

Figure 7. Mutation

DNA (random (0,1))	0.23	0.42	0.17	0.34	0.78	0.41	0.50	0.03	0.21
Mutation Index random(9) ex. random(9) = 4	0.45	0.33	0.67	0.21	~~0.33~~ **0.33 * 0.5 = 0.17**	0.42	0.54	0.10	0.72
Environmental Signals (assigned)	0.45	0.33	0.67	0.21	0.17	0.42	0.54	0.10	0.72
Component Index with Mutation	norm(0.23 + 0.42 + 0.17) + (0.45 + 0.33+ 0.67) *0.25) = 0.42			norm(0.34 + 0.78 + 0.41) + ((0.21 + 0.17 + 0.42)*0.25) = 0.13			norm (0.50 + 0.03 + 0.21) + ((0.54 + 0.10 + 0.72) * 0.25) = 0.28		

* norm() =(value - min) /(max - min)

Figure 7. *Maps of a Future War: Map #3 : Flight* Mutation

Maps of a Future War: Map #3 Flight

Figure 8. Example of Single Point Crossover

Parent A - Observation (weight 0.20)	Parent A - Belief (weight 0.44)	Parent A - Action (weight 0.36)
Parent B - Observation (weight 0.32)	Parent B - Belief (weight 0.82)	Parent B - Action (weight 0.44)
Child 1 - Observation (weight 0.51)	Child 1 - Belief (weight 0.62)	Child 1 - Action (weight 0.36)
Child 2 - Observation (weight 0.63)	Child 2 - Belief (weight 0.44)	Child 2 - Action (weight 0.43)

Figure 8. *Maps of a Future War: Map #3 : Flight* Example Component Assembly

Maps of a Future War: Map #3 Flight

Figure 9. Instantiation Weights

DNA (random (0,1))	0.23	0.42	0.17	0.34	0.78	0.41	0.50	0.03	0.21
Mutation Index random(9)	0.45	0.33	0.67	0.21	~~0.33~~	0.42	0.54	0.10	0.72
ex. random(9) = 4					**0.33 * 0.5 = 0.17**				
Environmental Signals (assigned)	0.45	0.33	0.67	0.21	0.17	0.42	0.54	0.10	0.72
Component Index with Mutation	norm(0.23 + 0.42 + 0.17) + (0.45 + 0.33+ 0.67) *0.25) = 0.42			norm(0.34 + 0.78 + 0.41) + ((0.21 + 0.17 + 0.42)*0.25) = 0.13			norm (0.50 + 0.03 + 0.21) + ((0.54 + 0.10 + 0.72) * 0.25) = 0.28		
Instantiation Weight	0.42			0.13			0.28		
Mutated Component Text	round(0.42) → Group 4			round(0.13) → Group 1			round(0.28) → Group 3		

* norm() =(value - min) /(max - min)

Figure 9. *Maps of a Future War: Map #3 : Flight* Instantiation Weights

4.3 Selection and Coherence Weights

Now that each instantiation has been assembled and weighted, one child can be compared to another, to agent rules, world rules, and to the narrative state of the system. Selection is carried out in two steps. First, an instantiation rule coherence is determined. Rule coherence is a measure of how closely instantiation components follow agent rules as determined by the narrative state as seen in Figure 10.

Maps of a Future War: Map #3 Flight

Figure 10. Rule Coherence

Narrative State: 'Consciousness of the Instant'

Instantiation Weight	Observation 0.42	Belief 0.14	Action 0.28
Change from Prior Instantiation	+0.10	-0.32	-0.14
Region Rule (increase observation)	yes abs(0.10)		
Boundary Rule (increase action)			no
Agent to Agent Rule (increase action)			no
Agent Rule (weaken belief)		yes abs(0.32)	
Rule Coherence	norm(0.10 +0.32) = 0.14		

* norm() =(value - min) /(max - min)

Figure 8. *Maps of a Future War: Map #3 : Flight* Rule Coherence

In the second round of selection, the state coherence of text fragments is compared to the conflict levels of the narrative state as shown in Figure 11.

Maps of a Future War: Map #3 Flight

Figure 11. Use of Coherence Weights

Narrative State	State Coherence	Instantiation Component		
		Observation	Belief	Action
	0.6	seeing battalions in the street	a problem with governments distant faltering disappearing in silence without debate protests overnight without warning	
	0.3			regaining the will of the moment demanding it much as we should have insisted on all the rest
military groups replace political groups (conflict - high) (weight 0.9)				

Figure 9. *Maps of a Future War: Map #3 : Flight* State Coherence

Initially, children of closest state coherence have a fifty fifty chance of being selected as a final instantiation, but as the narrative state tends toward conflict, the systems chance of choosing children of closer coherence increases. In this way, the map dynamically adjusts the need for narrative coherence to the amount of conflict in the system. Figure 12 describes the selection of a final child text.

Maps of a Future War: Map #3 Flight

Figure 12. State Coherence

Narrative State	Coherence Weight Child 1	Coherence Weight Child 2	Final Instantiation
consciousness of the instant (conflict - low)	0.24	0.65	Random Child 1 or Child 2
accept the account of the aggressor (conflict - moderate)	0.36	0.32	Random Child 1 or Child 2
military groups replace political groups (conflict - high)	0.46	0.32	Child 1

Figure 12. *Maps of a Future War: Map #3 : Flight* State Coherence

The process of selection gives us two measures, the child with the greatest rule coherence and the child with the closest state coherence. If conflict is low or moderate, the child with the greatest rule coherence is chosen. In states of high conflict, the child with the highest state coherence is chosen as in Figure 13.

Maps of a Future War: Map #3 Flight

Figure 13. Final Instantiation

Narrative State	Rule Coherence Child 1	Rule Coherence Child 2	State Coherence Child 1	State Coherence Child 2	Final Instantiation
consciousness of the instant (conflict - low)	0.24	0.65	0.70	0.21	Child 2
accept the account of the aggressor (conflict - moderate)	0.36	0.32	0.34	0.32	Random (Child 1 or Child 2)

military groups replace political groups (conflict - high)	0.46	0.32	0.34	0.44	Child 1
punish the innocent and the guilty (conflict - high)	0.32	0.32	0.62	0.13	Child 1

Figure 13. *Maps of a Future War: Map #3 : Flight* Final Instantiations

5. Implementation

This section describes the operations of one text agent at an initial narrative state in order to illustrate an evolutionary approach to text. All agents texts are written as fragments and classified hierarchically first by state, then by group. An example of text classification is shown in Figure 14.

Maps of a Future War: Map #3 Flight

Figure 14. Text Group Assignments

Narrative State	Component	Instantiation Weight	Group ID	Text
		0.1	1	bald stooping escorted by two soldiers one wearing the insignia
		0.1	1	flags hanging on terraces
		0.2	2	apparently in pursuit of something staggering forward stammering what was it he looked
		0.2	2	the border still far ahead of us
		0.3	3	odd the hair red scarf around her throat not from this area
		0.3	3	we looked up a sky full of clouds a blue sky
military groups		0.4	4	we argue grieve offer prayers send condolences
replace		0.4	5	so far from the city
political groups	Observation	0.5	5	and the child running up and down the line up and down
(conflict - high)		0.6	6	he went on talking he seemed to be a thousand years old
		0.6	6	shaking his head holding his hands over his ears
		0.7	7	he had a medal hanging around his neck
		0.7	7	she came toward us beginning to reproach us for walking toward the road who was she to interfere we
		0.8	8	no he said waving us back toward the white markers no I'm telling you for the last time
		0.8	8	even in outskirts now streets full of soldiers
		0.9	9	without asking sitting in the empty chair next to me he began whispering
		0.9	9	he stared at
		0.1	1	too bored to go on
		0.1	1	the guilty ones taking advantage of the confusion slipping out the back
		0.2	2	like the middle of nowhere
		0.2	2	impressed with ideas innovation leaving the house at all hours to hear a speaker or attend

		0.3	3	like one of their forms a piece of paper
		0.3	3	dedicated to the virtues of maintaining his position
military groups		0.4	4	because people will believe anything especially if it's in their interest to believe it
replace		0.4	4	we could have continued we could have gone farther now it's more dangerous more expensive
political groups	Belief	0.5	5	time to acknowledge a long list of grievances offenses useless demands
(conflict - high)		0.5	5	that visa it will never come through
		0.6	6	a problem with governments distant faltering disappearing in silence without debate protests overnight without warning

Maps of a Future War: Map #3 Flight

Figure 14. Text Group Assignments (Continued)

		0.7	7	there was something else something dependant of his good health but he was sick he was sick
		0.8	8	but going to the police or the embassy what a waste
		0.8	8	I have things to sell things people want
		0.9	9	he'll make us pay
		0.9	9	do people believe those stories
		0.1	1	we decided to go east hoping to get on a plane that would take us further
		0.1	1	but I refuse to pay attention
		0.2	2	coming over to look at the sky
		0.2	2	discarding our letters photographs anything that would draw attention
		0.3	3	I was looking out for myself looking ahead I had a ticket a way to the airport then at the last moment I turned back
		0.3	3	let's quit listening to these morbid stories
military groups		0.4	4	I thought I'm sitting here I'm still here while everything is moving around me
replace		0.4	4	though as I listened to her story I was annoyed by her plain accounting of the facts her matter of fact opinions her common sense
political groups	Action	0.5	5	I'll go back to the first town I think they'll take me back
(conflict - high)		0.5	5	we decided to back to Sweden we still knew some people there
		0.6	6	keep walking I told them until someone tells us otherwise
		0.6	6	he felt he was in danger I wanted to know why wasn't everyone here in some kind of trouble
		0.7	7	I was startled but I recognized him I understood the expression on his face
		0.7	7	we won't report it we won't say anything about any of this
		0.8	8	and if anyone tries coming near me
		0.8	8	I'm not going to sit here watching truckloads of refugees roll past keeping silent doing nothing
		0.9	9	let them try it they'll see what they get
		0.9	9	I'll make myself invisible move past this I'll move right between them

Figure 14. *Maps of a Future War: Map #3 : Flight* Text Group Assignment

Since what is of interest is the way evolutionary conventions might lead to emergent states, the start state of the system is somewhat arbitrary. The idea is to see if the map can produce emergent narratives, or emergent narrative states as text generations are computed. Therefore, the initial narrative state is chosen at random.

This initial state governs world rules (as shown above in Figure 5) as well as initial signal states for

base segments their generation zero text outputs, and story is assembled from these base classifications: observation, belief, and action. Floats 0-2 define the agent's 'observation' statements, floats 3-5 govern the agent's 'belief' statements, and floats 6-8 decide the agent's 'action' statements as shown in Figure 15. Figure 16 shows an example of a starting assembled text.

Maps of a Future War: Map #3 Flight
Figure 15. Groups Assignments

Narrative State	Component	Rule (assigned)	DNA (random)	Instantiation Weight Needed	Group Assignment	Text (randomly chosen from group population)
military groups	observation	increase observation	0.32	>0.3	Group 4	we argue grieve offer prayers send condolences
replace	belief	increase belief	0.45	>0.5	Group 6	a problem with governments distant faltering disappearing in silence without debate protests overnight without warning
political groups	action	increase action	0.29	>0.3	Group 4	turning to the window

Figure 15. *Maps of a Future War: Map #3 : Flight* Text Group Assignments

Maps of a Future War: Map #3 Flight
Figure 16. Assembled Text

Observation	→	we argue grieve offer prayers send condolences	→	we argue grieve offer prayers send condolences a problem with governments distant faltering disappearing in silence without debate protests overnight without warning turning to the window
Belief	→	a problem with governments distant faltering disappearing in silence without debate protests overnight without warning		
Action	→	turning to the window		

Figure 16. *Maps of a Future War: Map #3 : Flight* Example of Assembled Parent Text

This initial text is regarded as Parent Text A. When system signals reach a point of where text generation is called, the same routine is used to select new instantiation weights for Parent Text B. Weight values for both parent texts undergo mutation and crossover as described in

Section 4 (above). The parents then undergo crossover to produce two child texts whose coherence
weights are calculated for the selection of a final Generation 1 child text. With final coherence weight of the child text calculated, the narrative state of the system is updated and signaled to the system agents controlling regions, boundaries, and landscape textures.

6. Conclusions

This paper describes the generative construction of text in the Maps of a Future War: Map #3 Flight and explained the methods used to attempt emergent narrative states in this story. Through a system of text agents, components, DNA strings, signal, boundaries, state, and coherence weights, the story in this digital map was constructed by using an evolutionary approach based on genetic algorithms. The use of evolutionary methods in the assembly of this story helped achieve the emergent characteristics of the text.

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Automatic Synthesizing System of Choreography for Supporting Contemporary Dance Creation
(Paper)

Topic: (Dance)

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Abstract

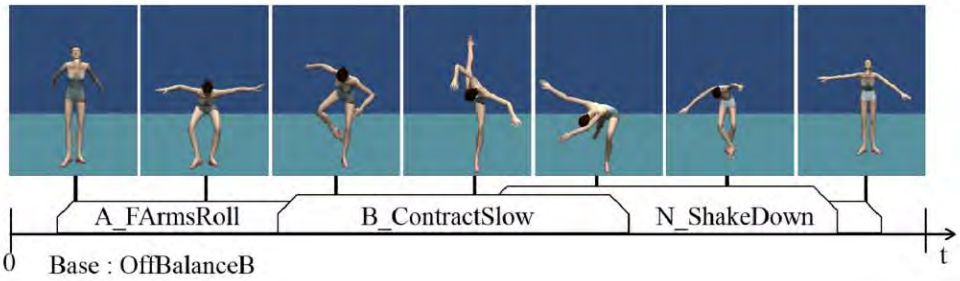
The purpose of this study is to support the creation of contemporary dance choreography using 3D motion data acquired by motion capture. In this study, we have developed “Body-part Motion Synthesis System” (BMSS) that allows users to create short choreographies by synthesizing body-part motions and to simulate them in 3D animation. Users can use the composed sequences as references for dance creation, learning, and training. Since the application runs on tablets, users can use it freely anywhere when they are creating dance choreographies.

This system automatically provides various short choreographies. First, users select a base motion and body-part categories. Then the system automatically selects and synthesizes body-part motions to the base motion. We randomly determined the synthesis timings of the selected motions. This feature allows many variations of choreographies to be generated each time.

We propose a method that automatically synthesizes a sequence of short choreographies based on the distance between starting/ending poses of motions, which would make it easier to consider the continuity of motions. A few short choreographies that contain a pose similar to the pose of the motion selected by user are connected.

We experimentally evaluated the effectiveness of BMSS ver.4.1 with 15 students who are studying dance choreography at university in Japan and USA. From the results of the experiment, we confirmed the effectiveness of this method for supporting dance creation.

BMSS



Example of motion sequence

email/address
asako@motionlab.jp

Key words: dance performance, choreography, 3DCG

Main References:

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Automatic Synthesizing System of Choreography for Supporting Contemporary Dance Creation

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Abstract

The purpose of this study is to support the creation of contemporary dance choreography using 3D motion data acquired by motion capture. In this study, we have developed “Body-part Motion Synthesis System” (BMSS) that allows users to create short choreographies by synthesizing body-part motions and to simulate them in 3D animation. Users can use the composed sequences as references for dance creation, learning, and training. Since the application runs on tablets, users can use it freely anywhere when they are creating dance choreographies.

This system automatically provides various short choreographies. First, users select a base motion and body-part categories. Then the system automatically selects and synthesizes body-part motions to the base motion. We randomly determined the synthesis timings of the selected motions. This feature allows countless variations of choreographies to be generated each time.

We propose a method that automatically synthesizes a sequence of motions by connecting choreographies based on the distance between starting/ending poses of motions, which would make it easier to consider the connectivity of choreographies. Based on this idea, a few choreographic motions that contain a pose that resembles to the starting/ending poses of the choreographic motions entered by user are connected.

We experimentally evaluated the effectiveness of BMSS 4.1 with 15 students who are studying dance choreography at two universities in Japan and USA. From the results of the experiment, we confirmed the effectiveness of this method for supporting dance creation.

1. Introduction

The purpose of this study is to support the creation of dance choreography using 3D motion data acquired by motion capture. We have been developing interactive simulation systems for dance using dance-motion archives. Automatic composition for ballet [1], contemporary dance [2], and hip-hop dance [3] using the motion clips of the whole body have already been developed in our project [4].

We developed Body-part Motion Synthesis System (BMSS) that allows users to create short choreographies by synthesizing body-part motions and to simulate them in 3D animation [5]. Since creating complex choreographies is very time-consuming, the BMSS version 3.0 supports the automatic synthesis of body-part motions to reduce the time needed to create them [6]. We experimentally verified its usability for choreographic education with contemporary dance majors [7]. In BMSS version 4.0, we improved it to interactively connect the short choreographic motions and play them as sequences. We probed its usability for choreographic creation by four professional choreographers [8]. This paper describes the latest version of BMSS with automatic generation of phrases and its evaluation.

There are some related works on computational dance study. Some research used dance notation and developed software applications [9, 10]. With this software, users can simulate already captured or precisely described dance animation. However, it is difficult to use these applications to compose original dances. A dance simulation system using 3D motion data with handwritten sketch inputs was developed [11]. However, it is also difficult to compose creative and effective choreographies using this system because the number of dance motions is limited. Our proposed software allows users to create an unlimited number of different varieties of dance movements.

Some studies have been made on synthesizing motions automatically using motion data. For motion combinations, one study automatically connected the basic motions of Japanese Noh and previewed them in 3DCG animation [12]. Other study focused on the synthesis of novel motion sequences from a database of motion capture examples using a statistical model [13]. Other study addressed motion synthesis using music, such as synthesizing dance motions based on emotions and the contents of a piece of music [14]. These studies generated natural motions by connecting or synthesizing multiple motions automatically based on rules. However, we support creation that targets contemporary dance without style or traditional manner restrictions. Rather than natural motions, our proposed system generates unexpected motions that are helpful for dances and choreographers.

2. BMSS

Figure 1 shows the Graphical User Interface (GUI) of BMSS version 4.1. This system automatically provides various short choreographic motions called Unit. First, users select a base motion and body-part categories. Then the system automatically selects and synthesizes body-part motions to the base motion. The system randomly determined the synthesis timings of the selected motions. This feature allows countless variations of Units to be generated each time. The generated Units can be displayed as animation using 3DCG characters. Users can control the camera view or the playback speed of the animation. Favorite Units can be saved, composed, and played as Sequences of dance on timelines. A smooth transition to/from the synthesized motion, with the base motion's

corresponding body-part, is achieved at the start and end timings of the synthesis to display them naturally.

Figure 1. GUI of BMSS 4.1.

In order to consider the connectivity of Units, we suggest the automatic generation of Phrases, which are automatically generated combinations of some Units. User can create a Sequence by selecting some of the saved Units or the generated Phrases. Figure 2 shows examples of Unit, Phrase, and Sequence.

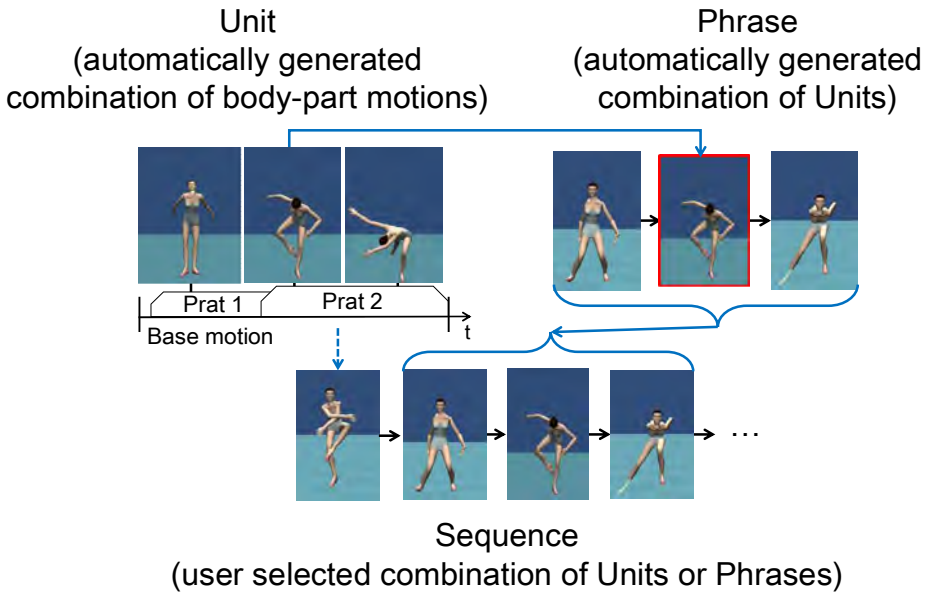

Figure 2. Examples of Unit, Phrase, and Sequence.

Users can use the composed Sequences as references for dance creation, learning, and training. Since the application runs on tablets, users can use it freely anywhere when they are creating dance choreographies. This provides an opportunity to develop new ideas for choreography creation. Occasionally, impossible and/or unnatural dance motions are created, but users do not have to completely reproduce actual motions in the 3DCG characters. They can incorporate various arrangements and ideas in their generated motions without our application by adopting such techniques as horizontal inversion and devising motions for the hands and feet to simplify balance.

3. Automatic Synthesizing Methods

3.1. Motion data

Motions are provided as short motion clips that were captured by motion capture from performances by professional dancers. Each motion clip consists of simple and uncombined movements. Each motion's potential for synthesis is analysed and separated into three main categories: Base, Blend, and Body-part.

The motion clips of the Base category are the whole-body movements that form the basis of the created choreographic motions. Motions that involve the whole body, like standing upright or one-leg balance, are assigned to this group. The Base category includes the sub-categories such as Stand, Move, Jump, Turn, and Floor. The motion clips of the Blend category are the whole-body movements that can be blended with the Base motion clips. This group mainly consists of hip movements like jumping and twisting, that which are made more effective by blending them together with other motions. The motion clips of the Body-part category are the body-part movements that replace the body-part movements of the Base motion clips. The Body-part category includes the sub-categories of body parts, such as Body, L-Leg (Left-Leg), Shoulders, Arms, and Neck. Only L-Leg motions are prepared as the replaceable leg motions, since unnatural motions can be generated when both legs' motions are replaced. Moreover, during performance of the choreography, users can horizontally invert these leg motions to the right side. Figure 3 illustrates body-part categories. The number of motion clips included in each category is shown in Table 1. There are 167 motion clips in total.

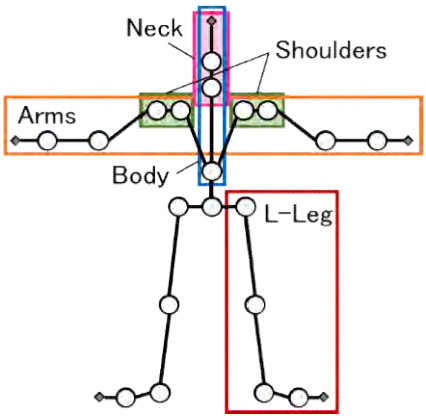

Figure 3. Body-part categories.

Table 1. Categories and the number of motions used in BMSS 4.1.

Motion category		Number of motions	
Base	Stand	20	60
	Move	12	
	Jump	10	
	Turn	6	
	Floor	12	
Blend			7
Body-part	Body	10	100
	Neck	10	

	L-Leg	26	
	Shoulders	8	
	Arms	46	
Total			167

3.2. Automatic synthesis of body-part motions

Figure 4 shows concept of generating Units. Short choreographic motions about five seconds long are automatically generated by synthesizing various body-part motion clips. In Figure 4, an Arms motion and a L-Leg motion are synthesized to the user-selected Base motion. Based on the motion categories selected by the users, body-part motions synthesized to the Base motion are selected and the synthesis timings are randomly determined. This feature allows countless variations of choreographies to be created each time.

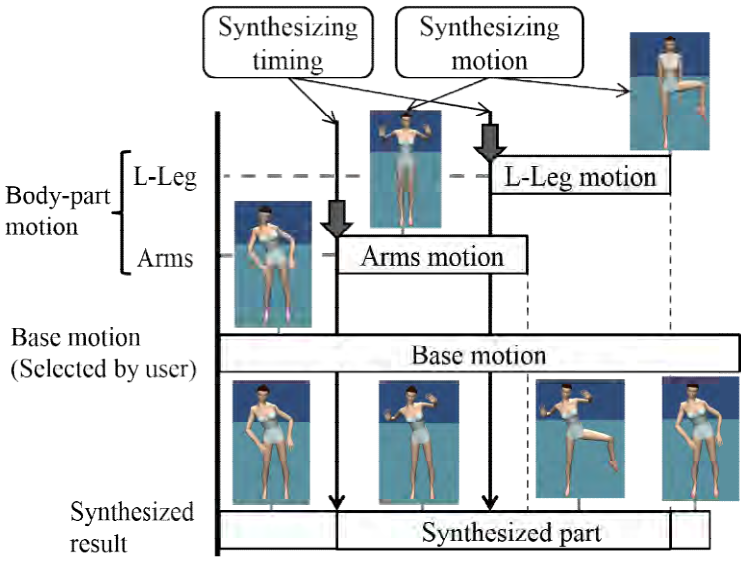

Figure 4. Concept of generating Units.

The motion clips that are used for the synthesis are automatically selected. First, it randomly determines the number of motion clips that are synthesized to the Base motion clip based on the upper limit of the categories selected by the users. Next, the motion categories are selected from the Blend or Body-part categories. Then one motion clip is selected for each category. To show many selections and provide an opportunity to develop new ideas for choreography creation, ten Units are created at the same time. The same motion clips are not selected as possible in the ten created Units to avoid duplication and to ensure a certain degree of variety.

The synthesis timing of the motion clips is automatically determined. Perhaps impossible or unnatural motions are generated if the synthesis timing is simply determined by a random number. To reduce the chance of generating such motions, we adjusted the synthesis timing by the constraints of body parts making contact with the floor [6].

3.3. Automatic generation of Phrases

Our system supports the automatic generation of Phrases to investigate motion connectivity. The connectivity between saved Units is evaluated using the similarity of starting/ending poses included in each Unit, determined by the distance between connectable poses. Based on this idea, a few Units are connected that contain a pose that resembles the starting/ending pose of the Units entered by users. In our system, the generated Phrase consists of up to four Units at present. In addition, it randomly selects a connecting Unit from within a threshold's range to make variations. Figure 5 shows examples of the created Phrases. Based on the user-selected Unit in red rectangles, the system suggests the following or previous motions from the saved Units.

We propose a method that automatically synthesizes a sequence of motions by connecting choreographies based on the distance between starting/ending poses of motions, which would make it easier to consider the connectivity of choreographies. Based on this idea, a few choreographic motions that contain a pose that resembles to the starting/ending poses of the choreographic motions entered by user are connected.

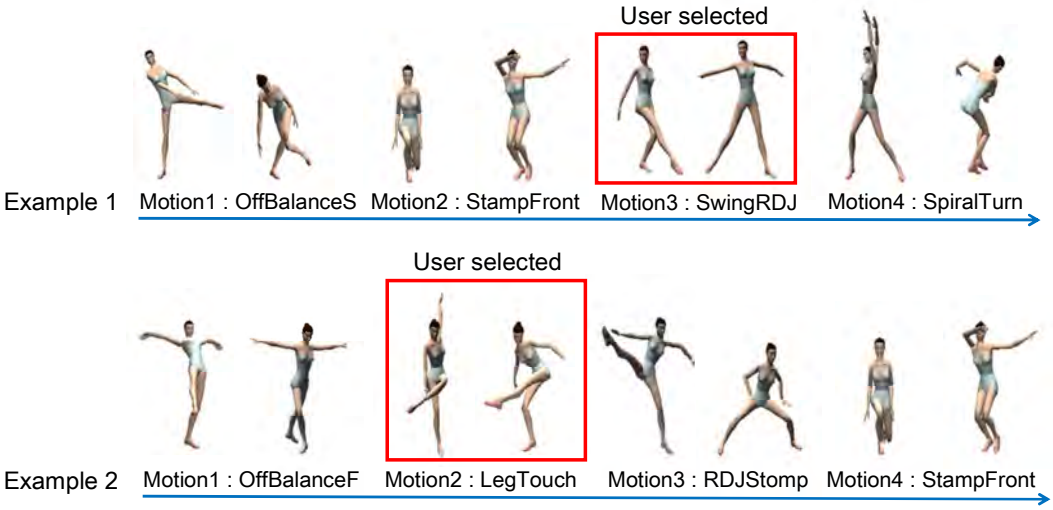

Figure 5. Examples of generated Phrases

4. Experiments

4.1. Method

We experimentally evaluated the effectiveness of supporting dance creation and our method's effectiveness of handling Phrases with eight University of Tsukuba students in Japan (JP) and seven University of California Irvine students in USA (US): 14 females and one male.

Our experiments were conducted by one set from two to four participants in a dance studio, and the experiment time per set was 90 minutes. First, we briefly explained our system to the students and they freely simulated and composed Units with the software. Second, they selected and saved around 20 Units that might have serve as seeds or hints of their own choreographies. Next, they created their own short, roughly 30-second long dance Sequences using the saved Units with two different methods: by hand or Phrases. After the students created their choreographies, they could freely add such techniques as iteration, inversion, or speed changes. They performed their choreographies themselves in

front of a video camera, answered questionnaires at four levels and explained the reasons. We asked them the system's effectiveness for contemporary dance creation by two methods: hand and Phrases. We also got feedback about the effectiveness of understanding the movements and the training of dance techniques.

4.2. Results and discussion

The results of the four levels are illustrated in Figure 6.

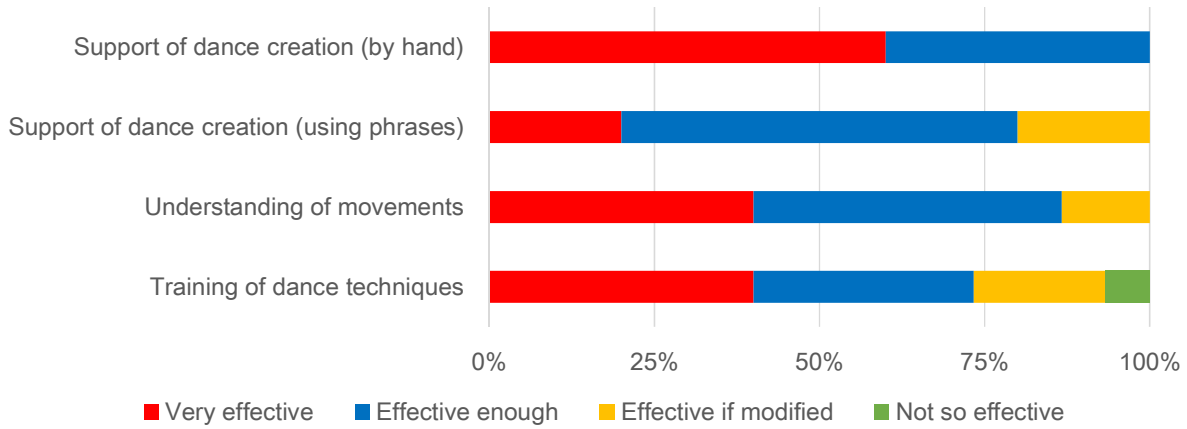

Figure 6. Evaluation by students.

All 15 students answered "very effective" or "effective enough" for contemporary dance creation by hand. None chose "effective if modified" or "not so effective". On the other hand, in terms of contemporary dance creation using Phrases, three students answered "very effective," nine answered "effective enough," and three answered "effective if modified."

By comparing these results, numerical analysis suggests that most students preferred to create Sequences by hand than using Phrases. The results indicate almost same tendency for students in Japan and US despite the difference of learning environments of contemporary dance. Several typical reasons are excerpted below. The student's country is shown in brackets: (JP) or (US). The Japanese responses were translated into English.

"I could imagine the connectivity of movements better by the hand method" (JP). "With the Sequence created by hand, it was easier to express by my actual body than using Phrases" (JP). Here are some positive reasons for using the Phrases: "[It] made new transitions I would have not naturally done and created repetition" (US), "it gives the new idea such as a way for a smoother transition in each movement" (US), "the time for creating with Phrases was shorter than by hand" (JP), and "it was easy because the flow of movements was just generated naturally by selecting a motion that I really wanted to input" (JP). The feedback suggests that our system effectively supports dance creation.

In terms of understanding the movements, 13 of 15 students (87%) chose "very effective" or "effective enough." We received the following comments: "Very easy to see dancer's movement on the screen," (US) and "some movements became hard to follow if the avatar was glitchy" (US).

In terms of training the dance techniques, 11 of 15 students (73%) chose “very effective” or “effective enough.” Three answered “effective if modified,” and one answered “not so effective.” The main positive reason was that it “gives good practice sequences for outside of class” (US). The “not so effective” reason was that “some movements were hard to understand when it comes to a simple movement, it’s easier to catch but in a harder one it’s more difficult to understand the concept of the movement” (US).

5. Conclusion

We developed a system that creates short contemporary dance choreographies by automatically synthesizing many body-part motions to support choreography creation. We proposed a method that automatically synthesizes phrases by connecting choreographic motions based on the distance between the starting/ending poses of motions to simplify the continuity of choreographies.

We experimentally evaluated the effectiveness of BMSS 4.1 with 15 dance students at two universities in Japan and USA. The students created choreographies using the system and performed them. We gathered questionnaire comments about the system’s effectiveness for creation, training, and understanding movements. Our experiment results confirmed that automatically generating choreographic motions and phrases effectively supports dance creations. We recognized that most students preferred to create sequences by hand than using phrases. However, using phrases increased the speed of sequence creation more than that by hand and sometimes suggested new connections of movements. We verified that BMSS is a helpful creation training tool for dance students who can discover new choreographic methods, new dance movements, and greater awareness of their bodies.

In the future, we will give this system to professional choreographers and get additional feedback to improve it. Creating longer dance sequences and performing them on stage is another challenge. We will also archive additional motion clips and adapt our system to such dance genres as hip-hop or classical ballet.

Acknowledgements

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TITLE :
STYLE-DIRECTED EVOLUTIONARY DESIGN
(Paper)

Topic: Design

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Abstract
Recently, an iterative methodology based on a cyclic process of prototyping, analyzing, testing and refining a solution or process is often used in the design process. It starts with a preliminary design, which is then analyzed to assess its feasibility and decide on changes and refinements. This process of evaluation and optimization is repeated until the quality and functionality of a design is satisfactory. In computer science such a process can be modeled by a search process, where all possible designs form a search space, thus it is possible to use search techniques such as evolutionary ones. As evolutionary search consists in evaluating and refining possible solutions, so it is highly analogous to a human design iterative process of analysis, testing and optimization [1]. Similarly to the refinement step in human design, in evolutionary search designs to be modified are determined according to their evaluation (fitness). The refinement step is often performed not on actual solutions (phenotypes) but on their coded equivalents (genotypes). Yet, in human design the process is usually directed not only by the desire to obtain an optimal artefact but also such a one that meets certain requirements. Design requirements are often related to styles [2]. This paper deals with style-directed evolutionary design.

The most popular approach in evolutionary computing is based on representing solutions as binary strings. In design problems genotypes in such a form are often insufficient, so we propose to use a graph-based representation of genotypes as it enables us not only to express geometrical properties of an object but also its attributes (like color, material etc.) and most importantly relations between object components. Using graphs as a representation of design artefacts in an evolutionary search process requires the adaptation of traditional evolutionary operators like cross-over and mutation as well as defining an appropriate fitness function. Moreover, these operations have to take into account the desired\required style of the artefact being designed. As the graphs selected to be transformed by these operators during the evolution and their structures are not known a priori, the operators must be defined in a way which allows for a dynamic computation of resulting graphs. In our approach, a cross-over operation can only exchange subgraphs, while mutation affects local and global attributes as well as the graph structure (by adding or deleting subgraphs). Moreover, a mutation operator is designed in such a way that it only allows changes within a range suitable for a given style of designs. A fitness function is specified in such a way that it prefers solutions adhering to the rules of a given style. The approach is illustrated by examples of designing gardens in different styles.

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Key words: graph structures, evolutionary design

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Style-directed Evolutionary Design

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Abstract

This paper deals with an evolutionary approach to design. The aim of this paper is to present a new approach to style-oriented evolutionary design. Designs are represented by means of graphs, in which graph nodes represent components of the design while graph edges represent relations between the components. Main graph evolutionary operators, i.e., crossover and mutation are modified in this paper. The operators are based on previous graph evolutionary operators but are extended to incorporate style-preserving features. The approach is illustrated by examples of designing gardens in the Japanese style.

1. Introduction

Recently, an iterative methodology based on a cyclic process of prototyping, analyzing, testing and refining a solution or process is often used in the design process. It starts with a preliminary design, which is then analyzed to assess its feasibility and decide on changes and refinements. This process of evaluation and optimization is repeated until the quality and functionality of a design is satisfactory. In computer science such a process can be modelled by a search process, where all possible designs form a search space, thus it is possible to use search techniques such as evolutionary ones. As evolutionary search consists in evaluating and refining possible solutions, it is highly analogous to a human design iterative process of analysis, testing and optimization [1]. Similarly to the refinement step in human design, in evolutionary search designs to be modified are determined according to their evaluation (fitness). The refinement step is often performed not on actual solutions (phenotypes) but on their coded equivalents (genotypes). Yet, in human design the process is usually directed not only by the desire to obtain an optimal artefact but also such a one that meets certain requirements. Design requirements are often related to styles [2]. The aim of this paper is to present a new approach to style-directed evolutionary design.

The most popular approach in evolutionary computing is based on representing solutions as binary strings. In design problems genotypes in such a form are often insufficient, so we propose to use a graph-based representation of genotypes as it enables us not only to express geometrical properties of an object but also its attributes (like colour, material etc.) and most importantly relations between object components. Using graphs as a representation of design artefacts in an evolutionary search process requires the adaptation of traditional evolutionary operators like cross-over and mutation as well as defining an appropriate fitness function. Moreover these operations have to take into account the desired\required style of the artefact being designed. As the graphs selected

to be transformed by these operators during the evolution and their structures are not known a priori, the operators must be defined in a way which allows for a dynamic computation of resulting graphs. In our approach a cross-over operation can only exchange subgraphs, while mutation affects local and global attributes as well as the graph structure (by adding or deleting subgraphs). Moreover a mutation operator is designed in such a way that it only allows changes within a range suitable for a given style of designs. A fitness function is specified in such a way that it prefers solutions adhering to the rules of a given style. The approach is illustrated by examples of designing gardens in different styles.

2. Evolutionary Design

As mentioned in the introduction the design process can be modelled by a search process. As evolutionary search consists in evaluating and refining possible solutions it can be seen as analogous to a human design iterative process of analysis, testing and optimization [1,3,5,7]. That is the refinement step in human design, which is based on earlier analysis and testing, can be modelled in evolutionary search by transforming designs according to their evaluation calculated by the so called fitness function. In many types of evolutionary search the refinement step is often performed not on actual solutions (called phenotypes, which in this paper are designs) but on their coded equivalents (called genotypes).

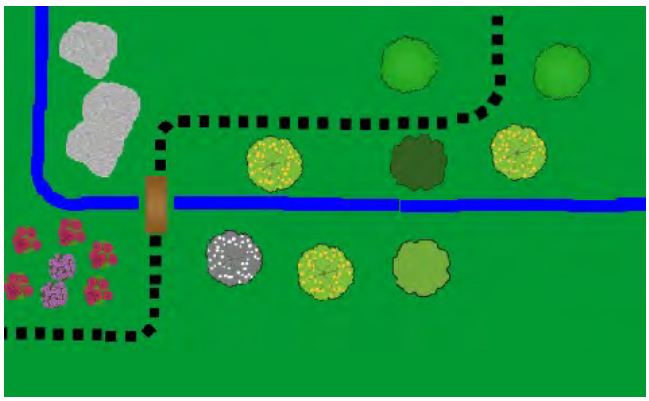


Fig.1 An example of a garden in Japanese style

In many optimization problems being solved with an evolutionary approach a binary coding is used, i.e. the actual solutions are represented by binary strings [1,3,5,7]. Yet in design problems they are usually insufficient as representing not only geometrical properties of an object, but also its other attributes (like colour, material etc.) and relations between object components is hard to achieve in a string form.

The representation of objects used in CAD problems like boundary representations, sweep-volume representations, surface representations or CSG (constructive solid geometry) [6] allow only for the "coding" of geometry of an object being designed and do not take into account the inter-related structure of many design objects, i.e. the fact that parts (or components) of an object can be related to other parts in different ways. Such a structure is usually represented as a graph [4,8].

3. Graph-based representation of designs

In CAD problems the knowledge about a design object can be expressed in a formal machine readable format. Such a format has to be on one hand well structured and machine readible, but at the same time rich enough to capture geometrical, numerical and relational properties of an object.

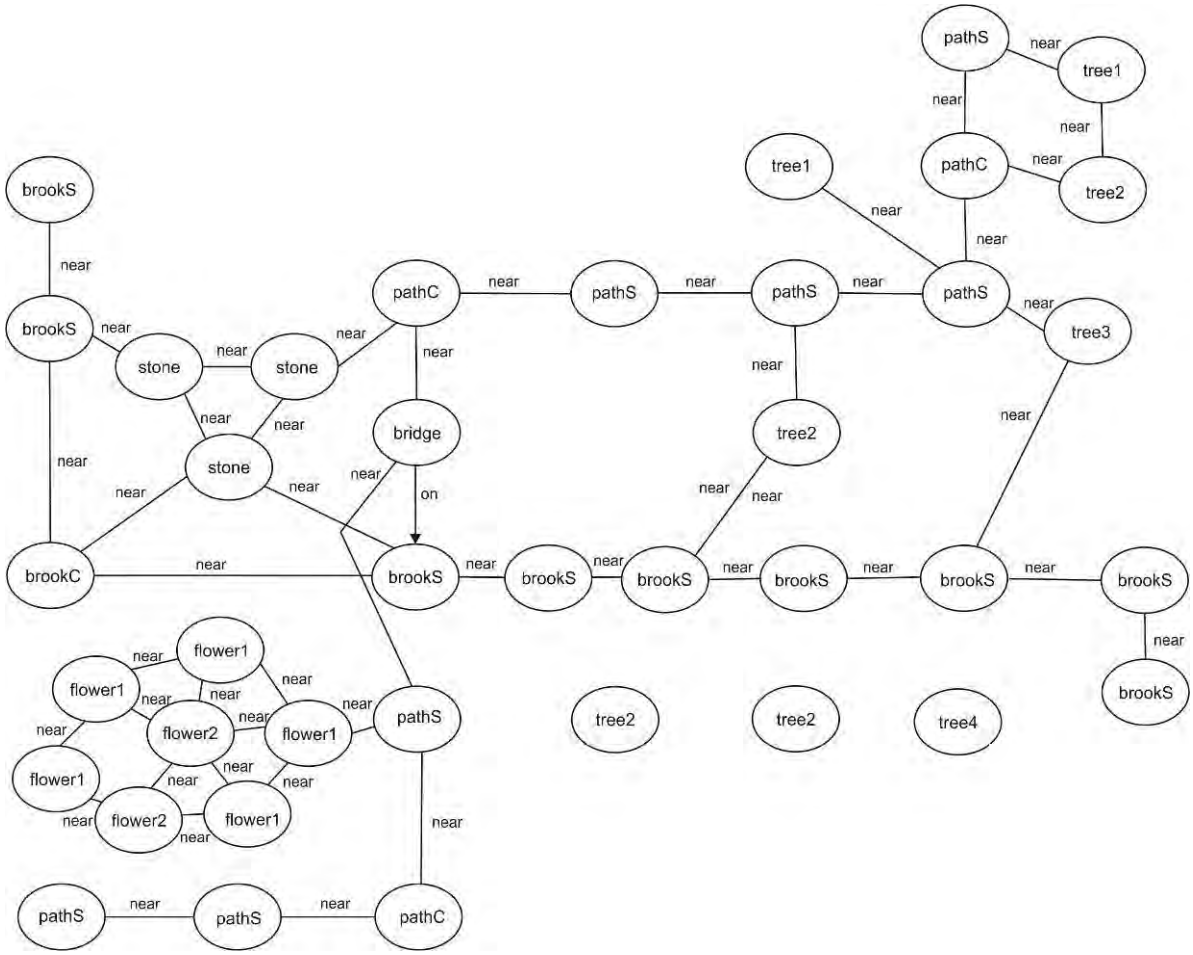


Fig.2 A graph representation of a garden from Fig.1

In this paper directed labelled graphs are used to represent design drawings. Graph nodes represent components (parts) of the object being designed, while edges express relations between them. Nodes are labelled by names of components (or types of components) and edges are labelled by names of relations between them.

In case of garden design the nodes are labelled by the names of the elements of the garden and the relations can be both directed and undirected. The edges representing the adjacency relation are undirected and labelled *near*, while edges representing the being above relation are directed and labeled *on*.

In Fig. 2 a graph representing the garden design presented in Fig.1 is shown. Nodes labelled *tree1*, *tree2*, *tree3* and *tree4* represent different species of trees, nodes labelled *flower1* and *flower2* - flower clumps composed of two kinds of flowers. Nodes labelled *stone* represent a group of three stones and nodes labeled *pathS, pathC, brookS, brookC*, and *bridge* represent straight and winding fragments of the path, straight and winding fragments of the brook, and the footbridge. Edges labelled *near* represent the adjacency

relation between garden components, and an edge labelled *on* represents the fact the footbridge is above the brook.

Style representation

As the design is represented by a labelled graph a similar representation is needed to encode the characteristic features of a style. It can be observed that a style can be defined as a set of elements that have to be present in the design to assure this style. Moreover in many cases these elements must be arranged in some predefined way. As objects are represented by graphs also style requirements should be represented by (sub)graphs [9].

For example if the designer wants a garden to be in the Japanese style there is a number of requirements to be fulfilled: stones, water, trees and flowers should be present, paths should be winding and at least one footbridge should be present and placed over the water.

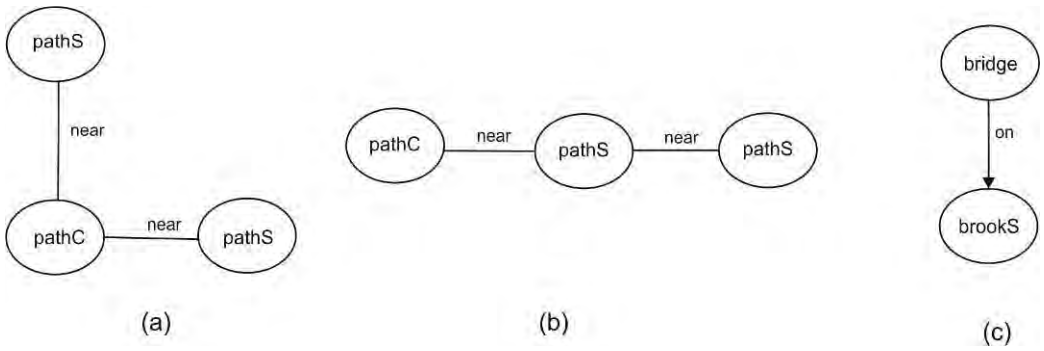


Fig.3 Examples of graphs representing style patterns

In Fig. 3 three examples of graphs representing different requirements for a Japanese-style graden are presented. In Fig.3a and b winding paths are represented while Fig. 3c depicts a graph representing the existence of a footbridge over a brook [9].

4. Evolutionary Operators on Graphs

As it has been mentioned, in this paper designed objects are represented by labelled and directed graphs. To use such a representation in an evolutionary design system a number of elements of this system must be defined. The genetic operators (usually a crossover and a mutation) constitute the fundamental element of an evolutionary algorithm. As in this paper a non-standard representation is used, also new genetic operators have to be defined.

The graph based equivalent of a standard crossover operator requires establishing subgraphs that would be exchanged during the process of evolution. When a crossover is performed on two selected graphs, G and H, the subgraphs g and h, respectively, are selected in these graphs. Then each subgraph is removed from a graph and inserted into the second one. As a result two new graphs are generated. However there may exist

edges connecting nodes belonging to a chosen subgraph with nodes which do not belong to it. Such edges are called embedding of a subgraph. So removing a subgraph from a graph and placing it in another one requires a method allowing for proper re-connection of these edges. The underlying idea is that all edges should be re-connected to nodes similar to those they were connected to in the graph from which they were removed. There is probably more than one possibility of defining similarity of nodes.

In this paper a similarity-like relation is used. The definition of this relation is based upon the assumption that graphs selected for crossover code designs consisting of parts with similar or even identical functions (even if these parts have a different internal structure, material or/and geometrical properties). Thus we can define the similarity on the basis of the node and edge labels.

It is important to notice however that the graphs to be crossed over and their respective subgraphs are selected during the execution of the evolutionary algorithms so the embedding transformations cannot be defined a priori (as it is in graph grammars. The idea behind the algorithm that generates automatically such an embedding transformation is to preserve the relations between the nodes as much as possible, i.e. to connect each edge removed from one graph to a node in the second graphs that represents the same or similar object (i.e. has the same label).

In addition to dealing with the graph embedding problem in case of using the evolutionary process to generate designs adhering to a particular style an additional step must be performed. During the process of selecting subgraphs in graphs to be crossed over it is possible that the patterns representing style requirements will be broken. As the result new graphs generated by the genetic operator could not represent designs in a required style. To prevent such a situation we introduce the notion of an unbreakable subgraph. An unbreakable subgraph is a subgraph which represents a predefined requirement, for example a style component. At the outset of a design process a set of unbreakable subgraphs associated with a given style is specified. Then in each graph G representing a design all unbreakable subgraphs are found and stored together with their position in the design in a set B_G.

After selecting two graphs G and H to be crossed over its subgraphs g and h are selected. In the first step a starting node *v* is selected in graph G and a similar node *w* is selected in graph H. Then two numbers, *i* and *j*, are randomly chosen for the size of the subgraphs in both G and H. Then in graph G starting from node *v* we select adjacent nodes until the subgraph built reaches *i* nodes. Each time a node *x* is selected in G to be added to the subgraph g it is checked against the set B_G to verify if it belongs to any of the unbreakable patterns. If no, it is added to subgraph g and the selection of the subsequent node is performed. If node *x* belongs to some pattern either the whole pattern has to be added to subgraph g being generated or none of its nodes. This decision is based on the size of the subgraph. If adding the whole pattern would not exceed the selected size *i* of subgraph g it can be added, otherwise node *x* is not added to subgraph g and the selection process is continued. If the whole pattern is added to g it is also added to the set of unbreakable patterns B_g associated with g and removed from set B_G associated with G. Similarly in graph H a subgrah is built starting from node *w*. As a result we obtain two subgraphs, g and h and at the same time two sets of unbreakable patterns B_g and B_h.

Formally, a crossover operator *cx* is defined as a 6-tuple (G, H, g, h, T, U), where G, H, g, h are graphs and their subgraphs, respectively. The crucial elements of this operator are T

and U that are called embedding transformations, i.e., they describe how edges of the embedding are to be re-connected. They are sets of pairs of the form (n, n'), where n denotes a node to which an edge was assigned originally and n' - the one to which it will be assigned in a new graph.

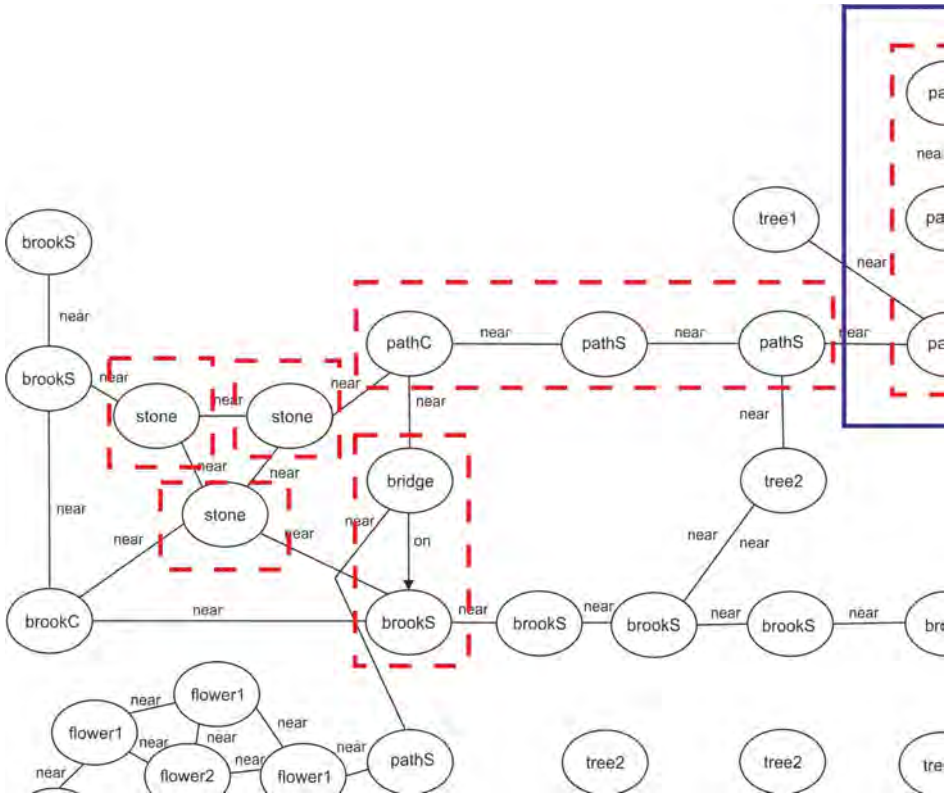


Fig.4 A graph G with depicted unbreakable subgraphs and selected subgraph g

As the result of the crossover we obtain two graphs G' and H'. Graph G' is constructed in such a way that it contains all nodes and edges remaining from G after removing g, all nodes and edges from h and edges connecting nodes from G-g and h obtained by applying transformation T. Moreover the set $B_{G'}$ is obtained by summing sets B_G and B_h. In an identical way graph H' is constructed from H-h and g and set $B_{H'}$ from sets B_H and B_g

As we have sets of patterns associated with newly generated graphs we can easily verify if each of the sets contains all required patterns. In this way we are able to evaluate the fitness of the object represented by such a graph by calculating the percentage of patterns present.

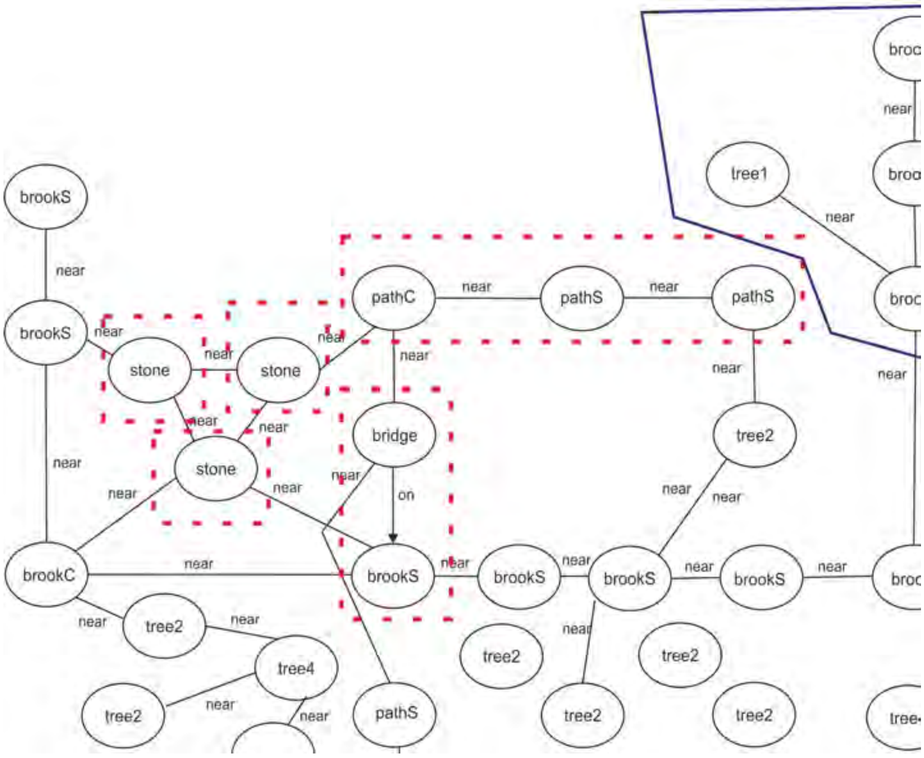
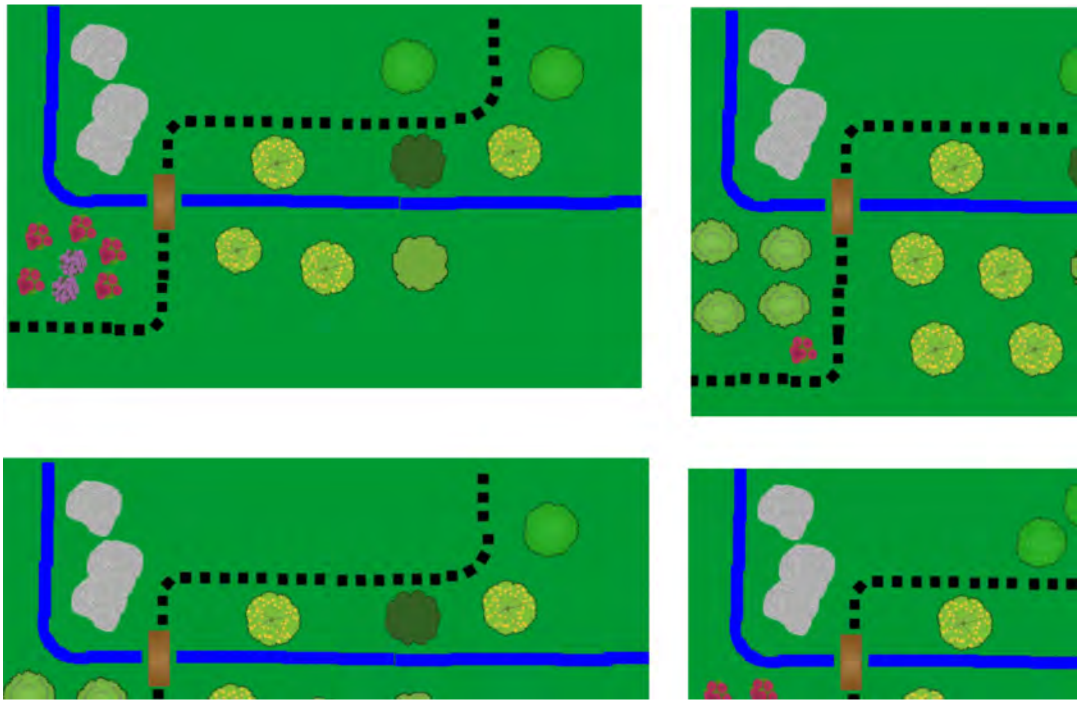


Fig.5 A graph H representing another garden with subgraph h

In Figs. 4 and 5 two graphs, G and H respectively, are depicted. On both of them some of the unbreakable subgraphs representing style patterns are marked by red dashed lines and subgraphs g and h selected for the crossover operation are marked with thick blue lines. Both graphs represent gardens designed in the Japanese style. In the first graph (Fig. 4) the selected subgraph contains one of the unbreakable patterns, while in the second one no style pattern belongs to the selected subgraph. After the crossover two new graphs are constructed according to the method described above.

Fig.6 Gardens represented by graphs from Figs. 4 and 5 (top row) and gardens represented by graphs



obtained after crossover operation (bottom row)

In Fig.6, top row gardens represented by graphs G and H are depicted, while in the bottom row gardens represented by the graphs after crossover are presented. It can be observed that as the subgraph h contains more nodes representing trees than subgraph g after the crossover one of the new gardens has a tree added to it. The path in the top right garden has also been replaced by an extension of the brook. It has to be noted that although in this case both resulting garden designs are in the Japanese style, it is possible that as the result of crossover the new designs may not follow all requirements of a given style. At the same time associating with each graph a set of style patterns makes it relatively easy to rapidly establish which patterns are missing and correct it.

5. Conclusion

In the proposed approach a graph is used as a genotype and equivalents of standard genetic operators are defined on graphs. These operators are more complex than standard binary ones but they provide us with benefits like the possibility of coding relationships between components of an artefact and ability to introduce structural changes which compensate for it. The strongest point of a graph-based representation is its ability to represent in a uniform way all types of relations and objects and to be able to preserve some required characteristics of the design.

In this paper such characteristics are related to the style of the object but in future we plan to investigate the possibility of applying such an approach to other features. It could be used to preserve some parts of the design that is considered optimal and allow only for the improvement of the remaining parts of the design. It is also ~~a~~ possible ~~option~~ to use this approach to assure the presence of a predefined number of some components within a designed object.

Another direction for future research is related to defining the strength of unbreakability of patterns. In this paper none of the patterns designated as unbreakable can be broken. Yet, it can be observed that in some situations it is possible that a given pattern is present in a graph multiple times thus breaking one of the occurrences would still allow for the required style to be preserved but at the same time give possibly more freedom for creative results.

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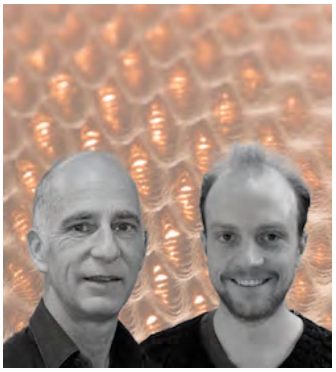

The Style Machine:
digital tactility through generative collaboration
(Paper, Artworks)

Topic: Art, Industrial Design

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Abstract
This project explores the creation and use of generative design software as an exercise in cross disciplinary collaboration. We propose a workflow that uses generative art and 3D printing as a means of communication of tacit knowledge between disciplines, in this case between a generative artist and an industrial designer. The relationship between generative artist, software, and artefacts is uprooted with the introduction of an industrial designer and 3D printer. The four nodes of this system, the designer, generative artist, software, and printer form a feed-back loop that constantly evolves a “sum greater than its parts”. The produced artefacts in this case function as a means of feedback and communication between collaborators.
This workflow provides benefits for both (human) collaborators; For the industrial designer, the collaboration allows a creative paradigm shift from prescriptive pre-meditated creativity, to reflexive and explorative creativity that maintains the hallmarks of their own developed “style”. For the generative artist, it provides a platform to explore how generative systems can be wielded in a collaborative context. The emphasis on collaboration shifts the focus from the process encoded by software onto the evolving multifaceted collaborative process.
A series of investigations, or “tactile conversations”, were performed to assess the relationship and tensions between the generative spontaneity of the software and the intentions of the designer. Through this process, we develop the software to act as a creative prosthesis that assists the creative process and functions as a collaborative mediator. The investigations involve different techniques to balance the system between all parties, we discuss the advantages and disadvantages of each approach. The techniques used to vary the parameters of the system are:

Using the human collaboration, and software with little generative automation (parametric software) as a feedback loop to evolve the software and artefacts produced.

Introducing stochastic generative features (apparent in the form and surface of the objects).

Varying the surface qualities of the printed artefacts both with software, and the 3D printer.

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Key words: generative design, collaboration, parametric

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The Style Machine:
Digital Tactility Through Generative Collaboration

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1)Using the human collaboration, and software with little generative randomness as a feedback loop to evolve the software and artefacts produced.
2)Introducing stochastic generative features (apparent in the form and surface of the

objects).
3)Varying the surface qualities of the printed artefacts both with software, and the 3D printer.

The Style Machine

Collaboration is by nature a generative exercise where multiple independent parties are working together to evolve a result, a sum greater than its parts. If we refer to Galanter's often quoted definition of generative art that

> *"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]

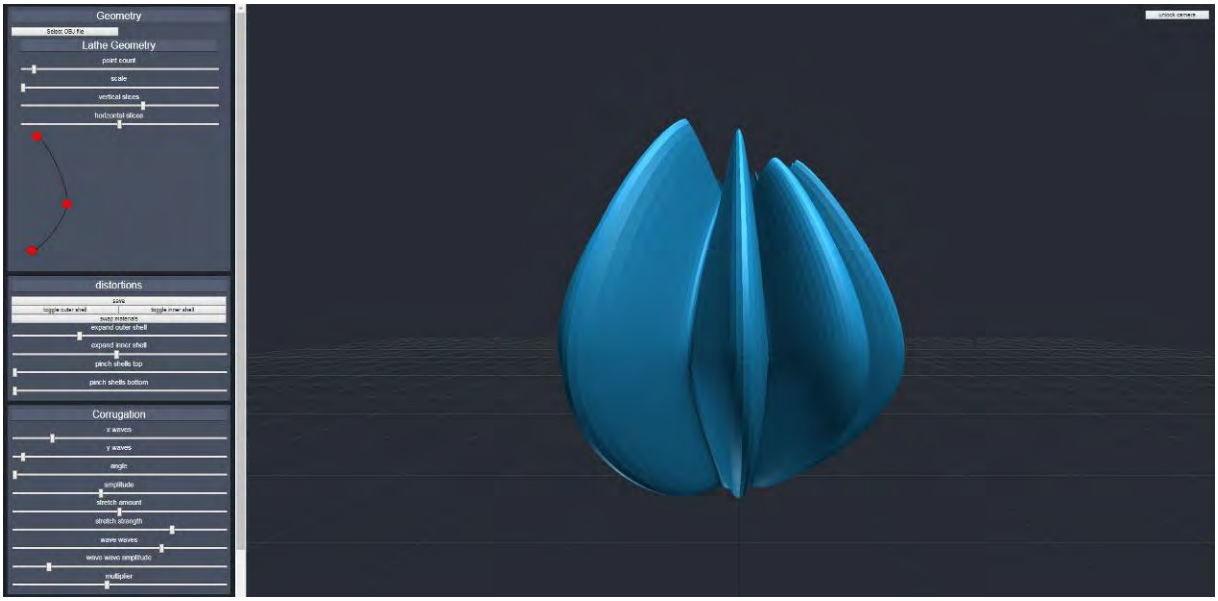
then we can see that by nature of engaging in a collaboration, the artist cedes some control to a system of negotiation with another creative entity (human, computer, or otherwise), and that this process must adhere to a certain set of communicative rules. This might seem too broad a categorisation, to say all art that has involved a collaboration is generative art tends to blur the identity of the work that is more appropriately considered generative.
So although it is true that in this interpretation any collaboration could be said to be generative, in most cases it isn't a particularly beneficial view; It doesn't offer a useful conceptual framework for those not interested in generative art and design. The benefit, however, of consciously taking the view of collaboration as a generative process from the perspective of a generative artist is that it offers a systematic way to think about how non-computational processes (whether human or otherwise) can be incorporated into a generative system.
The style machine uses this idea to develop a hybrid computational and human generative system with the purpose of communicating tacit knowledge between disciplines (in this case an industrial designer and generative artist). This sharing of knowledge facilitates the exploration, evolution, and production of artefacts based on a particular style.
The use of computation to create and execute generative systems has enabled a new way of thinking about design, a shift from labouring over a single form to thinking about designing automated systems from which designs can naturally arise. Although generative algorithms are frequently computational, generative rules need not necessarily be executed digitally, the work of Sol Lewitt [2], for example, relies heavily on the human execution of his instructions. Because a generative system need not be purely computational we explore in this project a collaborative approach to generative art and design that takes a broader view of designing a generative system than an artist and computer model.
Instead of focussing primarily on the computational aspect of the designed system, we instead view our generative system as a network of collaborators giving rise to an evolving series of forms. This view of generativity borrows from complexism [3] to describe a network whose resulting artefacts are an emergent property of the interactions between nodes. By taking this system wide view of generativity we enable a dynamic tactile conversation between two designers, a piece of software, and a 3D printer. This four node system is our generative process; the software is only one of four equally important steps in the evolving feedback loop that produces physical 3D printed objects. This system enriches the work of both [human] collaborators, enabling a freedom of creative

exploration that would otherwise not be possible.

Process

The style machine is built on the principle of working with as little resistance as possible. From its outset as manually created CAD designs created by the industrial designer, the goal was to produce objects for an FDM 3D printer that would have it work with as little resistance and as much beauty as possible, ideally the printing head would never lift or stop printing and there would be no support material. This concept of least resistance is extended to every aspect of the system, decisions are based on their ability to make each collaborator work as easily and smoothly as possible while maintaining a high level of quality. The process is continually re-balanced in a series of tactile conversations; a feedback process where the system is attempting to optimize towards the ideal balance of ease, complexity, variation, and beauty.
Initially the project grew from an Industrial Designer creating a variety of 3 dimensional forms to coerce a 3D printer to work with as little resistance as possible.
The variety of abstract forms the industrial designer initially created were considered to be vehicles of translation between an aesthetic thought and the 3D printer. During the process of creating these objects, a set of rules was developed to generate objects especially conducive to FDM 3D printing. These objects, became after several prints, an evidence of style. The evident style that was initially developed by the industrial designer was expressed as a piece of interactive software by the generative artist. This software was developed with the purpose of making the exploration of the style significantly more efficient thus reducing the resistance of the industrial designer's creative process. The software functions as a creative prosthesis, allowing easy access to new creative territory that would otherwise be inaccessible.

figure 1. Industrial Designer's established form style



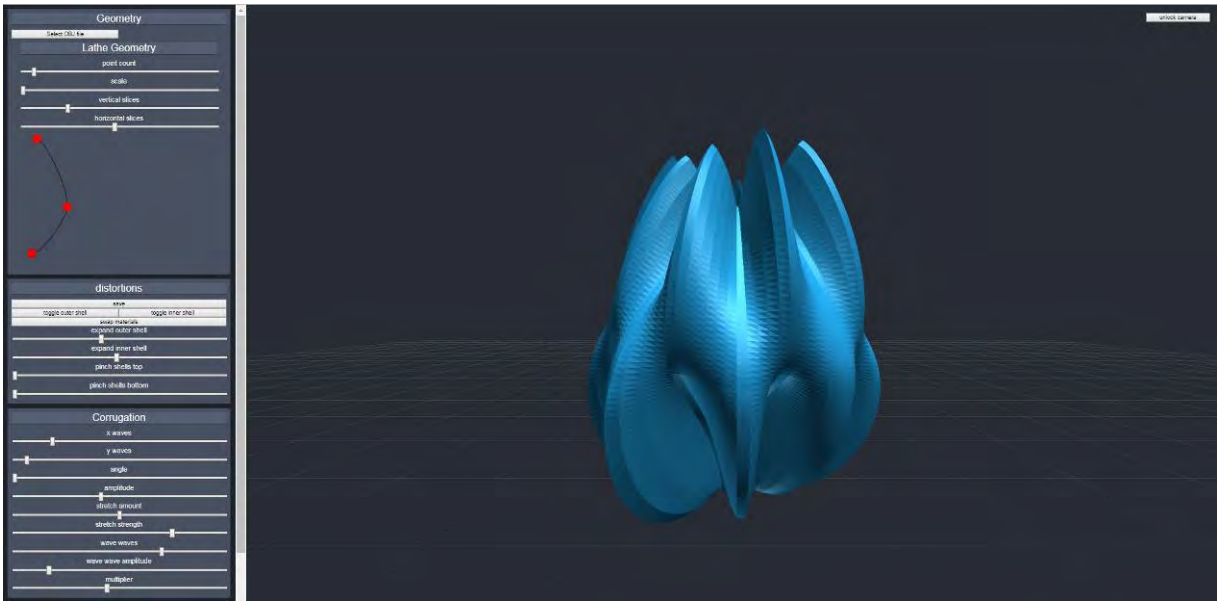


figure 2 & 3. The Style Machine software interface

This process of taking an established form style and building a parametric system around them “seeded” our four-node generative system of an industrial designer, a generative artist, Computer Software, and a 3D printer. This four node system comprises an evolving feedback loop. The artefacts created by the industrial designer using the software are fed back to the generative artist who makes observations and adjusts the system accordingly.

Generative collaboration

The style machine is a “collaborative-generative” system developed with the purpose of communicating tacit knowledge between disciplines of design. In the same way as all collaboration could be said to be generative, in some sense all generative systems are by nature collaborative. They are a collaboration between the system designer and the executor of the system, whether that be a computer, human, or other mechanism. When classifying the style machine quite specifically as a “collaborative-generative” system we

are describing something more defined: a process of collaboration between multiple humans and software who function as nodes or pieces in a larger evolving feed-back loop. The generative system in this case is seen as the collection of collaborative nodes that give rise to emergent outcomes. This view is taken as opposed to viewing the software, or algorithm, as the generative system.

The distributed view of our generative system is as an expression or “application” in Galanter’s terms of complexism in design. The system is a feedback-network of nodes continually giving rise to new and unexpected artefacts. The artist and designer become parts of the system, stages in the process, rather than having a top-down influence on it. This network would not exist with the absence of any of the individual nodes, and its continued evolution and feedback supports the title of a distributed generative system.

The introduction of multiple collaborators necessitates an agreed upon form of communication. In a more traditional computational system of artist and computer, the artist communicates with the computer via written software and the computer responds with artefacts. In the case of the style machine the 3D printed artefacts become the primary form of communication, a grammar that describes physical properties desired by the designer or artist. These artefacts form the vehicle of communication not only within the system (between designer and artist), but are also the externally visible products for outside observers.

The collaborative-generative system of the style machine looks like the following:

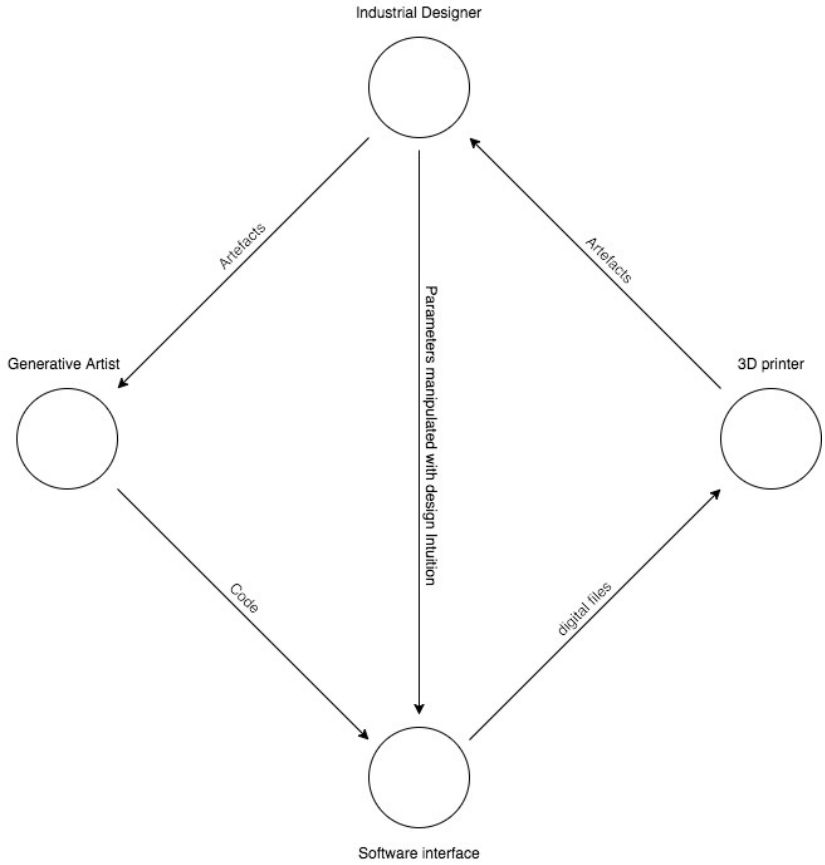


figure 4. diagram of the style machine’s generative feedback loop

Each node performs a specific function:

The industrial designer both seeds the process with their previously developed style and uses their trained understanding of form to draw out the very best and most beautiful objects from the software. The industrial designer offers insight into how the system can be

further evolved to a state of maximum ease and quality.

The 3D printer imbues the digital 3D models with tactility and surface qualities. The artefacts it produces are significantly richer in expression than the digital files they are printed from. The artefacts it produces communicate visceral and tactile information between the designer and artist.

The generative artist interprets the artefacts and develops and refines the software to provide a streamlined expressive tool for the industrial designer to wield. The generative artist's contribution is to understand the parametric landscape that the objects of the industrial designer sit within and to provide tools for the efficient exploration of that landscape. It is also the job of the generative artist to provide occasional mutations to the system to offer the opportunity of unexpected evolutionary progress of the initial style.

The software functions as streamlining tool allowing the industrial designer rapidly iterate and explore their style. This allows much greater depth and breadth of exploration of the initial style. The other function of the software is to change the mode of creativity of the industrial designer from prescriptive creativity - premeditated ideas meticulously executed in CAD software - to explorative, or reflexive, creativity. The reflexive creativity of exploring the parametric landscape encoded by the software opens up ideas previously un-imagined and offers new opportunities and trajectories whilst still maintaining the hallmarks of the initial style.

Tactile Conversations

With the structure of our collaborative-generative system set up, we undertook a series of continuing investigations, or tactile conversations. A tactile conversation can be seen as an evolutionary generation, a series of artefacts produced by a single iteration of the software. Each time a series of artefacts are produced, they are shared between the designers who observe and discuss the physical and aesthetic properties. This sharing of understanding then informs the next evolution of the software and the process repeats. These conversations also function as a method of communication of tacit knowledge between designers. The forms become vehicles of knowledge, expressing tactile and physical information that couldn't otherwise be communicated with words. The goal of each iteration is to balance the system between the needs of each collaborator, seeking the path of least resistance for all.
We have tried three methods of varying the properties of the system to try to enable each node to work with as little resistance as possible while still providing space for natural discovery and evolution. These are:

1) Parametric determinism
2) Stochastic generativity
3) 3D printed form studies

Parametric determinism:

The first iteration of the software was purely parametric, meaning there is no randomness involved in the software itself. Each variable of the system is exposed to the direct control of the industrial designer. Although this seems against the spirit of generativity, it is not the

software we consider the generative element of the style machine, rather it is the evolving collaborative-generative system that includes both the human collaborators and the machines. By shifting the focus off of the software and computer and onto the system as a whole we allow a greater breadth of exploration of generativity. In this iteration we aren't encumbered by the need to find an algorithmic fitness function, or seek techniques to cleverly adjust each variable and hope the computer happens upon a combination that is beautiful, refined, and unique. In this way using the industrial designers refined intuition regarding form helps the generative artist find his path of least resistance (in the lack of having to solve the previously mentioned problems). The downside of this technique is less systemic spontaneity.

figure 5. Early forms created with the style machine working as a procedural process

figure 6. Dynamic physical properties

Stochastic generativity:

This tactile conversation included the use of stochastic generative mutations to the original style. In this case the generative artist introduced some chaos, attempting to take the highly ordered parametric system and bring it closer to the fine balancing point of complexity by introducing some structural noise. In this case the industrial designer had

little control over the mutations, which would theoretically allow for spontaneity and evolution. In practise it simply added unnecessary resistance to the industrial designer's process, making him less able to find beautiful forms due to the unpredictability of the mutations. Although It's possible that other more beneficial and beautiful "mutations" could be developed, the idea of artificially introduced spontaneity seems to be an unnecessary burden. The spontaneity of this particular generative system arises through the interactions between collaborators, the software, and the printer (as described below). However through various smaller conversations and mutation tweaks, the industrial designer found unknown subtleties in the style machine that were intriguing and of value.

figure 7. Aesthetic anomalies from the introduction of noise into the style machine

figure 8. later forms using both generative and parametric processes together

3D printed form studies:

The final node of the conversation is the manifestation of physical 3d prints, here the artefact performs as a witness to the collaboration, acting as a measure of 'style' and the ease to which it is attained. This may seem un-research like, where the outcomes are evaluated by the researchers, however each new iteration offered new ideas that could be digested at an achievable pace by the designer and artist and acted upon. 3D form studies provided tactile objects, these in turn offered new dynamic and printed qualities, and larger artefacts presented previously unseen spatial qualities.
Much of the work was printed in a wood flour (PLA) material which is particularly sympathetic to visual and tactile interaction [4]. This material and printing method provided surface qualities dependant on 3D form and angle to axis. While an intuition is held by the Industrial Designer of the possible 3D printed outcome, the feedback between the nodes provides a rich source of complexity in this system, evidenced in the prints.
By leveraging these physical qualities, we don't have to rely so heavily on computational stochastic randomness to create subtle complexity and variation. This reduces resistance in the industrial designer's process and also for the generative artist who is left to add more precise and easily wielded aesthetic features to the software. This is a much more natural expression of spontaneous complexity than artificially injecting stochastic mutations into the form itself.

figure 9. Internal spatial qualities

figure 10. External qualities

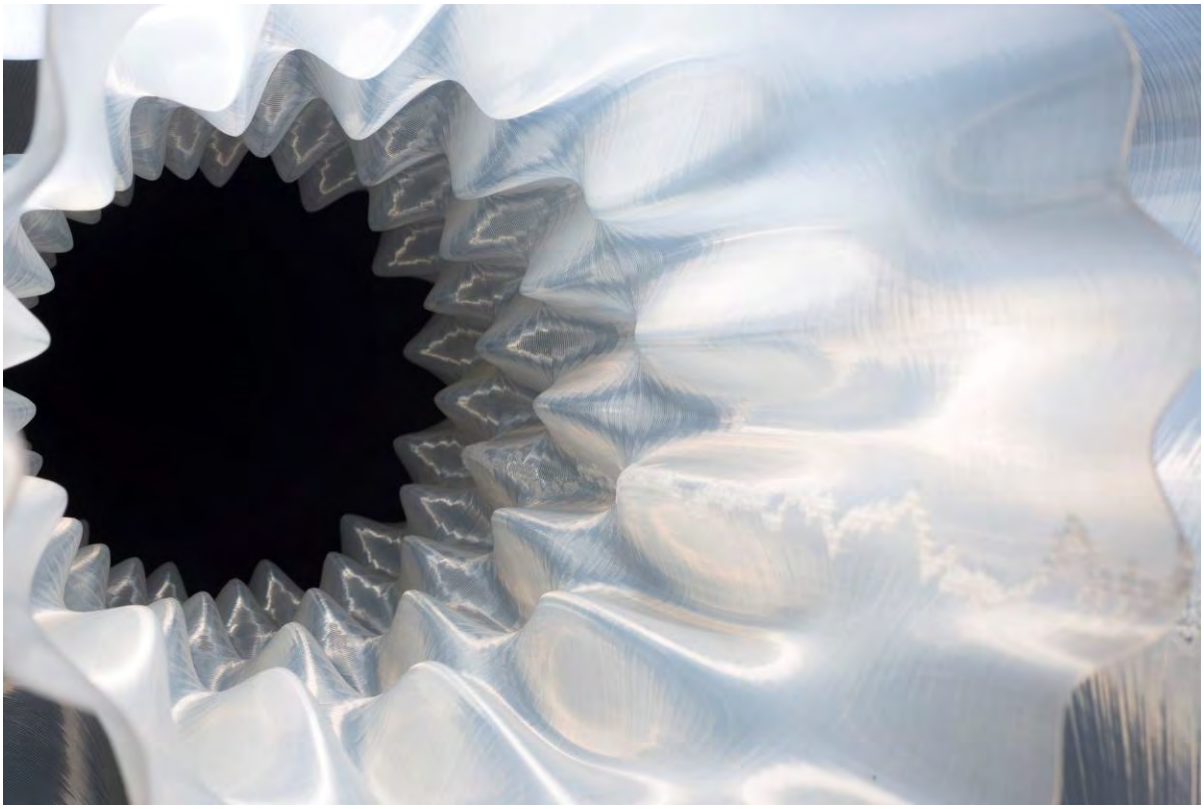


Figure 11. spatial qualities at a large scale and towards product

Figures 12 & 13. Post printing treatment of the artefacts by staining and surfacing.

Conclusion

The style machine presents an example of a “collaborative-generative” system. By taking a wider view of generative systems than the artist - computer paradigm we can begin to build a complex feedback network of software, hardware, and human collaborators. With the right conditions this system can not only generate and evolve complex and attractive objects, but also function as a means of communication of experiential knowledge between artists and designers with different views and experience. Further experiments in generative collaboration are warranted, it would be interesting to see what emergent properties come of a system with other diverse collaborators (in the form of humans, software, and hardware).

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BOTSOT: a Generative Sonification Toolbox
(Paper)

Topic: Music

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BOTSOT is the Botanical Sonification Toolbox – a series of generative sonic tools created to explore invisible communications, structures and information within plant species. Developed as a series of modular Max/MSP instruments, generative processes and a graphical user interface are used to reveal discrete, user-generated sonic representations, thus extending knowledge and understanding of botanical life – a world that is often only fully accessible to scientists. Through the use of data sets and quantifiable characteristics of any given plant species, BOTSOT allows for comparisons, iterative compositions and educational experiences, as well as deeper insights into plants through the medium of music.
Sonification of data is not a new notion - sonic representations and the use of data in music extend back through a rich tradition of computer and acoustic music alike. This paper explores the methodologies and compositional frameworks used in BOTSOT, presenting a fresh theoretical approach to sonification and generative music. The paper demonstrates this area of work is still one that requires greater attention in research and practice, providing a rationale behind codifying the natural environment into generative music tools. Using past examples of data sonification, the paper discusses the use of generative, reproducible processes and interactivity as a means of extending users' knowledge and understanding of botanical life and music, outlining the ways in which subjective interpretation and a curatorial approach to data sets may advance future work into generative music. Each 'module' of BOTSOT is described in detail, with justifications behind their development, as well as where their future may lie.

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Key words: music, composition, modular, interactive, creativity, botany

Main References:

[1] Mitchell Akiyama, "Dataffect: Numerical Epistemology and the Art of Data Sonification." (*Leonardo Music Journal*, 2014), 29–32.
[2] Marcus Maeder and Roman Zweifel, *trees: Pinus sylvestris.* (Zurich: COP21, 2015).

BOTSOT: A Generative Sonification Toolbox

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Abstract

BOTSOT is the Botanical Sonification Toolbox – a series of generative sonic tools created to explore invisible communications, structures and information within plant species. Developed as a series of modular Max/MSP instruments, generative processes and a graphical user interface are used to reveal discrete, user-generated sonic representations, thus extending knowledge and understanding of botanical life – a world that is often only fully accessible to scientists. Through the use of data sets and quantifiable characteristics of any given plant species, BOTSOT allows for extended comparisons, iterative compositions and educational experiences, as well as extending knowledge on plants through the medium of music.

Sonification of data is not a new notion - sonic representations and the use of data in music extend back through a rich tradition of computer and acoustic music alike. This paper explores the methodologies and compositional frameworks used in BOTSOT, presenting a fresh theoretical approach to sonification and generative music. The paper demonstrates that this area of work is still one that requires greater attention in research and practice, providing a rationale behind codifying the natural environment into generative music tools. Using past examples of data sonification, the paper discusses the use of generative, reproducible processes and interactivity as a means of extending users' knowledge and understanding of botanical life, outlining the ways in which subjective interpretation and a curatorial approach to data sets may advance future work into generative music. Each 'module' of BOTSOT is described in detail, with justifications behind their development, as well as where their future may lie.

1. Introduction

BOTSOT is the Botanical Sonification Toolbox - a set of generative sonic tools designed to synthesise physical characteristics of a large array of plant species. Music in the form of rhythms, drones and melodies is generated through these tools, uniquely sonifying plant species using curated data to meaningfully represent any given plant. Tools operate as either standalone generative instruments or in conjunction with other tools, with each module possessing the ability to musically and functionally communicate with every other in the toolbox.

Figure 1 – Modules in BOTSOT

BOTSOT was created out of an impetus to increase botanical awareness, providing understanding and access to data often only accessible through the eyes of a botanist. Wandersee and Schussler point to the prevalence of "plant blindness" and "zoocentric" observations, particularly in applied sciences [1]. Their work describes how people habitually fail to notice plants in their environment, pointing to key factors of plants' chromatic and spatial homogeneity, static proximity and non-threatening nature. These concepts profoundly influenced the creation of this toolbox from a personal artistic perspective, building on my past work in bioart and providing natural creative momentum.

Through iterations and comparative works, BOTSOT has created a body of work derived from a unique interactive process that extracts information from plants, presenting botanical data as sonic information. Individual generative modules allow for interactivity and diverse sonic results, whilst still retaining an iterative, repeatable outcome that reveals unique sonic insights in the world of botany.

This paper explores a renewed approach to generative music, using interactive sonification as an algorithm for generating unique and informative sonic results. An outline of the discourse will reveal elements of model-based sonification that do not manifest themselves in similar toolboxes, with an exploration of guiding principles of BOTSOT illustrating how the software encourages a greater understanding of plants through generative processes. Finally, a summary of modules and examples of applications and outcomes of the toolbox is discussed.

2. Context

2.1 A Tradition of Sonification

Examples of sonification can be found throughout multiple fields of computer music. The same can be said for 'toolkits' and interactive sonification engines that provide a creative framework for generative music. Past examples of similar sonification frameworks include SoniPy, a Python framework for the collection and integration of sonification modules [2], and Monalisa, a plugin style tool that integrates with existing Digital Audio Workstations [3]. Of particular note is the more recent work of Marcus Maeder and Roman Zweifel, "Trees: An artistic-scientific observation system", which shares many similarities with BOTSOT, sonifying multiple data sources received from plant sensors through a surround sound

installation [4].

In this paper, the “model-based sonification” definition proposed by Hermann is used to provide formal context and structure surrounding generative techniques [5]. Important features identified by Hermann (shown below) illuminate the key features of sonification technique on which BOTSOT builds.

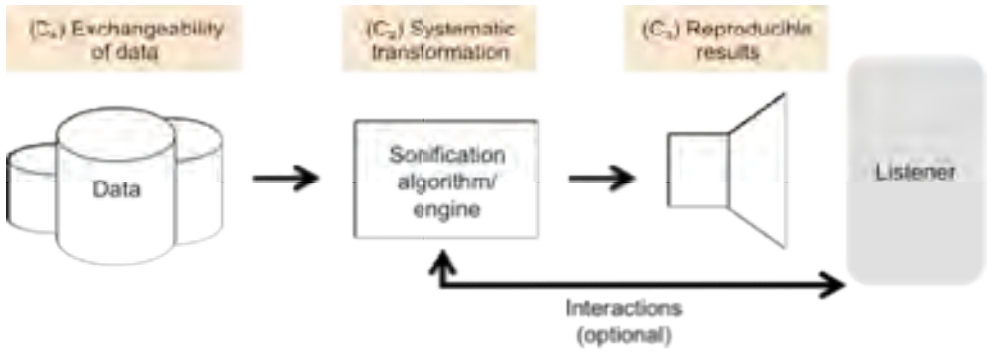

Figure 2 – The model-based sonification pathway

Expanding on this definition, BOTSOT seeks to bring fresh design principles and frameworks to sonification and generative music, with the use of human-computer interfaces and data that provides a new informative listening experience.

Supper has discussed the social context of sonification at the art-science boundary and how it perpetuates the notion of transformative listening experiences, stating “...producers and communicators of sonifications create the expectation that listening to a sonification yields a sublime experience…” [6]. BOTSOT relies on this precedent whilst also drawing from the context of practical auditory display [7]. In following sections, it will be asserted that new model-based sonification methodologies can generate music that facilitates elegant transformations of specific datasets and a heightened understanding of a given plant species.

2.2 Design Principles

In creating BOTSOT, a single core guiding principle drove the development of each generative instrument: how can any generative module capture the essence of a plant, and create a unique sonic signature that represents the plant in a way that may reveal information and characteristics previously lost to the phenomenon of plant blindness?

The existence of this broad goal necessitated the implementation of two key design principles, which would drive the creation of BOTSOT. These key principles would serve not only to differentiate the toolbox from preexisting generative tools, but also to create momentum for this style of generative music and the place it occupies within the arts and my broader community.

Through the lens of model-based sonification, BOTSOT modifies two key cornerstones of the traditional model through an altered data transformation pathway that distinguishes it from wide-ranging sonification methodologies that already exist, particularly in the area of bioart. They are:

- The use of ‘curatic data’ tailored and edited from plant species specifically for the purposes of sonification
- The use of a flexible human-computer interface, involving data navigation and

excitatory interaction

In the context of the previously explored model, these additional parameters form a new framework for data sonification, as seen below.

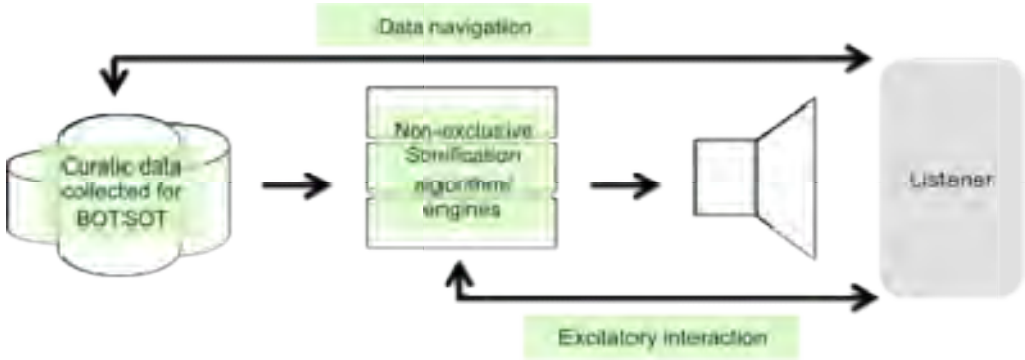

Figure 3 – The altered model-based sonification pathway

The end result is an extended sonic experience influenced by the user, whilst remaining inherently connected to the plant species, that stills allows for a generative experience consistent with more typical iterative model-based sonification processes.

3. Model-based Sonification

Within the framework of model-based sonification, each module in BOTSOT represents a single, non-exclusive "sound-capable object" [5]. The overall control of these modules differs from a standard sonification model through the aforementioned expanded process, outlined in greater detail below.

3.1 'Curatic' data

Data used for the purposes of sonification has traditionally been extracted through traditional methodologies related to large, accessible file formats [8]. Unprecedented access to data from a large array of sources has led to the inception of open datasets and streaming API clients - what has typically been described by Kitchin amongst others as a "data revolution" [9].

Data used in BOTSOT has been collected in collaboration with the University of Sydney School of Life Sciences specifically for the toolbox. Data collection that is formally integrated into the process of sonification has allowed for a greater amount of control, notably in areas of quality control and module creation. Additionally, data that has been collected differs from traditional formats typically associated with generative music.

Within the field of music, an explosion of open data has afforded composers the ability to generate music with relative ease. At the intersection of botany and music, strong emphasis is placed on numerical and quantitative datasets that derive directly from primary measurements, seen through examination of three significant botanical sonification examples as in Table 1.

Table 1 – Examples of data formats in botanical sonification

Name	Data input
Trees: An	Daylight [RGB brightness]

artistic-scientific observaton system [4]	Solar radiation Sun position Air temperature Rel. air humidity Rain Wind Soil water potential Tree branch diameter Tree sap flow
sLowlife [10]	Seedling height over time Blue light exposure
MIDI Sprout [11]	Resistance circuit (integer threshold)

Quantitative data, particularly in the form of easily ingestible text files and sensor-based applications, is a preferential format for the majority of standard music tools and software such as Pure Data and Max [8]. Additionally, excitatory systems are less present in the discourse, and tend to focus on a single systematic transformation. BOTSOT differs in this regard, with data derived and translated from less traditional forms, including shapes, descriptions and images.

In line with attempting recovery of information previously lost to the phenomenon of plant blindness, the 'curatic' nature of data collection that has been undertaken creates a stronger sonic solution to specifically identified problems such as chromatic and spatial homogeneity in plants by fostering a measurement approach that is intrinsically linked to the sonification process. Additional data editing has also occurred to make data more immediately accessible for use in an interactive context. Examples of data used in BOTSOT are seen in Table 2.

Table 2 – Examples of data formats and editing in BOTSOT

Module	**Data input**	**Data result**
Shape Sequencer	Image of macro shape	Distribution matrix
Keyword Synth	Scientific description	Scientific description with associated keywords
DNA Sequencer	Full DNA Sequence	Trimmed DNA Sequence
Image Envelope Generator	Image	Vector outline

BOTSOT's 'ground-up' approach for all aspects of model-based sonification has determined that the process of forming generative tools and collecting data have occurred simultaneously, to the benefit of each. For instance, beginning with the objective of increasing awareness around physical structures in plants, it was concluded that a simple matrix would accurately represent a simple two-dimensional shape, and a MIDI sequencer that could read that shape would be able to systematically transform density and physical distribution into sound. An accelerated methodology for collecting this data through photography and simple image analysis was then engineered, allowing for the immediate

testing and refinement of the data format, seen below.

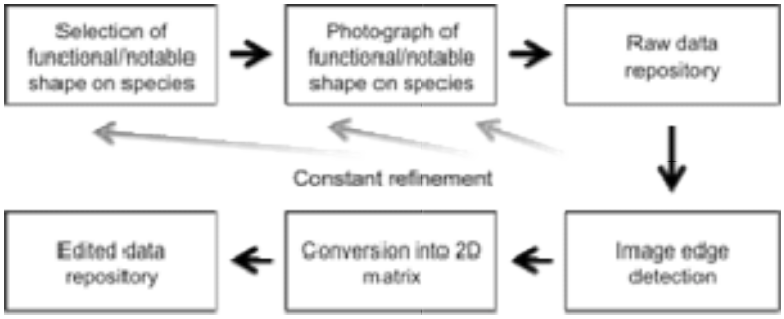

Figure 4 – Iterative data pathways in Shape Sequencer module

This curatorial collection of qualitative and quantitative data is rarely used in sonification, typically due to connotations of tarnishing the objective process of data representation [12]. To a certain extent, it would appear that a greater degree of data parsing and translation before sonification would produce a more abstracted and less systematic transformation of data into sound. On the contrary, the methodology surrounding data in BOTSOT has produced benefits of consistent control of data and easily adaptable methodologies, retaining the foundational requirements set out in Hermann's model-based sonification definition, namely systematic transformations of data and reproducible results. This approach bears the consequence of a lower quantity of data due to the labor-intensive, specific process.

3.2 The human-computer interface

Interactivity plays a key role in the generation of music in BOTSOT, with interpretation and generative processes undertaken by all users. BOTSOT uses the human-computer interface as part of model-based sonification in two distinct ways: for excitatory interaction and data navigation.

Modules in the toolbox are a series of dynamic processes, and it is the user who initiates sound generation. This style of generative music is typically associated with live performance (see for instance [13]). In the case of BOTSOT, the excitation of generative systems also includes the ability to change the systems themselves, that is, the systematic transformation of data into sound may involve any combination of systems. This feature allows for a greater amount of user control, and encourages unique creative processes that bring about a greater connection with the data and information surrounding any given species of plant.

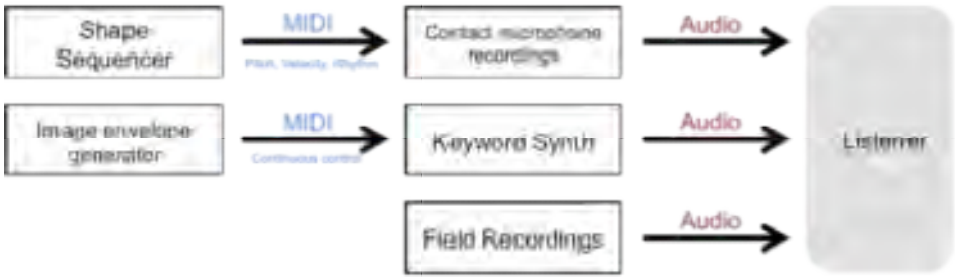

Figure 5 – Example of use of non-mutually exclusive modules in BOTSOT

Additionally, modules in BOTSOT also afford the user the ability to navigate the data itself. User interaction has been proven to be a constructive method for fast interpretation of

datasets of larger bandwidths [8], however, data is often sonified on an 'as-is' basis with user interaction maintaining focus on systematic transformations of data into sound. For example, in the case of [4], all data sources are excited simultaneously for sonification, with temporal movement remaining constant. Interaction and navigation with data from the user is a consistent feature of all BOTSOT modules, with the user able to select various datasets and decide on specific species of plant they desire to make music from. This seamless interface with data naturally gives rise to iterative processes and comparison, allowing for extended subjective experiences and thus a greater ability to personally and creatively reflect on plant species.

Within this framework, both interpretation and interactivity are inseparable. Work from figures such as Manovich has often targeted the subjective and interactive aspects of data representation, arguing that scientists and designers already 'map' data in ways that are aimed at understanding [14]. Thus, counterintuitively, for the reasons outlined above BOTSOT does not produce 'one sound' for any given plant species. However, the presence of systematic generative processes from data into sound determines that every plant input still provides a unique sound signature, and interactive but consistent processes, affording the user the ability to create musical variations in pitch, rhythm and tone colour even within discrete systems.

4. Realisation

4.1 Max

BOTSOT has been created exclusively in Max in order to allow for an accessible user interface that has the greatest potential for expansion and efficient adaptation in the future. Behind each module is the generation of exclusively MIDI or audio information. This was deemed important as it not only allows for inter-patch communication, but also communication with other pieces of software - a feature greatly enhanced by Max's flexible patching environment.

An accessible user interface remained a priority throughout development of BOTSOT. All patches include help files (accessed through the top right corner of every patch) that explain basic functions and processes. As well as this, all internals of patches are labeled with comments if the user seeks further understanding of the inner construction of the module and how data is transformed. Users can control the flow of MIDI information from the locked patch, but are also invited to unlock patches and take advantage of Max's powerful MIDI transformation capabilities. For more advanced users, the unlocked patch also contains a detailed MIDI control engine.

4.2 Data storage and exchange

BOTSOT in its entirety is stored in a Github repository under an MIT license, providing open access to all users. Users are directed through a simple readme file, with all required sonification data being stored within subfolders. Referencing is controlled automatically through the Max patching environment with central .coll files (marked in patches) that direct the module to additional resources, such as text files of DNA data, help patches, and images.

For data navigation, all modules contain the same 'plant selection engine', seen below.

Figure 6 – Plant selection engine

Different plants can be loaded into the selection engine depending availability of data, with the number of plants available constantly expanding. For backend data management and parsing, Python has been used, in particular Scikit and Numpy.

5. Modules

5.1 Shape Sequencer

The Shape Sequencer is a simple note-generating system that operates as a form of extension to the traditional MIDI sequencer. It takes a characteristic botanical structure from a given plant species (such as a flower spike from the *Banksia aemula*), and translates the shape into pitch, rhythm and velocity. A focus on discrete macro shapes and their relation to sound is a methodology useful for reducing the effect of seeing plants as spatially homogenous.

The sequencer uses a large matrix of pixels based on a graphic representation of any structure in order to trigger MIDI notes. A slider moves vertically through the matrix, crossing randomly selected points within the shape that trigger notes. These points cannot be manually selected, and are instead picked at random within the shape. This in turn allows for an accurate sonic representation of the shape through randomly distributed points, where denser areas of a shape have a greater amount and intensity of triggered notes. The small amount of user input includes basic functions like tempo and number of points, but uses an intentionally simple interface that contains only general vocabulary as opposed to music-specific or plant-specific terms.

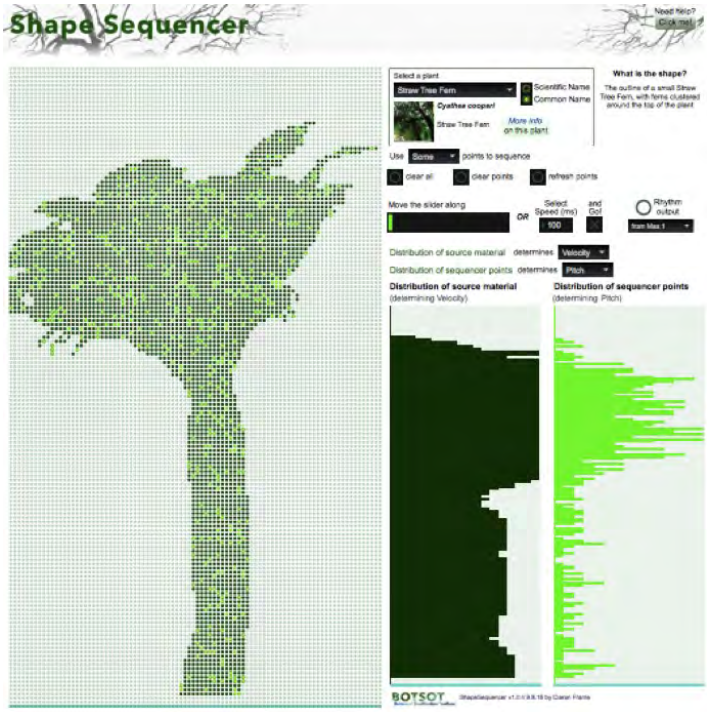

Figure 7 – Shape Sequencer interface (randomly selected points in light green)

5.2 Keyword Synth

The Keyword Synthesiser is a simple additive synth that generates a unique, playable sound for any plant species through a series of saved lookups based on keyword matching. By using the most common 200 words from scientific descriptions of plants and grading them against predetermined sound criteria, variables of the Tal Noisemaker synth [15] are altered based on an input scientific description of any given plant. Descriptions have been chosen as a data source in this module because of their ability to objectively and scientifically capture physical aspects of any given plant. Chromatic and spatial homogeneity were both identified as symptomatic features of plant blindness by Wandersee et. al [1]. Scientific descriptions of plant species can act as a partial solution to these problems by objectively revealing physical composition and standardised characteristics of plants. In order to generate unique sound synthesis from these keywords, a small database of keywords was constructed that references manually entered fitness scores that correlate to a particular synthesiser variable, as outlined in Table 3.

Table 3 – Controlled variables used for fitness scores in Keyword Synth

Synthesiser Variable	**Integer scale**	**Description**
Waveform Type	1–10	Sine–Noise
ADSR Shape	1–10	Exponential–Linear
ADSR Variation	1–10	Low rate of variation–High rate of variation
ADSR Transitions	1–10	Short–Long
EQ Frequency	1–10 where 5 is a flat response	Low Frequency–High Frequency

EQ Type	1–10	Notch–Pass
EQ Events	1–10	Number of discrete EQ events
LFO Frequency	1–10	Slow–Fast
LFO Amplitude	1–10	Low–High
Intensity	1–10	Small–Large (majority distortion)
Range	1–10	Limited–Wide pitch range (where 1 is mono)
Temporal Evolution	1–6	1 + 2 + > - > + 3 + > - 4 - > + 5 - > + > - 6 -

Descriptions can be entered into the Python script, which extracts the weighted average score for each of these categories based upon the previously entered data, and applies these scores to the aforementioned variables on the synth. Thus, each species is assigned a unique tone colour, representative of the objective physical characteristics of the plant. The resultant synth patch may then be triggered from other modules.

5.3 DNA Sequencer

The DNA sequencer is a simple rhythm machine based upon the unique genomes of every plant. All sequences of DNA from any living organisms can be broken down into four bases – Adenine, Guanine, Thymine and Cytosine. The DNA Sequencer takes these remarkably simple yet powerful building blocks, and translates them into rhythms. Not only are these sequences unique, they also inherently consist of patterns and repetitions – a feature that is suited to the creation of rhythm, as discussed in [16].

The sequences themselves originate from plants surrounding the University of Sydney main campus. When this data is collected, there is always a large amount of 'non-coding' DNA present within the sequence (as is the case for all living organisms) – that is, DNA that does not directly translate to proteins and thus characteristics and unique aspects of a particular species. For this reason, the DNA sequencer aims to use extracts from sequences that share a fundamental relationship with the plant (for instance, a section of the DNA sequence responsible for the purple colour of flowers on the *Jacaranda mimosifolia*). In this way, a systematic representation of the sequences within a given plant species can be formed through a relatively small sample of data.

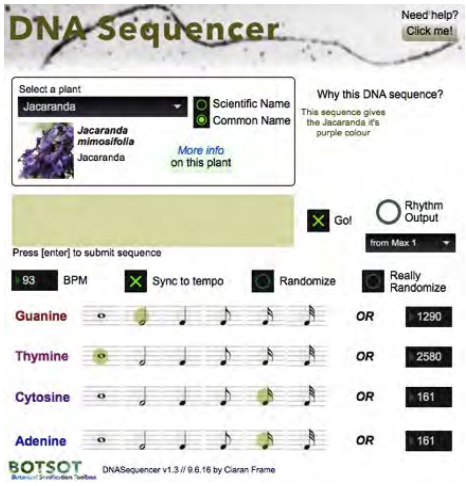

Figure 8 – DNA Sequencer interface

5.4 Image Envelope Generator

Any given species of plant exhibits any number of remarkable patterns and shapes, whether it be the curve of a leaf or a ripple in bark. These unique profiles and structures serve a purpose to the plant, and are present as a result of evolution. The input data for this module is a simple photo of a visible aspect of a plant species. From this image, an envelope is generated that is then transformed into musical information in the form of evolving MIDI data, using a slider to 'play' the envelope. This MIDI CC (continuous control) information is useful for mapping to temporal variables, and has been mapped to pitch and effects levels in arrangements thus far.

The module uses the Sci-kit Image library within Python, specifically the Canny edge detector. This edge detection algorithm uses a multi-stage process based on Gaussian filters to find the most prominent edges of any given image. In line with 'curatic data', users may also input their own macro and micro images for use in the module, as well as being able to choose from presets.

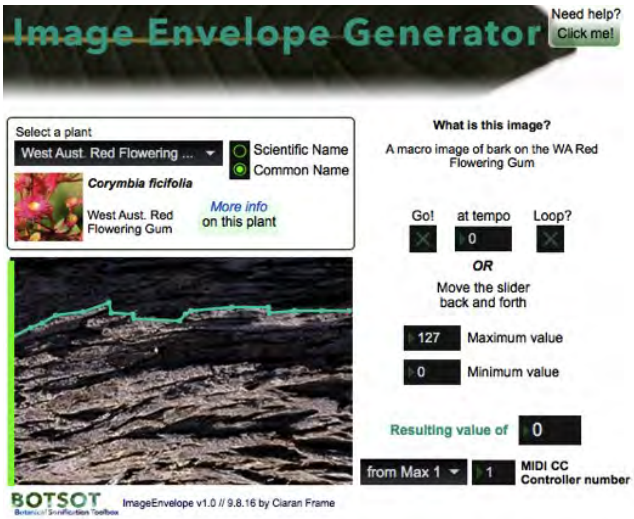

Figure 9 – Image Envelope Generator interface

5.5 Additional modules and supplementary material

In line with precedent of providing an environmental context to generative music, field and

contact microphone recording modules have been created for BOTSOT in order to provide a sonic anchor for the listener. Recordings of sounds heard every day from plants (for instance, the rustling of leaves) are important to the toolbox, as they act as a foundation for the context in which other abstracted sounds may exist.

Figure 10 – Collection of contact microphone recordings

Field and contact microphone recordings were extracted over a period of five months in order to capture audible environmental sound of numerous plant species. Within BOTSOT, users may trigger these sounds through MIDI or through simple playback, accessible from a large archive of indexed recordings. Field recordings provide macro context on a human scale, and contact microphone recordings uncover minute sounds and vibrations of resonant bodies through the use of an extremely sensitive diaphragm. Their use in the context of BOTSOT leads to a greater understanding on the user's part of the inner resonances and unique characteristics of the natural excitatory vibrations almost 'performed' by the species.

6. The Future

In early 2018, BOTOST will undergo its first live iteration. As an extension of heightened understanding of a given plant species, the audience will connect to various plant species through Bluetooth Low Energy controlled through a Raspberry Pi. The BLE connection will provide a simple web interface with a limited version of some BOTSOT modules, with audiences able to take part in their own unique interactive sonic tour, encouraging comparison in a physical context. In further development, BOTSOT will adapt to be used in a standalone software context.

7. Conclusion

BOTSOT has explored a unique approach to generative music, using fresh elements of model-based sonification as guides to forming a generative toolbox that encourages a greater understanding of plants through sonification of data and musical variations. Through the use of curatic data and a unique take on the human-computer interface, the resultant toolbox has formed new creative processes, uncovering an extra dimension of observation that cannot be achieved by simply observing a plant more closely. Throughout

the process, BOTSOT has illuminated detail and valuable information from plant species, both seen and unseen, to provide a framework for music creation that fosters understanding of botany as well as individual creativity in generative music.

For further examples, please see http://www.ciaranframe.com/botsot

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TITLE: ***Generative Art language***
Paper
Topic: Art, Poetry, Science
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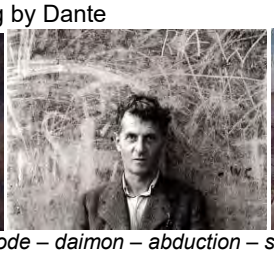
"All manner of thing shall be well
When the tongues of flame are in-folded
Into the crowned knot of fire
And the fire and the rose are one."
T.S. Eliot," Little Gidding"

In Roman age, the word *ars* always gained the significance of science too. Only in Renaissance art started to be explicitly associated with science. In our time, also technology becomes necessary for identifying a process of art, delineating three cultures. Going in deep it is difficult to sign the borders of each culture quality. The connection is too much deep, overlapping each other. Cultures are only one, in different aspects, able to work together for the human life quality, so far from *divide et impera,* but for integration toward complexity, as in the biological world.
Following the human history, the discovering of new paradigms and tools of cultural organization deeply the procedures of life language changed. From the wheel to the internet, to AI in smartphones, life communication performed its evaluative characteristics, in their different evolutions, that in a fast way we in their differences recognize. As a *crowned knot, art* represents a *visionary human conscience,* compactly working for centuries, performing a generative expression of human life. Where we identify a mystery not ending, that it is not possible to cut by a complete solving. To the main questions about what is and why and how we need deeply an expression of art, we know that any answer is not enough and it is not able to give an exhaustive answer to this eternal question. We need art. This is the only fixed certitude. In *Renaissance*, art became a generative result of complex rules, able to perform beauty, following too science laws and tools. During centuries, best references points in art and science, still to discover today, are Piero *della Francesca*, who teaches us from his books and paintings his complex knowledge in mathematics and in art and his best follower *Leonardo da Vinci.* Describing his times also following the *Fabulae* tradition, Leonardo *abandoned* figurative representations of thousand idea/codes in his *Codici and artworks,* still to discover today. Together, Piero by mathematics and paintings and Leonardo by idea/codes drawings discovered a new kind of art; where the different fields as music, poetry, painting, sculpture, and architecture all together work, following the same rules and structures, the same *science* for generating uniqueness by artworks codes. This *Renaissance* art language still today open researchers toward new interpretations as possible discoveries of their yet veiled mystery. Therefore, it is the main reference for GA.
In our digital civilization, another side of the same coin performs, in contrast, easy games as an ephemeral solution to the complex art question. A big number of digital companies' experts developed easy tools and software *free,* by flooding them on the internet and calling Generative Art their games for fast anonymous solutions. G.A. is not only a digital result or a spending time exercise for a fun game. This simplification might be dangerous for the young generation, missing any effort in their mind in learning math and poetic structures for gaining only fast solutions needed in our *social* times. Computers are not enough, they are very useful engines, but they are only tools, also in their new intelligent generation. Our evolution seems to work in identifying human beings only as users, trying to use the technological devices for improving the quality of a new social life. No clear answer works for identifying a revolution that might define and perform humanity toward a new atrocious slavery. The learning simplification is the first tool for bringing humanity into a new form of collective slavery to digital devices. Not only, can grow on the horizon also another vision. Following Renaissance tradition, with honest sincerity and passion, we work in Generative Art for gaining new complex art results, discovering where still today can grow *"….the interpretations of many who could come to see a diversity of truths*."
St. Augustine, The Confessions, 12.30(41)
Generative processes: T.S. Eliot' *"The present moment of the past",* as intimate meta-code -Characters: from Wordsworth *daimon* toward Wittgenstein similarity between town and infant language - Cezanne, the micro-organic light on Mont Sainte-Victorie in variations abducted by Piero - Mosaic structures as organic science - The GA hat of power on Piero della Francesca – The Angel intimate drawing by Dante




enrica.colabella@generativeart.com
Keywords: *meta-code – daimon – abduction – similarity - organic - variations*
Main References: Dante - T. S. Eliot - Wordsworth – Wittgenstein - Piero della Francesca – Leonardo - Cezanne

Generative Art Language

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Abstract

"All manner of thing shall be well
When the tongues of flame are in-folded
Into the crowned knot of fire
And the fire and the rose are one."
T.S. Eliot, Little Gidding [1]

Outside and inside, *language* works looking for the sound of "the tower of song".

In Roman age, the word *ars* always gained the significance of science too. Only in Renaissance art started to be explicitly associated with science. In our time, technology too becomes necessary for identifying a process of art, performing a process of three cultures. Cultures are only one, in different aspects, able to work together for the human life quality, so far from *divide et impera*, but for integration toward complexity, as in the biological world.
Following the human history, the discovering of new paradigms and tools of the cultural organization deeply the procedures of life language changed. From the wheel to the internet, life communication performed its evaluative characteristics, in their different evolution, that in a fast way we in their differences recognize. As *a crowned knot*, art represents a visionary human conscience, compactly working for centuries, performing a generative expression of human life. Where we identify a mystery not ending, that it is not possible to cut by a complete solving. To the main questions about what is and why and how we need deeply an expression of art, we know that any answer is not enough and it is not able to give an exhaustive answer to this eternal question. **We need art.** This is the only fixed certitude. In Renaissance, art became a generative result of complex rules, able to perform beauty, following too science laws and tools. During centuries, best references points in art and science, still to discover today, are *Piero della Francesca*, who teaches us from his books and paintings his complex knowledge in mathematics and in art and his best follower *Leonardo da Vinci.* Describing his times also following the *Fabulae* tradition, Leonardo left to humanity still to discover figurative representations of thousand idea/codes in his Codici and artworks. Together Piero by mathematics and paintings and Leonardo by idea/codes drawings discovered a new kind of art; where the different fields as music, poetry, painting, sculpture, and architecture all together work, following the same rules and structures, the same science for generating uniqueness by artworks codes. This Renaissance art language still today open researchers toward new interpretations as possible discoveries of their yet veiled mystery. So is the main reference for GA.
In our digital civilization, another side of the same coin performs, in contrast, easy games as an ephemeral solution to the complex art question. A big number of digital companies' experts developed easy tools and software free, by flooding them on the internet and calling Generative Art their games for fast unanimous solutions. G.A. is not only a digital result or a spending time exercise for a fanny game. This simplification might be

dangerous for a young generation, missing any effort in their mind by learning math and poetic structures for gaining complex fast solutions needed in our social times. Computers are not enough, they are very useful engines, but they are only tools, also in their new intelligent generation. Our evolution works in identifying human beings only as users trying to use the technological devices for improving the quality of a new social life. No clear answer works to identify the revolution that defines and performs humanity toward a new atrocious slavery. The learning simplification is the first tool for bringing humanity into a new form of collective slavery to digital devices. However, on the horizon can grow also another vision. Following Renaissance tradition, with honest sincerity and passion, we work in Generative. Art for gaining new complex art results, discovering where still today can grow:

"The interpretations of many people, who could come to see a diversity of truths."
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Generative processes: "*The present moment of the past*" as intimate meta-code - Characters: from Wordsworth *daimon* toward Wittgenstein *similarity between town and infant language* - Cezanne, the micro-organic light on Mont Sant-Victorie, in variations, *abducted* by Piero - Mosaic structures as organic science- The hat of power on GA by Piero della Francesca – The Angel intimate drawing by Dante

1 - Generative Art Language

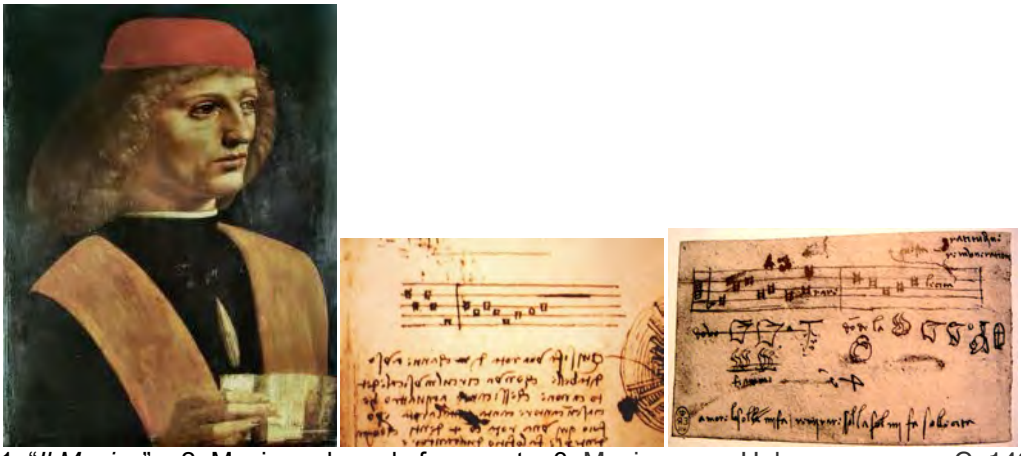
Memory is the heart of soul
Aristotle

Language is firstly *sound*, where are connected significance and significant. So the process is not linear and is still alive as the most complex human beings expression.
Around at the middle of the past century, Chomsky defined *generative linguistics* as a representation of a radical shift from '*products of behaviour* to ***states of the mind/brain*** that enter into behaviour'. A change of perspective ***from behaviourism*,** which dominated the social sciences in the 1950, **to mentalism**, which understands *'talk about the mind to be talk about the brain at an abstract level at which principles can be formulated that enter into successful and insightful explanation of **linguistic** (and other) phenomena that are provided by observation and experiment'.* [2]
Within such an approach, the Cartesian idea that ***language is a mirror of the mind*** resurrected. The main empirical assumption about language is that there is a *specific faculty of the mind/brain* that can account for the acquisition and use of language.
Psychologists of Chomsky time (such as John Watson or B. F. Skinner) rejected the study of mind as unscientific. The behaviour of organisms was explained with laws of stimulus-response conditioning. The organism (animal or human) was seen as **an empty black box** while the *stimulus (or the input)* and the *response (or the output)* represented the only objectively measurable entities:
Stimulus (Input) – Empty (Black Box) ____ Response (Output)

This post- Cartesian scientism may be useful, but it is not enough for the reason that does not exist *the perfect true* in human artefacts and expressions, being man a human unperfected. We are damned in choosing the next possible solution to a new performing problem under the corner, endless. We can try honestly to do our best. *Sing and walk.*
In this endless discovering, memory is the heart of soul, following Aristotle. Memory

becomes really a good sister especially in our time of digital revolution, where we have access in very easy and fast way perhaps to all human knowledge by internet. The new problem is how to manage *the big data* open to all with an efficient selection toward innovative e creative results. For this main aim, GA is a productive process. GA is an expression of complex not linear systems, able to connect data also in contest for experimenting results toward a complex quality. The discovering process is peculiar of art. For gaining complexity, we need to express a vision by a singular point of view, able dynamically to perform a plurality of representations for focusing and discovering a generative character quality. If we start our process without precedents, the possible quality to gain is very difficult to gain. However, if we focalize precedents as expressions of past characters *not to copy* but *to interpret* in a new open way for identifying data in evolution, we can gain more easy good results.
The generative process is open and any experience is a good effort for a new step.
If we study in deep Piero della Francesca, Leonardo, Borromini, Gaudì or Cezanne or the great poets Dante, Shakespeare, Balzac, Dostoyevsky, Yeats and so on we learn that they were great teachers for humanity, experimenting their best for beauty and science as a mirror of the nature complexity. That is our mirror too, also if now artificial ware becomes dominant: this is our next challenge.

2 - Music, the generative significance



1. "*Il Musico*" – 2. Music and words fragment – 3. Music score. Unknown source. C. 1480.

About music

Oh wonderful science, you preserve in life the precarious beauties of humans dying, those have more permanence that the nature operas, that ad continuum are variated by time, who bring them to their own oldness; and similar science has a similar proportion with the divine nature, as have its operas with the operas of nature, and for this it is adored

Leonardo, Trattato sulla Pittura

In his book on the artists' lives, Vasari wrote in a clear way that Leonardo was an excellent musician, lyre player and skilful improviser, expert of musical harmony and composer. No one ever says about this Leonardo ability.
For Leonardo, art and science coincide: from here derives his unifying conception of knowledge, free from barriers that saw the natural phenomena subjected to the same laws and that, therefore, made unitary the methodologies of investigation that he implemented. The unity of the natural and artificial world, without distinction of specific fields of investigation, became clear to his eyes in all its complexity. Leonardo was aware of the

vastness of his field of investigation, to the point where he later questioned his ability to dominate everything: *"As every kingdom divided in itself is destroyed, so every genius divided into different studies becomes confused and becomes weak. ".*[3]
Only music is the most complex integrations from several different fields. In fact, for Leonardo the musician defines his science as to be compared to that of the painter. Because music composes a body of many members, of which the speculator contemplates all the grace in as many harmonic times as there are times in which music born and dies, and with these times, she gracefully gives pleasure to the soul that resides in the body of her contemplative.
The *"Musico*" painting is the only male portrait made by Leonardo. Where anatomy, physiognomy and cycles of soul reveal, through the actions, attitudes, gestures and looking of the characters *"the motion of mind"*. This is the main task that Leonardo had set himself to gain also in the group of portraits performed at the court of Milan between 1485 and 1495. In addition, in *the Musico* too, where alludes to the eternity of painting compared to the transience of music, destined to vanish a moment after being performed.
The Leonardo *immanence concept* in music can survive in the generative art of variations, when, in memorizing variations in digital processes, we choose a singular variation in an open number of similar results. This choosing act is a creative act. In the same time is evocative of something of precariously lost, as in nature. This looks as a remembering to the Leonardo music concept before technologic devices.
We need this similarity.

2 - Poetry "The present moment of the past", processing an intimate metacode


Eliot

"There any people who appreciate the expression of ***sincere emotion in verse,*** *and there is a smaller number of people who can appreciate* ***technical excellence****. But very few know when there is expression of significant emotion, emotion which has its life in the poem and not in the history of the poet. The emotion of art is impersonal. And the poet cannot reach this impersonality without surrendering himself wholly to the work to be done. And he is not likely to know what is to be done unless he lives in what is not merely the present, but the present moment of the past, unless he is conscious, not of what is dead, but of* ***what is already living.***
No *poet, no artist of any art, has his complete meaning alone. His significance, his appreciation is* ***the appreciation of his relation to the dead poets and artists .****You cannot value him alone" you must set him, for contrast and comparison, among the dead. I mean this* ***as a principle of aesthetic,*** *not merely historical, criticism.*
The existing order is complete before the new work arrives" for order to persist after the supervening of novelty, the whole existing order must be, if ever so slightly, altered "and so the relations, proportions, values of each work of art toward the whole are readjusted" and this is conformity between the old and the new.
He must be quite aware of the obvious fact that art never improves, but that the material of art is never quite the same*.*[4]

This generative process is able to perform an intimate meta-code toward a possible.

3 Poetry meets generative technology

Characters: from Wordsworth daimon toward an artificial mother-son medium

A full-page view of one of the working manuscripts of The Prelude (DCMS 52), heavily edited by William Wordsworth.

Imagination [5]
Wordsworth was one of the Romantic poets most intent on interpreting, defining, and exploring the imagination.
The imagination is particularly important in Wordsworth's most famous work, the epic, multi-book poem, *The Prelude*. He originally wrote this poem in two parts in 1799, and then between 1804 and 1805 he rewrote and reworked it into thirteen books, though he never published this version. Three months after Wordsworth's death in 1850, his wife published *his last transcript of the poem*, which had grown to fourteen books.
Wordswoth in Prelude defines *daimon* as a performing character in the son connected to the mother voice sound. This works as a meta-code ~~as~~ a character indicator of possible *endless interpretations* connected to the *singular infant impressions*. Artist defines a possible iter inside his artworks for discovering the impressions of his remembering first reality. This process is *unstable* and *open* as natural ware.
Fragments from Prelude:[6]
v. 54:
"The holy life of ~~music~~ and of verse".
v.64
"My own voice cheered me, and, far more, the mind's
Internal echo of the imperfect sound;
To both I listened, drawing from them both
A cheerful confidence in things to come".
v.351
"The mind of man is framed even like the breath
And the harmony of music, there is a dark
Invisible workmanship that revoncilies
Discordant elements, and makes them move
In one society.,,,
The calm existence that is mine when I
Am worthy of myself! Praise to the end!".

This relationship mother-son is similar to the time on delay in TV when in a talking between two parties at a distance there is a minimum technical communication time slower

than the digital one.
The TV spectator listens directly to the live question, but the replay time needs a piece of natural time more from the interviewer's voice. In this fragment lies an entire unexplored world, which evokes ancient processes of knowledge related to our early childhood, where our learning took place essentially through the maternal voice capable of developing traits of happiness connection evoking what we already knew in the mother's uterus, where the maternal voice gained us throw the water sound too.
This is a generative process ***at a distance*** able to perform a meta-code as a character for translating a past time throw an interpretation.
"In the ancient world, the *Daimon* was a figure coming from elsewhere,, neither human nor divine, a middle ground between the two, inhabitant of a median region *(metaxu*), the same of the soul. We are born with a character, it is given to us, it is a gift from the guardian of our birth, as old stories say: *"Everyone enters the world with a vocation*"[7]

You Are Not Alone

In our technologic time, several medical studies have described the importance of this early maternal-infant bonding for the survival and development of an infant as well as the basis for a child's sense of self. Nurturing designed by nature.
Babies delivered prematurely do not benefit from those critical, intimate moments of nurturing care. In the United States, these new-borns, due to unfortunate necessity, are taken from their mothers and placed in the isolation of an incubator to receive medical interventions Camilo Anabalon, the designer behind **BabyBe,** wants to ensure all infants have access to the benefits of immediate physical nourishment. His work aims to offer premature infants the same emotional care available to those delivered complications-free by facilitating the nurturing crucial for them to thrive.

 [8]

3a - *Town meets infant language*

Wittgenstein similarity between town and infant language:

"Imagine that cities are built like language. That there is a perfect correspondence between urban space and the world of signs, between metropolitan architecture and the structure of language. A correspondence between streets, buildings and squares on one side and phonological, syntactic and semantic elements on the other".
Ludwig Wittgenstein in the Philosophical Observations suggests this parallel *(§18): "(And how many houses or streets do you want for a city to start being a city?) Our language can be considered as an old city: a maze of streets and squares, old and new houses, and houses with parts added at different times; and all this surrounded by a network of new suburbs with straight and regular streets, and uniform houses*
"Logical proof is no more powerful or more 'true' than the geometrical test. Therefore, mathematics does not need a logical foundation. Logic precedes the truth, this does not reflect it. Mathematics is logical because "it moves between the rules of our language". Logic constriction is a psychological, linguistic, social constraint. It convinces us, because

we agree on its results; but this concordance, as in the calculation, is due to training, to the use of a technique".

"*Work on philosophy like work in architecture in many respects is really more work on oneself. On one' own conception. On how one sees things. (and what one expects of them'*[9]

In the 1930s, Wittgenstein's philosophy of language was dramatically transformed – he now tells that the meaning of a word is its use in the language; and that words can be used in many different ways, for an indefinitely broad and heterogeneous range of purposes. The picture of language in *Tractatus* is now seen, not as wrong, but as overly narrow, as Wittgenstein himself writes - it is '"appropriate, but only for this narrowly circumscribed region, not for the whole of what you were claiming to describe"' Philosophical activity is hermeneutical, it does not consist in logical analysis, but in description of human 'language-games'. In this, he was visionary on Turing codes.

"Language sets everyone the same traps; it is an immense network of easily accessible wrong turnings. And so we watch one man after another walking down the same paths and we know in advance where he will branch off, where walk straight on without noticing the side turning, etc. etc. What I have to do then is erect signposts at all the junctions where there are wrong turnings so as to help people past the danger points.".....Perfect language results in poetry in which every word and every phrase is "an end and a beginning." The timeless and the time-bound are interchangeable and in the moment, if one is in the right place, like the chapel at Little Gidding. All will be well when the fires that both destroy and redeem come together to form a knot and "the fire and the rose"—divine wrath and mercy—become one".[10]

4 - Cezanne, "*beau motif* (beautiful motif)" in variations

"Theories are always easy", wrote Cézanne, and more "Of what you think you can only give proof, which presents serious obstacles, so I continue in my studies"



1- Cézanne, self-portrait [1878-80]
2- **Cézanne, *Abduction* [1867]**
3- Cézanne, self-portrait [1887]

"I owe you the truth in painting and I will tell it to you",
Cézanne,

A sense of the mystery of the world seized Cézanne toward a depth never expressed by another artist. He saw that ***nothing exists in isolation***: an obvious insight, yet one that only he could make us see. He performed each artwork as an expression of a generative process, where precedents give ideas and indications for the new results, defining a visionary poetics following the great artists of the past, especially Piero della Francesca.

Macroscale variations, a generative abduction process from Piero

"Painting from nature is not copying the object; it is realizing one's sensations"
Paul Cezanne

Piero della Francesca provided a bridge to modern art in Nicolas Poussin, Georges Seurat and Cezanne.
Although he lived in Aix-en-Provence, Cézanne took part in the first Impressionist exhibition in Paris in 1874, going back and forth throughout the year and for the following year.
It is therefore possible that he saw the extraordinary life-size copies of the Arezzo frescos produced in 1872.1874 by Charles *Loyeux* as soon as they arrived. Clearly, they must have impressed him a lot, because, a few years later, Cézanne repeated almost exactly a motif from one of the frescoes: in his vision of *Gardanne* he gave the urban landscape the same ***vertical composition*** of geometric solids that make up the view of Arezzo created by Piero in the background of the discovery of the Cross.
Cezanne abducted generative geometric rules and landscape vision by Piero, as it is possible to recognize in his art results. [11]- [12]

"Art is a harmony parallel with nature"
Cezanne


1.Piero della Francesca, Arezzo "*La storia della vera croce*"[1]
2- Paul Cézanne, *"Gardanne"*, Barnes Foundation, Lower Merion, Filadelfia, 1886

In his variations of *Mont SainteVictorie,* Cezanne gained his most important generative artworks following the complexity of Piero artworks.
Where, with his vision by a train, the *dynamic* **direction** is always the same following the horizontal way, but *the points of view* are very different; instead, all are **at the same distance**.
In a letter to Émile Zola dated April 14, 1878, Cézanne praised the Mont Sainte-Victoire, which he viewed from the train while passing through the railway bridge at Arc River Valley, as a "*beau motif (beautiful motif*)",and, in about that same year, he began to paint these variations:



1- First painted Mont Sainte-Victoire in 1870
2- *Mont Sainte-Victoire and the Viaduct of the Arc River Valley* (1885–1887), Metropolitan Museum of Art
3- *Mont Sainte-Victoire with Large Pine* (c. 1887), Courtauld Institute of Art

4- Montagne Sainte-Victoire, 1890, Scottish National Gallery
5- Mont Sainte-Victoire and Château Noir, 1904–06, Bridgestone Museum of Art
6- Mont Sainte-Victoire photo

Together Cezanne *abstract* paintings and a *real* photo of Mont Sainte-Victorie

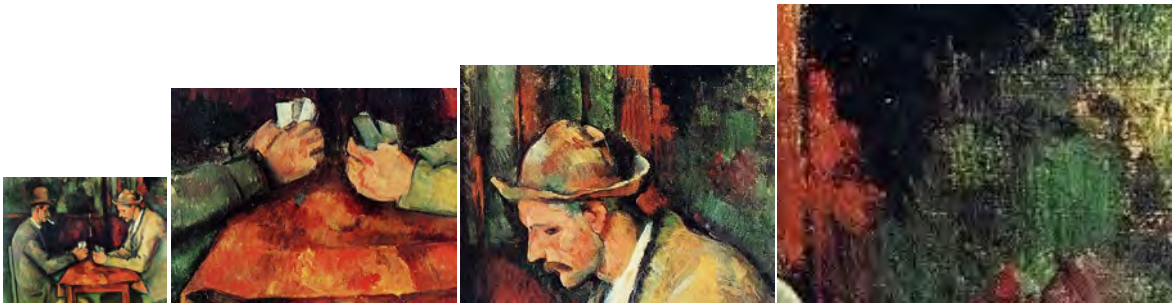
5 - Mosaic structures as organic science: a *micro- lighting* on art

……"….The blue jumble of clear stars!

For we desire Nuance yet more—
Not color, nothing but Nuance!
Oh! only nuance brings
Dream to dream and flute to horn!....

Art Poétique, By Paul Verlaine[ ]

Things have colour, they have weight, and the colour, and mass of each affects the weight of the other. It was to understand these rules that Cézanne dedicated his life.



1 Paul Cézanne, fragments of *The cards players* -2 Paul Cézanne, fragments of *Apples*

The micro-organic light *as idea code*

1-Paul Cézanne, detail *Mont Sainte-Victoire*, 1902-04, oil on canvas, 73 x 91.9 cm (Philadelphia Museum of Art)

2-Paul Cézanne, detail Mont Sainte-Victoire, 1902-04, oil on canvas, 73 x 91.9 cm (Philadelphia Museum of Art)

3-Paul Cézanne, detail *Mont Sainte-Victoire*, 1902-04, oil on canvas, 73 x 91.9 cm (Philadelphia Museum of Art)[12]

NUANCE ARE LIKE ELEMENTS STRUCURE OF A MOSAIC PIECE: in different elements able in their connecting to express *the lighting of each fragment in a whole.*
What Vico, in *The New Science*, deplores in modern education is **the loss of the perspective of the whole**. *He always insists that the flower of wisdom is the grasping of the whole through the particular and the specific*.

A generative art process tries to take alive this wonderful tradition started from mosaic, that here in Ravenna has one of the best representation over all world. Where we can discover an organization similar in its complexity to that of living things, characterized by the systematic arrangement of parts as elements fitting together into a unified organic whole.

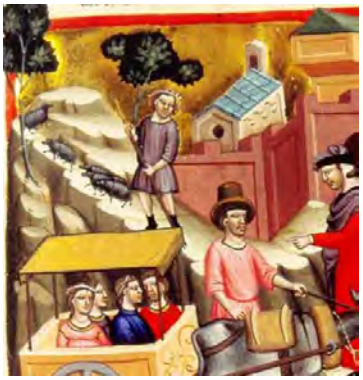
.The main part of a GA process works on the individual ability as poetic logic to perform a code as a structure able to connect logics at micro and macro scale. This generative process is following a first idea realized as a structure of organization: a paradigm that from a fist hypothesis becomes an organization structure.
This idea/code is able to generate recognizable variations, in perhaps endless number thanks to our digital devices.

6 - The hat of power on GA by Piero della Francesca

Flute Player in the "The battle of Eraclio e Cosroe", Arezzo

The hat of power we want to give as *homage* to Piero Della Francesca, the father of all generative artists.
Following my Poetic Logic paper at GA2015 [13], where I discovered ", ***in the face of the musician playing the flute with a Byzantine hat***, *inside The History of the True Cross*", ***the characters of the Piero face, I want to say thanks to this great artist, scientist and mathematician for his heritage too, still to discover.***
"La pittura Chiara" is still today one of the most great art and science gained by a human being.

7 - The Angel intimate drawing by Dante



Troubadours, Dante, Eliot

DANTE a philosophical poet

"Dante's imagination is visual ... it's visual in the sense that he lived in an era when men still saw visions ...
We have nothing but dreams .. "
Eliot

"La Divina Comedia" is a continuous dialogue between master and disciple, between *Virgilio* and *Dante* and between *Dante* and *Beatrice* for arriving to see *Paradise* and to listen to the *celestial spheres* music as visions that need a science.
The *hendecasyllable* is the ideal metrical tool to erase any rhetoric of the verse and translate it into *a musical orality* that from the language o*f the troubadours* brings the Italian language to a pure generation of beauty in extreme musical adaptability.

These maximal instruments, together with an incredible number of inner rules yet to discover, even at a distance of so many centuries, never reach the perfect comment, which in an *organic* vision of art is unattainable. The Divine Comedy is the perfectible work *par excellence*, to which all the great poets, not only of the Italian mother tongue, have dedicated study and deep reflection, thanks too at pluralistically translations.
Dante is the father of Italian language, the only one over all world generated directly by an artwork of a poet.
In my generation, we learned at school by memory long fragments of Divina Commedia. So we were connected with our previous generation that was costumed in quoting Dante fragments as *a true voice* in their real life.

Yeats too, followed this tradition:
*"I read Dante only with a prose translation beside the text. Forty years ago, I began to puzzle out the Divine Comedy in this way; and when I thought I had grasped the meaning of a passage, which especially delighted me**, I committed it to memory.** ; So that, for some years**, I was able to recite a large part of one canto or another to myself**, lying in bed or on a railway journey. Heaven knows what it would have sounded like had I recited it aloud; but it was by this means that **I steeped myself in Dante's poetry**."*[14]

7a - A generative meta-code from Eliot poem


Eliot writing a poem meta-structure

Eliot quoted the poem "*One Word More* "written by *Robert Browning* for his wife *Elizabeth* about a Dante preparation for painting *an Angel:*[15]

Dante once prepar'd to paint an angel:
Whom to please? You whisper "Beatrice."
While he mus'd and traced it and retraced it,
....
Says the poet—"Then I stopp'd my painting."
You and I would rather see that angel, 50
Painted by the tenderness of Dante,
Would we not?—than read a fresh Inferno.

After this discovering, I give a poetic homage to Dante and Eliot, great *philosophical poets,* with 4 generative quatrains*:*

The Angel intimate painting by Dante

"Dante's imagination is visual ... it is visual in the sense that he at a time when men still saw visions ... We have only dreams **...**" *Eliot*

"Dante once prepared to paint an Angel", *wrote Eliot.*
"It is sure; Dante painted his intimate Angel". Then we can say, following the Eliot poem.
More, you can put this question: "Why did Dante paint an Angel?"
In reality, he described in his Commedia thousands of angels:

An incredible lighted visionary Paradise figuration,
Through rhythmical emotional sounds, hidden between his poetic words.
"Dante painted an Angel," Eliot sings. "He painted his Angel ***with great tenderness*** *too"*
We add with emotion. "For ***whom to please?"*** *Nudging an answer.*

With impersonal time in his voice, Eliot ***whispers****:* ***"Beatrice".***
And, reflecting by open points of view, he decides to sing with ardour
That he prefers to see the intimate Angel of tenderness,
Painted by Dante, than ***"to read a fresh inferno".***

Oh ambiguous complexity of words, oh intimate discover of poetry,
Welcome at the open desco of song tenderness without time!
Where the intimate beauty of the Angel by Dante unveils "Four Quartet" too, as a shining site,
Generated by the splendor of evergreen laurel trees, for an infinite nudging toward beauty

8 - With the mouth of babies and infants

Nihil amantibus durum est,nullus difficilis cupienti labor/
Nothing for lovers hard is, no work difficult for desirous.
St. Girolamo

Poets sing their poems as infants discovering the invisible unknown with desire and *hard* work.
I want to finish with:

" 45 Mercy Street" by Anne Sexton

In my dream,
drilling into the marrow
of my entire bone,
my real dream,
I'm walking up and down Beacon Hill
searching for a street sign -
namely MERCY STREET.
Not there.

I try the Back Bay.
Not there.
Not there.
And yet I know the number.
45 Mercy Street.

I know the stained-glass window
of the foyer,
the three flights of the house
with its parquet floors.
I know the furniture and
mother, grandmother, great-grandmother,
the servants.
I know the cupboard of Spode
the boat of ice, solid silver,
where the butter sits in neat squares
like strange giant's teeth
on the big mahogany table.
I know it well.
Not there...

And Peter Gabriel's song: Mercy Street Lyrics, *For Anne Sexon*: [16]

Looking down on empty streets, all she can see
Are the dreams all made solid
Are the dreams all made real

All of the buildings, all of those cars
Were once just a dream
In somebody's head…..

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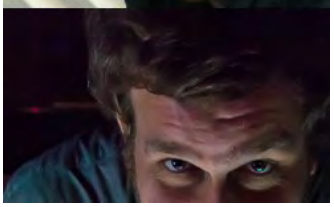

Pendulum – Exploiting Simple Physics for Generative Art
(Paper)

Topic: (Music)

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Abstract

Pendulum is a kinetic audio installation that directly relates physical movement with musical output. The installation consists of four free hanging pendulums that are actuated by computer controlled propellers. Each pendulum houses either a microphone or loudspeaker at its bottom. As the loudspeakers and microphones travel along quasi-periodic trajectories, their changing spatial relationships manifest sonically through continuously changing acoustic feedback.

This installation represents an attempt to exploit the interplay between simple physical and computational processes as main constituents for establishing the generative and interactive characteristics of an artwork. It is through this interplay, that the generative processes become perceivable and are rendered responsive to the surrounding environment and the presence and activities of visitors. This work highlights how natural and computational principles can be employed in a complementary manner for establishing consistency between the perceptual, behavioural and interactive aspects of an artwork while at the same time relinquishing the need for devising complicated mapping, sensing, and control mechanisms.

First showing of the Pendulum installation at the Zurich University of the Arts

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Key words:
Pendulum, Acoustic Feedback, Kinetic Installation

Pendulum — Exploiting Simple Physics for Generative Art

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Abstract

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This work highlights how natural and computational principles can be employed in a complementary manner for establishing consistency between the perceptual, behavioural and interactive aspects of an artwork while at the same time relinquish the need for devising complicated mapping, sensing, and interaction mechanisms.

1. Introduction

Pendulum is a kinetic audio installation that has been realised by the authors of this article. The installation consists of four pendulums whose movements result from a combination of passive physical dynamics and motorised actuation. Each pendulum houses either a loudspeaker or microphone at its end. The pendulums' movements cause the orientations and distances among the microphones and loudspeakers to continuously change. This gives rise to a variety of acoustic feedback effects. Simple computational algorithms are employed to control the motorised actuation of the pendulums and the attenuation and routing of the acoustic feedback. The musical content of the work emerges from the interplay between physical movement, acoustic feedback, and computational control.

Pendulum constitutes to some degree a continuation of one the author's previous experiments that dealt with the combination and blending of a generative system with the spatial and perceptual characteristics of its physical environment [1-3]. But *Pendulum* differentiates itself from these previous activities in that it exploits physical principles as integral constituents of the generative characteristics of the work. By doing so, the work connects with a tradition that is more firmly rooted within the field of sound art and electroacoustic music than it is within generative art.

2. Background

Artistic approaches that place their creative focus on the establishment of a close relationship between the physical characteristics of an electromechanical system and the musical content have started to emerge in between 1960 and 1970. These approaches took place as part of an avant-garde movement that formed in order to counter an increasing tendency in electronic music that aimed to liberate the perception of musical material from its sound producing origin. Several artists around that time experimented with the physical principles of loudspeakers. These artists treated loudspeakers not as hidden technical black boxes but rather as musical instruments in their own right. Famous pieces that were created through this approach are for example *Music on a Long Thin Wire* (1977) by Alvin Lucier [4] and *Rainforest* (1968) by David Tudor [5]. *Music on a Long Thin Wire* employs a deconstructed loudspeaker that consists of a long and exposed metal wire. The wire is mechanically excited by passing alternating current though it which is supplied by a signal generator. This causes complex vibrations and resonances that are amplified using contact microphones placed at either end of the wire. The piece *Rainforest* also exploits the resonant characteristics of physical materials. Here, several different customised loudspeakers are used. These loudspeakers consist of objects such as cartwheels, bedsprings and oil drums which are made to resonate by electromechanical transduction elements.

Within the context of kinetic art, even more radical attempts have been undertaken to coalesce technical mechanisms and sonic results. These approaches typically combine kinetic movement and physical materials to create semi-industrial assemblages that produce sounds though the repeated striking of these materials. The resulting sonic output consists of the acoustic emissions of the motorised movements and the vibrational response of the excited objects and surfaces. Jean Tinguely is a famous representative of this approach. He has been realising kinetic audio installation since the 1950's. Examples are the large industrial-sized assemblages that form part of the *Meta-Harmonie* series (1979-85) [6]. These assemblages consist of steel cogs, wheels, wires, belts and musical instruments that emit a cacophony of mechanical noises, as well as percussive and pitched sounds. This approach to kinetic sound art still enjoys some popularity among contemporary artists. One artist under the pseudonym of Zimoun has become well known for his room filling robotic installations which typically consists of a large number of small and simple motorised devices, each of them emitting sounds through mechanical collisions and movements [7].

Of particular interest among many sound artists who experiment with electromechanical principles is acoustic feedback. This phenomena results from a positive feedback loop that is established by routing an audio signal from a recording device to an emitting device whose output is then once again picked up by the recording device. This feedback gives rise to a variety of acoustic effects including sound colouring, pitch shifts, and volume

alterations. The motivation to employ acoustic feedback as a means for creating sonic artefacts started to play an important role in the 1960's as part of this decade's general rebellious attitude towards established cultural, social and political norms [8]. Of bigger interest in the context of this publication is the artistic use of feedback as a source of unpredictability and instability. Since acoustic feedback is hard to control, it can be integrated as an element of improvisation in a musical performance. An early example of such an approach is the piece *Quintet* (1968) by Hugh Davies. In this piece, five performers carry microphones in their hands and walk towards and away from loudspeakers that are situated in the corners and the center of a stage. The performers follow clear instructions as to what kinds of sounds they should produce through feedback. As the piece progresses, the routing of microphones and speakers changes and forces the performers to rediscover the positions and movements that are necessary for creating the desired musical results.

The sensitivity of acoustic feedback to changes of distance between sound recording and emitting devices can be exploited to drive musical changes and developments throughout a piece. By moving loudspeakers and/or microphones, the sonic output continuously varies due to changes in sound volume, signal phase, acoustic reflections and doppler effects. And also, through movement, the loudspeakers and/or microphones gain prominence on stage both as sounding and performative objects that draw the focus of the audience's attention. Accordingly, working with the combination of movement and acoustic feedback draws from artistic methods and offers creative opportunities that are of interest for musicians and kinetic artists alike.

The piece *Pendulum Music* (1968) by Steve Reich [9] illustrates very well how installation-based and performative approaches can be combined. In this piece, several microphones hang above an equal number of loudspeakers. At the beginning of the piece, the microphones are pulled by performers and then released to swing directly above the loudspeakers. From then on, the performers no longer interfere and its only through the gradually decreasing amplitude of the pendulum movements that the music of the piece transitions from brief and intermitted bursts to longer sounds that vary in pitch and colour until eventually the microphones comes to rest and the musical output settles into a continuous sound.

This piece is relevant in the context of this publication for an additional reason. It exemplifies how the autonomous behaviour of physical objects can form an integral element of a musical process. And it also shows how feedback can be exploited as mechanism that establishes an intricate and complex network of interdependencies between all elements on stage and the musical output. The piece contains in itself the transition from a conventional concert setting that centres on the activity of human performers to a situation in which the human performers relinquish control to allow non-human entities to play their own role in the unfolding of the work. Depending on the complexity of the behavioural relationships among all non-human entities, this unfolding takes place in an unpredictable manner that can lead to an emergent musical result. David Toop describes this kind of unfolding as the *drama of natural emergent phenomena* [10]. This focus on process and potentially open ended results is related to the notion of the *open work* by Umberto Eco [11]. But in contrast to Umberto Eco, Steve Reich makes a clear distinction between process-based musical works for which the autonomous processes took place prior to a performance and those works in which, as is the case with *Pendulum Music*, the processes are ongoing in front of the audience. Its this latter approach that in combination with the presence and behaviours of physical objects can

foreground the processual characteristics of an artistic work and therefore allows the audience to directly witness the processual unfolding of artwork's form.

3. Concept

The installation *Pendulum* has been realised in the context of a research project entitled *Feedback Audio Networks (FAUN)*. The goal of this research project is to explore the application of time-delay and feedback mechanisms as main principles for the generation of musical material [12]. But contrary to our previous experiments, *Pendulum* renounces the sole use of sound synthesis in favour of an approach that integrates both physical and computational processes.

The realisation of *Pendulum* is based on the establishment of a mutual dependency between kinetic movement and musical result. By creating a situation in which the musical output is almost exclusively dependent from and shaped by physical movement, the role of the composer and the methods of creation are drastically altered. As consequence, the composer needs to develop his or her musical ideas by working in the domain of physical movement. But even more importantly, the characteristics of this physical movement and its connection to the resulting sound underlie constraints and possibilities that are often outside of the composer's control. Therefore, composition becomes an exploratory endeavour throughout which an understanding and appreciation needs to be developed for the partially autonomous processes at play.

This creative technique is of course shared by many generative approaches. But what is more unusual is the fact that the autonomous processes result predominately from the interplay of physical phenomena whereas computational principles are relegated into a secondary role. In this secondary role, computation serves to allow a composer to exert a larger and more nuanced degree of control over the physical phenomena than would be possible otherwise. It is important to note, that in *Pendulum*, computational processes don’t contribute any acoustic material on their own. Rather, it is through computation that the diversity of the physically created musical material is expanded.

Working with kinetic movement and acoustic feedback directly rather than through a computer simulation offers several opportunities and benefits. First and foremost, the physical system creates interesting feedback and time-delay effects naturally, that is for free, without the need for developing an elaborate computational signal processing system. And the diversity of acoustic effects that originate from a physical system is likely larger that it would be from a simulation. This is owed to the fact that all physical and technical components involved add through their inherent imperfections and variations to the diversity of the musical output. Most of these effects would be very hard or at least time consuming to mimic in simulation. The surrounding space of the installation forms part of this network of interdependencies through its capability to alter the absorption, reflection and resonances of acoustic waves. For this reason, an installation whose musical output is produced through acoustic feedback effects naturally becomes site specific. The employment of physical principles as basis for creating music can have a beneficial impact on the audience. Since both kinetic movements and acoustic feedback are familiar phenomena, they can render the artistic intent and the musical result readily apparent for the audience. Furthermore, people’s intuition about everyday physics creates ideal prerequisites for interactivity. The physical behaviour of the installation invites the audience to intervene through physical activities. And the installation’s response to

interaction is again readily understandable due to its grounding in physical principles. This provides the unique opportunity to provide a playful and rewarding setting for audience engagement without the necessity to sacrifice the processual complexity of an artwork for the sake of clarity and intuition.

4. Implementation

This section provides a technical overview of the *Pendulum* installation. This includes a description of the hardware and software components that were specifically developed for the installation.

4.1 Hardware

The installation consists of four free hanging pendulums. Two of the pendulums are equipped with a loudspeaker and two with a microphone each. The microphones have a hypercardiod characteristics and record sounds in a highly directional manner. The loudspeakers consist of a broad band speaker driver and is used without casing. The main length of a pendulum is made from a hollow aluminium rod that is either two or four meters in length. These different lengths have been chosen in order for the pendulums to exhibit more diverse kinetic movements and to provide for the audience different listening and interaction situations. The upper end of an aluminium rod is connected with a steel wire to an electrical slip ring that in turn is fixed with a mechanical clamp to a support structure. The bottom part of a pendulum consists of a horizontal boom construction to which two propellers and either a loudspeaker or a microphone are mounted (see Figures 1 and 2). Each propeller is actuated by a brushless motor. The propeller-motor combination sits in a wooden cage that can be rotated about 180 degrees around its vertical axis. This rotation is controlled by a servo motor that is connected by a pulley with the cage's rotational joint. The loudspeakers and microphones are mounted underneath the propeller cages and point in a horizontal direction.

Three RGB light emitting diodes (LED) are attached to each pendulum. Two LEDs are fixed on top of the cages' rotational joints and follow their rotation. These LEDs emit their light through the cages and on the propellers. One LED is fixed to the aluminium rod just above the mechanical construction at the bottom of the pendulum. This LED points downwards and illuminates this construction. An absolute orientation inertial movement unit (IMU) that provides nine degrees of freedom (acceleration, gyroscope, compass) is mounted onto a horizontal section of the boom segment. Also mounted to the boom segment are two ESC brushless motor controllers.

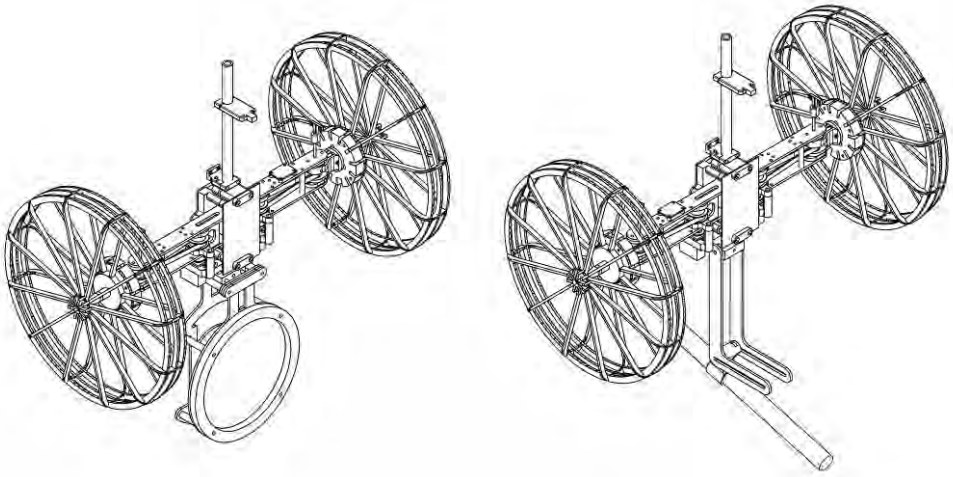

Figure 1: Loudspeaker and Microphone Pendulum. The two schematic images show on the left side a pendulum that houses a loudspeaker and on the right side a pendulum that houses a microphone.

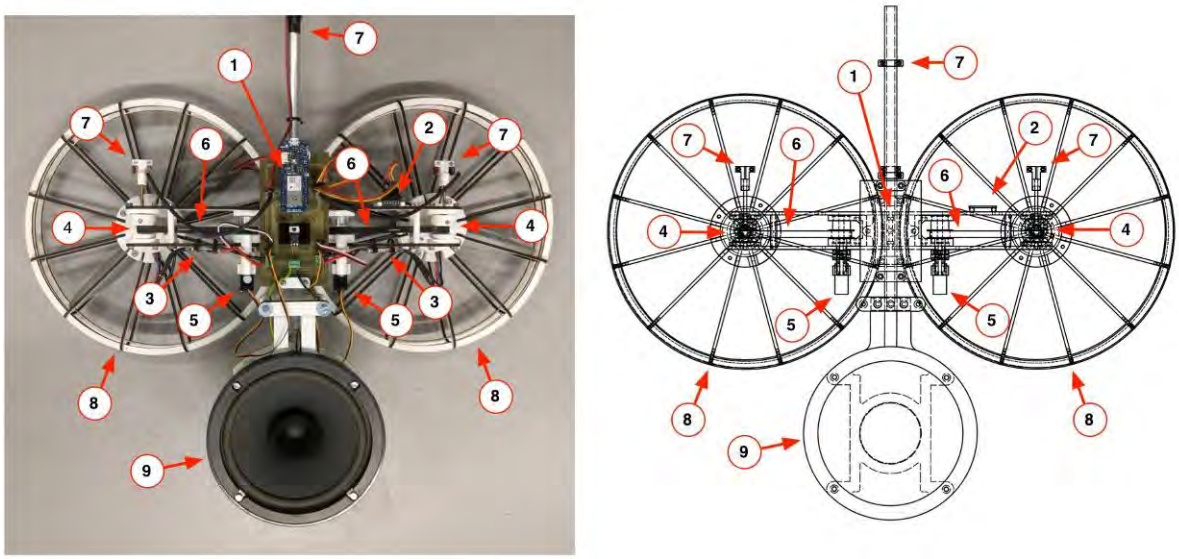

Figure 2: Pendulum Hardware. Both the schematic depiction (left side) and the photograph (right side) provide the same detailed view off the construction that is attached to the bottom of a pendulum. The following components are highlighted: 1) Arduino micro controller, 2) IMU, 3) ESC brushless motor controller (missing in the schematic depiction), 4) brushless motor, 5) servo motor 6) pulley 7) RGB LED, 8) propeller cage, 9) loudspeaker.

Placed vertically in the middle of the boom is a PCB board that contains the power conditioning electronics, control lines, and a Wifi-enabled Arduino micro controller. One 60 Watt power supply provides electrical power for each pendulum. The loudspeakers are driven by a mono audio amplifier. The power supply and audio amplifiers are mounted on a plate above each pendulum. The electrical power lines and the audio signal lines are passed first through a slip ring and then through a five core cable. This cable runs along the interior of the pendulum's hollow aluminum rod which it exits underneath the loudspeaker or microphone. The only additional hardware involved is an USB audio interface, a Wifi router, and a Mac Mini computer. The audio signals from the microphones

and to the loudspeakers run through balanced XLR cables which are connected to the audio interface. The audio interface provides phantom power for the microphones. All control signals that are exchanged between the Arduino micro controller and a Mac Mini computer as sent via Wifi. An overview of the entire installation setup is provided in Figure 3.

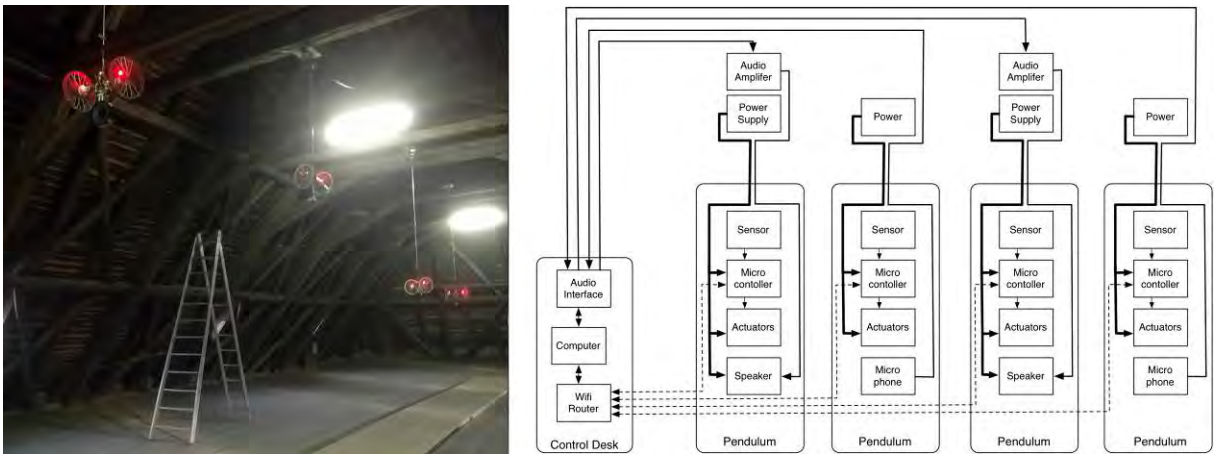

Figure 3: Installation Setup. The left photograph shows the setup of the four pendulums underneath the roof of the exhibition venue in Brugg, Switzerland. The pendulums were arranged in such a way that the two long pendulums and the two short pendulums were hanging pairwise and close to each other whereas the distance in between the pairs was larger. The pendulums carrying a loudspeaker and those carrying a microphone were placed in an alternating sequence. The graphics on the right shows the connectivity and power distribution among all hardware components. Different connection types are depicted by lines of different thickness. From thick to thin, these lines represent: power cords, audio cables, USB cables, PCB control lines. The dashed lines indicate Wifi-based communication.

4.2 Software

The software that controls the installation consists of two parts. One part runs on the Arduino micro controller and the other on a Mac Mini computer.

4.2.1 Micro Controller Software

The functionality of the micro controller software is very simple and only provides the means for remote controlling each pendulum. The micro controller operates as slave and the computer as master. Computer and micro controller exchange messages in the *Open Sound Control (OSC)* format over Wifi. These messages operate bidirectionally. Messages sent from the computer to the micro controller control the speed of the brushless motors, the rotation of the servo motors, and the colour and intensity of the RGB LED's. Messages sent from the micro controller to the computer provide sensorial information that has been acquired from the IMUs.

4.2.2 Computer Software

The functionality of the software that runs on the computer is more sophisticated. This software has been programmed in the Max/MSP environment and controls the kinetic,

visual and acoustic behaviours of the installation. The software's functionality is organised hierarchically.

At the top level is a scene progression mechanism that controls long term changes in the installation's behaviour. Each scene consists of a particular combination of kinetic movements, LED settings, and audio signal processing configurations.

Located underneath the top level are software modules that group particular combinations of control and processing settings and procedures into behavioural primitives. There exist different categories of primitives: those defining kinetic movement, those specifying light emission, and those controlling digital audio processing. Some of the primitives simply define fixed parameterisations, other comprise internal mechanisms that operate either in a closed or open loop. In case of the closed loop mechanisms, the sensorial information retrieved from the IMUs and/or from analysis of the acoustic signal is used to alter the operation of the mechanism. All primitives in each category can be independently chosen and combined arbitrarily with any other primitives from the other categories.

Finally, the lowest hierarchical level provides functionality that directly configures and controls the installation hardware. This includes calibration values, speed limits, and communication settings for the brushless motors and servo motors. It also includes intensity gain curves and communication settings for the RGB LED's. And it includes audio signal analysis, processing, and routing mechanisms for controlling acoustic feedback. This latter functionality will be explained in more detail.

4.2.3 Audio Processing

The purpose of audio signal processing is to provide more control over and increase the sonic diversity of the acoustic feedback effects. An overview over the audio signal processing chain is provided in Figure 4. The chain consists of two branches that are identical and run in parallel. Each branch is associated with one microphone. The outputs of the branches are then passed though a matrix that routes them to the two loudspeakers. This routing is not fixed and can be changed on the fly. Altering the routing strongly affects the feedback effects. If the routing passes the audio signal between pairs of microphones and loudspeakers that are closest to each other, the feedback effect will be strongest and the resonance frequencies will be highest, whereas a routing that involves those microphone loudspeaker pairs which are farthest from each other causes a faint feedback and low resonance frequencies or no feedback at all.

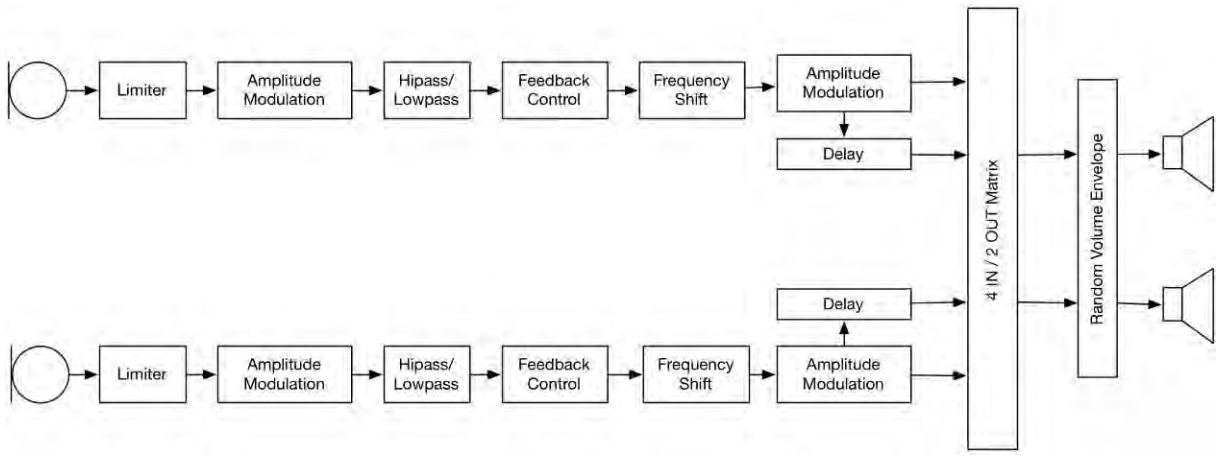

Figure 4: Audio Signal Processing Chain. The schematic figure depicts the digital signal processing chains that the two pre-amplifed microphone signals pass through before being rerouted through a matrix to the two loudspeakers.

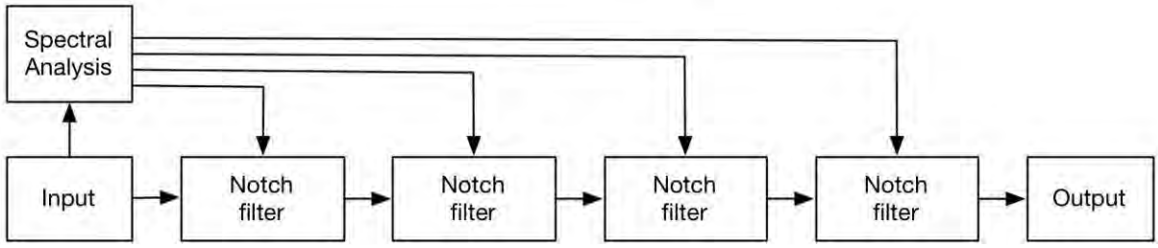

Figure 5: Feedback Control Mechanism. The schematic figure depicts the spectral analysis and filtering stages that form part of the feedback attenuation mechanism.

The signal processing units that from part of the chain between microphone and matrix operate sequentially. At first, the audio signal passes through a limiter unit that constrains the amplitude range. This unit prevents feedback from increasing the audio volume above a certain threshold. Next in the chain is an amplitude modulation unit that either creates a tremolo effect or enriches the sonic output by introducing spectral side bands. Then follows a high pass and lowpass filter that limit the range of frequencies that can be amplified through feedback. After that follows a feedback control mechanism that consists of multiple units. The purpose of this mechanism is to detect those four frequencies that dominate the spectrum of the incoming signal and then specifically attenuate them by passing the signal through four notch filters whose center frequencies correspond to those spectral peaks (see figure 5). The duration for the filters to move their center frequencies can be varied in order to alter the velocity with which the resonance effects are attenuated. Subsequent to the feedback control mechanism is a frequency shift unit. This unit offsets the incoming frequencies and reduces the strength of the feedback effect. This unit can also be used to create musical glissandi. After that, another amplitude modulation unit is employed. Before the audio signal is routed by the matrix, it is split into a direct signal and a delayed version of itself, both of which enter the matrix. The delay plays an important role for creating sonically interesting superposition and interference effects between an immediate and a delayed version of the feedback signal. A final signal processing step is applied after the signals leave the matrix. This step employs a volume envelope that is superimposed on the audio signals own dynamics. The envelope is created from a random walk that varies between zero and -two decibels. This effect is used to slightly and slowly vary the density of sounds during a scene.

5. Installation Behaviour

The following section describes the three types of behaviours that the installation can exhibit: kinetic movement behaviours, light emission behaviours, and musical behaviours. As previously described, kinetic and musical behaviours are inherently connected due to a physics-based dependency between acoustic feedback and movement. Therefore, the distinction between movement and music only serves the purpose of structuring this description. The movement dependency of the light behaviours is more trivial and more contrived. It is trivial since the emission of light from LED's obviously is affected by the orientation of and occlusion by the pendulums. And it is contrived in that several of the lights' behaviours are caused computationally by mapping the output of the IMU sensors to

light parameters. Nevertheless, the lights play an important role in shaping the visual atmosphere of the installation and highlighting particular kinetic movements and musical changes.

5.1 Movement

Obviously, a pendulum is a very simple physical object that exhibits periodic movements. In case of our installation, each pendulum possesses three degrees of freedom: it can swing in any direction and rotate around its own axis. The propellers serve to initiate and modify the pendulums' movements. By adjusting the orientation and speed of the propellers, each pendulum can be made to follow simple or complicated spatial trajectories. These trajectories have been organised as a set of movement primitives that are schematically depicted in Figure 6. The *Oscillation* primitive is created by orienting the propellers in a perpendicular direction with respect to the pendulum's boom segment. Each propeller is turned on and off in alternation. This switching is triggered whenever the gyroscope sensor value reaches a minimum. The *Rocking* primitive is similar to the *Oscillation* primitive in that it causes the pendulum to swing back and forth. But contrary to the *Oscillation* primitive, the two propellers are oriented in parallel with the pendulum's boom segment facing into the same direction and they are turned on and off at the same time. To decide wether the propellers should turn off or on, not only the gyroscope sensor value is taken into account but also the compass sensor value along the X-axis. For positive orientations, the propellers are turned off, for negative orientations, they are turned on. The amplitude of the swinging movement is larger for the *Rocking* primitive than for the *Oscillation* primitive since both propellers contribute simultaneously to the propulsion. For the *Rotation* primitive, the propellers are oriented in parallel with the pendulum's boom segment but face into opposite directions. This causes the pendulum to rotate around its own axis without deviating from its vertical hanging position. In the *Circling* primitive, one propeller is oriented in a perpendicular direction with respect to the pendulum's boom segment and the other propeller is oriented more or less at 45 degrees. This orientation causes the pendulum to follow a circular path with the perpendicular propeller facing towards the center of the circle and the other propeller facing outwards. This movement primitive is difficult to achieve since small deviations of the propellers' orientations or small differences in the propellers' speeds will cause the pendulum to rotate around its own axis while still following the circular trajectory. This latter type of movement is aimed for as part of the *Looping* primitive. Here, the first propeller has the same orientation as in the *Circling* primitive but the second propeller is oriented in parallel to the pendulum's boom segment. For both the *Circling* and *Looping* primitives, the propellers' orientations are not fixed but slightly altered in response to the gyroscope sensor value in order to stabilise the pendulum's orientation and subsequently its trajectory. Finally, the *Stepping* primitive is somewhat unique in that the propellers are not rotating but rather the propellers' orientation is continuously changed. The propellers swing back and forth between the two orientations that puts them in parallel with the pendulum's boom segment. The overall pendulum movement is small and consist of a slight back and forth rotation around its own axis.

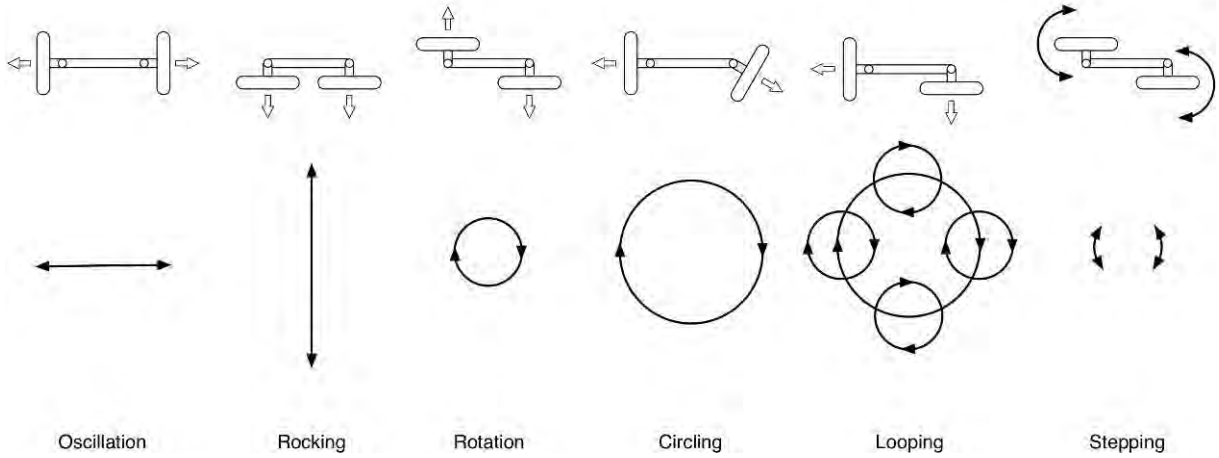

Figure 6: Movement Primitives. The schematic depiction shows all the movement primitives that have been used for the exhibition. The upper half of the image shows a top down representation of a pendulum and the lower half shows a top down view of the pendulum's movement trajectories. The outlined arrows represent air propulsion, the black arrows represent trajectories.

5.2 Light

A total of five light primitives have been created so far. These primitives are used to either highlight the pendulum's shape or to accentuate particular movements by synchronising light changes with these movements. The *Constant* primitive simply sets all LED's to a fixed colour. This primitive is mainly used to cause the mechanical parts of the pendulum, in particular the propeller cage, to cast shadows onto the walls and ground of the exhibition space. The *GyroBrightness* primitive turns the two side LED's off. The brightness of the center LED is changed depending on the gyroscope sensor value. The LED turns off when the pendulum passes through a vertical orientation and turned on when the pendulum reaches its maximum deflection. This light behaviour accentuates the pendulums' swinging motions. For the *OrientationBrightness* primitive, all three LEDs change their brightness at the same time in dependency of the compass sensor value. The rotation angle is subdivided into an even number of angular segments. Whenever the compass sensor indicates an orientation that lies within one of the even numbered segments, the LED's are turned on. And whenever the orientation lies within one of the odd numbered segments, the LED's are turned off. This light behaviour causes a stroboscopic effect that is synchronised with the pendulum's rotational movements. The *OrientationColor* primitive also makes use of all three LEDs but this time the hue value of the LEDs is changed in correspondence with the compass sensor value. One full rotation of the pendulum is mapped into the full range of hue values. This light behaviour is mostly used to enhance the visual effect of slow pendulum rotations. Finally, the *ServoBrightness* primitive makes use of the two side LEDs. The brightness of these LEDs is turned on and off whenever the servo motors that control the cages' orientations exceed an upper or lower threshold in their control value. This gives rise to brief light bursts that alternate with longer phases of darkness and thereby accentuate small non-translational movements of the pendulums.

5.3 Music

The musical primitives take the form of grouped parameter settings for the audio signal processing units. These settings were stored in a hash table from where they could be

recalled through numerical indices. A total of ten musical primitives were created for the exhibition. Figure 7 provides an overview over the parameter settings for each of these primitives. Not all parameters are represented in this table but only those whose value changes between different primitives. It should be noted that the parameter settings are very similar for the two audio signal processing chains. The reason for this similarity is based on the aesthetic decision that all the pendulums should behave in a similar manner within each scene.

What follows is a brief description of each musical primitive. The *PureFeedback* primitive barely modifies the incoming microphone signal. It therefore renders the acoustic feedback effect audible in its immediate physical form. The *LocalAmplification* primitive is used in situations in which the microphones and loudspeakers are positioned at a large distance from each other. Accordingly, little feedback is audible. Rather, this preset amplifies local sounds that originate from the immediate vicinity of the microphones. The *AmpModResonance* primitive is one of only two primitives that employs amplitude modulation. This effect is controlled by the compass sensor value. This primitive is also rather unique in that it boosts instead of attenuates the resonance frequencies in case of microphone 1. Pitch shifting and a long delay gain is employed to create slow glissandos and acoustic interference. The *Resonance* primitive is the only other primitive that boosts resonance frequencies. In this primitive, the boosting effect is applied for both microphones. Furthermore, the spectral width of the feedback effect is limited to a narrow range between 53 and 500 Hz. This primitive employs a brief delay time. The *SlowAttenuation* primitive strongly attenuates feedback but only after a long delay. Similar to preset 1, this preset barely modifies the incoming microphone signal. The *QuickAttenuation* primitive also leaves the feedback signal largely unmodified but it very quickly and strongly suppresses it. The *WeakAttenuation* primitive represents a variation of the *QuickAttenuation* primitive in that it employs an intermediate interpolation time and only weak feedback attenuation. The *NarrowLocalAmplification* primitive is used to amplify local sounds within a very narrow and low spectral band. The *FeedbackEcho* primitive represents a variation of the *PureFeedback* primitive from which if differs by the use of a very long delay time which gives rise to an echo effect in the feedback signal. The *AmpModAttenuation* primitive represents a variation of the *AmpModResonance* primitive. It employs feedback attenuation rather than amplification.

	1	2	3	4	5	6	7	8	9	10
Pendulum 1										
Lowpass Freq in Hz	20	685	53	53	200	20	51	53	20	53
Highpass Freq in Hz	4000	6000	16000	500	4000	3000	1119	500	3000	16000
Interpol. Time Max in ms	1500	500	800	800	1500	70	200	40	1500	500
Interpol. Time Min in ms	500	200	100	100	30	50	100	20	500	100
Filter Gain in dB	-12	-11	2	2	-26	-23	-9	-3	-12	-8
Filter Q	1.83	2.5	1.6	1.6	1.93	1.8	2.5	1.6	1.93	1.6
Frequency Shift in Hz	0.	0.	0.	-1.	0.	0.	-171.	-9.	0.	0.
Delay Time in ms	13.	200.	59.	16.	13.	13.	2000.	20.	8000.	59.
Delay Feedback 0.0–1.0	0.89	0.2	0.77	0.81	0.89	0.89	0.	0.72	0.2	0.77
Delay Gain Out in db	-6.	-6.	0.	-3.	-6.	-6.	-6.	-4.	-6.	0.
Master Gain in dB	-2	0.	0.	0.	-1.4	-1.	-1.	015748	-2	0.
Pendulum 2										
Lowpass Freq in Hz	20	500	53	53	200	20	40	53	20	53
Highpass Freq in Hz	4000	6000	2000	1600	4000	3000	1200	500	3000	2000
Interpol. Time Max in ms	1500	500	800	800	1500	70	200	40	1500	500
Interpol. Time Min in ms	500	200	100	100	30	50	100	20	500	100
Filter Gain in dB	-13	-12	2	-5	-28	-23	-11	-3	-13	-6
Filter Q	1.88	2.5	1.6	1.6	1.88	1.7	2.5	1.6	1.88	1.6
Frequency Shift in Hz	0.	0.	-2.	6.	0.	0.	-206.	6.	0.	-2.
Delay Time in ms	20.	200.	59.	20.	20.	20.	2000.	30.	8000.	59.
Delay Feedback 0.0–1.0	0.355	0.2	0.736	0.66	0.355	0.355	0.	0.578	0.2	0.736
Delay Gain Out in db	-6.	-6.	0.	-7.	-6.	-6.	-6.	-8.	-6.	0.
Master Gain in dB	-2	0.	0.	0.	-0.9	0.9	0.9	0.	-2	0.
Matrix Preset	1	2	3	2	1	1	4	2	5	3

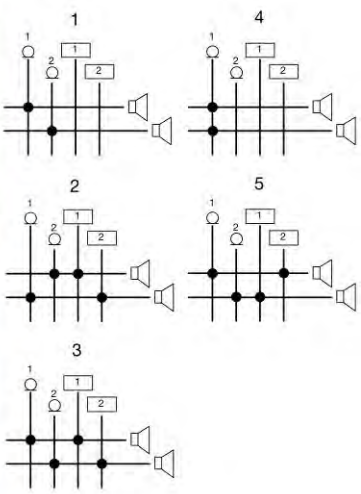

Figure 7: Musical Primitives. The table lists those parameter settings for audio signal processing that vary between musical primitives. For each primitive, the corresponding settings are listed in the column underneath the numerical index of the primitive. The routing configuration of the output matrix is also represented by numbers. The correspondence of these numbers with particular matrix configurations is shown on the right side of the table. In these graphical matrix depictions, outlined circles represent direct audio signals, outlined rectangles represent delayed signals, and filled black circles represent connected signal lines. The correspondence between the numerical index of a primitive and its name is as follows: 1) PureFeedback 2) LocalAmplification 3) AmpModResonance 4) Resonance 5) SlowAttenuation 6) QuickAttenuation 7) WeakAttenuation 8) NarrowLocalAmplification 9) FeedbackEcho 10) AmpModAttenuation

6. Installation Scenes

During the exhibition, the installation progressed repeatedly through a total of thirteen different scenes. Once a scene has finished, the pendulums return for a duration of ten seconds to a default setting before the next scene is initiated. In the default setting, the pendulums are at rest, all motors and led's are turned off, and audio output gain is set to zero. The progression of scenes is partially deterministic and partially randomized. The first and last scenes play the role of opening and closing a full play through all the scenes. These scenes are always chosen at this particular location in the play through. The intermediate scenes are chosen at random through a ballot type system that ensures that each scene is picked only once during a single play through. The duration of each scene is randomised within lower and upper time limits. The exact values of these limits are specific for each scene.

Each scene combines a particular set of movement, light and music primitives. The combination of primitives is always identical or at least very similar for all pendulums. This is based on the aesthetic decision that all pendulums should behave similarly within a scene. This endows each scene with a clear internal consistency and recognisable characteristics. Figure 8 provides an overview over all scenes, their minimum and maximum duration and the different primitives that they are comprised of. For some scenes, a link to a video excerpt on Vimeo is provided. Another visual impression of the exhibition situation and some of the scenes is given by Figure 9. Each of the scenes is described in some detail throughout the following paragraphs.

Scene	1	2	3	4	5
Min Duration in secs	40	30	60	40	40
Max Duration in secs	90	90	100	60	60
movement primitive	Oscillation	Rocking	Stepping	Rotation	Rotation
light primitive	GyroBrightness	Constant & OrientationBr.	ServoBrightness	OrientationBrightness	OrientationBrightness
music primitive	PureFeedback	PureFeedback	LocalAmplification	AmpModResonance	FeedbackEcho
Scene	**6**	**7**	**8**	**9**	**10**
Min Duration in secs	40	40	30	20	30
Max Duration in secs	70	80	90	60	50
movement primitive	Circling	Looping	Oscillation & Stepping	Rotation	Looping
light primitive	OrientationColor	OrientationColor	Constant	OrientationBrightness	Constant
music primitive	SlowAttenuation	SlowAttenuation	AmpModAttenuation	Resonance	SlowAttenuation
Scene	**11**	**12**	**13**		
Min Duration in secs	30	30	40		
Max Duration in secs	80	70	50		
movement primitive	Rotation & Stepping	Rotation & Stepping	Rotation		
light primitive	Constant	Constant	Constant		
music primitive	QuickAttenuation	WeakAttenuation	NarrowLocalAmplification		

Figure 8: Installation Scenes. The table lists for each of the installation scenes their minimum and maximum duration and the different primitives they make use of.

Scene 1 [13] is the opening scene. Here, the pendulums' movements gradually build up as each propeller turns on and off in alternation. Initially, the pendulums are constantly illuminated by white light from the center LED. But as the pendulums gain momentum, the illumination becomes repeatedly interrupted whenever a pendulum's gyroscope sensor value exceeds a certain threshold. Acoustic feedback is initially very strong. But after a brief moment, the side-wise movements and orientation changes of the pendulums cause them to only occasionally come sufficiently close to and aligned with each other for feedback to happen. As a result, feedback becomes more intermittent and sonically resembles the occasional chirps of birds.

Scene 2 is similar to scene 1 in that the pendulums' deflections gradually gain in amplitude. But due to the stronger propulsion of pendulums that results from the simultaneous actuation of both propellers, the swinging motions exceed those of scene 1. As a result, the distance changes among microphones and loudspeakers are more pronounced and cause stronger and shorter feedback effects. The scene combines two light primitives. The center LEDs change their brightness depending on the orientation of the pendulums. The side LEDs are always emitting maximally bright blue light that casts shadows onto the inclined surrounding ceiling walls.

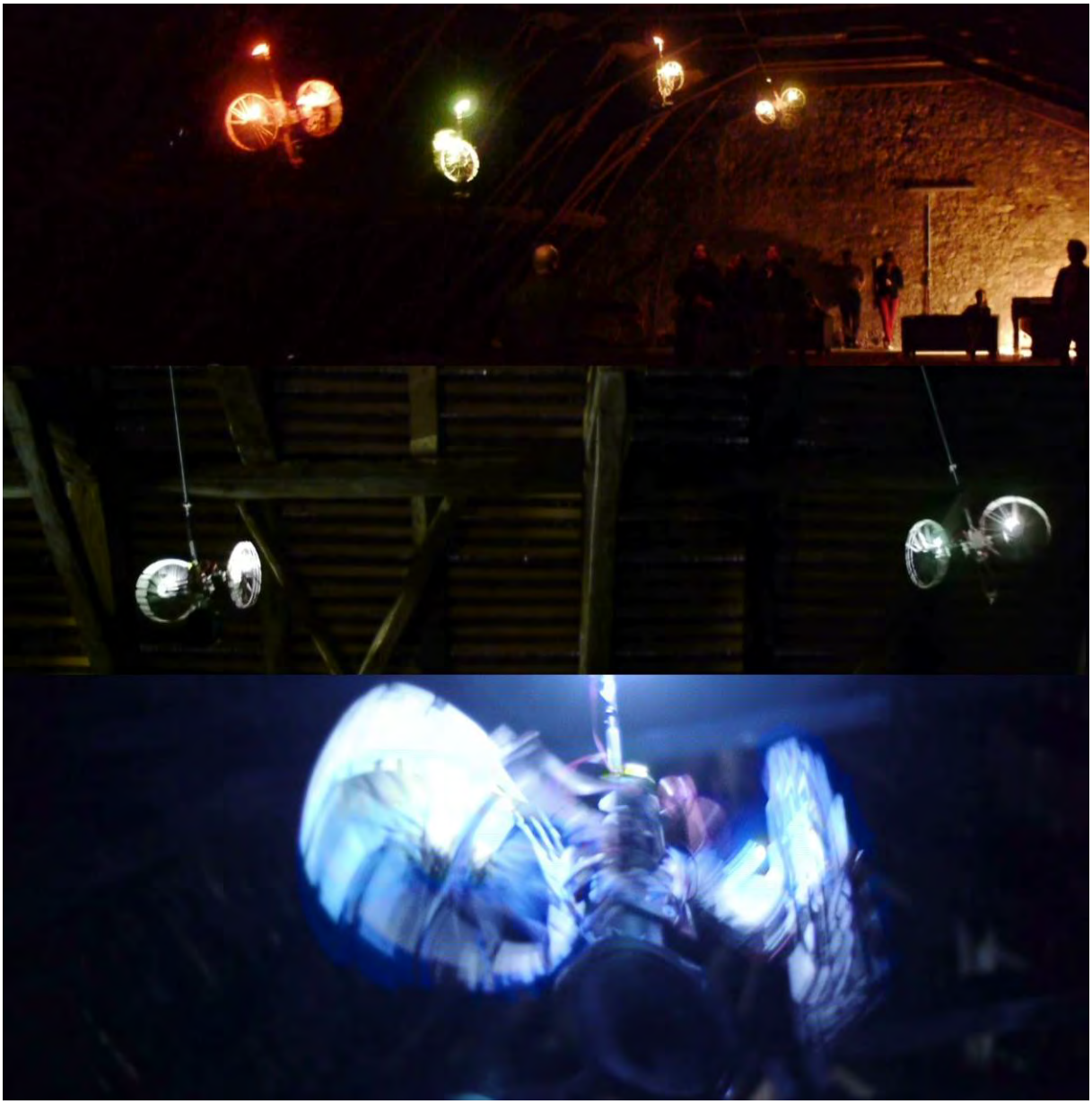

Figure 9: Exhibition Situations. The photographs provide a visual impression of the exhibition situation. The top image shows scene 6 being played during the opening of the exhibition, the middle image shows two pendulums performing scene 10 with the wooden roof construction of the venue as backdrop, and the bottom image shows a closeup of a pendulum that rotates very quickly during scene 5.

Scene 3 [14] is very calm and the pendulums barely move. There is no acoustic feedback and all audible sounds originate from the amplification of the electrical noises produced by the servo motors and the occasional collisions between propeller cages and the horizontal booms. This gives rise to a sound quality that is reminiscent of insect noises. Light emissions appear as short pulses that interrupt an otherwise very dark scenery. These pulses result from the servo motors briefly exceeding the upper and lower thresholds of their control values.

Scene 4 is very loud and aggressive. The pendulums rotate quickly around their own axes which leads to the occurrence of repeated bursts of acoustic feedback. The feedback sounds are additionally *chopped up* via amplitude modulation. This creates rhythmically

changing textual patterns. On top of this, the pendulums' own noises are also amplified. The lights support the acoustic rhythm by alternating in synchronicity with the sound between darkness and white light at full brightness.

Scene 5 [15] employs the same fast pendulum rotation and the same light settings as scene 4. But this time, the pendulums that carry microphones rotate at a different speed than those carrying loudspeakers. This creates more complex rhythmical patterns. Also, in this scene, feedback is much weaker both because the matrix routes the audio signal in between the most distant microphone and loudspeaker pairs and because the feedback signal is attenuated rather than boosted.

Scene 6 [16] is a colourful spectacle with the pendulums performing circling movements. The orientations of the pendulums are mapped onto the hue values of the LEDs. As a result, the pendulums illuminate themselves and their surroundings with light that continuously changes colour. Feedback effects dominate the musical output. But these effects appear only sporadically since the pendulums rarely come sufficiently close to other. The feedback signal is slowly but strongly attenuated.

Scene 7 is similar to scene 6 but the pendulums follow more complicated trajectories. The trajectories combine a circling movement with rotations around the pendulums' axes. This creates different periodicities at which feedback can take place. As in scene 6, the LEDs change their colour in correlation with the pendulums' rotations, but these changes now happen at a much faster speed. Accordingly, this scene continues the musical and visual atmosphere established in scene 6 but at a higher and more complex pace.

Scene 8 [17] also employs rather complicated pendulum movements. These movements result from the combination of standard swinging movements with back of forth rotations of the pendulums' propeller cages. These cage movements create forces that repeatedly alter the direction of the swinging movements. With respect to light, the scene is very simple. All LEDs are constantly turned on and emit a purple colour. The repeatedly occurring acoustic feedback is transformed via pith shifting into glissandi that re-appear as echoes on the neighbouring pendulum's loudspeaker.

Scene 9 [18] creates a very melodic musical situation. The pendulums rotate around their own axis at low velocity. The LEDs emit white light that changes its brightness in synchronisation with this rotational movement. The musical output is dominated by resonances that are amplified within a very narrow and low frequency range. The remaining frequencies are barely audible since the feedback effect is faint. This is due to a matrix routing that only combines distant microphone and loudspeaker pairs.

Scene 10 [19] combines a looping pendulum movement with a strong but slow feedback attenuation. This causes occasional and briefly sustained feedback bursts. The LEDs emit constant white light.

Scene 11 [20] employs a combination of movement primitives that causes the pendulums to oscillate back and forth around their own axes. This gives rise to frequent and repeated feedback events. The feedback is very quickly attenuated which further strengthens the pointillistic characteristics of the sound emissions. In addition to this, the musical output also contain amplified noises that originate from the servos' movements. The LEDs emit constant blue light.

Scene 12 employs the same combination of movement primitives as scene 11. But contrary to scene 11, the spectral bandwidth of the acoustic signal is clamped to a narrower and lower range. Also, feedback attenuation is a bit slower in taking effect. In combination with a two seconds long delay time, the musical output is characterised by a slow and deep rhythm that is reminiscent of gurgling sounds. The LEDs emit constant red light.

Scene 13 closes the sequence of scene successions. This scene is very calm. The propellers are in a perpendicular orientation with respect to the boom and rotate very slowly. The pendulums barely move at all. The musical output consists only of noises produced by the pendulums themselves that are heavily filtered so that they only contain low frequencies. The LEDs emit constant and very dim red light.

7. Discussion

Composing for the *Pendulum* installation has turned out to be a fascinating but also challenging endeavour. This is largely owed to the fact that the combination of pendulum movements and motor actuations gives rise to a wide range of different kinetic behaviours most of which are difficult to control. Accordingly, the compositional activities focused for a considerable amount of time on the acquisition of an understanding concerning the different movement capabilities of the pendulums and the assessment of the reliability with which these movements could be achieved. The acoustic feedback on the other hand and the methods of its control was dealt with in a more straight forward manner. Many of the signal processing units that we chose to work with such as limiter, notch filters and frequency shifts are commonly used for controlling and attenuating acoustic feedback. But in our case, these elements have been implemented in such a way that their feedback subduing activities could either be turn off or delayed before taking effect. In the end, it was both the configuration of these signal processing elements and the control of the pendulum motors that formed the main compositional tools for exploring the creative potential of this installation.

The capability of this predominantly physical system to behave in unexpected ways became evident not only during the compositional process but also while the installation was exhibited. For instance, the transfer of the installation from the working situation at our university to the exhibition venue led to a change in the pendulums' movements. Part of the change was due to an alteration of the mechanical coupling between the pendulums. This alteration originated from material differences of the support structure to which the pendulums were attached to. In the exhibition venue, these support structures were made from wood rather than metal as was the case during the realisation of installation. Another change was due to significant differences in room temperature between exhibition venue and university workshop. Contrary to the normal office temperature at the university, the temperature in the venue was only barely above the freezing point. The low temperature altered the viscosity of the lubrication oil in the slip rings and resulted in a higher amount of friction. Finally, throughout the duration of the exhibition that lasted for a little bit less than two weeks, signs of wear in the mechanical joints and cabling started to increasingly affect the installation. The effects ranged from a further increase in friction up to the point of cables breaking. The pendulums affected in such a manner could no longer be actuated. This drastically altered the acoustic feedback situation. While these issues were of course less than favourable, they never led to a complete breakdown of the installation. Rather,

they caused musical behaviour of the installation to increasingly diverge from the originally envisioned result.

The capability of the *Pendulum* installation to encourage interaction is largely owed to its physical instantiation. That the installation's musical content arises mostly from acoustic feedback was readily understandable by the audience. Based on this understanding, many visitors spontaneously decided to affect the musical output by standing close the a microphone equipped pendulum and producing sounds on their own. Depending on the particular scene that was active at that moment, these audience contributed sonic elements would remain audible for an extended period of time as part of the installation's musical behaviour. More courageous visitors dared to intervene directly with the kinetic behaviour of the pendulums by manually stopping them and subsequently pushing them into a different trajectories. These altered trajectories affected the acoustic feedback and the IMUs' sensorial values and therefore led to an altered visual and musical outcome.

8. Conclusion

To conclude, we would like to generalise our approach of combining physical and computational processes for creating a generative artwork. Based on our experience with the *Pendulum* installation, it seems evident that even simple mechanical and acoustic systems can exhibit a richness of behaviours that can readily be exploited for generative purposes. While the same holds true for many purely computational approaches, the physical systems outshine their computational competition with respect to their capability to integrate site specific environmental factors and audience participation into the core principles of their operation. This integration emerges naturally from the sensitivity of the acoustic and kinetic elements with respect to the material, geometrical and environmental properties of the exhibition environment. And since some of these properties such as temperature and humidity can change according to seasonal or circadian rhythms, an installation's behaviour can even become correlated with these periodic patterns. Wether such effects take place and how the physical system will respond to them is hard to anticipate. Accordingly, it is not only the physical behaviours themselves but also their sensitivity to site-specific situations that operate with a large degree of autonomy and can therefore be considered to constitute processes to which an artist delegates part of his or her own creative authority. With respect to interactivity, artworks whose behaviours are based on physical principles that are familiar to visitors from everyday experience exhibit a rich potential for audience engagement. The physical principles themselves provide affordances that invite playful interaction and open-ended exploration. It is through this familiarity with physics, that even highly complex musical behaviours can be traced back by the audience to basic causalities and therefore become accessible for intuitive understanding and playful experimentation.

While researching historical and recent precedents to our approach, we were somewhat surprised by the apparent scarcity of documentation concerning physics-based works in the field of generative art and, on the other hand, by the abundance of information about such works within the field of sound art. We therefore conclude, that physics-based approaches possess a largely untapped potential for generative art. And we would like to encourage generative artists to gain inspiration from activities undertaken by practitioners in electroacoustic music and kinetic art.

Concerning our own plans for the future, we would like to further exploit the capability of the *Pendulum* installation to provide natural affordances for playful and open-ended interaction. We aim to integrate the pendulums into stage performances where they likely offer ample possibilities for improvisation. The improvisation between pendulums and human performers could take place on the level of physical movement (dancers) or acoustic interaction (musicians) or a combination of both. These plans are already taking concrete shape in the form of the context of a theatre performance which is planned to premiere at the end of 2018. Here, the pendulums will act both as scenographic elements and musical instruments that play alongside regular musical instruments.

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SELFHOOD, an experience around the self

Topic: Interactive Installations

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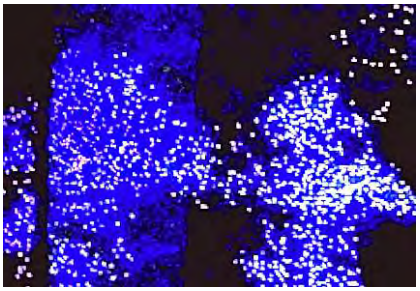
Abstract
Aiming to instigate a reflection on the self through a practical and interactive experience, the SELFHOOD installation was conceived. A representation of each participant is created in a form of a cloud of points and sounds, suggesting their *selves*. The dynamics of visitors' movement is sonified in such way that colors and sound textures are fused in a surround hexaphonic sound diffusion system. The generative sound machine of the installation is the CromaCrono≈ system that operates with a small set of compositional operations making possible real time control [1].

Philosophical questions about the self are presented. It thereby foregrounds the fact that cognition is a highly embodied or situated activity and suggests that thinking beings ought therefore be considered first and foremost as acting beings.



This research is anchored in a multimodal laboratory where we study human cognition and creativity supported by digital interfaces, computer graphics and motion capture [2]. These systems can be evaluated from the perspective of the interaction between agents and devices generating sounds, video and 3D graphics. The assumption is that the interaction of an organism/agent or group of agents within an immersive space, using various interactive devices, indicates how these processes affect their behaviour and the meaning that is constructed by them [3].

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Key words: creativity, cognition, interactivity, multimodal, sonification

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SELFHOOD, an experience around the self

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1. INTRODUCTION

In the development of new music interactive technologies, a mixed reality environment [1] can function as a laboratory to evaluate interactive behaviour [2, 3]. With the advent of new technologies that have emphasized interaction and novel interfaces, alternative forms and modes of interactive media have been realized [4]. These developments raise fundamental questions on the role of embodiment as well as the environment and interaction in the understanding of the man-machine interplay. In addition, it places emphasis on a more situated and externalist view. Moreover, body's perceptual, cognitive, motor and kinaesthetic responses have to be reconfigured to the needs and constraints concerning action and perception in this new space and the interface can now be optimized to its user [5, 6, 7]. In line with these recent developments, we present here the SELFHOOD installation as an interdisciplinary research framework. SELFHOOD is an installation in which two particle systems based on Boids [8] are used to generate images and digitally synthetizing sounds. The generative sound machine of the installation is the CromaCrono≈ system that operates with a small set of compositional operations making possible real time control. Our research is anchored in a multimodal laboratory where we study human cognition and music creativity supported by digital interfaces, computer graphics and motion capture. It is an interactive environment with a large 3D screen and a six channel sound diffusion system. The key point discussed here is the creation of new art forms based on interactive narratives, virtual soundscapes and synthetic visualization [9]. The assumption is that the interaction of an agent or group of agents with an immersive space,using various interactive devices, indicates how these processes affect their behaviour and the meaning that is constructed by them. These systems can be evaluated from the perspective of the interaction between agents and devices generating sounds, video and 3D graphics.

Next section talks about the concepts about the notion of the self behind the artistic view of the SELFHOOD installation. Following, the SELFHOOD installation and their technical aspects are described. Then, aspects concerning artificial conciousness are approached. Finally, the conclusions are presented.

2. CONCEPTS

Many are the attempts of describing the self. Strawson and Prescott [10, 11, 12] enrolls some of them: I know that I exist; the question is, what is this 'I' that I know? [13]. The soul,

so far as we can conceive it, is nothing but a system or train of different perceptions [14]. What was I before I came to self-consciousness? … I did not exist at all, for I was not an I. The I exists only insofar as it is conscious of itself. ... The self posits itself, and by virtue of this mere self assertion it exists [15]. The 'Self' ..., when carefully examined, is found to consist mainly of ... peculiar motions in the head or between the head and throat [16, 17]. The ego continuously constitutes itself as existing [18]. Any fixed categorization of the Self is a big goof [19]. The self which is reflexively referred to is synthesized in that very act of reflexive self-reference [20]. The self ... is a mythical entity. ... It is a philosophical muddle to allow the space which differentiates 'my self' from 'myself' to generate the illusion of a mysterious entity distinct from ... the human being [21]. A self ... is ... an abstraction ..., [a] Center of Narrative Gravity [22].

Ibsen [23] too, in his famous play Peer Gynte, plays with the concept of self: "Begriffinfeldt comes in with Peer, locks the keepers in a cage, and tells Peer that rea-son died the previous night. Peer realizes that Begriffinfeldt is insane, and that he's now locked in an insane asylum. Begriffinfeldt calls for other inmates of the asylum to come out and introduces Peer as their emperor. Peer says there's a misunderstanding and suggests that the inmates of the asylum are far from being themselves; they are beside themselves. Begriffinfeldt happily tells him that the inmates are more themselves than anybody, and that Peer is their perfect emperor. … Begriffinfeldt crowns him with a crown of straw and pronounces him emperor of the self".

Returning to Descartes [13], what is this 'I' that I know? What constitutes a self [21]? All the semiotic signs that compose our knowledge were defined along the time by successive generations, so that people could communicate, define concepts, elaborate, construct. There are common, universal signs and concepts; there are others that are specific, differentiated, associated with a culture or a region, p. ex. Is the set of signs associated with the knowledge of each person "his/her self"? Removing the signs (concepts, habits, beliefs, strategies, etc.), does the self cease to exist? But if the signs were elaborated through generations, how to define individuality; perhaps the individual combination of signs? And how do we modify the others, and are modified by them?

Aiming to instigate a reflection on the self through a practical and interactive experience, the SELFHOOD installation was conceived. A representation of each participant is created in a form of a cloud of points and sounds, suggesting their selves. The dynamics of visitors' movement is sonified in such way that colors and sound textures are fused in a surround hexaphonic sound diffusion system. The generative sound machine of the installation is the CromaCrono≈ system that operates with a small set of compositional operations making possible real time control.

3. INTERACTIVITY AND CREATIVITY

For over fifty years there has been a re-thinking of the nature of cognition. Instead of emphasizing formal operations on abstract symbols, this new approach focuses attention on the fact that most real-world thinking occurs in very particular (and often very complex) environments, is employed for very practical ends, and exploits the possibility of interaction with and manipulation of external props. It thereby foregrounds the fact that cognition is a highly embodied or situated activity and suggests that thinking beings ought therefore be considered first and foremost as acting beings.

This shift in focus from Descartes' "thinking thing", and the picture of human being and subjectivity it suggests, to a more Heideggerian approach to being in the world, in which agency and interactive coping occupy center stage, is an extremely important development, the implications of which are only just beginning to be comprehended [24]. Heidegger, and his successors such as Gadamer and Ricoeur [25], held that situations where a system, tool or symbol becomes present–at–hand may be crucial to the individual's learning and to the differences between individuals. The ongoing 'feedback loop' of interpretation and understanding integrates these two modes, and affords variation in people's understanding as well as consistency in their behaviour.

In this way, creativity can be considered as the variation of an individual's subjective understanding from his or her prior understanding and from others'. The individual may then be very conscious of his or her own activity, rationalising it and very aware of it, i.e. the system, tool or symbol is present–at–hand. With experience of its use, however, it may become understood and familiar, i.e. more ready–to–hand and embodied.

Similarly, as two people perceive one another's use, with each interpreting and reacting to each other, they can achieve intersubjective consistency of behaviour. A use or activity that is new and present–at–hand for one of them can thus become learned and ready–to–hand for both. The circular process of interpretation, whereby perception and activity are influenced by understanding, but also feeding onto and changing understanding, thus relies on the interplay between ready–to–hand and present–at–hand interpretation. Dourish [26] suggests that people's interaction with systems is a fundamentally embodied phenomenon (p. 145).

Our research is anchored in a multimodal laboratory where we study human cognition and music creativity supported by digital interfaces, computer graphics and motion capture. It is an interactive environment with a large 3D screen and a six channel sound diffusion system. The key points discussed here are: investigation of new paradigms on human cognition mediated by interactive technologies that attempt to describe how the creativity operates [27, 28, 29, 30]; development of new technologies that incorporate interactive techniques based on the integration of multimodal signals [31] the creation of new art forms based on interactive narratives, digital music instruments, virtual soundscapes and synthetic visualization [9]. These systems can be evaluated from the perspective of the interaction between agents and devices generating sounds, video and 3D graphics.

In the first setup of the SELFHOOD installation (Figure 1), a vision system identifies the body of the visitors and creates a visual representation of each one, suggesting their selves. Three projectors, a Kinect 2 sensor, a computer and loud speakers were used in the first setup.

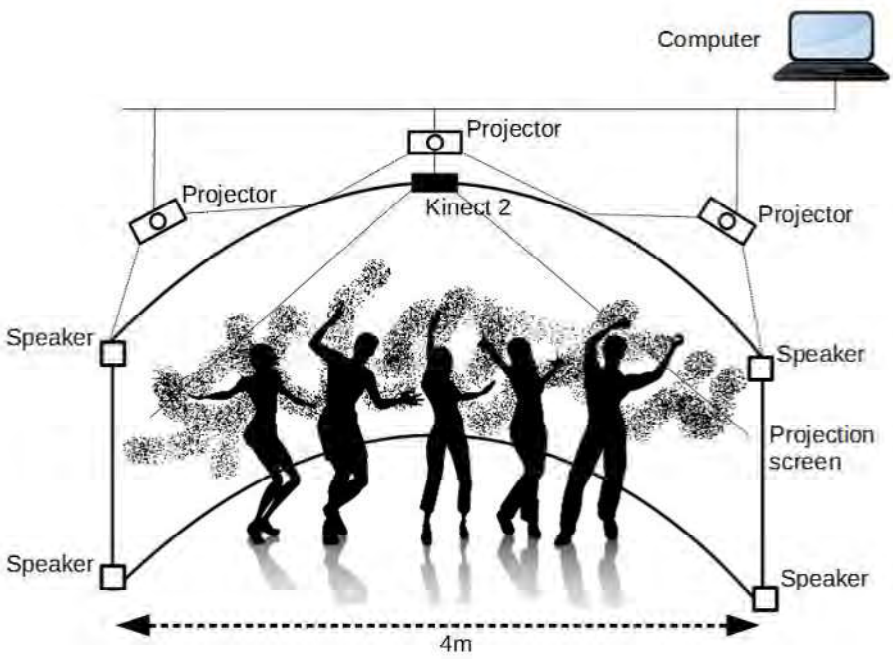

Figure 1. Layout of the SELFHOOD installation, with three projectors, a kinect 2 sensor, a computer and loud speakers.

Since the self is still something misunderstood, a cloud of points and a sound drone were first used to represent it. Different colors are assigned to different clouds, which are displayed on a curved screen, following the movement of their owners.

4. THE SELFHOOD INSTALLATION

SELFHOOD sound and image generative processes dialogues also with the mathematical notion of dynamic system. We conceive that man-machine interaction can be described by concepts such as stability, instability, and disturbance and it is capable of producing self-organized behaviour when implicit and explicit interactions are coupled. Moreover, we started your model searching for a simulation of a dynamic system to be the core of the machine counterpart behaviour. Thus, we chose the Boids algorithm to be our intrinsic machine generative engine, for its characteristic of simulating in computer software the collective organization of bird flocking. Created by Reynolds [8], the Boids algorithm is a computer model of a dynamic system that simulates bird flocking controlled by a set of simple rules to determine their flights, collective organization and trajectories in space. Procedural models simulating complex natural phenomenon can aid scientific understanding of them [8, 32]. Further, the computer simulations help to recreate the phenomenon and control it and they can be also used in computer animation, games and the arts. Figure 2 depicts the diagram installation.

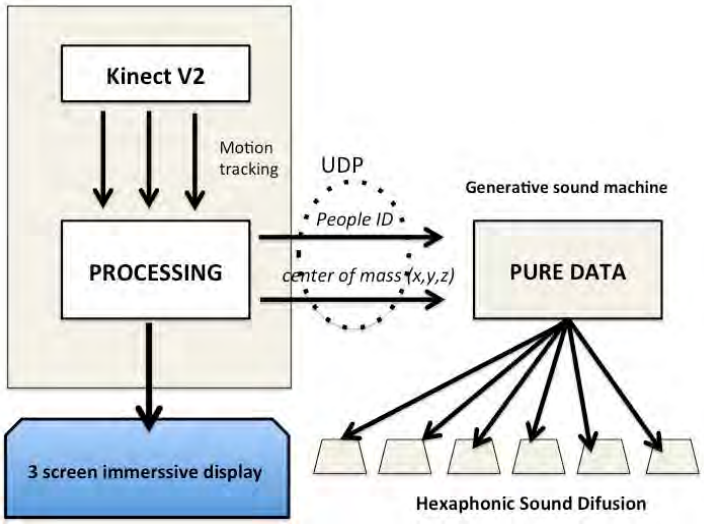

Figure 2: Diagram of the SELHOOD implementation describing the visualization in PROCESSING and sound generative machine in PURE DATA.

4.1 The Visual Particle System

In order to create a visual representation associated with each participant, three main components were applied: a physical sensor capable of tracking the user's body, a programming environment/language focused on visual effects and a screen.

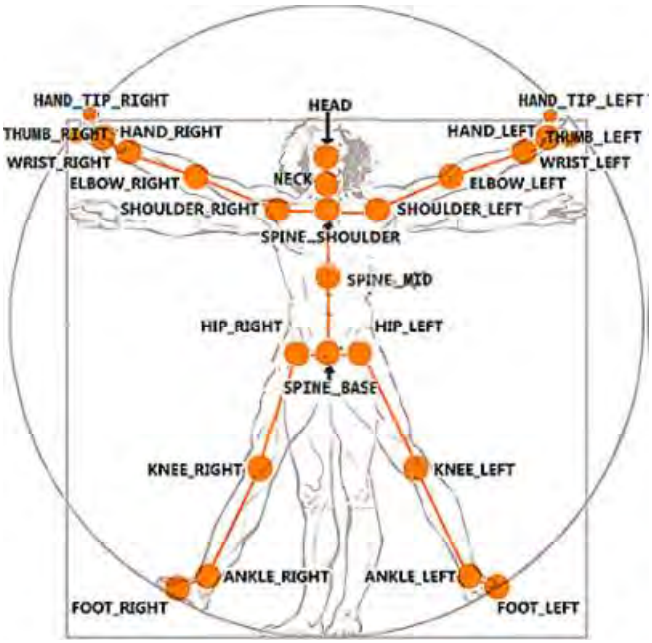

Figure 3: The skeleton that is made up of the joint types relative to the human body

The first component is the Microsoft Kinect V2 sensor [33], which utilizes a set of two sensors (a colored camera and an infrared sensor) to track up to 6 bodies (at 30 Hz) from 0,5 to 4,5 meters away. Each body is represented as a set of 25 joints with real space coordinates relative to the sensor's position, depicted in Figure 3, and a color id. This id is used to differentiate one body from another. The sensor data can be acquired through the Microsoft API or through distributed libraries. The KinectPV2 library was used to allow the

communication between the Processing environment [27] and the Kinect V2 sensor. With this library it is possible to detect the bodies and their joints. It is also possible to get the visual input from the camera and the infrared sensor.

By using these tools, the SELFHOOD environment creates a representation of its users in a form of a set of particles systems. Each body contains 25 particles emitters located in each one of its joints. These emitters create colored particles that match the color of the id of their bodies. Figure 4 shows the representation of the selves through particle systems. The particles are created with a random initial velocity at a random direction that is affected by a gravitational force present in the simulation. Depending on the distances between bodies, their self representations interfere with each other by sharing and acquiring particles of different colours. The closer the participants are, the more particles they share; the particles of each self representation have different colours

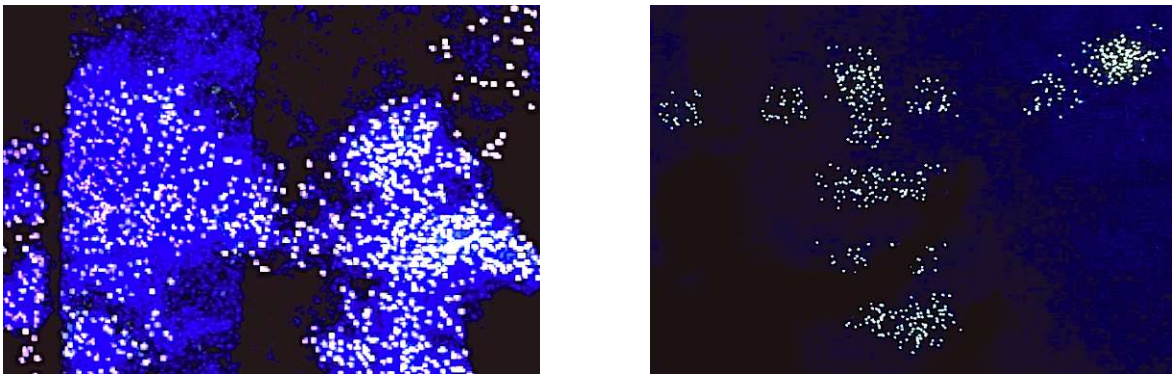

Figure 4: Self representation in the SELFHOOD installation.

4.2 Sound Generative Process

The SELFHOOD generative sound machine, CromaCrono≈ [35], was developed in Pure Data [36] and synthesizes sounds in real time by four different standard synthesis methods: additive synthesis, FM, wave-shaping, and Karplus and Strong algorithm [37]. Further, a Granular Synthesis engine post-process is applied to the initial synthetized signal. The whole sonification system works as a unified generative process (see Figure 4). Boids trajectories [8] are used to control the display of hundreds of primitive geometric shapes that vary in shape, colour, speed and dispersion in space. All these variations produce the audio-visual texture which is coupled with generative rules for controlling sounds and interactions with the visitors.

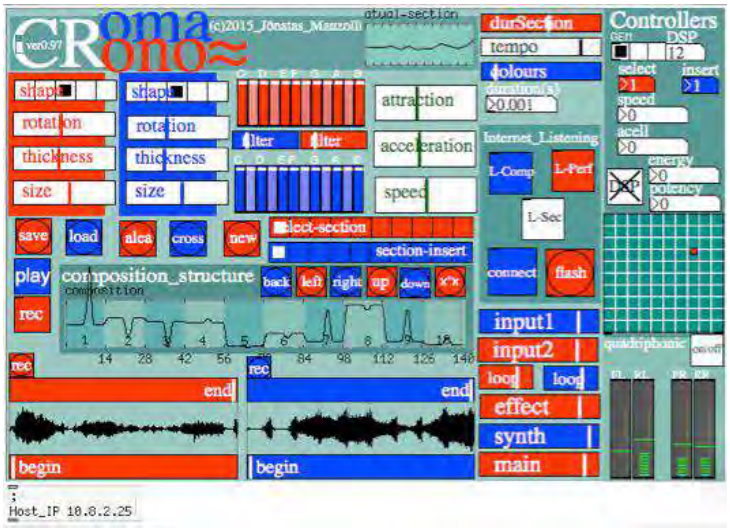

Figure 5. GUI of CromaCrono≈ showing all the integrated control parameters of the system (top), and in detail the "Composition Curve".

The Boids algorithm [8] is used to control several parallel processes generating an animated audio-visual in real time. Boids trajectories are hooked to the articulations of people's body as they are interacting with SELFHOOD. As showed in Figure 1, the main control function of the system is linked to the 3D-coordinates from each visitor (i.e. up to six person interacting with the system). Six lists (person0, person1…, person6) encapsulate all the data from each person's skeleton, that is received from the Kinect V2 using a UDP message. Here, the sub-patch "coordhood" maps the 3D coordinates into sound synthesis control parameters (Figure 5, left). The global variable "number-of-people" controls the speed of the grains and the Granular synthesizer (Figure 5, right). A performance video demonstration can be found in the following link: https://youtu.be/9F-s3Cafhc4 [38].

4.3 Experiments around the SELFHOOD

The first venture in the SELFHOOD installation was taken along by the authors themselves, who had artistic and musical background, and by the developer, a student with high technical skill but unfamiliar with artistic-interactive environments.

The authors called for first experiment the administrative staff of the nucleus. These people knew about artistic and interactive environments, but as distant spectators. They walked around the room, seemingly unconfortable.

Next, a researcher from the nucleus, an artist, music and performer, was invited to try out the installation, already very familiar with such environments. She explored the environment, experiencing it with large and restrained, slow and fast gestures. The student-developer who was observing the performance understood then to which it was applied his work, and happened to accompany the researcher-performer with similar gestures. Subsequently, when performing technical tests in the environment, he began to perform some choreography.

Later, an experienced ballet teacher from the university was invited to try out the installation, but she was not familiar with interactive environments. It was a surprise to note that despite all her artistic and didactic experience, the environment was revealed to her

as an absolute and pleasant novelty, which she experienced long and pleasantly. In the end, she said: This is really cool!

Following, music students were invited to experience the environment. The students who witnessed the full operation of the interactive environment were very intrigued about the project. It was possible to perceive their curiosity about how the system behaved as a whole. They remained entertained along all the time they stayed in the studio, performing movements in front of the Kinect sensor, in order to find out what a particular gesture would result, be it in the sound produced, or in the characteristics extracted from it. For example, they explored the system's ability to detect not only the positions relative to each of their bodies, but also the way it recognized details, such as the state in which their hands were. Among the reactions observed, the most recurring were those of surprise, as well as fun.

According to the student-developer who followed all the experiments, his experience in the installation was a unique and very significant process. It was interesting not only to be able to work as a developer, but also to study the interaction of the participants with the environment and each other, making possible to learn about the technical as well as the artistic aspects of the project.

5. CAN AN INSTALLATION HAVE A *SELF*?

According to Prescott [11]; human episodic and autobiographical or event memory can be considered as an attractor network operating in a latent variable space whose dimensions encode salient characteristics of the physical and social world. To be effective, event memory should have at least the following properties: compression; pattern completion and pattern separation.

The operation of the perceptual systems that provide input to event memory can be analogised to a deep learning process that identifies psychologically meaningful latent variable descriptors. Instantaneous memories then corresponds to points in latent variable space and episodic memories to trajectories through space. In a recall, voluntary episodic memory corresponds to a situation where event memory is primed with cues corresponding to a specific past event to be recalled. And since event memory is a generative process – hypotheses – it is possible, through appropriate choice of the initial state, to initiate trajectories that do not correspond to actual past events, but to imagined episodes.

Event memory can be employed to imagine or predict scenarios that might unfold in the future. The construction of the self arises out of the ability to have internal processes that are attached from the here and now.

Till the moment, the SELFHOOD installation is only reactive. Since there are studies today about artificial consciousness, should it be possible the installation to have a self? In his seminar about artificial consciousness, Gudwin presents several architectures aiming to engender consciousness in an artificial system; Figure 6 depicts the CogSys architecture [39]. Specific system components are enviewed for the processing of attention, perception, sensing, emotion, learning, language, conciousness, imagination and planing, behavior and motor, as well as episodic memory, perceptual memory, sensory memory, working memory, semantic memory, procedural memory, motor memory, and an episodic buffer, all of this to bring conciousness about!

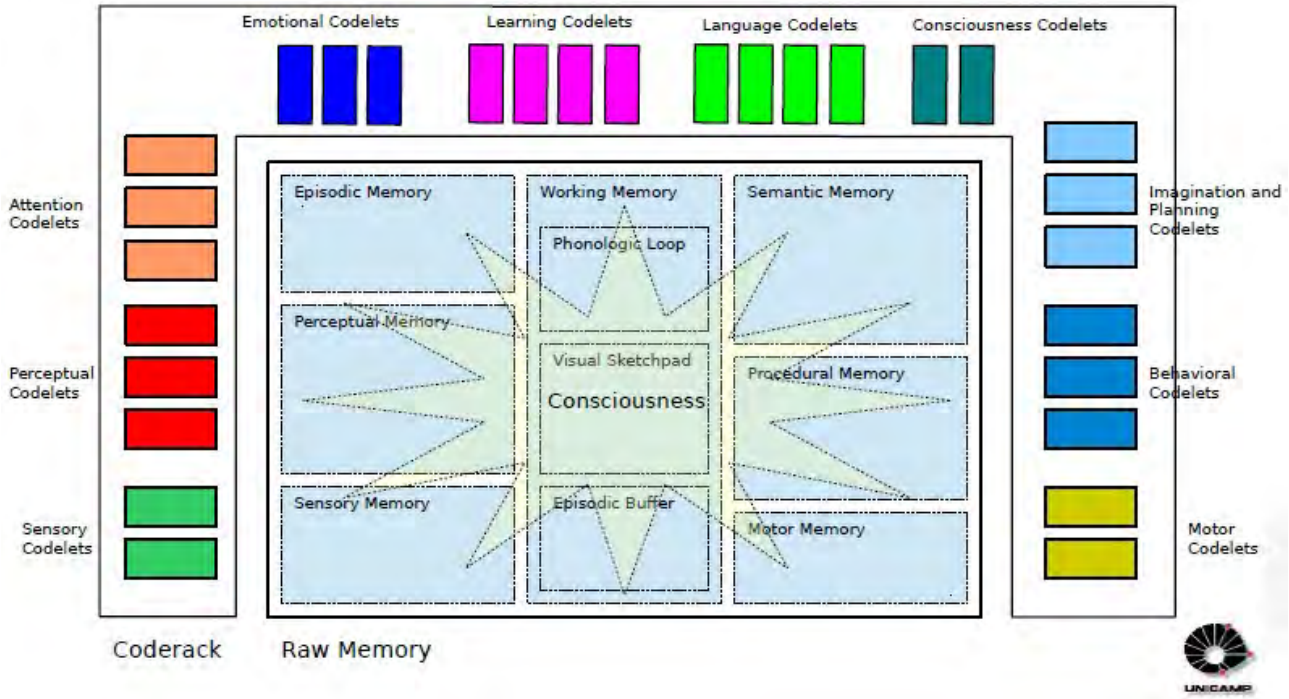

Figure 6. The CogSys architecture.

Is it enough? In the science fiction short story "The Last Question", Isaac Asimov [40] went much further:

Someone had once told Jerrodd that the "ac" at the end of "Microvac" stood for "analog computer" in ancient English, but he was on the edge of forgetting even that.

Man's last mind fused and only AC existed -- and that in hyperspace.

Matter and energy had ended and with it, space and time. Even AC existed only for the sake of the one last question that it had never answered from the time a half-drunken computer ten trillion years before had asked the question of a computer that was to AC far less than was a man to Man.

All other questions had been answered, and until this last question was answered also, AC might not release his consciousness.

All collected data had come to a final end. Nothing was left to be collected.

But all collected data had yet to be completely correlated and put together in all possible relationships.

A timeless interval was spent in doing that.

And it came to pass that AC learned how to reverse the direction of entropy.

6. NEXT STEPS

By the moment, the SELFHOOD installation is only reactive but it is being re-designed to *surprise*. After some experimentation, reactively responding to the interaction, it will surprise, changing the visual representation and sound responses, and its behavior from responsive to pro-active. As Dourish [26] emphasises, many of the assumptions as to what should be supported and what should be inhibited are hidden or implicit in the craft of

system design, which reflects the way that it is not just the external devices for input and output devices that affect a person's use and interpretation of a computer system. The internal digital components are designed to support some activities and interpretations while inhibiting others, exhorting designers to be more aware of the communicative significance of their systems. Moreover, *meaning arises on multiple levels* as use of a system involves acting on it and eventually interacting with other people through it.

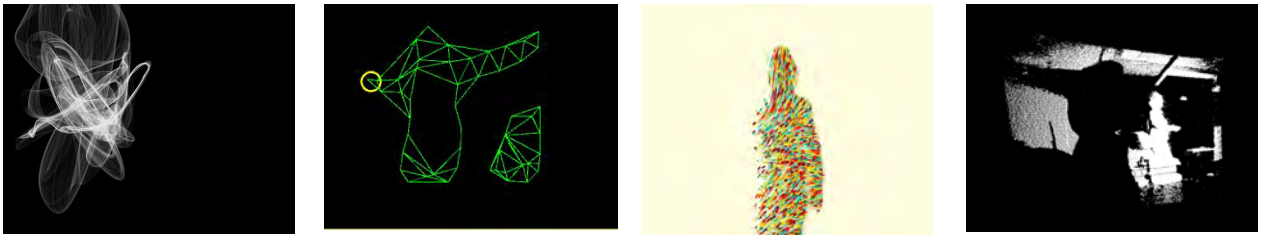

Figure 7. New visual representations that are being developed for the SELFHOOD

Two other principles reaffirm to software engineers their unavoidably limited influence on systems' use and interpretation: users, not designers, create and communicate meaning and users, not designers, manage coupling. The latter refers to the referential coupling between a system's internal representations and the context of use.

CONCLUSION

In order to instigate a reflection on the self through a practical and interactive experience, the SELFHOOD installation was conceived. In the SELFHOOD installation a representation of each participant is created in a form of a set of particle systems, in different colours. Different visitors interact with each other by their distances, sharing particles. The closer they are, the more particles they share, suggesting how they influence "each other selves". SELFHOOD generative sound machine was implemented with a system for producing digitally synthesized sounds in real time, called CromaCrono≈. The concept behind the system searches for an expansion of the notion of sound texture, from physical and tactile sensations to the cloud of events that are perceived surrounding the subject. Then, texture is conceived as a mass with a density of interwoven processes, which increases as muchthe processes are interconnected.

This research is anchored in a multimodal laboratory where we study human cognition and creativity supported by digital interfaces, computer graphics and motion capture. These systems can be evaluated from the perspective of the interaction between agents and devices generating sounds, video and 3D graphics. The assumption is that the interaction of an organism/agent or group of agents within an immersive space, using various interactive devices, indicates how these processes affect their behaviour and the meaning that is constructed by them. The ongoing 'feedback loop' of interpretation and understanding integrates these two modes, and affords variation in people's understanding as well as consistency in their behaviour.

The approach presented here reinforces that the notion of self can be explored by virtual and/or physical sources of stimulation governed by a number of principles that underlie human experience, creativity and discovery.

Acknowledgements

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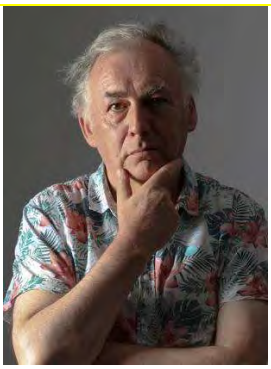

THE PORTRAIT MACHINE
(Paper and/or Artwork/ Live Performance)

Topic: Portaiture, Generative Art, Psychology

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Abstract
Some portraits just 'work' and some are lifeless or flat. The Portrait Machine is an attempt to find out why this is, and whether artificial intelligence can influence the effectiveness of a generated portrait. Volunteer sitters (conference attendees) are photographed, and then the images are mixed and detourned by a generative art programme to produce an image which is given to the sitter.
The system also analyses visual and behavioural data about the sitter and attempts to situate her or him within the 'big five' personality scales, which are commonly used by researchers and psychologist to make basic character assessments. Does this make the resulting portrait more or less effective?



The system is both an experiment and an attempt to create art. Examples of the results are shown here.
I should like to display a poster explaining the system, and also to have a table and a flip chart available nearby. The system consists otherwise of my laptop and can be set up in a few minutes. I would like to set it up and be available during conference refreshment periods, when I can make portraits of anyone who wishes to take part. Every volunteer will receive one or more of these images of themselves, including copyright and full ownership of an original graphical art work (in the form of a .png file).
I would also be happy to give a talk about the principles behind the system. (See separate submission).

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Key words: Portaiture, Generative Art, Psychology

The Portrait Machine

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Premise

This project is a two-way experiment. Firstly, it explores how a generative art system can relate to people; and secondly, it explores how people in turn relate to the system and to digital art works in general.

It is often remarked that some portraits 'bring the sitter to life', and others are lifeless or flat. The Portrait Machine is an attempt to find out why this is, and whether artificial intelligence can influence the effectiveness of a generated portrait. Volunteer sitters (conference attendees) are photographed, and then the images are mixed and detourned by a generative art programme, to produce an image which is given to the sitter.

The system analyses visual and behavioural data it has observed about the sitter, and attempts to situate the sitter within the 'big five' personality scales, which are commonly used by researchers and psychologists to make basic character assessments. The image is then generated using these scales to influence the generative process. Does this make the resulting portrait more or less effective? Limited evidence suggests that it may do so.

The system is also an experiment and a performance. I will make portraits of anyone who wishes to take part. Every volunteer will receive one or more of these images of themselves, including copyright and full ownership of an original graphical art work (in the form of a .png file), if they wish to do so. Limited evidence suggests that those who enjoy digital art do not think primarily in terms of legal ownership or financial value.

1. Introduction

This paper and demonstration will be a small-scale social experiment, to see how conference attendees respond to direct involvement with a generative artistic process, and how sensitively the process can respond to them.

Throughout the GA2017 conference, for example during refreshment breaks, attendees will be invited to have portraits generated for them, pavement-artist style, but by my laptop.

These will combine images, live feeds, and random elements, into a composite 'interpretative' portrait in their environment at an instant in time and space.

Several portraits can be generated for each sitter, who can select one, which will be given to her or him, in the form of .html or .png code emailed to them, or downloaded to a memory stick the sitter supplies.

The objective of this process is to examine the ways in which a machine can relate to people, and people to a machine and its products.

2. When is a portrait 'successful'?

Portraits have been a staple of art for a long time, though traditional artists lost their monopoly after the invention of photography. For a human to paint or draw a good portrait demands a high degree of skill. Yet it is quite difficult to evaluate whether a portrait is 'good' or not.

Kant held that art was disinterested – that we have no desire to make use of the art work to a further end, but only wish to contemplate it. [1] Portraits are perhaps an exception to this view, since they serve not only as mementos of the sitter, but also as explanations or impressions of their deeper character. Photography allows us to make more or less accurate records of the shape of a face, but it seems generally to be agreed that not only painted but also photographic portraits differ in how well they 'explain' or elucidate the sitter.

Classical views of art make much of a painter's ability to 'interpret', rather than just represent, the sitter. Henry James spoke of good portraits having "the quality in light of which the artist sees deep into his subject, undergoes it, absorbs it, becomes patient with it, and almost reverent, and, in short, enlarges and humanizes the technical problem". [2]

The really good portrait, in other words, might be said to combine an accurate record of the shape of a face, a set of psychological insights, and the 'disinterested' aesthetic appeal of a beautiful object.

Photography is generally thought to produce an accurate record, though of course this can be distorted in many ways.

But can an artificial system produce psychological insights? If a real artist were painting the sitter, he or she would rely on a brief acquaintance, making judgements based on the sitter's appearance, manner, conversation, and so on. These judgements would then have an impact on the way the artist painted the portrait. The Portrait Machine attempts to mimic some of the observations that the artist could make during a short acquaintance with the sitter.

Whether the system can produce objects with 'aesthetic appeal' is a difficult question, which is not covered by this paper. There is much controversy over 'beauty', and whether this is an absolute quality or simply a set of social conventions. Perhaps it is a personal decision whether some of the images produced 'look good' or not. Two examples produced by The Portrait Machine are offered, so the reader can decide.

3. Gathering data about people: the 'Big Five' traits

When someone volunteers to act as a sitter, three photographs are taken, using a webcam. Two of these may be used in the portrait, the third, of the sitter's clothing, is analysed by the system. The system also observes the sitter's behaviour both during the sitting process, and in a simple task. Visual and behavioural measures are made from these observations.

The analysis is structured around the 'big five' personality traits. According to Gosling et al, "The Big-Five framework enjoys considerable support and has become the most widely used and extensively researched model of personality." [2]

The 'big five' scales have been summed up [3] as:

E - EXTRAVERSION, ENERGY, ENTHUSIASM (I)

A - AGREEABLENESS, ALTRUISM, AFFECTION (II)

C - CONSCIENTIOUSNESS, CONTROL, CONSTRAINT (III)

N - NEUROTICISM, NEGATIVE AFFECTIVITY, NERVOUSNESS (IV)

O - OPENNESS, ORIGINALITY, OPEN-MINDEDNESS (V)

Suitably re-ordered, they offer the mnemonic OCEAN. Psychologists see them as the most significant characteristics, and measure the extent to which any individual subjects exhibits each characteristic. Measurement is normally done using questionnaires or interviews.

The core of The Portrait Machine is an attempt to use its own measurements to place the sitter on the OCEAN scales.

As an example, the sitter is asked to write 'three sentences', in three boxes on a form. (No further explanation is given.) When the sitter presses 'enter' on the form, the system looks only at:

5. the number of words and characters in each box
6. the timing with which the sitter writes in the boxes (eg do they go back and correct themselves? Do they take longer over one box than the others?)

The system scores the complexity or simplicity of the sentences (long sentences with long words, or short sentences?). It also looks at the comparative lengths (is one sentence longer than the others, or are they all about the same). It also looks at the fluency with which they entered the sentences, whether they hesitated or not, and whether they went back to make corrections. The actual 'content' of the sentences, or indeed whether they are grammatically sentences or not, is not noticed.

As a second example, the photograph of the sitter's clothing is analysed to identify

- colourfulness (eg how many colours are used)
- saturation and brightness of colours

Once these and other 'scores' have been built up, they are translated into assumptions on the 'big five' personality scores, using a matrix. This matrix is to some extent arbitrary, but in many cases the links between observations and the Big Five types seem justifiable. For instance, someone who goes back and corrects 'sentences' scores more highly on 'conscientiousness', although a sitter who makes a large number of corrections scores lower on 'emotional stability'. Someone with brightly coloured clothing is judged more likely to be extraverted, and so on.

This is not meant as a serious psychological evaluation. It depends on many assumptions. However, from it the system makes a guided but random selection of colours, layout, background, other images and so on, designed to express or embody this mix of personality traits.

3. How does the system turn analysis into an image?

The Big Five 'scores' are used to provide a set of instructions to the drawing software, and three images generated. The generation process involves

1. overall composition of the image. The system chooses from several 'wire frame' templates, controlling the complexity, symmetry and balance of the final image.
2. selecting none or more from a library of background images.
3. blending the selected images with one or both of the webcam images of the sitter, which are placed in the selected template.

All these decisions are taken by a set of algorithms, which attempt to match OCEAN characteristics to the image being generated: for example,

8. how many images are to be used? (Conscientiousness, constraint/ openness, originality/ energy, enthusiasm,).
9. How balanced should these images be? (Conscientiousness, control/ neuroticism nervousness).
10. Should the colours be bright or dull? (extraversion, energy/ neuroticism, nervousness/ openness, originality)?

The matrix which controls this process is in a sense the heart of the system. It is partly controlled by observations, partly by random selections within categories selected after observations, and partly on a totally random basis.

4. How do people react to the system?

The other half of this experiment is to see how humans react to the machine.

The first observable variable is whether individuals allow themselves to be portrait subjects at all. At conferences such as GA2017 one would expect a degree of openness towards a generative art work, but sometimes people have other calls on their time.

The process takes two or three minutes, which allows time for a short semi- structured interview. This second set of inputs is designed to elicit the value sitters place on digital art. Have they been to recent exhibitions? Do they own digital art works? How familiar are they with the field?

The third variable comes when the system generates three portraits, and the sitter is invited to choose one or more that most 'captures' his or her personality. Of each group of three images, two are based on a psychological assessment, but the third is based on a deliberately different assessment. (The 'wrong' score for that sitter.)

My theoretical assumption is that the more one or two images stand out from the others, the more likely it will be that the system is demonstrating an effect. Of my small sample in early experiments, about half asked for all three, but the remainder showed a clear preference for one or two of the others and a clear rejection of the third.

The selected images are then emailed to the sitter. As a final variable, the sitter is offered a 'certificate of ownership' of the image as an original and unique art work. (Should I ever become a 'hot' artist, it might command high prices!). This is designed to test the extent to which sitters place monetary value on digital or generative art works. I am glad to report

that so far most sitters have initially been puzzled at the concept of having 'ownership', let alone sole ownership, of a digital art work. Few actually 'possessed' any such works, except those they had made themselves, and few thought of these works as having any monetary value.

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IMPERFECTION IN FABRICATION: SEEKING AUTHENTICITY THROUGH DISSOLVENT FORMING

(Paper)

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Abstract

This study aims to investigate the concept of authenticity in mass customization through accentuating situations of imperfection in digital fabrication processes. The motivation of the study was derived from whether it might be possible to explore new methods which can be considered as combination of craft, mass production and craftsmanship in digital age. In other words, when using digital fabrication tools, how can we differentiate the final product specifically to the designer, even if the work, algorithm and design flow is the same? In a broader sense, this study can be considered as an attempt to seek improvisational values in the context of hand and material encounter in digital fabrication.

This paper introduces a methodology called Dissolvent Forming and its implementation. Dissolvent Forming is an experimental surface finishing work in which polystyrene material is shaped with a chemical reaction unlike the traditional physical subtraction methods. Dissolvent Forming covers three components: programming code, tools and actions. Processing environment was used to generate a graphical user interface. The tool component includes design of a chemical end-effector that can be used with industrial robotic arms. In the scope this paper, a small scale prototype of end-effector which is compatible with Arduino Braccio robotic arm was developed and tested. The action component consists of 2D drawing; the translation of the drawing into robotic arm through programming environment; subtraction of polystyrene material by using end-effector and chemicals through robotic arm.

To sum up, it is aimed to create an experimental design and fabrication flow to provide uniqueness in mass customization by programming and simulating the material (polystyrene) behaviour. The expected target in the project is to create a complete software-production package. The drawing, design and material forming processes are executed concurrently. The selected surface finishing outcomes produced in user tests will be introduced and discussed.

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Key words: mass customization, digital fabrication, craftsmanship, dissolvent forming, digital materiality.

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Imperfection in Fabrication: Seeking Authenticity Through Dissolvent Forming

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Abstract

This paper introduces a methodology called 'Dissolvent Forming' and its implementation in the context of digital fabrication. Dissolvent Forming Methodology (DSM) is an experimental surface finishing work in which polystyrene material is shaped with a chemical reaction unlike the traditional physical subtraction methods. DSM covers three components: programming code, tools and actions. Processing environment is used to generate a graphical user interface for controlling the variables. The tool component includes design of a chemical end-effector that can be used with industrial robotic arms. Moreover, DSM covers three layers: Conceptual framework, simulation model and fabrication model. In the scope this paper, a small scale prototype of end-effector which is compatible with Arduino Braccio robotic arm was developed and tested. The action component consists of 2D drawing; the translation of the drawing into robotic arm through programming environment; subtraction of polystyrene material by using end-effector and chemicals through robotic arm.

This study can be considered as an attempt to create an experimental design and fabrication flow to provide uniqueness in mass customization through programming and simulating the material (polystyrene) behaviour. In the proposed and examined workflow, the actions of drawing, design and material forming were executed concurrently. In the scope of the paper, a series selected surface finishing outcomes were examined in user tests and the findings derived from the user test were presented.

1. Introduction

The advances in digital design and fabrication technologies have been transforming the relationship between designers and design models. The way designers engage with the notion of 'form' has been diversified and has become more complex. In the conceptual ground, there has been a shift from form to formation, geometry to the relations resulting with geometry, typology to topology[1], object to field[2]. Beyond the conventional physical models or three dimensional representation in computer environment, various models

such as performative, generative, evolutionary[3], parametric, mathematical, meta models have become a part of understanding, manipulating and developing design models. Today, the integration of different tools, methods and approaches became more crucial to coordinate and handle complexity of the digital production processes. On the other hand, new skillsets are required to grasp the “disjointed, complex and often voxellated” [4] nature of design data.

In Aish’s words, “Tools require complementary skills to be effectively used”. Aish et al. [5] underlines the necessity of cognitive skills to expand the affordances of the tools. Cognitive skills have potential to become complementary for exploring new potentialities of form, geometry, material and computation. In this sense, getting familiar with the basics of computer programming, logical operations, data types, loops and conditional expressions might be helpful for designers to gain a better understanding of how digital design and fabrication tools might perform. However, there is a delicate line between being a passive user of existing tools and actively participating in the design, development and future of tools. At this point, there is a risk to be trapped in the given frame of digital interfaces and not generating out of the box ideas. As a result, either the linear logic of the computer programming or strict workflow operations of digital tools might dominate the design alternatives through decreasing the diversity. Similar algorithms, operations and assumptions might lead similar outcomes to some extent. Moreover, widespread sharing of open source code, samples, tutorials may result with morphological similarities in designs made through digital means. Therefore, a crisis of authenticity occurs. Picon [6] conceptualizes one of the dimensions of this tension as transition from authorship to ownership . Another dimension of the authenticity crisis is concerned with whether the design environment allows to make mistakes and encounter emergent situations. These concerns in mind, this study focuses on the new and creative use of conventional digital fabrication tools, as well as the search for authenticity that carries the imprint of the designer on repeatable and iterative production cycles..

Regarding the authenticity problem in numerical manufacturing processes, we argue that the concepts of ‘imperfection’, ‘error’, ‘human subjectivity’, ’information loss during translation’ have potential to provide opportunity to allow exploration of emergent possibilities in design process. Zoran [7] indicates the field of creativity embedded between the computational control over digital design and fabrication processes and imperfection in his article titled “A Manifest for Digital Imperfection” [7] underlying also the problem of style, identity and authorship in digital design and fabrication processes. Moreover, Krapp[8] highlights the insightful potentialities of error culture, the concepts of noise and glitch in a broader perspective for all productions in/through digital media.

This study aims to investigate the concept of authenticity in mass customization through accentuating situations of imperfection in digital fabrication processes. The motivation of the study was derived from whether it might be possible to explore new methods which can be considered as combination of craft, mass production and craftsmanship in digital age. In other words, when using digital fabrication tools, how can we differentiate the final product specifically to the designer, even if the work, algorithm and design flow is the same? In a broader sense, this study can be considered as an attempt to seek improvisational values in the context of hand and material encounter in digital fabrication.

2. Authenticity in Numerical Manufacturing

"Abstract and concrete have, for instance, become seamlessly linked one to another. Uniqueness and variation can now be reconciled" [6]

Digital design and fabrication technologies led to the re-emergence of originality and diversification debates in design. Since the 1990s, with the exponentially growing use of parametric design approaches, it has become possible to control the digital design model directly from the initial assumptions to the final production. In the context of numerical manufacturing technology, the search for authenticity has different foundations, including but not limited to material (matter), tool, operations, parameters and flow of the algorithms. The reflection of digital transformation in architecture was outlined by Corser as:

"Starting in the mid-1990s, however, three powerful forces began to emerge that are starting to transform significant aspects of both design practice and project delivery: intelligent, feature-based parametric modelling; building information modelling (BIM); and mass-customization" [9].

Remarkable number of pioneering applications in this area have been reflected in architecture practice and smaller scale boutique experiments as well. Relatedly, the search for the 'non-standard' has become more apparent in repetitive and automated processes. For example in the facade of Eberswalde Technical School Library which was designed by Herzog & de Meuron in 1997; materiality and pictorial character, representation and abstraction, repetition and differentiation come together [10]. The differentiation in Eberswalde Technical School Library sample was achieved through the changes in texture, color, pattern and topologies [10]. Beyond ornamentation, Acoustic Barrier project located in Utrecht Leidsche Rijn in the Netherlands designed by ONL (Oosterhuis and Lenard) can be considered as one of the pioneering works which brought new understandings to the CNC based manufacturing techniques [11]. The design information was decoded through parameters, logical operations and relations and the structure of the Acusting Barrier was generated by scripts. In that sense, it can be considered as an early sample of 'informed design' technique, rule based customization or in other words information driven design process [11]. In addition to these, as a notable example for CNC-milled foam finishing, Ruy Klein's Klex1 project [10], and as demonstrating digital craftsman values in the surface finishings De Young Museum which built in 2005 [10, 12] can be listed.

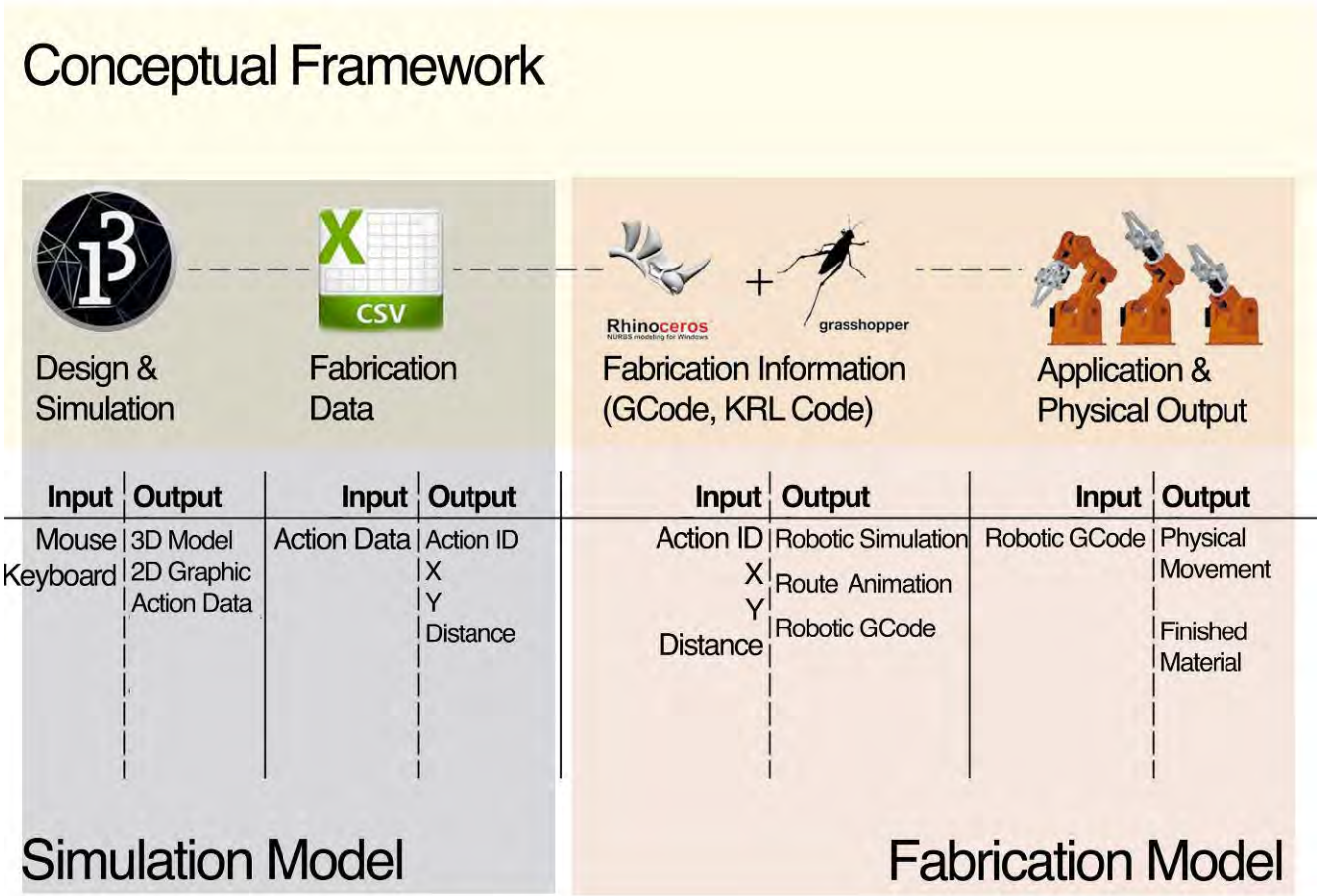
Apart from reflections of the digital fabrication on architectural practices, search for aesthetic on the interdisciplinary platform are progressing in various focuses and drivers such as material, workflow/algorithm and interaction [13-17]. The common denominator of the out-of-the box digital fabrication studies concerning authenticity is that the design process itself is designed in a holistic manner. There has been a need for integrating different technologies, medium, data, actions and operations in relation with the requirements of each design process. Therefore, the action of translating the design information from one medium to another, from one type of representation to another accelerates the possibility of encountering emergent results and also loss of information to a certain extent. In the context of numerical manufacturing, the tension between automation and craft values, precision and imprecision, geometric model and the fabricated, creates a buffer zone for designers to explore affordances of the material and tools intuitively.

Suggesting an embodied and continuous experience of making in everyday life in which physical and digital environments are fused, Devedorf unfolds the discourse of "being the machine"[13]. Devedorf's hybrid fabrication system proposal can be considered as a search for qualities between human and machine modes of producing [13]. FreeD, hand-held digital milling tool, is a computer aided finishing approach which leds a shift from a precise and fully informed digital manufacturing process to the human subjectivity [16, 17]. Similar to FreeD, DSM has contributions to the design of the workflow, tool and mechanism. On the other hand, different than FreeD, the actions, design decisions and manipulations made in DSM are recorded in a history panel which provides recursive jumps in the action history. Considering the subjective contribution of the user in computer aided manufacturing process, Computer Aided Painting (CAP) is another work which combines user's contribution and effector properties to get similar results in digital medium [18]. The design of an end effector and the spraying event mechanism of CAP and DSM have similarities, while the workflow as a whole and the algorithms used are different. MetaMorphe [15] consisting of direct manipulation, scripting interface, generative module layers focuses on utilizing the existing repository of 3D models. Direct manipulation allows user to make partial changes in the scale of the 3D digital model. Scripting interface of MetaMorphe, allow users to manipulate the design model through programming. Generative module and genetic algorithms provide opportunity to differentiate models [15]. Different than MetaMorphe, the workflow of DSM, the actions of drawing, design and material forming were executed concurrently. Moreover, John's experiments involving wax vaporizing and melting operations allow immediate changes in the physical state of material [14]. Therefore the enhancement of the affordances of the material leads unpredictable and emergent outcomes. In Johns' words: *"Rather than developing design in a linear progression from idea to computer-simulated model to fabrication tool and material result, the process allows these elements to operate concurrently or in rapid and recursive succession" [14].* In addition to those, as an intuitive and feedback-driven formation processes, 'Procedural Landscapes' by Gramazio-Kohler research group involves the tension between the computer generated model and the final outcomes [19].

3. Experimentation

Dissolvent Forming Methodology (DFM) is derived from of a series of iterative and reflective experiments that focus on the subjective qualities in producing surface finishing by using digital fabrication tools. Five experiments were executed in total to inform the conceptual framework. In addition to this, simulation and fabrication models have been developed (Figure.1). A small scale prototype of end-effector which is compatible with Arduino Braccio robotic arm was developed and tested.

Figure.1 - Framework Diagram



3.1 Experiment Setup and Implementation

The exposure of polystyrene material to acetone in different forms is visually investigated. The initial experiments were made with the help of a container by means of pouring the foam into the foam (Figure.2). The resulting foam, which was extracted from these experiments, was intensively pierced by liquid.The materials used on the further experiments, chosen based on general information and the first experiment The second experiment in *Figure.2* shows the effect of acetone solution (constant) on a specific EPS material (constant). The amount of solution used with syringe (variable) is multiplied by the number on the columns (1ml for the 1st column, 5ml for the 5th column). The rows named “a” “b” “c” are repeated processes for comparison purpose. Similar visual effects were achieved with equal fluid and equal touch area each time. Conclusion of this experiment was; with a single variable, the effects of same amount of acetone used on the EPS material are similar in a threshold by empirical observation. Both depth and spread is increasing when the amount of applied solution increases.

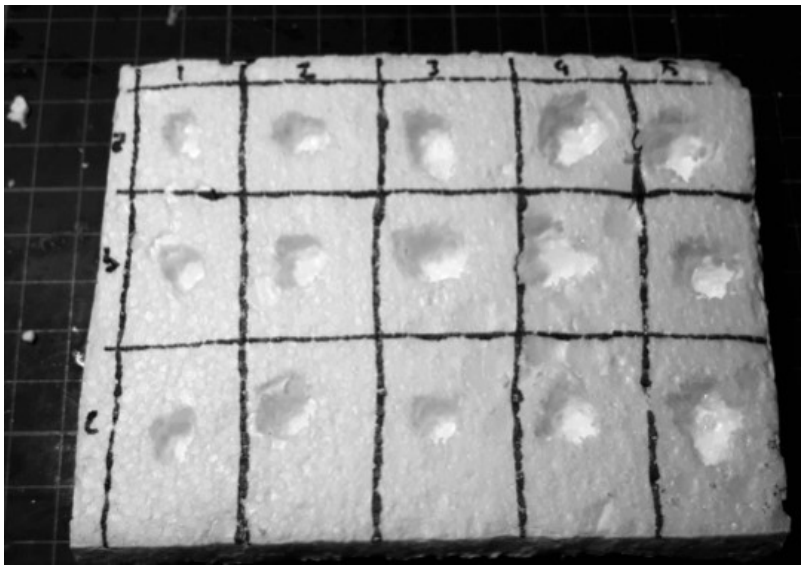


Figure.2
Identical process used in each row (a, b, c) supplies visual comparison. Each column (1, 2, 3, 4, 5) represents repeatedly increased use of solvent amount.

In the third experiment; it is tried to compare different expose methods (variable) with same amount of acetone solution (Figure.3). It is aimed to keep the amount of solvent constant but to reduce the size of the droplet as in syringe experiments. To achieve this, a 9cc-capacity airbrush and a regulated air compressor are used. It was sprayed with acetone paint gun. As a result, it was seen that the sprayed acetone did not affect the foam.

Since the solvent was in an extremely volatile physical state, it became clear that it lost its ability to dissolve in air without spraying. It was understood that the particle size formed after spraying was important.

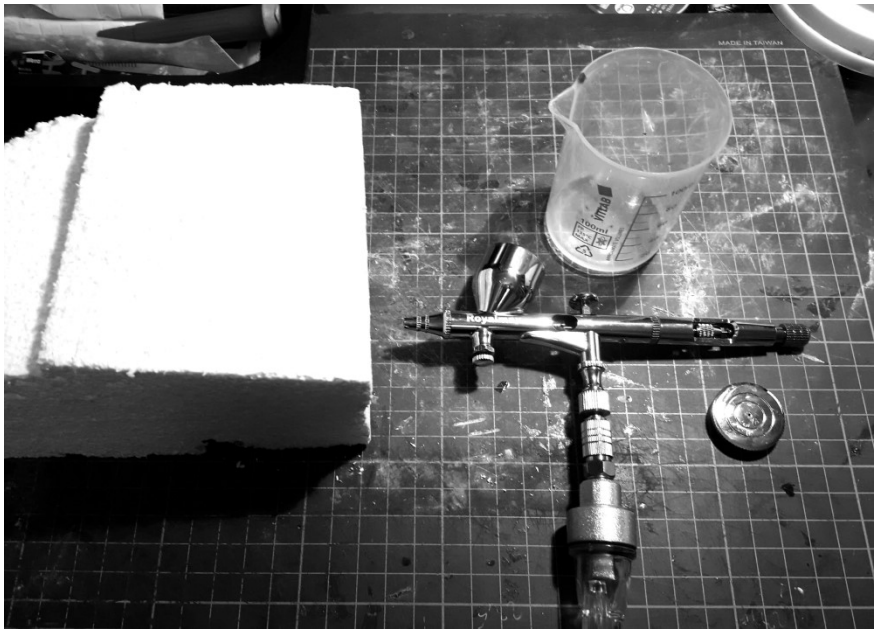


Figure.3
Airbrush setup used in the third experiment

In the fourth experiment, it is tried to eliminate the problems of the third experiment. To increase the spray particle size, spray paint nozzle is used (*Figure.4)*. The solution again pressured with the syringe mechanism to remove the air particles. The tool provided a successful spray and was considered a tool prototype for the next stage.

Figure.4
A syringe modified with a spray cap to achieve smooth spreaded exposure

In the fifth experiment, a better developed tool prototype is built (Figure.5). In this stage not only the problems are eliminated but also tool itself evolved to a end effector. A progression mechanism and a flexible arm has been added to the prototype. To provide a digital control over spraying action; progression mechanism derived power from a BYJ48 stepper motor with ULN2003a driver. Internal library (*Stepper.h*) of the ULN2003a driver is used in Arduino to create precise actions with digital inputs.

Outputs and insights derived from the experiments to refine the Conceptual Framework are listed below:

System Properties as constants and variables

Functional relationships between constants and variables;

a. *Applying variable pressure causes complex results*
b. *Pressure used on syringe changes both amount of solution used in unit time (ml/sec) and particle structure*
c. *Unstable exposure distance changes results dramatically. To reduce complexity spraying distance should kept steady in a single stroke of spray.*

Measurements of the effects based on multiple trials. Further to these inferences, the end effector was tested by using working tool prototype.

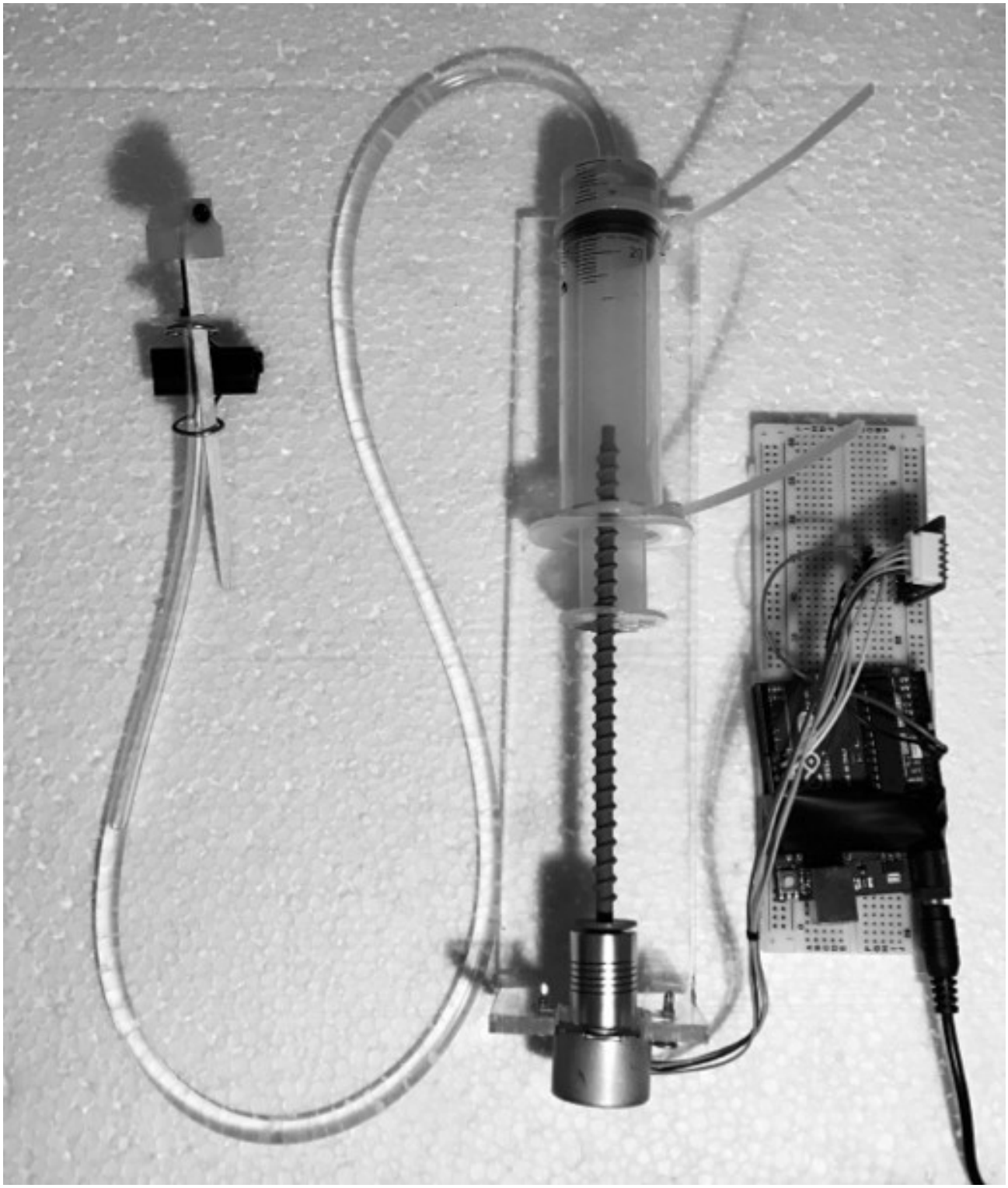


Figure.5 Modified syringe with digital controller and flexible transforming spray nozzle

3.2 Simulation Model

Constraints and variables defined in conceptual model, formed the [SYSTEM PROPERTIES] in the Simulation model. Desired model, shaped around the [SYSTEM PROPERTIES], with the ingredients; an interface that is used to design [SIMULATION], a viewer where 3D aspects of the design in progress can be seen [MONITOR] and the data recording, required for fabrication [RECORD FILE] (*Figure.6).*

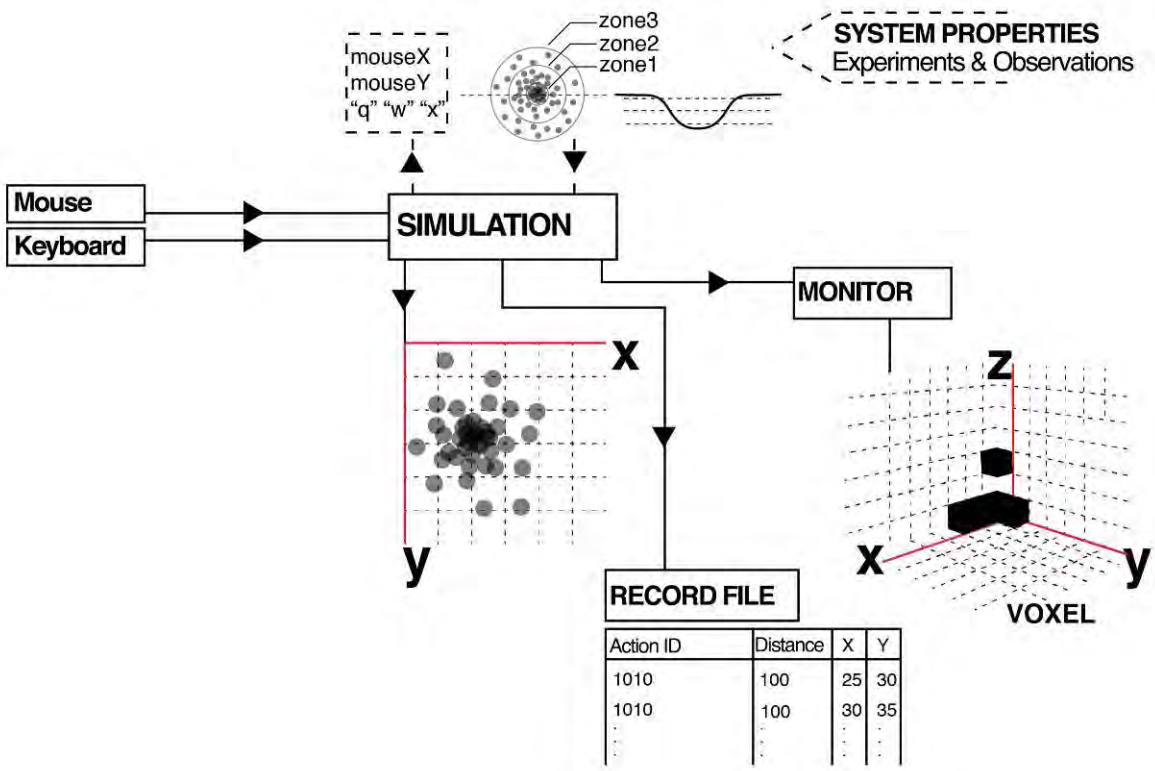


Figure.6 Simulation Model Outline with the [SYSTEM PROPERTIES], [SIMULATION], [MONITOR] and [RECORD FILE]

[SYSTEM PROPERTIES] (*Figure.7a, Figure.7b, Figure.7c)*

a. Constants
    1. Polystrene Material (30kg/m^3 EPS Block)
    2. Acetone Solution (%90 pureness)
    3. Spray Nozzle ("MTN - Montana" brand "Soft Cap" model, https://www.youtube.com/watch?v=AvPURr_aeS8)
    4. Spray Pressure
    5. Amount of spray (3ml per second)
b. Variables
    1. Spray-Material Distance
    2. Spray Movement (also defines spraying time)

[SIMULATION] was designed at the center of the whole application. Simulation part of the application basically converts mouse and keyboard inputs into stains in black-and-white range in the two-dimensional plane. This event is programmed through the direction of the

data obtained from the observations. With the "Q" and "W" keys, the spray size, ie the distance of the nozzle in the factory, can be changed.

[MONITOR] simultaneously shows the voxel based 3D model of the design.

[RECORD FILE] is being created in the background of the application. When the design is finished, the "X" key is pressed and all the operations are converted to the fabrication data as a single file.

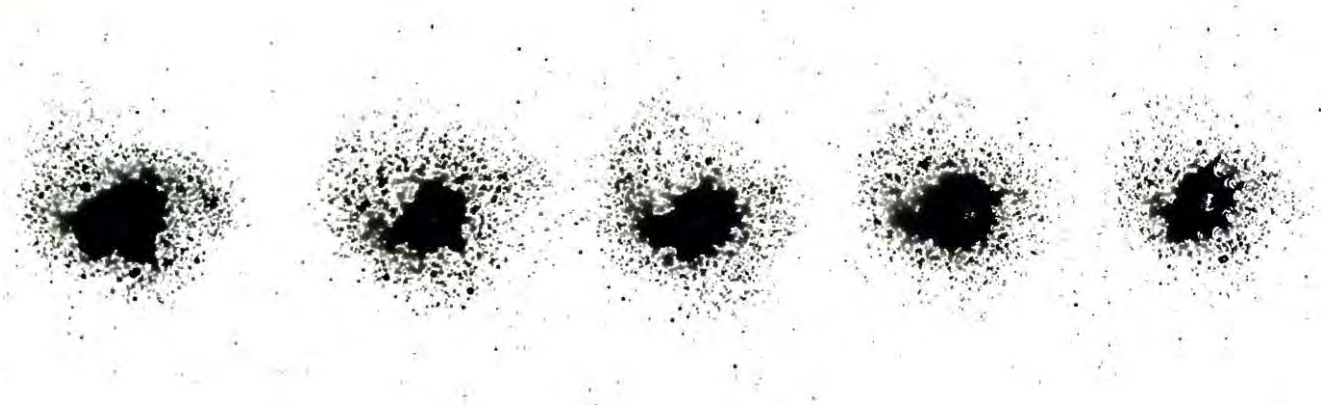
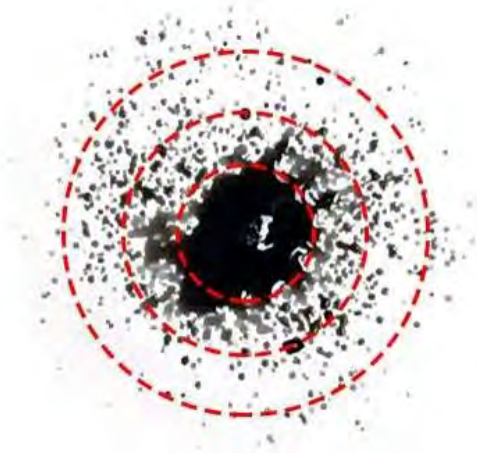


Figure.7a - Spray nozzle tests, with same amount of solution (3ml/sec), constant pressure



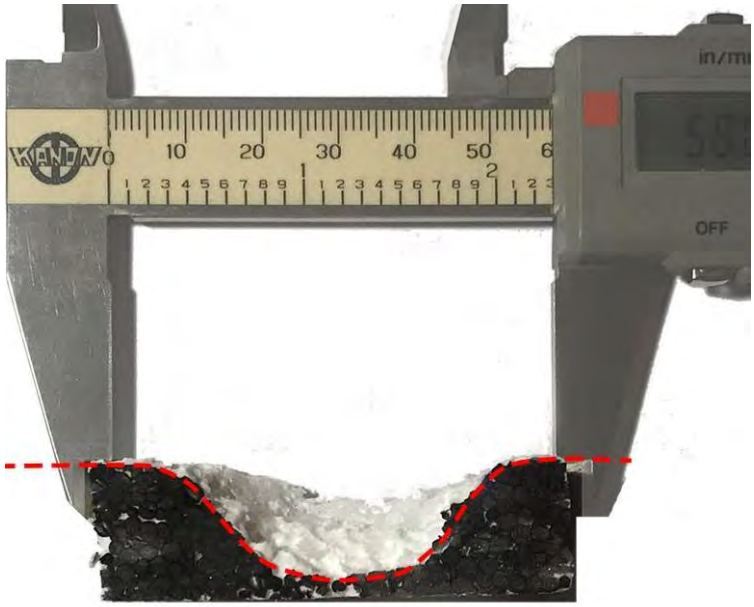
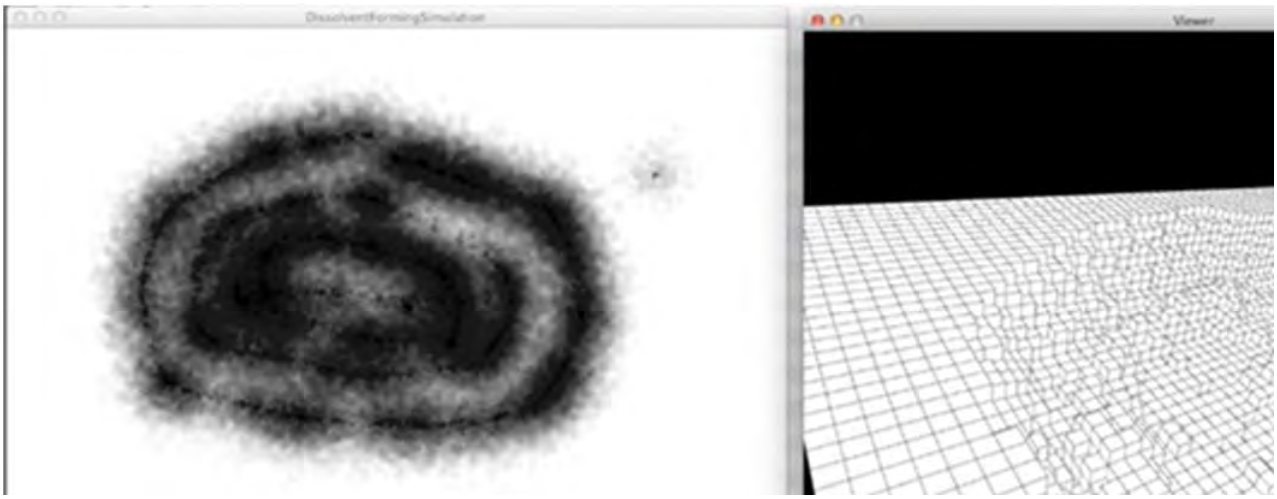


Figure.7b Density zones used in simulation *Figure.7c Sectional effect on Polystrene*

3.3 Fabrication Model

The application created in the simulation model consists of 2 screens; design interface and Monitor *(Figure.8)*. The design interface window works as a painting medium. Simulates the spray stains when mouse is clicked and dragged. At the same time three dimensional effect can be seen from desired camera views in the right wind

Figure.8 - Design interface (left), monitor(right)



When design process is finished, action record happened in the background can be written on a file. Sequential operations saved as a 'Comma Separeted Value' CSV file. File contains; [ActionID], [Spread Size], [X Axis], [Y Axis] values in an order. This file is separated into meaningful components using the Rhinoceros / Grasshopper plugin. Separated components are transformed into sequential coordinates for robot and run commands for the end effector *(Figure.9)*.

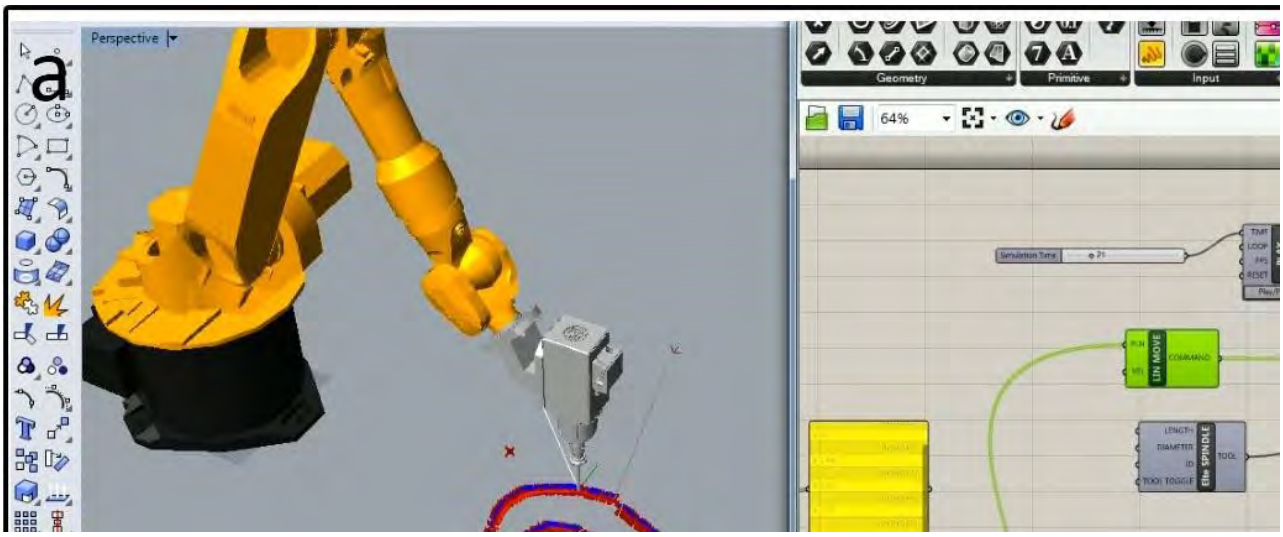


Figure.9 - KUKA robot showing the path (left). CSV values are used (right)

In the Rhinoceros, the KUKA PRC plug-in in the Grasshopper plug-in provides the KRL output of KUKA robots and robot simulation. The KRL output contains the corresponding angles in the robot joints of the instantaneous points forming the specified route. Within the scope of this project, processes up to this part have been applied but the end effector has not been used with the robot since it can not provide necessary security by the date of this paper. To finalize the project end effector is used manually with positioning helpers (*Figure.10)*.

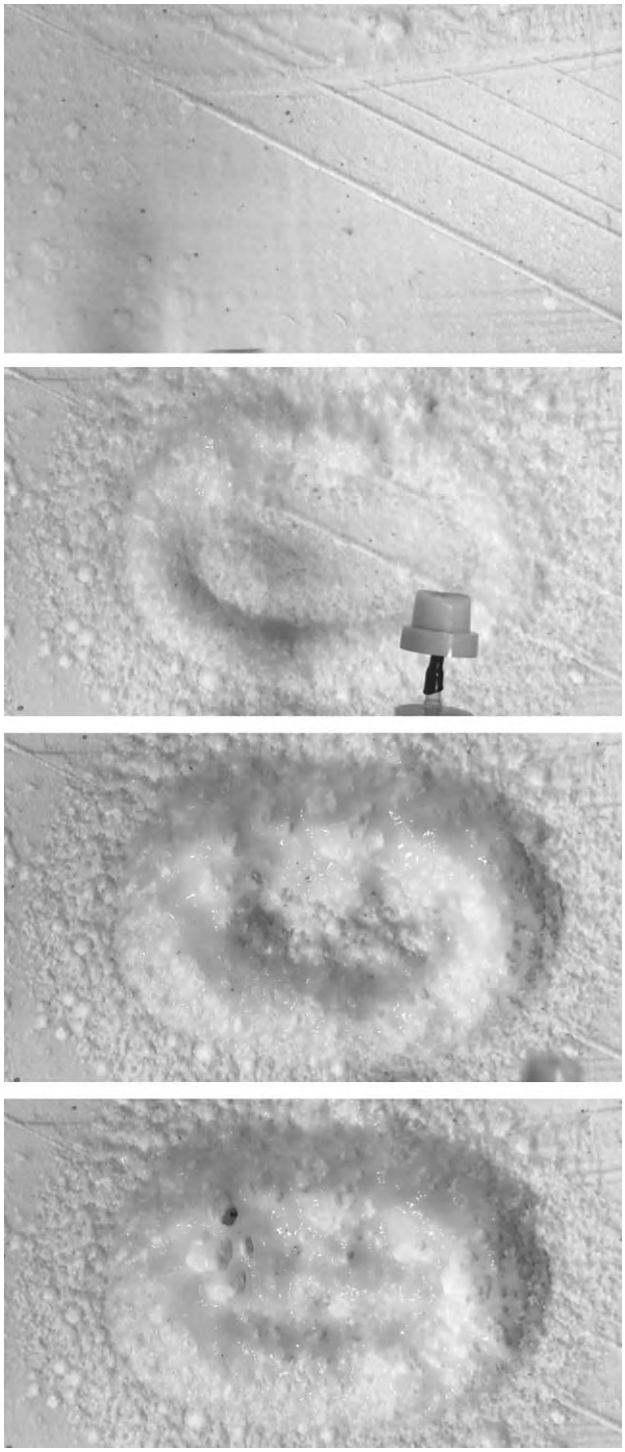


Figure.10 - Sequential images from fabrication process

4. Conclusion and Discussion

In the context of authenticity problem in numerical manufacturing processes, we argue that the concepts of 'imperfection', 'trial-error', 'human subjectivity' have potentials to provide a crucial ground for designers to test new, different and unexplored possibilities. An experimental design and fabrication flow called DFM to provide uniqueness in mass customization through programming and simulating the material (polystyrene) behaviour was designed and tested.

- Material studies and physical experimentation play an important role in designing customized tools and workflows. In this study, chemical transformations and their analysis have informed the calibration and design process of DFM. Utilizing chemical transformation on material led decrease of control over the fabrication process. As a result, DFM can be considered as formative fabrication process. However, the numerical manufacturing process can no longer address additive or subtractive fabrication process.
- Level of Detail (LOD) approach in the digital modeling simulated in a physical digital hybrid world. Macro scale decisions made digitally by the personal skills/aesthetics and micro scale details emerged by the medium of chemical properties. Material behavior is unpredictable in micro scale.
- Design of DFM covers the inseparable components of computation, subjective skills and material (properties) itself. A cooperation between computer, human and material. In other words, DFM involves integration of material, human and computation interaction in a dialogic way.
- There had been limited human factor during the design and development process of DFM. However, further to development of DFM, the workflow can result with unique qualities in surface finishing in each usage.
- The limitation of DFM is being a customized process. This is why, it is difficult to adapt it to different contexts. Due to linear recording feature of the methodology, the system does not allow real time material level manipulations. In the future studies it is aimed to improve this feature.

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TITLE The Black Swans
(Installation, Live Performance/Paper)

Topic: (Subjectivity - Art & Computer generated Music)

Author(s):
James Whitehead (JLIAT)

Abstract
My proposal takes the form of a possible installation/performance and or a paper. My recent work has involved using autonomous computer generated sound works using software i have written which produces midi data that is then used to 'play' synthesisers. Computer simulated 'music'. The process is stochastic within pre-given limits (deterministic chaos). No human control of the system is given once this process begins. Each 'play' is six hours and stored on read only usb drives embedded in a Black Swan Device. extract - https://youtu.be/chfy0tR7-n0 Scores and program listing etc. here http://www.jliat.com/blackswans.pdf. Therefore an installation could be one such device which uses embedded wifi which allows any audience with a smart phone, tablet or PC to access and listen to the recording. Alternatively an actual continuous 'performance' could be produced using a lap top loaded with my software and a suitable midi synth. The motivation behind these works is discussed in part here http://www.jliat.com/The-power-of-the-black-swans.pdf. This takes the form of an 'extension' of “The Work of Art in the Age of Mechanical Reproduction” - Walter Benjamin, entitled 'The Work of Art in the Age of Post-Mechanical Reproduction.' which could form the basis for the presentation of a paper. The basic synopsis being that with the digital media a new crisis for art and the artist has arisen, that of the ubiquity and ease of 'artistic' production and desemination, the breakdown of artist/audience dichotomy, and a radicalization of Art and Capital. Something positive in some respects, but in an original 'creative' move problematic. Two solutions offer themselves, the exploitation of personal subjectivity, a 'private language' and the supplanting of human 'creativity' by cybernetics, AI, or stochastic algorithms, which in part looks at a possible Accelerationism, and its overcoming. More details here - www.jliat.com e. james@jliat.com bio - http://jliat.com/bio.html

James@jliat.com

Key words: Stochastic Art, Computer simulated 'music'
Main References:

The Black Swans.
The Work of Art in the Age of Post-Mechanical Reproduction.

('Post-Mechanical Reproduction' 'Mechanical' as in a machine which is physical and makes physical stuff using force. 'Age of Post-Mechanical Reproduction' = 'Age of virtual production.' "Ecstasy of Communication" - Baudrillard)

James Whitehead aka JLIAT

Abstract:
This paper sets out a subjective response in Art to the post-modern situation of confusion and complexity in the nature of art, the development of technology and a perceived crisis in the Humanities. This response is the production of totemic objects or 'devices' similar to those of pre-agrarian humans, made in order to deal with a world which for some is alienating, mysterious and threatening.

Introduction:
This paper will use three unrelated, as of yet, subjects.

One: The Cuba Missile Crisis of 1962.

Two: Alienating hyper-complex systems and Accelerationism.

Three: An addendum to "The Work of Art in the Age of Mechanical Reproduction" by Walter Benjamin " – 'The Work of Art in the Age of Post-Mechanical Reproduction'.

Each of these can be regarded as a global crisis whose overcoming is beyond the scope of this paper, beyond the scope of any individual, perhaps even beyond the scope of humanity.

That they are related, or will here become related requires a move which is certainly neither overtly rational or properly academic. One which in my case re-asserts the individual despite the scale and complexity for any individual by and from all three crises. This involves a strategy towards and with technology to 'generate' novel devices. The power of these devices, these 'technologies', is generated by a psychological force, 'the essence of [this] technology is nothing technological'. I've compared this to Pre-agrarian art, whereas such an art might use a dead animal bone, I use a broken computer circuit boards. In the naivety of practice and object I also note a comparison with the Cargo Cults of Polynesia [1].

One:
The Cuba missile crisis marks an event in the cold war of the 1950s and 60s, one of the closest to an actual nuclear war. Cuba had become a communist state after the revolution of 1959, and in October 1962 the United States became aware of nuclear missile sites which the USSR was installing on Cuba. The then ICBM technology would in effect give the USSR a first strike capability. President Kennedy's advisers therefore were convinced a nuclear strike by the USA on Cuba was the best option. He instead enforced a blockage of Cuba by the US Navy. Ships from the USSR – carrying more missiles were already underway, and the reality of a Nuclear War was common to all, if these ships didn't turn back the US Navy would sink them and a Nuclear War would almost certainly follow. The then ICBM technology was significant in making the crisis as ICBMs at the time were

liquid fuelled and took around 15 minutes to prepare, missiles fired from Cuba could effectively destroy U.S. missiles before launching was possible[2]. In 1962 I was eleven, living with my mother and grandfather in Birmingham. My grandfather, who had fought in the Great War was very interested in politics, I remember the T.V. broadcasts from the USSR each Mayday, long columns of soldiers and more worrying for a young boy, missiles, at which my grandfather would point and say, "you see these, they are pointed at us!" So though only 11 I was still very aware of the then current situation. In late October I watched the skies in fear. I had from library books seen diagrams of nuclear weapons, I was very afraid, perhaps traumatised, a feeling of helplessness caught in this showdown between superpowers. I sketched imaginary devices for cutting up nuclear weapons before they could detonate, I imagined and made models, one of these had the head of a swan, it was the Swan Device. These devices were obviously not practical, rather like the aircraft and control towers made of palm trees by tribes in Polynesia they were neither Art or Technologies, but in some way strange totemic devices.... I want you to hold this 'nature' of such devices rather than dismiss them as silly childish toys or products of 'primitive' and ignorant minds. The boy had to deal with something he could have no power over and not fully understand, the creators of Cargo cult 'devices' were in a strange way in a similar position, they witnessed the arrival and departure of advanced western technologies and commodities during the War in the Pacific in WW2 and constructed unreal effigies in the hope of returning the good fortune they brought.

Two:
SPIEGEL: And what takes the place of philosophy now?

HEIDEGGER: Cybernetics[3].

Heidegger predicted the end of philosophy with the advent of computer technology. It would be wrong to say he was averse to technology, more that he saw it as (another) crisis or challenge.

Contemporary philosophy however is anything but over, though can be seen as being in crisis, a crisis of 'meaning'. We have competing philosophies of the likes of Badiou, Laurelle, Deleuze... and the more recent Speculative turn. It is marked by dense exercises in metaphysics or analysis within which factions fail to agree. The texts open themselves to multiple interpretations, from considerations of brilliant insights but for others that they are nonsensical rubbish. Particular attention to some of these excesses has been drawn by Alan Sokal and Jean Bricmont...

"that famous intellectuals such as Lacan, Kristeva, Irigary, Baudrillard, and Deleuze have repeatedly abused scientific concepts and terminology..."[4].

for instance quoting Lacan

"Thus the erectile organ...is equivalent to the square root of -1[5]."

Or as Ray Brassier has said of more contemporary philosophy,

"The 'speculative realist movement' exists only in the imaginations of a group of bloggers promoting an agenda for which I have no sympathy whatsoever: actor-network theory spiced with pan-psychist metaphysics and morsels of process philosophy. I don't believe the internet is an appropriate medium for serious philosophical debate; nor do I believe it is acceptable to try to concoct a philosophical movement online by using blogs to exploit the misguided enthusiasm of impressionable graduate students. I agree with Deleuze's remark that ultimately the most basic task of philosophy is to impede stupidity, so I see little philosophical merit in a 'movement' whose most

signal achievement thus far is to have generated an online orgy of stupidity[6]."

His main target has been Graham Harman and his fellow Object Orientated Ontologist Tim Morton. My point here though is not to dam contemporary theory, but indicate its complexity and hence confusions and interpretations within it. For Morton, despite some 'remarkable' ideas regarding physics, he addresses another contemporary crisis. Global Warming or Climate change. And one would suppose a consensus here, or if not a disagreement drawn from scientific evidence. But this is obviously not the case, it is the site of a political lack of consensus.

If all this seems to be getting us nowhere or confused as to what to do, Accelerationism offers an answer. We accelerate the cause of the current problems, technology, to the end. It has two political 'flavours', Right and Left. For the Right technology produces via capitalism The Singularity of an artificial super intelligence with the ability to solve and resolve the current crises. Nick Land, a founder of The Cybernetic Culture Research Unit is a proponent of Right Accelerationism. And he is significant as being a tutor at Warwick of many now involved with Speculative Realism and even those exponents of Left Accelerationism, Land was influential in the arts, associated with personae such as Jake and Dinos Chapman, mixing cybernetics with art and occultism. Land is now linked with Dark Enlightenment, and Neo-Reactionism (NRx) anti democratic and extreme right-wing movements. Paul Mason in 'Post Capitalism: A Guide to our Future' sees a solution to the current political, economic and environmental problems via a Marxism which employs technology. Both left and right are reactions to the perceived failure of neo-liberalism yet like technology itself are products of it.

Space and my limited individual capability precludes detailing the complexity of modern physics, biology, neurobiology, computer technologies and mathematics. Whatever they produce, they all do produce a feeling of personal alienation.

What of art? Again there is a clear right/left divide. The super-collectors such as Saatchi, and an art industry focused on the gallery system and auction houses contrasted with politically active movements in Art of the Left, in the UK typified by Art Monthly.

But as much as this is seemingly bifurcated and confused so is the nature and legitimation of Art itself. To the left the art work disappears in favour of collective activism and is validated by the social results of such confrontations. On the right, money!

Quote Damien Hirst 1990.

“I can't wait to get into a position to make really bad art and get away with it” [7].

Damien Hirst's 'Treasures from the Wreck of the Unbelievable' of 2017 consists of 190 works across 54,000 square feet of gallery spaces in Venice. Galleries owned by François Pinault, amongst other holdings owner of Christie's Auction House and is estimated to be worth 13.7 billion dollars as of 2015.

The artworks of 'The Treasures' were produced ***for*** Hirst at Hirst's personal expense, at a cost of between 50 and 100 million UK pounds to manufacture.

Whatever else art has become 'technological' in the complexity of its social, political, economic, philosophical structures and networks. It too brings therefore an alienation [8] for any individual. The individual is now part of a network[9], group or industry. Culture is now an industry.

Three:
Art in its broadest sense was defined by Walter Benjamin as being once that of objects which had traditional and ritualistic values. Places of worship, architecture, painting, sculpture, drama, literature, music and performance were cultural 'spaces' in which individuals could interact, communicate, learn, entertain and be entertained. Within this framework individual works of art were unique productions. Art in the Pre-Industrial age consisted of singular objects, a statue, painting or building. It gained an Aura which was its validation by and from the society in which it was located. For Benjamin Art had no intrinsic Aura, Art's Aura was given to it by the bourgeoisie, or proletariat or by an authority, civil, religious, institutional or capital. It is a consequence of the Aura, no matter its source, that the powerful would collect and associate themselves with such art once societies developed strata and simple economics. The 'powerful' would collect artworks, commission art, musical compositions, and latter endow institutions. Benjamin's argument is that with mechanical reproduction of the industrial age the 'original' was no longer needed once the quality of production was such that difference from an original could become trivial or non existent. In the post-industrial age digital reproduction is 'perfect'.

In the post-modern, post-industrial age of digital reproduction and creation art or culture for the majority is neither the elite of High Art or the political activism of the left. Art today in the broadest sense as a communal activity exists as perfectly reproducible and transmittable digital data. As music, drama, the movies, also as news, and especially sport, as video games, and as the internet and social media. This is the cultural input for the many.

And Social Media in particular is significantly different to all past cultural activity because it has all the sociality of these other mass forms of art/entertainment but with no external content. There is no external 'origin' or originator. Social Media has no external content as its focus, it is just social interaction without any object. It mediates individual directly with individual without anything other. The only requirements for its engagement therefore is to be an individual who uses it. It is Baudrillard's “Ecstasy of Communication”.

In social media reproduction of art has become redundant, and in the post-industrial digital age reproduction of art has become perfect, and creation and creativity facilitated for all by software and hardware. Art is the product of an industry, it is no longer an individual activity. And because of this no longer are art galleries or institutions validated by their collections of individuals work, their collections are validated by the institution, by the industry. Institutions such as The Louvre or National Gallery gained status because of their contents of 'great' works of individual Artists. With the industrialization of art now an artist gains his or her status by virtue of the galleries they are exhibited in. The artist can no longer decide to be an artist, this decision is made by 'the industry' of galleries, curators, collectors etc. Mass society can no longer provide the artist with any criteria because it has established itself as self-sufficient and in no *need* of art. The audiences can and do amuse themselves. And for any artist to be accepted as an artist it is for the system to decide. Such an individual is subsumed into the system or is alienated from it.

A Strategy:
A strategy for how an individual can produce art, an art fundamentally different from the contemporary technological system has recourse to the production of art not just prior to industrialization but prior to the development of agriculture. With agriculture came communities of cities and nations, class structures, commerce, specialization in craft and technology. For Benjamin here the societies created Art and art's Aura. Yet art existed before agriculture, in pre-agrarian cultures individuals made objects we now consider as art. For example the "Venus of Tan-Tan",

Venus of Willendorf the Swimming Reindeer. And some of these works such as the Lion-man figurine date to some 40,000 years ago, 28,000 years before the beginnings of agriculture.

Pre-agrarian art had an essential quality which an individual now, as attempting to be an artist and make art works, can also utilize. In Pre-agrarian art the object's Aura was significant to its maker, and primarily significant. Such cultures, if they can even be called that, lacked even the rudimentary structures of agrarian societies in which sophisticated communities developed. Pre-agrarian artworks could be 'secret', were in effect secret without the need of communication and audiences. They could never be known, shared or communicated with more than a handful of others. The significance of these works or in Benjamin's term their Aura could not be social as they exited and were created for many millennia before societies existed.

The resource the individual today has is simply a need or desire to make a work, a thing, an object, despite an alienated world around them. We can only speculate of how these pre-agrarian objects gained a value. But as someone now who simply feels the need to make 'special' objects, the need is sufficient and provides the value. And I think this need is no different from the totemic or fetish quality of so called primitive art. We may ourselves had this experience of the totemic object, or many of us have, as children in our interaction with 'special' toys. Such an interaction is not primarily religious, it lacks the sophistication for any religiosity. The experiences of such objects are difficult to describe because they occur even before we acquire a language sophisticated enough to signify them. The possibility of these objects opens the possibility of an individual making, for what ever else it could be called, an art object.

The Black Swans are examples of such objects. Their creation derives from remembering a personal psychological experience of an historically profound event. In 1962 my swan device was not 'real'. The object, or 'device' then as now is totemic or fetishistic.

The current devices do function, not only as objects but devices for the location, storage, performance of soundworks. But these are also not 'Real'. They use comparatively simple computer programs to 'simulate' modern music, to produce a cargo cult un-real 'replica' of avant garde music. Cargo cult because of the simplistic algorithms which are nothing like the sophisticated structures of serial music. And they are manufactured from the dead waste of contemporary technology...

Post Script:
"Because the essence of technology is nothing technological, essential reflection upon technology and decisive confrontation with it must happen in a realm that is, on the one hand, akin to the essence of technology and, on the other, fundamentally different from it. Such a realm is art[10]." - Heidegger.

https://www.youtube.com/watch?v=YZ608OQdHOk

Notes:

[1] “A cargo cult is a millenarian movement first described in Melanesia which encompasses a range of practices and occurs in the wake of contact with more technologically advanced societies. The name derives from the belief which began among Melanesians in the late 19th and early 20th century that various ritualistic acts such as the building of an airplane runway will result in the appearance of material wealth, particularly highly desirable Western goods (i.e., "cargo"), via Western airplanes. Cargo cults often develop during a combination of crises. Under conditions of social stress, such a movement may form under the leadership of a charismatic figure. This leader may have a "vision" (or "myth-dream") of the future, often linked to an ancestral efficacy ("mana") thought to be recoverable by a return to traditional morality. This leader may characterize the present state as a dismantling of the old social order, meaning that social hierarchy and ego boundaries have been broken down.” –Wikipedia

[2] The mainstay of the USA's ICBMs at the time was the Atlas missile developed under the direction of John Von Neumann who amongst many other things was responsible for the design of the principle computer architecture still in use today.

[3] Interview given in 1966. Quoted in Frank J. Tipler, The Physics of Immortality (London: Macmillan, 1994) p.86.

[4] Sokal, Alan & Bricmont, Jean, Fashionable Nonsense x.

[5] Ibid. p.86

[6] Ray Brassier interviewed by Marcin Rychter "I am a nihilist because I still believe in truth", Kronos, March 4, 2011.

[7] Julian Stallabrass, High Art Lite: British Art in the 1990s, p.31.

[8] Ray Brassier has picked up many strands of alienation – see https://monoskop.org/images/2/24/Brassier_Ray_Alien_Theory_The_Decline_of_Materialism_in_the_Name_of_Matter.pdf and elsewhere https://contingentpower.net/tags/ray-brassier. And an accompanying nihilism in which he equates philosophy to extinction. See Nihil Unbound pp.238-239. His trope is extinction, part perhaps of a leftish Accelerationism.

[9] Networks are an obvious contemporary feature, ones which become for many their environment for work and leisure. There are sociological models such as ANT. Key to a network is connectivity and opposed to individuality. A mesh network (the internet) is non hierarchical & so rhyizomic. “The multiple must be made... subtract the unique from the multiplicity to be constituted... A system of this kind could be called a rhizome.” Gilles Deleuze and Félix Guattari 'Capitalism and Schizophrenia' p.6.

[10] Martin Heidegger Ibid. pp. 237,238

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EXAMPLES OF APPLICATION OF NUMERICAL MODELS IN ENGINEERING AND ARCHITECTONIC DESIGN

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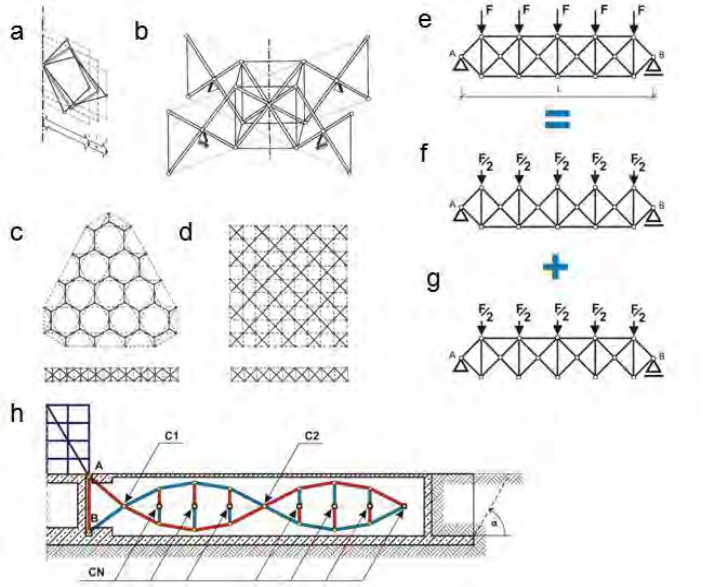
Abstract:
Spatial structures are widely applied in modern architecture and engineering since middle of XX century. They are defined as structures built by members quite uniformly arranged in space, while the forces between their component parts are transmitted also in spatial way. In spite of sometimes very complex forms, especially in case of tension-strut type of systems, they are mostly the very efficient structural systems of various types of buildings. Due to their application the buildings can get unique and interesting architectonic views. Numerical models defined by applications of various programming languages are very helpful in structural design of bearing structures [1]. Moreover application of principle of superposition can significantly enhance processes of design of various types of trusses [2]. Suitable application of this principle was basis during invention process of the two-stage method of calculation of statically indeterminate trusses as well as in the design process of structural concept of system of combined foundation. This type of foundation system makes possible to locate heavily loaded buildings on ground of small load carrying ability.



Images of a-d) selected type of tension-strut spatial structures, e-g) schemes of basic procedures of two-stage method of approximate calculation of statically indeterminate trusses, h) scheme of structural concept of the system of combined foundation

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Key words: Numerical model, programing language, space structure, design, architecture, engineering, roof, tall building

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[1] Janusz Rębielak, "*Shaping of space structures. Examples of applications of Formian in design of tension-strut systems*", Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław, 2005
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Examples of Application of Numerical Models in Engineering and Architectonic Design

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Premise

Spatial structures are widely applied in modern architecture and engineering since middle of XX century. They are defined as structures built by members quite uniformly arranged in space, while the forces between their component parts are transmitted also in spatial way. In spite of sometimes very complex forms, especially in case of tension-strut type of systems, they are mostly the very efficient structural systems of various types of buildings. Due to their application the buildings can get unique and interesting architectonic views. Numerical models defined by applications of various programing languages are very helpful in structural design of bearing structures. Moreover application of principle of superposition can significantly enhance processes of design of various types of trusses. Suitable application of this principle was basis during invention process of the two-stage method of calculation of statically indeterminate trusses as well as in the design process of structural concept of system of combined foundation. This type of foundation system makes possible to locate heavily loaded buildings on ground of small load carrying ability.

The paper presents selected examples of defining numerical models of statically indeterminate trusses, which then are subjected to suitable processes of calculation of forces acting in their members. Moreover there are presented proposals of shaping of structural systems of multi-storey buildings including the innovative system of the combined foundation. An example of program defined in programing language Formian the numerical model of selected type of structural system is also presented.

1. Concept of two stage method of calculation of statically indeterminate trusses

The proposed two-stage method of calculation of the statically indeterminate trusses was invented by the author during the preliminary analysis of a group of the spatial tension-strut structures, schemes of which are shown in Fig. 1 a-d. These structures are built by means of struts, which constitute all their cross-braces, and by means of tension members, which are located in outer layers and moreover being their vertical members. Structural system built it this way has to be suitably pre-stressed. Simplified scheme of vertical cross-section of a basic truss system, representing this group of structural systems, is shown in Fig. 1e. It represents a plane truss being a four-fold statically indeterminate structure.

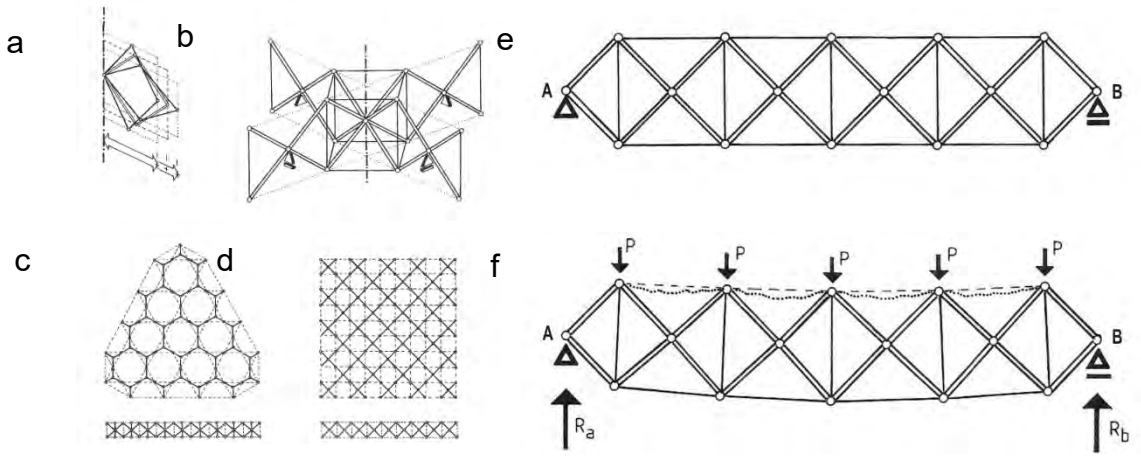

Fig. 1. a-d) Selected type of tension-strut spatial structures, e) scheme of cross-section, f) shape of bending of overloaded tension-strut structure

From analysis of Fig. 1f follows that certain number of the upper chord members are not able to take the compression forces, because they are constructed as cables, what implies that they are excluded from process of the force transmission. This type of structural system has to be calculated by application of sophisticated and complex methods. Number of the excluded members equals the degree of statically indeterminacy of the basic truss, see Fig. 1e. It means that the basic truss is the four-fold statically indeterminate system. From the general, basic conditions of equilibrium follows, that the approximate calculations of forces acting in particular members of such truss could be carried out in two suitable stages, see Fig. 2, by application of principle of superposition. The point of this method is that static calculations are carried out in two independent stages for statically determinate trusses, shapes of which are received through remove from space of the basic truss the number of members equal to statically indeterminacy of this truss.

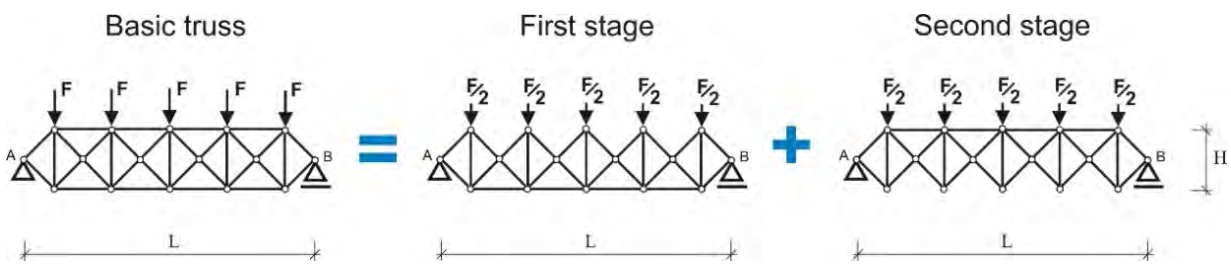

Fig. 2. Schemes of two stages of the proposed method of calculation

It implies that in the first and second stage there are considered the statically determinate trusses, what further implies that in both stages can be used one of very simple method of the force calculations, for instance the Cremona's method. In order to verify correctness of the two-stage method there were carried out some computations of simple form of the plane statically indeterminate truss having the same shape like the basic truss shown in Fig. 1e and in Fig. 2. It has the clear span equals 5.00 meters and the construction depth equal to 1.00 meter. In the basic case the truss is loaded in symmetrically way by means of concentrated forces applied to all nodes of the upper chord, each of value 1.00 kN. In the first stage four members of the upper chord are removed and concentrated forces of value equal to 0.50 kN are applied to all nodes of the upper chord, see Fig. 3. In the second stage, like previously, four members are rejected but this time from the lower chord of the basic truss and the statically determinate form of truss is loaded by concentrated

forces, each of value equal to 0.50 kN and applied to each node of the upper layer, see Fig. 4 The own weight of the truss is not taken into consideration [1,2].

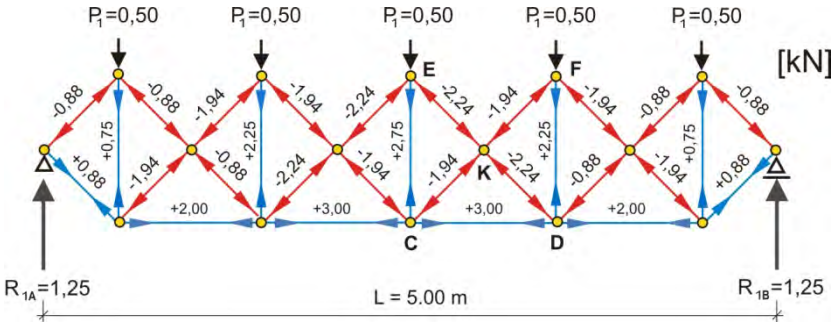

Fig. 3. Force values calculated in the first stage

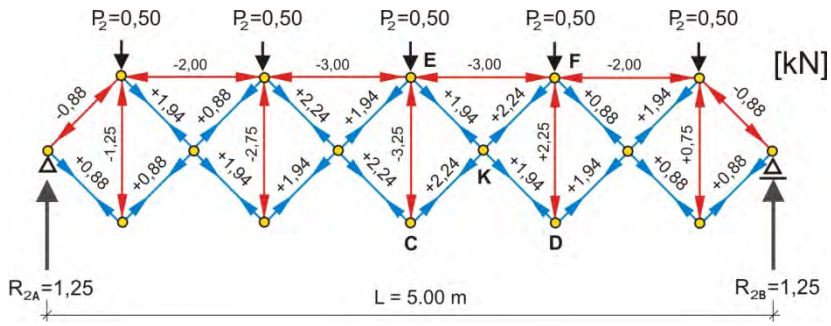

Fig. 4. Force values calculated in the second stage

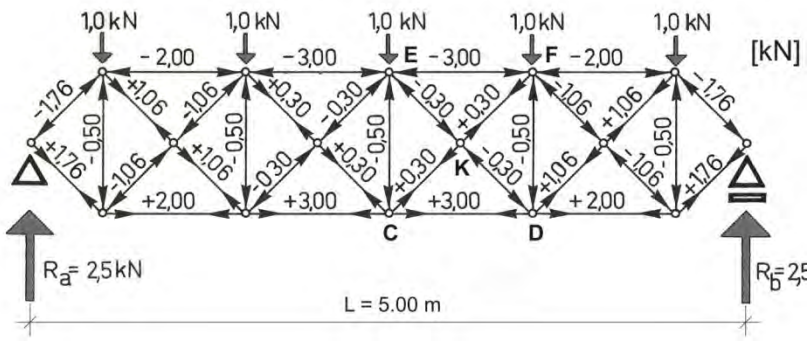

Fig. 5. Force values calculated in the basic truss as a result of appropriate application of principle of superposition in the proposed two-stage method of calculation of statically indeterminate trusses

One should be aware that the two-stage method gives in result the approximate values of forces because each simple method applied in the both independent stages, like e.g. the Cremona's method, does not take into consideration differences between stiffness of members joined to the same nodes [3,4]. Simplicity of the two-stage method is caused by suitable application of rule of superposition. The feature can be considered as the most important value of this method that is why it can be especially useful for the preliminary and even for the very advanced calculations of the statically indeterminate trusses based on numerical models of such structures defined in appropriate programming language.

2. Structural concept of system of combined foundation

Principle of superposition has been also applied during invention of structural system of combined foundation [5]. Very large surface of the foundation can guarantee that the stress value in subsoil will not exceed permissible value of the subsoil load ability. Increasing the foundation surface has to be made with respecting the basic rules of theory of structures and engineering design of foundation systems for e.g. tall buildings [6]. The point of this structural system is to transmit the outside big force V, see Fig. 1c-d, by means of suitable nodes of an intermediate structure, to the matter of basic components shaped in form of e.g. beams (1) located on a common horizontal base. The load force V is applied to the upper node A of a short strut AB, which is inserted tightly inside appropriate guides and which has only one degree of freedom along the vertical direction. To the lower node B of this short vertical strut is connected the intermediate structural system composed of two independent parts.

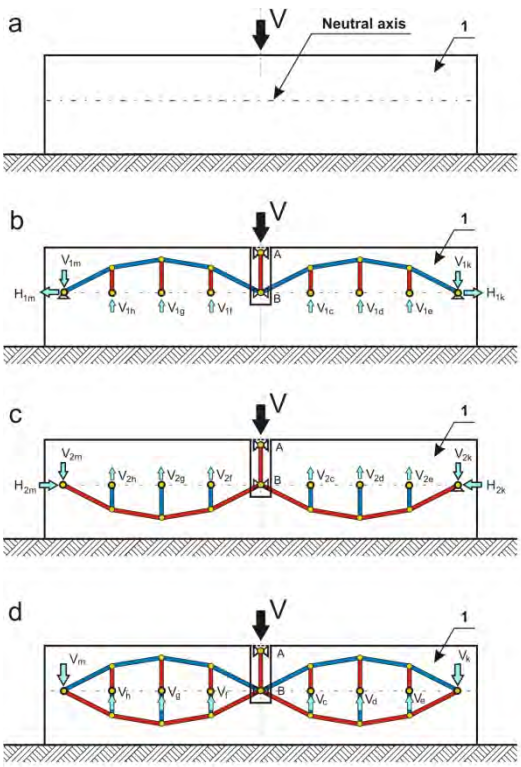

Fig. 6. Analytical schemes of structural concept of system of combined foundation

Scheme of its upper part is shown in Fig. 6b while scheme of its lower part is presented in Fig. 6c. Patterns of both parts are symmetrical towards the horizontal central axis of a beam, where moreover are placed nodes connecting these parts to the main bodies of the beams. After combining both parts, see Fig. 6d, the horizontal components of reactions are wiped out because shapes of both parts of the intermediate system are symmetrical towards the horizontal central axis. Final lenticular shape of the intermediate system can be put in the narrow space between two parallel beams, or it can be suitably arranged around the body of a single beam.

Lenticular segment, consisting of all appropriate component parts, can be considered as the structural unit of foundation system shaped in this way. If suitable bracing system, having form of a kind of lenticular girder, is suitably arranged in structure of the aboveground stories and multi-story building is supported on the above described foundation, see Fig. 7a, then the whole structure is called the combined system of tall building [7]. Number of replication of lenticular units along horizontal direction is optional, see Fig. 7b, what implies that horizontal surface of that foundation system can be very large, see Fig. 7c, and theoretically it can be unlimited. The proposed system of foundation makes possible the safe location of even very heavily loaded building on subsoil of very small load carrying capacity.

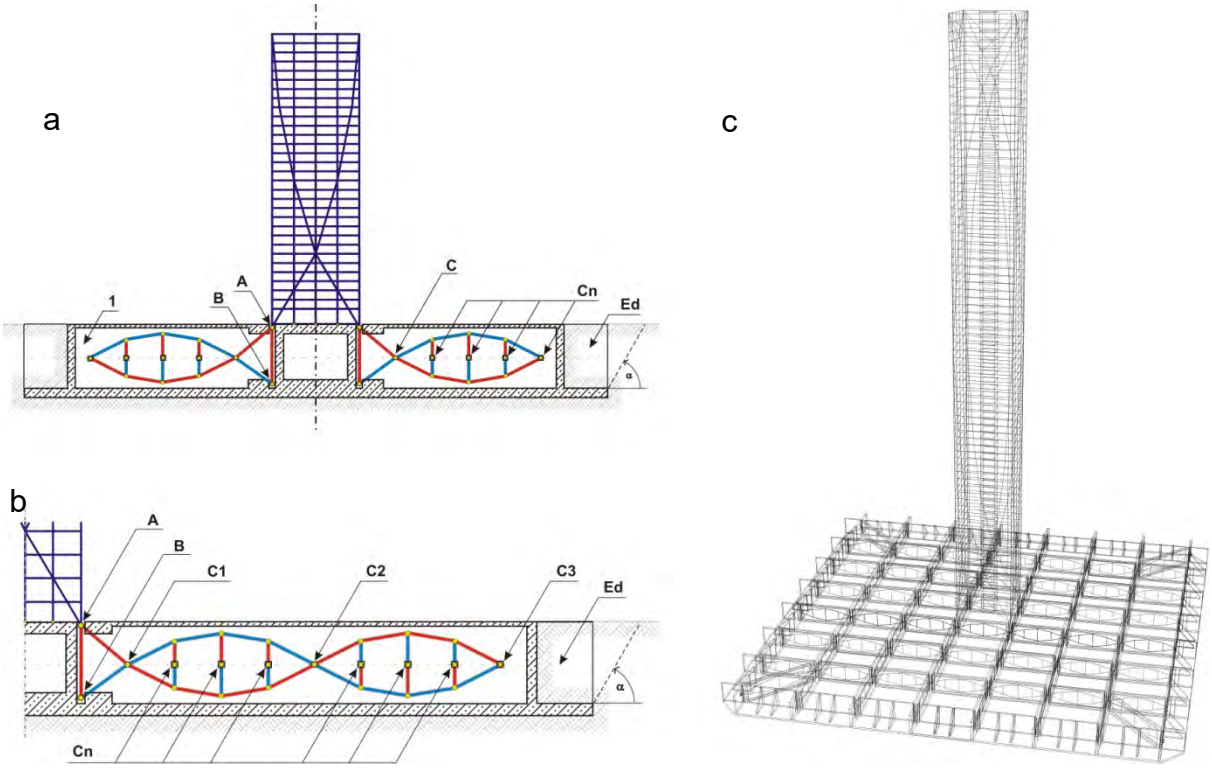

Fig. 7. Example of forms and applications of system of combined foundation

Design process of such complex structural system is also complicated, difficult and it takes a long time. Efficiency of the design process is considerably enhanced by application of numerical models defined e.g. in the programming language Formian [8]. It makes possible to use parameters, which applications make the process very flexible. Numerical models, defined by suitable sets parameters, enable the fast and easy modifications of shape of the designed building, which often has to be adjusted to the current requirements of the investment process.

Below there is presented text of Program F, prepared in programing language Formian, which defines numerical model of structure presented in Fig. 7.

Program F

```
01. use &,vt(1),c(1,1),vm(2),vh(0,-40,26,0,0,0,0,0,1);
02. Belp1={[0,0,0;40,0,0],[40,0,0;40,0,10],[40,0,10;0,0,10]};(*)Foundation beam(*)
03. Plyta={[0,0,0;40,0,0],[40,0,0;40,0,-1.5],[40,0,-1.5;0,0,-1.5]};(*)Base slab(*)
04. ScianOp={[34,0,0;34,0,10],[33,0,0;33,0,10]};(*)Retaining wall(*)
05. LiniaS=[0,0,5;40,0,5];(*)Central axis of foundation(*)
```

```
06. Os1=[6,0,1;6,0,22];(*)Axis of outer column(*)
07. Budynek={[6,0,13;0,0,13],[6,0,10;0,0,22],[0,0,16;6,0,16],[0,0,19;6,0,19],
      [0,0,22;6,0,22],[0,0,10;0,0,22],[3,0,10;3,0,22]};

08. TrojkGl={[6,0,1;11,0,5],[11,0,5;6,0,10]};
09. Soczewka=lam(3,5)|lam(1,21)|{[11,0,5;16,0,8],[16,0,8;21,0,9],
      [21,0,9;21,0,5],[16,0,8;16,0,5]};

10. Tuleja={[6.35,0,0;6.35,0,10],[5.65,0,0;5.65,0,10],[0,0,1.5;5.65,0,1.5],[0,0,9;5.65,0,9]};
11. PlytaGor={[0,0,10.5;6,0,10.5],[6,0,10.5;34,0,10.5],[34,0,10.5;34,0,10],
    [34,0,10.5;40,0,10.5],[40,0,10.5;40,0,10]};

12. Bloki={[6.35,0,9;9.25,0,9],[9.25,0,9;9.25,0,10],[6.35,0,1.5;9.35,0,1.5],
    [9.35,0,1.5;9.35,0,0]};

13. PolowaF=Belp1#Plyta#ScianOp#LiniaS#Os1#Budynek#TrojkGl#Soczewka#Tuleja#P
    lytaGor#Bloki;(*)Half of the foundation(*)
14. CalyFund=pex|lam(1,0)|PolowaF;
15. StropyG1=pex|lam(1,0)|rin(3,12,3)|[0,0,25;6,0,25];
16. StropyG2=pex|lam(1,0)|rin(3,15,3)|[0,0,14.5;6,0,14.5];
17. Parabol1=pex|lam(1,0)|{[0,0,22;3,0,34],[3,0,34;4.5,0,46],[4.5,0,46;6,0,58]};
18. SlupyB=pex|lam(1,0)|rin(3,3,12)|rin(1,3,3)|[0,0,12;0,0,34];
19. TallBudA=StropyG1#CalyFund#Parabol1#StropyG2#SlupyB;
20. draw TallBudA;(*) See Fig. 7(*)
```

2. Example of possible application of system of combined foundation

When particular components parts will be constructed as the waterproof boxes then the system of combined foundation will have a huge hydrostatic lift. That is why it may be considered as a kind of an artificial floating island and it could be the base for a building located there, see Fig. 8 and Fig. 9. The Ocean Agave is planned as a relatively small and independent settling unit that is self-sufficient in terms of energy and food supply. The conceptual design was prepared for needs of international architectonic competition eVolo2015 (author: Janusz Rębielak; technical cooperation: Wojciech Kocki and Maciej Rębielak). It is designed as an artificial island free-floating in subtropical ocean areas, in the far distance from land, and able to house a minimum of 120-150 persons.

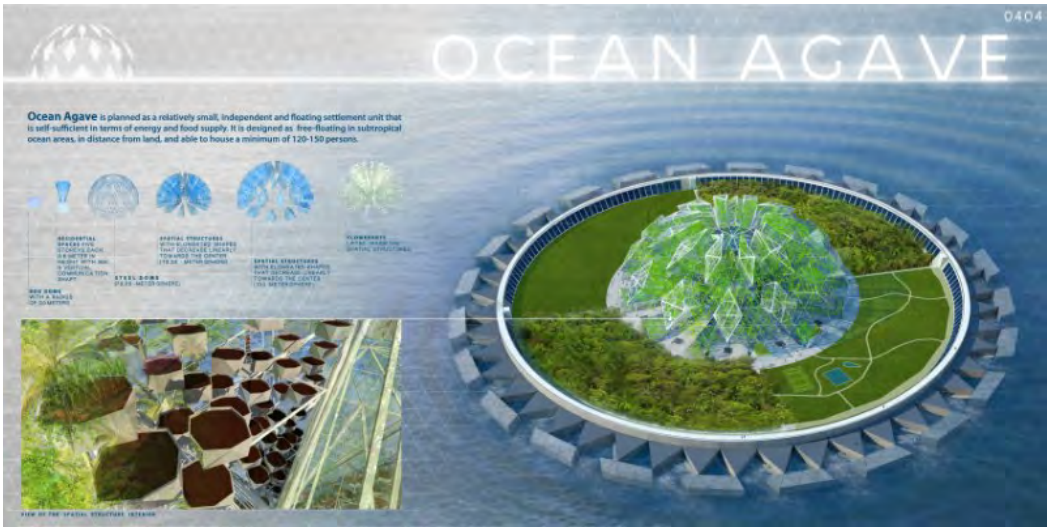

Fig. 8. Bird view of the floating platform called Ocean Agave

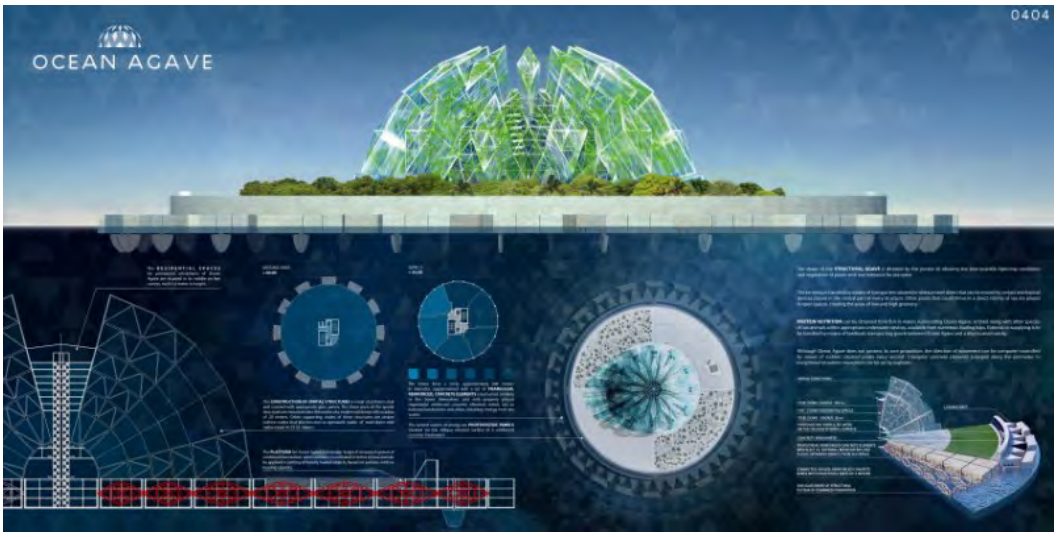

Fig. 9. Analytical schemes of the Ocean Agave

The platform for Ocean Agave is a circular shape of the proposed system of combined foundation, which in theory is unrestricted in terms of area and can be applied in settling of heavily loaded objects, based on surfaces with no bearing capacity. It is created using properly connected, sealed, reinforced concrete crates with structural depth of 15 meters, and with substantial uplift pressure. The draft of the designed structure is estimated between 2.50 and 3 meters. The crates form a circle, approximately 400 meters in diameter, supplemented with a set of triangular, reinforced concrete elements, constructed similarly to the crates themselves, and with properly placed trapezoidal reinforced concrete elements which act as breakwaters and allow obtaining energy from sea waves. The center of the base houses is a complex structure called Agave, divided into several dozen spatial structures with elongated shapes that decrease linearly towards the center, and whose axes converge in the central point of the whole setting. Their cross-sections are mostly rhombus-based, while only these directly connected to the upper platform's surface have their cross-sections shaped into triangles. A structure built this way possesses a form that closely relates to a sphere of 100-meter radius. The construction of spatial structures is made of stainless steel and covered with appropriate glass panels. The lower parts of the spatial structures are mounted onto the nodes of a smaller rod dome with a radius of

20 meters. Other supporting nodes of these structures are proper indirect nodes that also function as openwork nodes of a steel dome with a radius of 73.33. meters. The main residential structure is as tall as the before-mentioned radius, and is situated vertically over the central point of the structure.

Closing remarks

Appropriate application of principle of superposition makes possible to find new and very effective methods of calculations as well as the types of structural systems. Numerical models of architectonic buildings and of their structural systems, generated by application of selected sets of parameters and by means of suitable programing languages, make the design process fast and very efficient.

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COURCHIA Jean-Paul

Art and brain: thinking beauty.

Topic: art and science
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Abstract: Art and brain: thinking beauty
What is beauty? This notion is very subjective. Is beauty the representation of a beautiful thing or the representation of something beautiful? Asks Emmanuel Kant. As art evolves and beauty becomes superfluous, we will delve into the thought processes that trigger feelings of pleasure and happiness when glancing at a work of art. With the help of Emmanuel Kant, Sigmund Freud and Georg Wilhelm Friedrich Hegel, we attempt to understand the anatomy of beauty. Each of the aforementioned philosophers is unique in his view and understanding of beauty, and the feelings triggered in an individual because of being subjected to beautiful things. For Kant [1], our impression of beauty is governed by perceptions of morality, sensuality and rationality. Beauty appears through the prism of everyone's sensitivities and is, in essence, the product of positive feelings. Hegel, unlike Kant, thinks that beauty reveals truths and subconscious meanings vested in all us throughout time. For Hegel [2], man-made constructions, such as The Sphinx, are reminders that human civilization aspires to detach itself from nature. Art thus becomes superior, in a way, to nature because of this near spiritual undertone. Finally, Freud [3], understands human appreciation for beauty as an act of sublimation. Art allows the mind to let unacceptable thoughts that are to this point suppressed deeply into the subconscious, resurface in a socially acceptable manner. Beauty thus becomes the agent of a peaceful mediation between ego and superego.
Kant, Hegel and Freud seem to all agree that beauty is not imparted on us by art or any other medium; it is however the product of a personal energy triggered by an outside stimulus such as a work of art. In his book *When beauty saves us* [4], Charles Pépin expounds on this topic eloquently. It is thus up to us all to become the adjudicator on matters of beauty; and through introspection, discover if we belong to the Kantian, Hegelian or Freudian school of thought.

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Key words: generative art, camera obscura.

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Art and brain: thinking beauty.

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What is beauty? This notion is very subjective. Is beauty the representation of a beautiful thing or the representation of something beautiful? It is a paradox. Beauty is the intangible proof that can hardly be expressed. Everyone appreciates beauty but no one knows what it truly is. The words "it's beautiful" are often uttered with a universal undertone rarely considering the myriads of opinions on what makes something beautiful. We can say that beauty is proof without truth. Is beauty an intrinsic feature of a piece of music, a poem, a painting, or is solely the product of an effect operated by a subject on its viewer. Charles Beaudelaire 1868, oddly affirmed that "strangeness is a necessary ingredient in beauty" (*Curiosités Esthétiques*, *1868*). When humans judge anything, scales are often involved. Is a thing valuable, is it moral, is it rational, is it sensual? This process is completely dismissed when assessing beauty; beauty is not scalable.

The aim of our presentation is to go beyond the definition of beauty and investigate the effect of beauty on its subject. This work is strongly inspired by Charles Pepin's magnificent book: *When beauty saves us* (Robert Laffont – 2013), where he explores the notion of beauty as it was understood by the philosophers Immanuel Kant (1724 – 1804), Georg Wilhelm Friedrich Hegel (1770 – 1831) and Sigmund Freud (1856 – 1939).

For Kant [1], our impression of beauty is governed by perceptions of morality, sensuality and rationality. Beauty appears through the prism of everyone's sensitivities and is, in essence, the product of positive feelings. In the *Critique of the Power of judgment*, Kant introduces the concept of "free play" of human cognitive faculties (understanding and imagination). He says in the *Conflict of the Faculties* that "the greatness of man was inseparable from this struggle, in him, between his different faculties." For Kant, rationalism rules, at all times, over imagination. Beauty can only be imparted on someone who finds harmony between rationalism and imagination, at which point internal conflicts between internal forces is dissolved. Finally, Kant adds three criteria to his definition of beauty; it must be without interest, without concept and without purpose.

Hegel, on the other hand, thinks beauty reveals truths and subconscious meanings vested in all us throughout time. For Hegel [2], man-made constructions, such as The Sphinx, are reminders that human civilization aspires to detach itself from nature. To be sensitive to the beauty of the sphinx is to adhere to the idea that every culture aspires to tear itself away from nature. Art thus becomes superior, in a way, to nature because of this near spiritual undertone. Through the example of the Apollo, we understand that Greek statues are not only beautiful forms, they embody Greek principles: philosophy and democracy. For Hegel, the meaning of beauty is revealed by the symbols buried or purposefully omitted from a work of art. “A symbol is always the presence of an absence” says Charles Pepin [4]. The talent of the artist is to find a good balance between the presence and the absence.

Finally, Freud [3], understands human appreciation for beauty as an act of sublimation. Art allows the mind to let unacceptable thoughts that are to this point suppressed deeply into the subconscious, resurface in a socially acceptable manner. Beauty thus becomes the agent of a peaceful mediation between ego and superego. Facing a work of art, in the spirit of sublimation, the spectator finds the common point with the artist, not his talent but the origin of this one, his impulses repressed.

As art evolves and beauty becomes superfluous it is thus up to us all to become the adjudicator on matters of beauty; and through introspection, discover if we belong to the Kantian, Hegelian or Freudian school of thought.

[1] Critique of the Power of judgment (Kritik der Urteilskraft) Immanuel Kant (1790).

[2] Hegel's Aesthetics: Lectures on Fine Art. Georg Wilhelm Friedrich Hegel (1998).

[3] Beyond the Pleasure Principle. Sigmund Freud (2008).

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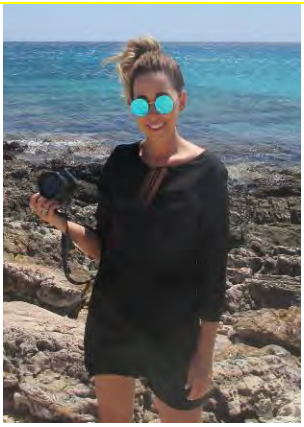

Chronophobia – Temporality, Technology, and The Artist
(Paper)

Topic: Art, Philosophy

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Abstract
Time could on the surface be thought of as linear, flowing like a conveyor belt moving horizontally from past to present to future. However, through surveying ideas, philosophies, and representations of temporality, and looking at the interplay between contemporary art and technology, we can understand how time is a much more complex notion. Philosophers such as Deleuze, Serres, Bergson, and others have looked at concepts of memory, eternal recurrence, the time-image, multi-temporality, presentness, duration, and temporal thickness. Their views are the antithesis to the concept of the present moment being a fixed, distinct point on a linear timeline and instead hold that the present is an accumulation of temporal events that dip into the past and the future simultaneously.

This paper provides some examples of ideas and representations of time through the ages, as well as a discussion on cinematic time. This is followed by an examination of temporality as it relates to the intersection of art and technology with a particular emphasis on generative machine code and human interaction. Finally, I conclude with an analysis of the relationship between the ideas and concepts presented and the development of temporal experiences in my own artistic practice.

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Key words: Temporality, Technology and Art, Non-Linear Time.

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[1] Timothy Barker, "*Time and the Digital*", University Press of New England, New Hampshire, 2012.
[2] David Rodowick, "Giles Deleuze's Time Machine", Duke University Press, North Carolina, 1997.
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TITLE
***The Light Keeper*, Ceiling Installation**
(Paper and Poster)

Topic: Architecture and Generative Process

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Abstract
The *Light Keeper* is a permanent ceiling installation for the Centre for Indigenous Initiatives (formerly Centre for Aboriginal Culture and Education) at Carleton University. The Centre aims to increase the recruitment and retention of Indigenous students, faculty and staff by ensuring Indigenous cultures, traditions and worldviews are sensitively represented at the University. The installation is located on campus in the Indigenous Centre, named Ojigkwanong, meaning "morning star" in Algonquin, as a tribute to the renowned Anishinaabe Elder Grandfather William Commanda. The installation was designed and built by the author along with architecture students and in consultation with the centre's architect Douglas Cardinal. The design is based on the theme of *light* as symbolic of knowledge and on the fact that the Carleton campus is on traditional, unceded territories of the Algonquin nation.

The ceiling installation is envisioned as an interconnected, woven assembly and support structure made of bands of birch plywood with coloured wire-mesh highlights at key locations. The design was generated from the inherent properties of the materials with no pre-conceived designs other than what emerged out of the haptic exploratory process. The dimensions and configurations extracted from this generative process led the design possibilities and were modified accordingly as the project evolved and in response to the specifics of the interior site. The design originates from one singular band of thin birch plywood with its ends overlapped together to create a circular frame that recalls the basic frame of the traditional native drum. The diameter of this circular frame is the minimum allowed by the pliability of the birch plywood. Accordingly, the basic design elements are the circle, the circular drum frame, and the interwoven "sounds" that would emanate from this source.

Overall, the ceiling is composed of modulating patterns within the overall collaborative weave, with the configurations and their inter-connected parts envisioned as symbolic metaphors for the Centre's mission/vision and the worldview of Indigenous Peoples.

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Key words: Generative process, modularity, Emergence, Indigenous culture

Main References:
[1] Reid, Bill and Bringhurst, Robert, "*The Raven Steals the Light*", University of Washington Press, 1996

Ojigkwanong: The Light Keeper
Ceiling Installation, Centre for Indigenous Initiatives, Carleton University

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Abstract
The *Light Keeper* is a permanent ceiling installation for the Centre for Indigenous Initiatives (formerly Centre for Aboriginal Culture and Education) at Carleton University. The Centre aims to increase the recruitment and retention of Indigenous students, faculty and staff by ensuring Indigenous cultures, traditions and worldviews are sensitively represented at the University. The installation is located on campus in the Indigenous Centre, named Ojigkwanong, meaning '*morning star'* in Algonquin, as a tribute to the renowned Anishinaabe Elder Grandfather William Commanda. The installation was designed and built by the author along with architecture students and in consultation with the Centre's architect Douglas Cardinal. The design is based on the theme of *light* as symbolic of knowledge and on the fact that the Carleton campus is on traditional, unceded territories of the Algonquin nation.

Overall, the ceiling is composed of modulating patterns within the overall collaborative weave, with the configurations and their inter-connected parts envisioned as symbolic metaphors for the Centre's mission/vision and the worldview of Indigenous Peoples.

The Raven, Light and Knowledge
As a symbol of a wise, courageous, cunning and paradoxical trickster, the raven permeates the stories of many diverse cultures. For example, as told by the acclaimed artist Bill Reid and the poet, cultural historian and scholar Robert Bringhurst in their book *The Raven Steals the Light*, for the Aboriginal peoples of the Northwest Coast the story of the raven recounts how a greedy and selfish elderly chief kept *light*, symbolising knowledge and wisdom, in his house locked in a bentwood box. The cunning raven tricked and distracted the elder, allowing him to steal the *light* and bring it to the earth and humanity in the form of the sun, moon and stars.

Of equal importance to the installation design is the naming of the Aboriginal centre as *Ojigkwanong,* meaning '*morning star'* in Algonquin. The light emitting from '*morning star'* is symbolic of Elder William Commanda's worldview and mission. Thus, the symbolism of the raven and of *Light* as wisdom and knowledge to both Indigenous peoples and Carleton University, offer the conceptual vision and catalysts for the project. The raven as a significant inhabitant of the land and the land's history, is much in line with the centre's initial design visioning sessions facilitated by Douglas Cardinal that called for a response to the land on which *Ojigkwanong* is located.

The Light Keeper
The ceiling installation is envisioned as an interconnected, woven assembly and support structure made of bands of birch plywood with coloured wire-mesh highlights at key locations. The design was generated from the inherent properties of the materials with no pre-conceived designs other than what emerged out of the haptic exploratory process. The dimensions and configurations extracted from this generative process led the design possibilities and were

modified accordingly as the project evolved and in response to the specifics of the interior site.

The birch bands were joined together with stainless steel fittings that serve as "beaded" connections. Overall, the ceiling is composed as modulating patterns within the overall collaborative weave, with their configurations and inter-connected parts envisioned as metaphors for the Aboriginal Centre's vision and focus. The design originates from one singular band of birch plywood with its ends overlapped together to create a circular frame similar to the basic frame of a traditional native drum. Thus, the basic generative design elements are the circle, the drum, the braided and/or woven 'sounds' emanating from this source, and the birchtree.

The Birch Tree

Found throughout almost all of Canada (referred to as the *Land of the silver birch* in a popular traditional folksong), birch trees provided numerous materials for survival. Birch wood and birchbark, being inherently resistant to decay, was used to make many practical things, such the iconic canoe, storage containers, snowshoes, bowls, wigwams, including beer/wine and syrup. Lightweight and highly maneuverable, the birchbark canoe was initially the main means of water transportation for Indigenous peoples and the *voyageurs* that used it later in the Canadian fur trade. Eventually it became primarily a very popular recreational vehicle, acquiring the status of a Canadian cultural icon. These cultural, practical and structural characteristics of birch are important underlying conceptual currents of the design in addition to their related resonances with the broader ethnic and multicultural diversity within Canada.

The Generative Circle and Drum

The design originates from the circular frame created when the ends of a singular band of birch plywood are overlapped together, recalling the basic frame of a traditional native drum. Where the band-ends overlap, a central pivot point allows the ends to rotate, de-forming the frame and re-aligning the end corners. This allows for additional extension bands to be added at both ends and they in-turn are braided together as allowed by their inherent de-formability. The initial circular frame, pivot point and braiding or weaving sequence generated the subsequent basic design configurations that emerged and were woven together throughout the installation. Thus, circularity is inherently embodied throughout the design reflecting the importance of the circle and circularity to Indigenous peoples. Overall, the design consists of turbulent woven patterns of birch bands that are highly ordered when surrounding the circular light fixtures throughout the Ojigkwanong ceiling and within its circular Ceremonial Space.

The Ceremonial Space

The Ceremonial Space ceiling design is based on the four cardinal directions (North, South, East and West) of the Sacred Circle and Medicine Wheel, their corresponding elements (earth, fire, water and air), and their associated colours (red, white, black/dark-blue, and yellow). The very center of this assembly is inhabited by *light* as a glowing Sun or '*morning star*.' Appropriately coloured wire-mesh fabric that has been folded into a fluidly flexible origami pattern is sculpted into forms that recall attributes associated with the dynamic Sun and corresponding element of each of the four cardinal directions. The element of earth was envisioned as a combination of the forms of the other three elements of air, water and fire.

The *Light Keeper* ceiling installation in *Ojigkwanong* contributes towards Carleton University's goals and commitment towards leadership in Indigenous affairs through cultural research, visibility, education and knowledge.

Project Images:

Figure 1: © M. Báez, *Light Keeper,* Circular Ceremonial Space

Figure 2: © M. Báez, *Light Keeper,* Central Sun detail

Figure 3: © M. Báez, *Light Keeper,* Generative process: Initial circular frame made from one birch-plywood band with the ends overlapped together with a central pivot. Additional bands are added and woven into the generative cellular unit. 5 of these units are shown in combination on the right.

Figure 4: © M. Báez, *Light Keeper,* Perimeter area detail

Figure 5: © M. Báez, *Light Keeper,* partial view, Ceremonial Space and perimeter area.

Figure 6: © M. Báez, *Light Keeper,* Circular Ceremonial Space detail.

Ojigkwanong *Light Keeper* installation student team:
David Anderson, Etai Atias, Jesse Bird, Aniq Chaudry, Zabdi Falcon, Sara Farockhi Boroujeni, Diego Juarez Gallo, Jon Miura, Jason Surkan and Antoinette Tang.

Additional installation student assistants:
Nahid Ahmadi, Mohammed Ali Navid-Bakhsh, Audrey Caron, Fiona Estwick, Alexandra Ianoul, Honey Kim, Dylan Morris, Heeva Salemi, Bernice Shum, Barbara van Waarden, Charlie van Waarden, and Nourhan Zaky.

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The Centre for Indigenous Initiatives

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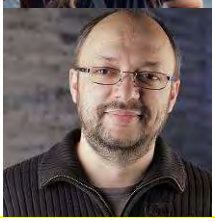

Creating 3D shapes by time extrusion of moving objects
(Paper)
Topic: (Art, Design)

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Abstract
The idea behind this paper is to investigate forms created as “time imprint” of moving 2D and 3D objects through space while simultaneously changing their transformations: translation, rotation, scaling, etc. The movement develops along a path that can be either assigned or random. In this manner, the movement, only possible with the time component, remains “frozen” in the form of a solid model. Hence, we may assume time as a modelling tool, which connects and unites successive movements of an object into a whole.
The procedure in question is visualized with Blender 3D animation and modeling tools. The render examples visualise time based extrusion of the object’s random transformations in 3D space. The transformations are randomly generated and controlled by noise function.
In order to examine the possibilities of such a creating of 3D shapes for more interesting results, we start from a 2D figure (snow flake), via elementary 3D figure (cube), and then examine how the form is enriched by introducing more complex figures as generatrices, for example concave polyhedron (CbP II-8), or a group of objects. For the procedure itself, we adopt a path which can be the simplest one (straight line, circle), or more complex (with curves, angles or nodes). We also explore what kind of "time imprint" in space leaves the chosen starting figure in a free movement, i.e. for a non-geometric path, but also randomly generated one.




The given modelling method provides simple and quick, but very intriguing options for creating a wide range of shapes that can be used in various areas of art and design: from graphic design, to a novel way of sculptural and even architectural design. These forms may convincingly represent natural and bionic forms, e.g. hair strands, vegetation growth, etc. The possibility of 3D printing enables the physical materialization of these shapes, suitable for further processing and use for decorative purposes, such as architectural ornaments or jewellery.
As an integral part of the research, we include animation which shows the method of generating shapes in the described manner.

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Key words: generative, 3D modelling, free form, extrusion, animation

Main References:
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Creating 3D shapes by time extrusion of moving objects

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Abstract

The idea behind this paper is to investigate forms created as “time imprint” of moving 2D and 3D objects through space, while simultaneously changing their transformations: translation, rotation, scaling, etc. The movement develops along a path that can be either assigned or random. In this manner, the movement, only possible with the time component, remains “frozen” in the form of a solid model. Hence, we may assume time as a modeling tool, which connects and unites successive movements of an object into a whole.
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As an integral part of the research, we include animation which shows the method of generating shapes in the described manner.

1. Introduction

3D modeling of solid figures can be performed as a CAGD or as a procedural modeling. Today's computer software enables both modeling methods to be about equally elegant, fast and convincing. If we desire to model some simple geometric form, the complexity in the procedures required for the same results would be insensibly different. However, when it comes to more complex forms, these two processes become a matter of choice. Free forms of nature (empirical forms) and free forms that are geometrically based, as products of an algorithm, will choose its natural allies in terms of modeling tools. Thus, CAGD will be a more natural choice for modeling a human figure or figures of other living species, while parametric modeling will be a more logical choice for abstract free forms. Yet, there

are also such natural forms that are closely related to mathematical formulas. The relationship of Fibonacci sequence with certain forms in botany and zoology is known, but these are not the only natural forms where procedural modeling can be applied in modeling. With implementation of generative approach, topographical surfaces, vegetation, or other natural forms can be successfully performed using procedural modeling.

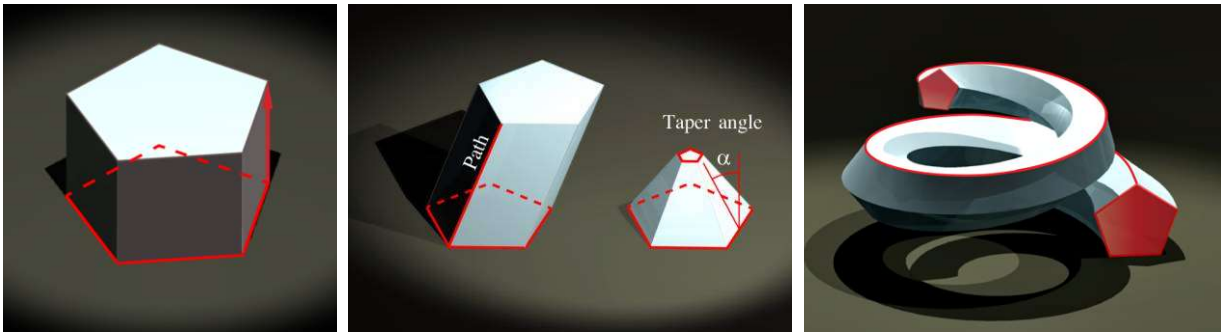
Our intention was to get shapes that are created by continuous connection of the successive movements of an object, as a solidified animation. In other words, we search for the shapes created by "time imprinting" of the original feature into space, its arbitrary movements, and dynamic change of a position (i.e. 3D transformations). This is also a process that imitates the natural occurrence of similar forms of growth, arisen over time: from the growth of plants, through the formation of cave stalactites or underground canals, all the way to, for example, hair strands. We did not want to stay on the literal interpretation of these forms, but to extend the theme by using the same approach: a time imprint of the original shape in the form of a 3D figure.

2. Time as a 3D Modeling Tool: Time Extrusion

The procedure itself is a variation of the sweeping scheme, whereby the starting object does not remain in a predictable position to the path, and the path also does not have to be predictable. The object moves along the path extruding its successive positions into one "mass", a unified solid object. In this way, if we would treat each of these successive positions as one "frame" of the animation, the shapes obtained in this way could be treated as a solidified animation, a frozen motion of the object. As motion is possible only with the time component, which also applies to growth, we have linked these two processes through the time component of generating shapes that remain as their consequences (imprints) in the space.
Time extrusion in this case means that the moving object extracts out all of its previous versions - positions, sizes, shapes, and transformations, leaving its complete history recorded in a single moment, in the form of a solid.

2.1. 2D figure time extrusion

When a profile (2D figure) in plane x-y is "extruded" by some of the 3D modeling procedures from the plane to the space (adding the third dimension), the 3D figure appears. This will be a surface, if the figure is an open linear, or a solid model, if it is a closed polygon. In this case, each edge of the profile will equally participate in the creation of a new solid's surface.
Let us try to replace the third dimension in the previous case with a time dimension. When a 2D profile performs a motion defined by a path, a 3D figure arises by linking its sequential positions.
Regularly, in CAGD modeling, if the path is a straight-line, it is a case of extrusion (Fig. 1 a and Fig. 1 b), and if it is a curvilinear path, it is sweep (Fig. 1 c). Since sweep scheme is more general case of extrusion, it also allows a certain twist of the profile during the motion, which in fact means that the profile can rotate around the path at the same time. During this process, the profile can be scaled, whereby another spatial transformation is performed. These transformations are linear and thus predictable, because the position of the profile's plane along the path is known in each moment of the motion[1].



a) b) c)

Fig. 1: 2D profile extrusion (a, b) and sweep (c)

Therefore, what these standard procedures have in common is not only the predictability of the profile position at any given moment, but also the predictability of the surface that envelops the resulting body. On the contrary, if the motion of the profile along the path is unpredictable, randomly-generated with noise formula which means that the rotation angles and the tilt of the profile plane to the path line can be variable, the 3D object to be created in this way will have a more complex geometry, unpredictable edges and the surfaces, and will be closer to the natural free form structures. In this case, some of the edges of the initial profile may be "swallowed", within the volume of the new solid. It depends on the current position of the profile, i.e. on its position at the observed point of the path. Which of the edges will that be, which will take over their places and roles, remains a matter of occurrence, which brings a new variety of form and introduces a factor of contingency, an intervention of chance.
Creating 3D objects in this way is done according to the following: Let us imagine that we have an initial 2D object. It can be a simple one, like a regular polygon, or more complex, like a snow flake (Fig. 2).

Fig. 2: 2D profile of a snowflake

The form of the snow flake is taken as an example because it is also a result of growth [3] and the unpredictability of forming its shape is under the influence of several factors, from the crystal structure of the ice, to the influence of the external environment. Thus, it is a good example of a combination of geometric patterns and natural phenomena.

By taking a snow flake for an example (Fig. 2), we wanted to indicate the possibilities of triple-generational forms that could be obtained in this way: the unpredictability of the shape of the profile itself, the unpredictability of its transformations along the path of motion, and the unpredictability of the path itself.

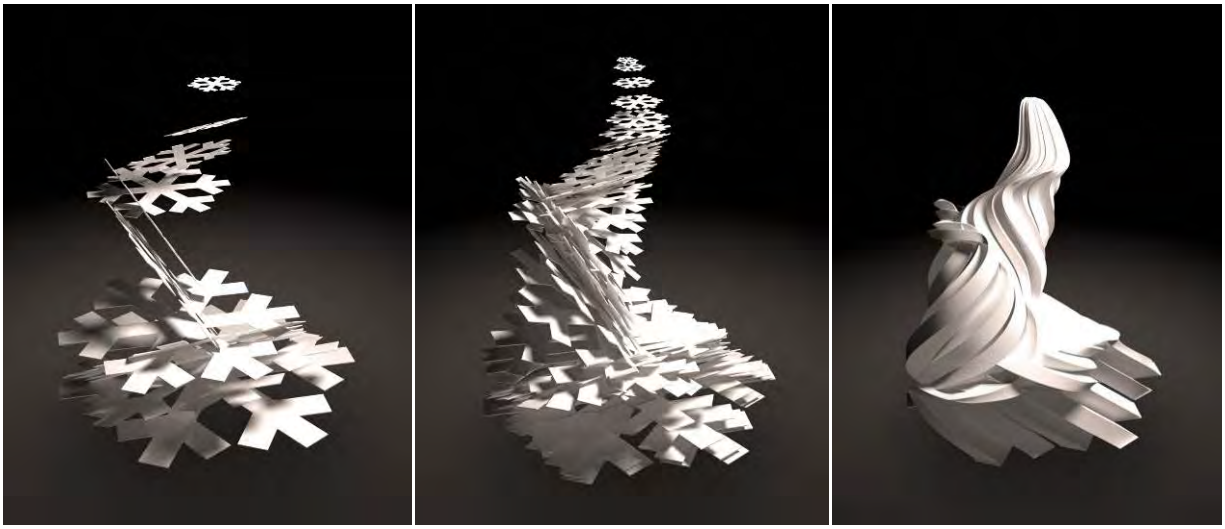


Fig. 3: Solidified motion of a snowflake, displayed by phases - frames

In this way, the solidified motion of snowflake (Fig. 3) in its form carries not only the recorded path of an arbitrarily chosen profile, but also manages to simulate an ephemeral process from the micro world perpetuated, to enlarge it and bring it from the everyday life to an artistic interpretation.

2.2. Forming the shape by motion of 2D figure

In the process of forming 3D shapes by changing its transformations, either they were random or given, the edges of the object should be considered. Every edge is, in fact, simple linear spline. Hence, we can also consider the object as a group of edges (splines).

The object moves through space and time. We can observe this movement as a movement recorded through a video, as a spatio-temporal set of transformations that are continuously integrated and make animation of the movement. Each frame extrudes each edge of the object. Polygons (the inner surfaces of the polygon) that make up the object are no longer important, so they might be even invisible. They are important for a static display of the object [1]. Accordingly, we come to what is particular for this modeling: as a standard, 2D objects are extruded, and the method presented allows and justifies an extrusion of 3D object as profiles, which then allows additional shaping and even lateral surfaces of the solid as new surprise factors in the final result.

3. Procedure Description

We used Blender3D with Cycle render for the visualization.
Random transformations of the objects have been generated with noise function applied to function curves. The phase parameter of the noise function (Fig. 4) has been used for fine tuning of transformations.

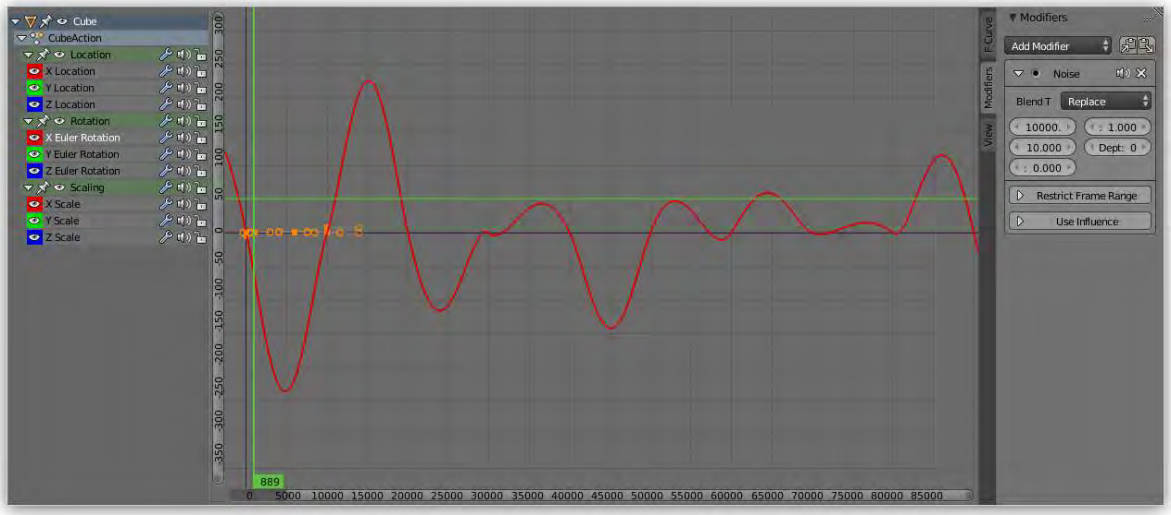


Fig. 4: an example of a finction curve used to rotate in Blender3D

DupliFrames tool with high number of duplicates has been used to duplicate objects along a transformation path.

If we extrude in time random positions of the profile along an arbitrary (random) path, practically countless possible positions of the profile are multiplied by yet another component of innumerable positioning possibilities. So, the actual shape will be the one of the possible cases which, in an elusive manner, connects certain positions between the random in one continual movement. This result gives an illusion of coordination between all of the previous randomities into a thoughtful sequence, which comes out of the frame of the author's idea (Fig. 5).

Fig. 5: a) The shape obtained by motion of a profile along a random path

3D figure time extrusion

Since in standardized 3D modeling procedures, extrusion capabilities of 3D profiles (already three-dimensional figures) are not specifically considered[2], we will notice some extra properties of such extrusion, examined from the geometric aspect.
By including a 3D figure in creating a new solid, the uncertainty of its shape increases for one more level, due to the unpredictability of the of the surface's outline, which the solid itself leaves behind as a trace of its movement.

3D figures can be defined by different geometric surfaces. Locally speaking, they can be, depending on Dupin's indicatrix [9] of the tangential planes, or. Gaussian curvature:

- parabolic (cylinder, cone), the tangential plane touches the surface by a straight line, Gaussian curvature equals zero
- elliptic (spheres, ellipsoids, torus ...), the tangential plane touches a point, the Gaussian curvature is positive
- hyperbolic (reversible hyperboloid, hyperbolic paraboloid ...), the tangential plane touches two lines, Gaussian curvature is negative.

Depending on the complexity of the 3D profile's surface itself, as well as on the complexity of the path, different and not always predictable results can be expected in the creation of the newly obtained solid's envelope surface.
Let us take a simple parabolic surface – cylinder, as an example (Fig. 6). Its motion along a path will give an envelope surface corresponding to the motion of a cylinder's directrix along the path. Such a surface can be: from 2D surface (plane) to more complex ruled surface. The axial plane of the cylinder remains perpendicular to the path, due to the base circle tangentiality.

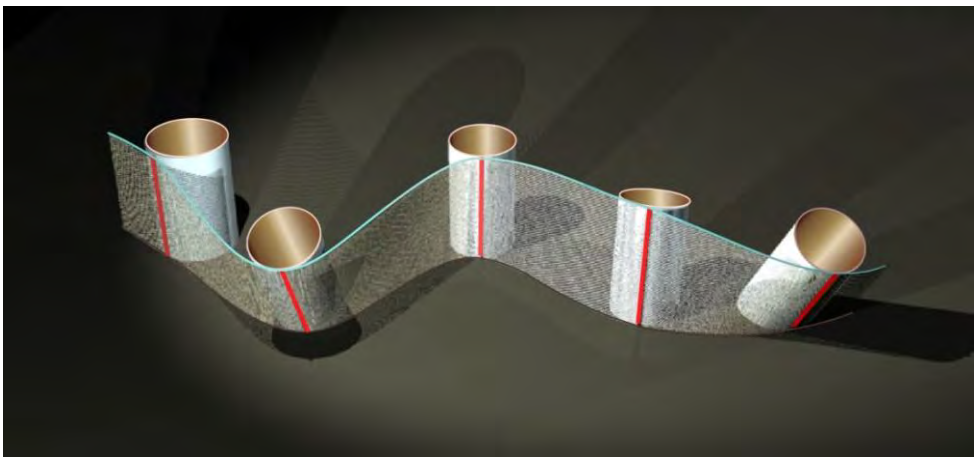
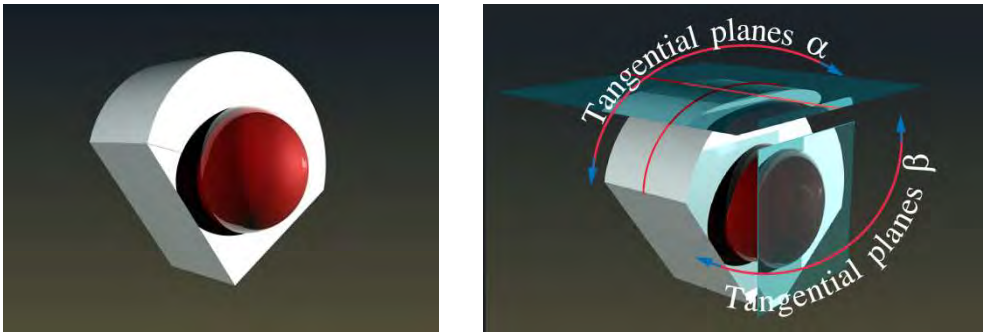


Fig. 6: The surface that arises an envelope swept surface of a cylinder

As another example, the motion of the sphere along a circular path will give the torus, corresponding to the motion of one of its great circles. Even the movement of the sphere along a more complex path will not provide notably different results, comparing to the motion of a circle. In these cases, the transition from the 2D to the 3D figure is not reflected on the final outcome of the obtained solid and its outline, because the surface normals stay perpendicular to the path.
But, if it is the case of a composite solid, as in Fig. 7, where there is a combination of cylinder, sphere and cube, then its movement along an arbitrary path, even be it just a translation (no other transformation applied), as in Fig. 8, already produces less predictive outcome concerning the surface that will be the result of its extrusion.



a) b)

Fig.7: a) an example of a 3D figure b) the surfaces of the figure that leave their imprint in space by time extrusion

We show an illustration of 24 translated positions of described composite 3D figure along the path in Fig. 8, in order to show that on certain sections of the trajectory, the different surfaces of the figure are visible, the ones that will form the final surface of the solid[3].

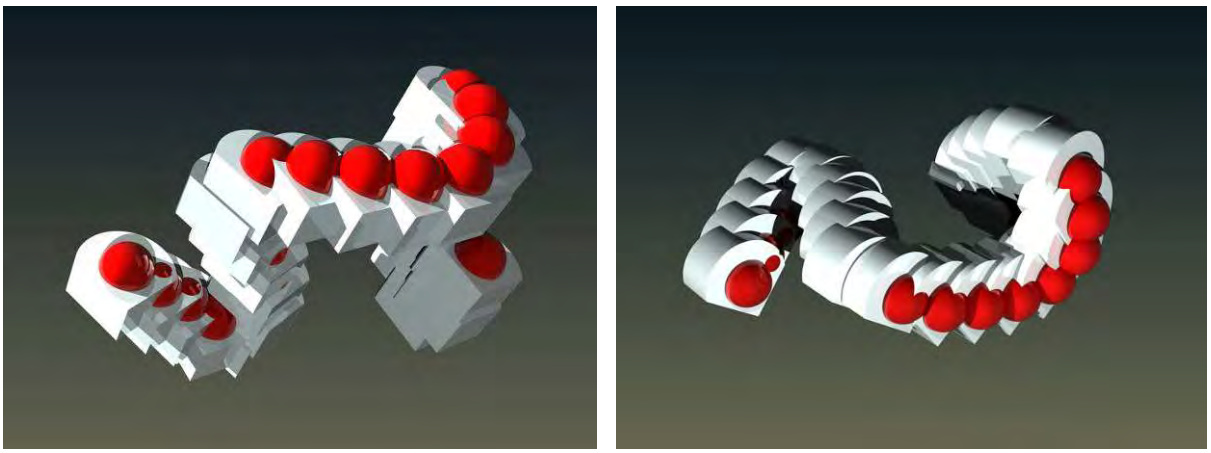


Fig. 8: The given 24 positions of the 3d figure during the motion along the path

If we add to the above the unpredictability of the 3D figure's position, due to the change of transformations while moving along the path, the effect of the unpredictability of the final result is further increased.
Thus the outlines, as well as the tangential plane to the surface of the so formed solid, are also of unpredictable position for each of the "frames". If the (random) rotation of the object is involved, and the 3D figure has curves, bumps, cavities, torsions etc., then the resulting surface gets an additional unforeseeable attribute, because what at one point was in the interior of the solid, "swallowed" by the mass of the other positions, may at some other point be found on the surface. In this way, the surface of so formed solid is not created only by the edges of the profile, but also by the curvature of the surfaces, the tangential planes of the figure itself, as the envelope of the newly formed solid's surface.
For example: the 3D profile, during the simulation, can be rolled over the given surface, thereby modeling the resulting solid which perfectly fits the surface, and yet it is chaotic and spontaneous.

To sum up: when a 2D object is swept along the path, a 3D solid is created; when the 3D object is swept along the path, 3D solid is created again, because in our 3D space we can not physically present more dimensions, but the resulting 3D solid carries information about the 4D that was present while it was in motion.

Fig. 9 shows a solid formed by random 3D transformations of the cube that moves along the simplest - straight line path. The result is a 3D figure that emerged as a time imprint of such a movement of cube in space.
The random-case example could be an illustration of the solidified motion of the play dice while throwing it.

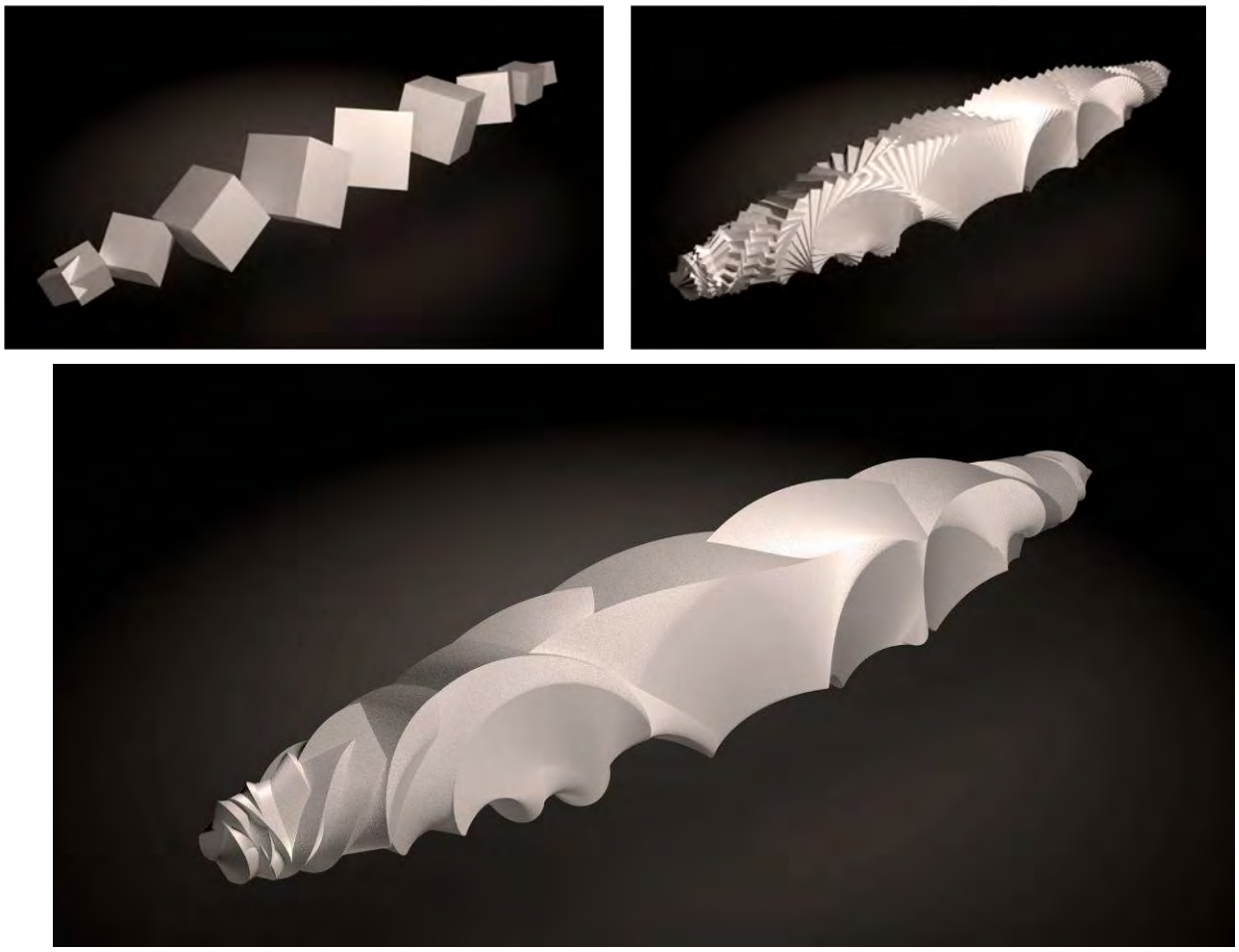


Fig. 9: examples of 3D object – cube time extruded linearly

4. Animation as a modeling tool

When we transfer the above considerations from theoretical to technical aspect, we may treat the animation of an object, which is by definition time-dependent, as a 3D modeling tool. Animation can be defined by key-frames which are describing transformations, thus creating a continuity of movements and creating a spatial-temporal framework characteristic for this way of modeling.
If we have assumed that 3D solids are created by changing transformations in time, and that transformations involve changing positions of the solid (translation, rotation, scaling), such a motion of the solid can be associated with path animation. Path animation is just a variant of translation ("translate along a path") that allows us to visually define the path of the object. Path is actually a helper object and will not be displayed in the model, alike the path in 3D modeling tools which is also just an auxiliary object, not displayed in the final result .

Additional value of animation as a modeling tool lies in the fact that it is a creative process, and as such has expressiveness. It has its own language: acceleration and deceleration, interruptions and repetitions, squash and stretch (concepts introduced by Disney), inertia, forces that affect the object. In this way, transformations are complemented by deformations, the object experiences alterations over time, all of which are recorded in a solid form.

Animation can also be a spontaneous simulation of motion generated by the influence of force such as gravity, vortices, attractive and reactive fields, simulated winds, etc. Right then, the element of the occurrence takes effect, by turning modeling process into an experiment in which each result comes as a surprise.
The motion of the cube from Fig. 9 could now be complemented by changes in its successive shapes, when scale transformation would be randomly applied to its individual dimensions, not only to the overall solid. The result is the additional unpredictability of its final form (Fig. 10).

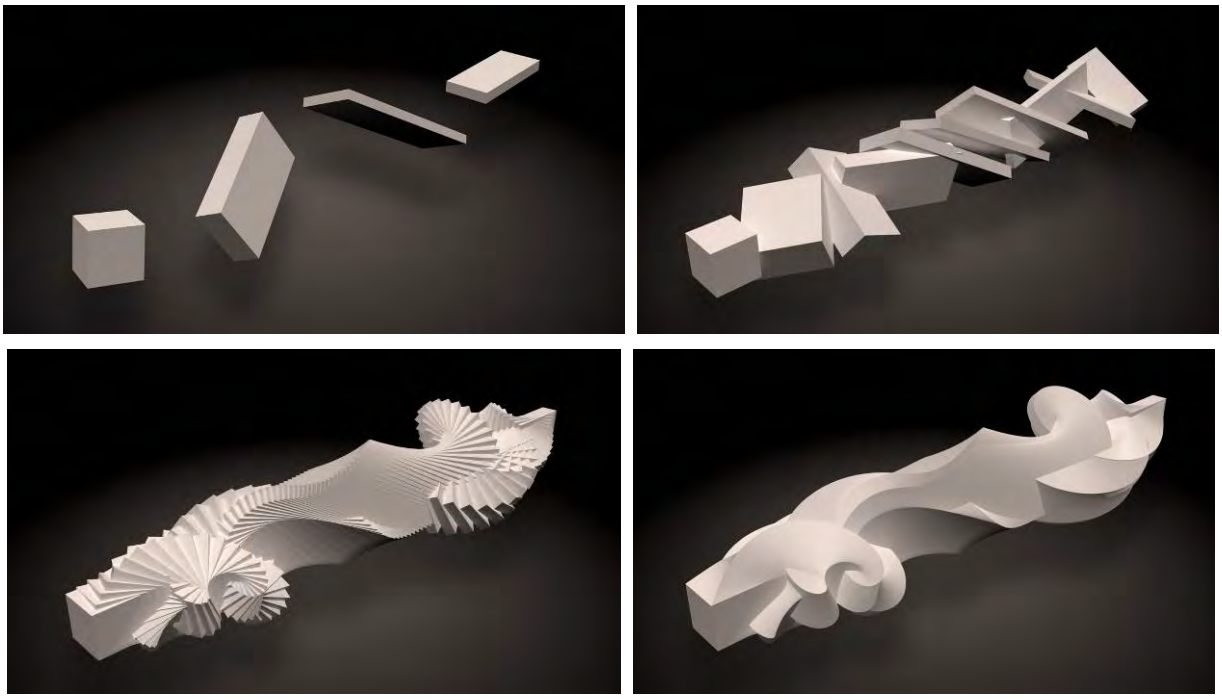


Fig. 10: Time extrusion of the cube randomly scaled by its individual dimensions

As a result of this process, we get a solid that is actually a three-dimensional projection of a four-dimensional space-time structure, its imprint in 3D space, using the time dimension.

5. Examples of complex forms generating using the time extrusion technique

Based on the aforementioned procedure, we can approach the experiment of generating forms by random motion of a complex 3D object (concave bipyramid CbP II-8 **Errore. L'origine riferimento non è stata trovata.**) and by a group of objects set on the assigned or random path, in order to compare the results and see clearly the differences in the "time imprint" of these forms in space.

The sequence of solid formation by random rolling of CbP II-8 along a path, as time extruded motion of the shape, we show in the Fig. 11.

Another example is given, showing a group of objects that move by random paths and transform dynamically (Fig. 12).

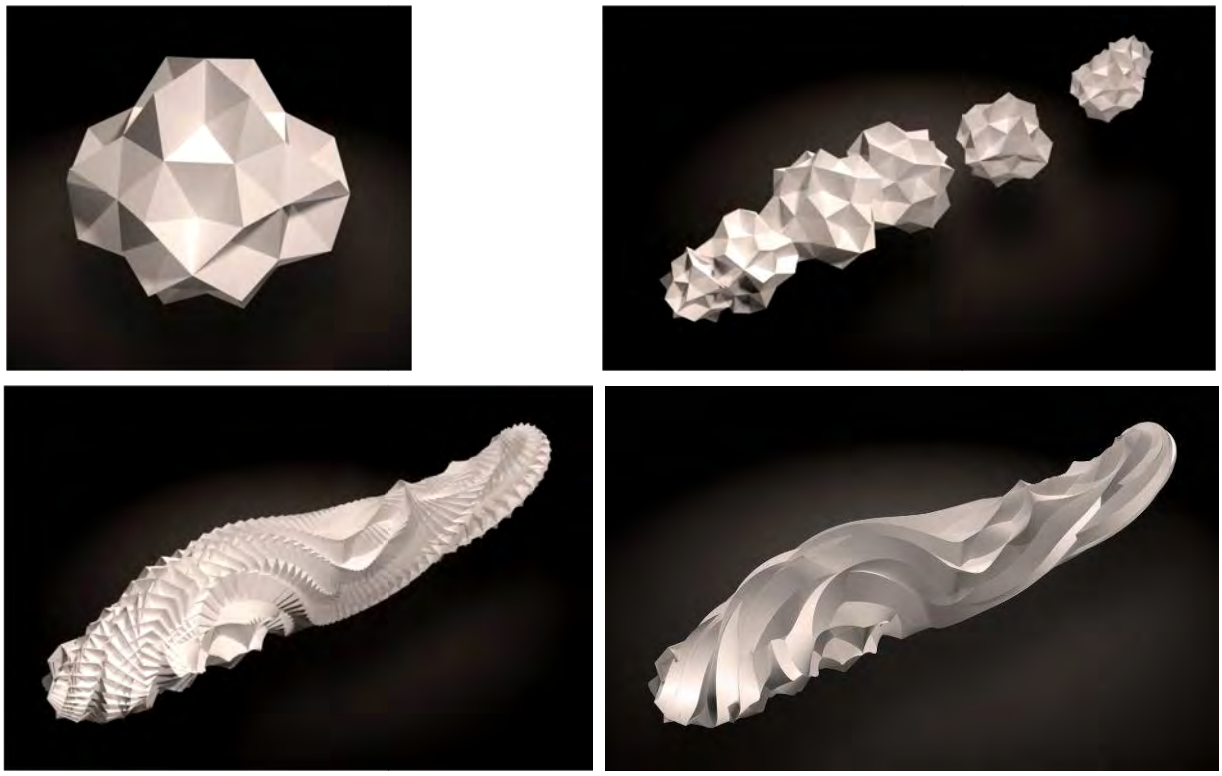
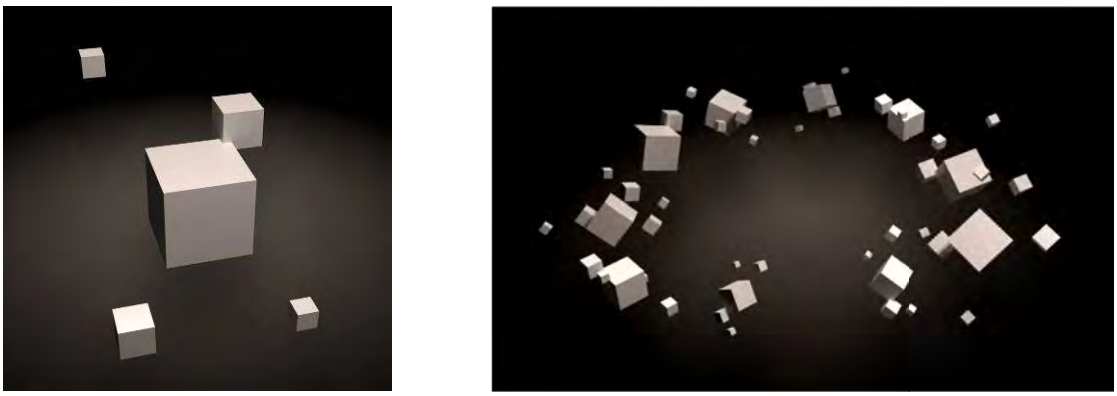


Fig. 11: 3D object –Concave bipyramid of the second sort (CbP II-8) time extruded

The space between the objects in the group allows each individual element to appear in its shape, without losing and disintegrating the edges within the solid's mass, making the starting figure unrecognizable. The composition of several elements adds an extra challenge in the interaction of the figures themselves: when and whether they will be interlaced, crossed, penetrated or bypassed, creating a fluid play of shapes struggling simultaneously for domination and harmony.



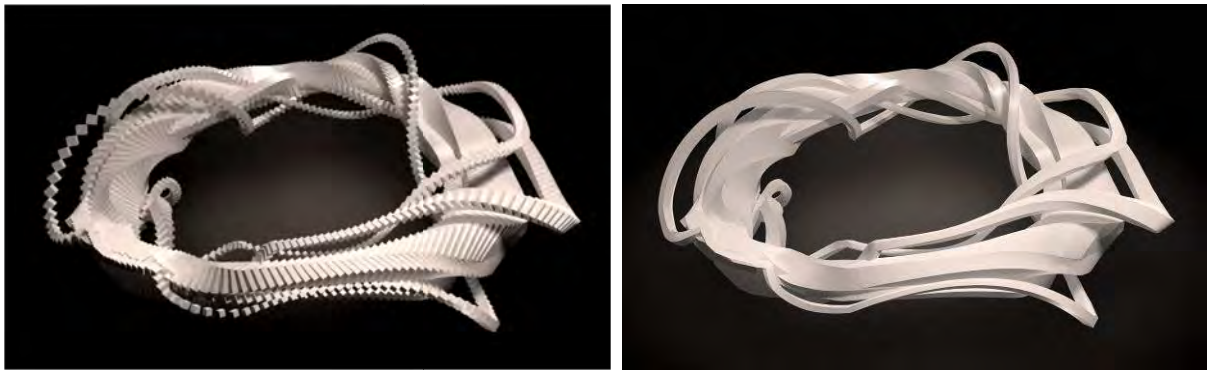


Fig. 12: example of group of 3D object time extrusion by a random closed path

The results we have obtained testify that the more complex initial forms will produce the even more complex outline of the outcoming surface of the solids. Although this was expected, the playfulness of the shapes, outlines, masses and volumes would always give an unexpected and surprising result, which we can not know before the end of the experiment.

6. The Prospects of Application

The forms obtained by time extrusion, due to their playful and vivid lines can be used as decorative elements or act as individual sculptures. They can also be used more widely. Such shapes are characterized by continuity, which makes them suitable for 3D print [6]. This feature greatly contributes to their applicability in different areas of arts and design. They can also be applied at certain time lapse simulations of natural, physical or mechanical phenomena, in science and engineering.

Let us mention just a few of the possible applications of these forms:

- In architecture: from constructive elements, such as pillars, to ornaments [4], elements of interior decoration, elements of landscape architecture (patterns of green or floral areas), urban mobiles and the like.
- In design: 3D modeling of natural forms, e.g. human hair, vegetation, to forms in digital graphic design, illustration, animation, etc.
- In applied art: jewelry, everyday items.
- In art / sculpting: sculptures, fountains.
- In science: as 3D simulations of natural processes.

Conclusion

Starting from the basic tools and procedures for 3D modeling, we transposed extrusion from the instant spatial operation to the motion in time. This motion provides freedom in the form of random movements of the profile itself, and also a randomly defined path. We examined the results of the motion of a 2D figure, and then raised the problem for one dimension and examined the time extrusion, a solid trace in space, left by 3D profile during its motion, i.e. the changes of its transformations. We concluded that such time extrusion of profiles can be equated with solidified animation of the profile itself. Animation as a creative process gives additional freedom and variety of transformations, deformations and re-shaping of the figures. Taking all these factors of unpredictability, coincidence and

freedom of movement, we generated random animation in Blender 3D software and examined the formation of shapes in the described method. We used selected 2D and 3D profiles in the experiment. The forms we obtained as a result of this study, along with analogies with natural forms, carry an additional component of the human impact – an artistic one, but also go beyond artistic, providing surprising and boisterous forms with the sophistication of human influence. As such, they might find application in numerous fields of design, arts and science.

Notes

[1] In most commercial programs, this position is orthogonal by default, but it is also possible to specify a different angle between the path tangent and the plane of the profile at the given point.

[2] They are not yet included in standard procedures, although techniques have been considered in some recent research.

[3] In this paper, we do not provide an example of a solid obtained with a 3D figure with curved surfaces, because their polygonal modeling would take too much time to render. These forms can be modeled volumetrically, so this might be a subject of further research.

Acknowledgement:

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TITLE
Surface and Structural Generative Processes in Music

Topic: Music

Author:
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Abstract
The discussion examines the use of generative processes applied to musical parameters active on multiple structural levels of a musical work. Examples demonstrate application of processes to pitch, rhythm, timbre, formal structures, and proportions in the author's acoustic and electro-acoustic music. Further investigation explores how processes generate structural integration, disruption, and decay or disintegration.

Biography:
Mark Zanter, composer/performer, has been commissioned by the UIUC Creative Music Orchestra, CU Symphony, the American Composers forum, the WV Commission on the Arts, WVMTA, Due East, Şölen Dikener, Rick Kurasz, Çetin Aydar, Ankara University Soloists, Lindsey Goodman, Trifecta!, Awea Duo and many others. He has appeared on NPR's Live at the Landmark, WILL, IPR, on WVPN In Touch With The Arts, is published by Les Productions d'OZ, Schott European American and MJIC, and his works have been performed nationally and internationally at festivals including, MUSIC X, June in Buffalo, Soundscape (Maccagno, Italy), NYCEMF, Echofluxx14 (Prague, Czech Republic), SEAMUS, Atlantic Center for the Arts, Seensound (Melbourne,AU), NFA and ICA International Conferences. Zanter has received awards from ASCAP, AMC, ACF, Meet the Composer, WV Division Culture, WVMTA; *Lament and dream* for string orchestra, piano and percussion received special distinction for the ASCAP Rudolph Nissim Prize. Zanter's music has been issued on the Ablaze, Navona, and innova record labels. Dr. Zanter is professor of music; and Distinguished Artist and Scholar at Marshall University.

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Key words: generative sequences, fib, pi, musical structure, improvisation, music theory

Surface and Structural Generative Processes in Music

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Abstract:

The discussion examines the use of generative processes applied to musical parameters active on multiple structural levels of a musical work. Examples demonstrate application of processes to pitch, rhythm, timbre, formal structures, and proportions in the author's acoustic and electro-acoustic music. Further investigation explores how processes generate structural integration, disruption, and decay or disintegration.

1. Compositional Process

In my music processes are used to generate sequences of intervals, permutations of pitch, rhythm; or to shape phrase and formal proportions. Processes generate segments that can be expanded, contracted, abstracted with the relationship between segments often being mirrored on different levels. My general practice is to use processes that generate material; and to review and refine output using observation/evaluation, while taking into account how tools and the medium influence musical choices. As will be seen, the choice of specific processes generates diversity between individual works, while at the same time unifying those works stylistically (Soddu, Colabella, 2013).

Adopting the approach that creative thinking is a form of problem solving (Gilhooly, 1996), I will position the discussion within the context of Wallas' four stages of creative activity: preparation, incubation, illumination, and verification (Wallas, 1926) focusing mainly on the first and last stages. Generative processes are used in the first stage, preparation, where concepts and problems are identified, defined and assessed in reference to chosen materials, the medium, and large-scale proportions of the work. Processes generate material providing intermediate solutions that parse multi-dimensional problems into manageable parts. The refinement, development, and evaluation (i.e. verification) of processes, is also integral. In verification the composer can be both creator and observer, gauging the effectiveness of processes on both micro and macrocosmic levels. New processes can be created at various stages during composition and at each stage, work may be interrupted to solve problems, make refinements, or create connected alternates as the need arises (Reitman, 1965).

I often map sequences of numbers to pitch durations, or glean them from a motive, fragment or theme. In other works I employ numeric triangles, and/or the Fibonacci sequence to dictate surface rhythms or structural proportions. When these sequences are mapped to durations, the surface of a composition exhibits rhythmic variety while at the same time unfolding a larger schema of proportional segments, structural phrases, or formal sections. In this case I find the Fibonacci sequence particularly useful since the proportions between members of the sequence approach .681, or 1.618 as the sequence

unfolds making it a reliable method for integrating structural proportions between sections of a work. The proportional relationship between numeric triangles approaches 1.0 as the sequence unfolds, which dictates careful planning and limits the length of sections if particular proportions are desired. Figure 10 demonstrates the application of the Fibonacci sequence to large structural proportions in my work *Kaleidoscope*.

As a performer, improviser I am concerned with the malleability/flexibility of processes and this informs my composition, which is more formalistic. The influence of improvisation can be traced in my compositional process where invented processes generate the surface of a work. This method enables the shaping of segments that are easily perceived, and grouped into hierarchical structures integrating recursive elements on multiple levels. This is a well understood trait of historical music illuminated by Schenkerian analysis, and the Generalized Theory of Tonal Music (Rowe, 2001).

2. Composing with schema

The example from *Character Study IX* for solo guitar exemplifies the approach. The work is composed around a master sequence of interval classes that unfolds over the course of the work. In the excerpt below IC5, IC4 are the main constituents. Other intervals arise as embellishments, parts of a transpositional schema, as completions of gestures, or as a segment of the master sequence. Unfolding the sequence slowly limits interval content, and freely composed phrases operate within this limit. Figure 1 below demonstrates.

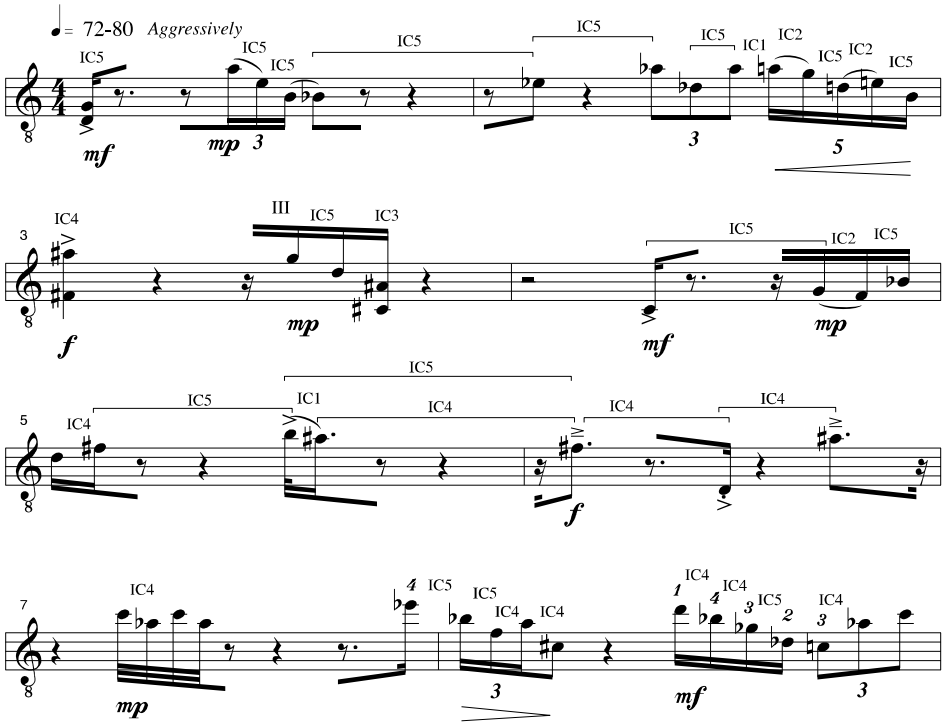


Figure 1: *Character Study IX* for solo guitar, mm. 1-8.

As this work progresses the master sequence emerges as all interval classes are introduced. The composition of the surface of the work is informed by preparation and observed in verification. Results are continually monitored and reshaped to control density, proportion and ensure adherence the pre-compositional plan.

In the example below new intervals are introduced in mm. 21-ff and the master sequence

begins. Compare the figure below with the opening of the work where IC5 and IC4 the first two intervals of the sequence are presented over two measures. The process gradually unfolding a theme in smaller segments is termed epiphanic. (Shiff, 1998) It is an integrative process used in both *Character Study IX*, and *String Quartet*.

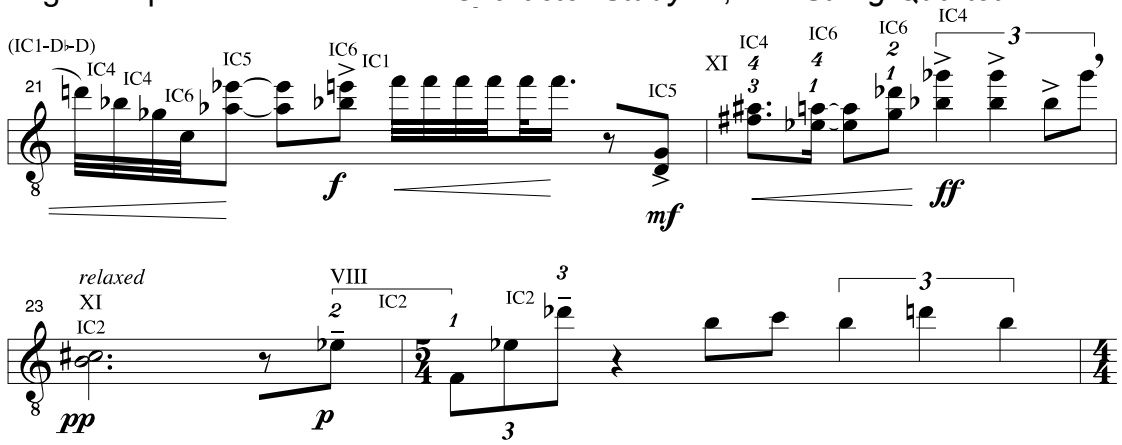


Figure 2: Character Study IX for solo guitar, mm. 21-24

3. Generative Sequences

In much of my concert music I employ numeric sequences such as numeric triangles, the Fibonacci sequence, or Pi to generate surface textures. The next few examples will demonstrate their use in *String Quartet* (2011), *Gestures I* (2012), *Kaleidoscope* (2007), and *Artifacts* (2014).

Often numeric triangles or the Fibonacci sequence are used to generate rhythmic durations. In the opening of *String Quartet* numeric triangles are mapped to sixteenth note durations.

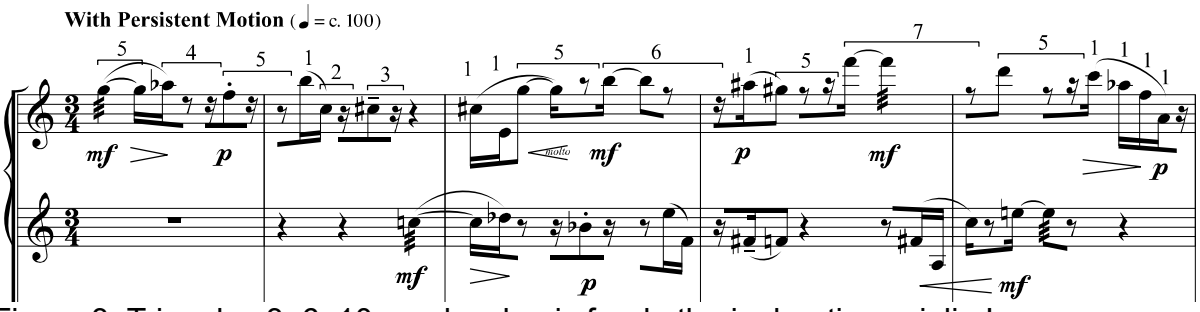


Figure 3: Triangles 3, 6, 10 used as basis for rhythmic durations violin I

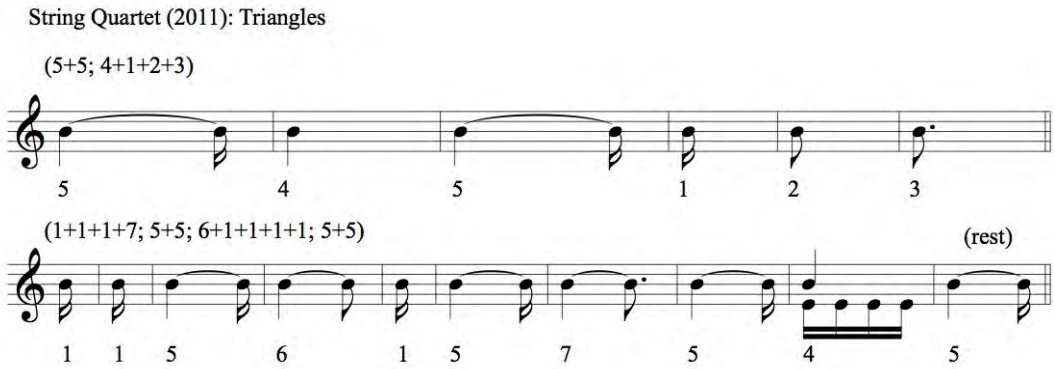


Figure 4: Triangles 3, 6, 10 shown as single durations

The Fibonacci sequence is employed in a similar manner later in the work. In mm. 74-ff violin II uses a repeating sequence of 3, 5, 8 sixteenth notes. The violoncello uses durations of 1-3 sixteenth notes freely in counterpoint with violin II, while violin I and viola perform a slow melody that unfolds the interval sequence (m. 78: Ordered PC intervals: 1, 2, 3, 4, 6; m. 86: IC 1, 2, 3, 4, 5; m. 94: IC 1, 2, 3, 4, 5, 6, 7).

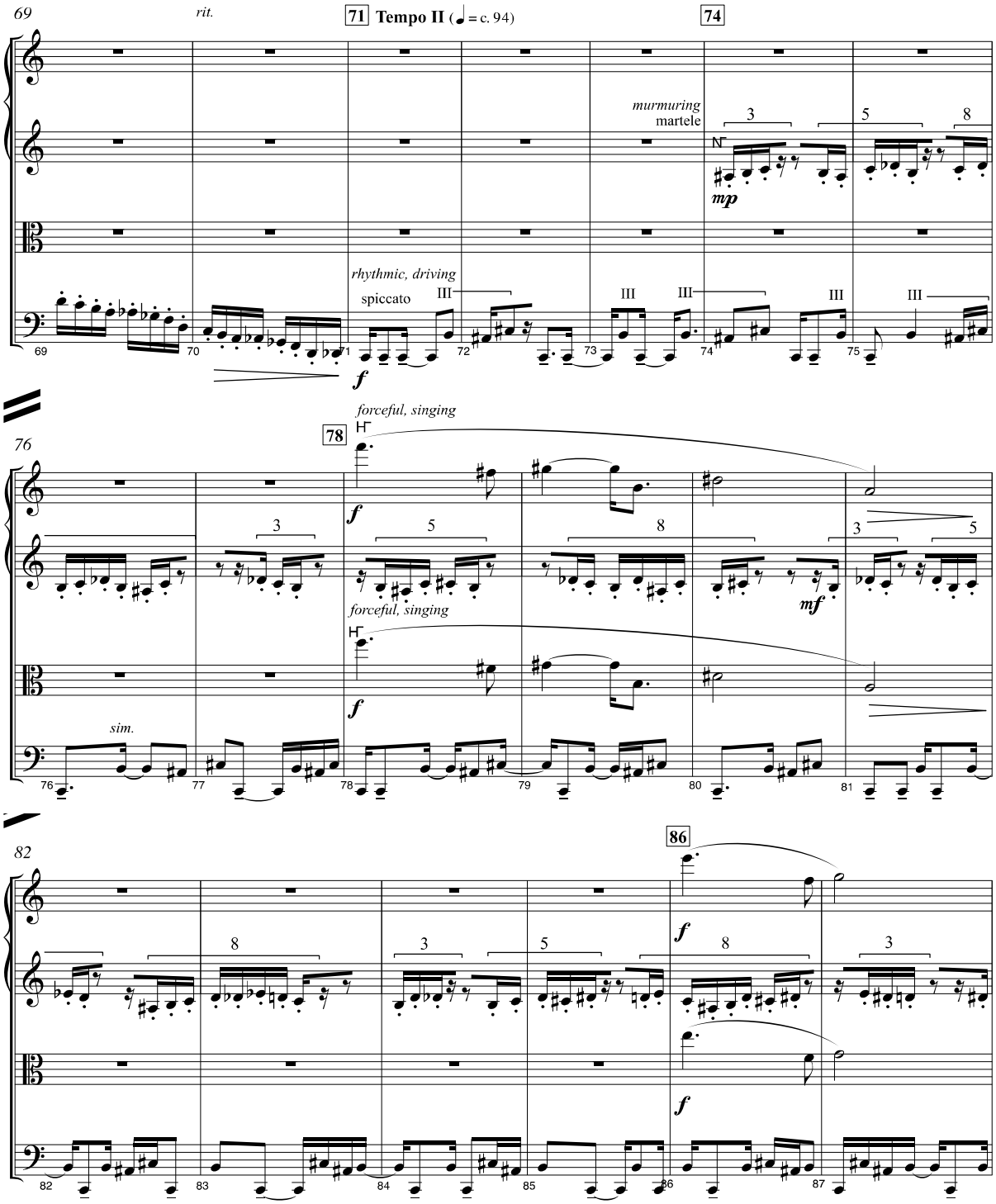


Figure 5: String Quartet Fibonacci sequence, mm. 74-ff in violin II.

String Quartet (2011) also employs an interval series using permutations that unfold gradually into increasingly complete statements; Ordered PC intervals 1, 2, 3, 4, 5, 6, 7, 8.

OPCi: 1-7 shown below.

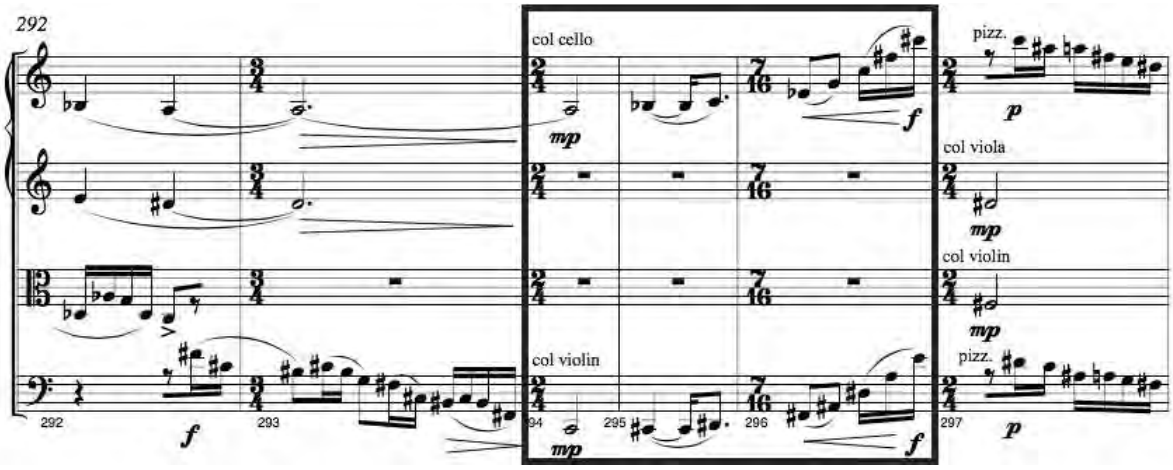


Figure 6: *String Quartet*: interval series, m. 294.

In early portions of the work, the interval series is abstracted and appears in forms that are distributed within and between parts. In the figure below notice the gradual accretion of interval classes 1-6. Violin 1 and 2 imitate each other, as do the viola and cello at IC5. The rhythmic offset of imitative voices combined with transpositions generates all intervals in mm. 3, 4-5. Variations of this type appear throughout the work, with the full series only being revealed later.

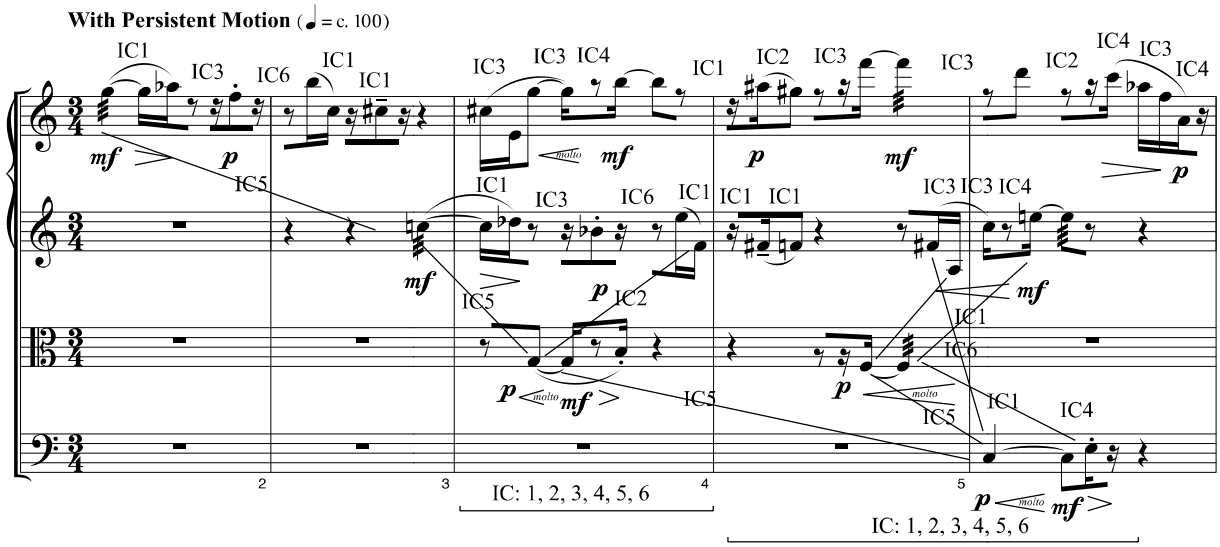


Figure 7: *String Quartet*: interval series, mm. 1-5.

Another striking example of the interval series appears in mm. 503-507. In m. 503 violin I presents OPCi 1-8, and in mm. 504-507 the violoncello, viola and violin II play sonorities using the interval series to expand outward from the central set (014) in m. 505. The expansion results in the inversion of the original set $T_{11}I$ (014; 7TE).

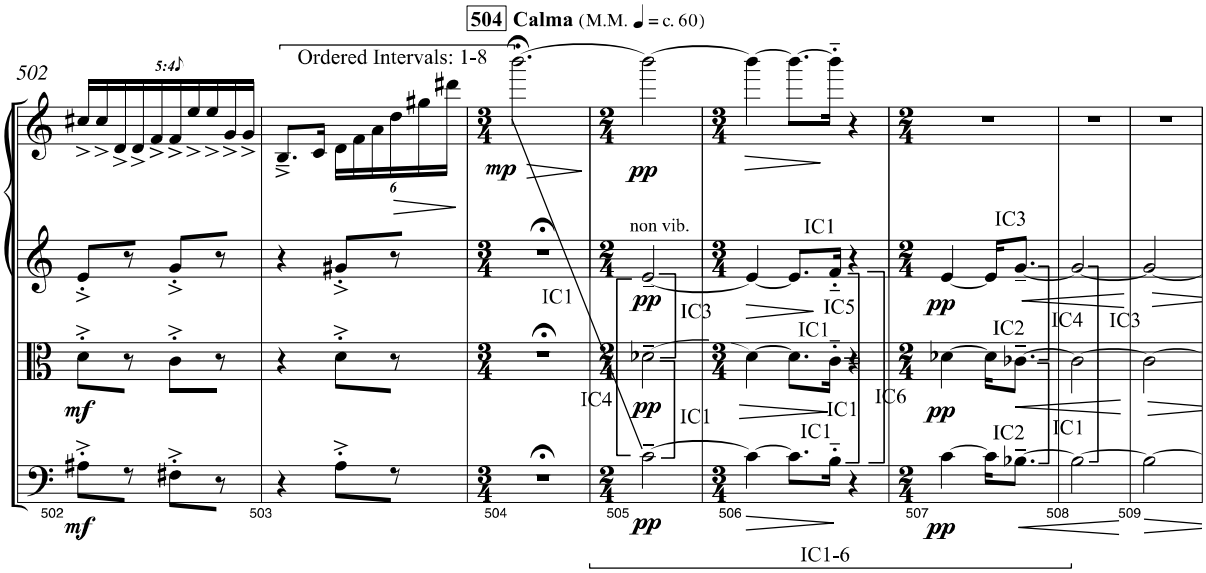
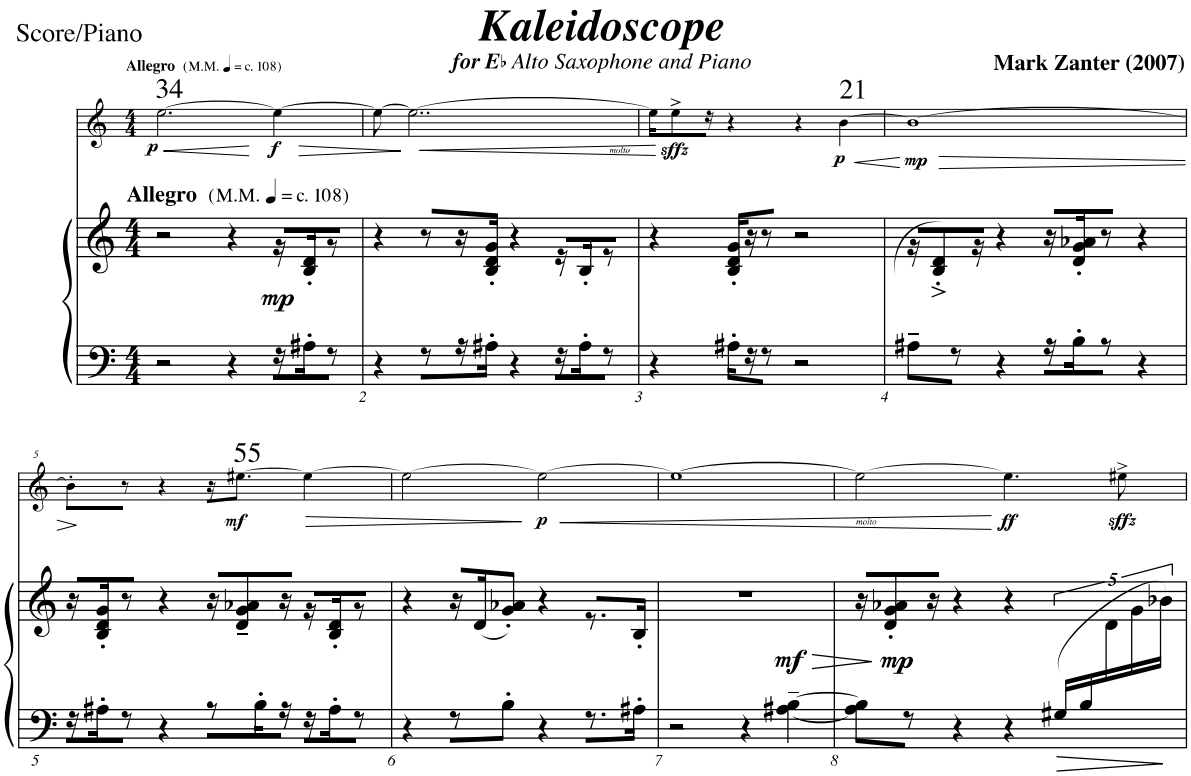


Figure 8: *String Quartet*: interval series, mm. 503-507.

Kaleidoscope for alto saxophone and piano is another example where the Fibonacci sequence is used to generate longer and shorter durations. The work also employs the sequence to generate sectional proportions. The example shows the beginning of the work where the saxophone's sustained pitches use durations of sixteenth notes generated by Fib. Stabbing rhythms in the piano are often, but not consistently 3, 5, 8, or 13 sixteenths. Contrasting rhythmic durations between parts parses them into perceivable slow and fast layers.



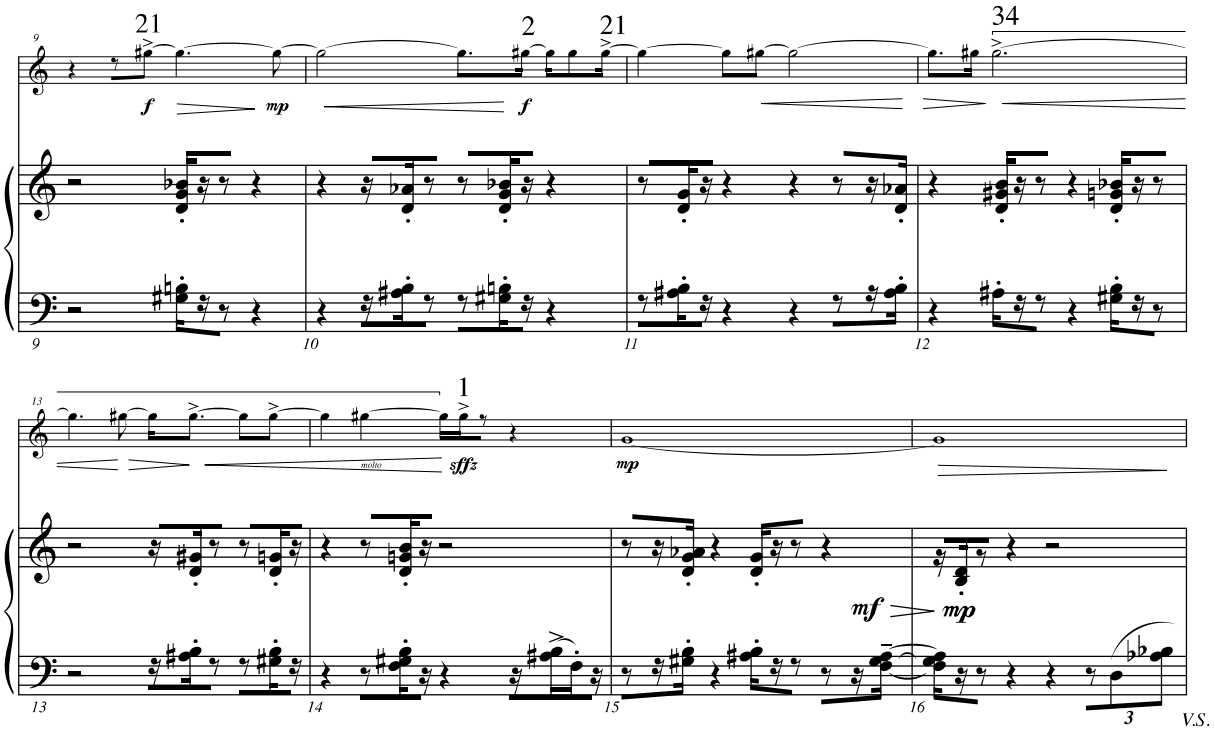


Figure 9: Kaleidoscope: Fibonacci sequence in saxophone melody, mm. 1-14.

Formal proportions in Kaleidoscope use the Fibonacci sequence throughout. The table below shows formal sections and their length in sixteenth notes. Tempi for this work were also calculated so that the durations of each section maintained the proportional relationship (A:B = B:C [B+A]).

	A:B; B:C		D:C; C:E			F:E; E:G					
Section	A	B	C	D		E		F		G	
16ths	416	258	674	416		1090		674		1764	
				258	158	694	416	416	258	674	1090
Content		Develop A (Saxophone long tone-short tone retrograded)	B’	A’	B”	C’	C”	A”	B”	E’	E”

Figure 10: Kaleidoscope: Fibonacci sequence proportions sections A-G.

In my electro-acoustic work I use processes to control/generate rhythm or pitch. In *Artifacts* (2014) a rhythmic generator using the Fibonacci sequence generates rhythmic density in the middle portion of the work. The screen shots of the Max/MSP subpatch show how Fib is used. The LH portion of the window shows the rhythmic generator. In this example Fib numbers are input into the top number box (e.g. 377 shown). Rhythms are generated by the middle portion of the patch using modulo 3-7 and rhythmic multipliers; multipliers are generated by a Fib process using values based on 75 milliseconds (150ms+225ms = 375ms; 225ms + 375ms = 600ms etc.). The RH portion of the image shows the fib mod rhythm generator, and a table of MIDI note values that is generated by a random walk object that generates table values using a range of all pitches (128) and a step size of 5 (drunk 128 5). MIDI note values trigger sounds from two sets of audio samples (bells, drums—not shown). Though the modulo portion of the patch limits the type

of rhythms, each Fib number generates a distinct rhythmic texture; enabling growth/development through a sequence of rhythmic textures that are perceivably related (compare: 5, 13, 55, 610, 144; 3, 21, 987).

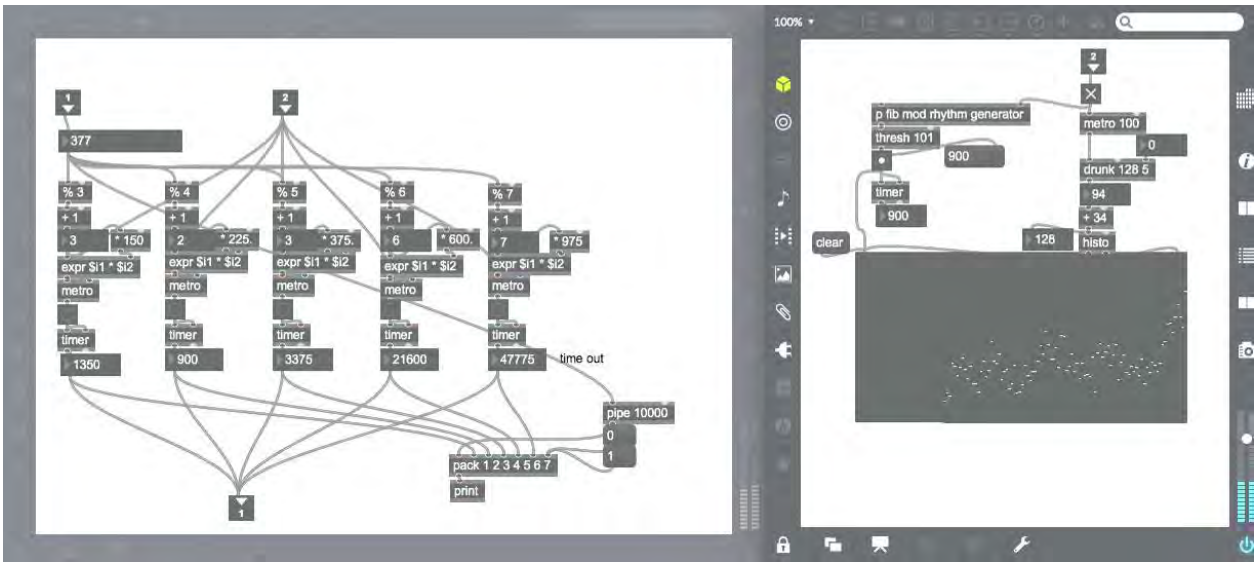


Figure 11: Max/MSP Fib rhythm generator (LH—Rhythmic Generator; RH—Pitch Generator)

Gestures I employs modular form. It uses open instrumentation and realizations of the work vary based on the number of pages chosen from page sets A-D (a minimum of four and a maximum of thirteen); and the order of pages selected by the performer.

The Fibonacci sequence is used to generate tempi and the number of events on each page. In the figure below the tempo of A1 is M.M. 100[1], while C2 is M.M. 89; and the number of events is twenty-one and eight respectively. Rhythmic activity varies considerably from page to page and performance instructions enable the mixing and matching of pages to produce varied musical textures. Pages B1, B2 both containing one event—a short composition—seed all pages. The temporal position of B in performance may influence the perception of that music as epiphanic (xxB), disrupted (xBx), or fragmented to dissolution (Bxx).

In *Gestures I*, Numeric strings from Pi generate the repeats of looped events (Pi: 3.14159**265**358979**323**8**46**26**433**832795028841971693993**7**5105820974944592307816406286208998628034825342117067982148086513282306647093844609**55**058**223** etc.). Pi digit segments 265, 433 appear on A1; and 63, 223, 37, 323, 46, 34, 55 appear on C2 (the first 500 values were used throughout the work. Pair 63 does not appear within the first 138 values shown). The use of Pi strings in *Gestures I* does not take advantage of the non-repeating properties of the digits, rather in using it to dictate the number of repeats for a segment, it gives weight to the passages it supports and increases the duration of the page. Examining C2 below, some events may be repeated up to seven times. Combining that with the slower tempo and longer durations influences the duration of the page.

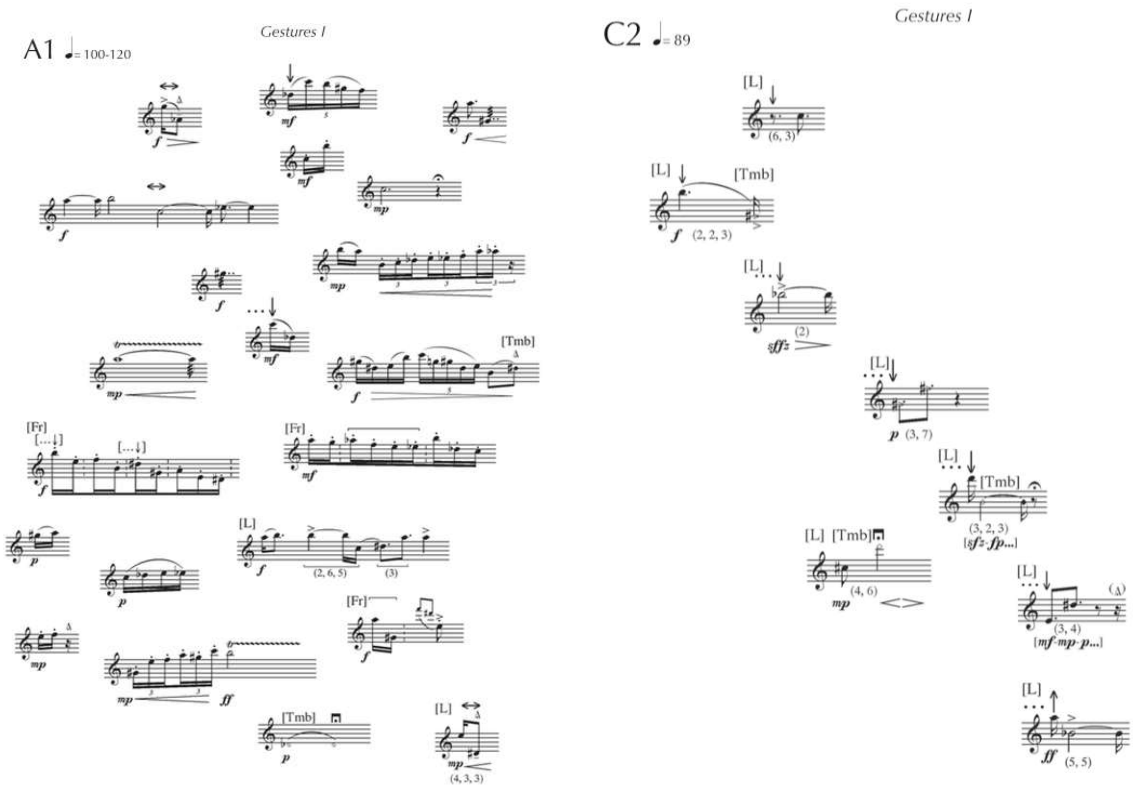


Figure 12: *Gestures I*, page A1, C2

4. Integration, Disruption, Disintegration

Scales are tonally flexible, and facilitate registral connection of pitches. They are important for generating surface pitch and structural relationships. I often use symmetrical scales; whole-tone, octatonic, those generated by transpositions of the augmented triad, or scales derived from the harmonic series. In the following examples I will focus on structural usage of scales in *Persistence of Memory* (2012) and *Donna Lee Triptych* (2009). The examples also demonstrate the cross cutting technique (Shiff, 1998)[2] which disrupts relationships that unfold in relation to each scale, or structural line (e.g. Donna Lee Triptych).

The example below shows the first part of *Persistence of Memory*, which unfolds WT0 (F#6-E6-D5-C5-Bb5-Ab5-Gb5) in the upper register and the chromatic scale in the lower register. Scale structures integrate surface motions into a unified whole while cross cutting back and forth disrupts their unfolding. The rhythmic character of material written for the scales links cross cut sections. WT0 features sustained pitches (fed into live signal processing), while chromatic passages use fast rhythms.

The first pitch G5 is a structural link for both scales on the first page. It is the first pitch in the chromatic cycle, and appears after the completion of WT0 on Gb5 in the second to last measure of the first page. The first crosscut begins on Ab4 and ascends chromatically to E5 before descending to F4. F4 leaps to E6 the second pitch in WT0. Here the chromatic and whole-tone lines are intertwined: WT0—F#6, E6, D5, C5; Chromatic: F4, E6, Eb6, D5, [C#5]. The fourth system suspends the progress of each scale prolonging elements from system two. It begins with WT0 [A#5], Chromatic: B5, G5 from system two are prolonged in the middle of system three, and it concludes with C#5 the continuation of C5, the end of system two. System five continues with a chromatic segment connecting C#5-F5; C#5-E4, while the next pitch in WT0 does not appear until system six on Bb5 with material

mimicking the opening figure. WT0 continues with Bb5-Ab5-Gb5 completing the WT0 cycle and connecting chromatically to G5, which concludes the chromatic cycle on page one.

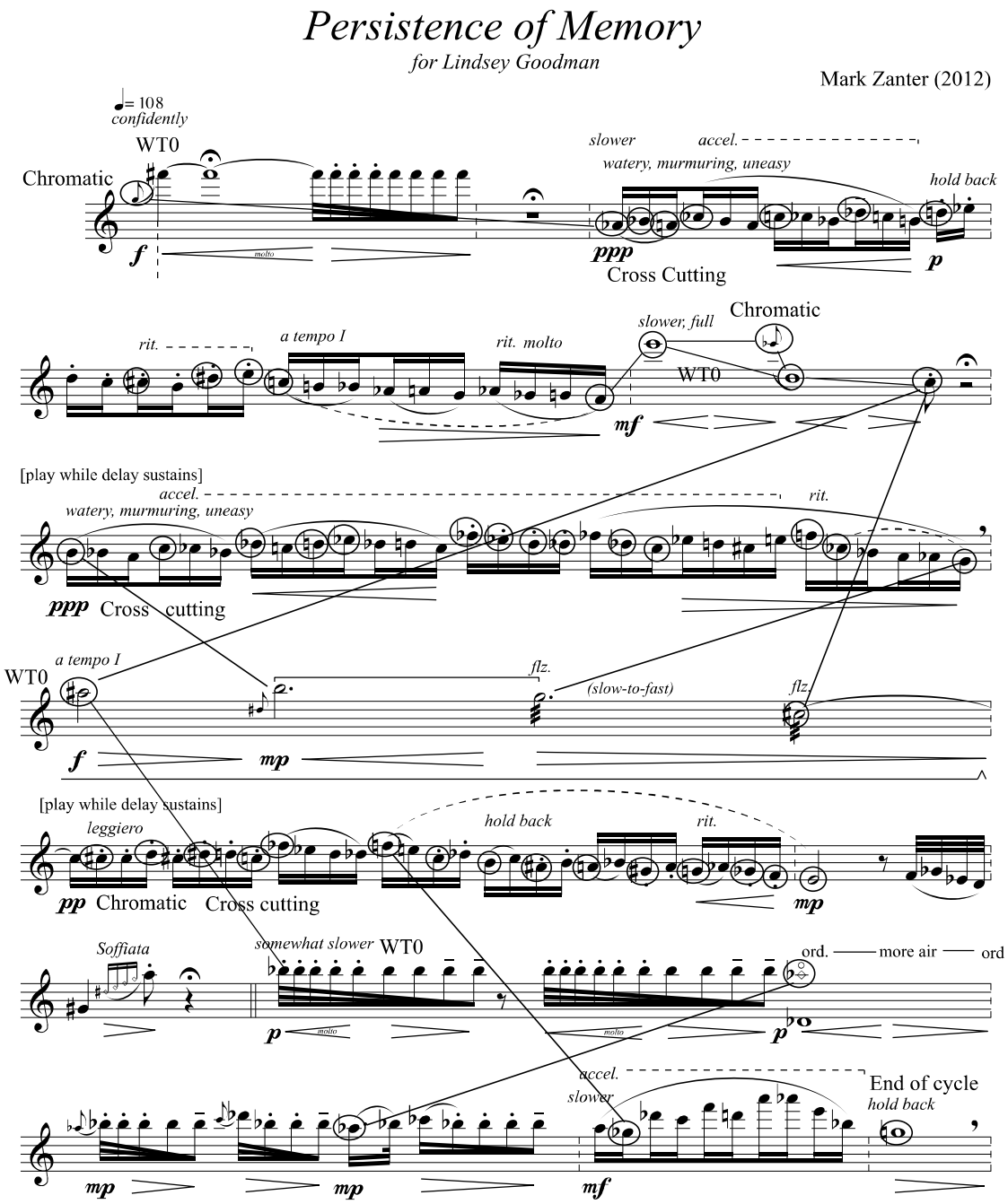


Figure 13: *Persistence of Memory* (2012)

In *Structural Models for Improvisation* (Zanter, 2001) improvisational models are constructed from structural analyses of original sources, in the case of *Donna Lee Triptych for improviser and live electronics*; Charlie Parker's *Donna Lee* (1947). Structural analysis reveals chord tone structures that support the melody. In the figure below model II closely resembles the structure of Parker's *Donna Lee* (chord symbols added to the model demonstrate a close affinity to the original). Models II, and III abstract elements of the tune with III being the furthest from the original source. In the case of this work analysis of *Donna Lee* yielded a structural line; the line was formed into a model, and the model was abstracted to create additional models.

In performance, models guide improvisation. They may be performed in any order and segments of each model may be cross cut to and from. The improviser interprets each model as they see fit, performing the model and responding the computer improviser, which reads player's input and responds using the same pitches and rhythms in different permutations. The myriad combinations of the models, interpretations of the structural lines, and response of the system yield a work with an enormously diverse musical surface guided by the context suggested by each model.

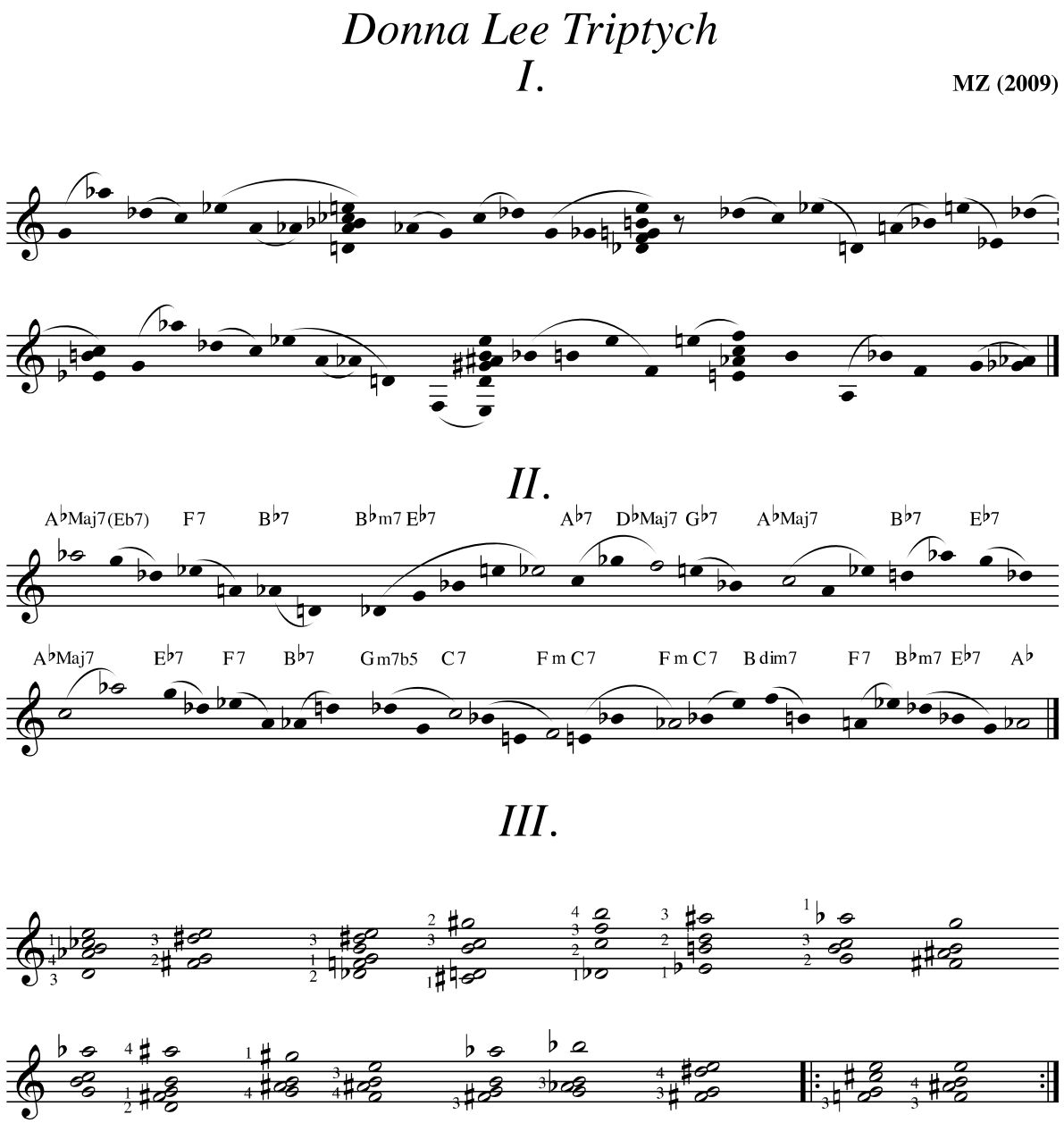


Figure 14: *Donna Lee Triptych* (2009): Model II resembles tune's melodic structure. I and III are abstractions of II each containing a different treatment of the main structure.

In the preceding examples it has been shown how processes used generate structural integration and disruption. For the last portion of the paper I will discuss use of decay as a metaphor for structural disintegration.

Metaphors are useful tools for focusing attention while composing a work.

Decay (def.):

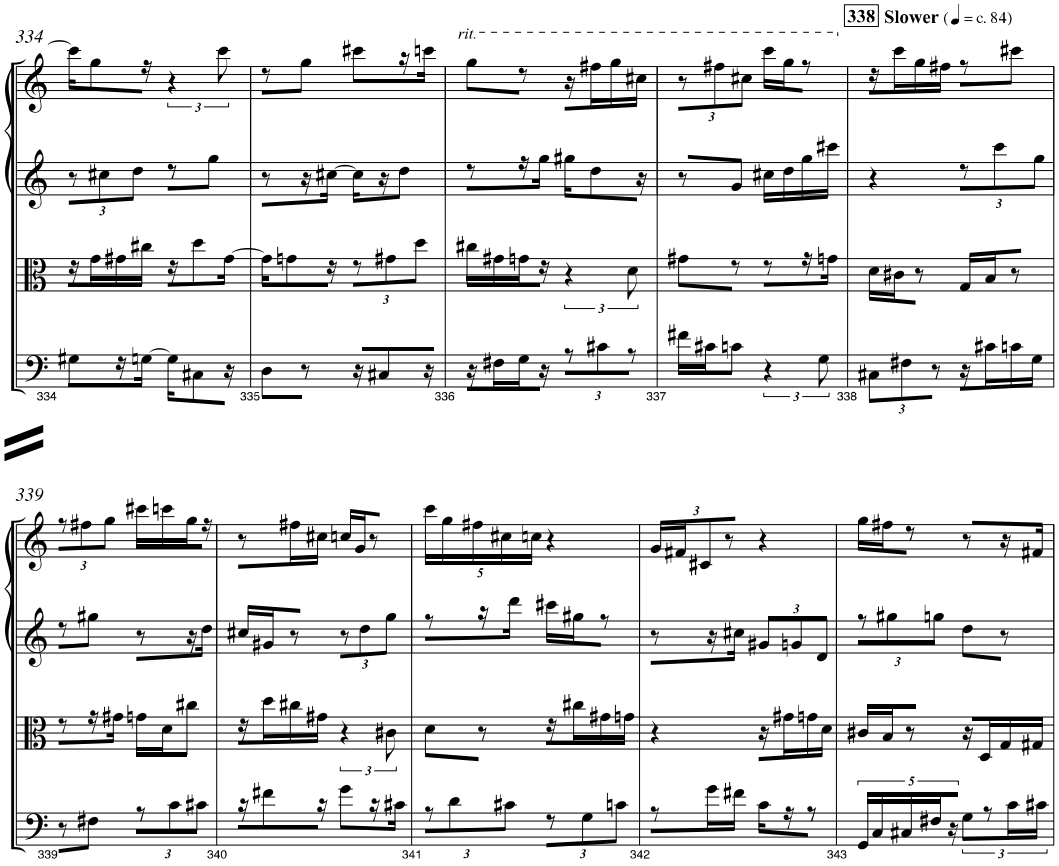
- to decline from a sound condition (deconstructing, deteriorating).
- to decrease gradually in size, quantity, activity, or force (delay).
- to undergo decomposition, or to destroy by decomposition (deconstructing, stretching)

Realized as:

- Deconstructing/deterioration (abstracted, split into coherent but altered pieces, evolution through deteriorating, diminishing, or augmenting). Signal processing, and time stretching alter timbre, and characteristics of sounds.
- Deteriorating (falling apart, segments are/become heterogeneous, decrease in size, smearing). Stretching (phrases, augmentation, tempo changes, stretching audio, transposing-sample speed adjustment)
- Decay (delay, decreasing force, activity, or size)

1. Decay processes are not prescriptive (may be realized a number of ways)
2. Decay process can be applied within other conceptual frameworks serving structural functions, as a foil to the current process, or as part of the devolution of a work.

In String Quartet the slower tempo, increasing rhythmic variation, variation of phrase length; give the impression of falling apart, the gradual disintegration of the preceding section.



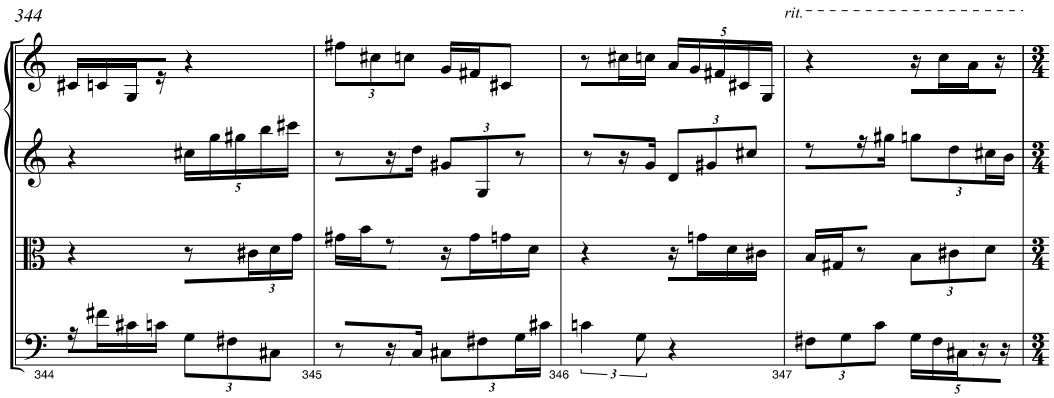


Figure 15: *String Quartet* (2011) disintegrating texture:

The last section of *Lament and dream* (2013) for string orchestra, piano and percussion also deteriorates in the final bars of the work. In both cases deterioration serves the structural function of terminating a section or work. In this example a timbral shift is also employed.

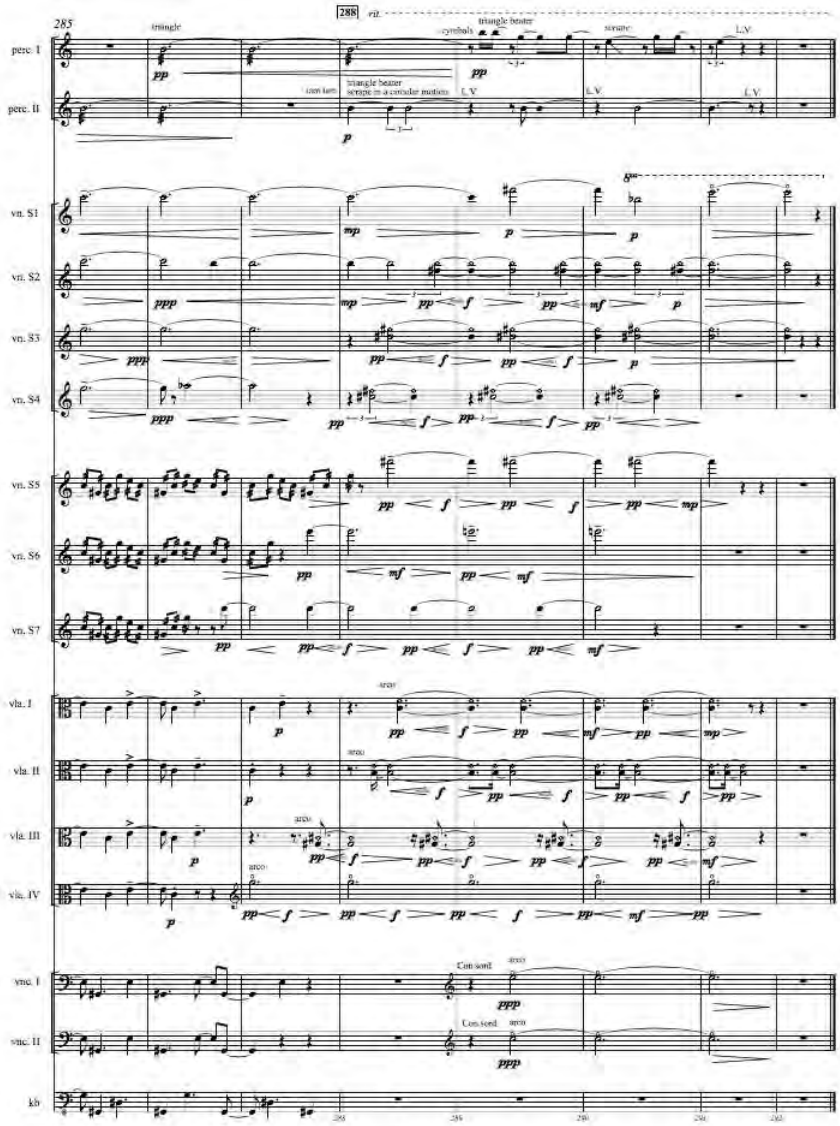


Figure 16: *Lament and dream* (2013), final bars

Three Movements for five cellos use delay (imitation), and augmentation to deconstruct mvt. III. Delay effect: Direct imitation accompanied by decrescendo. The idea is spatialized

in the ensemble.

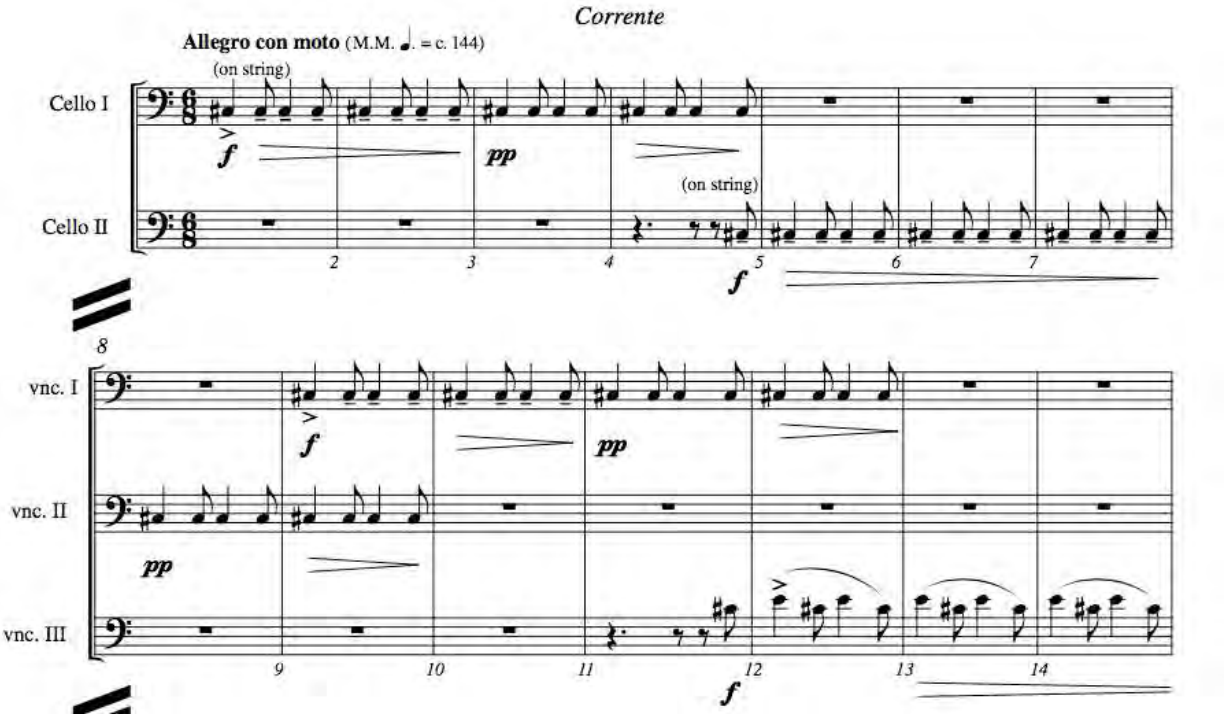


Figure 16: *Three Movements for Five Cellos* (2007), delay effect, Mvt. III

Augmentation/expansion of the delay figure in violoncello II, III.

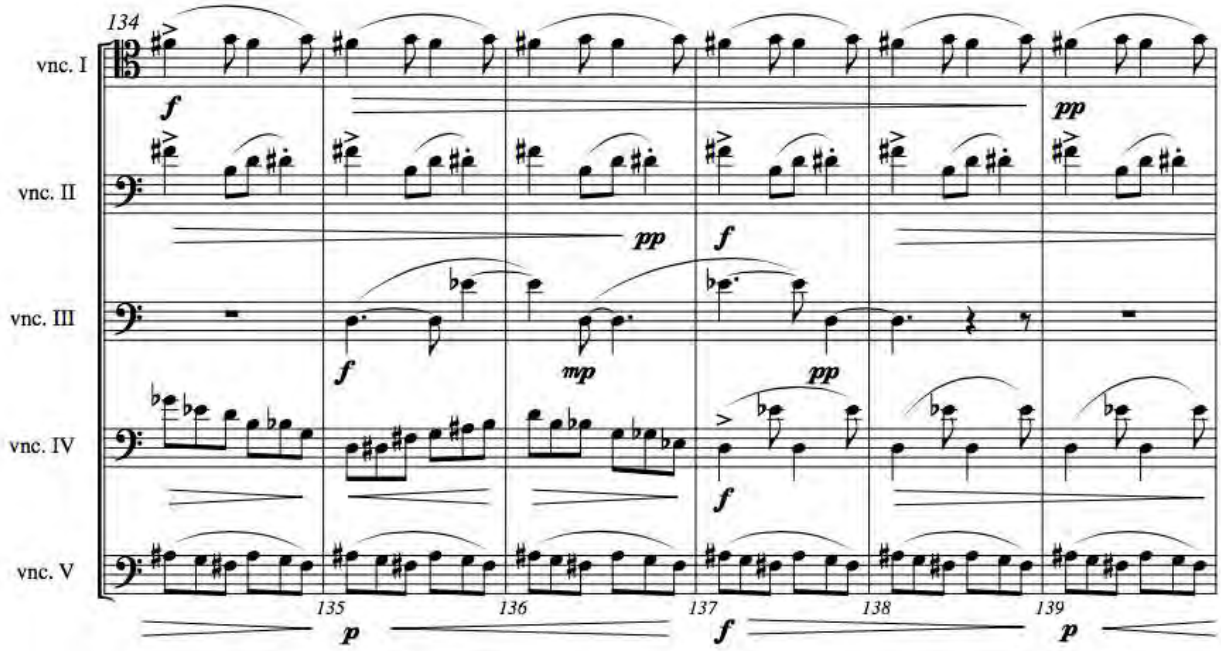


Figure 17: *Three Movements for Five Cellos* (2007), Mvt. III.

Truncated figures, slowing tempo, soft dynamic, and weak articulations result in smearing the onset of each pitch contributing to the perceived deterioration at the end of mvt. II.

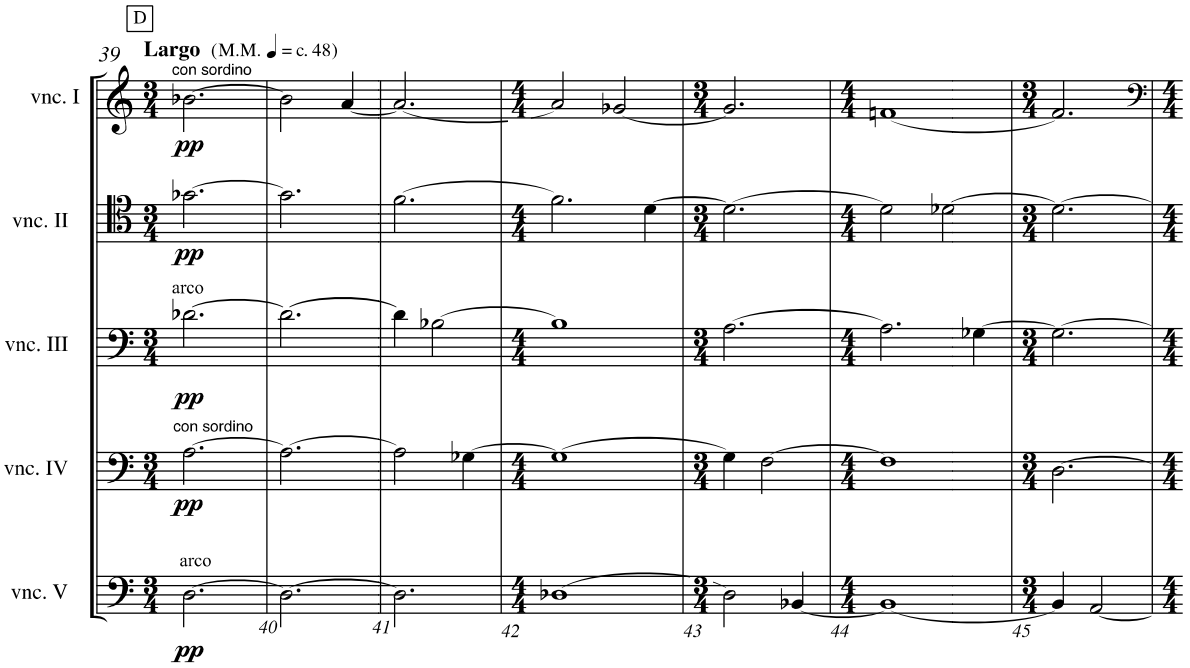


Figure 18: *Three Movements for Five Cellos* (2007), Mvt. II

Stretching phrases through the addition of or variation of material in the interstices between tones of the initial thematic statement. I have used this technique as early as 2001 in *Impromptu Variations* for solo piano, but have since used it in *Disappearing Ink* and *Persistence of Memory* both from 2012. The example that follows shows how this works in the beginning of *Disappearing Ink* through several statements of the opening figure.

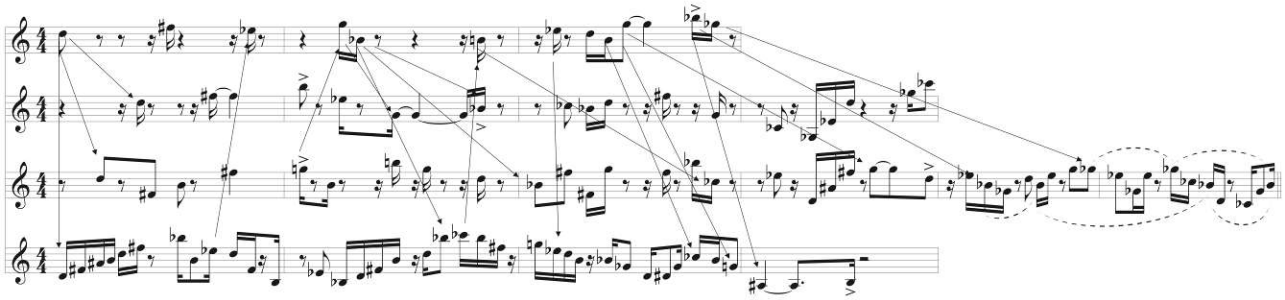


Figure 19: Disappearing Ink (2012) Thematic statements and expansion

The discussion herein has addressed the application of Generative Processes in compositional preparation, and development in verification; and examples have illuminated the trace of these in the musical surface and structure in ten of my works. Further discussion demonstrated their use for integration, disruption, and decay or disintegration.

Notes:

[1] Gestures I, page A1 surface rhythms are often 6:4; 9:8 increasing the perceived rate of rhythmic events to be 1.25 to 1.5 times faster than sixteenths at the original tempo of M.M 100. If one pleases tempi between M.M. 125-150 may be interpreted as Fib 144.

[2] Cross Cutting describes the cutting back and forth between shots in film. The technique is common in Elliott Carter's music, but was/is also used extensively in the music of Carl

Stalling (Warner Brothers: Looney Tunes), and John Zorn.

References:

[1] Collins, David: A Synthesis Process Model of Creative Thinking in Music Composition, Psychology of Music 2005; 33; 193, New York: Sage Publications, 2005.
[2] Gilhooly, K.J.:Thinking: Directed, Undirected and Creative. London: Academic Press, 1996.
[3] Reitman, W.R.: Cognition and Thought. New York: Wiley, 1965.
[4] Rowe, Robert: *Machine Musicianship*, Cambridge, MA: MIT Press, 2001.
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[6] Soddu, Celestino and Colabella, Enrica: Why Generative Art? Proceedings of Generative Art Conference GA2013, http://www.generativeart.com/, 2013.
[7] Zanter, Mark: Structural Models for Improvisation, DMA diss, University of Illinois, 2001.

Paper: Is DNA expression generative art?

Topic: Design and professional art

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Abstract
Some authorities assert generative art is produced wholly or in part by stochastic algorithms executed autonomously or in part by digital computers. While this perspective is certainly plausible, a much broader perspective in this report emphasizes the human brain as computer, and then the spontaneous DNA expression of conceptual primitives. Gene expression is a chemical transcription of DNA coded information, and cognitive neuroscientists believe infants use this mechanism to reformulate innate perceptual information into conventional ordinary language image-schemas. A central assertion here is human perception implements a generative mechanism during infancy that utilizes DNA coded conceptual primitives to create visual knowledge. Moreover, shared human DNA information establishes wide appreciation for these images, a collective affinity for their preference. Survival functions of these images have been studied by anthropologists.

A conceptual primitive is genetic information linked to visual images instinctively recognized by humans. During early childhood, these conceptual primitives are triggered by specific environmental stimulation and spontaneously organized into conceptual hierarchies. Children socially interact with these images, which establish foundations for languages and literacies. Hierarchical expression of these images underlies children's early expressions from visual art through early writing literacy. This report reviews generation of visual images from conceptual primitives and their implications for visual arts and culture.

Conceptual primitives have phylogenetic origins that appear early in children's drawings and are directly related to eight images in nature and visual art. They are Circle, which symbolizes recursion and infinity, while Undulating line evokes movement, harmony, and direction. Jagged line, also called Zigzag, represents danger, threat, and harm. Spiral is one of the oldest images to assert movement but toward change and advancement. Other key images are Cells, which present stability and position, as well as Floral pattern, Sun burst, and Upright. These images are examined in this presentation in children's drawings, Western paintings, and popular culture.

Cell structure

Spiral

Undulating line

Circles

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Key words: Visual attractors, conceptual primitives, DNA images

Lima, M. *The Book of Circles*. Chronicle, 2017.
Changeux, J. P. Climbing Brain Levels of Organisation from Genes to Consciousness. *Trends in Cognitive Sciences*, *21,* 168-181, 2017.

Is DNA expression generative art?

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Premise

Philosophical discussions about creative introspection and artistic expression typically emphasize a mystic, magical process that originates in the human imagination [1]. Western literature is full of commentaries on the creative power of imagination [2], and museums thrive on presenting products of this imagination. More broadly, imagination is now recognized as the central generator of scientific knowledge. Coherence and rationality of knowledge is grounded on human experience and imagination

This paper presents an alternative, less mysterious, view asserting that much Western art includes primitive structures originating in human DNA. Creative imagination and introspection certainly have a central role in human creativity, but artistic production is also saturated with special insights derived from subtle genetic influences. In other words, gene regulation during visual art making underlies much more history of Western arts than is commonly understood. The creative processes of imagination from this perspective are to an important extent generated by DNA coding. Likewise, originality of art making is recognized as intertwined with evolution and natural selection. Therefore, a goal of this commentary is to address the title, Is DNA expression generative Art?"

In support of this idea, following sections first present a group of image templates identified in Nature that also appear in history of visual arts. A claim is made here that they have acquired unusual status during human evolution, and artists for centuries have perceptively integrated them into artworks. Furthermore, these image templates function as visual attractors because of their shared genetic origin, which contribute to the enormous appeal of visual art.

To increase an appreciation for image templates, they are linked here to conceptual primitives in cognition, as well as graphic structures in children's drawings. Their close relations with other mental entities that are usually associated with language development and early literacy provide support for their developmental origins. Evidence is then presented of their evolutionary function in drawings from Palaeolithic archives.

The final goal of this report is to consider the mediating influence of DNA on the sensitivity to image templates. Gene regulation is a mechanism that describes a complex interaction between chromosomes and environment, which do *not* follow Mendelian laws of genetics yet influence behaviour and diseases. Under certain environmental conditions, these genes complete a complicated chain of chemical transformations generating cell products and interest here is in their contribution to producing image templates.

1. Introduction

A hypothesis in this report is certain human chromosome genes are sensitive to primitive

image schemas that Western artists integrate into visual art. These primitives differ from the aesthetic primitives related to elementary design [3]. Professional art training emphasizes composition design primitives such as color, form, spatial organization, motion or movement, and depth. However, training does not typically capture the less explicit primitives that are central to this report. Artists integrate the aesthetic primitives presented here into the thematic and affective effectiveness of an artwork, which may contribute to compositional integrity. Consistent with the view of this report, Dissanayake [4] referred to aesthetic primitives as "ingredients", "primitives are not art, but *ingredients* of art (p. 10)."

Like images in Nature, aesthetic primitives form highly predictable patterns distinguished by symmetries, hierarchies, spirals, waves, and cracks. Their regularity has led to mathematical models [5], as well as claims of universalism. However, unlike common appearances in Nature, which are widely acknowledged, schematic primitives in culture and art are less frequently recognized. Schematic primitives evoke reactions to paintings, architecture, and sculpture without provoking recognition because their appeal is at an instinctive, affective level. However, their pervasiveness on systematic inspection in paintings and artefacts is difficult to deny. Some speculation suggests aesthetic primitives are coded in human DNA and are products of natural selection and evolution.

The influence of heredity and DNA in particular, on human behaviour is a contentious topic in contemporary social science research. Genetic determinants of fixed human characteristics are widely accepted such as eye or hair color. But many aspects of human physical and emotional function are also directly affected by DNA, and they are governed by more complicated hereditary mechanisms called gene regulation. For example, feature detectors are innate neuron structures that extract physical cues from perceived objects and influence vision perception [6]. Feature detectors range in sophistication from general perceptual sensitivity to very simple stimulation such as colors and shapes, but other feature detectors respond to physical object properties such as edges and boundaries, as well as their motion. Genes regulating vision perception require light stimulation before "switching on" cells that will become light receptors [7]. This sensitivity has obvious implications for physical function and survival, and natural selection has benefited those organisms with it.

Linguists and cognitive scientists also emphasize the function of innate mental structures during language, literacy, and conceptual development [8]. Graphic primitives, conceptual primitives, image schemas, and mental models are cognition-related terms for describing innate mental structures. They first appear during infant preverbal development and are elaborated during early linguistic expression. They also appear in young children's drawings and, later, in early writing. In general, they are instrumental to developing facility with cultural sign systems.
A key assertion here is innately coded DNA information embody primitive images that are expressed in response to sensory stimulation. This interaction between innate DNA and sensory conditions leads to formation of primitive schemas. This report is particularly interested in sensory conditions created by professional artists during art making.

Both neuron sensitivity and cognition described above evolved over millions of years in response to environmental variation and their current sophistication has established extraordinary foundations for human behavior. However, the role of genetics during this evolution remains controversial despite empirical demonstrations of highly organized behaviours dependent on predominantly genetic mechanisms. For example, honey bee

hive organization displays very complex behaviour systems in some ways comparable to human activity and directly attributable to DNA coding [9]. This influence of genetics on human social organization, however, remains speculative [10, 11]

2.0 Jungian archetypes and universal images

The primitive images discussed here have ancient antecedents in Western philosophy. Plato in particular is widely recognized for asserting idealized universal forms and human sensitivity to primitive images of them in ordinary experience [12]. In 18th century philosophy, Kant [13] emphasized the prominence of innate logical forms or universal categories on human knowledge. Transcendental schemata are produced to mediate relations between innate categories and sense impressions. These metaphysical foundations, however, have never gained wide approval among aesthetic philosophers. Contemporary visual arts discussions tend to emphasize cultural products uniquely expressed by idiosyncratic artists.

Drawing on Kant's a priori categories, Jung presented enormous support for innate, subconscious archetypes, which he asserted underlie personality development [14, 15]. He believed innate universal symbols are genetically expressed during human development, and he characterized their manifestation with distinct personality types. The Hero. The Warrior, and The Regular Guy among many others are Jungian personality types derived from the potentialities of innate mythic archetypes and shaped by environment.

Jungian archetypes and universal symbols are from a collective unconscious of instincts and myths inherited from ancestors. Among many presented symbols, Jung's Mandala received substantial attention and was studied in several cultures [14].

Jung's archetypes gained substantial influence over psychological thinking in the 20th century and became central to the practice of analytical psychanalysis, which remains an important perspective on human psychology. Jung's assertion that archetypes are genetically transmitted is a landmark in the study of personality by bringing attention to transgenerational factors that influence development. While his insights into a collective unconscious tended to shroud his perspective in mystery, they gain new meaning in the contemporary context of DNA coding and epigenetics.

2.1 Universal images

Jungian psychology has stimulated many studies into archetypes, and Borgognoni Vimercati, an Italian restoration artist, undertook an ambitious historical investigation of archetypes in Western art. Her idea was a class of archetypal images are manipulated by professional artists in paintings and are instinctively recognized because they are coded in DNA [16, 17, 18]. She described several properties of these images including appearances in both Nature and history of visual arts. An interesting elaboration of Jung's archetypes is their simultaneous appearance at several levels of scale in Nature, which she documented with examples. Also, reactions to her images are accompanied by a predictable affective response. Unlike Jung's archetypes, but they are independent of personality. She called them Universal Images (UIs).

Her UIs are listed below with corresponding affective associations:

- Upright = Power, authority, stability, domination, prominence
- Floral motif = serenity, harmony, comfort, sympathy, kindness
- Sunburst = warmth, happiness, joy, expansive
- Zigag line = Danger, unpredictability, harm, pain
- Wavy line = Peaceful, tranquility, calmimg, aimless
- Cells = security, network, community, collaboration,
- Spiral = dynamic action, movement, power, direction, energy
- Circle = Infinity, continuous, cyclical, certainty, inclusive, clarity
- Rainbow = Wonder and fantasy

Figure 1 presents a set of primitive schema templates representing Uis identified by Borgognini Vimercati. With exception of Jung's mandala, archetypes and UIs show little correspondence. Growing consensus among scholars is UIs represent aspects of human evolution related to survival and adaptation, in particular, stability, security, harmony, and danger [19] in contrast to Jung's assertion of personality motifs

In general, symbolic interpretation of UIs seems to elicit broad existential commentaries. For example, the Upright symbolizes dominant, rigid authority, while the Circle [19] points to mixed reactions of unity and stability, or could be interpreted as movement, infinity, cycle, and stability. The Undulating line [20] evokes harmonious movement and direction. Jagged line, also called a zigzag, represents danger, threat, harm, pain, and conflict. The Spiral [21, 22, 23] is a symbol of movement, change, and advancement. Cell structure presents stability, limits, definition, position, and social organization. Other UIs are Floral pattern and Sunburst, and ancient Greeks discussed the rainbow as an important natural image. Indeed, Iris was the Greek goddess of the rainbow.

> And for Plato, Iris, the vision of the rainbow, is the embodiment of wonder in domain of the visual. The rainbow is a natural phenomenon that not only strikes the eye with its beauty, calls for explanation as well. And yet, even when an explanation is at hand, and we understand how the rainbow is created, there remains a sense of wonder (p. 21) [24].

These images appear in art, nature, and science, across cultures, and have been found in children's drawing instrumentally linked to early literacy development. More specifically, UIs function as conceptual primitives that are transformed during early drawing into alphabet letters central to literacy development [25, 26]. Paleolithic studies show them appearing in prehistoric art.

Although inspired by Jung's archetypes, UIs differ significantly in their function during art making. Jung's archetypes were the product of inherited instincts interacting with environment, and their emergence defines personality types, while Vimercati's UIs are primitives integrated by artistis into paintings. In other words, Jung's archetypes were the outcome of latent images rather than instrumental to their production. UIs are manipulated during the production of art. In addition, Borgognoni Vimercati's emphasis on continuity across levels of scale in Nature establishes a much broad context for collective unconscious. Disperson of UIs across art and Nature also has significant implications for understanding their phylogentic origins.

2.2 Appearance in Nature

UIs in Nature occur spontaneously but predictably, yet are unique events. A defining characteristic of UIs is their representation of foundational structures. They are Nature's building blocks. Figure 2 presents UIs in Nature and across levels of scale. A primitive schema template appears at far left, then iterations are presented across Figure 2.

2.3 Appearance in Classical Greek, Italian, and Contemporary Western art

Artists have long manipulated primitives such as color to elicit affective reactions. Kandinsky [27] wrote extensively about color and emotion and emphasized their spiritual aspects. Contemporary artists, however, refer to aesthetic primitives in more restricted terms such as lines, shapes and forms during image composition, which is consistent with a formal treatment during professional arts training. Some commentators are expanding this idea of primitives into neurological and psycho-sensory functioning [4], which encourages consideration of biological and artistic interactions. However, beyond generic compositional training, the function of image primitives during art making is not well understood.

A common misconception about UIs is artists "hide" them in visual art. On the contrary, in traditional Western paintings, artists carefully blend UIs into an image, while in contemporary art, artists simply "stick" them on an image anywhere convenient. Always, affective properties of UIs are consistent or complimentary to an artwork theme and typically move an artistic narrative it in that direction. Figure 3 presents UIs in Classical Greek art, which provides amply examples of spirals, undulating and zigzag lines, as well as uprights (columns) and cell patterns. Figure 4 presents examples of UIs in Italian paintings, where undulating lines expressed in draping are widely prevalent. Figure 5 presents UIs in Contemporary Western art, which is a striking contrast because image content is defined by only a particular UI. Figure 6 presents a composition of UIs upright, circle, and undulating line by Monet.

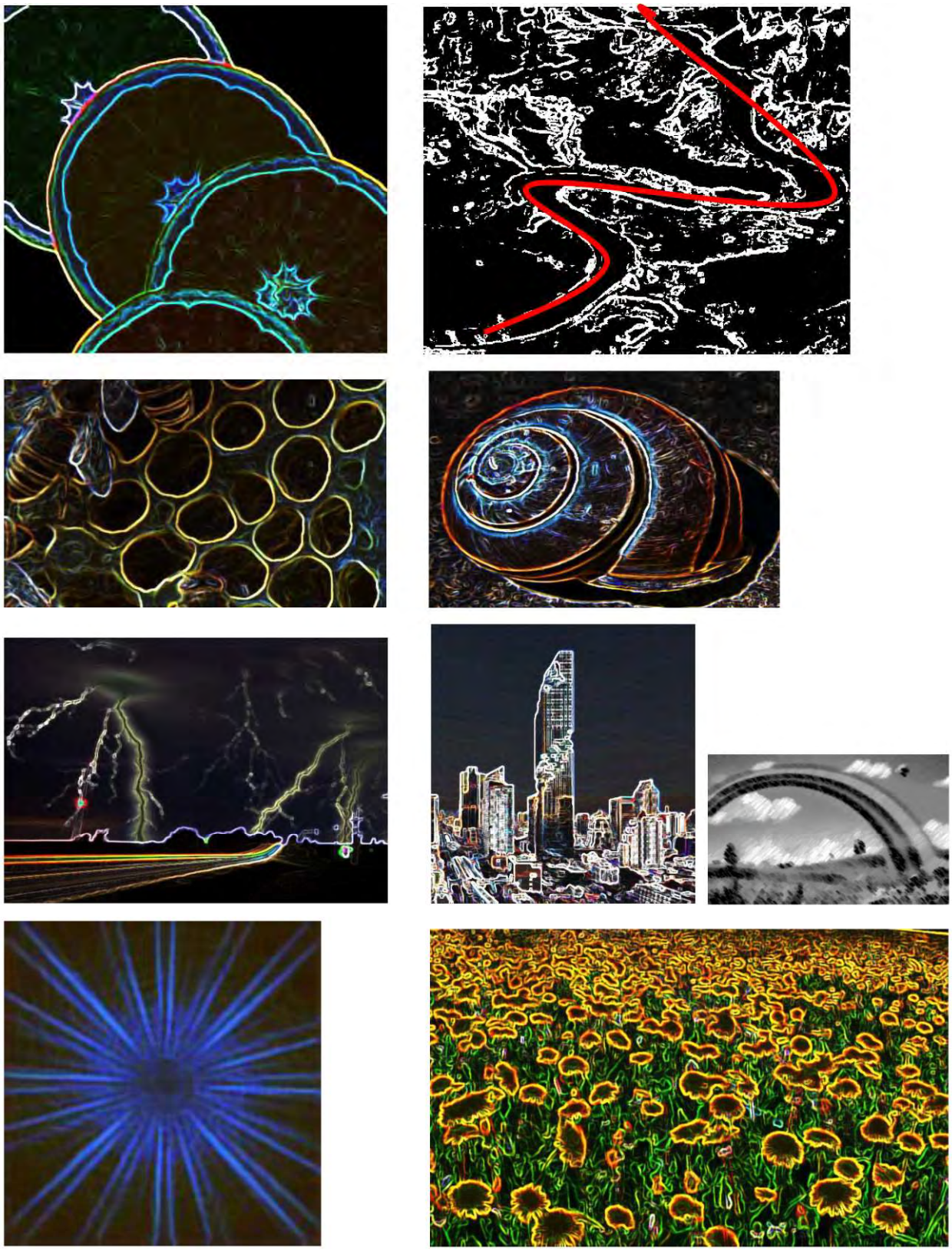


Figure 1. UIs generic template

Figure 2. UIs in Nature

Circle = stability, stationery, embracing

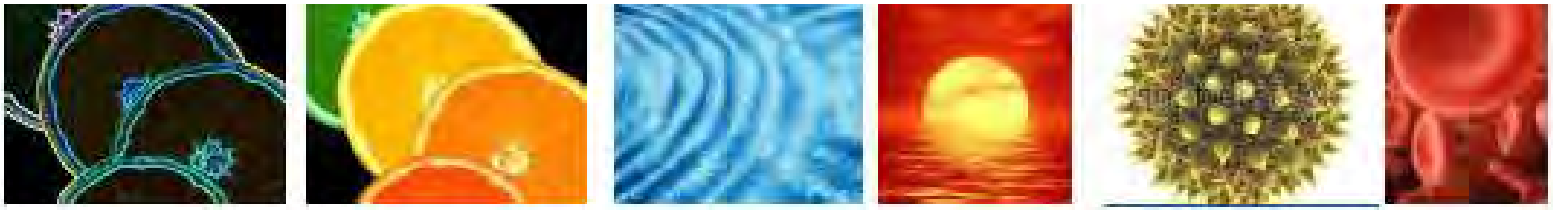


Figure 2. UIs in Nature (continued)

Figure 3. UIs in classical Greek art: Zigzag, spiral, upright, undulating line, cells, and circle

Figure 4. UIs in Italian paintings

Cristóbal de Villalpando, 17th century

Athena Scorning the Advances of Hephaestus, Bordone, 16th century

Bernini, 17th century

Angel with the crown of thorns
Bernini, 17th century

Figure 4.

UIs in Italian paintings (cont.)

Andy Goldsworthy, 1997

Nate Halley, Bursting, nd

Anonymous, nd, **Geometric Trinity, 2003**
Akimoto Art Museum

Anonymous, Honeycomb, 2003

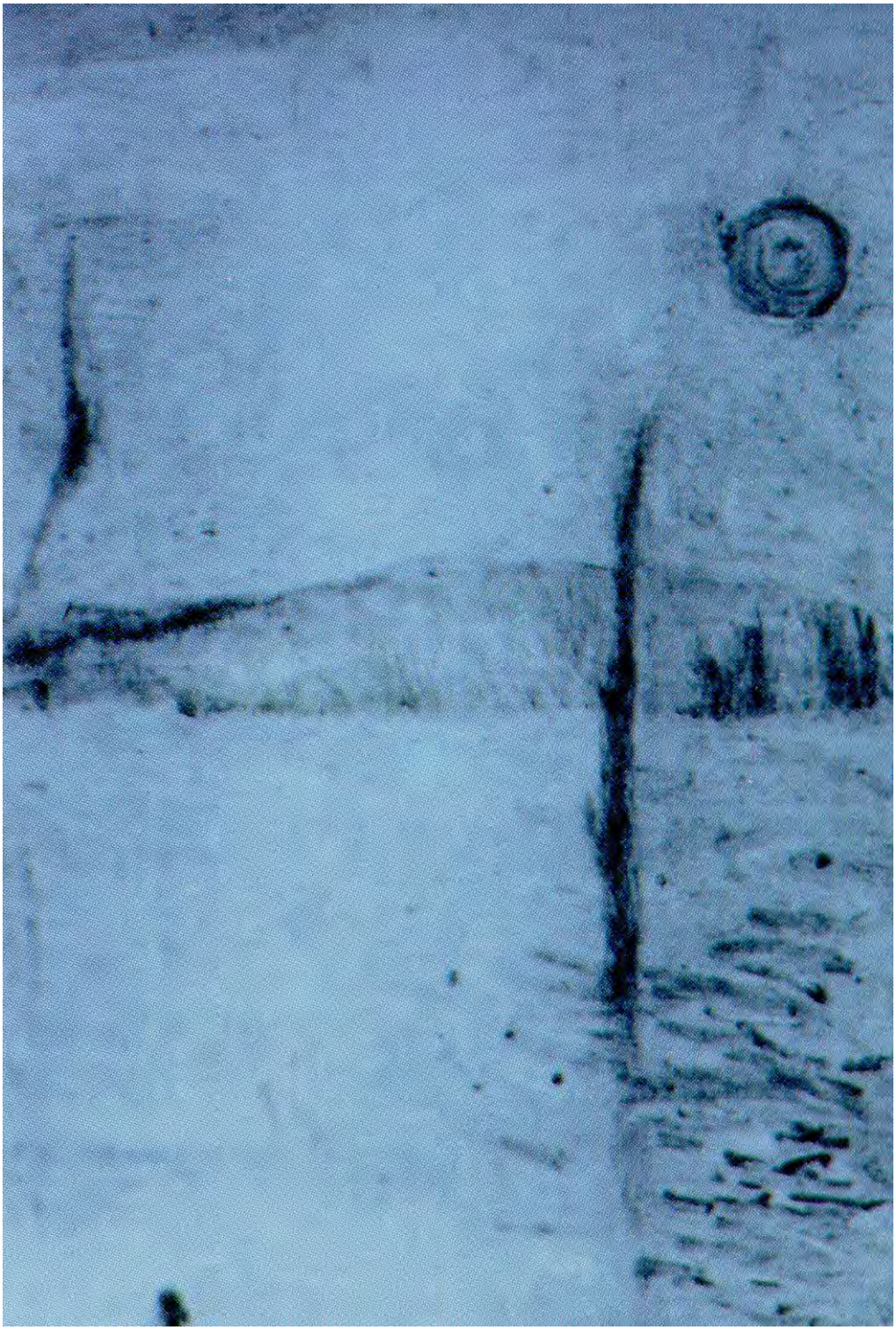
Figure 5. UIs in Contemporary art

Anonymous nd

Rhythmic curves, Anonymous, nd

Spring splendour, nd

Figure 5. UIs in Contemporary art (continued)



C. Monet, 1874

Figure 6. Composition of UIs

3.0 Primitives in early literacy, child drawings, and Paleolithic art

Prior sections presented a set of UIs purported to appear throughout Nature and in Western art, yet they differ significantly from innate psychological archetypes. Following sections consider broader relations of UIs to innate conceptual entities in early literacy and children's drawings. Their appearance is also noted in Paleolithic anthropological archives.

At first blush, the assertion of UIs in visual arts at any level of human development seems unlikely. What possible function could they fulfil during human evolution? How would they differ from other conceptual entities? How could these images be transmitted across generations? Yet, a central fact is art depends on a cultural environment in which art makers exercise their talents over time. This issue becomes especially relevant if artists extract patterns and images from experience over millions of years. Any contributions of art making to human survival or fitness could be preserved in DNA, which gives new meaning to Jung's idea of collective unconscious.

3.1 Relations to linguistics

A question of innate mental structures first appears in linguistics in relation to language. Chomsky [28] strongly supported innate conceptual primitives dependent on environmental context, which appears in following quote:

> "Children display . . . from virtually their first words . . . they bring to bear thousands of rich and articulate concepts when they play, invent, and speak to and understand each other. They seem to know much more than they have been taught—or even could be taught. Such knowledge, therefore, must be innate in some sense. To say it is innate . . . is only to say that it is produced by the child's system of concept generation and combination, in accordance with the system's courses of biological and physical development, upon their exposure to certain kinds of environmental input." [28]

The idea here that children are endowed with a primitive structural grammar format that is stimulated by local environment and shaped by cultural conventions is central to this report. This innate generative grammar corresponds to the underlying primitive images in visual art.

> Chomsky argued that it [language] is incited by social context and discourse context but essentially uncaused—enabled by a distinct set of innate principles but innovative, or "creative. [29]

Following sections review a probabilistic model for generating images from primitives. Finally, gene expression is considered as a plausible model for human sensitivity to image primitives in visual arts.

3.2 Image schemas, graphic schemas, and conceptual primitives in literacy development

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Early literacy is a complex process of youngsters establishing spatial orientation and much research suggests an inmate activation of primitive imagery. Early products of

this action are the familiar incoherent, external expressions of infancy such as body movements, gestures, and babbling. These idiosyncratic expressions are substituted for discrete objects, which establish simple concepts -- first physical then non-physical concepts. Among early innate actions is spatial orientation and spontaneous expressions may begin with random marks.

This early process of spontaneously implementing innate responses occurs in a hierarchy, spatial concepts precede abstract ones, and incoherent expression such as scribbling precedes conventional alphabet letters. Significantly, drawing precedes writing. A crucial transition is differentiating scribbles into shapes and forms, which substitute for objects and ideas. A scribble becomes an object, and an alphabet letter is an object. Through this iterative process, conceptual hierarchies are formed that lead to early literacy, genetic foundations ensure this process reoccurs with successive generations.

3.2.1 Perspectives on image, graphic, and primitive schemas

Johnson [30] originally proposed embodied mental models derived from personal experiences that pointed in the direction of self-constructed knowledge. Meaning and rationality, coherence and understanding are fundamentally derived from this interaction of mental model and experience.

> An image schema is a reoccurring dynamic pattern of our perceptual interactions and motor programs that give coherence and structure to our experience (p. xiv) [30]

The function of these models serves to capture everything that can be known about reality. They assert innate predilections or tendencies, which establish a framework for comparing conformity of spontaneous experiences. However, mental model construction depends critically on individual actions on encountered experience, and continuous integration of future perceptions and actions to defined structures. Stable, predictable relations that result are the basis for knowledge.

Contemporary empirical studies of early conceptual development are being conducted from several perspectives. In context of mental models, Mandler emphasizes function of spatially defined schematic images derived from basic cell sensitivity, which establishes foundations for iconic imagery [31, 32, 33, 34, 35]. Several schematic images related to concepts of animacy or movement, causality, agency or direction of causality, and containment are functional during infant development. These primitive perceptual structures are foundations for mental models. Figure 7 presents schematic images that appear during infant development.

More recently [36], Mandler has clarified the instrumental function of spatial and motion primitives during schema development, which leads to three kinds of cognitive structure and constitute building blocks of image schemas. ”She proposed that the infant’s repetitive patterns of noticing aspects of its own bodily movement in relation to objects moving in the environment --relationships among objects, space, and time -- are “distilled” or “condensed” into conceptual primitives [37]”. This perspective is supported by empirical research showing an innate inclination among infants to recognize visual cues of motion that trigger animacy perception of adults [38]. Bodily self-propulsion, in particular, was the stimulation that triggered the perception. .

The developmental importance of schemas cannot be overemphasized; innate primitives expressed in embodied mental models define the growth of knowledge for children. They are instrumental to forming concepts and knowledge networks.

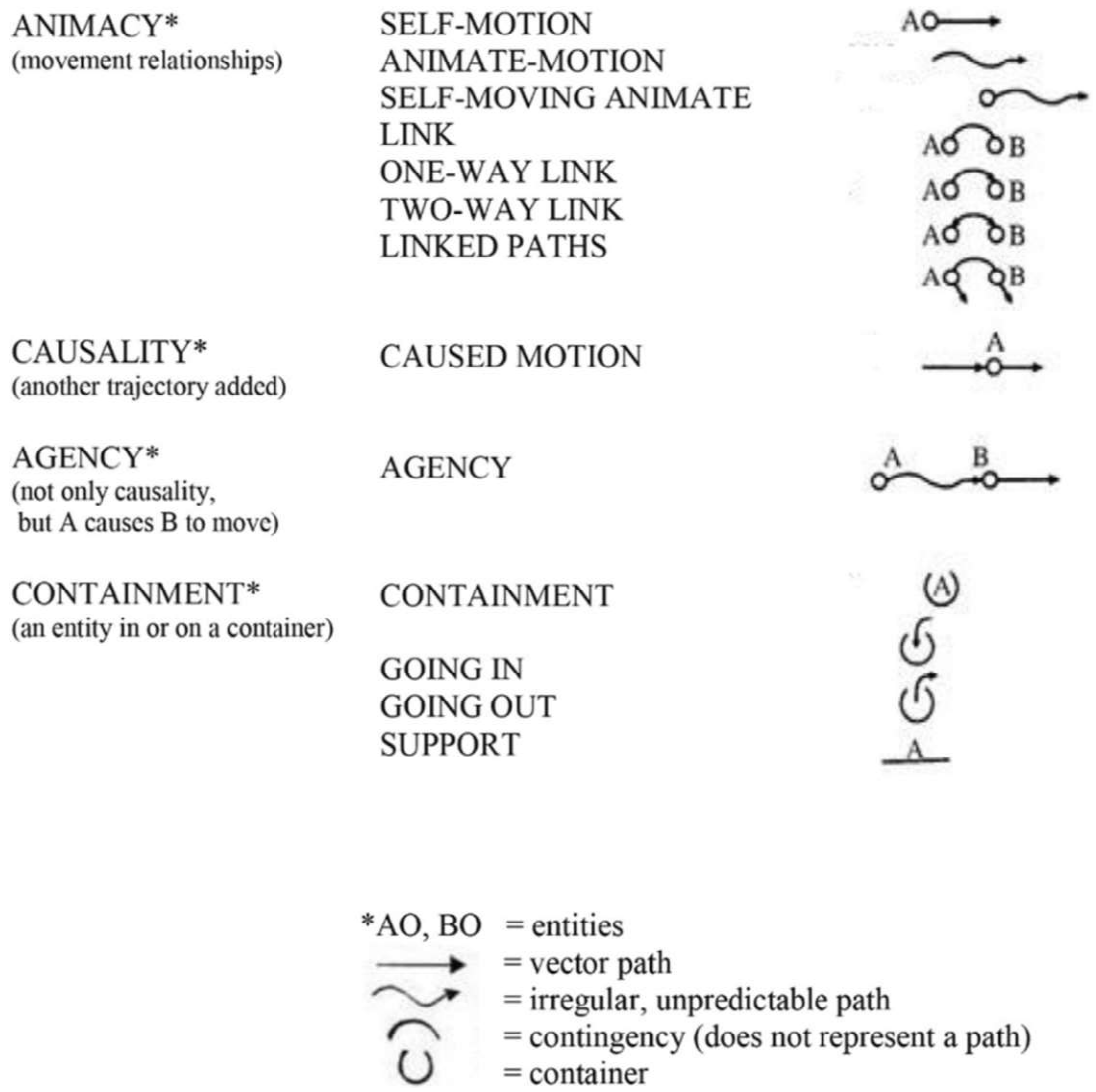


Figure 7. Mandler presents image schemas related to self-motion, animate motion, containment, and direction (going in vs going out) [31]. ”Accordng to Mandler, conceptual primitives form the foundations for visuospatial meanings that are instrumental later for relational thought and language (p. 5) [37]”.

The first image schemas are formed from innate spatial and motion primitives, providing infants with a way of understanding and remembering events without the burden of the infinite detail that events present (p. 1) [36].

> Babies are not Piaget’s sensorimotor creatures. A rich system of conceptual structures and cognitive habits is already in place before verbal activity begins. Language and culture necessarily build on this system. They boost it and change it, sometimes in dramatic ways, but they are also influenced by it (p.19) [36].

Spelke [39, 40] proposed innate primitive principles that implemented explicit rule structures for elaborating primitive forms. Carey [43, 44] emphasized a bootstrapping procedure where children begin with only innate primitive images and construct concepts scaffolding more complex concepts from simple ones. Experience elaborates these templates according to Quinan bootstrapping to establish complex concepts that conform to culture conventions. While predominantly linguistic, they also function artistically.

Empirical links between proto-drawing and conceptual schemas, not surprisingly, show strong correspondence during literacy development. This construction of literacy skill hierarchies are directly constructed from schematic primitives in drawings and this dynamic process is called emergent writing [25, 26, 45].

3.2.2 Examples from children's drawing

Some of the strongest evidence supporting cognitive primitives is found in preschool drawings, an environment explicitly organized to stimulate mental development. A long tradition of empirical studies have examined primitive imagery in children's drawings at least since Luquet in the 19th century, and those studies pointed to developmental relations between drawing and intelligence. Contemporary research now emphasizes very close developmental origins between drawing and early writing and drawing. In general, drawing and early writing literacy share a pathway that does not truly differentiate into independent, separate domains until children are about six years old [46]. then visual arts becomes a separate developmental strand and recognized as artistic aptitude and ability. Before the age of two years, children do not distinguish between drawing and writing. Therefore, artistic expression during early childhood could share important dynamics and genetic mechanisms with early literacy.

Visual stimulation during early childhood provokes innate, latent image inclinations, and children spontaneously embellish them during drawing to establish primitive schemas. They are transformed during their reappearance in early writing. Consequently, children's preschool drawings provide a convenient vantage for viewing the instrumental influence of primitives on conceptual development and early literacy.

Developmentally, children talk before they draw, and gestures and body motions appear before they talk. Moreover, drawing occurs in a socio-cultural context before they write. Children first scribble and gain control over drawing primitives, which they manipulate and transform during their assimilation of letter conventions of early writing. The dynamics of this process are a fascinating example of primitives in action [47] sometimes called emergent writing. Latent innate primitives stimulated by early learning present schematic templates, which children attempt to approximate in their early drawings. Children engage in much iteration involving successive efforts at scribbling in drawings to establish correspondence with schematic templates. Then hierarchical linkage approximate conventional alphabet and then early literacy. Manifest confusion and disorganization if not chaos observed by adults during this process of establishing a neurological substrate for conceptual foundations, which are extended and elaborated into multiple literacies throughout child and adulthood.

Primitive components, conceptual primitives appear early in children's drawings. Levin and Bus [41] referred to them in children's drawings as templates that establish an initial starting point for constructing more complex images. Mental templates impose order on unfamiliar perceptual experience, and children compare their drawing products with an

a priori schema and improve this match with practice. They verify predictable relations in conformity with innate spatial and temporal principles.

Levin and Bus [41] in studies of child drawings proposed a graphic template that functions as an initial starting point for constructing more complex images. Perceptual experiences can be compared to a template to establish consistency and predictable relations in relations with spatial and temporal principles. Oakley [42] also emphasized function of templates.

In addition, empirical studies suggest these highly personalized templates are instrumental to children's symbolic conceptual development. Hierarchical development underlies children's progression from early visual art expressions through early writing literacy. In other words, these templates during early drawing establish foundations for a learning continuum that transform into complex conceptual structures. Figure 8 presents templates that children purportedly implement during early drawings and several UIs that spontaneously appear there have been circled. The broad range of UIs from circles to floral patterns appearing in early drawings was unexpected. In addition, children demonstrated a hierarchical progression, circles and spirals appear first for younger children, then undulating lines and rainbows appear for older children.

Figure 9 presents additional evidence of UIs in children's drawings from the perspective presented in Kellog's coding system [48]. Early scribbling demonstrates successive manipulations of circles, as well as spiral.

UIs also are functional during preverbal infant development. Yamagata [49, 50] conducted experiments that demonstrated children will select elaboration of a circle when given a choice between alternative primitives. One year old children understand the abstract function of a line in representation and will inscribe concrete details in a primitive circle. In other words, the circle facilitated graphic semantic expression. This capacity to abstract and express appears uniquely human. When chimpanzees were presented with primitive components, they could not complete the activity [51]. Figure 10 shows primitive components that were presented to children.

> They found that a drawn contour (DC) task, in which the child was given a circle for a facial contour, had facilitative effects with 1⁄2–2⁄2 year-olds as compared with a no drawn contour task (NC) (drawing on a sheet of paper). That is, in the DC task, 1⁄2-year-olds drew something inside the contour indicative of primitive component parts (p. 131) [49].

Yamagata emphasizes below that infants do not have motor capacity to draw yet, they already have the abstract capacity to represent symbolic function with a primitive image.

> This fact seems to indicate that, on the basis of symbolic function, children at 1 year of age can understand that a line stands for something or extract the component parts, but they still have not learned how to draw. To learn to draw, it seems both acquisition of drawing method and motor development to produce controlled line drawings are indispensable (p. 139) [49].

Features	Israel	Dutch
(1) Scribble	Father (3:3)	Father (3:1)
(2) Big Good Figure	Grass (3:2)	Name (3:1)
(3) Small Good Figure	Flower (3:4)	Bird (4:3)
(4) Linearity (no segmentation)	Mother (3:3)	[illegible]
(5) Segmentation (no linearity)	Name (3:8)	Flower (3:5)
(6) Linearity & Segmentation (wavy line)	Name (3:2)	Name (3:10)
(7) Simple Units No variety	Flower (3:5)	Name (3:5)
(8) Complex characters Unintended variety (pseudo-letters)	Flower (3:11)	Father (3:7)
(9) Complex characters Intended variety (real and psuedo-letters)	Sun (4:3)	Name (4:4)
(10) Conventional symbols (random letters)	Sun (4:5)	Three Flowers (3:8)
(11) Invented spelling	Grass (4:5) דשא	Mother (3:8)
(12) Conventional spelling Own name	ניצן (4:5)	Monica (4:2)

Circles

Flowers

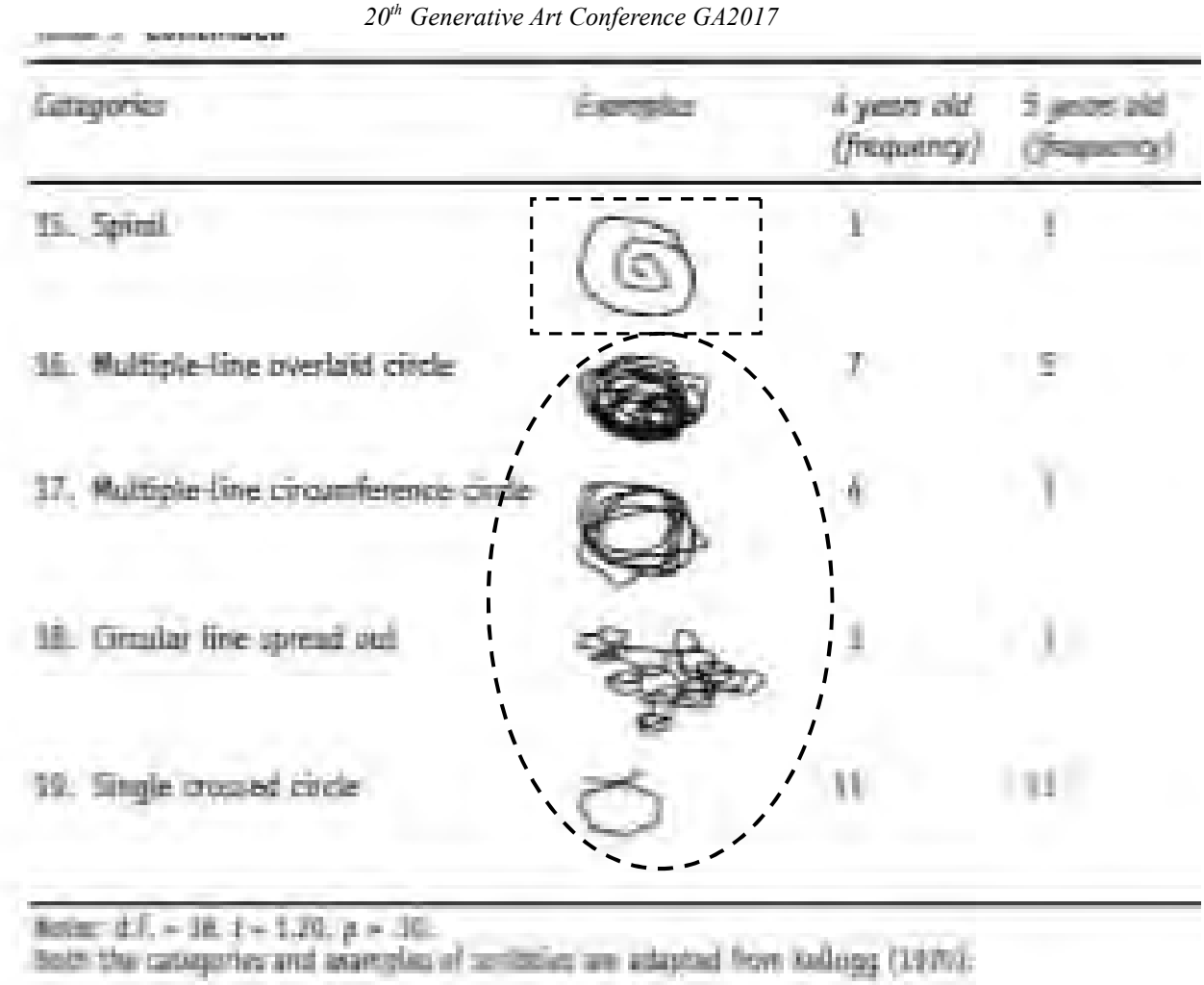
Wavy line

Flowers

Flowers

Flowers

Figure 8. Children's drawing and early writing (p. 895) [41].



Categories	Examples	4 years old (frequency)	5 years old (frequency)
15. Spiral		1	1
16. Multiple-line overlaid circle		7	5
17. Multiple-line circumference circle		4	1
18. Circular line spread out		1	1
19. Single crossed circle		11	11

Note: d.f. = 18, t = 1.20, p = .16.
Both the categories and examples of scribbles are adapted from Kellogg (1970).

Figure 9. Drawings show several manipulations of the circle, as well as an explicit spiral [48].

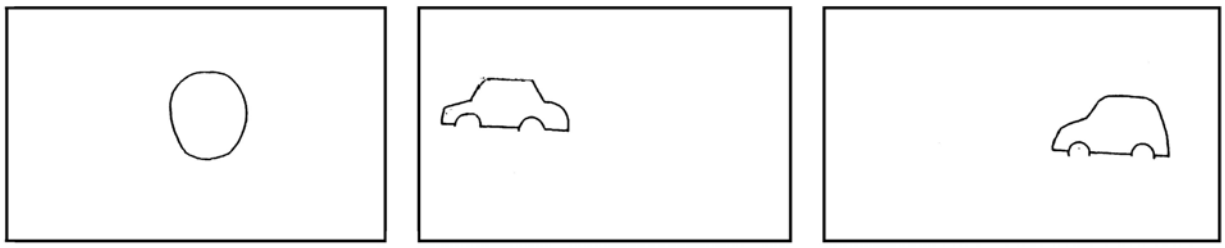


Figure 10. Primitive contours from Yamagata [49]. When presented these primitives, infants select the cirlcle for drawing.

3.2.3 Paleolithic origins of UIs

Much speculation has occurred about primitive images in Paleolithic art that have appeared across multiple geographical sites. Perspectives on neuro-development leading to these expressions, as well as their function in communication and ritual are prominent. Dissanayake in the quote below speculated on their preservation as symbolic states related to safety, order, and harmony. In general, image primitives in Paleolithic art tend to increase the weight of their collective importance, which suggests they arise out of the struggle for survival and adaption.

> Neuroscientist Derek Hodgson, for example, proposes that primitives may appeal to us aesthetically because, as inherent features of the brain, they come to connote what has been safe, secure, and understood; they provide order in the midst of disorder; and they convey a sense of pattern and harmony in the midst of the chaos and confusion of nature. Certainly features such as straight lines, edges, contours, geometric shapes, and contrast attract attention, give cognitive satisfaction, and can be used . . . by artists (p. 9) [4].

Figure 11 presents several image motifs from the Lower to Middle Paleolithic, they also appear across the Upper Paleolithic period. The correspondence between uprights, sunburst, zigzag, circle, floral pattern, rainbow, spiral, and undulating line is striking.

Hodgson also discussed the question of neuron sensitivity to specific lines and shapes [53]. In particular, “certain stable, invariant percepts may trigger recognition because . . . early visual areas are already pre-tuned to be responsive to particular stimulation. Their discrimination functionally contributes to survival in the world at large.” Figure 12 demonstrates a similarity between rock carvings and abstracted linear motif of animals common in Paleolithic drawings.

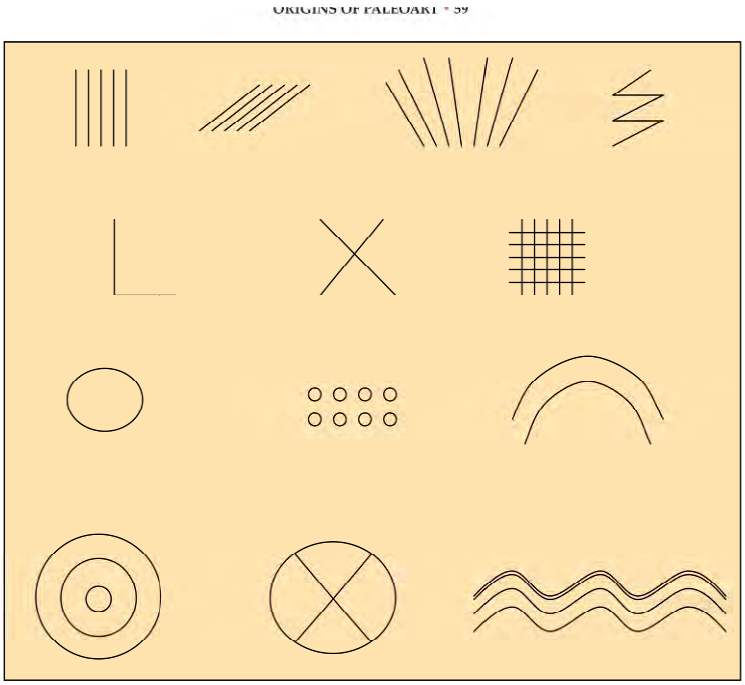


Figure 11. UIs in Paleolithic art. From Hodgson [52]

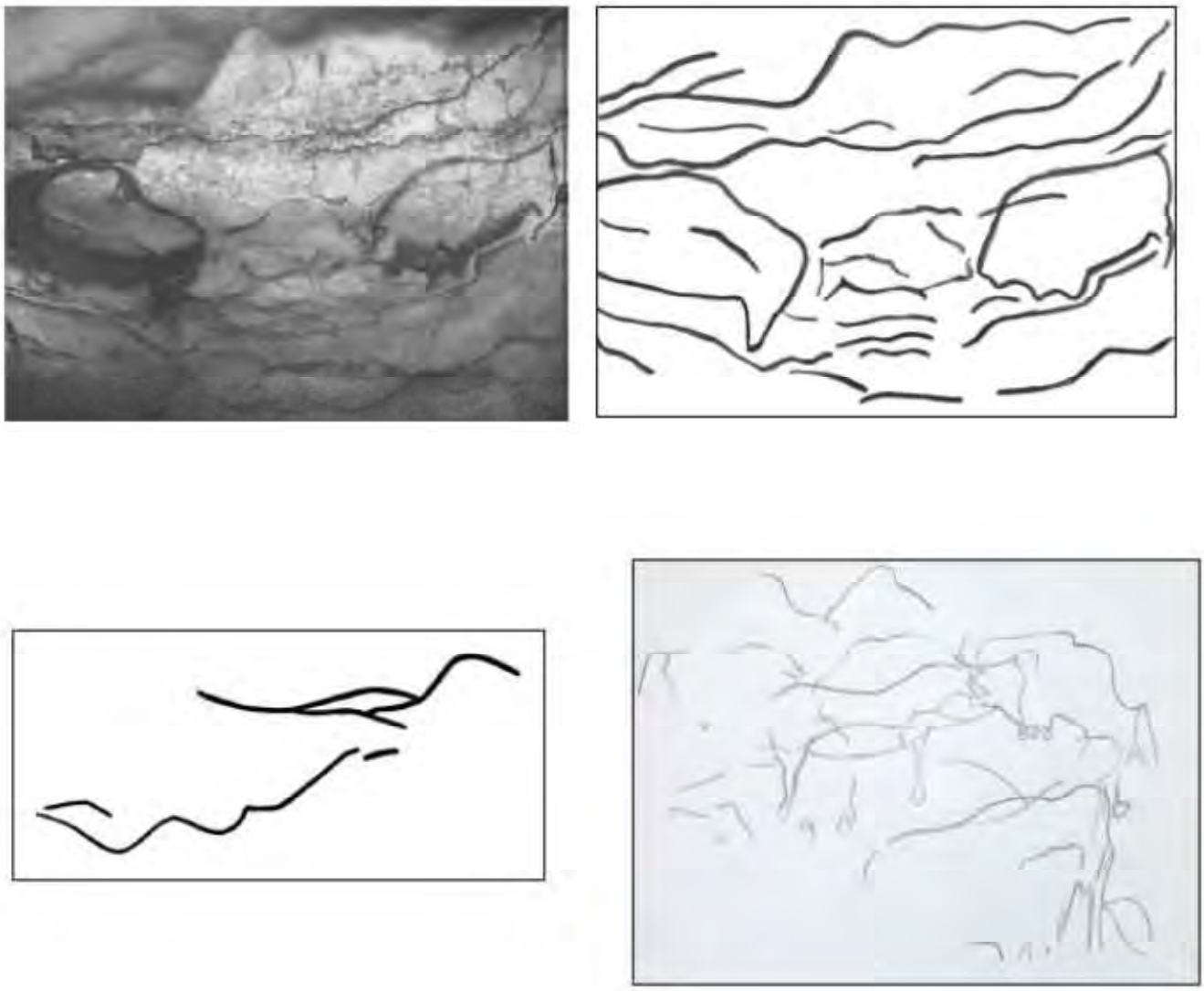


Figure 12. From Hodgson [53]

3.2.4 Probabilistic models for generative learning from primitives

The hypothesis of an innate generative grammar introduced by Chomsky and now the predominant in language and conceptual development is also relevant for describing the function of primitives in early drawing. Contemporary research is actively developing conceptual growth models with ideas about primitive components, reusing components, and extending conceptual hierarchies with probabilistic statistical methods. Lake et al. [54] present an approach to probabilistic generative models.

> As programs, rich concepts can be built "compositionally" from simpler primitives. Their probabilistic semantics handle noise and support creative generalizations in a procedural form that (unlike other probabilistic models) naturally captures the abstract "causal" structure of the real-world processes that produce examples of a category"(p. 1333) [54].

> In short, BPL can construct new programs by reusing the pieces of existing ones, capturing the causal and compositional properties of real-world generative processes operating on multiple scales (p. 1333) [54].
>
> By testing our classification tasks on infants who categorize visually before they begin drawing or scribbling (52), we can ask whether children learn to perceive characters more causally and compositionally based on their own proto-writing experience. Causal representations are prewired in our current BPL models, but they could conceivably be constructed through learning to learn at an even deeper level of model hierarchy (53) (p. 1337) [54].

Figure 13 shows a set of primitives that children implement during concept formation. An emphasis on line segments, circles, and curves are prominent among them.

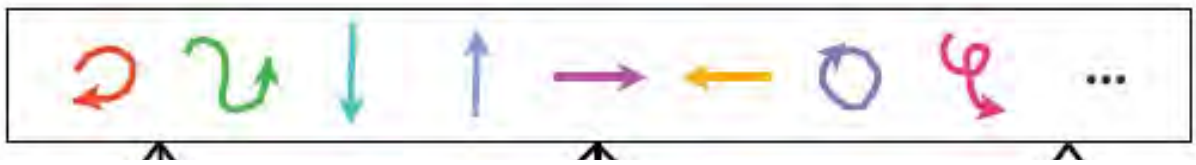


Figure 13. Primitives and operations in concept learning

4.0 What is DNA expression?

4.1 gene expression, and epigenetics

A classic example of Mendelian genetics is flower color transmission where genes provide instructions for a protein that defines the color of flower petals in successive generations. In general, human physical characteristics are stored in DNA, and over 18,000 human characteristics follow Mendelian genetic laws. However, many characteristics, about 5,000, have functional relations to a phenotype that is dependent on physical and social conditions independent of genetics. Some of these characteristics are related to disease and health. In other words, non-Mendelian genetics describe heritability that does not follow classical principles because transmission is mediated by more complicated cellular components that interact with the environment. A key mechanism in non-Mendelian genetics is gene expression, which is described below:

- Gene expression is a tightly regulated process that allows a cell to respond to changing external environment – within body chemical or external social conditions.

- Gene expression acts as both an on/off switch that controls vital protein production and also a volume control that increases or decreases amount of proteins.

Gene expression is a process of converting DNA coded instructions into products useful to the human body. These products are initially proteins, but DNA expression eventually may become a functional product such as an emotion or behavior.

This special area is called epigenetics, which describe changes in genes during imprinting and coding. In general, epigenetic gene expression responds to Internal (hormones, gender, affective states) and external (temperature, light, invariant perceptions) stimulation. The following quote from Lobo succinctly presents key issues surrounding gene expression.

> The expression of genes in an organism can be influenced by the environment, including the external world in which the organism is located or develops, as well as the organism's internal world, which includes such factors as its hormones and metabolism. One major internal environmental influence that affects gene expression is gender, as is the case with sex-influenced and sex-limited traits. Similarly, drugs, chemicals, temperature, and light are among the external environmental factors that can determine which genes are turned on and off, thereby influencing the way an organism develops and functions (p. 1) [55].

An important point here is these cell products become functional to the organism with important consequences for health and well-being including cognition and learning. An area not investigated yet is relations between conceptual entities and gene regulation. For example, during early literacy development gene expression is believed to produce idiosyncratic conceptual products that can be socially conditioned to approximate culturally-defined language and literacy conventions. In other an experience may trigger a primitive stored as DNA information, which is expressed in terms of UIs. Other experiences may present affective feelings of peace and tranquillity, which might trigger a wavy line. These primitives then become instrumental to constructing more complex schemas with explicit symbolic properties.

A general idea here is human reactions to visual images are mediated by gene activity. Normal affective reactions to visual images are mediated by gene activity. When children try to draw certain objects, gene expression leads to predictable emotional and behaviour reactions. Not surprisingly, some genes are probably sensitive to specific objects, while others function in networks. Moreover, DNA information is transmitted from generation to generation subject to natural selection. DNA information interacts with environmental and individual context. DNA can take various forms …instructions to “flip” on or off.

Gene regulation of artistic behaviour would contribute to understanding primitive images in visual arts. Indeed, on/off switching of genes during manifestation of schematic primitives in drawings is no less interesting than the instrumental function of these same primitives to abstract concept development that are assimilated into conventional language. Mimicking this process during early development is differentiation of art ability and early writing literacy.

4.1 Domain examples of mental structures during gene expression

Effects of gene expression on mental structures appear across a wide range of human characteristics and mental performance in particular. Researchers are identifying a growing body of innate cognitive structures that appear to be triggered by embodied physical experiences. For example, infant visual sensitivity to detect animacy or motion patterns is dependent on an a priori self-experience of self-propelled bodily motion. In other words, infants ’spontaneous efforts at self-propulsion trigger animacy perception among animals and humans. Velasco, [56] found comprehension follows perception,

that is, the speaker's bodily experience and environment trigger the linguistic expressions that carry conceptual meaning to language. Others [38, 57, 58] described an innate cognitive capacity that infers causal relations between two events or objects distinguishes humans from all other animals
Munar, et al., [59] identified visual preference for curvature as a potential aesthetic primitive. Innate primitive mental structures have been identified for quantitative processing related to physics [37] while Dehaene,et al. [60] found core geometry knowledge among Amazon Indians. Rugani, et al. [61] hypothesized an innate structure related to number-space that maps observations to a mental number line. A similar structure was found among new-born chicks. Kersey et al. [62] also found innate number primitives are an abstract concept in humans.

Innate human predispositions are not restricted to physical observations. Detection of social stimuli were linked to a primitive at birth [63]. Liang [64] found gene expression related to a bee's role scouting for food sources versus nest sites. Changeux, [65] described brain levels of organisation from genes to consciousness.

5.0 Conclusion

In conclusion, imagination is nontrivial. The idea of gravity linking heaven and earth is profoundly imagined, an idea generated by Newton's creative insight. Likewise, the idea that a flash of static on a wool sweater is the same energy as a lightning bolt is pure imagination. The consequences of these creative insights and many others have changed the course of human evolution. The generation of ideas in the affairs of man is a central driver of practical knowledge and technological change, which is the undercurrent advancing civilization.

Therefore, it could be argued that most contemporary aesthetic philosophy is doomed because it fails to integrate artists and art making into human evolution. Art making sophistication parallels the advance of civilization but contemporary aesthetic philosophy tends to separate the art maker from this evolution. The artist is presumably transcendent and insulated from human change. The consequence is a philosophy of art generally estranged from the advances of civilization, and a sterile exercise in obscurity.

UIs have been identified across Nature at several scales, and they were found in visual art through the centuries, as well as in children's early drawings. A process was proposed concerning how UIs function in visual art, and speculations presented about the influence of DNA expression.

While the metaphysical discussion has pointed in the direction of an empirical aesthetic philosophy predominantly led by Plato and Kant, Jung's demonstration of archetypes in personality development is a practical milestone. Jung's archetypes, however, are a product of aesthetic primitives, a personality outcome after years of consolidation. This report has suggested that DNA information functions at an even more elemental level and has attempted to point in the direction of how they might look. A step forward now

is to understand better how these primitives function as components in the human construction of knowledge.

Awknowledgements

I am deeply grateful to Ambra Borgognoni Vimercati for loaning her collection of Universal Images for this presentation. More importantly, I am indebted to her for introducing me to primitive images in visual arts and the profoundly difficult question of their meaning and function in human affairs.

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Origin point : harmonic echoes of a mineral cosmology (Mende Cathedral)

Topics: Art, Architecture, Music

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Abstract

"Mende Cathedral" is an interactive sound installation that transposes the architecture of a Gothic cathedral into sound timbres and music, through a method using a mathematical object called "spherical harmonic". It can be seen as a contemporary and poetic version of the harmony of the spheres, revisited in the light of current scientific models from the fields of music, acoustics and astrophysics.

To experience it, the visitor is invited to bring a headset, to hold a small luminous module called a "harmonic lantern", and then to wander in the nave and collaterals of the building.

The transposition takes place in each point of the space by taking as a center the position of the visitor who, through his movements and displacements, will hear a different and unique musical composition for each of his trajectories.

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Key words: music, architecture, cosmology, spectral composition, generative music

ORIGIN POINT
Harmonic echoes of a stone cosmology

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1 - Introduction

On these two photographs appear an old lady and an little girl. Both listen to music in a Gothic cathedral. The cathedral is located in the city of Mende, in Southern France, in the Department of Lozère. The object they hold in their hands is called a *harmonic lantern*. The harmonic lantern is a very simple device. Its only external features are an audio output, which can be connected to a headset, and a volume knob. They hold it vertically, like a candle. If they stand still, they hear nothing. When they walk the aisles of the cathedral, or when they move the lantern, they hear a music whose spectrum is very rich in harmonics that vary constantly according to their position. Each of their trajectories determines a different musical sequence. The harmonic lantern has a peculiar feature: at every moment, it stands at the centre of the world. In other words, each person carries a harmonic lantern carries the centre of the world with him.

The lady and the girl are experimenting an *in situ* installation *called Mende Cathédrale*, developed from a research-creation program called *Origin Point*. It is designed to be

very intuitive and extremely simple to use. It is meant for places accessible to all audiences. The photo above comes from the first presentation of this installation, which took place from July to October 2017. The device, as well as the music produced, represents both the conclusions and the results of several years of theoretical work, research and development spanning several disciplines. The purpose of the present paper is to summarize the main lines of this research, and to show how the final installation has become both the focal point and the synthesis of the conclusions of this work.

2. Architecture as a small cosmology

The starting point of the project, the one from which it emanates, is anchored in the following statement: any architecture, from the most miserable to the most sumptuous, is a small cosmology. This can be read through several elements, ranging from the symbolical to the analogical. Every building, even the most ordinary house, is loaded with a symbolic charge that connects its inhabitants to a set of questions for which there are no answers. The European suburban pavilion, the North American bungalow, are often presented as examples of the sheerest banality, or of the most saddening mediocrity. Yet, like any house, they shelter processes and actions that are essential for the perpetuation of life: to eat, to sleep, to reproduce, to excrete… Through this, they concretize in wood, brick or stone an assertion that is everything but obvious: human life, or the life of human beings, deserves to be perpetuated.

Very few people actually wake up in the morning wondering why they should stand up and start their day, rather than staying in bed, wondering why they should do anything at all and questioning the very necessity to do something, to conclude that life in general, and their life in particular, is useless and meaningless. In the same way, very few people would sit down to a meal, then get up and quit the room without eating because of similar concerns. People seldom question the need to start a family, less again the meaning of the chain of events that, from the birth of the Universe, generated this moment where they decide to have children and to perpetuate this very chain. To feed, to breathe, to wash, to talk with fellows or brethren, all these daily actions are suspended in a fragile balance above an abyss of vertiginous questions that are most of the time kept at a safe distance, in order for people to be able to live their daily life. This is where the role of the house becomes primordial: through its banality, through the everyday routines it induces, all its most ordinary aspects become safeguards that protect the reckless individual against the risk of endless questionings about origins, purpose, existence. Hovering between the biological materiality of the world and the vastness of the symbolic territories it dissimulates, even the most ordinary house can be said as talking with the gods.

The second cosmological connection of architecture appears through a set of analogical relations. In every historical period, it is possible to associate many, and sometimes most, elements of the building with the main elements of the cosmology that prevails at the same time, and in the cultural area where it is located. Such associations can be sometimes subtle and sometimes obvious, but they appear at all scales, on all types of architecture, be they domestic, secular or religious, nomadic or sedentary. An eloquent example can be found in of the simplest houses of all, namely the Tuareg tent (fig.1). At a first glance, nothing seems to connect it to anything remotely or closely connected to the cosmos. A closer examination reveals that it maintains a constant dialogue with all scales of the world. A simple diagrammatic plan however shows that it is connected at

several levels; for instance, it is oriented according to the four cardinal points. Despite the square shape of its structure, its name in Tuareg means "circle ", which makes no sense on a rational point of view, but illustrates the fact that the inside of the tent actually has the status of the centre of *something*. The areas facing the four sides of the tent have different significations. The western area, in front of the entrance, is open to the world and to encounters with other humans. It is the place for dining, for the tea ceremony, for receptions. In contrast, the eastern area, in front of the only blind side of the tent, is dedicated to contemplation and prayer. The northern area is seen as the evil one: supernatural beings gather there at dusk. They are called the *kel-esuf,* "those from the loneliness". On the contrary, the southern area is beneficial. It's the area of luck (*baraka*), and it is the place where woman give birth to their children.

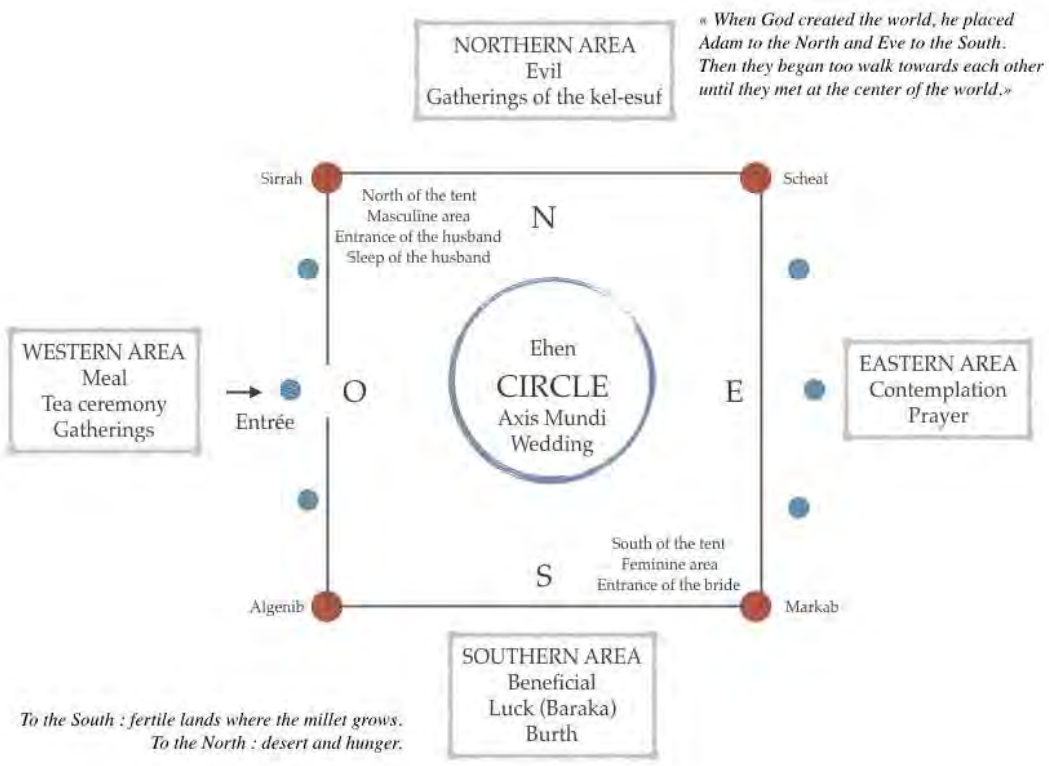

Fig. 1 – Symbolic Diagram of the Tuareg tent.

There is a first coincidence between this orientation and that of most Christian churches: the opening to the secular world, the reception, the meeting, is on the west side, in a kind of analogy with a church parvise. Prayer and contemplation, corresponding to the dialogue with the divine beings of the religious cosmos of the tribe, take place against the eastern wall, which presents no opening, like the apse of a church. The beneficial and evil aspects of the northern and southern areas establish another connection with larger scale, namely that of the territory. They reflect the geographical situation of the Tuareg habitat: "The North is the kingdom of desert and hunger; in the South are fertile lands where the millet grows; inside the tent, the north side is the male area, that of the husband; this is where he sleeps; he enters the tent on that side, on the wedding day. The south side is the female area, the domain of the bride, through which she enters the tent on the wedding day."

The plan thus determines not only the places of the spouses, but also the trajectory that leads to their encounter at the centre of the circle. This trajectory is also symbolical:

“When God created the world, he placed Adam to the North and Eve to the South. They then began to walk towards each other until they met in the centre of the world”. The nuptial march of the spouses replays the meeting and mating of the original couple, from which all human life originates. The centre of the tent, whose Tuareg name, "ehen", means “wedding”, becomes at this very moment the symbolic centre of the world. The four pillars of the tent complete the cosmological connexion at an even larger scale: each of them bears the name of the main stars of the Pegasus constellation, Sirrah, Scheat, Algenib and Markab, which is approximately shaped as a square, and which is very obvious in the desert night sky. According to the Tuaregs, these stars were placed on the celestial vault by God to remind them that the whole sky is a gigantic tent, supported by four immense pillars placed very far away, out of human reach, on the four cardinal points.

To describe all the symbolic, poetic and analogical links that connect architecture to the cosmos and to the territory, we will use, for reasons that will be described in the following sections, the expression "harmonic connection". It is actually difficult to find a building that does not present a harmonic connection to some degree. If we decided to present the first installation from the Point Origin program in a cathedral, it is precisely because this building is a cosmological echo, by its symbolic load and through multiple analogies. To clarify this concept, we will look at a sequence that will take us back more than 2500 years in the past. It will allow us to recapitulate briefly the transformations that progressively led to the unique shape of the cathedral, and to see how it evolved afterwards. Then, thanks to a few selected examples, we will see how the successive changes in the cosmologies of different times have been reflected in the architecture of the corresponding periods.

3. Harmonic connections: the being and the world

The harmonic connection manifests itself by many different ways. It is not always obvious: it may imply permutations and substitutions between elements that could make it challenging to detect. An important point to consider is that it is not a scientific theory, not even a proven historical fact, but rather a poetic connection in the etymological sense of the term – a generator of *poiesis*, of creative possibilities. The history of architecture shows that architectural design in general does not bother with historical or scientific truths, except when it explicitly uses them as the basis for a dedicated scenario: many major architectural pieces are based on myths, legends and fictions without any correspondence with history, nor with the reality of some ancient facts. The examples that follow are gathered only because they all present formal analogies with the cosmology of their times and places.

The following figure (fig. 2) illustrates different hypothesis about the structure of the cosmos at different times in history, from ancient Greece to today. The antique cosmos consists essentially in a planetary system, most of the time - but not always - centred on the Earth, or close to it. The sphere and the circle are common to all of them. As it is well known, in the cosmos that prevailed in Greece 2500 years ago, the planets circled the Earth in simple or complex orbits, depending on the models; but every orbit was always the result of combinations of circular motions. Beyond the farthest planets lied the sphere of fixed stars. These systems were invented in order to try to explain and predict the movements of the planets, especially those of the outer ones (Mars, Jupiter, Saturn), which at this time defied any attempt at prediction, hence their Greek name

planetai, or wandering star.

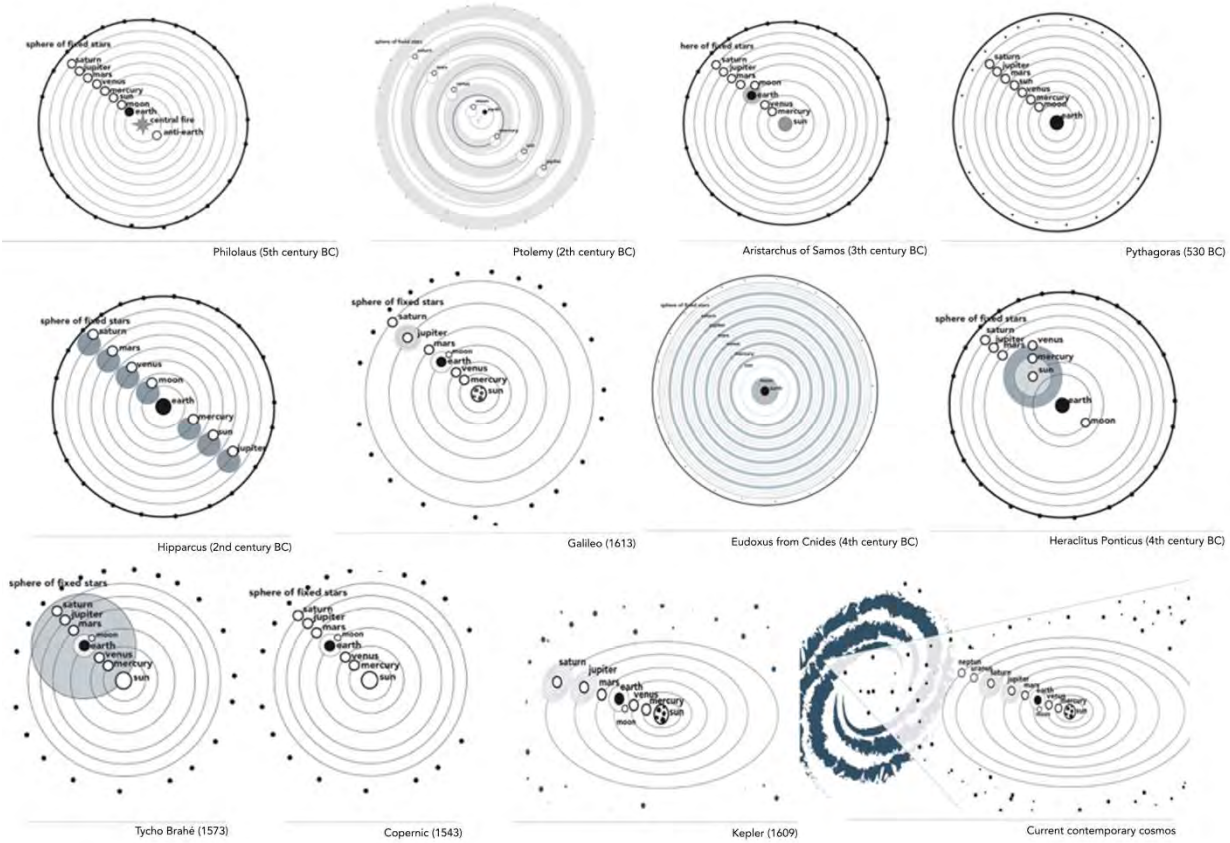

Fig. 2 – Schemas of planetary systems from the Antiquity to today.

In line with the writings of Anaximander of Miletus, whose explanations of natural phenomena are sometimes strikingly modern, Greek science has constantly sought to rid nature of any supernatural causality: the explanation of nature should be found in nature. The planetary movements had thus to be related to understandable geometric patterns that would allow to predict their trajectories with the best possible precision. From this injunction were born a series of extraordinary models, all based on the notion of epicycle, in which the planets orbited around small circles whose centres revolved around the Earth along large circles called "deferent", and whose successive evolutions, which implied modifying or adding epicycles and circular movements to get closer to the observational data, served as a basis for Western cosmology for nearly 2000 years (fig.2). Although far from being free from all symbolic *a priori* - the obsession with the circular nature of celestial movements, and for the circle as a perfect form, brought the evolution of astronomy to a stall for centuries - the epicycles model is one of the first, if not the first model in history to use the notion of *harmonics*. Very different from that of *harmony*, it will not be properly formalized until the XVIIIth century through the work of French mathematician Joseph Fourier. As we will see later, it has become today a major principle for describing the physical reality.

As in the case of the Tuareg tent, the link between cosmos and architecture in ancient Greece unfolds on symbolical and analogical levels. The first one uses the notion of proportion, a very broad concept whose impact on the ancient world is impossible to overestimate. The second one associates elements of ancient buildings with elements of the celestial world.

The concept of proportion in this time was exclusively used to describe ratios of integer numbers. It was also impregnated with a symbolical load of mythical magnitude. Some special ratios, such as half or double, two thirds, nine eighths, were so important that they were given names, just like the numbers themselves: sesquialter, diatessaron, diapason... The origin of this status has been the object of innumerable publications. The most plausible hypothesis roots it directly in musical harmony. On the one hand, the divisions of the vibrating string of an ancient instrument, the monochord, produced sounds whose frequency was getting progressively higher when the length of the vibrating section of the string was decreased. The associations of the sounds produced by certain divisions produced timbres that were considered singular, either through their similarities, or just because they were pleasant to the ear ("harmonious"). The ratios of the corresponding lengths were therefore considered as having particular properties. On the other hand, the knowledge of the time imposed no theoretical limit to the number of divisions of a string. The frequency of the corresponding sounds could then rise indefinitely, giving the monochord the status of a messenger between the finite world of men and the infinite world of gods.

The gods themselves were morphologically similar to men, but the proportions of their bodies were, for the same mythical reasons, based on ratios of integers. As a result, the ideal body for a human being should show the same proportions: the body became the mean by which the gods revealed these proportions to men, in order for them to replicate them in all aspects of earthly life. It is from this hegemony of the concept that the injunction of harmony for all aspects of the world was born[1]. Harmonic proportions are found everywhere in the Antique world: law, economy, phases of pregnancy... and of course architecture and music, whose scales result - for obvious reasons - from these same proportions. The Greek temple, the very place where the supernatural world encounter the earthly one, is naturally based on such proportions, constantly reminding to mankind the structure of the cosmos it inhabits. More than a simple state of things, harmony was an operator that actively ruled the world. Its power flowed along three lines: first, it was a descriptor, revealing to human beings how the Universe was made; second, it gave a list of instructions or injunctions about the actions to be taken to make the world harmonious – that is, to reach a satisfying arrangement of human affairs; third, it was a messenger between worlds, transmitting to mankind the information of the celestial realms that the gods wanted to communicate to them[2].

At the analogical level, the Greek temple can be seen as a topological inversion of the cosmos, through an antisymmetrical scheme that reveals both the connections and the differences between the two worlds. The plan of circular temples, or *tholos*, illustrates this fact better, because of the similarity between the circle of the plane and the celestial circles; but the overall topology remains the same even in the case of a rectangular plane (fig. 3). Greek cosmology places man and his world at its centre, surrounded by the spherical layers of the celestial world, where the planets reign. Each planet has its own layer. The last layer is the sphere of fixed stars, a celestial world through which the presence of the Gods can be felt and seen. The Greek temple echoes this sequence by reversing its order: human beings wander at its periphery; then comes the intermediate zone, made of progressively smaller circles delimitated by the colonnades and the walls; in the very centre lies the most sacred place, the *naos*, which is only accessible to the priests, and represents the passage through which the two worlds communicate. This tiny place is immense at the symbolical level: everything happens as if the whole sky was projected in it and engulfed into it, in the manner of a spherical mirror whose reflection includes all the points of the universe, even the most remotely located.

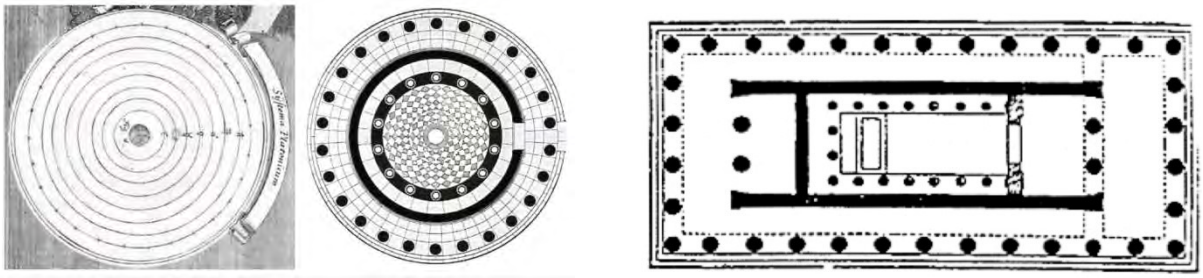

Fig. 3 – Left, tholos and planetary system; right, ground plan of the temple of Hephaestos (415 BC), by F. Hazan. The two buildings share the same topology.

Some 1500 years after the first Greek cosmologies, the Romanesque churches, as well as the abbeys of the same period, reflected the structure of an entirely different cosmos in a completely different way, corresponding to the radical transformations that affected the celestial worlds following the transition towards the Christian era. The example of the first Basilica of St. Peter in Rome illustrates these changes.

One of the main differences between the polytheistic skies of the Greeks and the monotheistic sky of the Christians is that the second is open and accessible to mankind: there are well established situations and circumstances by which humans can become celestial beings, through beatification or canonization. These circumstances consist essentially in a life marked by ordeals, good actions and behaviours and initiatory phases, which will distinguish in the long run those who deserve to enter the celestial world. The righteous will go to heaven; the blessed and the holy will become celestial beings themselves. The drawings and photograph below illustrates two stages of Romanesque architecture that reflect this model (fig. 4). The two buildings are designed along a linear trajectory that leads towards a symbolic sky. In the left picture, the wanderer first crosses the westwork, a part of the building that is still connected to the terrestrial world, but gives access to the parvis (or paradise, the two terms being equivalent). The path then opens to the nave, whose spans reflect the initiatory stages, to reach the *saint des saints*, materialized by the tabernacle, the house of God at the heart of the building. It symbolizes, like the *naos*, the connection with the heavenly world. In the right picture, corresponding to a later scheme adopted by the vast majority of Romanesque and Gothic churches, the parvis is placed outside; the westwork is built directly against the nave. It is accessed through a porch that opens on the narthex, already inside the church, and then to the nave. The access to the paradise, or parvis, becomes far less restrictive and gets closer to the world of humans. The main threshold is shifted to correspond to the very moment when the path towards the heavens begins. The most essential point of this trajectory is that it is a two-way path: the Catholic religion states that anyone can speak to heavenly beings, asking for divine intervention, and that an answer will be provided. The nave of the church becomes the passage through which the world of men and the divine world communicate between each other and mutually infiltrate themselves, a situation that was not conceivable for the religion of ancient Greece.

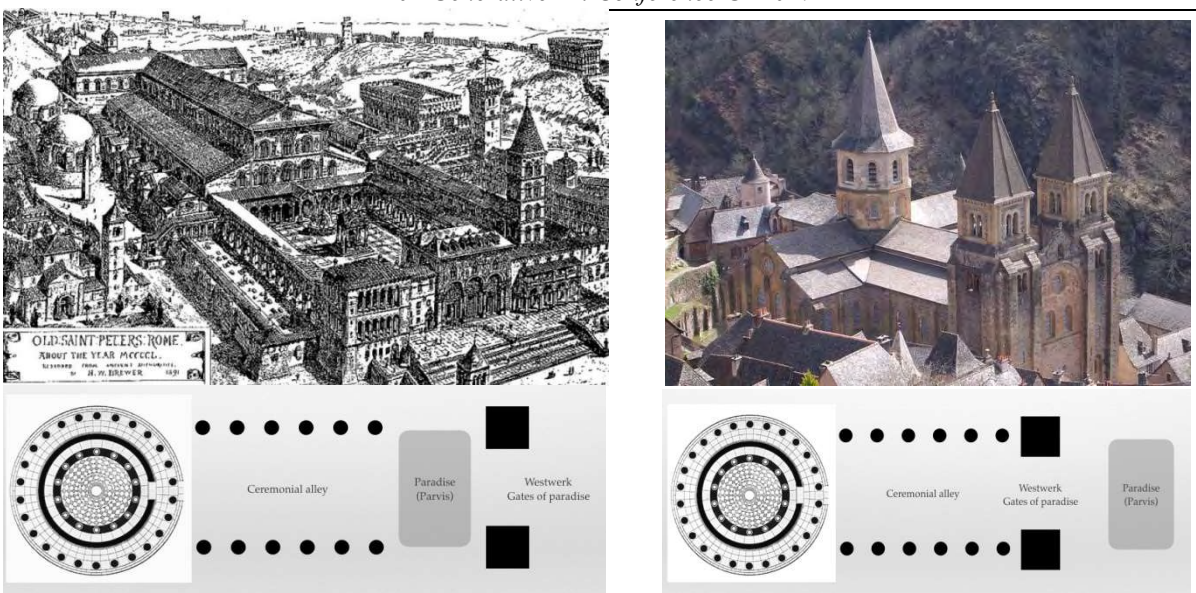

Fig. 4 – Two stages of the evolution of Romanesque churches, showing the displacement of the parvis out of the main body of the building.

The coincidence between the spatial orientations of the Christian church and the Tuareg tent described previously is worth noticing. In both cases, social events, meetings and celebrations take place in front of the main entrance, located to the west. In both cases, the east side, which corresponds to the apse of most Christian churches, is blind. It corresponds the most sacred location: the space dedicated to the prayer in Tuareg tents; the choir that houses the relics, and where the ambulatory processions take place, in Christian churches. This is not a coincidence, since the tent described above comes from tribes who were converted to this same religion, but it shows that the harmonic connection can be found at all scales of architecture, in extremely different times, places and cultures.

Another similarity, perhaps more important, is present. It will be remembered that the centre of the Tuareg tent corresponds to the place where the wedding and sexual intercourse happen. It therefore symbolizes the origin and perpetuation of life. Christianity has constantly and stubbornly ignored the sexual symbolism of cathedrals, a symbolism which, in the light of psychoanalysis and early works on the unconscious, has become obvious. Just like the tale that rid the conception and birth of the Christ of any sexual connotation or desire, the symbolic centre of the cathedral represents the symbolic place where life perpetuates, but it hides in an obsessional and almost neurotic way any element pointing to the biological and corporeal aspects of human reproduction.

The architecture of the Renaissance marks another step in the harmonic connection sequence. The reinterpretation of Vitruvius by Alberti around 1440 is one of the most important events of Renaissance architecture. It chronologically corresponds to the introduction of new and specific elements both in architecture and in the arts, a discipline of which the same architect also treated a few years earlier in his treaty *De Pictura*, describing among many other things the proper method to create perspective drawings. It marks the beginning of a hybrid period that lasted several decades, where sciences and arts oscillated between an ancient world still dominated by divine forces and heavenly beings, and a new one during which, progressively, humans reconciled themselves, after a 2000-year eclipse, with the idea of a nature explainable by natural

phenomena, themselves understandable by the power of rational thought.

Fig. 5 – Alberti's façade for Santa Maria Novella in Florence. The Renaissance façade was directly applied on an older Gothic nave.

Despite its coherence, the famous facade of Santa Maria Novella in Florence (fig. 5) is emblematic of such transitional architectures. Built in front of on a Gothic nave, it presents many elements still characteristic of this mediaeval style; but he skills of the architect allowed him to integrate them in a facade which, at first sight, fully corresponds to the canons of the new classical style, which derived directly from the writings of Vitruvius. The architect tamed the irregularities of the previous style to incorporate them in the clear, precise and austere style of the early Renaissance. Everything happens as if the cosmos could not be understood anymore by symbolic or mythological representations with ineffable causalities, but through the clear and transparent power of geometry, itself a product of humans'brains and reasoning.

The same duality appears, though on a slightly more blurred way, in a painting like the Wedding at Cana by Veronese (1563). This work is based on a double perspective that is not obvious at a first glance, and that determines two vanishing points (fig. 6): the first one stands in the face of Christ, the second one points towards an empty area of the cloudy sky. Neither of them corresponds to the centre of the painting. Veronese could not ignore the rules of perspective, precisely described in Alberti's *De Pictura*. They clearly state that the vanishing point of any perspective is the place where the infinite stands. The painting thus supposes the simultaneous existence of two infinities. The first corresponds to the Christ himself, which is in tune with the ancient cosmos. The second is in an early evocation of an infinite sky, a concept that was impossible even to imagine in the previous centuries. In the indeterminate zone that lies between the two points, precisely halfway, appears a dish in which a piece of lamb is sliced before being served to the guests. Exegetes of the work have been writing that it corresponds to the sacrificial lamb: it evokes the double nature of Christ and testifies for the necessity to join the most Earthly considerations - food - to celestial considerations - religion - to reach a full and complete description of the world.

Architectural echoes of the different stages that led to the contemporary cosmos can be similarly found during the following centuries. One of the main impacts of the Copernicus heliocentric model has been to dislodge the habitat of mankind, and consequently human beings themselves, from its singular and central (or nearly central) position in the universe, stripping them from a most privileged status. The dimensions of the sky, without becoming yet infinite, were multiplied by colossal factors in the new

model. Along these transformations, the Earth was put into motion and became a *planetai* like the others seven, marking for humans the start of a perpetual wandering in a space which, over the centuries, was to become increasingly huge and elusive. The entire sky, rather than the Earth alone, has become the house of man and of his endless perambulations.

Published in 1543, the Copernican system was already circulating confidentially since 1513 and was rather known in educated circles. It preceded by a few years the completion of Palladio's Villa Almerico Capra, known as Rotonda (1566-1571). The architect explains the striking symmetry of the architecture by its location on the top

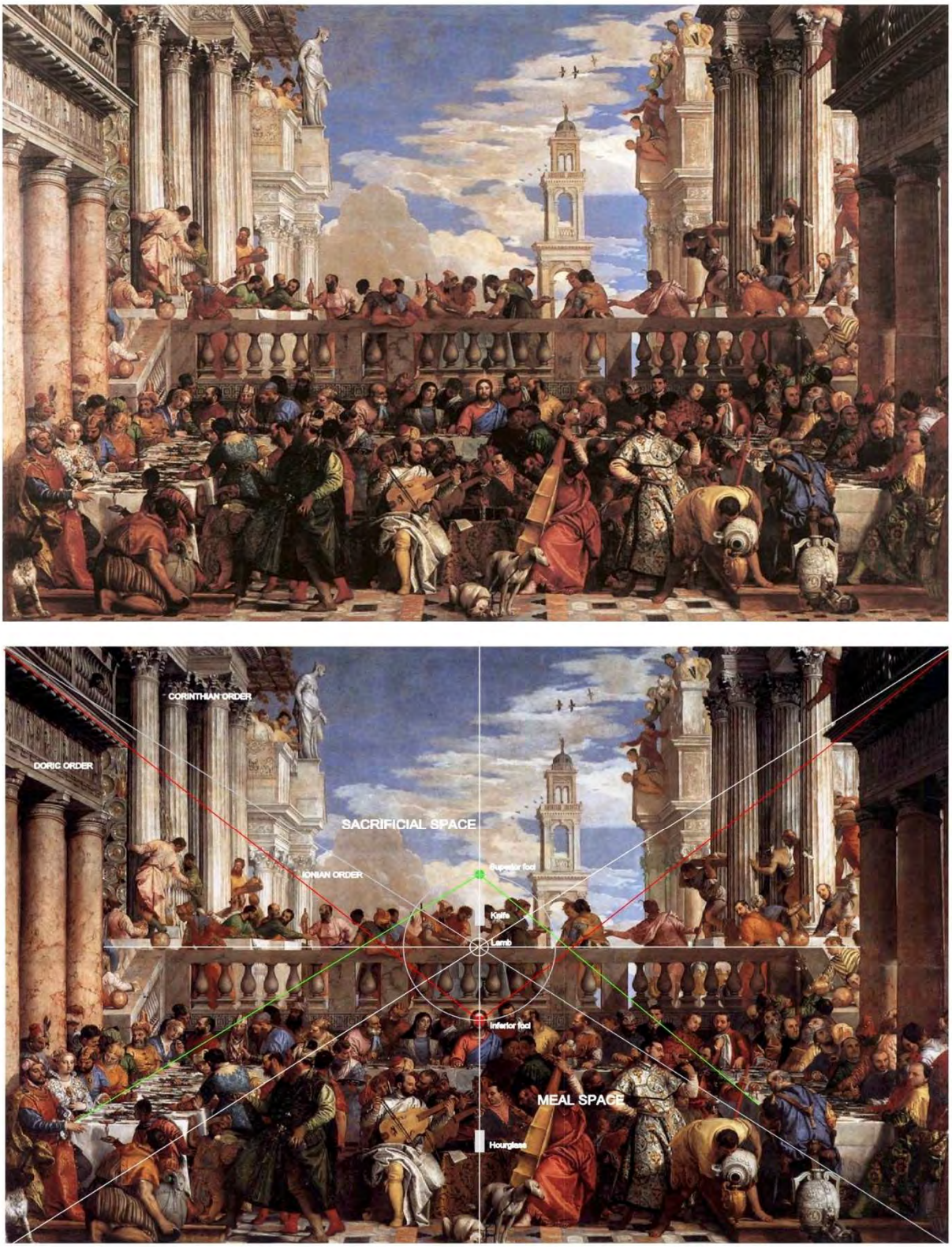

Fig. 6 – The Wedding at Cana (Veronese, 1563). The bottom picture shows the two vanishing points: the bottom one is on the Christ's face; the top one is in the sky. Midway between both is a piece of lamb, symbolizing the sacrificial meal.

of a hill: it enjoys a peripheral view that justifies the implementation of identical façades, composed more or less like theatre stages, on its four sides, so as to contemplate the scenery of nature in all directions. Without refuting this interpretation, it is also possible to see in this centralized plan, one of the first to resurface since the Paleochristian and

Byzantine eras, a first representation of the new cosmos on the surface of the Earth. For the first time, this representation is not proposed in a sacred building, but through a domestic one, which can be considered as the most profane type of architecture. The use of a dome on a house in the Western world, an element that was also found only on monuments, reinforces the image given of the new cosmos: instead of occurring at the very centre of the world, the wanderings of humans take place in the space unfolding beneath a stone sky. Several other elements concur to this cosmological interpretation: the architecture by itself evokes no domestic function, but is much closer, through its monumentality and morphology, to a mausoleum; the diagonal orientation with respect to the cardinal points determines a division of the world into four quarters on which the four façades open, a configuration that can also be found in the almost contemporaneous dungeon of the Chambord Castle in France (completed in 1547), partially attributed to Leonardo and also infused with a strong cosmic symbolism. From these clues, it is not unreasonable to suppose that here too, just like in the Touareg tent and the Medieval church, the building, through its architecture, anchors in the territory an echo and a model of the emerging cosmos.

We can find a similar chronological coincidence between the introduction of the ellipse as a celestial figure in Kepler's Astronomia Nova (1609) and the first uses of elliptic shapes in Western architecture. Among the main examples is the esplanade of Saint Peter's Basilica in Rome, designed by Bernini (completed 1667). It is not unreasonable to suppose that Bernini, a highly educated man, was fully aware of Kepler's work. According to several authors, this may have faced him with a dilemma when designing this work, which can be seen as a symbolic evocation of a cosmos dominated and illuminated by the large basilica. He could either base his design on the old cosmology and use a circular plan, a position without risk for him. But if he did so, the architecture of this highly symbolic place would soon become obsolete to the light of the new knowledge. If, on the other hand, he designed it according to the new cosmology, he would deploy just in front of the basilica, and in front of the private apartments of the pope, vast geometrical figures that would remain heretical for decades, in a flagrant insult that could have led him directly to the stake. Bernini evaded the question by declaring that the colonnade represented two open arms, intended to welcome the crowd of the faithful. This assertion is refuted, and considered as an alibi, by most commentators of his work, on the basis of the drawings accompanying his texts, and of several other clues that point towards a cosmological meaning: the central Egyptian obelisk comes from Heliopolis, "the city of the Sun"; the opening of the colonnade and of the two trapezoidal arms define angles that correspond to the sunrise location on the solstices; the positioning of the fountains at the foci of the ellipse corresponds to possible positions of the Sun in the new system (fig. 7). The architect later used of the ellipse in the church of Saint-Andre-du-Quirinal (1661-1670), which served as a model for many churches of the Baroque and Mannerist periods, generalizing the use of this new cosmic figure to sacred architecture as a whole.

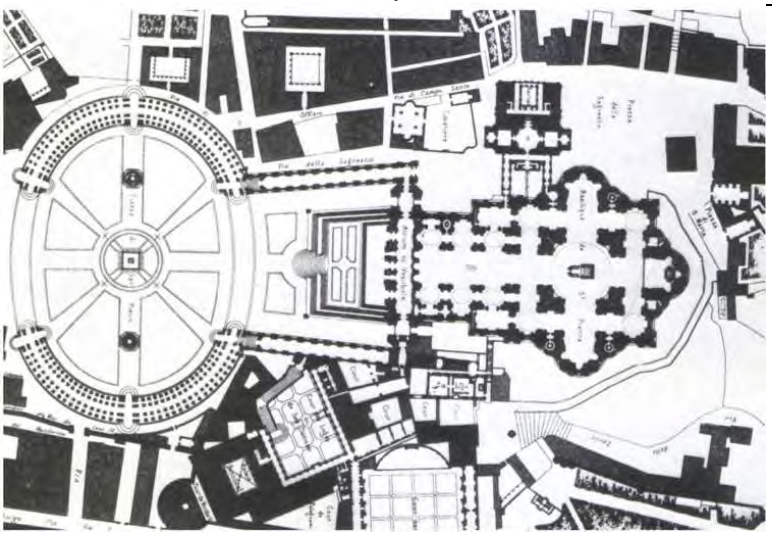

Fig. 7 – Plan of the elliptical esplanade in front of the St-Peter basilica in Rome, by Bernini (completed 1667).

The following centuries saw, in the same way, many formal correspondences between the cosmos and the architecture of a given time. After the publication of Newton's *Principia Mathematica* (1683), in which he formulates the law of gravity, a completely new image of the universe began to emerge. Huge celestial spheres, hovering in a space of gigantic proportions, were majestically revolving and orbiting without any support. During the following century, several architects, today known as “revolutionary”, but who would be more aptly called “newtonian”, published impressive drawings of buildings that were just as utopian as enormous: their size reached dimensions that were never seen before in the history of architecture (fig. 8).

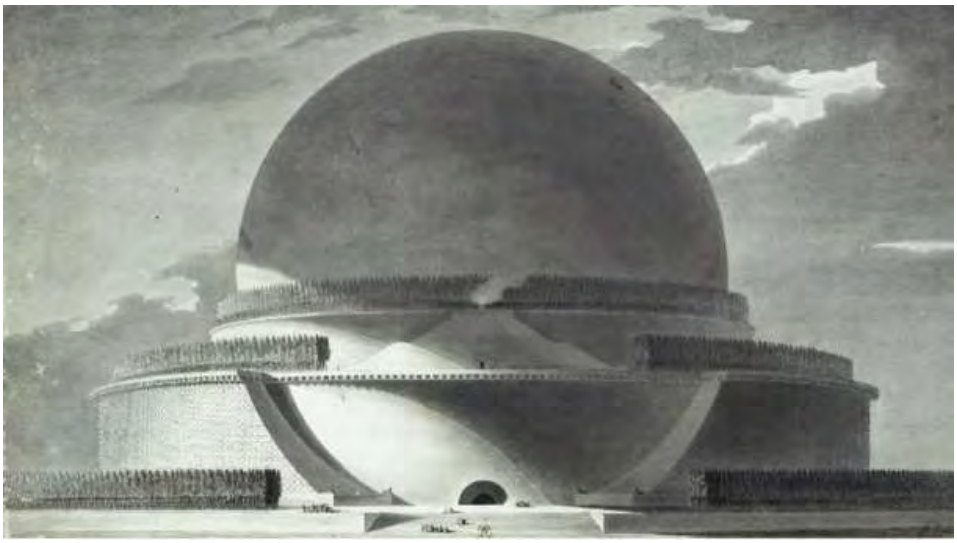

Fig. 8 – Newton’s cenotaph by Etienne-Louis Boullée (1784).

Also for the first time, several of these architects, Boullée and Ledoux among others, used a new architectural form, namely the complete sphere, rather than hemispheres, like in domes or cupolas, or quarter-spheres, like in *cul-de-four* vaultings.

In another historical premiere, Newton presented the hypothesis of an infinite space, a conclusion that logically derives from his theory: in a finite space, the stars would necessarily attract each other, to ultimately crash on each other. The huge size of some the revolutionary architects' buildings can be seen as figures of the potential architectures made possible within a universe of unlimited dimensions; but the first explicit architectural evocations of an infinite space are actually found in the architectural treaties published Jean-Nicolas-Louis Durand, then professor at the Ecole Polytechnique in Paris, published from 1800 on (fig. 9). Durand implicitly states through his drawings that the plans of remarkable buildings should be determined by the partitioning of a set of meshes chosen on a grid that extends well beyond the building, without apparent limits: the spaces were humans wander become closed cells, only differentiated from outer cells by the will of the architect, within a universe that extends far beyond any known frontier.

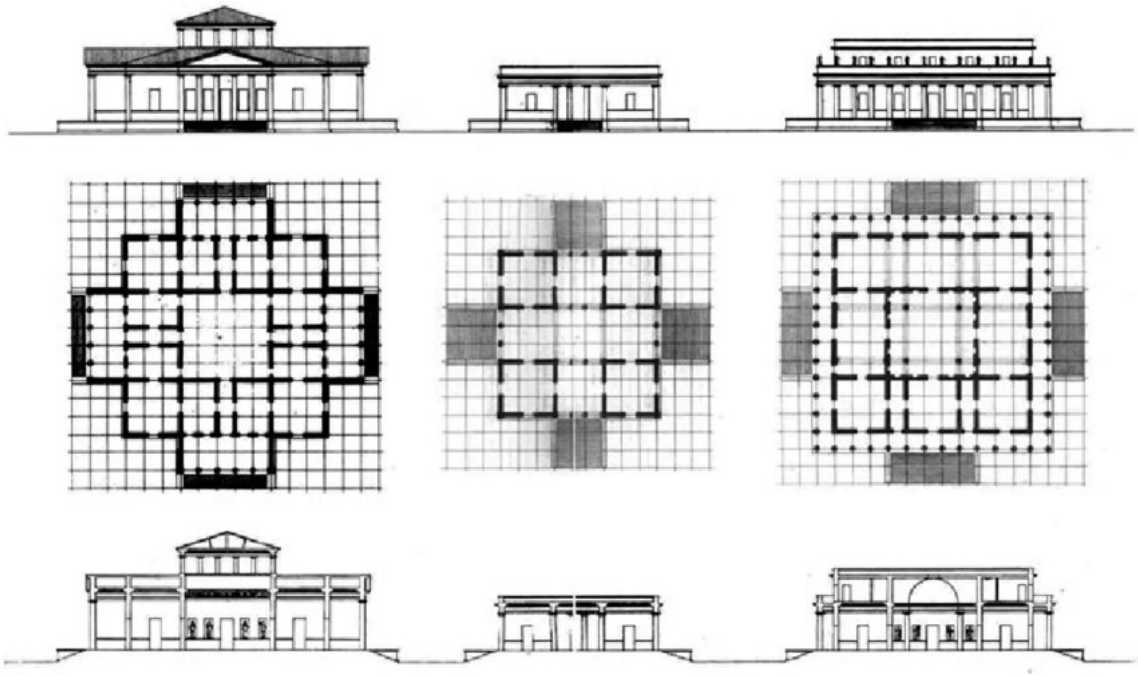

Fig. 9 – Building plans by J.N.L. Durand, plate No 2, Précis des Leçons d'Architecture Données à l'École Royale Polytechnique, 1825.

Despite its apparent neutrality, the grid itself is a powerful icon: it represents the Cartesian coordinate system, established decades earlier by Descartes. This conceptual tool, thanks to which Newton could derive its laws, is in fact a device for tracking precisely the behaviour of objects, events and phenomena. It assigns an address to each point in space, instantly determining the time and distance required for reaching it. It announces, also for the first time in history, the worrisome image of a world in which getting lost becomes impossible. In the same way the new physical laws unify the description of apparently unrelated phenomena, and reduce the complexity of the world to a small set of simple principles, Durand's method of composition and analysis unifies all architectures by reducing them to the permutations and combinations of the cells of a perfect grid.

Throughout this cosmological sequence, the entire structure of the universe has evolved both geometrically and topologically. A pattern however seem to persist: the circle and its three-dimensional version, the sphere; but its status has undergone considerable

changes. Like it is well known, for Greek geometers, the circle was a symbol of perfection and thereby had a privileged status among all other shapes; for modern science, its status depends on the way it is considered. It can be seen as a special case of the ellipse; or, since Desargues' projective geometry, all conical curves (circle, ellipse, parabola, hyperbola) can be seen as variations of a same curve seen from different angles and points of view; none of them can be seen anymore as special.

Compared to the circle, especially on the cosmological point of view, the ellipse poses a problem: it has three characteristic points - the centroid and the two foci. All of them could legitimately claim the status of centre, raising the crucial question to know what – and who- lies at the centre of a world of which the ellipse has become the main figure. By this, the very centre of the world ceased to be unique, and began to multiply. The history of cosmology, i.e. the history of the stories of the Universe, actually follows the history of the displacements of the centre of the world.

Fig. 10 – The perceptual sphere. The only acceptable centre in the contemporary cosmos is the point where I stand at any moment. All events, objects and phenomena of the world are projected on a virtual sphere whose centre is my position, and on which they draw constellations that constantly move and transform.

As we have seen, this highly symbolic point, whose existence has never been questioned for thousands of years, has long hovered very close to the Earth, shifting from the surface of a flat world to the middle of a spherical Earth, from empty points in space to the mythological inferno, before flying towards the Sun and to pulverize itself, from Galileo to Einstein, on every point of the Universe: the relativistic model implies that no place can claim to be at a privileged position anymore. There is still however a point that can be seen as being slightly different: it is the precise point where I stand at any given time. It might seem presumptuous to consider myself as the centre of the Universe, but it must be added immediately that the same can be said for every human being - and probably for every living organism. At every moment, I stand at the very centre of my own perceptual sphere, a virtual surface on which all objects, phenomena and events are projected in the manner of perpetually moving and transforming constellations. It is through it that I scan the world, in order to determine at every

moment my next interactions with it (fig. 10). It moves constantly with me, opening in every direction various horizons that appear and disappear according to my displacements.

4 . From harmony to harmonics

During the Enlightenment, the birth of modern science brought an abrupt end to the ambitions of the harmonic connection to say anything sensible about the cosmos, and completely eliminated any human reference (foot, thumb…) from its new measurement system: starting closely after the French Revolution, every distance was determined in relation with the size of the Earth (the meter was initially defined as the 10 000 000th part of the quarter of the meridian). It may be time to remind that this connection, in the antique harmony of the spheres, implied another element, music, which we did not yet discuss. How did it evolve along this sequence of paradigmatic changes? It has actually not escaped them: the progressive ordering of the Universe and of architecture was accompanied by a similar rearrangement in all areas of music, including written text and musical notation, on which we will not elaborate here. We will only mention that the final standardization of the musical staff took place between in 1650 and 1750; and that the description of sounds in terms of frequencies, after the birth of acoustics, also followed a precise mathematical formulation, which was formalized in Helmholtz's treaty *On the Sensation of Tone as a Physiological Basis for a Theory of Music* (1863). From then, the score and the staff were based on a descriptive model that was, through several of its aspects, at least as accurate as the new scientific models of the cosmos. Each musical note of the classical score has a specific address in a time-frequency space in which durations are precisely determined. It is interesting to note that these "musical equations" appeared less than half a century after the publication of Newton's laws of gravity.

The great victim of this ordering is harmony itself, as well as the proportions system on which it was based. The virulence of the writings of some authors of the time, especially in England, with authors like Hogarth and Burke, leaves no doubt about the fierce determination of the new scientific establishment to exterminate all traces of what became to be seen as a set of obscurantist superstitions. Still, one of the harmonious cosmos elements, directly derived form the notion of proportion, managed to get through these hard times to become today one of the key elements of the scientific model of the world. The name of this element, "harmonic", echoes its musical origins. The notion of harmony has completely disappeared from all scientific models; it remains confined in the field of arts. The concept of harmonics on its side can be found in a tremendous number of fields. In science, it is now used to describe the basic components of a complex phenomenon. It is used to analyse, combine and reconstruct sounds, lights, images, shapes, signals. We owe the theory of harmonics to physicist and mathematician Joseph Fourier, who derived it from a research about heat propagation in solid bodies. As it is well known to all musicians and composers of electronic music, this theory postulates that all complex periodic timbres, such as the sound of a clarinet, a *grand orchestre* or a mechanical device, can be decomposed into a set of simple signals. In the case of sound waves, these elements are simple signals that correspond to basic trigonometric functions - sines and cosines; but the decomposition can be done on any basis of functions called "orthogonal", i.e. functions that, in a graphic representation, always intersect at right angles.

These simple signals correspond to the harmonics. To each sound corresponds a

spectrum, which consists essentially in the list of harmonics required to create it. They are defined by their wavelength, amplitude and phase – this last term representing the amplitude of a given harmonic at the beginning of the sound. The epistemological importance of this discovery can not be overestimated: it proposes a unifying principle for all the sounds of the world, from the simplest to the most elaborated, which allows not only to compare them, but also to rebuild them using elementary signals, in an operation known as "additive synthesis". It also allows the creation of brand new sounds by applying different operations on combinations of spectra coming from different sound samples.

Despite the importance of this theory, Fourier's name fell into oblivion for a hundred years: his name does not even appear in the 1974 edition of the *Encyclopedia Universalis.* The last decades of the XXth century completely transformed this situation. The important developments in signal processing required by computer science, information technology and telecommunications have led to a massive revival of interest for this work, to the point that some authors do not hesitate to say that Fourier will soon join Newton, Maxwell and Einstein in the pantheon of the greatest theoretical scientists. His work extend far beyond music: applications are found in a wealth of disciplines - optics, image processing (the jpeg format is directly derived from it), pattern and shape analysis, cosmology, planetology, acoustics ... Far to be a local and anecdotal discovery, it offers a way to describe the physical reality with only one object, the wave, which has the unique and singular property of being able to describe simultaneously an element and its opposite: several wave trains meeting on a same area can create simultaneously, depending the additive or destructive nature of their interferences, sound and silence, light and darkness, matter and space, and so on.

Beautiful scientific instruments were created to analyse musical timbres according to this new model, like an extraordinary tonometer with its 670 tuning forks, or a sound analyser with resonant spheres (fig. 11), both built by Rudolph Koenig in the XVIIIth century. The image of a timbre that can be decomposed into elementary sounds, just like white light can be decomposed into primary colours, became the preeminent model in acoustics and physics. It led in the following decades to a first unification of harmony, chord, timbre, and melody, which came to be considered as four aspects of the same phenomenon, mainly differentiated by their temporality. The idea to use spectral principles as a full basis for sound or musical composition came however much later, essentially because the required technology did not exist before. It find its premises in the mid-XXth century, with works by Xenakis, Ligeti, Stockhausen and several others; but the expression "spectral music" did not appear before 1979.

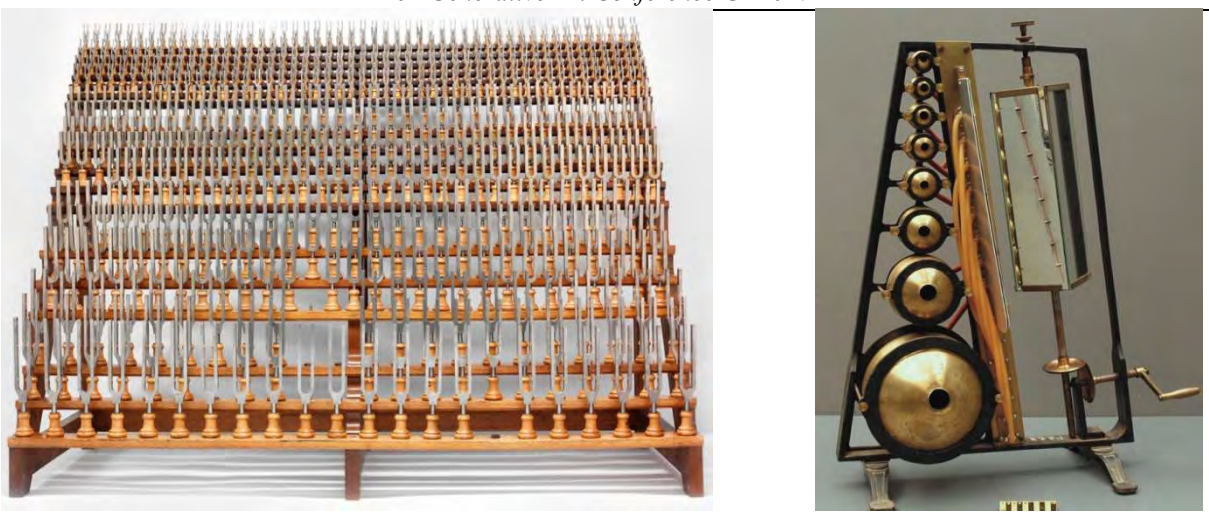

Fig. 11 – Left: tonometer with 670 tuning forks; right: frequencemeter with resonating spheres. Both instruments by Rudolph Kœnig, XVIIIth century.

The importance of Fourier's work and of spectral music theory, in the context of our discussion, lies in the fact that it leads to nothing less than a new version of the harmonic connection, reinterpreted and redefined in the light of contemporary science. It is precisely between 1960 and 1990 that Fourier's work was reconsidered to become a major cosmological principle; no rigorous demonstration could claim to give spectral music a cosmological status as such, like for the ancient music of the spheres, but the analogies it presents with the cosmological model of harmonics cannot be easily dismissed.

Such analogies are found in several places throughout the period leading up to the birth of modern science, whose beginning can be approximately dated at the time of the publication of Kepler's *Mysterium Cosmographicum* at the turn of the XVIIth century. Several authors could pretend to symbolize this transition, but Kepler occupies a special place: a hybrid character, rooted in the ancient cosmos and precursor of contemporary cosmology, he saw his career oscillating between astrology and astronomy. He was able to finalize the three laws that bear his name, and to describe the orbital features of any revolving object, by starting from a major feature of the ancient harmony of the spheres, namely the song of the planets: in the ancient cosmos, every planet was constantly singing. The farther it was from the Sun, the lower was its voice. Men could not hear them since they were used to it; but new born babies were so terrified by these loud rumbling voices that they screamed and cried night and day - thus proving the theory. By trying to tune the song of the planets, Kepler derived one of its laws, namely the one that links their respective periods to their distance from the sun. The tuning of his new version of the ancient cosmos was obtained from the tone of the Earth: since its orbit is slightly elliptical, its plays a melody of only two notes, separated by a semi-tone interval. According to the astronomer, this semi-tone could only be the one that separates the notes E and F: in latin, these notes are called *Mi* and *Fa*. They perfectly represent the fate of mankind, summed up in two words, *MIsere* and *FAmes* – misery and hunger. Despite this optimistic origin, devoid of any scientific basis, Kepler's laws remain today as valid as they were at the time, and are expressed in the very same terms since then. They can be now directly and easily derived from Newton's laws, and they are used each time a satellite is launched into orbit.

Kepler is the first in a series of authors who have attempted, from the knowledge of their

time, to develop new versions of the harmony of the spheres that became progressively more rigorous on the scientific point of view, and in which the concept of harmonics gradually became an essential element of the new cosmology. Everything happened like if, despite the relentless refutations of the old models by the new science, astronomers and astrophysicists could not bring themselves to imagine a universe without music at all scales and at all levels. This resilience of the model raises a number of questions, many of which being not fully understood, on the importance of musical analogies for the description of the world. In the next paragraphs, we will see two theories, one by Louis de Broglie and the other by Jean-Pierre Luminet, that will provide us with examples drawn from both ends of the cosmological scale.

At the level of the microcosm, in the early XXth century, Louis de Broglie, a French physicist, tried to find the laws that define the distances between the electron orbitals and the atomic nucleus, in the specific case of the hydrogen atom. He found the answer by using a direct musical analogy. By assuming, for theoretical reasons, a spherical shape for the orbitals, and by associating to each electron a spherical carrier wave of specified wavelength, he could find that the only allowed orbitals were those that corresponded to a whole number of wavelengths, just as for the frequencies emitted by the vibrating string of the monochord, or of any musical instrument. His theory allowed him to predict the radius of all orbitals with unprecedented accuracy. At the other end, at the macrocosm level, French astrophysicist Jean-Pierre Luminet recently proposed a new cosmological model that states that the Universe could be much smaller than what was previously calculated from the Big Bang theory. The Fourier analysis of the spatial distribution of the cosmic microwave background radiation, a remnant of the colossal radiations emitted shortly after the Big Bang, gives a spectrum in which the largest wavelength, or in other words the larger harmonics, are almost completely absent, when they should have been dominant. This suggested him an unexpected hypothesis according to which these wavelengths are missing because the universe is not big enough for them to travel. The dimensions of the cosmos must then be derived from the wavelengths of the largest present harmonics, which shrinks them by an order of magnitude. If we see the Universe as big as it appears, it is because it is the object of multiple reflections on itself, like a room of mirrors whose shape would be dodecahedral. This model leads to a fascinating idea: looking in a particular direction, it should be possible, by using instruments considerably more powerful than our present telescopes, to contemplate our own Solar System - or rather, the place where our System stands - as it was billions of years ago, and even before his birth.
Besides these three examples, a wealth of books from all realms (science, architecture, poetry, arts, philosophy, esoterism, metaphysics…) uses direct and explicit reference to the music of the spheres. At the cosmological level, the mathematically redoubtable string theory, first enunciated in the 80's, postulates that the most fundamental particles of the universe should not be represented as punctual spheres, but as infinitesimal strings whose vibration modes in a 11-dimensional space generates all the particles we know. It is the first theory to propose a convincing unification of the four fundamental forces known today, but it is unfortunately unverifiable experimentally, and faces insurmountable mathematical obstacles that currently confine it to the status of mathematical speculation. The fact remains that despite its complexity, it presents several analogies with the ancient theories, and has occupied most of the research time of major physicists and astrophysicists during the last decades.

On its side, the field of architecture sees regularly, among students, researchers and practitioners, the emergence of projects based on a particular musical form, as if the link between both disciplines has remained privileged across the centuries. A common but

approximate quote states that architecture is to time what music is to space. Countless authors, from Frank Lloyd Wright to Hassan Fathy, through Goethe, Paul Valery and Le Corbusier, associated in one way or another the too pairs space/architecture and time/music, either describing architecture as a frozen music, or an architectural promenade as a musical symphony, with its opening, its movements, its crescendi and its finale. Several of them, such as Valery or Le Corbusier, directly associate it to human body proportions. Their writings are mostly devoid of any cosmological reference, but they clearly suppose that any architectural or musical piece is a small cosmos, locally and temporally defined, in which all elements are organized according to a unique and particular arrangement: architecture installs and distributes matter in space, and space in matter, and works on the boundaries between them; music distributes and installs sounds in silence, silence in sounds, and works on the transitions between them.

Of course, things are not that simple: the relations of architecture to time, as well as the relations of space to music, are essential to fully appreciate these arts. What interests us here is that any known form of organization can be used to compose an architectural work or a musical piece; and that the discovery of new forms of organization is likely to trigger the appearance of new musical or architectural forms. This is for instance the case for fractal geometry. Introduced in the 70s, it helped to characterize shapes and configurations previously reluctant to any geometric reduction, such as clouds or mountains. It created a paradigmatic change when it managed to introduce these elements into the broad category of ordered objects: by doing so, it completely transformed the very meaning of words such as “order” and “organization”, and even added a new meaning to the word “harmonic”. The repercussions of this shift were felt in all areas and at all levels, and triggered the emergence of architectural or musical works designed directly from fractal patterns or algorithms - cosmic echoes under which, even in the most modern world, still shine the faint glows of the principles into which the ancient universes were anchored.

4 . Mende Cathedral

Fig. 12 – Notre-Dame and Saint-Privat cathedral, Mende (France), completed 1512. The West and North portals were built during the XIXth century. Left: aerial view. Right:

the westwork seen from the parvis.

As we have seen, the passage from the harmony of the spheres to the contemporary Universe as a model for describing the world was accompanied by the disappearance of the concept of harmony as a cosmological operator, in favour of harmonics. Nonetheless, the two concepts present important similarities in their respective roles. Just as harmony, harmonics are messengers who convey important information about the status of inaccessible worlds, such as atomic orbitals, or the most remote layers of the observable universe. Like it, they play an ordering role: all harmonics-based compositions show patterns or rhythm of various kinds that distinguishes them from random compositions; like it also, they allow a description of the world by abstract objects that are both simple and limited in number. Retrospectively, it is worth noticing that the epicycles of the Ptolemaian solar system and of many of its predecessors, just like the ones that Copernic used in a desperate attempt to preserve the circularity of his heliocentric orbits, correspond exactly to the contemporary definition of harmonics. Thus emerges a new connection between the ancient and modern theories, in which a deep equivalence is established between the concepts of orbit, wave and rhythm; and which states that any phenomenon that can be described by one of these figures can also be described by the other two.

It is from these considerations that was born, several years ago, the Point of Origin research-creation program, from which the *Mende Cathédrale* project constitutes a first experimental installation. The basic idea underlying it was to explore the possibility of implementing, at least theoretically, the possibility to define a new method for transposing an architectural form into a musical form, in a contemporary version of the harmony of the spheres rethought in the light of the models proposed by modern science for music, acoustics and cosmology. In other words, the objective was to directly produce an architecture from a musical form, or the reverse, based on cosmological considerations, with a condition that was not met in any of the similar attempts that we studied, namely reversibility: the transition from one realm to another, just like the reverse transition, must be done without any loss of information, and must allow to fully restore the original form. This condition proved to be a very strong constraint. We quickly realized that it involved the use of strictly formal descriptions that should be reducible to numerical data and mathematical relationships. After several attempts, we developed a method that was based a particular mathematical object, called "spherical harmonics " – an object that is conceptually simple and fully in tune with our previous theoretical research, but whose handling requires a fairly advanced knowledge of mathematics.

The starting point of the installation is precisely the interpretation of any architecture as a small cosmology in which the visitor wanders without precise destination, like the human trajectories on Earth and in the Universe, constantly carrying with him his own centre of the world (Fig. 13). At every moment, the whole architecture of the cathedral is converted into a set of musical timbres; the conversion is made from the precise point where the visitor stands. Since each point determines a different transposition, the timbres and sounds constantly changes when the visitor travels the church. Any wandering in the nave of the cathedral becomes a musical trajectory among an architecture made of timbres and sounds, concretized by the specific frequencies of the waves, which by their interferences reconstitute the whole shape of the cathedral as accurately as the geometry of the stones. Any displacement in the cathedral determines a specific musical sequence; it is virtually impossible for two visitors to produce the same music.

To better understand the process by which the building is converted into sound waves, it might be useful to describe its different phases. The first phase consists in decomposing the building, or rather a digital model of it, into segments that can be individually analysed; these segments should ideally be topologically similar. The second phase consists in analysing each segment so as to convert its physical shape into a wave series. In the third phase, these waves are converted into sound harmonics. The fourth and final phase consist in combining these waves through a sound synthesis process, in order to produce the desired timbres.

The segments needed for the first step can be obtained by several different ways. For instance, it could be possible to split the cathedral into extremely thin slices like a cake, and to analyse them separately; or, to break it down into small cubes, similar to

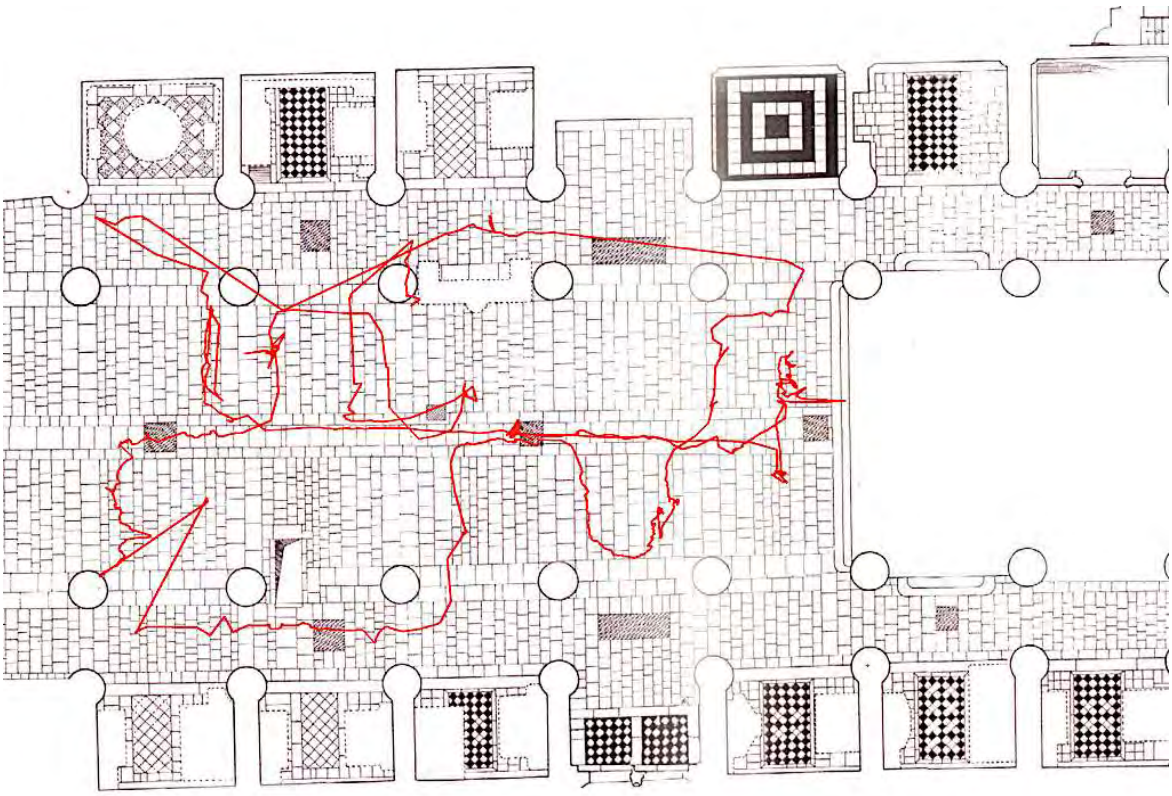

Fig. 13 – Wandering trajectory of a visitor in the installation space. Each point of the trajectory corresponds to a precise timbre. By walking the church, the visitor creates his own and unique musical sequence.

voxels, whose edge would be small enough to represent the smallest details one wishes to consider. The decomposition method that we used splits the cathedral into spherical shells. From each possible standing point for the visitor, a series of concentric spherical shells, separated by constant intervals, is generated. All shells have the same thickness; their radius increases up to the moment where they encompass the whole cathedral. For a visitor standing right in the middle of the nave, and for one-millimetre thick shells separated by null intervals, it would take about 8200 spherical shells to encompass the whole building. The radius of the smallest shell would be 20 centimetres, the radius of the largest about 84 meters. The crucial point here is that the intersection of each of these shells with the cathedral determines a unique pattern on its surface: a kind of spherical slice, whose precise pattern depends both on the position of

the visitor in the nave and on the size of the shell. The combination of all spherical slices fully reconstructs the building, like a 3-D puzzle in three dimensions similar to a Russian Matryoshka (Fig. 14, 15).

The second step consists in considering individually each of the spherical slices (Fig. 16), and in analysing them in order to be able to produce a wave-based description for each of them. The waves that are used for this step, the spherical harmonics mentioned above, are not sound waves or light waves, but they behave in exactly the same way.

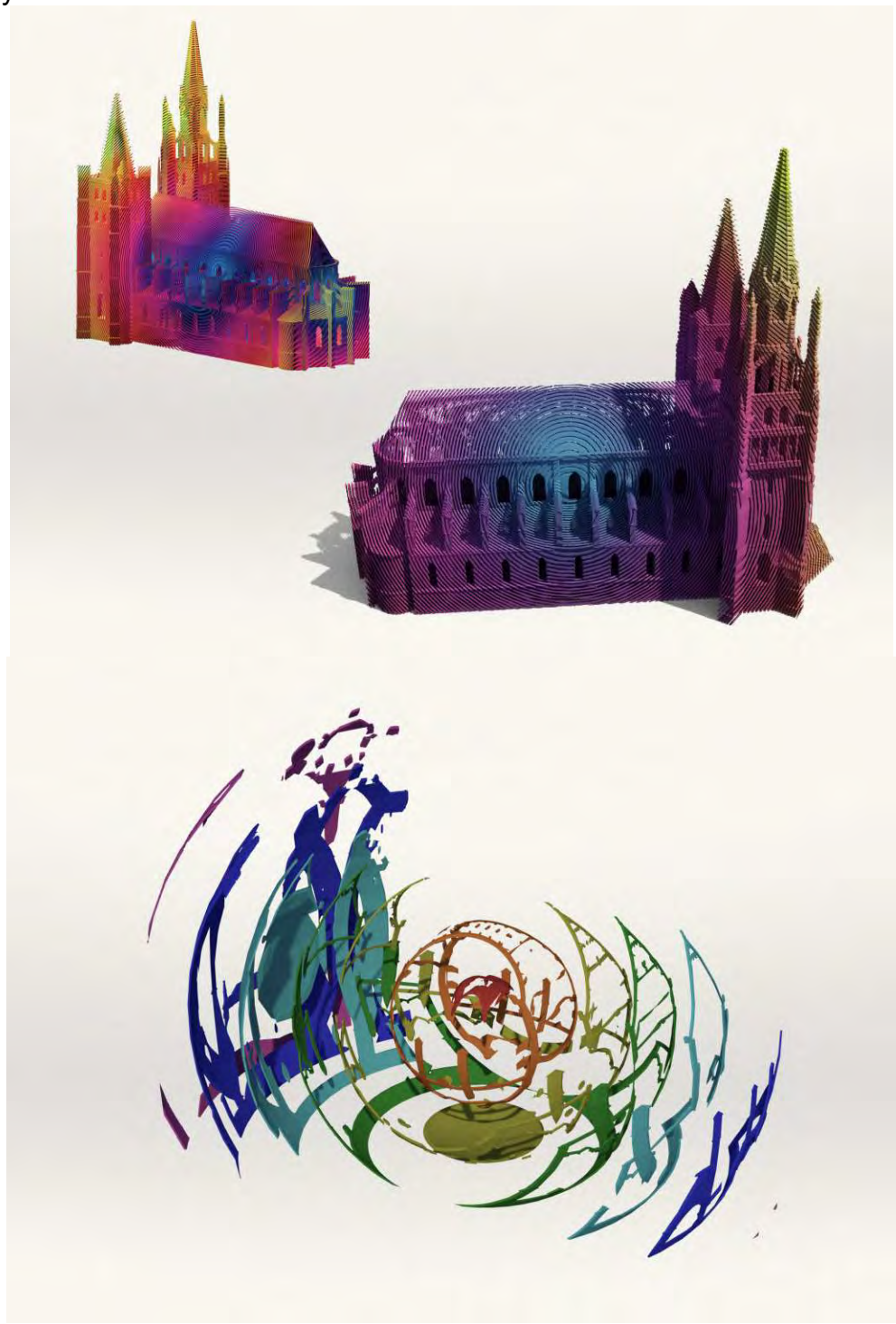

Fig. 14 - The first step for transposing the architecture of the cathedral into musical

sequences consists in decomposing the building in series of concentric spherical shells. The two pictures on the top show the full decomposition; the colours indicate the radii of the shells. The smallest ones, in blue, are almost completely inside the church. The largest ones, in yellow, intersect only the top of the spires. The bottom picture shows a series of very thin shells, separated by large intervals. The patterns created by the intersections of the spheres with the building appear clearly.

In multiple domains of science, they are used, as their name suggests, to describe the modes of vibrations of spherical surfaces or objects (Fig. 15). They are based on elementary signals that are not trigonometric functions, like for the sound harmonics, but rather another family of orthogonal functions called "Legendre polynomials". Analysing each shell with the proper algorithm, it is possible to obtain at the output the whole spectrum of spherical harmonics required to produce each of the intersection patterns for all the spherical shells in which the church has been decomposed.

An aquatic analogy will help understand the unrolling of this abstract mathematical process. Let's imagine a perfectly spherical planet, entirely covered with water, crossed by two families of huge tsunamis. The first family travels parallel to the equator, the second from pole to pole. The two families intersect systematically at right angles when they meet, which gives a fairly good idea of the behaviour of orthogonal functions. It can be proven that by launching several of these tsunamis with appropriate wavelengths, amplitude and phase, interference patterns can be created that can draw anything on the surface of the planet, including irregular patterns without any symmetry. The only condition is that the wavelength of each tsunami must be a submultiple of its equator, a condition identical to the condition that De Broglie's imposed on the wavelengths of his electrons in order to find their distance to the nucleus. It should be mentioned here that the spherical harmonics used by De Broglie's are completely similar to the ones we use for our process.

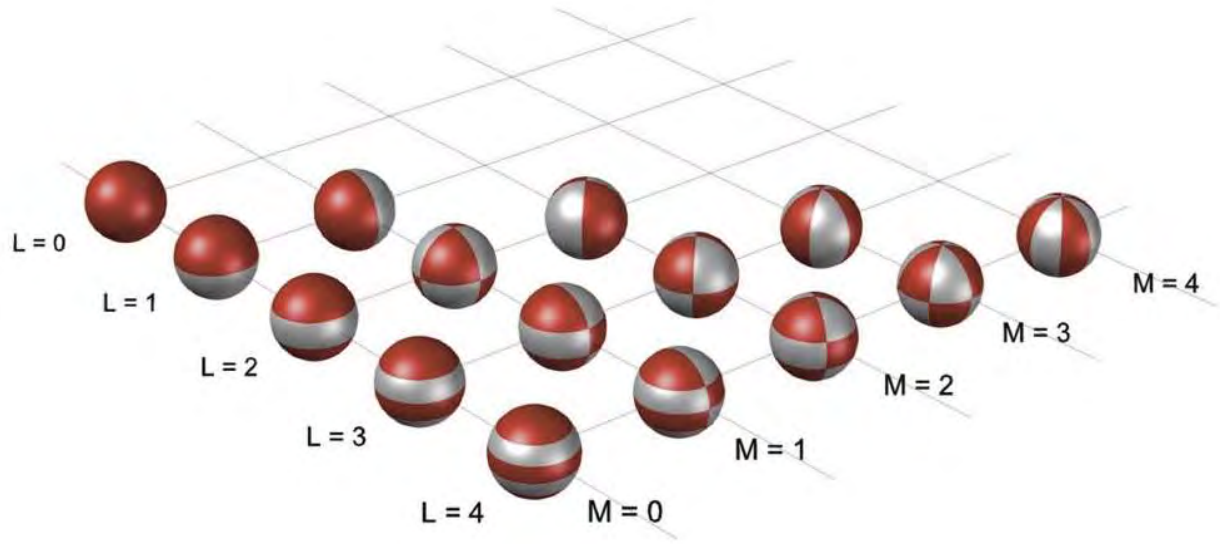

Fig. 15 – The first spherical harmonics. These mathematical objects correspond to the modes of vibrations of a sphere. The L series includes all vibrations parallel to the equator. For each L-order harmonic, there is a series of M-order sub-harmonics, corresponding to vibrations parallel to the meridian lines. By combining sets of spherical harmonics with specific amplitudes, frequencies and phases, it is possible to recreate any pattern at the surface of the sphere. They thus play for spherical vibrations the role

than sound harmonics play for the analysis and reconstruction of complex sounds.

As a consequence, each pattern can be described by a list in three columns, giving the values of the abovementioned parameters for each of the spherical harmonics needed to recreate it - the equivalent of a sound spectrum applied on a spherical surface. The process yields a list of numbers that represents the geometry of the cathedral in a description that is as austere as it is accurate.

Several factors have led us to use spherical harmonics for this project, among all other options. The first one is the cosmological status of this mathematical object that is used today, as we have seen in De Broglie's and Luminet's case, but also in many others, to describe phenomena and objects of all scales, originating from all realms. The second is related to the very concept of centre of the world, of which we discussed in the first sections. Since the only valid centre today is the position from where I contemplate the world, any description of this world can be temporarily centred on me, and must move with me; the spherical shells are the mathematical equivalent of the perceptual sphere described in section 3 of the present paper, and any spherical pattern naturally suggests the use of spherical harmonics. The third comes from a concern directly linked to the fundamental principles of spectral (or Fourier) analysis. This process only works with objects that can be described by a periodic signal. This presents no difficulty while working with light or sound signals, which are periodic by essence. It is much less obvious in the case of a finite, material object. Working with linear harmonics would have required, in the case of the cathedral, a preliminary step consisting in repeating infinitely the cathedral in all directions, in order to artificially "periodize" its geometry. Moreover, in most cases, the signal must be modified by another mathematical object called a windowing function in order to smooth its ends - an operation that eases its analysis by limiting the computation time. These two operations modify the original object by introducing mathematical artefacts that change the harmonic structure of the spectrum. Spherical harmonics do not present these problems: since the pattern is drawn on a sphere, the spherical harmonics repeatedly scan it while travelling on the surface, which *de facto* creates the required periodicity.

The accuracy of the wave representation, corresponding to the needed resolution, depends on two factors: the thickness of each shell – the thinner the shell, the more it will be able to capture small details - and the frequency of the highest harmonic used for the analysis: here also, shorter wavelengths will capture finer details. These two parameters can be adjusted to become as small as desired. When they become small enough to capture the smallest details of the building, then the transformation becomes theoretically reversible. Since nothing is perfect, like in any situations of this kind, the amount of calculations needed increases very rapidly when harmonics of higher frequencies are added: they quickly become unmanageable. The *Mende Cathédrale* installation had to take these considerations in account.

Following our first tests, we limited the area of the installation to the nave and to the adjacent collaterals, excluding the choir and the ambulatory. In this area, whose dimensions are approximately 40 m x 20 m, we defined a square grid whose points were spaced 30 cm in all directions, up to a height of 2,30m. More than 60 000 points were thus generated; they cover all the possible positions for the visitors. For each of these points, 20 concentric spherical shells, infinitely thin and separated by intervals of one meter, were selected among all the possible shells. The size of the smallest shell corresponds to one half the width of the nave. Each shell was decomposed in harmonics up to order 80.

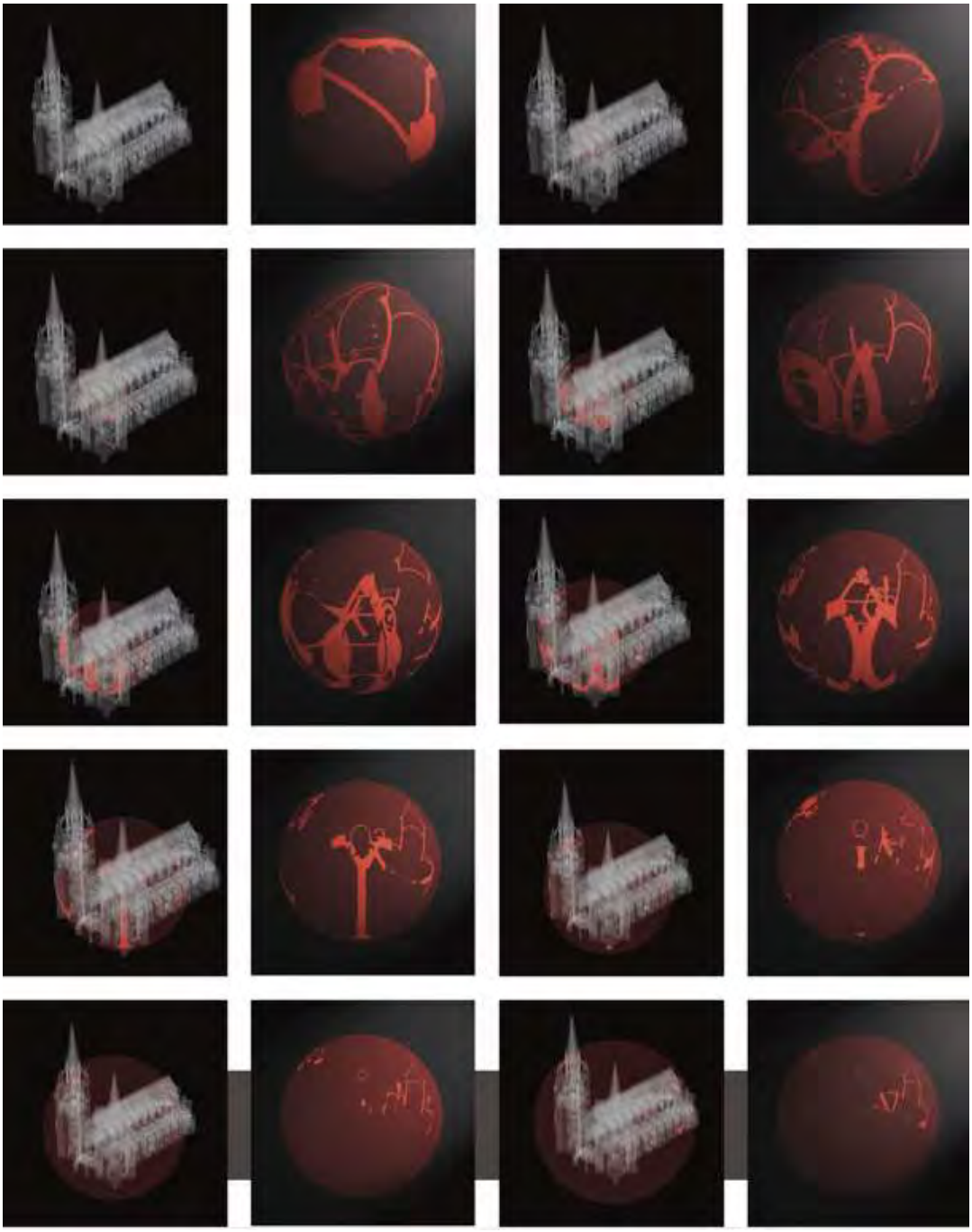

Fig. 16 – These pictures shows how the intersection patterns transform when the spherical shell grows. The pictures in the first and third columns show the sphere inflating in the cathedral, up to the point where it almost encompasses it. The pictures in the second and fourth columns show the resulting intersection spheres, with their unique patterns.

The third step is more systematic. It consists in converting as directly as possible the spherical harmonics into sound harmonics. It is conceptually very simple: each spherical harmonic is converted into a musical with the same amplitude, wavelength and phase. Two phenomena unfortunately combine to make this problem slightly more complex.

The first phenomenon is the number of spherical harmonics required to describe a

spherical pattern. Since the surface is bi-dimensional, this number is much larger than for linear harmonics: each harmonic of order N is actually associated with 2N+1 sub-harmonics. Though half of them can be eliminated by symmetry, the harmonic of order 50, for instance, generates 51 sub-harmonics that must all be considered in the transposition. The resolution of order 80 that we used for our spheres generated, for all the points considered, a total of 3.4 billion harmonics and sub-harmonics, the combination of which, as can be expected, describing the architecture of the cathedral with a very good precision. We then had to find how to use each of these spherical harmonics while reducing the amount of data to be computed. We managed to develop a reversible and lossless process that allowed us to generate all the sound timbres without leaving any information behind.

Fig. 16 – Detail of an intersection shell. Like any pattern on a sphere, the one that appears in this picture can be decomposed into a sum of elementary spherical harmonics, which are then directly converted into sound harmonics.

Once this was done, we were still left with a huge set of sound harmonics, from which we had to produce identifiable timbres. In conventional models of composition, such as in classical music, the composer starts from a silent space in which he distributes and arranges musical notes. Here, the initial space can be seen as an extremely dense harmonic jungle, which, without processing, would produce a constant homogeneous sound, similar to a white noise. The composition method then corresponds to the selective pruning of this the jungle, in order to generate simpler sounds that could be used use to create convincing musical sequences. The process we used is similar to certain methods of composition used in spectral music. It literally corresponds to a form of sound sculpture. It leaves a great freedom to the composer, and allows him to explore many different orchestrations while maintaining a precise correspondence with the architecture of the church.

The second phenomenon is caused by the fact that the frequency of sound harmonics increases rapidly, and quickly reaches the realm of ultrasounds, which, in addition to making them inaudible, is out of the frequency range of standard sound cards. We still

decided to keep all harmonics up to the 80th order: on one hand the interferences of ultrasonic waves can produce sounds in the audible range; on the other hand, the addition of ultrasonic waves to audible waves can slightly shift the phase of the latter. The combined phase shifts from multiple high-frequency harmonics can modify the sound waves in a way that becomes perceptible. We also decided to keep standard sound cards for this step, considering that the deformation of ultrasonic waves potentially caused by the insufficient resolution of such cards was a characteristic of our devices. The instrumental artefacts thus created are considered as similar to those that appear in classical music, when a perfect sound wave is altered by the physical characteristics of a particular instrument.

Fig. 15 – The harmonic lanterns. These small modules are held like candles by the visitors when they travel the installation. They contain all the electronic equipment required for positioning, with a 10 cm precision, and for playing the different sounds. Each lantern possesses its own IP address for maintenance and updates.

In the Mende installation, the cathedral has been divided into thirty-five zones, each one corresponding to a different composition of harmonics. As mentioned in introduction, every visitor holds in his hand a harmonic lantern, a small and approximately cylindrical module that contains both the positioning antenna, the timbres corresponding to the 60 000 positions, a controller that associates each position with a given timbre, a volume control, a miniature sound card, as well as several other components. A headset allows the visitor to listen to his own music at the desired volume, without ever disturbing the atmosphere of the cathedral. The areas close to the entrance have been orchestrated in order to produce more familiar timbres, evoking bells or organs. Towards the other end of the installation, the sounds become more contemporary. One for instance consists in a “harmonic rising fall”, in which thousands of harmonics are produced very quickly, separated by less than a millisecond. In areas where the visitors can walk, such as the aisle or the collaterals, the sounds are shorter, and become even percussive at times. In the sitting areas, they become much longer, generating a contemplative experience for the visitors who wish to sit and listen for more than a few minutes. Each point of space becomes a small drop of sound, hovering still in space, that the visitor triggers when his lantern passes through it. The lanterns are polyphonic, so that the precise sound heard in one spot depends not only on its location, but also on the direction from which the

visitor approached it. In the middle of the nave, in the central aisle, lies a small island of silence. It allows the visitor to rest his ear before resuming his musical journey. If he stands within this island and turns on itself, holding the harmonic lantern at the end of his arm, it will hear sequentially the sounds from eight different zones, composing by this very simple movement a full timbral symphony.

5. Conclusion

Starting from a theoretical work on the ancient harmony of the spheres, the Origin Point research-creation program tries to explore the potential of new and poetic transpositions of this theory, based on the contemporary scientific knowledge about the cosmos, and of what science tells us today about acoustics and music. This massively interdisciplinary project has implied mathematicians, physicists, musicians, historians and architects. The *Mende Cathédrale* installation constitutes the first artwork generated by the program. It was simultaneously considered by our team as an art experiment, as a demonstration of our technological devices, and as an artwork meant for all audiences. The decision to present it in the cathedral of Mende, apart from the fact that any installation coming from the program should be presented in an architecture based on some cosmological scheme, was taken because of the particular atmosphere of the church. As opposed to most famous cathedrals such as Chartres or Paris, it is never filled with crowds of tourists. Quite the contrary: it is a living church, still used by the community. There are still lots of visitors from the outside – it is one of the main monuments of the region- especially during the summer, but the audience during the installation time was equally distributed between citizens and families from Mende, people from neighbouring provinces and tourists from farther regions. People from all ages came to experience it; a lot of people came several times. Through this project, we came to the conclusion that the presentation of digital art pieces in non-dedicated spaces such as galleries, museums or festivals has a tremendous potential for reaching the most diverse audiences, and thus to contribute more efficiently to the diffusion of less familiar forms of arts.

Obviously, the visitors in the church did not have to go through all these theoretical and technical explanations in order to appreciate the work: as it is said in introduction, experiencing the installation is extremely simple. For those who were interested in knowing more about its genesis, an exhibition was set up in a close-by gallery. It provided all the necessary explanations, in the form of posters and small bronze and polymer sculptures. By this, we tried to make another statement with a slightly cosmological overtone: reality implies every scales of the world. Just like a man or woman who appreciates a good meal does not have to know anything about the biology of the meat, the molecules and the atoms that compose them in order to appreciate it, the visitor of the installation does not need to know anything about its history and development in order to listen to the music. However, any information or knowledge about a given work can strongly modify his appreciation of it and considerably enrich his experience. The imaginary and the rational components of our minds are everything but independent: our artistic, poetic and scientific visions of the world constantly feed each other. They are strongly interrelated and can never be separated. One of our hopes is that the work we presented will be seen as an example and an illustration for these statements.

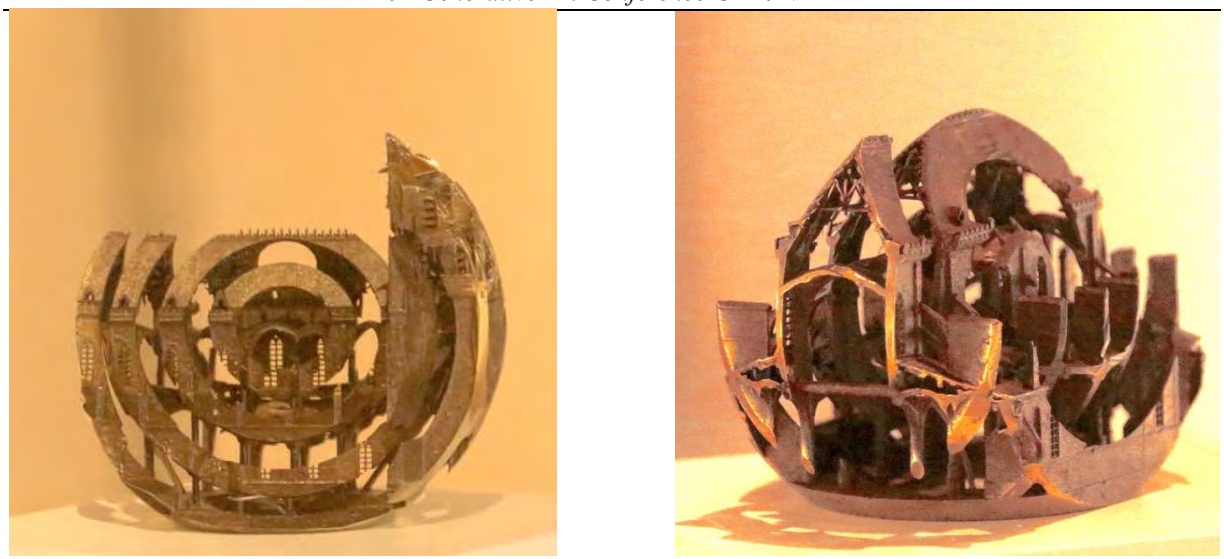

Fig. 16 – Two of the bronze sculptures that were shown in the exhibition presented along with the installation. They evoke the spherical decomposition process at the origin of the architecture-to-music transposition.

The reader who is interested in knowing more about the installation is invited to go to the internet address www.nxigestatio.org/NXI/MENDE-CATHEDRALE, in which he will find several pictures, sounds and documents about the work.

Notes

1 – It is worth noticing the etymological relations between the words "harmony" and "Olympus". Both derive from a proto-Indo-European root indicating the concept of "rising above". Mount Olympus was the residence of the gods. It was the place from where the harmony radiated towards the world, and imposed, through proportions, it reigns over it.

2 - The unit of measure used to implement these proportions, namely the ancient foot, is also drawn from the morphology of a supernatural being, namely the semi-god Hercules: the architecture of the time is both dimensioned and proportioned by elements of cosmic nature.

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Evolutionary creativity. The inner life and meaning of art

Paper

Topic: Art, Design, Third Life

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Abstract
In art and design making it is possible to identify three main modes. In the first one the artist physically and directly shapes the matter or uses some simple body-based tools, like pencils, brushes, chisels, and so on. This happens, for instance, in traditional paintings, sculpture and ceramics, in lute manufactoring and so on. The second mode is the art-making mediated by some device or machine, which more or less automatically and industrially involves a process which is strictly driven by starting instructions. Though these instructions can change in time, the device must strictly follow them, and in fact the quality of the final result depends on its precision to attain to the model those instructions represent: the result must be as close as possible to the starting model. This happens in traditional design, in di technological arts, in printing and graphic arts, as well as in computer imaging, video, cinema, numeric controlled devices, 3D printing. This multiform and rapidly growing realm involves software- and digital-based manufacturing, processing and automation, Artificial Intelligence, Artificial Life, Big Data, Internet of Things, autonomous agents and objects, and also Robotics technologies, nanotechnologies, and nanorobotics... But it also involves biological-based technologies, like Genetic engineering, Synthetic Life and biology, De-extinction as well as hybrid technologies (organic/inorganic), like in biorobotics.
Generative art can be considered a further step in art and design. Instead of a direct, unmediated construction process or of a mediated controlled one, there is an autonomous and open process which can limit or eliminate the human intervention and can be influenced by inputs. The artist is a processes' activator setting up some general boundary conditions, but in the process of art making there are variables and interaction levels which make the final outcome (if any) as the (not necessarily) final result of an evolution: using a terminology from the art realm it is a work in progress. This evolution does not generate a fixed result strictly dependent from a starting model, it can create a range of outcomes depending on variables that can be external (like inputs from the environment and/or the user) as well as internal (in the process itself). The final result is open and it can never be completely predicted, it can present a variety of possibilities. If the process is interactive the context is fundamental: people can collaborate in creating the final outcome and even being co-authors, but also the artwork's and the process's environment have a great influence. In the so called "interactive arts", also called "contextual arts", the artwork resides in the process itself more than in the final result.
It is possible to generate outcomes which simulate or emulate the behavior of living systems and beings, as well as of natural phenomena. Generative art does not only concern the digital realm, it can also be biological-based, giving birth to organic and hybrid (organic/inorganic) constructs. In mirroring nature and life Generative art forms and processes can be considered as paths towards the advent of a "Third Life", the life that humanity is giving to its artifacts, being the "First Life" the biological life and the "Second Life" the life in the symbolic realm.

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Key words: art, life nature, evolution, Third Life

Main References:

Pier Luigi Capucci, "The Ambiguous Magnificence. Life and Art Between Evolution and Creation", in Dmitry Bulatov (ed.), *Die and Become! Art and Science as the Conjectured Possible*, Gdansk, Łaznia Center for Contemporary Arts, bilingual (Polish/English), 2017.

Evolutionary creativity. The inner life and meaning of art

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1. Simple mediations

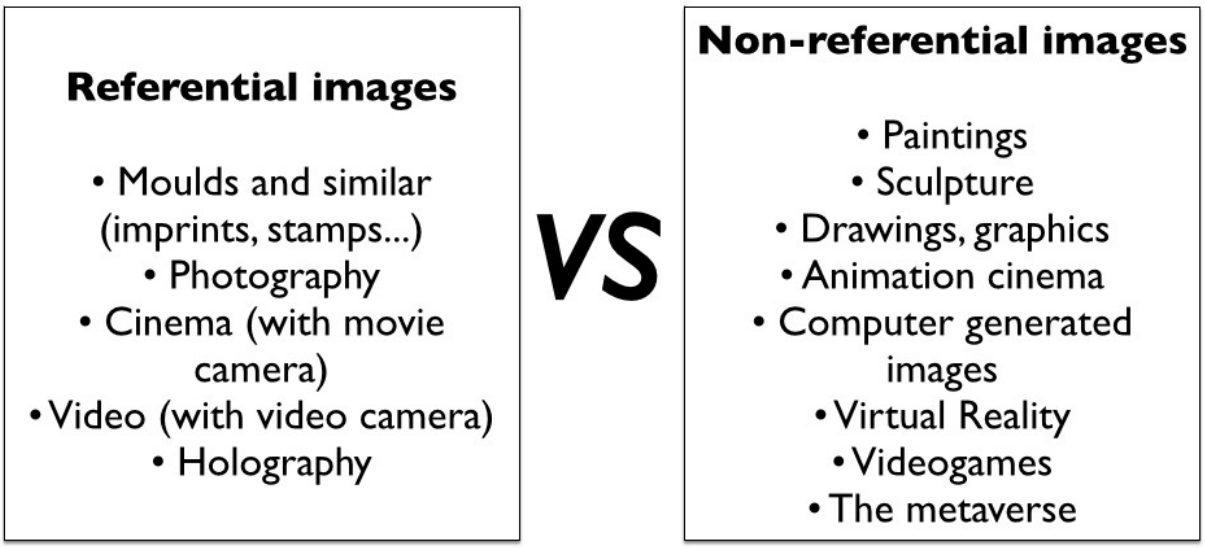
In art and design making it is possible to identify three main modes. In the first one the artist physically shapes the matter with the body or with parts of the body, or he/she uses some body-based tools, like pencils, brushes, chisels, and so on. This simple mediation happens, for instance, in traditional paintings, in sculpture, in ceramics, in lute manufactoring. A large part of art, maybe the most celebrated in books, manuals, catalogues, exhibitions and events, deals with this making mode, from the prehistoric palaeolitic parietal wall paintings until the XIX and XX Centuries art avant-gardes.

2. The controlled mediation of a device or a machine

In a second art-making mode the artwork is a construct mediated by some device or machine. The final outcome is shaped by a more or less extended and complex automatic process. A device and a machine involve a process that, more or less automatically and repetitively, is strictly driven by starting instructions and conditions. These instructions can remain constant throughout the process, or they can change, being modified during the artwork making, but the device is supposed to strictly and exactly follow them. In fact, the measure of the final result's quality depends on the precision of the device or the machine in following those instructions, in representing the model or repeating the project described by those instructions. The final outcome must be predictable, unique in a serialization or with just a few controlled variations, as close as possible to the starting or evolving model. This mode is typical in the artforms based on techniques and technologies like 2D and 3D printing, photography, cinema, video, computer simulations, numeric controlled devices, and more in general in traditional design and graphic arts, as well as in a large part of technological arts. Just in these days a historical exhibition at MoMA in New York, "Thinking Machines: Art and Design in the Computer Age, 1959–1989", celebrates the creativity mediated by computers [1].

2.1 The example of photography

A perfect example of this mode is photography. Photography is based on a device that, if activated just by pushing a button, generates an automatic image, after the photographer has chosen the viewpoint or arranged the scene, the object(s) and/or the subject(s) in front of the camera. Photography and cinema from real life (not computer generated) are "referential images" [2, 3].



1. Referential and non-referential images

In this picture the images' realm is divided in two families, based on *how* the images are obtained and not on *what* they represent: "referential images" and "non-referential images". In the first category the images can only be obtained *in presence* of the referent (from Latin *res ferens*, which means "that carries the thing"), that is of what is represented [4]. In this category the presence of the subject, of the object or of the phenomenon during the image making process is mandatory: without this *being there*, in front of the camera, there is no image. Recalling Roland Barthes, in front of a photo I can never deny that the represented subject, object or phenomenon *has been there*, for some occurrence, in some time of its existence, in front of the camera [5, 6]. The image is logically and technically built by that co-presence (*being there*) during the image making process: it is the subject/object's emanation made of the light it has reflected or generated, which has been recorded through a chemical and physical process. On the other hand, in the "non-referential" images that co-presence is simply not mandatory nor relevant during the image making process.

That *being there*, which defines photography and cinema from real life as referential images, also makes them uncanny. No way to escape their cruel as well as luring fascination, they can talk about life and death, as Barthes noted [5]. About life: because classic photography certifies that something *has been* there, in front of the camera, that it once has existed, which is at the core of the social and documentary use of photography. About death: because, sometimes intolerably, photography rise the evidence of a loss, of somebody or something whose light – for some reason, in some instance, in some moment of its life, by will or by chance – was once reflected, caught and recorded onto a two-dimensional chemical support, and at the same time that he/she/it can't be again anymore in that way, in that situation, or at all. Photography is the contemporary monument. Instead of an expensive but durable single representation made in stone or bronze in order to defy eternity, photography generates a moltitude of cheap and frail pictures, of ephemeral instances, of short-living emanations, that can anyway survive to the individual's life, against the infinity of time [7].

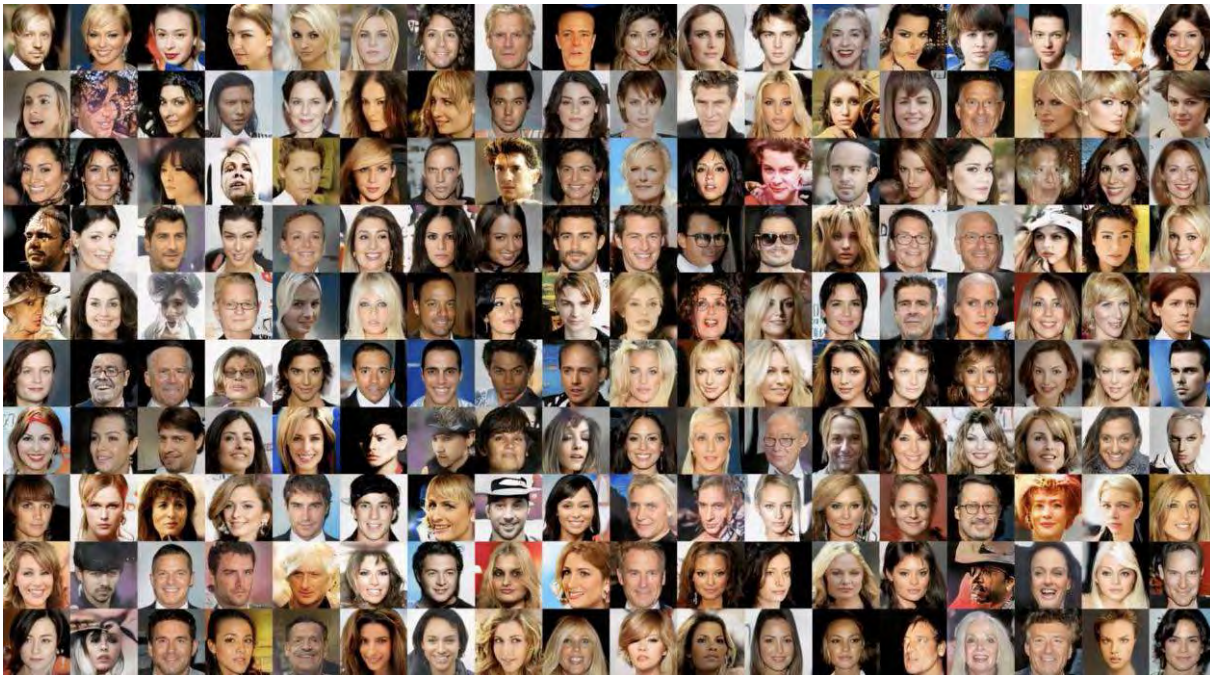
Although in the history of photography there are examples of artists searching for unexpected visual effects, most photographers aim at strictly controlling the final image in its character of an exact representation of reality. In fact, just because of its referential condition, photograpy is socially, bureaucratically and legally considered as a proof.

3. Leaving autonomy to devices and machines

A further step in art making is the use of a machine or a device with a certain degree of autonomy [8, 9]. Instead of a direct or slightly mediated construction process through simple tools, or of a device-mediated controlled process, in this mode an autonomous and possibly open process can take place, limiting or eliminating the human intervention. This process can be eventually influenced by new inputs during its running, generating a dynamically evolving outcome. In creating these artworks the artist and the designer are activators of processes. They set up some general boundary conditions, but during the art generation process some more or less known and expected variables and interactive inputs can make the final outcome – if any – similar to the result of an evolutionary process: like a *work in progress*, using a tipical expression from the art realm. This evolution does not generate a fixed result which is strictly dependent from a rigid starting model; instead it can create a range of outcomes which depend on variables that can be external (like the inputs from the environment and/or from the user) as well as internal (that are inside the process itself). Consequently, the final result is open and it can never be completely predicted, since it depends on variables that escape the artist's control. If the art-generation process is interactive, the relevance of the context becomes primary: people can collaborate in creating the final outcome, even becoming co-authors, and also the environment, where the artwork is located and where the processes take place, can have a great influence, similarly to what happens in the natural processes. In the so called "interactive arts" [10, 11], that have also been called "context arts" [12], the artwork resides in the process itself instead than in the final outcome.

3.1 Two examples: GANs and generative visual aesthetics

Today the generative applications in the digital realm have reached a great standard, for instance in the realm of the human figure's simulation. The pictures generated by Generative Adversarial Networks (GANs), a class of Artificial Intelligence algorithms used in unsupervised machine learning described by Ian Goodfellow and colleagues in 2014 [13], are a good example, like in this example shows [14]. With Generative Adversarial Networks it is possible to get at the same time a wide variation in the outcome and an impressive photorealism, with pictures that look like photographs to human observers [15].



2. Tero Karras, Timo Aila, Samuli Laine, Jaakko Lehtinen, Progressive Growing of GANs for Improved Quality, Stability, and Variation *(still image from the video)*

In the art field the research of the Chinese artist Raven Kwok (Guō, Ruìwén) is based on exploring generative visual aesthetics through computer algorithms and software processes. He builds up systems with customized rules and algorithms to generate and produce the visual outcomes. Actually he codes his artworks mainly using processing, one of the most used programming language used by artists and designers around the

3. Raven Kwok, Skyline*, 2015 (still image from the video)*

world. *Skyline* is a code-based generative music video he has directed and programmed for the track *Skyline* by IA artist Karma Fields. The entire music video consists of multiple stages that are programmed and generated using Processing software [16].

4. Generative art beyond the digital and computers

4.1 Piotr Kowalski, *Dressage d'un cône*, 1967, installation

The generative art mode should not be considered as a research field only related to computers and digital technologies. In the past there have been interesting examples in this direction, for instance a study on Hans Haacke's *Condensation Cube*, an artwork made in 1963 [17]. Here I would try to follow this line, that I think it is theoretically interesting, presenting two examples. The first one is historical: Piotr Kowalski's installation *Dressage d'un cône*, created in 1967 [18, 19, 20].

4. Piotr Kowalski, Dressage d'un cône*, 1967*

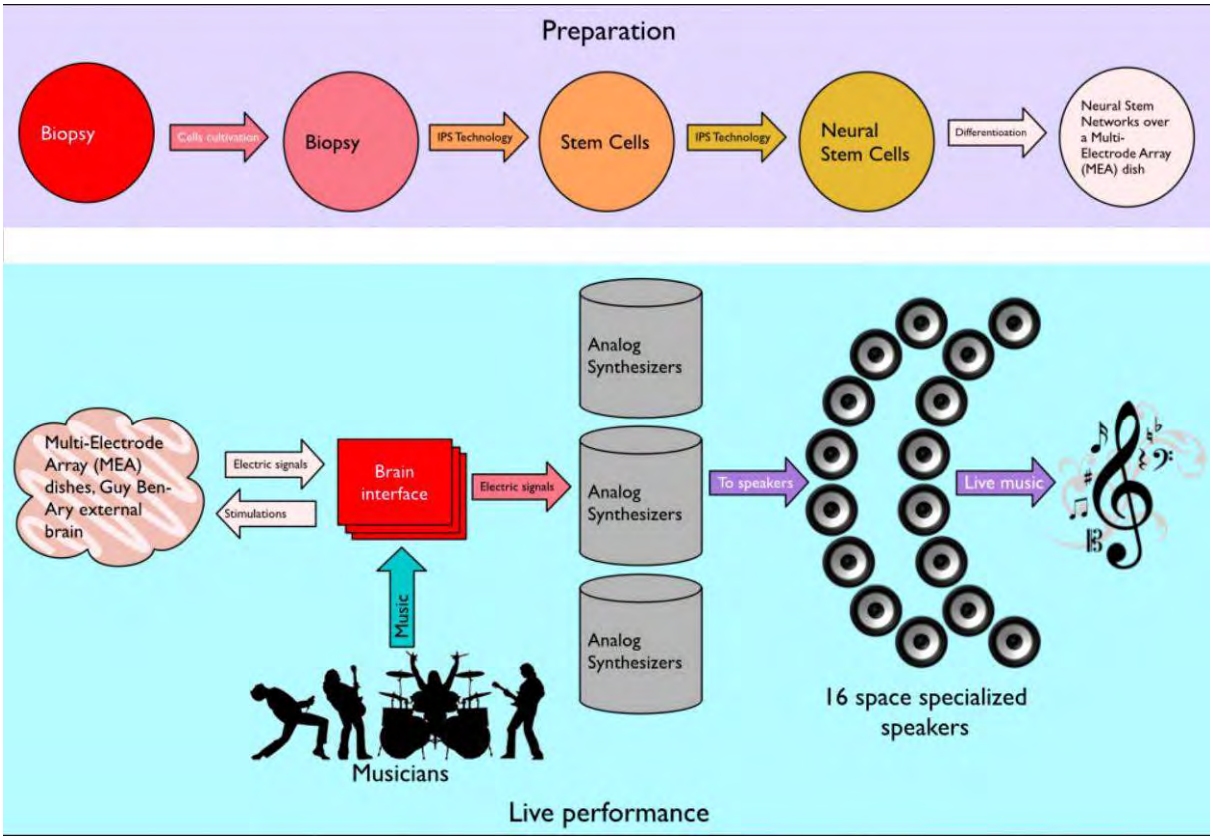
In this installation seeds are progressively sown on each of the trays under dark bells on flattened wet cotton. They remain in the dark for two days and then they are bathed in a photosynthetic light scattered by ramps of neon lights. The trays are put in rotation by electrical engines which are activated when the seeds germinate and remain in motion until the plants maturity. The centrifugal force, that is stronger moving away from the center of the plateau, forges the cone shape of the plants correcting the force that makes the grass grow vertically. The first sown tray forms a perfect cone after about ten days. The shape of the cone depends on the rotation speed and on the growth rate of the plants, which in turn depends on the context (light, water, earth, and so on), and Nature adapts to the external conditions finding a new balance. *Dressage d'un cône* springs out from a combination of nature and culture, from the reciprocal influence between the vital vegetable processes and the motion of a machine. According to Frank Popper, Kowalski transforms a scientific affair – the mutual action of gravitational and centrifugal forces – in a plastic demonstration, revealing the hidden geometries of nature through science and technology [21, 20]. According to Jean-Christophe Bailly, who wrote a book on Kowalski's work, this installation resides at the boundary between the "natural" and the "artificial". Is here that nature becomes artifice, or is artifice that becomes nature? [19].

4.2 Guy Ben-Ary, *CellF*, 2015, installation

The second example is from the bioart realm [22]. In 2015 the artist Guy Ben-Ary created *CellF*, a collaborative project that has involved scientists, engineers, artists and musicians, which has been called the first neural synthesizer [23, 24]. *CellF* is a completely autonomous tool consisting of a biological network of neurons that grow in a Petri capsule and control in real time an apparatus of analog modular synthesizers, built on an *ad hoc* basis, interacting with human musicians and playing with them. According to the artist, choosing to use analog synthesizers depends on the fact that there is a similarity in the way neural networks and analog synthesizers work.

5. Guy Ben-Ary, CellF*, 2015. Performance at Ars Electronica 2017*

CellF neural network has been created from the artist's body, making a biopsy from his skin, whose cells were cultivated. Using iPSC (Induced Pluripotent Stem Cell) technology [25], these cells have been transformed into pluripotent cells, which can evolve into different types of body cells. Then the cells have been made to evolve in neural stem cells to create the network of neurons that was grown to reach about 100.000 cells. This is a much smaller number than the 100 billion neurons in the human brain, interconnected by trillions of synapses, which makes this "outer brain" a symbolic brain, also to show the future possibilities of these technologies. These neural networks, however, produce a massive amounts of data, respond to external stimuli, show plastic properties and have a lifespan [23].



6. Guy Ben-Ary, CellF*, 2015 (installation scheme)*

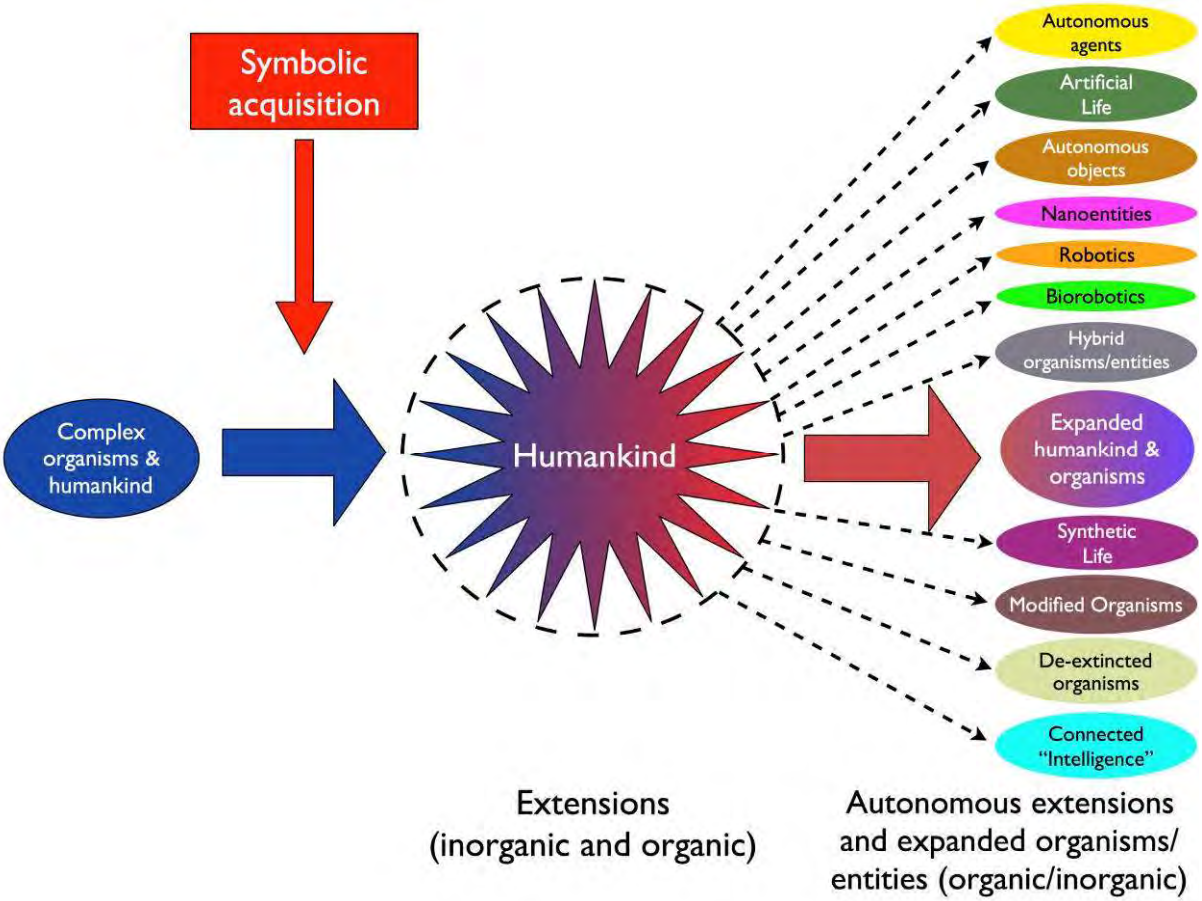
The music created by the human musicians is sent to the neurons as a stimulus, the neurons respond by controlling the analog synthesizers and creating their own music: together they perform live, weighted or improvised tracks, or jam sessions that are not entirely human. The sound is spatialised, reflecting the spatial disposition of the activity within the Petri's capsule, and it is sent to sixteen loudspeakers. Therefore walking in the performance space is a bit like walking in real time in the artist's outer brain. In *CellF*, the musician and the musical instrument become a single entity, a kind of cybernetic musician, a rock star in a Petri capsule that plays post-human music. Ben-Ary declares that *CellF* has been inspired by his narcissistic desire to reincorporate himself and follow one of his adolescent dreams: becoming a rock star. *CellF* is a radical way to reflect on the nature of musical instruments and how music can be produced.

According to Ben-Ary, "*CellF* addresses my 'interest in problematising new bio-technologies and contextualizing them within an artistic framework'. It started with a new materialist question underpinned by the belief that artistic practice can act as a vector for thought: What is the potential for artworks using biological and robotic technologies to evoke responses in regards to shifting perceptions surrounding understandings of 'life' and the materiality of the human body?" [23].

5. The Third Life

With the generative art making mode it is possibile to create outcomes that simulate or emulate the behavior of the living systems and beings, as well as of the natural phenomena. Generative art does not only involves the digital realm, it can also be biological-based, giving birth to organic and hybrid (organic/inorganic) constructs. Step

by step these forms are becoming autonomous, and due to the pressure of the anthropic environment they could evolve as living entities, organic, hybrid and inorganic. These forms are not the result of a natural selection, they are selected by the human culture and habitat. The more the anthropic environment expands and develops, the more these forms proliferate, diversifying and evolving.



7. The Third Life

We are going to assist in an extension of the idea of life to a complex panorama with organic, inorganic and mixed life forms. In mirroring nature and life, also the generative art forms and processes are leading to the advent of a "Third Life", the life that humanity is giving to its artifacts, being the "First Life" the biological life and the "Second Life" the life in the symbolic realm [26, 27].

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Random Hexagons and Other Patterns Continuities Paper (and Artworks)

Patterns Continuities on Surfaces of Polygons (Generative Art)

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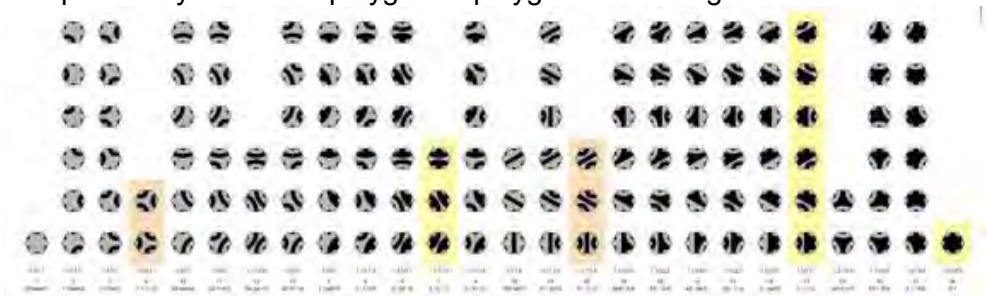
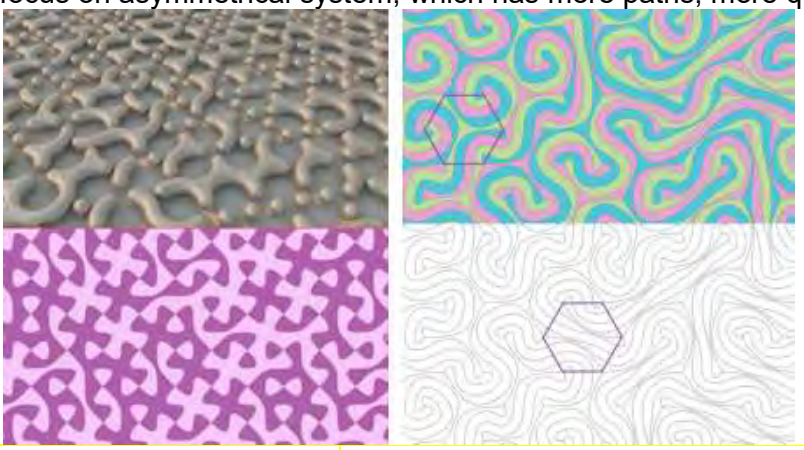
Paper

Focus of this research is in the logic and possibilities creating new not repeating patterns using polygon tiling. These patterns can be applied on surfaces but also polyhedrons.
Pattern continues from polygon to polygon when their touching edges are either symmetrical or reverse.
With symmetrical edges the focus is in the pattern inside the polygon. How different type of patterns wind through the polygons, fork or end. How different limitations alter the whole.
With asymmetrical edges there are two main areas: the pattern inside the polygon and the logic how pattern system from polygon to polygon can be organized.



How can these systems be applied to different polygons or their combinations? Can we find something what is simple, surprising and interesting?
My paper covers possibilities, alternatives and classification I have found so far.
I cover first the simpler symmetrical system and show what could be produced from that. Then I focus on asymmetrical system, which has more paths, more questions, more surprises.



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Key words: Polygon, tesselation, tiling, pattern continuity

Main References:

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Random Hexagons and Other Patterns Continuities

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Abstract

This study focuses on generation of non-repeating patterns using regular polygon tessellations. Number of tessellations using regular polygons is limited. In this study I'm limiting used polygons to triangle, square and hexagon for practical reasons. Shapes are categorised by number of segments at each edge of the polygon as well if edge is symmetrical or not. Segments on edges are joined inside the polygon in all possible ways under certain rules, which gives us several different shapes for each polygon in different categories. Combining and rotating different shapes gives huge variation of different non-repeating, but continuing patterns. These patterns can be designed, random or originate from any source data. Using parametric algorithms different variations can be generated easily.

1 Introduction

Polygonal tessellations create interesting and fascinating patterns. These tessellations (tilings) are used in architecture, textiles, board games and many other applications for practical, structural and decorative purposes.

1.1 Tessellations

Using only one polygon we can create only three tessellations on a flat surface (Fig. 1.).

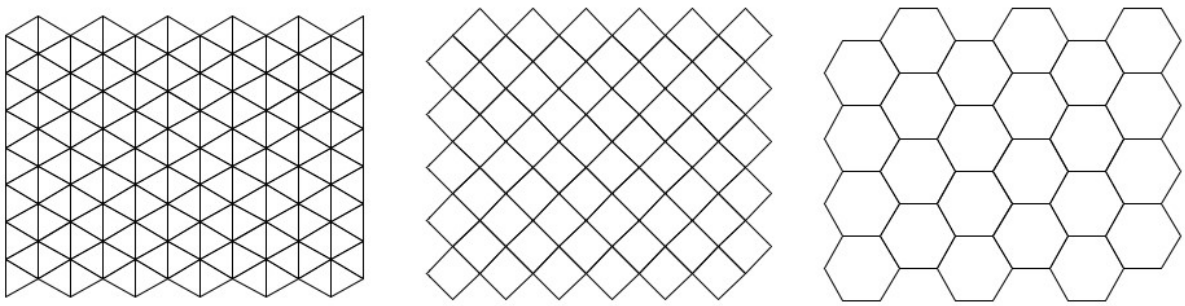


Fig. 1. Tessellations of regular polygons on a flat surface.

Using combinations of triangles, squares and hexagons we can create many more so called edge-to-edge tessellations (Fig. 2.) [1]. Some of these tessellations have a system, which allows for infinite number of almost similar tesselations.

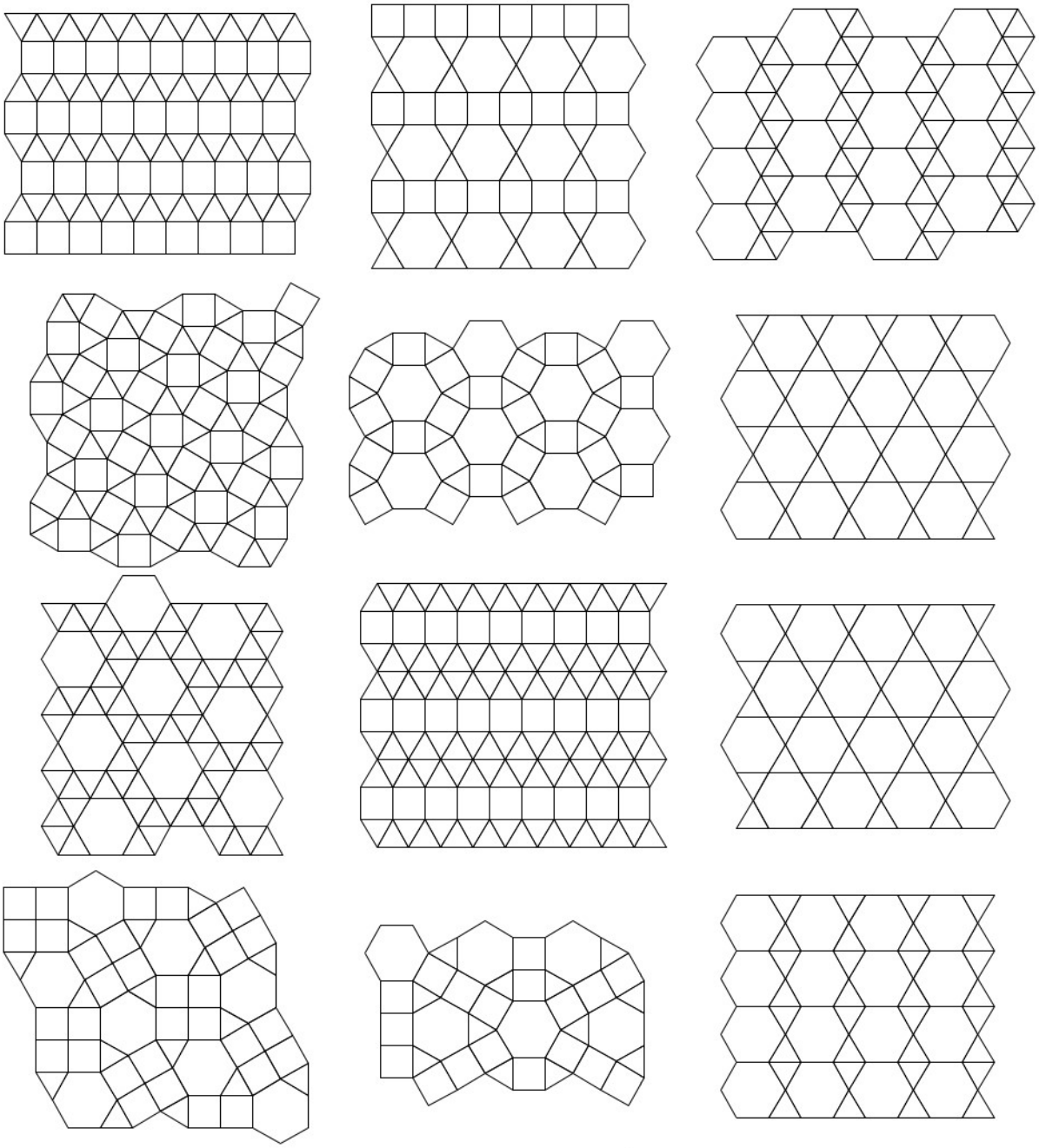


Fig. 2. Different tessellations of regular polygons on a flat surface.

There are some more tessellations if we use also octagons and dodecagons, and many more if we include curved surfaces like polyhedras, but those are excluded from this study.

1.2 Pattern continuity

By pattern continuation I mean pattern, usually a color, which continues from tile to tile creating bigger pattern.

There are different variations of this idea. A popular variation is a polygon with stripes and stripes connect different edges of the polygon at same positions at every edge.

Rotating this kind of a polygon creates a pattern where stripe continues unpredictably or randomly meet itself again and closes the pattern.

One of the most successful examples is by Neil Katz [2]. One single hexagon with three stripes gives surprisingly variable stripe when rotated randomly (Fig 3.) and many interesting patterns when rotated under control (Fig. 4.).

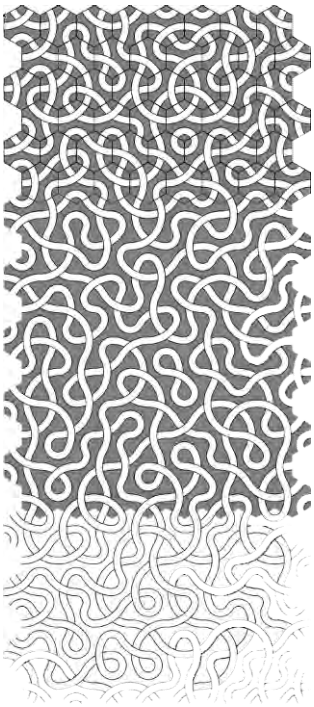


Fig. 3. One single striped hexagon used in random rotations creates interesting and non-repeating pattern of stripes.

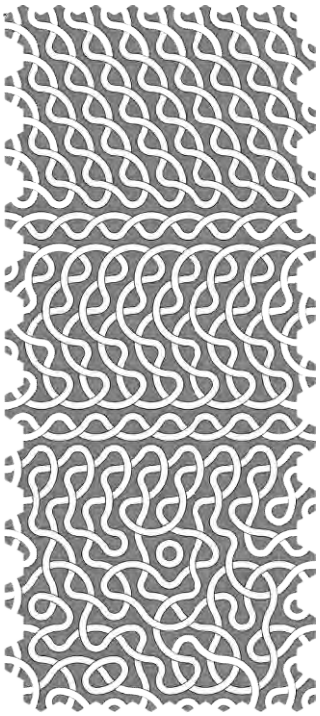


Fig. 4. One single striped hexagon used in different rotations.

The stripe has one connection on every edge. These edges can be connected in five different ways if the stripes are allowed to cross each other, and only two ways if crossing is not allowed. Naturally these five different striped hexagons can be mixed.

Using one of these tiles in certain rotation, changing rotation or random rotation we get many different patterns which seamlessly connect to each other (Fig. 5.).

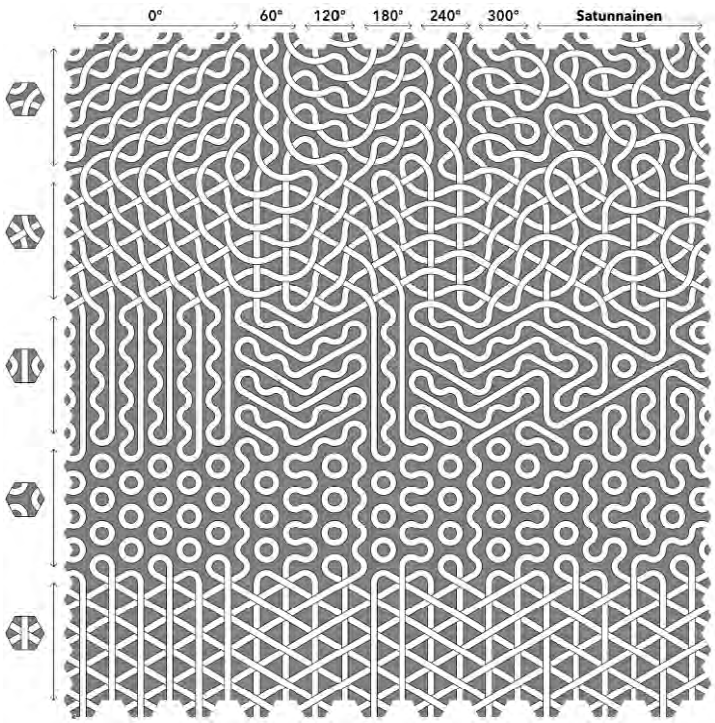


Fig. 5. Five different striped hexagons used alone in different rotations.

It is also possible to use different combinations of these striped hexagons. Pairs can be for example: two which have curved, crossing stripes, two without crossing stripes, or all five randomly combined (Fig 6.)

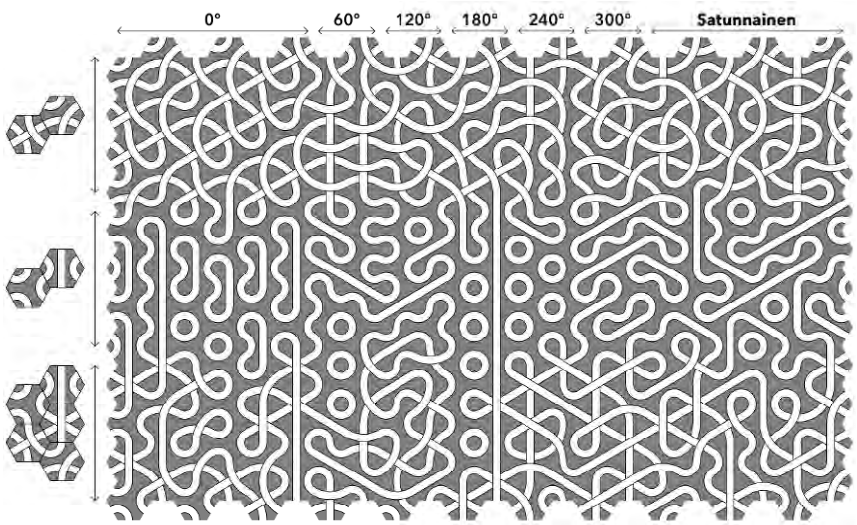


Fig. 6. Five different striped hexagons used in different combination and rotation.

It is an interesting exercise to colour the stripes, because it is extremely hard to predict where they end (Fig. 7.).

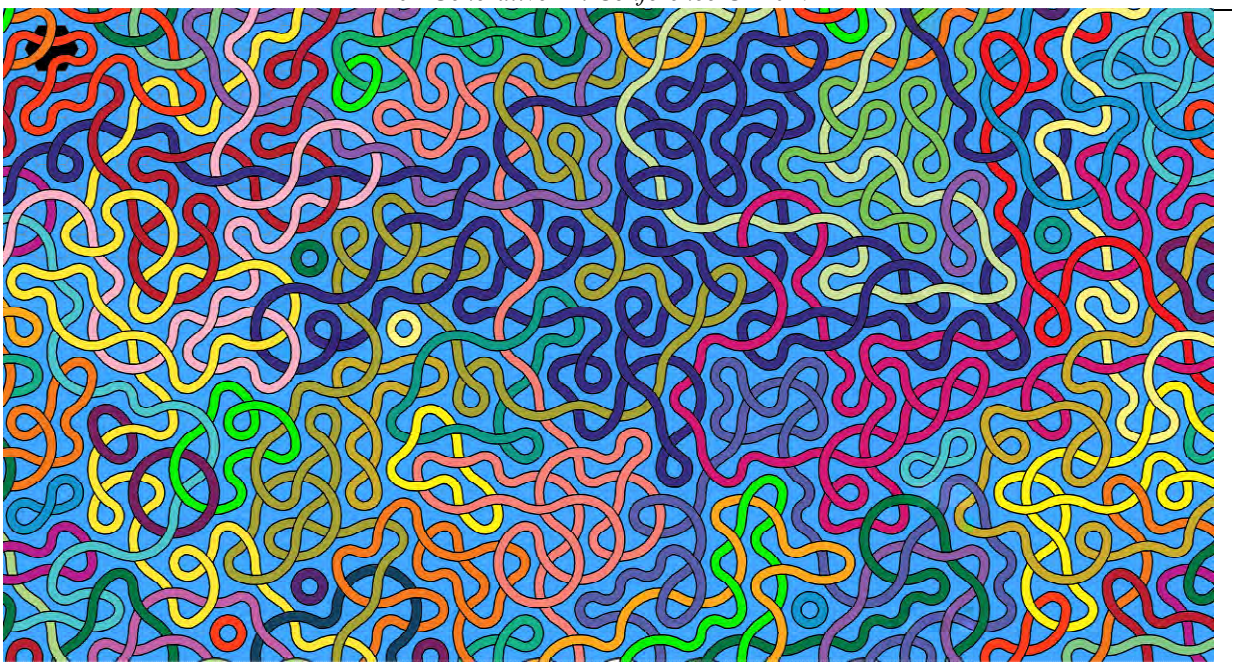


Fig. 7. Stripes hand coloured.

In this study stripes are not used. It means that stripes cannot cross over each other, so they appear more like shapes—coloured areas—than stripes.

Using those two striped hexagons where stripes do not cross we get a patterns which already have different, more graphical appearance (Fig. 8.).

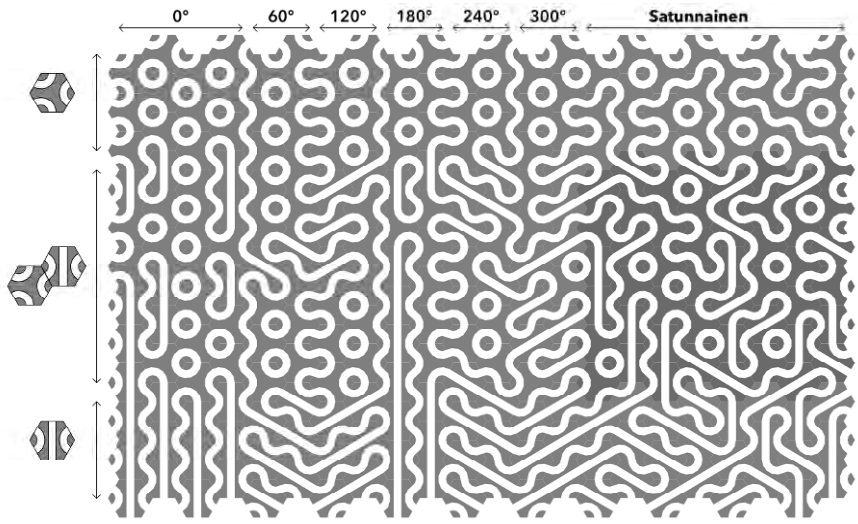


Fig. 8. (ABA 5/2) Striped hexagons without crossing stripes alone and combined. On darker area both rotation and shape are random.

1.3 Different symmetries

Edges can be symmetrical. In the example in the introduction the hexagon had symmetrical edges.

“Symmetrical edges” means that every edge of the polygon is similar and symmetrical. In the example in the introduction the hexagon had symmetrical edges. I name these

edges “ABA” according to the colours of one edge. Listing the colour of every edge of a hexagon would be “ABA-ABA-ABA-ABA-ABA-ABA”, where “-“ is the corner.

“Symmetrical corner” means that the colour on both sides of the corner is the same. It is the “A-A” part, where “-“ is the corner.

Two colors are enough to show logic of four different combinations of symmetries: ABA-ABA, ABA-BAB, AB-BA and AB-AB. All symmetries are not applicable to triangle, but for square and hexagon they are. Different appearances of these are demonstrated with square (Fig. 9.).

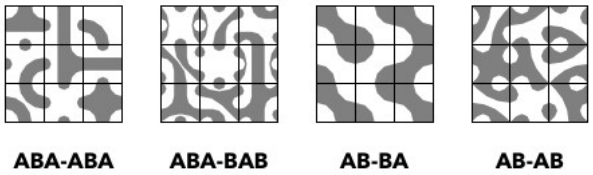


Fig. 9. Different logics of different edge and corner symmetries demonstrated with squares. A symbolises white and B grey.

ABA-ABA square has six, ABA-BAB has 28 (it has same topology as ABA hexagon in chapter 2.2.), AB-BA has only one and AB-AB has also six different shape topologies. Topologically ABA-ABA and AB-AB are same if corner is not considered as part of topology (A-A is topologically considered as -A or just A).

2 Symmetrical edges and symmetrical corners

Using symmetrical edges different shapes inside the polygon are possible. The shapes are kind of topologies. Shapes inside the polygon connecting edges could be any shape if they meet every edge similarly.

Allowing dead-ends and forking gives a lot of variation. Without dead-ends or forking triangle wouldn’t have any possible shape, square only one and hexagon two (Fig. 10.).

2.1. Topologies

There are three different topologies for triangle, six for square and 28 for hexagon. If forking is allowed, but dead-ends not, left are one triangle, two squares and five hexagons (Fig. 10.).

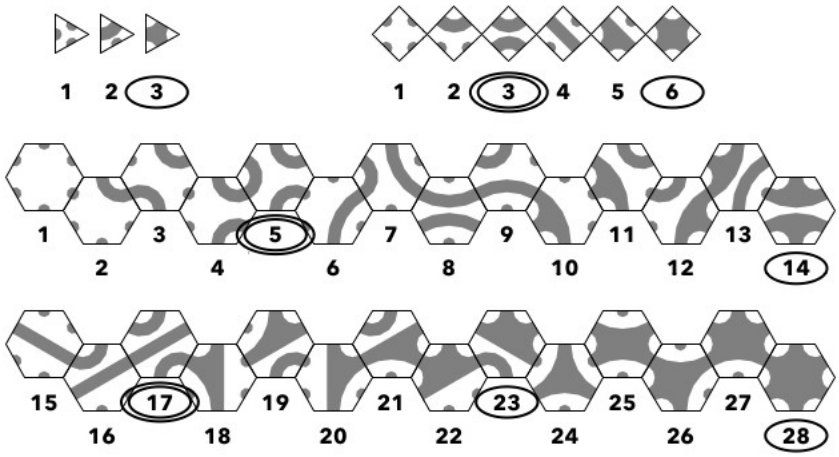


Fig. 10. Different topologies of polygons with symmetrical edges. Topologies without dead-ends are marked with small oval and ones also without forking (stripes only) with big oval.

2.2. Rotations

In this study rotation means the rotational phase of the polygon. The polygon has as many rotation phases as it has edges. In other words number of rotation phases tells how many different rotational positions polygon could have so that it stays perfectly in the grid. So triangle has three rotations, square has four and hexagon has six.

Some of the shapes are more or less symmetrical to the center of the polygon and so they have no difference in certain rotation phases. So triangles 1 and 3, squares 1 and 6 and hexagons 1 and 28 have only one appearance as they look same in every rotation phase.

Squares 3 and 4, and hexagons 5 and 24 have two appearances. Triangle 2 and hexagons 3, 8, 14, 15, 17 and 25 have three rotations. Rest of the squares have four and hexagons six rotations (Fig. 11. and 12.).

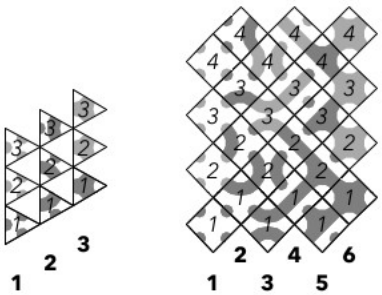


Fig. 11. Different rotations of symmetrical triangle and square. Number inside the polygons is the rotation phase.

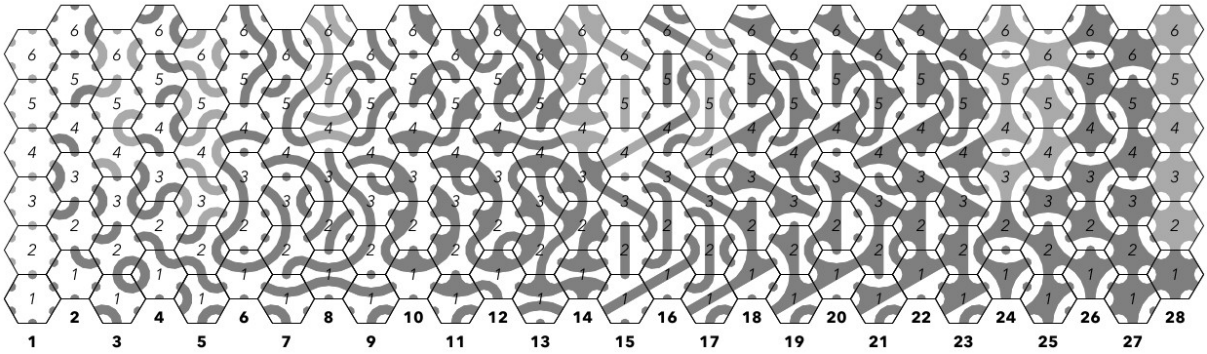
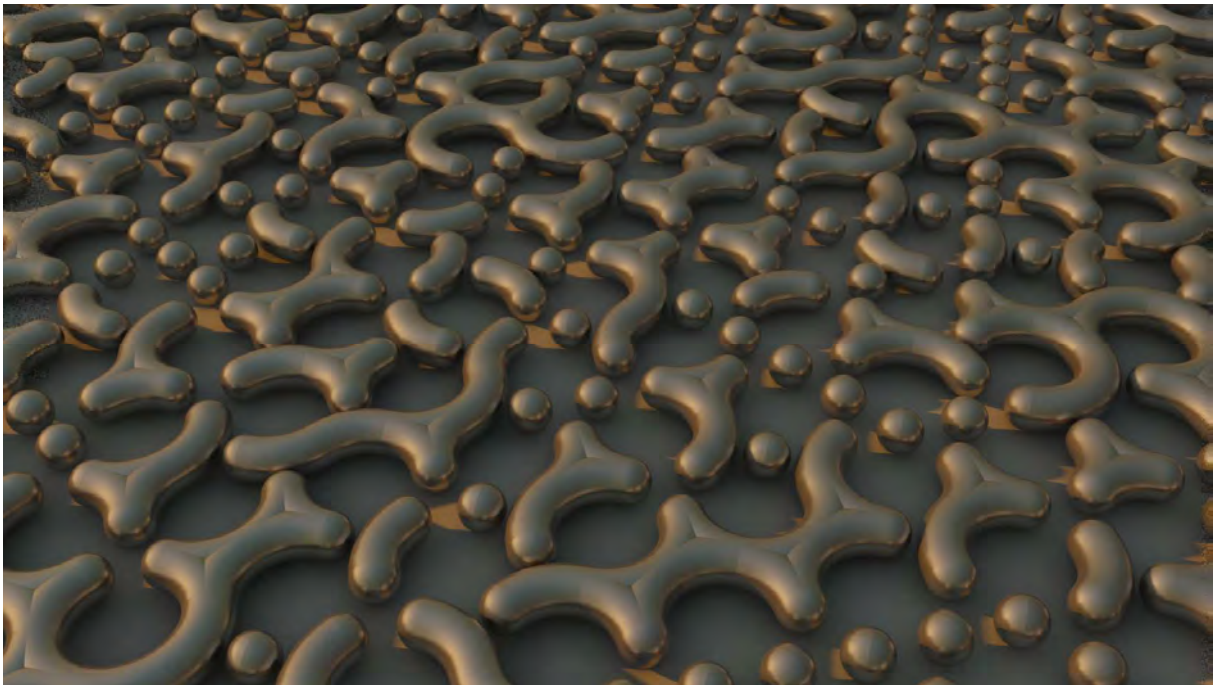


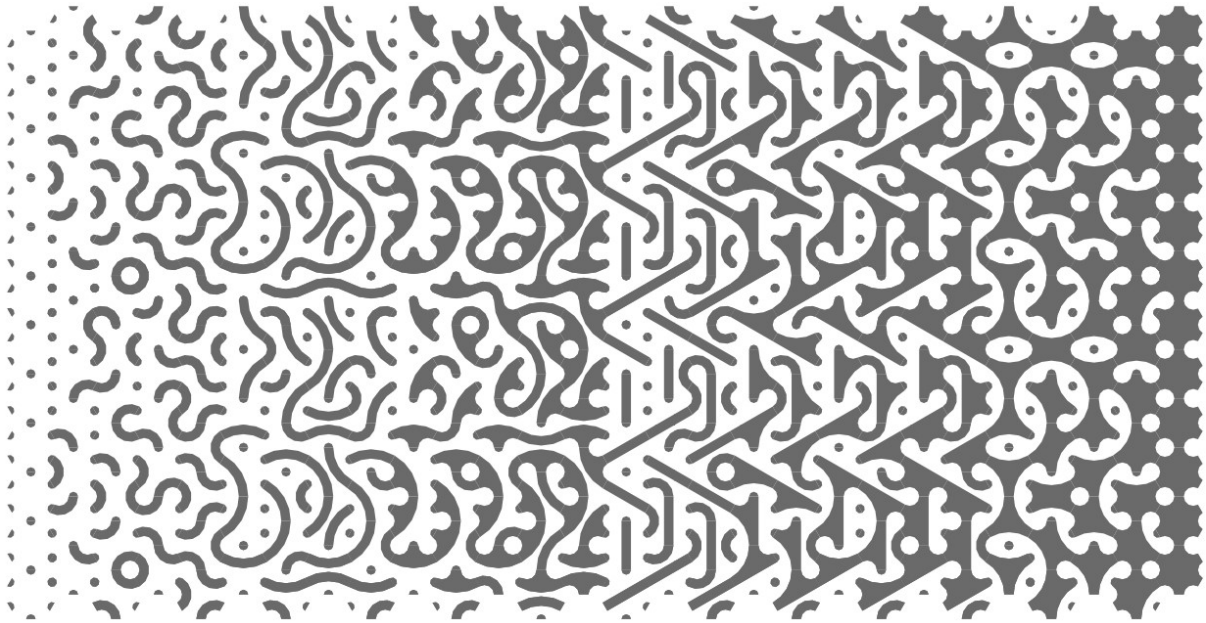
Fig. 12. Different rotations of symmetrical hexagons. Note that some topologies appear similar in different rotations. They have lighter grey pattern. Number inside the hexagons is the rotation phase.

2.3 Examples

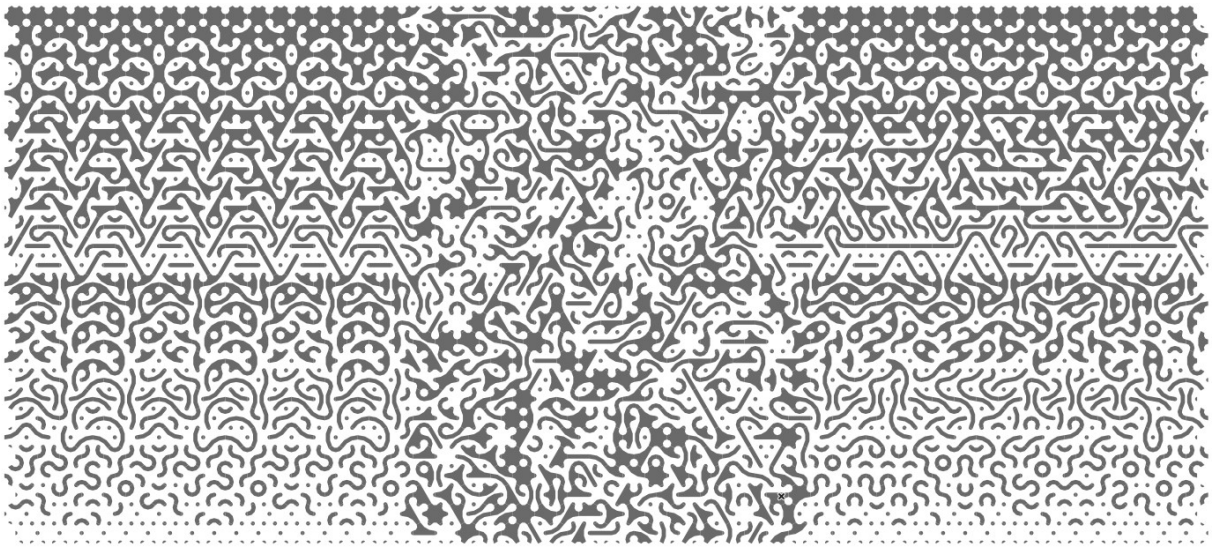
Here are examples created with polygons with symmetrical edges.



Pict. 1. (ABA 5/3) Random triangles in random rotations.

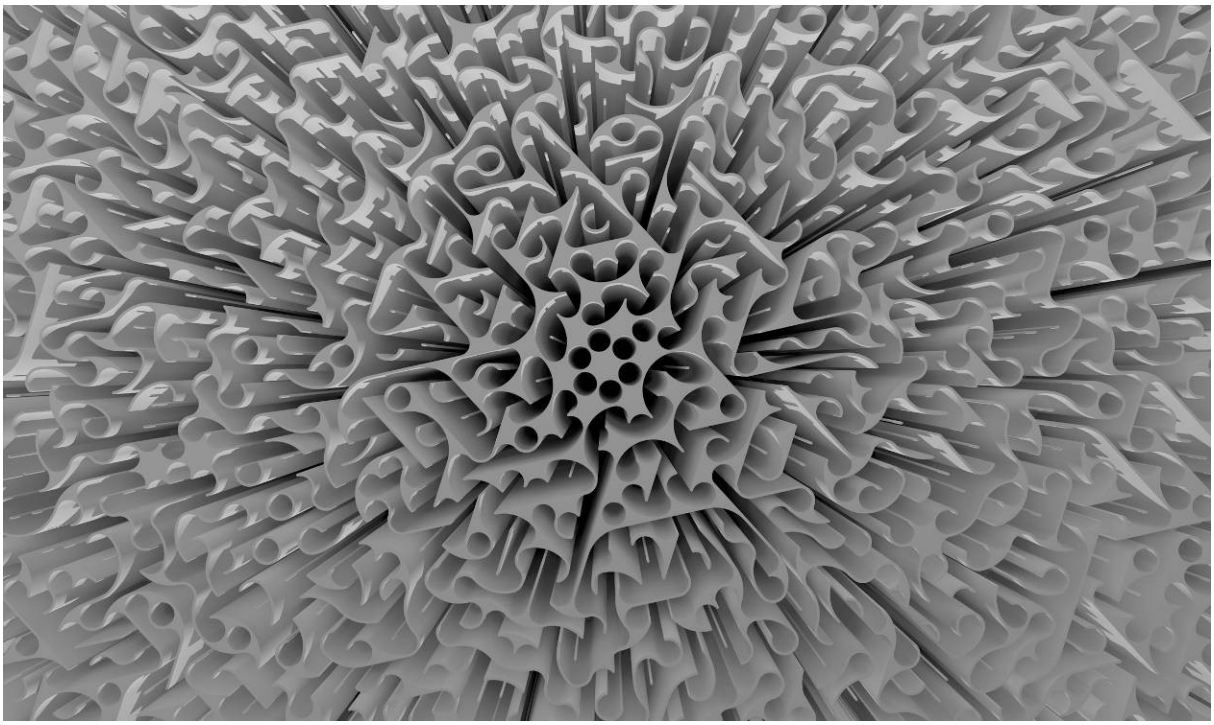


Pict. 2. (ABA 132/28) Same regular hexagonal pattern and rotation repeated as in figure 11.

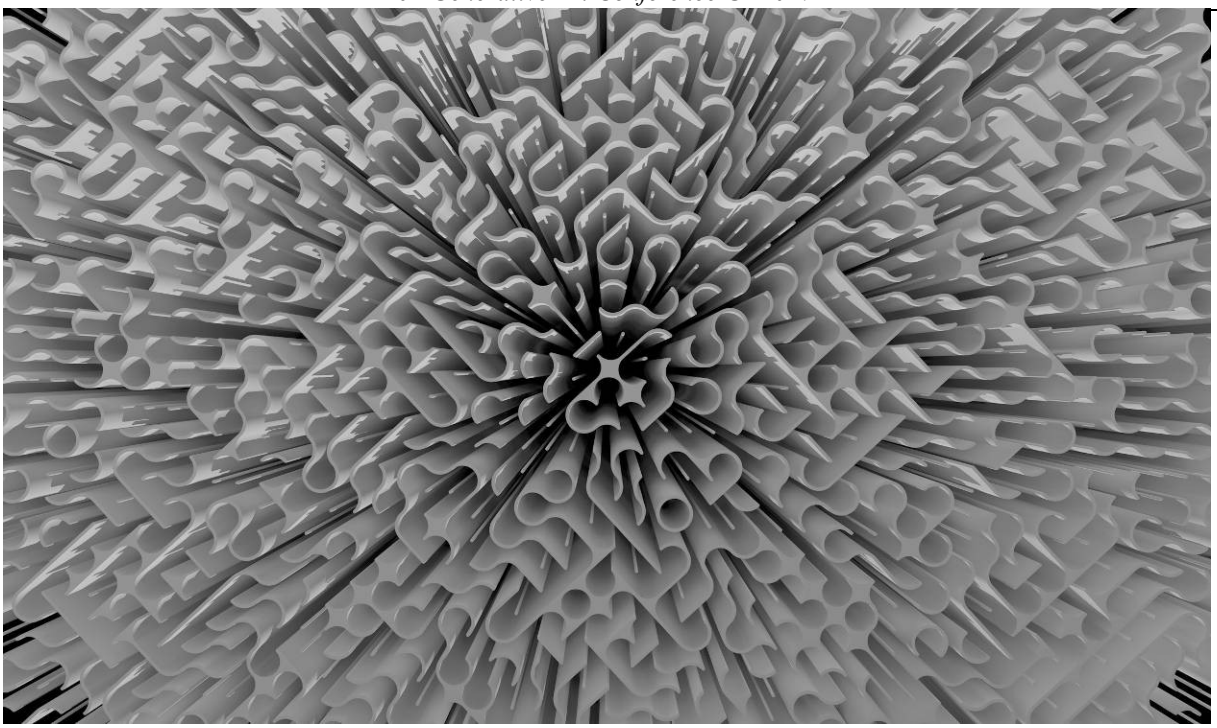


Pict. 3. (ABA 132/28) Left third is hexagonal patterns 1-28 from bottom to top in rotations 1-6 (from left to right). Middle third is hexagonal patterns 1-28 randomly in random rotation. Right third is hexagonal patterns 1-28 from bottom to top, but rotation is random. This is to show how order can be controlled and surprisingly left and right thirds appear at first sight almost similar.

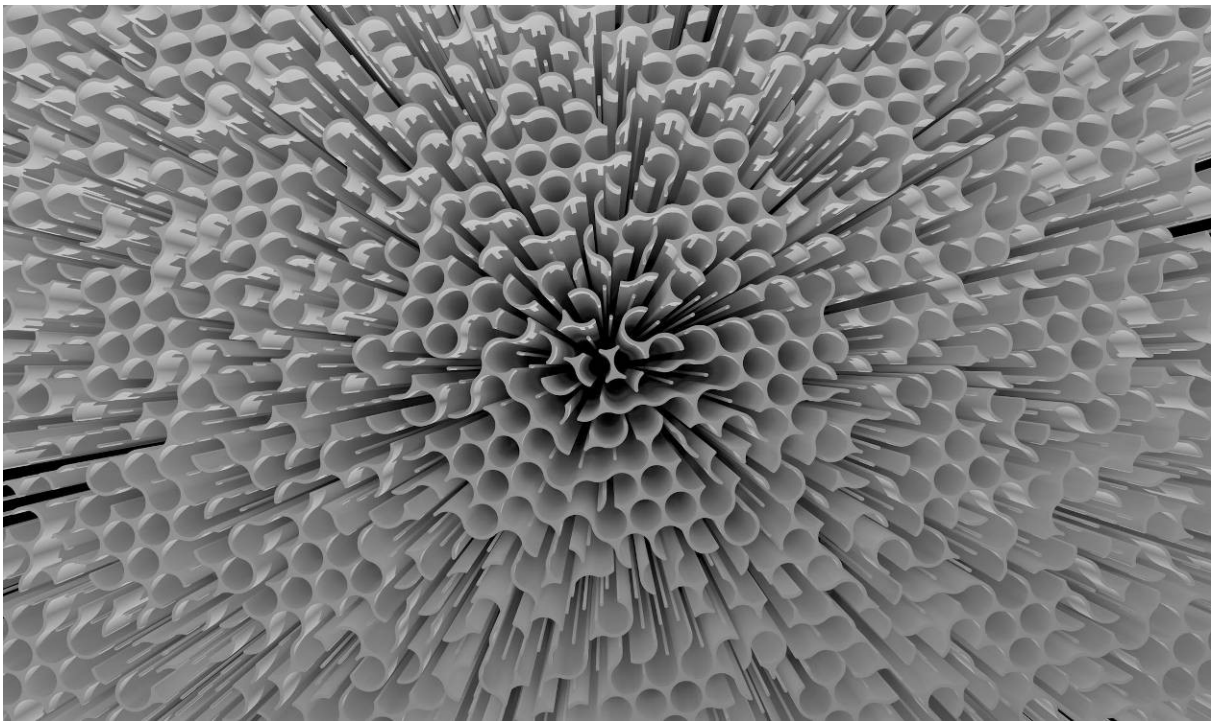
Pict. 4. (ABA 132/28) 3D labyrinth created with hexagons.



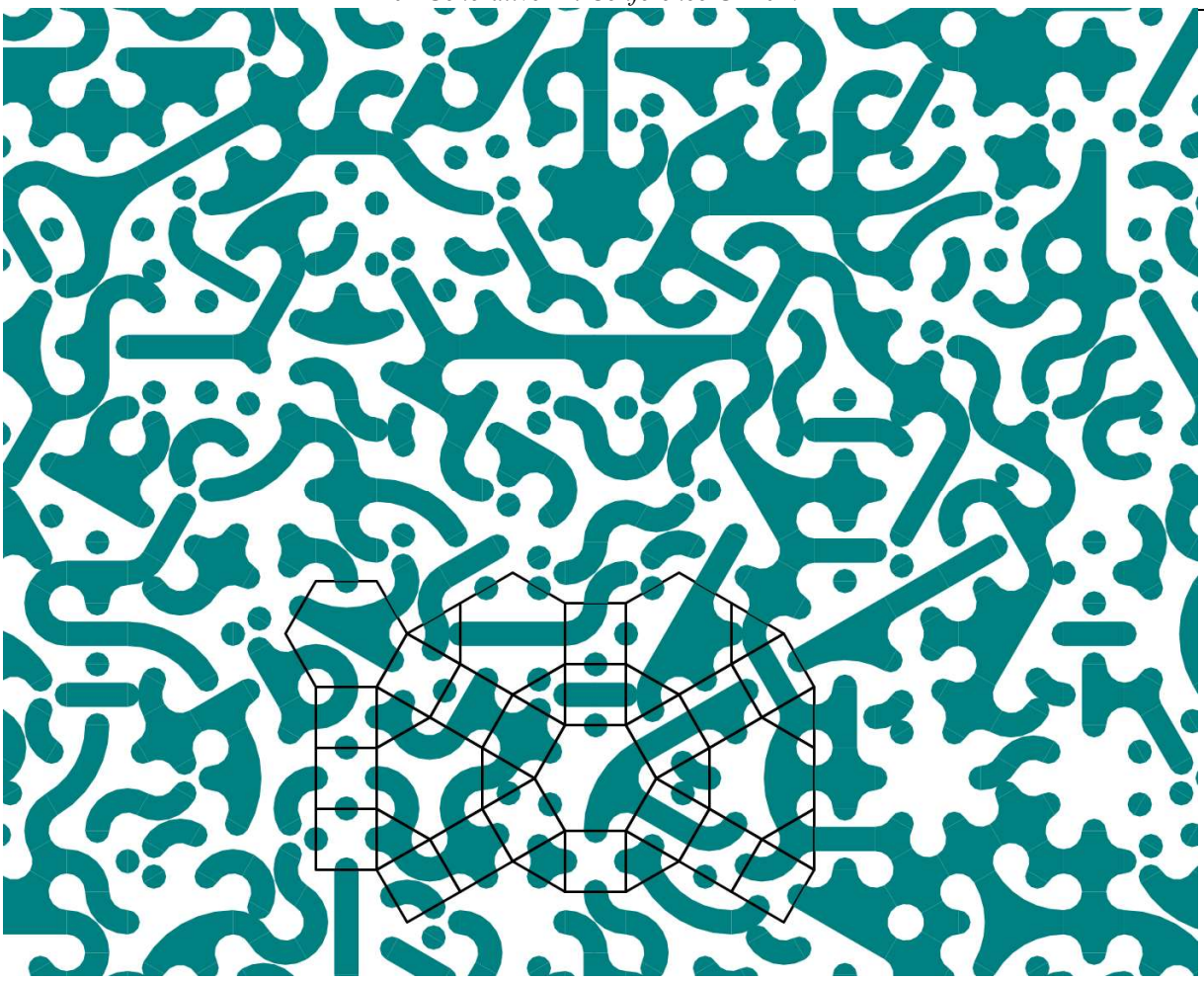
Pict. 5. (ABA 132/28) 3D labyrinth created with hexagons.



Pict. 5. (ABA 14/6) 3D labyrinth created with squares.



Pict. 5. (ABA 5/3) 3D labyrinth created with triangles.



Pict. 6. (ABA) Total chaos is tightly organized with tessellation combining different polygons. All patterns and rotations are random.

3. ABCBA

"ABCBA" type of edge behaves like "ABA" in two layers. The inner or top shape just must fit inside outer or bottom shape. I call outer or bottom shape as master shape and inner or top shape as sub shape. We get 255 different ABCBA hexagons, 19 squares and six triangles (Fig. 13.).

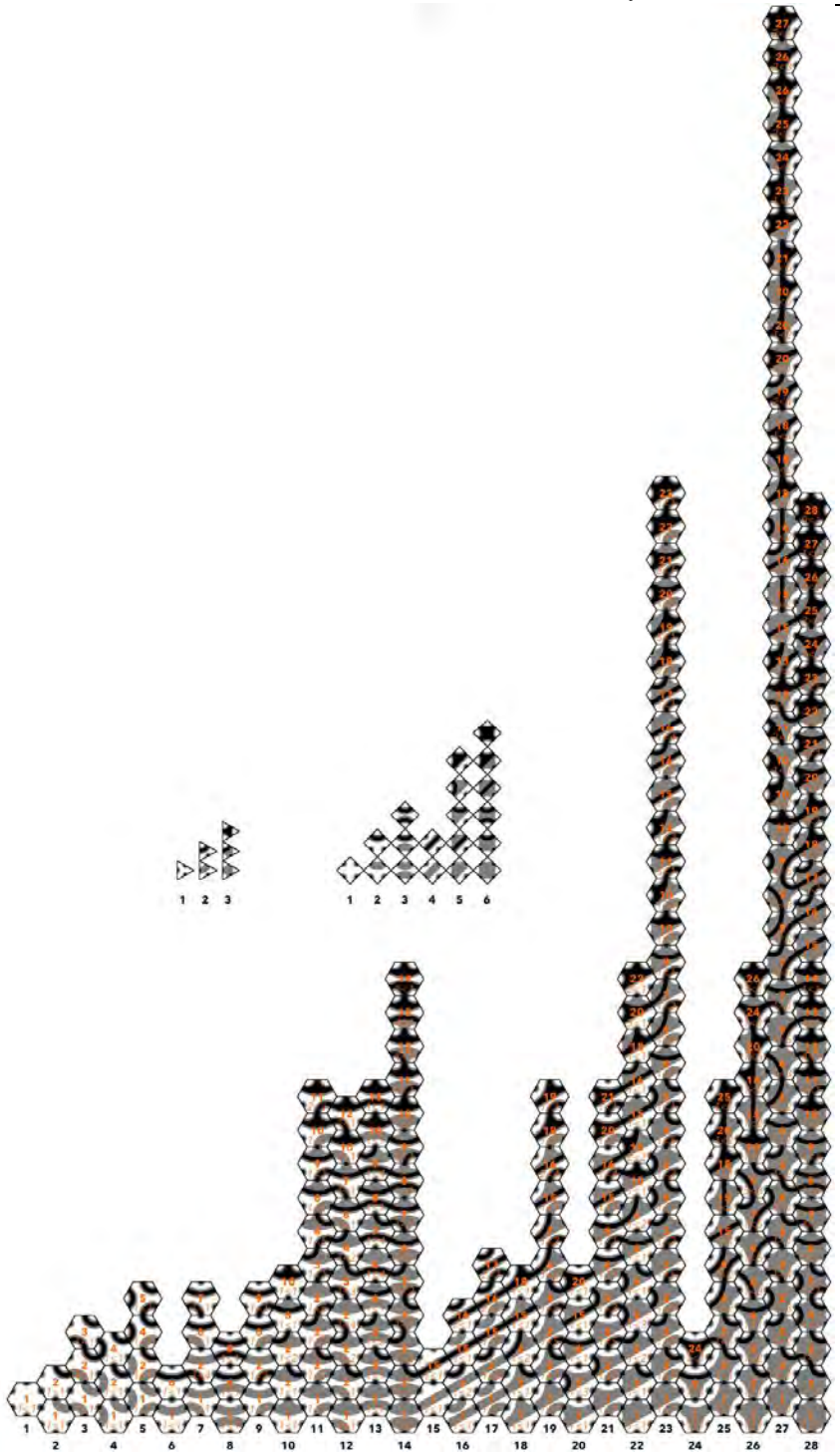


Fig. 13. Schedule of different ABCBA type polygons. Grouped by master shape. Inside hexagons is marked number and rotation of sub shape. 6 triangles, 19 squares and 255 hexagons.

Patterns created with “ABCBA” edges are naturally one level deeper and thus more interesting (Fig. 14., 15., 16.)

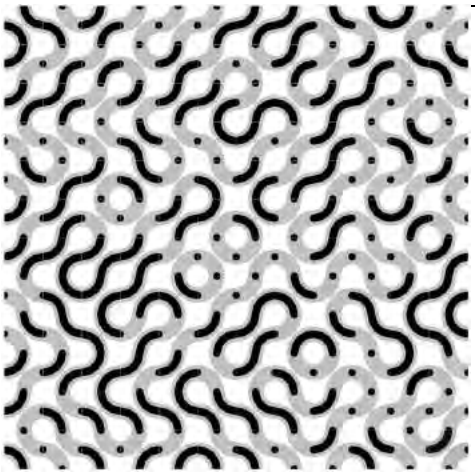


Fig.14. ABCBA (8/3/4) squares number 3.

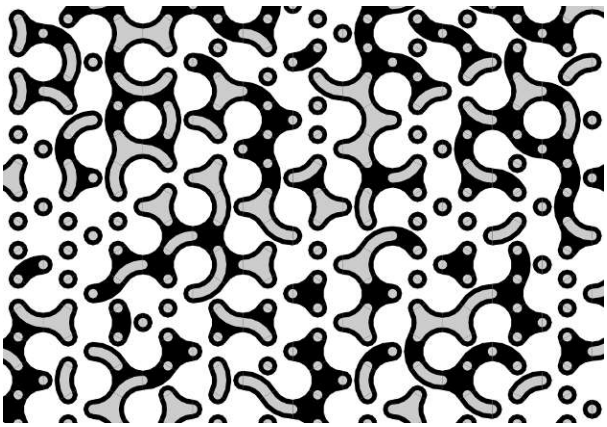


Fig.15. ABCBA (9/3/3) triangles.

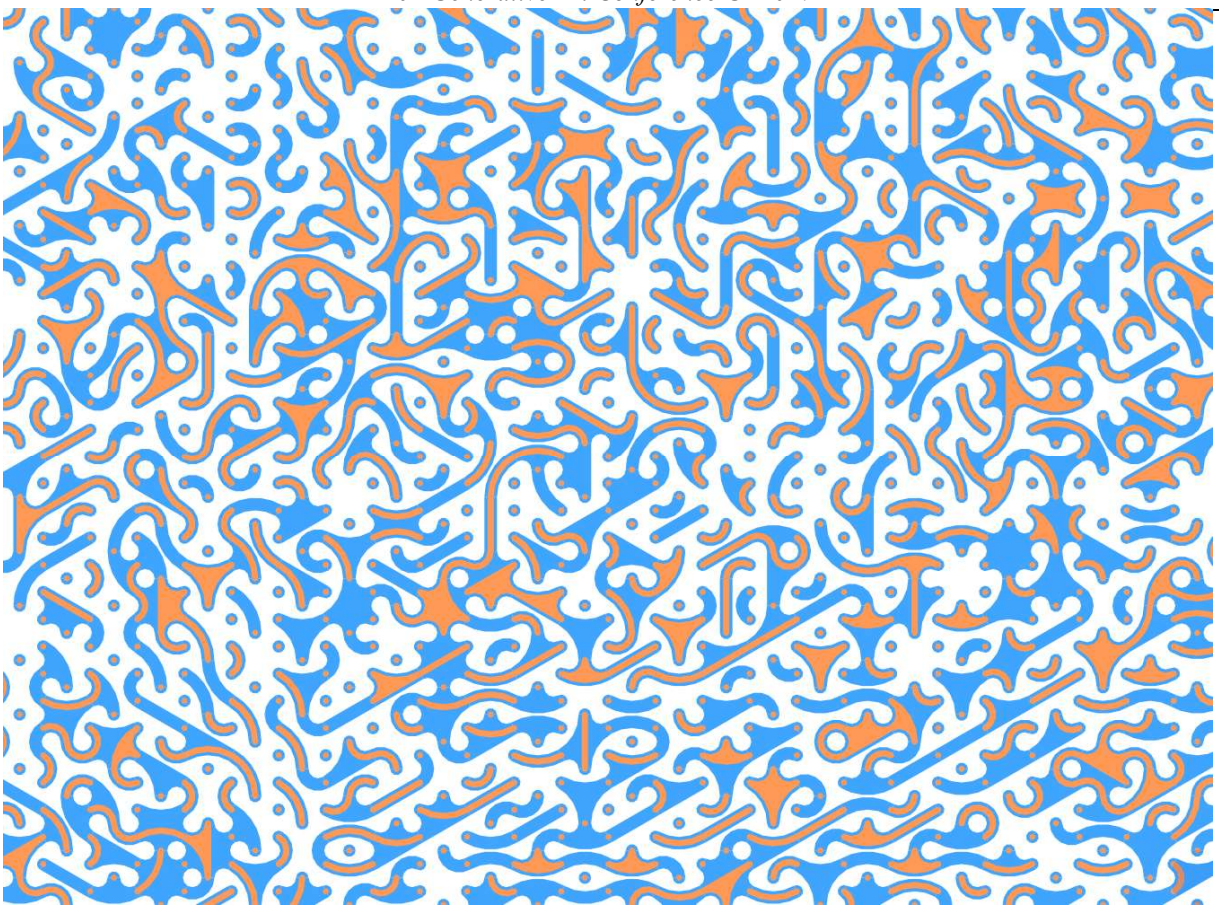
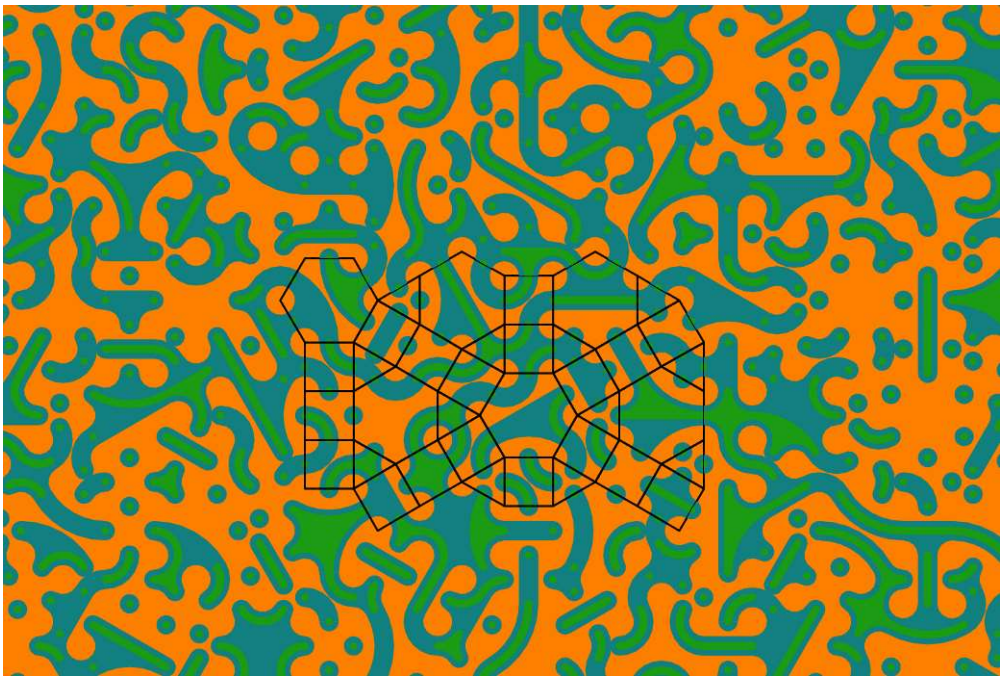
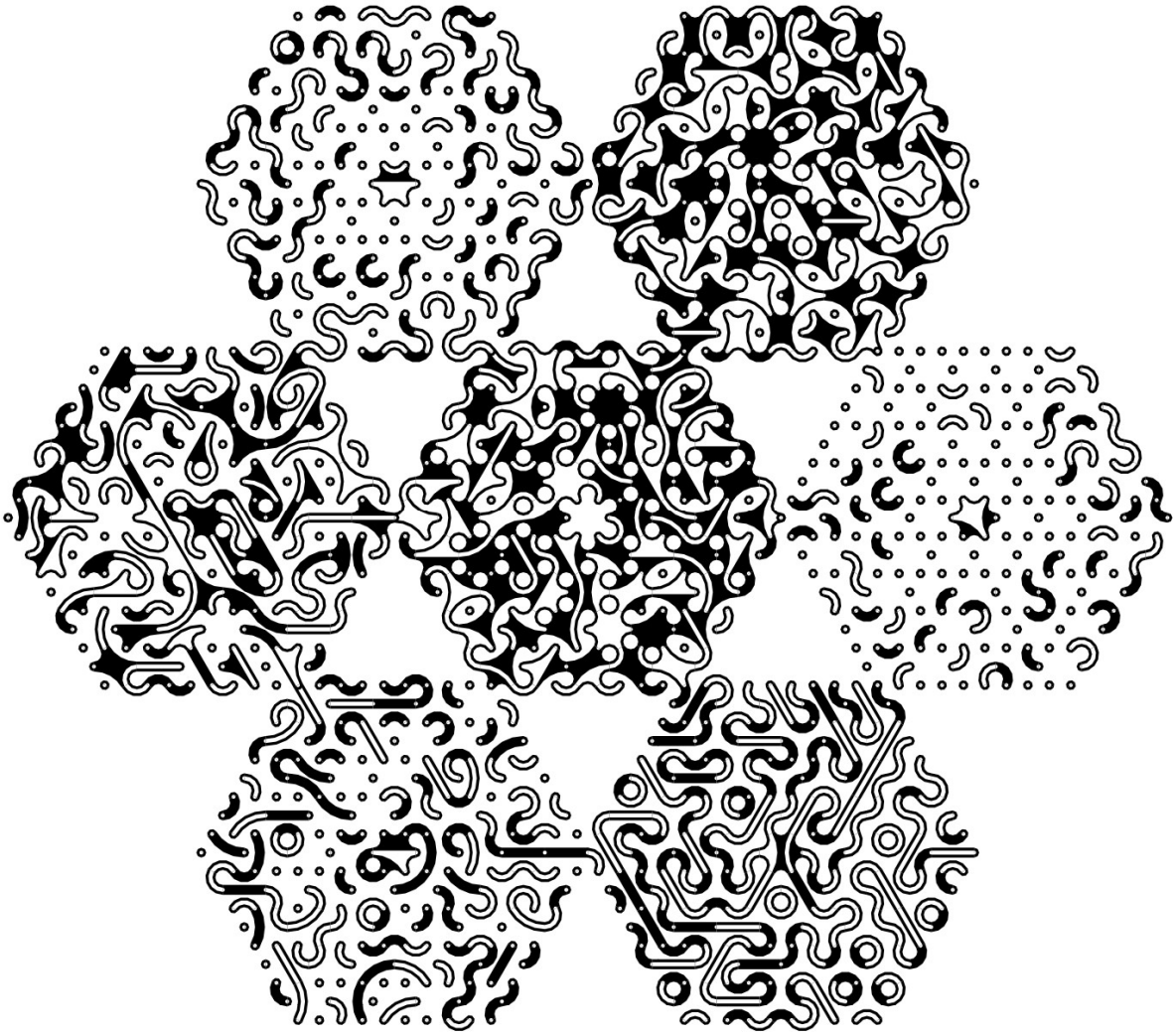


Fig.16. Random ABCBA hexagons. Upper part of the image they are randomly rotated and at lower part they are all at rotation 1 (angle 0).



Pict. 7. Total tightly controlled chaos with different ABCBA polygons.



Pict.8. ABCBA hexagons. All seven tessellations have different parameters for group of random hexagon shapes. All centre hexagons are 28 except the absolute centre which is 1.

3 Future work: Asymmetrical edges and asymmetrical corner

Here is a small glimpse to the next steps in this research.

Asymmetrical edges mean that single edge of the polygon is asymmetrical. This means that edge of neighbouring polygon must be mirrored for the pattern to continue in the next polygon. Simplest asymmetrical edge is “AB” and the edge of neighbouring polygon must be “BA”.

Also corner can be symmetrical or asymmetrical. In chapter 2 asymmetrical corners were not covered. Asymmetrical corner means that colour on both side of the corner are different, such as “B-A”.

Chapter 1.3 shows different combinations of symmetrical and asymmetrical edges and corners.

In this chapter argumentation is missing, as this work is still to be done.

3.1. AC-BC hexagon

For hexagonal tiling of asymmetric corner three colours are needed. For triangles and squares two colours would be enough. The need is similar to chessboard. For hexagonal chessboard three colours are needed (Fig. 16.).

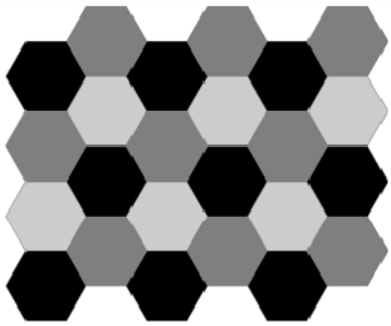


Fig. 16. Hexagonal "chessboard" pattern demand three colours.

Similarly AC-BC hexagons are needed in three "colours". So actually there are also variations BA-CA and CB-AB. These variations are colour phases (Fig. 17.).

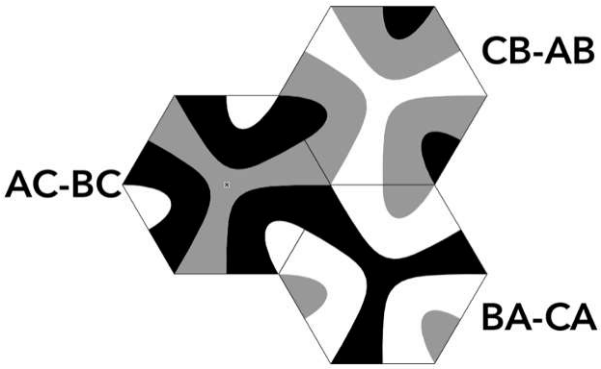


Fig. 17. Different colour phases of AC-BC are BA-CA and CB-AB. A symbolises white, B grey and C black.

To make this colouring system work, only three shapes (topologies) are possible. It is important to note that AC-BC hexagons cannot be mirrored or pattern (colours) will not continue from polygon to polygon. Those shapes are named here as "I", "Y" and "*" (star) according to their dominant appearance (Fig. 18.).

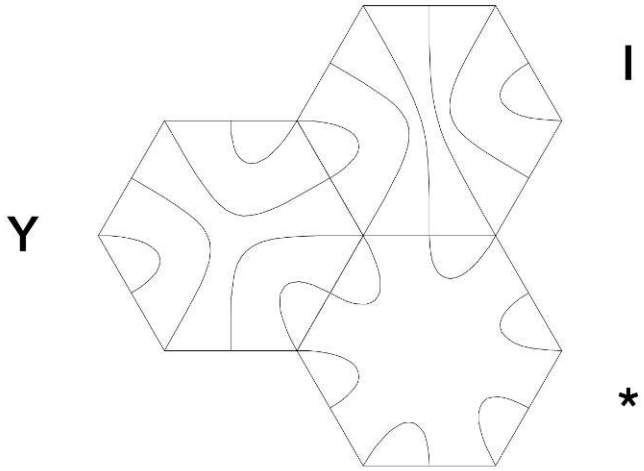


Fig. 18. AC-BC hexagon shapes are named here as "I", "Y" and "" (star) according to their looks.*

Star has only one rotation, Y has two and I has three. Rotations can be controlled or random (Fig. 19.).

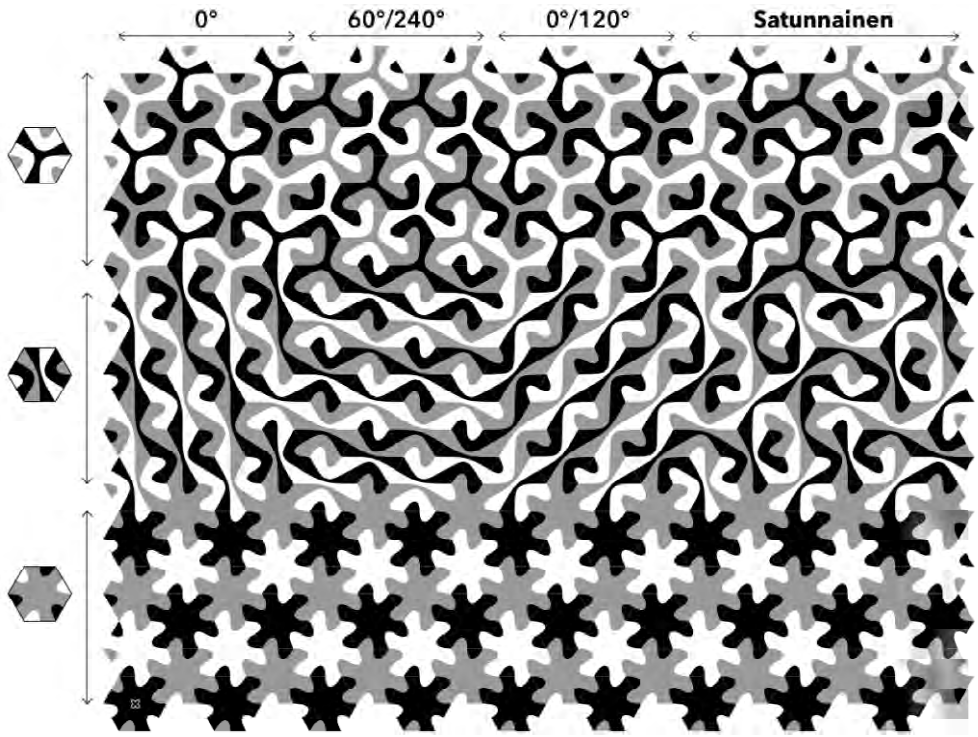


Fig. 19. AC-BC hexagons in different rotations (Satunnainen means random).

If they are also randomly mixed resulting pattern gets more interesting. Random selection can be either by shape or taking also rotation in considerations. If shapes appear equally many times Star will be dominating, because it looks the same in every rotation. If shapes are selected taking in account also their rotation the result is less Starry (Fig. 20.).

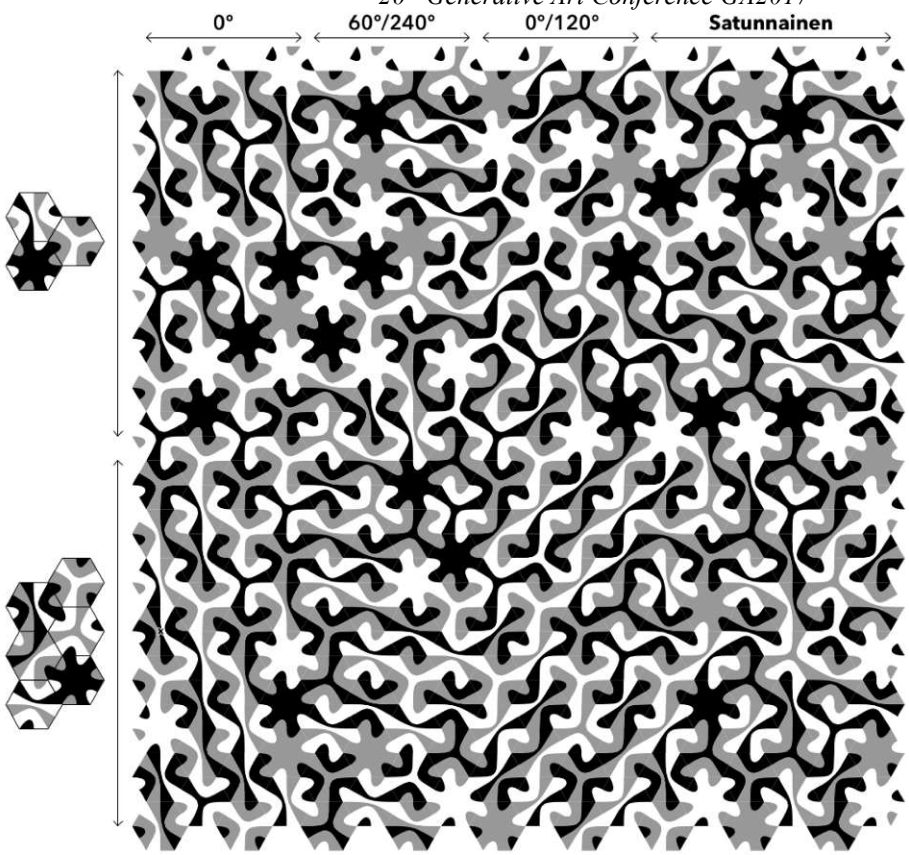


Fig. 20. Hexagons selected randomly. At upper part one third is each shape. At lower part every rotation has one sixth. Stars are more dominating at the upper part.

3.2. ABC-ACB and ABCA-BACB hexagons

All colour systems are not possible, but surprisingly many are. For example ABC-ACB hexagon gives similar, but different patterns as AC-BC hexagon (Fig. 21.).

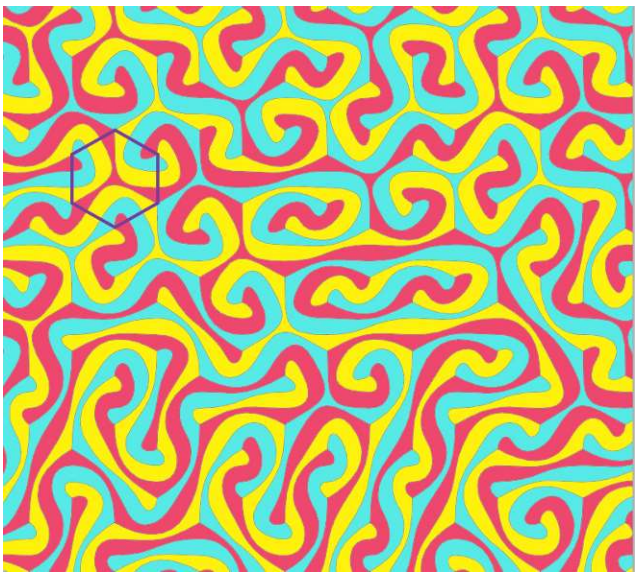


Fig. 21. ABC-ACB hexagons.

Also ABCA-BACB hexagon is possible (Fig. 22.). As this is future work, the logic and limitations of all different possibilities are not yet known.

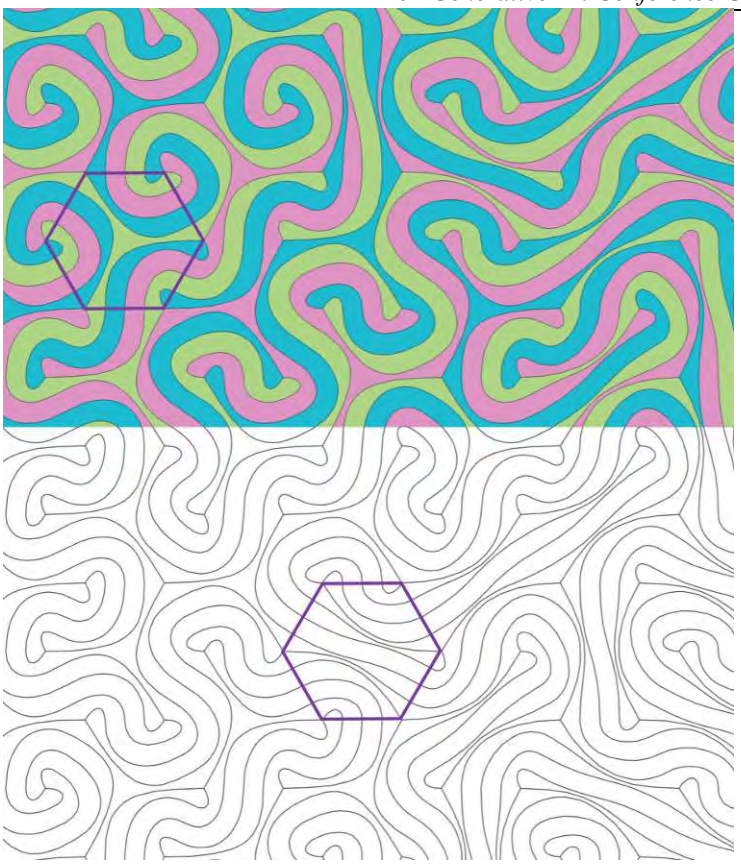
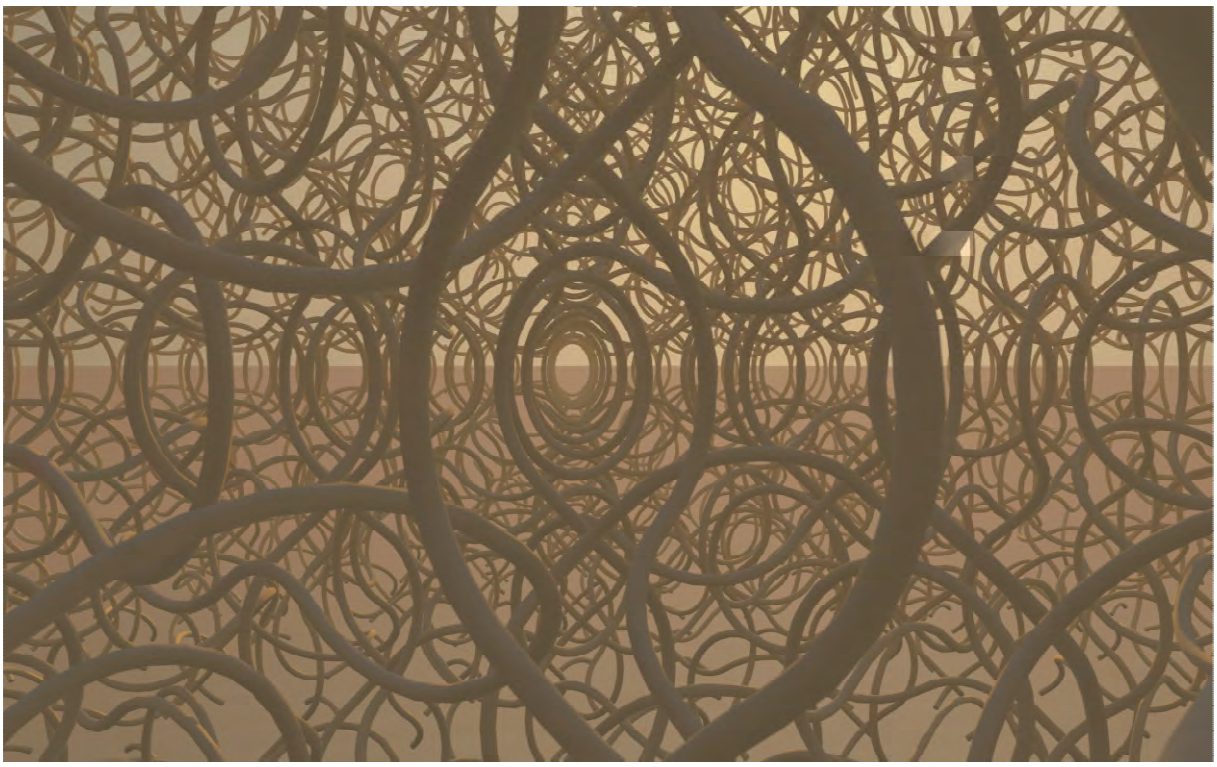


Fig. 22. ABCA-BACB hexagons.

3.3. 3D

After solving the logics of two dimensions, next is applying them, if possible in three dimensions.



Pict. 9. One 3D application "ABA" without forking or dead-ends.

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Ethnographic Symbols in Latvian Regional Architecture

Topic: Architecture

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Abstract

Geometric symbols arranged in ornaments are an integral part of the existence of mankind as a way of communication in order to pass on to the life drive and skill of living to next generations. The symbol of Latvianity is one of the richest and most complicated symbolic sign systems in the world – the belt of Lielvārde, in which ancient information has been encoded that characterizes belief into strong symbol energy and defensive magic, includes in us the special relation to nature, the world and universe.

One of the drawbacks of modern architecture is underestimation of semantic significance: building obtains an amorphous character, loses its spatial peculiarity and dialogue with the space user. In Latvian regional architecture the demand for semantic precision means to give back the historic centres their lost content, conformity of forms and hierarchy of artistic expression. Reviving historical experience, including Latvian cultural traits in the revelation of the building's semantic essence, an impulse is given to broader creative searches in order to highlight the affiliation and essence of the building.

Complicated symbolic sign system in the belt of Lielvārde, symbolic signs and building aesthetics

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Key words: ancient information, belt of Lielvārde, ethnographic ornaments, Latvian regional architecture, symbolic sign system

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Ethnographic Symbols in Latvian Regional Architecture

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Premise

Abstract

Geometric symbols arranged in ornaments are an integral part of the existence of mankind as a way of communication in order to pass the life wisdom and skill of living to next generations. The symbol of Latvianity is one of the richest and most complicated symbolic sign systems in the world – the Lielvārde belt, in which ancient information has been encoded that characterizes belief into strong symbol energy and protective magic, includes in us a special relation to nature, the world and universe.

One of the drawbacks in modern architecture is underestimation of semantic significance: building obtains an amorphous character, loses its spatial peculiarity and dialogue with the space user. In Latvia regional architecture the demand for semantic precision means to give back the historical centres their lost content, conformity of forms and hierarchy of artistic expression. Reviving historical experience, including Latvian cultural traits in the revelation of the building's semantic essence, an impulse is given to broader creative searches in order to highlight the affiliation and essence of the building.

Keywords: ancient information, belt of Lielvārde, ethnographic ornaments, Latvian regional architecture, symbolic sign system

Introduction

On the eastern coast of the Baltic Sea up to the Vistula in the west, in the south of the Prypiat, the upstream of the Dnieper and east of the River Oka, in the north of the

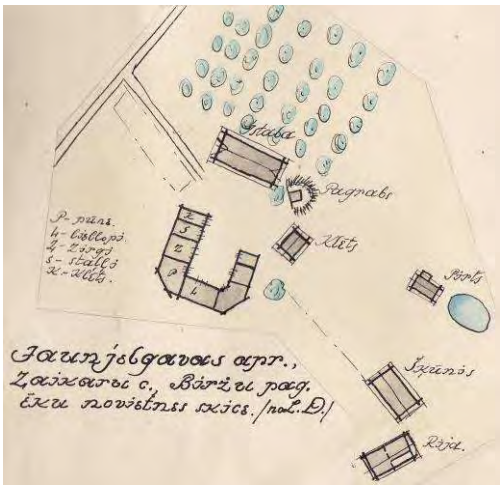
Gauja there stretched the area populated by the Baltic ethnic group representatives belonging to the Indo-European language family. The West Baltic tribes Natangians, Bartians, Nadruvians, Warmians, Pogesanians, Pomesanians and Sambians obtained a common name Prussians (*pruzzi*), but in the eastern part of Vidzeme and Latgale at the basins of the River Daugava and Velikaya (Russian: *Вели́кая*, earlier Mude) the East Baltic tribes Latgalians (Latin: *Lethi, Letthigalli*) can be found archeologically since the 6th–7th centuries, who used to live in farmsteads in forest and swamp areas. *Sēta*, or *viensēta*, *savrupsēta* is called a separate farm with farmstead buildings within the borders of the farmland [3, *423*]. In the western part of the populated area the most dominant place of residence was *ciems* (village) – a greater number of farmsteads built closely together, forming a sort of common settlement. However, each farm representing an independent unit and located on its own farmland. On the right and left bank of the Daugava on the border of Lithuanian lands there lived Selonians (*Sêlen*) and their land was called Selonia (Latin: *Selonia*). Curonians (Latin: *chori, curones*) lived in the basin territories of the Venta, Tebra and Durbe's junction rivers Saka, Bārta (in the upper course Vereta) and the River Šventoji and Neman's lower course. In the territories northwards from the Daugava Latgalians together with Curonians created the Semigallian (Latin: *Semigalli*) tribe on the plain of the Lielupe River (*flumen Semgallorum, die Semgaller Aa*) and partly in Western Vidzeme (Picture 1).

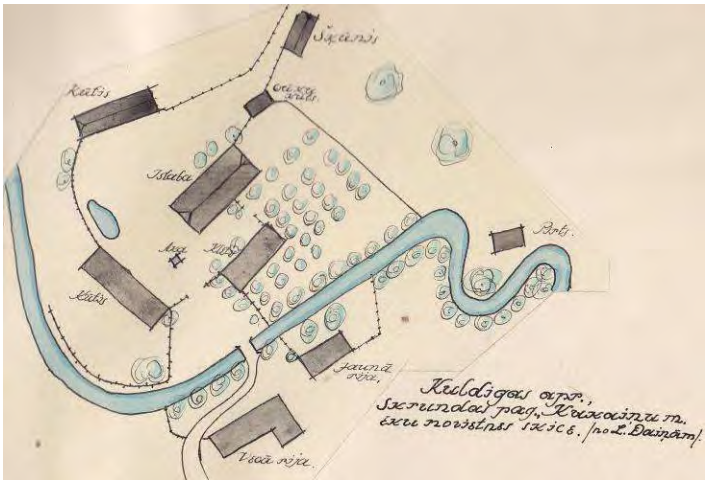
Picture 1. Territories populated by the Baltic tribes on the Baltic Seacoast around 1200. [8]

In the middle of the first millennium BC the representatives of the Baltic tribes started building hillforts or defended settlements on lands appropriate for agriculture in the vicinity of forests rich in game and market places on precipices by river junctions and spring estuaries into big rivers or lakes. Following the peculiarities of the relief, construction of enclosed building complexes was started on top of hillforts. Due to the increase of population the defended settlements became too cramped, so craftsmen and merchants started establishment of urban settlements on the crossroads near

market places since the late first millennium BC. In *Latgale* and *Augšzeme* predominated *sādžas* (villages) – a row or cluster of farmsteads, closely built together along a common road, on small lots, but without a direct connection with their tilled fields.

The dominating type of settlement in rural areas was a separate individual farm. The general character of the farmstead was determined by separate buildings which had developed types of their own for each separate function and by the use of log construction. The farmstead consisted of separate buildings such as the *istaba* (dwelling-house), the *klēts* (granary), the *pirts* (steambath-house), cowsheds or barns, and the *rija* (threshing-house). Important features of the general aspect of the farmstead were also fences, gates, orchards, gardens, trees and shrubs [3, *436*].





Picture 2. Sketch of buildings placement in a farmyard in Zaikari Village, Birži Parish, Jaunjelgava District. [5]
Picture 3. Sketch of buildings placement in Kundziņi yard, Skrunda Parish, Kuldīga District. [5]

Appearance of *sēta* (courtyards) marked essential changes in the Latvian farmer's life and culture: a proper base for existence was created cultivating a plot, building a permanent house for themselves and cattle, rooms for crop processing and storage. The type of activity and lifestyle related to a farmstead also affected the national physical and spiritual development and character formation – all Latvian generations till the middle of the 19th century were born and grown up in a rural courtyard (Picture 2, 3), where the everyday life was important for the development of spiritual culture. Every next generation took over the customs, household order and work techniques tested through a long-term experience. In the rural farmsteads the family has to be mentioned in the first place – the base for the social order of the farmstead. In the family life the need for unity, youth's growth in good virtues and your parents' honouring were emphasized [3, *375*]. The residents of farmsteads tried to avoid sudden changes and innovations which did not comply with their needs in life. Folk traditions were not frozen, they followed the changes. Inhabitants living in farmsteads felt independent from the neighbourhood in the closed lifestyle. Nevertheless, they did try to maintain good relationships, which did not develop into closer social commitments or visits. Life in villages promoted social proximity [3, *376*].

The rural courtyard – the maintainer and enhancer of national living force affected the Latvian culture [3, *372*], which did not develop in an isolated way from the world, but rather in communication with neighbouring nations: Latvians got involved in the common culture development of the Baltic Seacoast. During the second half of the 19th century the members of the intelligence, descended from the rural farmsteads and

broader education acquired people, encouraged the nation released from slavery, to cultivate their abilities in order to raise their welfare, cultivate and strengthen their national awareness. Culture introduced a rapid prosperity of Latvian economic life, prepared the nation for national independence consummation. The sense of national belonging united people. Contemporary Latvian national culture started to develop, which boomed in a short time. The living force of the rural courtyard and the nurtured wisdom flowed into the new stream of the Latvian culture. The national awareness has always been alive in rural farmsteads, but it was felt more strongly together with the resistance to the nobility's power and arbitrariness. The Latvian national culture never broke the link between the traditions of the past and today, but rather cultivating its peculiarities got closer to the level of Western Europe in the 20th century.

1. Latvian lifestyle and symbols of Latvianity

The Baltic ancient tribes – Curonians, Semigalians, Selonians, Latgalians and Livs – had already their own religious preconceptions and mythology before Christianity was introduced, but merging the cultural heritage into one united Latvian culture the ancient Indo-European roots of the Baltic culture were preserved. Latvians as every comprehensive nation have got its own language and spiritual tribal order cultivated during the development related to the history of civilization – the very base of honour and dignity, which was created by the moral ideals of *Dainas'* (Latvian folk songs) deity, that was manifested in the national wisdom as a moral activity and attitude, cognitions of unworldly realization and universal interconnections. They permeate the ethical core, encoded in the images of *Dainas'* deity, signs and symbols and cultivated in traditions of wisdom, and for the nation existing in historic time they serve as the value measurement from the past to future.

People in farmsteads used to stick to wisdom full of ideals, following positive thoughts and profound virtues. Enmity, envy, malevolence, slander, idleness were rejected. Industriousness was appreciated highly, which created physical and moral satisfaction. Modesty and frugality were acknowledged, which helped to nurture life, but meanness was censured and the lords who made their peasants work very hard and live in poverty were hated. In daily life concord was appreciated more than full granaries [3, *374*]. The traditions of deity and cult did not disappear till the middle of the 19th century, but they transformed due to the impact of Christian Church. In the enlightened piety the nation obtain power to overcome hardships of life and emerged vices. The religious life also rooted in farms during the second half of the 19th century, where the church order was observed and part taken in all events related to church. A strong impact of church was in Latgale [3, *375*]. Cultivating their heritage and refining it with creative contributions, Latvians have confirmed themselves and their Latvianness as an integral part of the European and world's cultural heritage value. The base of the Latvian world-view, culture and creativity is *Dievturība,* but the base of the Latvian god-comprehension is a creative thought – the base of the whole outset.

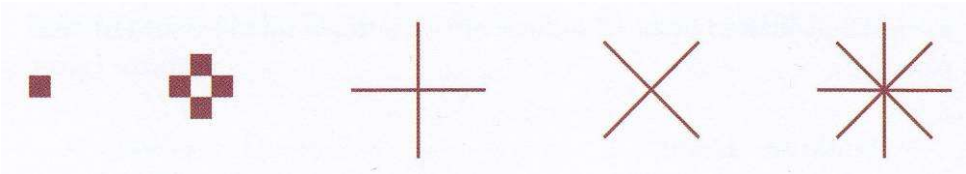
Dievs (God) (*Dieviņš* – diminutive form of *Dievs*), the source and causality of everything, the world's soul, the guard of virtues and legal order, is paramount and is manifested in four world's basic elements – earth, fire, water air, also four cardinal directions – east, west, north, south. Latvian wisdom is based on God's realization and the world's creative cognition. In God all opposites are united – light and darkness, mother and father, the good and bad. In Latvian comprehension God is the representative of everything that is light and good, the one who gives advice and benefits. Good is good and everything that is good comes from God – the travelling companion, adviser and helper. God thinks, knows, allows, gives, does not give, takes,

helps, guards, protects, takes care, nurtures, raises, pities, punishes, separates, creates and develops the world. On the initial level it is a thought, soulful energy – the light that gradually transforms into formations of material nature. God as the highest advice of advice and creative thought cannot been discovered completely, but realization is created about the order of things in the world, eternal changeability through a constant creating and recreating, as this is the universal principle of the world's existence. God – the former, the current and the almighty one – is united in the variety and wholeness of His manifestations [2, *24*], but in the middle there lives a creative manifestation of God's essence, existing everywhere, the common essence of all matters – soul, which is the human being's eternal, timeless part, and it comes from God, whose presence is conceivable in the Universe, surrounding the environment and human being. The world as in the enteral order, where also the human being has own space, is perceived in its wholeness and unity. For Latvians, also the Balts, nature is alive, figurative and sacral. The figurative and intuitively perceptible conform to the rationally perceivable and practical as mutually complementary knowledge about the world and its powers. God is comprehended as Cosmic Intelligence who administers everything with the help of natural laws.

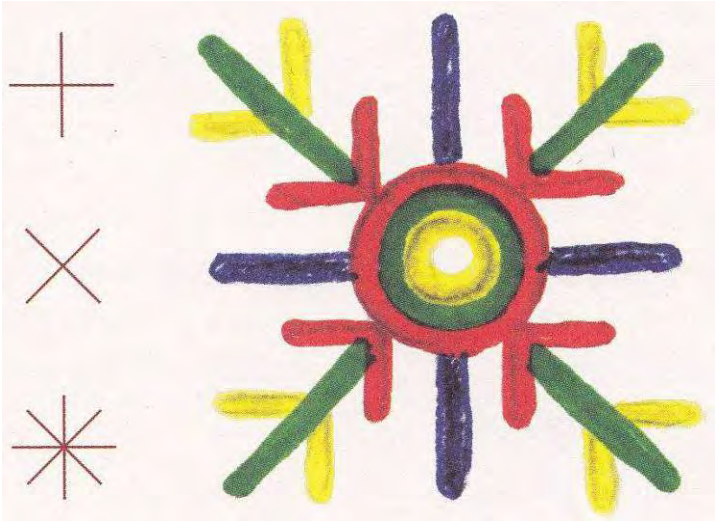
In the sign symbols everything starts with a point, and extending it, a line is formed. The line can be positioned vertically or horizontally, it can also be slanted. The point and lines can be crossed or grouped, supplemented with other points and lines. This is how symbols are created. The level of origin in the pattern is symbolized by points, drops, crosses, straight and slanted crosses, the signs of Sun Wheel or Light and Heaven – stars.

Over hundreds and thousands of years, symbols have an integral part of human existence. Symbols were a form of communication, arranged in ornaments, it was a way to decorate and be decorated. Symbols served to pass on to the next generation the particular family, people's or nation's wisdom and the way of life accumulated over hundreds of years. Latvian ornaments or Latvian cultural symbols are one of such symbolic sign systems. They are characterized by a belief in the powerful energy of symbols and their protective magic. Therefore, it is not by accident, that Latvian cultural symbols are encountered not only adorning ancient relics, clothing. It is considered that they encompass our special connection with nature, the world and the Universe, bringing people back to themselves.

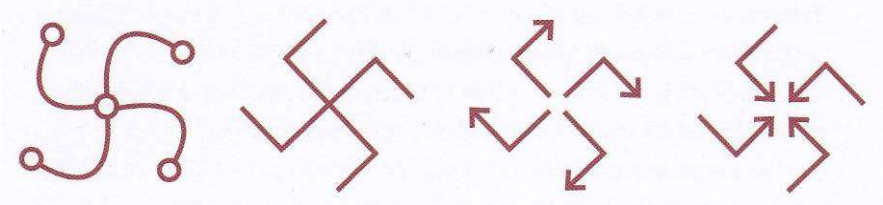
The principal form of God's Sign is the crosses of Heaven's stars – the symbols of the highest and original manifestation levels, which show the world's manifested beginning – the centre, infinity, division of time and space either into eight or four symmetrical parts, the world's rotation (Picture 4). The world's arrangement into this, that and afterlife. The world's cyclic movement created by God – rotation, where life alternates death as logical and natural events. God's Signs are a cross with four equal-length branches, which can stretch out infinitely – similarly to the spiritual world that is infinite beyond all borders of the material world. God's (Golden) Cross has two different states of varied meaning: the straight or rigid cross is the stopped energy, peace, death, darkness, non-creating state, rigidity, but the slanting or moving, also rotating cross [2, *34*], called as transverse cross or gold cross, is released energy, restlessness, life force, light, creating state, cyclic movement. In one sign – Sun Wheel, Star both included crosses symbolize simultaneous existence of this and afterlife, cyclic change of light and darkness, life and death (Picture 5). They all are God's Signs in a broader sense: they also come from God the same way as the world and symbolize God in the wholeness of their manifestations [2, *36*]. The sign of God-Heaven, which has got a significant symbolic meaning, attracts the divine and creative forces, is used as a link between the highest powers, it is the source of light's energy, manifests God's presence on every step and helps us find the best solution.



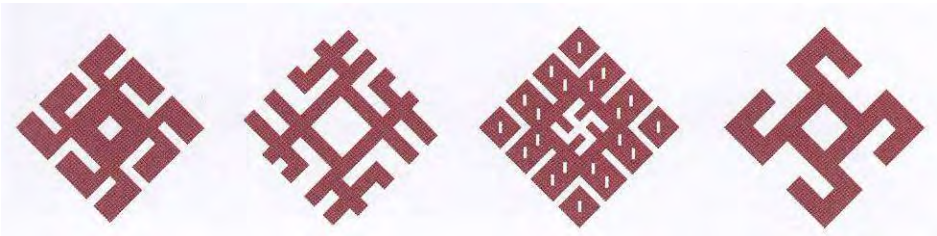
Picture 4. Crosses of stars – signs of the world's beginning and further development: beginning or the centre, a cross with four branches, the straight cross, slanted cross, rotation cross. [2, 34]



Picture 5. Power of cross: the straight cross, slanting cross, rotation cross. [2, 37]

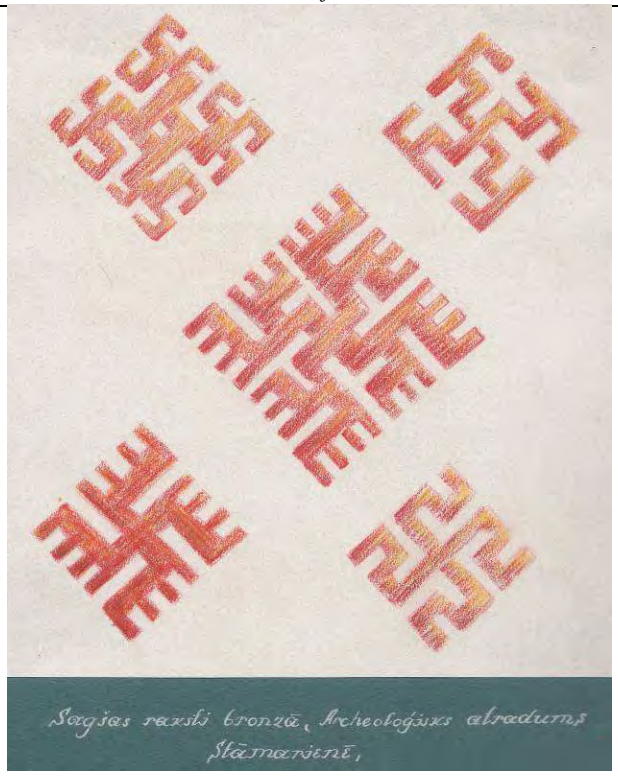


Picture 6. Principal form of Thunder Cross – ends of branches bending due to rotation of God Cross. [2, 44]



Picture 7. Thunder or Sky blacksmith's attributes: axes, Sun and other images. [2, 50]

Picture 8. Thunder develops the world created by God, arranges the main principal elements and forces. [2, 51]



Picture 9. Sign patterns in a wrap. Archaeological find in Stāmeriena. [5]

Thunder is the world's creator and governor, the first manifestation of God's presence in this world as a flash of light in the Universe constantly being created. Thunder is mighty, all inclusive, direct, impatient, relentless, highly honoured and revered. Thunder develops the world created by God, arranges the main basic elements and forces, oversees and restores the world's movement each time when it is under the threat to come to a halt or it has been taken over by darkness, cold, standstill and harmful forces [2, *50*]. Thunder is a fair judge, unifier for collaboration and people's helper. Rotation of the Universe is symbolized by the sign Thunder's Cross, whose principal form is created turning God's Cross and bending the ends of its branches due to the rotation (Picture 6, 7, 8). Rays of light and space curve in the Universe. Our galaxy has got such a form, where at one end of the branch there is the Solar System with the planet Earth. The sign shows the centre, unity of four and eternal rotation, cycle of energy accumulation and discharge – the Universe's breathing in and breathing out – motion which has started in one direction, creates preconditions for motion in the other – opposite direction [2, *44*]. Fire-cross is a strong and popular sign all over the world, created from two crossed bolts of lightning which symbolize light, fire and life, attracts happiness and energy, protects from the evil and undesirable natural phenomena, including fire disasters.

Due to God and Thunder's initial unity the situation of self-initiative and self-organization is created: in the initial push God's desire is expressed and the God and Thunder's dance starts – motion (Picture 9), from which time and the world as a space starts [2, *44*]. Thunder strikes in the cross – in the centre of all events, initiates and causes the creative processes, brings into motion the earth's fertility, initiates emergence of life. Thunder provides continuity of the cosmic time flow, cyclic time flow in the world created by God, arranges energies – the main principal elements of the world's creation, and influences events. And whatever Thunder does, it is done in compliance with God's regulations and advice of advice [2, *48*]. Relations between the human inner and outer world are revealed in relationships between God and Thunder: they are reflected as images of consciousness of the individual "I" and the common

"we." God is related to the consciousness of the human individual "I" and is manifested in the soul link with the true "I" in the human. Thunder is in the link with the communality's "we" consciousness. The individual's personality consciousness is determined by integration into the human mutual relationship net up to expansion – in the nation [2, *50*].

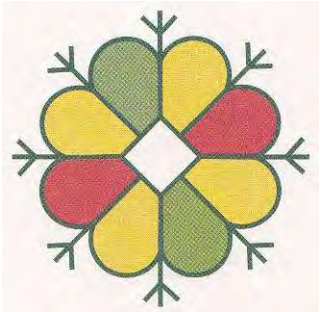
Picture 10. Needle – Laima Sign: a – elements of needle in different groups, b – needle in Laima's whisk. [2, 60]

Picture 11. Thunder Cross includes four directions of the needle. [2, 63]

God is the one who provides happiness, but God's daughter *Laima* also *Laime* (Laima sign) is the Goddess of destiny maker, giving life to people and nature, happiness carrier which is related to birth and success. She decides upon people's destinies according to the laws created by God. *Laima* forges the person's life activities and arranges the events in life. *Laima* as the promulgator of the highest causal relationship laws decides whether the human will have a happy or unhappy life, compatibility with people and order of all matters [2, *58*]. *Laima* spins, weaves and pulls the thread of life, health and welfare. Spinning – the activity due to which the so varied world's powers and events caused by them meet up and are woven or twisted into a united thread of time and destiny (in a belt, rope, wreath, fabric or tangle) – is symbolized by the *Laima* Cross Sign which is created rotating God's Cross and bending the ends of its branches. This is the sign of compatibility, which symbolizes rotation, development of cyclic and rhythmical events and movement around the common centre or the centre of events – God. *Laima* Sign (also Needle), the symbol of the world's tree, harmonizes relationships among people, helps not to give up the circumstances, encourages purposefulness at work in order to obtain a lifelong fulfilment, defends from wrongdoers. Needle is like *Laima's* footprints (Picture 10), and if one steps on them, the person's life becomes easier, happier. *Laima* shows an even and constant course of events, where moments of tension are equal with moments of relaxation – the same way as the day follows the night, work is followed-up by relaxation. Needle is daily life, daily care daily routine, it is a part of any happier life. The fir and pine needle design is considered as the symbol of fertility, health, and long life. This symbol has many variations.

Both *Laima* and Thunder work in a different area. However, they are closely knit together, for they represent a different scale of a common time flow, provide a course of time and determine or affect the destiny. Thunder is the creator of the cosmic time cycle in macrocosm, in the Universe of planets and stars, but *Laima* is the decision maker of the person's life and destiny in microcosm, in the human Universe. This coherence is confirmed by the principal form (Picture 11), which is equal to *Laima* Cross Sign and Thunder Cross. The unity points to *Laima* and Thunder's common initial essence and their descendence from God [2, *62*]. *Laima* is manifested as compatibility and order of all matters, as climbing up a hill, as rhythm, as conformity of events. However, it can

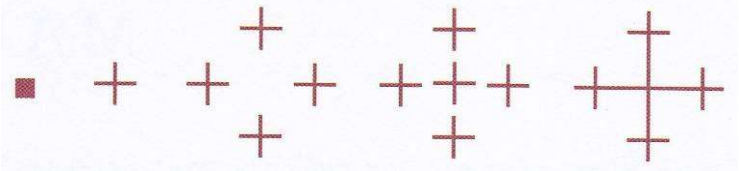
also be manifested as lack of this conformity – in a disturbed course of events, misfortune, destroyed conformity and rhythm, in a tangle of different forces, an unfavourable decision. The colours of *Laima* – pulsation of life and success: green, red, yellow (white) (Picture 12).



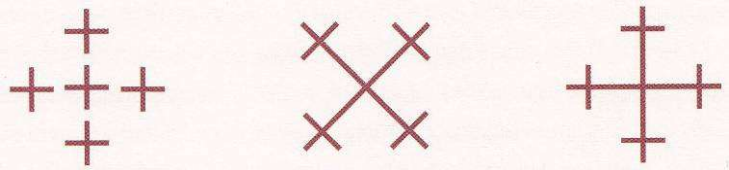
Picture 12. Laima – colours of pulsation and luck in Sun: green, red, yellow (white). [2, 81]

In the world all events are arranged like on the waves or hills in an upward or downward sequence. *Laima* is sitting on a hill, *Nelaimīte* (Misfortune) – downhill. *Laima* and *Nelaime* walk simultaneously along the same life footpaths and they meet up on a foot-bridge [2, *68*]. *Laima* as destiny and the human being's free will and mutually supplementary and connected volumes (Picture 13). The Latvian does not look at destiny as unchangeable. The human being is given an opportunity to affect their destiny with their free will and choice and sometimes even to change it essentially. Every man is the architect of his own fortune and destiny. Everything in the world is the sequence of phenomena whose real source is accumulation of causes and conditions [2, *80*]. The spruce, pine, needle – the evergreen tree, the symbol of eternal life, which in *Laima's* whisk is manifested as a cyclic coherence, since only the one who gets old and dies can get renewed. The upwards going spruce is *Laima*, but downwards – misfortune, which is the opposite of *Laima*. The middle between the top and bottom is the foot-bridge – the active threshold of balance between the twists of life events which go up the hill or also take down, and it is the border where light and darkness, the creating and destroying forces, the forces of time and destiny meet. The human being's task in life is to overcome the border and optional situation: getting over the foot-bridge means you have to overcome it and it brings you joy of living and wealth. Virtue – the amount of bustle and tension of action – requires from the human certain characteristics in order to be able to work hard, overcome inertia, develop and implement the real values. Vices oppose the good of virtue. Virtues are polarized, they oppose the vice.

Picture 13. Painter Ansis Cīrulis (1883–1942). Laima. [9]
Picture 14. Ansis Cīrulis. Sketch of wall painting "Māra". [10]



Picture 15. Dot, little cross, a set of crosses, Māra Cross or Cross-cross. [2, 96]

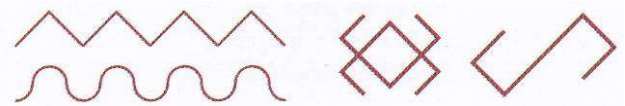


Picture 16. Māra is twofold, and twofold is Māra Cross. [2, 97]

Picture 17. Māra's World blossoms beautifully in its diversity as a flower garden. [2, 98]

Picture 18. Māra Sign: a – in Latvia nature [11], b – on the sign trail. [12]

Picture 19. Māra addresses Veļi Mother, Mother of Earth and Mother of Graves. [2,102]



Picture 20. Zig-zag, Little Toad. Grass Snake. [2, 102]

In Latvian folklore deities – Mothers have an important place. *Māra* (Picture 14) as Goddess of the material world, women's defender, fertility provider, governor of the land and underground knows Mother of Forest, Wind, Sea, Milk, Cattle, *Velis* (Ghosts and Soul), keeping under her control also the Kingdom of Underground. *Māra* takes part in people's life activities, also in weddings when two (the male and female) merge into one, creating a new absolute wholeness. The main characteristics of *Māra* is her love and holiness. *Māra* is especially close to a woman helping her in the most important events in life: when getting married, in labour and children's upbringing, she helps in christening, she is the health protector, also cattle purveyor, household supervisor, young people's match-maker and engagement organizer. *Māra* Sign has got lots of varieties: *Māra* Triangle, *Māra* Land, *Māra* Cross also Cross-cross or Fire-cross (this is not the same as Thunder Cross) award profoundness and security (Picture 15). Latvians see *Māra* in different plants and animals (the beetle and black adder); a linden tree is the symbol of a girl, but an oak tree – the symbol of a boy. *Māra* rules over the live and lifeless, it symbolizes the land. She keeps the secret of fertility, but at the end of life when the human being finishes the course of life, their body again gets into Kingdom of Mother of Land – *Māra*. Land is the Great Mother – holy, clear and fair. A human and plant are born from it and return to it. The symbol of Land Mother is a straight, horizontal line, but the second symbol – a hook or triangle, whose 90 degree angle points downwards, also in Indian Yantras means land, substance and Land Mother. Drawing the sign on a horizontal plane the sides are pointing to the north-west and north-east – they are the directions, where the sun sets during the Summer Solstice in Latvia and rises in *Jānis'* morning. The sign has a deeply symbolic purpose and power which opposes God's Triangle. Merging God and *Māra* Signs a rhombus is created which characterizes balance and conformity. The pattern together with other signs create a

meaningful symbolism. Both of these signs, covering over each other, obtain a hexagonal star, called as *Lietuvēns'* Cross, who has a strong defence against the evil. *Māra* as Mother of Sea and Mother of Water is symbolized by a zig-zag sign, which reflects the river flow and plain of the land. *Māra* Wave is water, for *Māra* is also Goddess in rivers, lakes and seas. In Latvian patterns *Māra* Sign – Grass Snake (Picture 20) can often be met, which manifests wisdom, inquisitiveness, agility, sharp mind, adroitness. Sages use the sign for serious activities as the symbol of the underground. The Latvian poetess Māra Zālīte has said that the numerous Mothers of Latvian folklore are "different manifestations of Mother *Māra*." In Latvian godliness God, *Māra* and *Laima* are invisible, but their presence can be felt. *Māra* Churches are especially emphasized, which are ancient Latvians' holy groves and sacred places in nature. In *Dievturis'* explanation God is the World's Father and *Māra* – the World's Mother. *Māra* Triangle can be forked and enriched. The typical *Māra's* colours are white, black, also maranot (red-brown which can be obtained dyeing the material in bedstraw roots (*Galium*)), as well as ginger, bay, brown, grey. *Māra* Cross symbolizes the material part of the world created by God. The symbol of perfection and fertility. *Māra* is a protector of health, custodian of women and supplier of bread. Protects against evil spirits. *Māra* Cross is the sign of the live matter, which is closely connected with fertility, fire and home, protects from the evil spirits, takes care of people and the family and defends the material wellbeing – home, bread and hearth. In comparison with God's Cross, the ends of *Māra* Cross are crossed over, and their extension into infinity is interrupted with a new dot or little cross, which points to the limitedness and finitude of the material world in contrast to the infinity of the spiritual world [2, *96*]. The material manifestations have beginning and end. The human being's life in the physical world is connected with the birth when the soul embodies into the physical body, and dying – the death. *Māra* by her essence is twofold, and also *Māra* Cross can be looked upon in two positions of different meanings: the slanting cross and the straight cross (Picture 16) [2, *98*]. The Cross-cross is an enhancement of the simple cross, and is considered as a sign symbolizing the mythological *Māra* – the ruler of the material world. Belief claims that the Cross-cross is the symbol of the mistress of the homestead who would make this sign in the ashes of the hearth so that *Māras's* luck would guard the home until the dawn in which case it was known as the Fire-cross. Bread would also have this symbol drawn on the top as a symbolic gift to *Māra* who would give the bread her blessing and protection as it baked. The design of Cross-cross and its many variations are also often found on household items frequently used by women. The Cross-cross – a combination of four crosses, this symbol has been carved on ancient sacrificial stones for bestowal of divine favours. Cross-crosses have been found decorating women's wraps during the Iron and Bronze Ages. *Māra's* World flourishes in its magnificence and diversity as a flower garden (Picture 17). The slanted *Māra* Cross symbolizes the life creating and highday condition of the material world (Picture 18), it points to the borders to be unlocked, birth, diversity of natural forms and their development possibilities in the future (Picture 19), which is best expressed by the set of *Māra* and other signs. Movement blossoms outwards – away from the centre of the sign. The straight *Māra* Cross symbolizes the border between this world and the afterlife world, where everything freezes, closing life borders in the world of four kinds – four cardinal directions, four seasons, four stages in life and the return of matter in its initial stage. The movement for crosses with a life energy smothering character happens backwards to the centre of the sign. The individually short-term essence of growth is emphasized. The material welfare is protected with *Māra* Cross – home, bread, fire (the housekeeper drew Cross-cross on a bread loaf before it was put in the oven and in the evening it was drawn in the ashes of the hearth, so that the fire with *Māra's* blessing would not disappear till the next morning), as *Māra* herself is a bread baker. Crossing over the

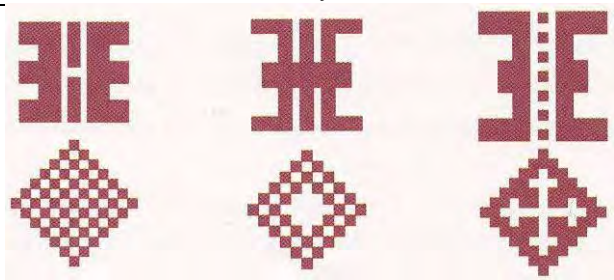
ends of the cross a sign is obtained which expresses both seclusion, abundance and death. A thing, on which *Māra* Cross has been drawn, is symbolically donated to *Māra*, receiving back in return her blessing and surveillance. *Māra* Cross is often included in women's jewellery and clothes. Scientists are sure that *Māra* Cross creates a special energy around it, which defends, heals and brings luck. *Māra* Day in the ancient calendar marks the end of the summer. *Māra* Sign is drawn as an equal triangle, a hook or half-circle with the top turned down. Viewing this sign on the horizontal field, the sides of the sign are pointed northwest and northeast, and this symbolizes where in Latvia in the summer solstice sun rises and sets. The sign is related to symbolic roots and is empowered with the opposite force of God's Sign, so when putting them together the balance of powers is gained. If both of these signs are drawn one over the other, the six sided cross of Bad Spirit is gained. *Māra* Cross can also be with smaller crosses and stripes. *Māra* as a symbol has many different kinds, and she has several ways to exist – like a triangle of *Māra*, water of *Māra*, land of *Māra*, cross of *Māra*. All these signs present the basic principles, security, and relations between Heaven and natural powers.

In the world of four-dimension time space *Laima* represents the time dimension – motion and events in time – destiny, but *Māra* represents space – three spatial dimensions of the world, types, levels and forces of matter arrangement. God, *Laima* and *Māra* know the course of following events (Picture 21). *Laima* and *Māra's* collaboration is manifested in relation to fire. A purposeful human life and happiness cannot be imagined without fire, skills and ability to control the energies hiding in the depths of matter. *Laima* requires reverence, respect and skill to apply fire for creative and good-natured purposes, but if there is something missing, *Laima* will leave you and Misfortune will come. Fire is sacred and divine, similar to life [2, *86*]. Fire as an element is related to the holy-fire dedicated to Thunder, hearth fire of every home and bonfires of Solstice rituals. Fire blazes and whirls, but always precisely in rhythm (Picture 22). Fire has a real and symbolic relation to the original forces of the Universe – God, Thunder, Laima and *Māra* in the centre of the ritual action and space. Ambiguity and relation are manifested by Thunder and *Laima* Cross Signs, which is simply called as Firecross (Swastika) relating it to fire.

Picture 21. Painter Jēkabs Bīne (1895–1955). God, Māra, Laima. 1931. [13]

Picture 22. Fire flames and whirls, but always precisely in rhythm. [2, 88]

God's sons – the morning star *Auseklis* and evening star *Rieteklis*, which alternately die and then are reborn again. *Auseklītis* (also Star) – the morning star with eight rays symbolizes the light's victory over darkness. This sign helps overcome hardships in relationships, finances and career, protects from the evil. Therefore years ago it was drawn on doors and at the end of driveways to defend from the evil. Moon Cross is the people's defender and helper at night. The sign attracts celestial fertility forces.

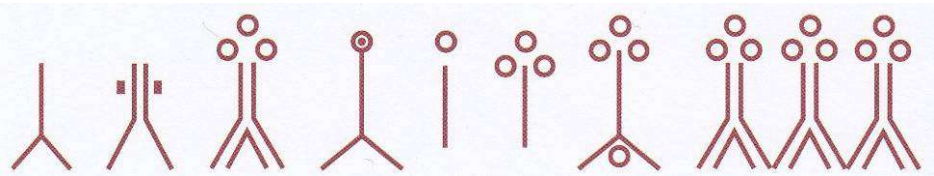


Picture 23. Ūsiņš Signs. [2, 123]

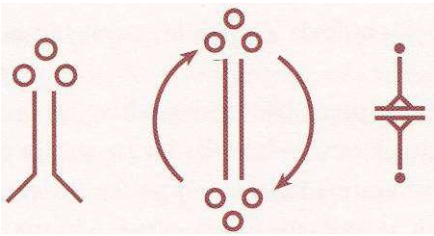
Ūsiņš – deity of the heavenly light, the usher of the renascent spring Sun that brings light, warmth, green grass, leaves for the trees, opens the door for spring and other goodies. *Ūsiņš* Sign consists of a combination between Moon and Sun Signs (Picture 23): Moon as if takes Sun from the bottom and darkness up to the top, at the same time reflecting the light provided by Sun in the surrounding space. The sign symbolizes the renascent spring Sun in nature, the ability to raise again from a dead condition to a live renewal condition and the ancestors' spiritual energies, advice, effect of knowledge on the human and live world, renascent light of knowledge in the human being [2, *124*].

Jānis (Picture 24) – the symbol of the heaven and land, unity of masculine power and feminine principle, collaboration and fusion. *Jānis* Sign shows the border between two periods of time and the movement directions of the sun and light, includes the gate on the heavenly hill with three suns at the tops (Picture 25). *Jānis* Gate during the upward journey of the sun and light and downward journey of the Sun and light is like a neutral gap where the sun's movement stops (Picture 26): it is neither going up nor down, but the border is like the abyss of darkness – emptiness, in which the light can disappear and perish if nobody helps to find it. During this time people with ritual bonfires help the light movement not to break, but with songs they overcome the abyss of darkness. God's son *Jānis* returns the whole fertility power to the Earth in order to become *Jumis*, so that fruit of the earth would yield and the cycle close.

Picture 24. Ansis Cīrulis. Jānis. 1931. [14]



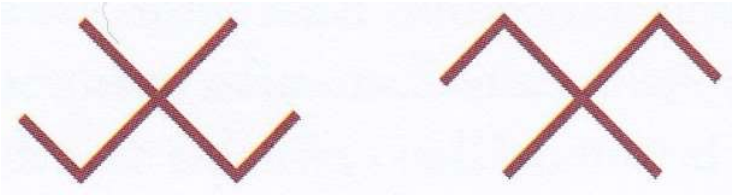
Picture 25. Different Jānis Signs. [2, 128]



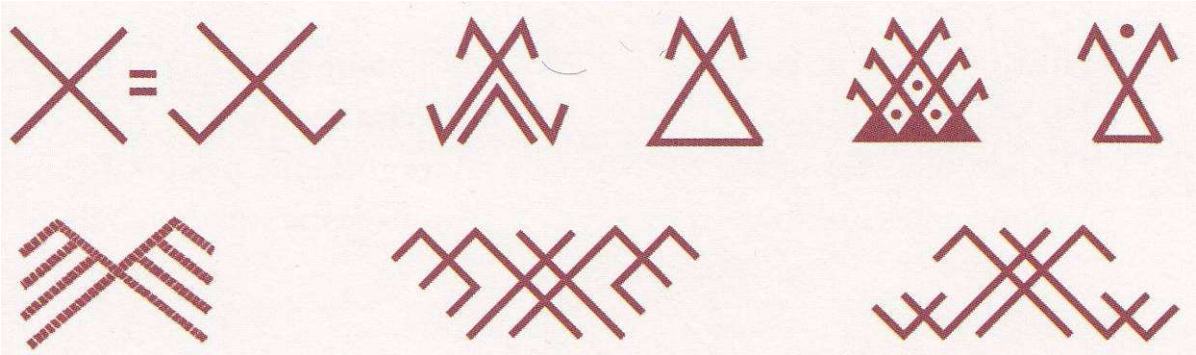
Picture 26. Jānis Sign. Sun's journey from downhill and darkness to light. [2, 129]

God's presence is in the course of the light and fertility (life) cycle. The ancient deity of fertility *Jumis* includes the unity of the masculine and feminine principle – fertility

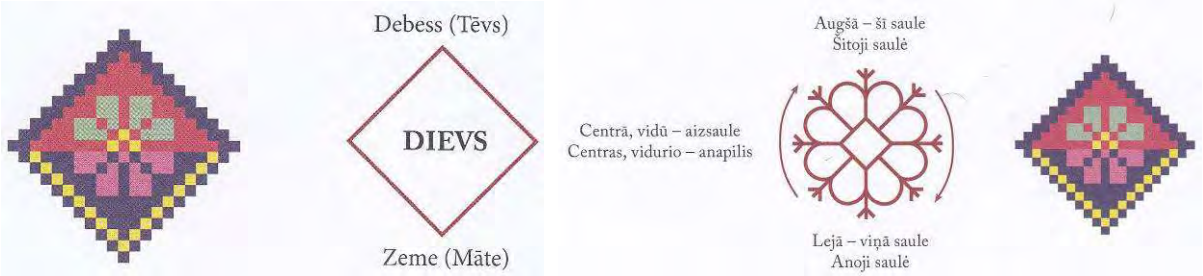
in nature and in relation to people, and is connected with two directions: during the first half of the year – motion upwards towards light, but during the second half of the year, when grain ears bend due to the heavy weight – motion downwards towards the earth. The principal form of *Jumis* Sign, developed from the slanting God's Cross Sign points to a special condition and direct relation to the world's higher and life renascent powers (Picture 27). *Jumis'* presence provides prosperity and happiness: happiness without prosperity is not only under a threat, but it is also impossible. *Jumis* is the symbol of development (Picture 28), fertility and blessing bearer. It protects and blesses twice. *Jumis* on the roof ridge brings fertility and prosperity. If *Jumis* is drawn on tools, the work will be done much easier and twice better. It is also recommended to keep the sign in the wallet.



Picture 27. Jumis Sign in Latvian patterns. [2, 130]

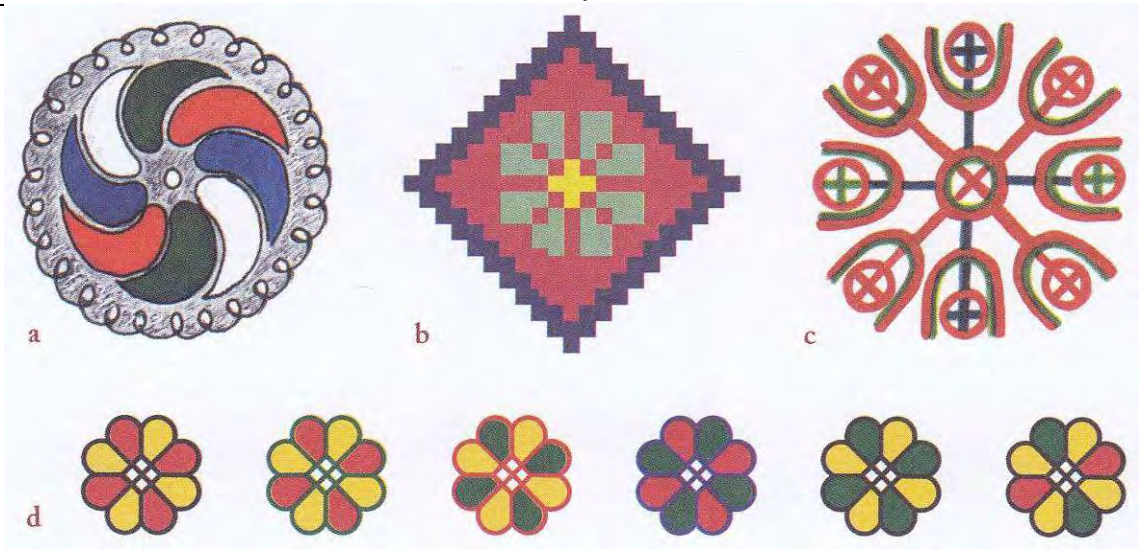


Picture 28. Beginning of Jumis Sign from a cross and beautiful expansion with complicatedly woven branches. [2, 131]



Picture 29. God (in the middle) is revealed and Heaven (Father) and Earth (Mother): they symbolize the couple principle of masculine and feminine powers, collaboration, fusion and unity of the powers in order fertility would continue, harvest ripen, children be born. [2, 120]

Picture 30. Sun of two sorts move: uphill – this sun, in the centre – afterworld, downhill-ultramundane. [2, 152]

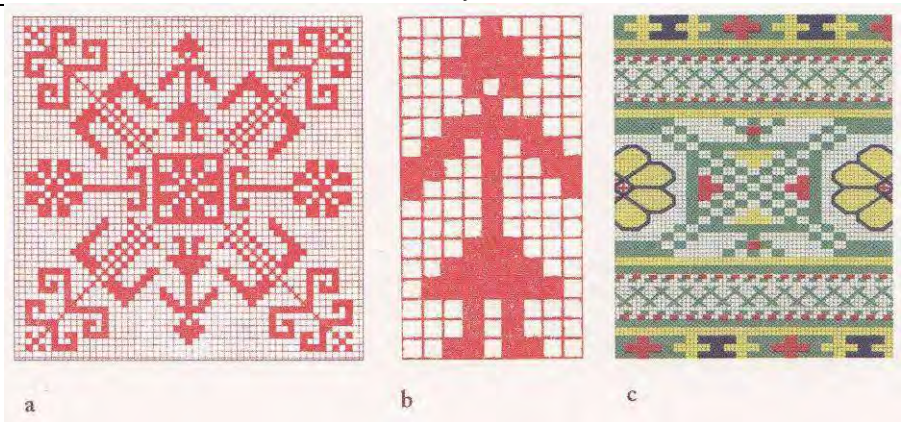


Picture 31. Little suns: a – in a disk fibulae, b – in a mitten pattern, c – in a wrap, d – in fabric patterns. [2, 134]

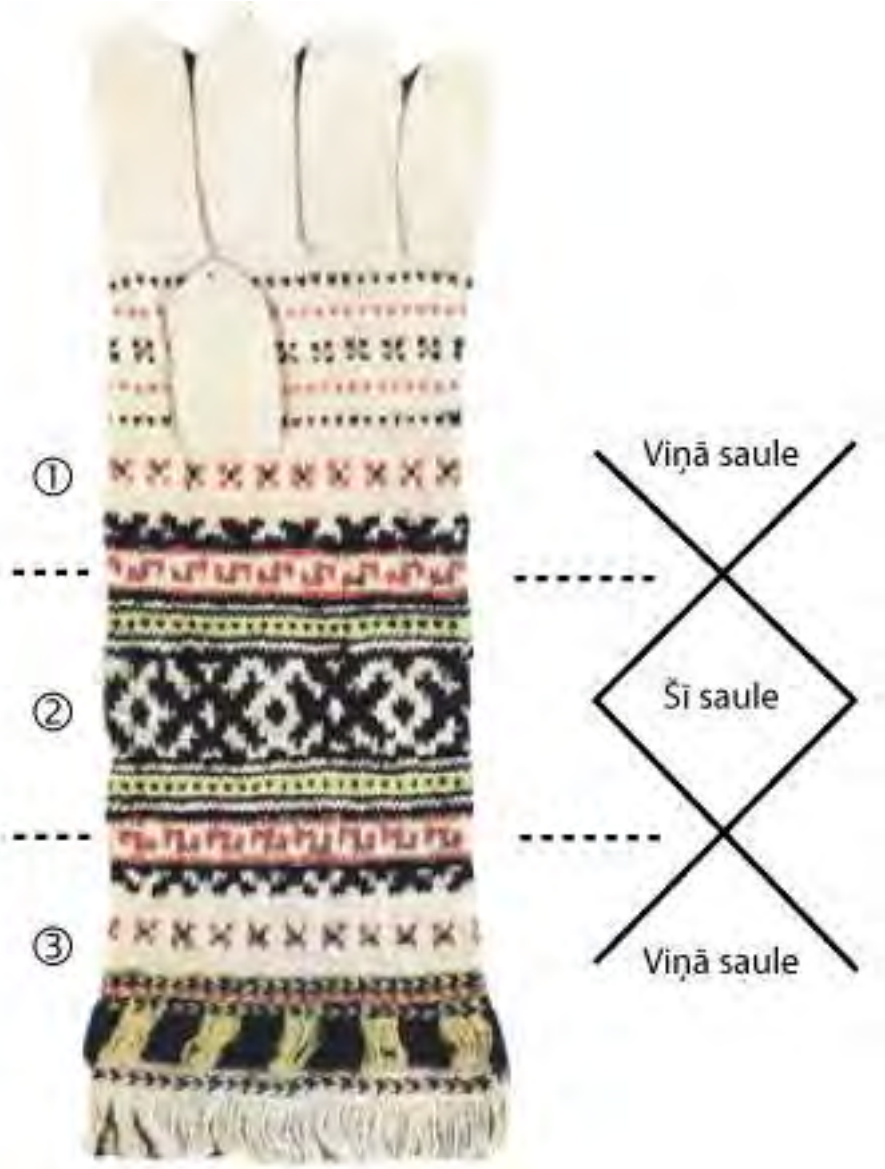
God's sons are four seasons that come starting form Christmas, and each of them arrives in certain time. Sun as a daughter dresses up in the mornings and evenings, adorns herself and waits for suitors – God's son *Jānis*, *Auseklis*, Moon, Thunder or even *Dieviņš* – *Ūsiņš*. Sun is betrothed and given away, taken across the sea. The wedding of Sun and Moon – a part of the heavenly eternity myth – re-echoes again and again in the annual customs on the earth. Sun, once rising up on the heavenly hill, then again setting down, determines the essence of events and traditions happening during a year and the character of the human experiences. The cult of light and fertility, psychological experiences and spiritual development and improvement tasks for every human being's soul in the annually cyclic and life-long course come from the heavenly myth. Sun is the symbol of eternal motion and life. It strengthens confidence and helps to find the right way in life. It protects the kin. Sun Sign was drawn on furniture, blankets, carpets, children's cradles, dowry chests, jewellery, women's garments of honour and mittens and socks meant for men.The circle is a universal symbol representing eternity. It is associated with infinity that has no beginning and end. The circle is the symbol of Sun. The Sun and Moon cults were widely spread in ancient agrarian societies. Latvian folk songs, as well as folk tales and stories place Sun in a position of honour. It is in constant motion and the symbol of life. Sun Symbols can be found in Latvian territory as early as the mid-Stone Age. The circle is combined with other elements. In Latvian design, Sun Symbol can be found on many things ranging from house design elements to handkerchiefs.

The world is formed of three vertically placed spheres – the underground, earth and heaven, but the structure was understood and modelled according to the similarity to a tree in nature, creating the symbol of World Tree. In the centre of the mythical world – in the middle between the heaven and earth, between light and darkness, between the past and future – there is a Man whose image is characterized by a vertical three-part division and a horizontal four-part division, marking seven coordinates: the centre, top, bottom, north, east, south, west. The flow of light never ends, and the World is infinite, but in the narrow daily life we call the world as Mother Earth with her Heaven, people and beings. The infinite and also closed World is God himself (Picture 29) and his *Laidums* (Creation), in the shapes of *Laima* and *Māra*. The principal symbol of the world's comprehension in the complex arrangements of World Trees and varieties of symbolic meaning is characterized by trees growing in several directions even up to their arrangement in a circle. The image of World Tree is related to the sun's way –

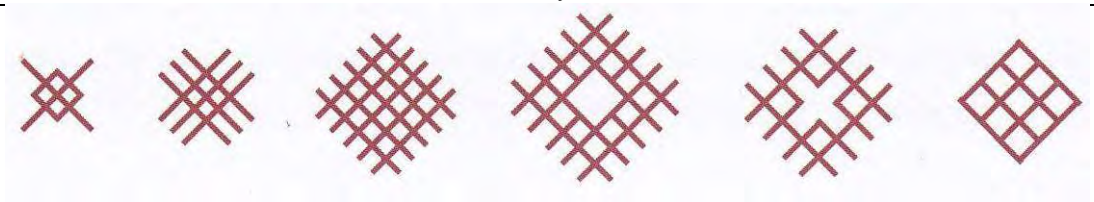
personification of the sun's rise and set (Picture 30), and is also called as *Austra* Tree of dawn (also Sun Tree, World Bush, World Tree, Little Oak Tree, Great Bush, Little Spruce), which gives people power and advice, protects the kin and family, promotes development, encourages to enhance and preserve moral values. *Austra's* Tree, in which the awareness of our past, present, future, our ancestors, children and ourselves are combined, is enriched with elements of *Auseklītis, Māra* Sign: heavenly bodies settle down on the branches in dawn – the Sun (Picture 31), Moon, stars, birds. This is the symbol of human knowledge which shows an upwards aspiration of the world's order. The sign that unites our ancestors, us and our children, past, present and the future. In the simplest version the sign reminds of a new tree that has just started branching, but in more magnificent derivations the sign is as rich as its explanation. Sun or *Austra* Tree is an element of a peculiar pattern that has similar motives also in ornaments of other nations. In other cultures it is also called as World Tree and it divides clearly the world into three spheres (Picture 33): in the symbol of *Austra* Tree the human being's impression about the world is expressed: the roots were related to the underground world, but the trunk is the middle world or the place where we reside together with animals and plants. The foliage of the tree symbolizes the higher – spiritual Heavenly World to which everybody aspires. The leaves of *Austra* Tree were of silver, the roots of copper, but branches of gold. Usually the tree was an oak. *Austra* Tree symbolizes the sun's course and the world order. *Austra* Tree is mentioned into Latvian *Dainas*, it is also encountered in Latvian national ornaments. *Austra* Tree is the symbol of daily rhythm, it reflects the human preconceptions about the world, symbolizes its link with the spirituality. The side branches of Sun Tree are placed symmetrically to the middle part and they "grow" on the slant upwards or both upwards and downwards. The sign of this pattern integrates into the triangular platform whose top points downwards, but sometimes the platform of Sun Tree is a square or rectangle. Candles are used to adorn Sun Tree, also Needle and Moon Sign. Sun Tree is very diverse. Sometimes the treetop is emphasized, in other versions – the middle part in whose extension the sun or another element of the pattern is placed. In decorations Sun Trees are most often placed along the sides of the pattern. They are especially often used in embroideries of woollen shawls (woollen shawls of Krustpils, Latgale, *Augšzeme*, Eastern-Vidzeme). The wives of Latgale and *Augšzeme* also decorated with them their kerchiefs and aprons. In its turn wives of Courland embroidered the shirt sleeves with beautiful motives of Sun Tree (the shirt from Rucava). The sign of Sun Tree is often reflected together with Sun Sign. *Austra*, Sun Tree is the compilation model of human knowledge and preconceptions (Picture 32). The central part of the earth is particularly magnificent, that is – part of our life. This is the preserver of the beautiful and valuable. *Austra* Tree protects the kin, family, unites us with God, and gives us power and advice. Sun Tree – a combination of the basic design elements creates diversified symbol extensions. Such is Sun Tree, which represents reaching upwards and growth. Sun Tree – a combination of the basic design elements creates diversified symbol extensions.



Picture 32. Human, Sun and Tree Sign in a united world's model the connection and dependence between Nature and a Man. Sun in the World's centre. [2, 167]



Picture 33. Pattern signs of the Universe's space-time division in the groom's glove from Krustpils: a – the afterlife, b – this world, c – the afterlife. [2, 150]



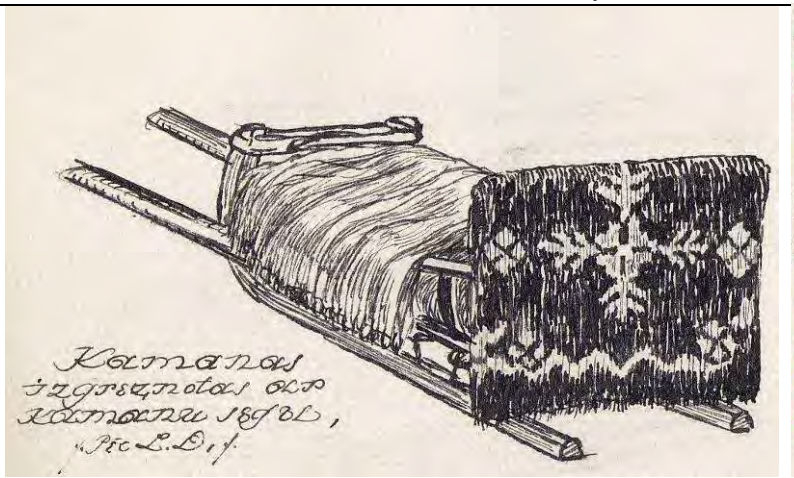
Picture 34. Symbolism of the world's fabric. [2, 144]

The symbolism of the world's fabric (Picture 34) provides a supplement to the world's figurative comprehension, which emerges from the awareness that the visible material world has been woven on a grid created by invisible forces, which symbolizes the self-organization of the Universe and is related to diverse events in nature, human society and the world's mythical vision. The intuitively figurative knowledge is reflected in the geometrical pattern.

2. Mutual correlation and arrangement of geometric signs in Latvian patterns

Signs are the most laconic, ancient form of information and vibration expression, but their arrangement is related to the world's models and structural development logic of the signs found in the pattern (Picture 35). The principle of the twins was important – Father and Mother, spirit and matter, as well as the signs of the world's wholeness and cyclic renewal for the horizontal division of the circle – Heaven and Earth, and in the nature existing relations of the cosmic forces marked along the vertical. The unity of a Man and Cosmos is confirmed by the comprehension typical to the Indo-Europeans and Balts about the Man's place in the events of the world's space-time created by God. The Man and Tree are revealed in the understanding as the symbol of the world's (Universe) construction, single motion and life – the world's axis, mediator between the Earth and Heaven. Common understanding of the Indo-European and Balts' sacral space on the four-part horizontal structure of the Universe (cardinal directions) and three-part vertical structure (Heaven – Earth – the underworld) is essential. Every nation, which has gone through its development from so distant past, includes the internal terms of preservation and development and spiritual principles in its cultural heritage, historical experience and mythological awareness. The Latvian pattern as a structure embodies also the future development possibilities and it is the feeling code of Latvian life, also the task – the programme for our art, environment and spirit. The pattern has an overall organizing impact: arrange, organize – this is the principal function (Picture 36). The Latvian pattern is the feeling code of our ancestors' life, a united system that covers all its levels of manifestation.

The origin of all signs is the most diverse God's Crosses: they start as dots in the centre and aspire for closing in the grid of the World's fabric. The system of signs has to be looked at as a set of cyclic motions, where one sign changes into another moving into time and space. The same sign can appear in several places, but with a different symbolical meaning. It complies with the universal essence of the signs' geometrical construction structure and symbol's polysemy: a sign is revealed through another sign, but the image through another image. The strict construction of the system's internal links allows some complimentary variations and manifestations.



Picture 35. A sledge with a splendid blanket in whose pattern Sun, Needle and Zig-zag are included. [5]
Picture 36. A sledge blanket with a geometrical pattern. [5]

God is revealed in the Universe, nature and the Man. In the centre of the system there are signs which symbolize God's significance in creation and existence. The world in its most profound essence is diverse and united, cognizable rationally, but changeable. The geometrical signs of ancient deities are revealed in their profoundness and purity, and they obtain a logical justification of mutual relations. The symbols in the system are mutually interpretable and they are interwoven by oneness, cyclic renewal, preserving the ambient character of the world's oneness [1, *151*].

The structural construction of the pattern starts with the smallest element – the dot, which is the first flash of consciousness in the darkness, symbolizes an individual object, thought, idea, impulse and is the beginning and end of something. A little cross with a dot or little eye is a star – the smallest dot of light in the sky, also the light or soul given to a human being at birth. The little cross marks the centre – the centre of all activities where the world starts from [1, *152*].

All divine is manifested as life, an opportunity to be, flourish and develop [1, *153*]. The straight God's Cross – the sign of the world's order which points to immobility, passivity and symbolizes the orientation of four kinds, centre, infinity, unity of the material and ideal, as well as the timeless space – the world , also the afterlife, and the slanting God's Cross – the sign of the world's order in the position that points to motion, activity and symbolizes the activity, rotation, dynamics created by God, at the same time preserving the world's orientation of four kinds, the symbolism of the material and ideal unity, included into one sign, makes Sun Wheel or Cross of Rays which symbolizes the centre, infinity, world's rotation, division of time and space into eight symmetrical parts, also combines the life and death aspects set by God's order. In the world's motion created by God life and death correlate as etiological and natural events of a big Course. Every individual life finishes eventually in order to provide a place for another one, a new one: such is the natural law, and a Latvian accepts it in a deep understanding. Sun Wheel symbolizes simultaneous existence of the afterlife and eternal motion in this world and afterlife. Star Sign on the border between this world and afterlife preserves an open outline. The rays of the star coming out from the centre can continue infinitely [1, *154*]. The afterlife is situated in another dimension – beyond the borders of the visible world. However, at the same time it has as close link with this world and existence in the afterlife as the centre with a circle in all its circling motion stages [1, 159]. The principal form of Sun Wheel and Sun Sign is a closed circle or a closed circle with a centre (Picture 37), which symbolizes togetherness, unity, safety, light and marks the demarcation idea of the internal and external world, the fight

between light and darkness or the good and evil. The circle with a dot in the centre symbolizes the sun and the world, the beginning of the world from a bud, from a nucleus. This is also the unity of the male and female, to which just *Jānis'* symbols point at – the big ritual sign formed by people standing in a circle and swaying around the fire raised on a vertical post. In Latvian mythology the circle is the symbol of Sun (also Moon), harmony, completeness and defence related to eternal, tireless motion, recurrence, return, cycle, wholeness, space with no dimensions. The sun does its course along the circuit together with the satellite moon. In Sun Sign concentric circles around the centres of nucleus manifest the idea of radiation, pulsation and mark a new direction of motion – from the centre to sides and back to the centre. Sun is round and it has got spokes so that it can roll. The Sun sits in the wheel or on the branches of the Light Tree whose upper branches help staying up on the heavenly hill, but the branches going downwards are not able to hold it – the Sun slides down the arms of the tree and sinks in order to continue its circuit in the afterlife. A grand and impressive circuit sign of Sun or World Tree is created [1, *156*].

Sun is the main stop point in the division of the world's Universe space-time between this world and afterlife. The sun rises and during the day while moving in the sky it is in the slanting cross position, but in the evening it dies and is situated in the straight cross position. In the symbols it has been clearly acknowledged. Duality is symbolized by the Sun Wheel included in the Sun Sign, which divides the circle into days and nights, good times and hard times, as well as prediction about the life after death in the plans of another existence and temporariness of this life, emphasising its cycle. Sun Wheel with Suns at the ends of spokes creates Sun Cross that has two conditions. In the pattern the direction of the Sun's course or the eternal living condition manifests life and is often emphasized by rhythm, colour or form. The signs show the sun's course strictly geometrical and symmetrical: the sun in its circuit both appears and disappears, dividing the time circle into days and nights, good times and hard times. Sun Sign is reflected as a circle, square, rhombus, a wheel, since the sun always rolls over the sky. In its simplest form it is a circle, but it has got lots of extensions, the most common is the eight-pointed sun, where the rays of the sun symbolize the world's tree oak and eight times. Sun Sign with twelve rays directed to four sides symbolize the year divided into twelve months. Latvians have used the solar year as a measurement. The circle in Latvian mythology is the symbol of wholeness, completeness, defence. Observing the sun's course in the sky, the annual celebrations have emerged when the honourable guests are God, *Māra, Laima*, Thunder. Walking the sun's direction, i.e. clockwise, the rituals are performed. The circle marks the demarcation idea of internal and external world, fight between light and darkness, the good and evil, defence of the good. In the group of Sun Signs lines of different directions like fibres weave through and create the fabric [1, *155*]. In the grid of the world's fabric the system of signs is described by the central symbolism, wholeness, development from the simplest to the most complicated, cycle, structural oneness.

Picture 37. Džems Bodnieks (1910–1987). Kokle 1951. [15]
Picture 38. Hope chest in Vecpiebalga. [5]

For Latvians Sun and white colour is the symbol of the highest values. Human beings with their power of nature and virtues at work become white themselves and similar to Sun. The Sun is as beautiful as a flower (Picture 38, 39), and the expansions of the pattern are shown as flowers, whose form is a peculiar symbol of the events in the world's Universe and harmony. In Sun Sign (sun's circuit) the abstract's understanding (time relativity) of the Sun's life and Human's life mutual relativity is included, as well as the prediction about life after death in conditions of another existence and temporariness of life in comparison to the soul's course in the world. Sun Sign and Sun Wheel manifest the link between the Heaven and Earth, God and *Māra*, spirit and matter. Past and Future meet up in continuous Present [1, *157–158*].

Picture 39. Suiti hope chest with painted sign patterns. [16]

Signs do not have any nationalities. In the world the patterns of the Lielvārde belt have one of the richest and most complicated system of geometrical ornaments (Picture 40). The changeable geometrical pattern with ancient information encoded of

the red white belt up to 270 cm long and from 5 to10 cm wide woven from linen threads and woollen yarn of the Latvian national costume around the Daugava's waterway has been created by 22 elements into different combinations (Picture 41). In the middle of the belt or on its sides a blue, green or violet thread has been woven in.

Picture 40. Artist A. Vārpiņš. The Lielvārde belt in Latvian national costume. [17]

Picture 41. The member of National Applied Art Studio "Kalme" from Alūksne Rūta Strada. Signs of Latvian pattern in the Lielvārde belt. [18]

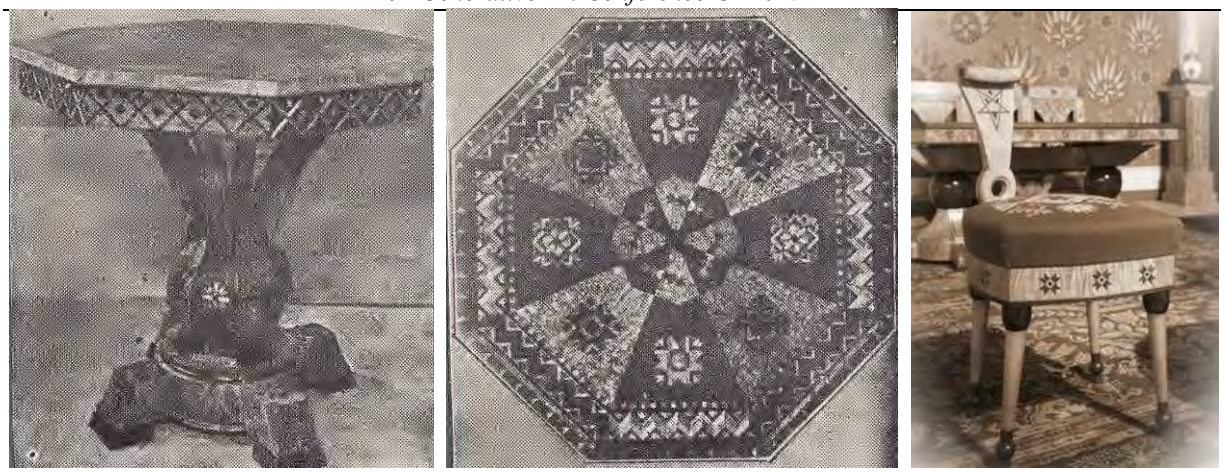
Each geometrical sign of the Latvian pattern is a peculiar structural wholeness with a certain informative inherent value. A sign of the pattern with its structure and vibrations, which it creates during the rational and intuitively imaginative perception, provides an informative preconception about the representable object and phenomenon. The information contained in the pattern and its structure of signs, describes and supplements the levels of the spiritual, astral and physical plan. The knowledge of exact, philosophical, ethically aesthetic and practical character and permeated with intellectual cognitions on the world's spiritual reality and our tradition of wisdom promote the skill to perceive, understand and interpret this information. The layers of the identified and also unidentified information in the pattern during a period of time can be revealed in unprecedented situations and interconnection since the pattern as a cosmic grace keeps existing even if the projection in a culture has been lost and it is waiting in an encoded information condition for the one who will understand it. Such an opportunity can also be related to the especially complex structures of the pattern

and signs in the Lielvārde belts, where the structures of the symbols reveal their significance gradually on the comprehension level available for our knowledge.

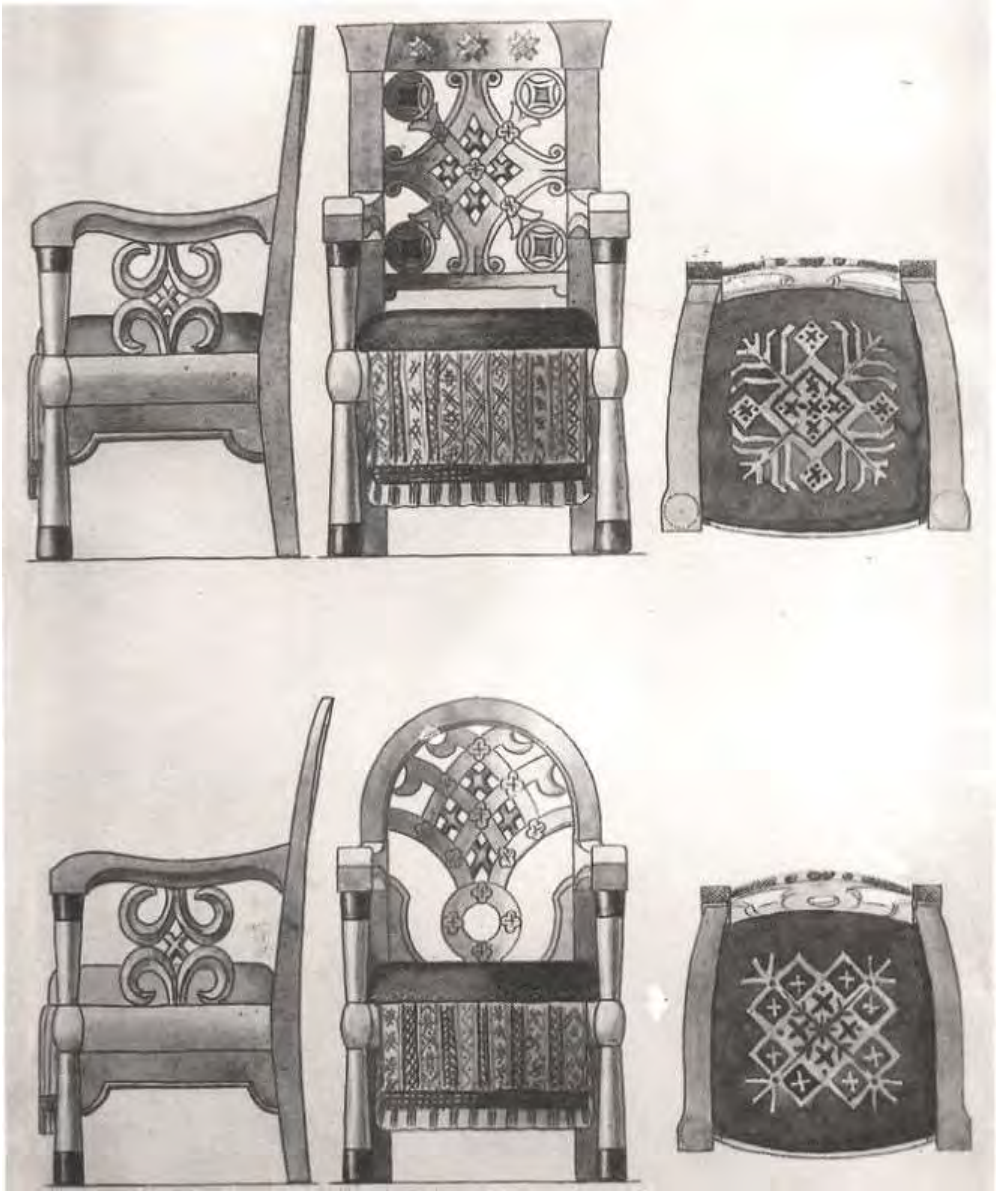
In Latvian contemporary culture, the Lielvārde belt leads its own independent, symbolic existence in people's consciousness and its motifs are often used in contemporary culture (Picture 42).

Picture 42. A mug decorated with the pattern of the Lielvārde belt. [19]

The outstanding furniture designer Cīrulis, who was able to understand wood well and was well informed about the art and design processes in the world, included the Latvian feeling into the form of objects, but the construction of furniture was supplemented with an ornament in the intarsia technique (Picture 43, 44).



Picture 43. Ansis Cīrulis. A little table and surface made in the intarsia technique. [5]
Picture 44. Ansis Cīrulis. Art Deco style chair with Latvian patterns. [20]



Picture 45. Ansis Cīrulis. Drawings of chairs-projects. [21]

Picture 46. Ansis Cīrulis. State president's chair in the representation hall. [22]
Picture 47. Ansis Cīrulis. A little table. [7]

Picture 48. Ansis Cīrulis' furniture in memorial exhibition "The sun courtyards". 2008. [23]

The first President of Latvia Republic (1922–1927) Jānis Čakste wanted to transform the big guest room of Rīga Castle into the Ambassadors' Accreditation Hall and in the adjacent small guest-room make a study, also create a contemporary interior and arrangement in the rooms that would manifest the national self-esteem and introduce the foreign ambassadors with Latvian culture. Therefore in 1923 the procurement for the interior of the hall was announced. The work was assessed by artists Vilhelms Purvītis, Teodors Zaļkalns, Rihards Zariņš, Ernests Brastiņš, architects Pauls Kundziņš, Eižens Laube and ethnographer Matīss Siliņš. The Jury gave the highest assessment to the versatile artist, master of composition, form, colour and rhythm Ansis Cīrulis' (1883–1942) project "Rebirth" (Latvian: "Atdzimšana"), which was

implemented from 1926 till 1929. In the magnificent interior of the hall created by the artist, the ceiling frescos with Latvian deities Laima, Jānis, Mother Earth and White Father and wall paintings, furniture, carpets, curtains, lamps can be seen. The set of furniture in the Ambassadors' Accreditation Hall in Riga Castle created a solemn mood and became the Latvianness canon of 1920s affecting the Latvian applied art, woodworking, furniture design in the 20th century. Cīrulis was inspired by Jūlijs Madernieks (1870–1955) whose subtle geometrical ornaments in furniture fabric (Picture 45) were called as "*madarojums*" (block printing).

Picture 49. Ansis Cīrulis, Elga Kivicka. A chair of Rīga Castle Ambassadors' Hall: a – overview [24], b – furniture fabric [25]. 1923, implemented 1926–1929.

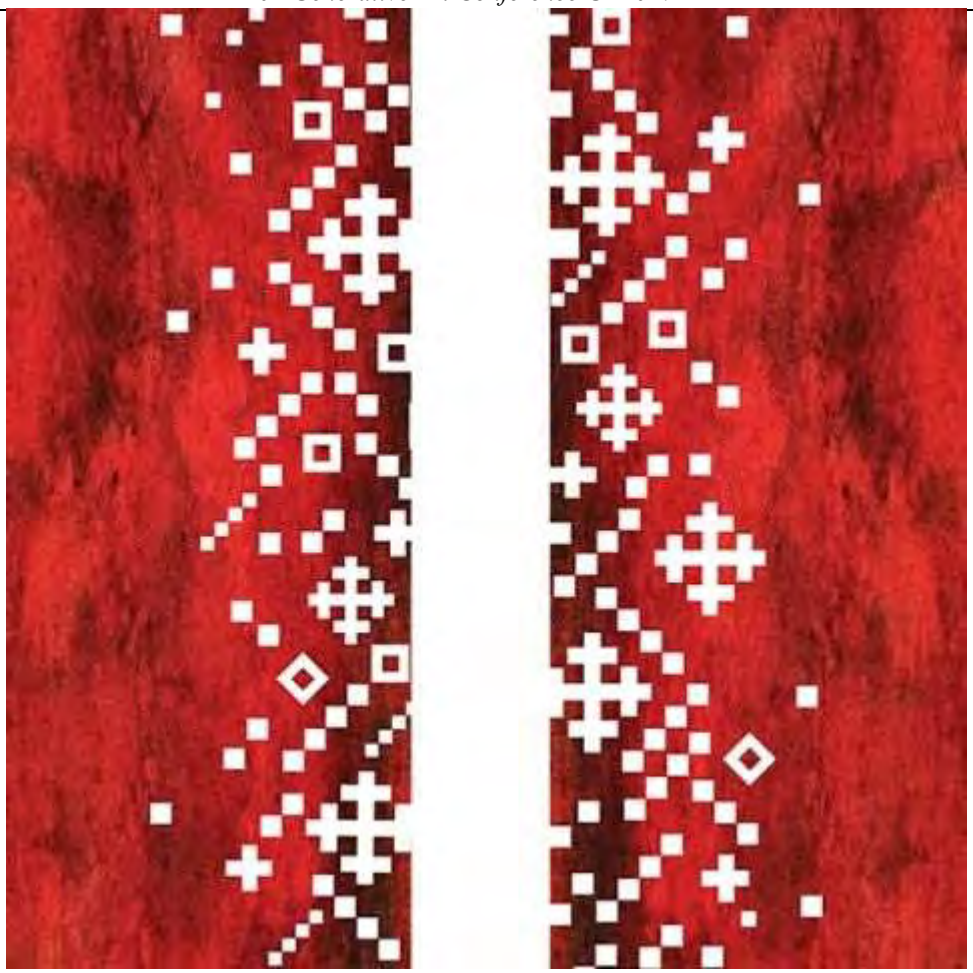
The embodiment of Latvianness in the subject world (Picture 46, 47, 48, 49) obtained a wide recognition also abroad. Cīrulis's work made in the peculiar "*madarojums*" technique won the "Grand Prix" in the worldwide art exhibition in Brussels in 1935, but the splendid furniture set designed by him from the Karelian birch obtained the gold medal in the 1st International Crafts exhibition in Berlin in 1938. The main value of the heritage left by Ansis Cīrulis is the professional design.

The contemporary Latvian artist Brigita Ektermane has got emotionally light paintings – strength patterns of every month or new combinations of the existing signs: they are alive, developing and changing. Similarly to the Lielvārdes belt – there is not one single real belt, as every weaver has put into it something from herself, something has been changed, and also in the combinations of the signs this process can be observed with respect, as they all come from God (Picture 50, 51). Using the signs in our daily life which are written into our Latvian genes, we can regain belief in ourselves and obtain strength: Latvianness is the way of our existence in the world. Signs are a healing element – energy and information carriers, but sign paintings – our icons at which to light a candle, stay alone with yourself. It is important not to deplete the spiritual things like old clothes. Wisdom comes slowly, but stays with the human for ever. Right now time is fast when everybody is in a hurry and comfort is really important, the bright side of life, but this is illusory and misleading.

Picture 50. Brigita Ektermane. Motion starts from the centre. [26]

Picture 51. Brigita Ektermane. Māra's zig-zag. [27]

There is an opinion that Māra in Latvian *Dainas* is the same as Maria, Jesus Christ's mother, also called and God's Mother. During the Livonian Crusades in the documents signed by the Roman Pope *Māra* Land (Latin: *Terra Mariana*) appeared (Picture 52) or the name of *Māra* Land (*terra matris*) [1,151].



Picture 52. Brigita Ektermane. Māra Land. [28]

Sun – the symbol of life and enteral motion without which life is not possible. The light of the sun symbolizes inspiration and spiritual vision, protects the kin, brings God's blessing, it is the promulgator of development harmony in the Universe and the highest aesthetic values. Sun Sign (Picture 53, 54) symbolizes togetherness, unity, safety, light, eternity and infinite space without any dimensions. In the centre of the Sun Sign there is the human soul, the highest I. The centre also symbolizes the subtle or thought energy, God's advice. Sun is associated with a good annual harvest, is the farmer's helper. The image is ascribed to the mother's functions. Sun teaches justice and compassion, gives the human an impulse to activate in themselves the inner power and light – it shines for everyone equally. Sun Sign is applied in order to transform, change the bad that has been accumulated in life. The fibula (brooch) is a direct symbol of Sun Sign. Sun Sign, painted in the interior, chiselled in jewellery, woven into clothes, can be applied for self-esteem increase, self-protection, good luck, good mood, encouragement, optimism.

Picture 53. Brigita Ektermane. Latvian Sun Sign. [96]

Picture 54. Brigita Ektermane. Original painting. [30]

In Latvian mythology the Heaven is considered and the most ancient deity of the light cult, it is like the world's roof. The top of the triangle or hook is pointed upwards, so

that the pointed end aspires the heaven. This is the base of all signs, crosses and patterns (Picture 55). The Heaven is the realm where the ruling power God stays. Therefore his graphical reflection complies with the symbolical depiction, the three circles above the pointed end mean the sun's path – sunrise, zenith and sunset. God stands over time, space and lifetime (Picture 56), the human can feel best it in the soul experience. In daily life God's presence is manifested in four areas – praying, praising, forgiving and thinking positive thoughts. God Sign symbolizes light, aspiring to completeness, development, masculine energy, God's advice, protection, surveillance and blessing. God – the creator has set the rules according to which live. In compliance with the sign our ancestors made roofs for their houses, thus living under God Sign, as well as when being away from home, remembered, thought about home. Also God Sign is the symbol of trinity, family – mother, father and child. It also symbolizes the past, present and future. Actually they all are God Signs as they the same way as the world come from God. Latvian *Dieviņš* (little God) is present everywhere, a smart and kind advisor, timeless, for ever active, always awake. The ancient Latvians did not have any mediators in the relationships with God, they could communicate in any place- at home, on a field, in a forest under a spruce or oak. Life and the world are like a task, which is an opportunity given by the father: every moment is important and it cannot be lost. The world we create in our imagination and thoughts, we also create in our physical plan. God is one, but the manifestations can be many. God's Sign is sacral and invites to start with oneself, get free from haughtiness, boastfulness, fear, hatred, anger, impatience, condemnation, revenge, envy and offence.

Picture 55. Brigita Ektermane. God Sign – the base of all Latvian crosses and patterns. [31]

Picture 56. Brigita Ektermane. God stands over time, space, lifetime. [32]

The roofs of our houses are under God's Sign, also the Heaven is like the world's roof, the spiritual guard, link with the Highest Forces. The sign creates safety, protection, good health, attracts energy, belief into one's strength. God's presence can be felt on every step, also blessing in marriage. If there is one individual sign, then it is one storey, if a combination of signs – totally something different, but if the colour therapy is added, then absolutely other opportunities come up.

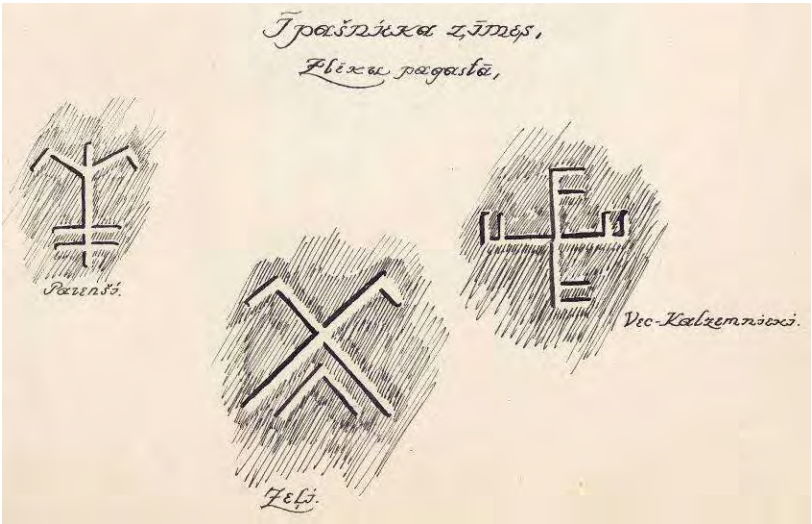
3. Sign symbols in Latvian regional architecture

The ancient Indo-European (Aryan) and Balts' common principal feature is also included in the spatial concept of dwelling, where the planning is characterized by a rectangle, also a square with a marked centre. The Balts built form wood and withe houses of rectangular planning with a gabled roof where in the middle the main room – a common living-room with a stove was placed. The principal form of Latvian threshing

barn also included symbolism of the Balts (Aryan) sacral space and time, which reminded of a quadrangle pyramid in whose centre there was fire. It was considered the signs had a magic, sacral meaning (Picture 57), and they tried not to reveal the information to strangers in order not to lose the power.

Picture 57. The barn door with a Latvian pattern in Ķoniņciems, Kuldīga Region. [5]

In the culture-space of traditions a man marked their things with property signs (Picture 58) and protection signs. One of the most often used signs was *Jumis* Sign, which was used in the affiliation signs, clothing patterns and architecture. In Latvian mythology the deity of cornfields is symbolized by two grown-together pieces of fruit which characterises welfare, luck, development. In the Indo-European and Balts' traditions and symbols the combination of masculine and feminine energy and fertility symbols have got deep roots. The fertility principle is directly related to the principle of twins typical to the Indo-Europeans, which is reflected in symbolism and the structure of the pattern.



Picture 58. Property Signs in Zlēkas Parish. [5]

In the farmyards on doors, walls, but most often on door-posts of residential buildings signs were cut out or painted whose task was to protect from illnesses, plagues, evil spirits, fire and other misfortunes. In all regions of Latvia the most common

protection sign was the slanted cross – one of the most ancient protection signs in the world. In Latvia the slanted crosses found on houses most often were drawn on the front door.

Picture 59. Protection Sign – the slanting cross carved in wood. [33]

In 2002 in Alsunga five buildings with protection signs were identified and registered. The bipartite barn "Anuži" had a carved year "1834" and on the doors a 40x30 cm big slanted cross was gently cut with a knife or another instrument (Picture 59). The sign itself and the carving fact was important and not its visual effect the sign left. On the left side of the building there used to be a grain barn, but on the right side protected with the slanting cross – a cloth barn in which meat and other valuable things were stored.

In "Lienoti" barn next to the entrance door of the loft a cruciform window was identified which was made as a cross with extended ends, but inside of "Pūpoli" grain barn on the wall not far from the door a slanting cross was found supplemented with two more slanted lines. The tripartite barn was built in the 1930s.

In "Dižarāji" barn, built in 1930, the protection signs – six-pointed little suns (Picture 60) cut on the door jam and on the door-posts of the loft doors a little bit above the floor. The little suns were known only on the barn doors up to now, they have been found in several places in Courland and Vidzeme. According to the "Dižarāji" host's report, carved little suns and other signs were found on the logs of the old knocked-down house "Žibi".

Picture 60. Protection Sign – six-pointed sun. [34]

The bath-house "Dūņi," which in the middle of the 20th century was converted into a stable and moved closer to the residential building, could have been built in the 19th century. On the steambath-house wall not far from one corner three protection signs were carefully and deeply cut in one line – *Lietuvēns* Cross to protect the building from evil spirits, a vertical line and Fire-cross (Picture 61), whose branches are directed leftwards, possibly in order to prevent from fire. Traditionally, the left-side fire had a relation to the rising sun, fire in its most active expression. In its turn the left side Fire-cross symbolized the setting sun, fire in its passive condition. The vertical line in the middle enforces the effect of the two other signs. The Fire-cross cut on the steambath-house "Dūņi" has all ends, except for the right side, broken in a straight angle twice.

Picture 61. Protection signs – Lietuvēns Cross, a vertical line and Fire-cross. [35]

The drawn signs on the foundations, walls and doors of old buildings for the 21st century people seem like a new discovery. However, for the moment the question is not answered whether the protection signs and property signs are only evidences of

historical times and whether in certain conditions they could return in a modified form. It seems that in crucial moments (individual or collective) the deepest – magical function of the ancient protection signs revive, at least partly. In the late 1980s and early 1990s during the time of unclear future perspectives, when Latvia from the Soviet power changed to the national independence renewal, one of the traditionally applicable protection signs *Auseklītis* became a popular decoration on clothes and buildings. When the crucial situation was solved positively and the national independence was regained, *Auseklīši* disappeared quickly. In the 21st century the ancient culture-signs disappearing from the topical circulation still preserve their ornamental, decorative function. The little suns, the geometrical patterns of *Auseklītis* and little crosses emphasize the necessity of the historical value preservation.

Picture 62. A barn with a porch and decorative supports in a Latvian peasant's yard. [5]
Picture 63. A barn with Jumis Sign at the roof end in Nida Village, Rucava Parish. [5]

The symbol *Jumis* of the crop-growers' fertility has got its graphical sign, which in the ornament can be met like an image of a bifurcated ear. *Jumis* is responsible for productiveness. Therefore in folklore *Jumis* of Barley, *Jumis* of Rye, *Jumis* of Linen, Nuts and others are mentioned, and each of them has their own beliefs and rituals to be performed. The roof overhangs of a barn above the porch were supported by decorated posts (Picture 62), but *Jumis* Sign at the roof end of a barn, threshing barn (Picture 63) or residential building decorated the house (Picture 64) and brought blessing to its inhabitants. *Jumis* is double good at everything, and it refers not only to material values, but also to new knowledge, being at the right moment in the right place, recognition in creative work, happiness in family, love, faithfulness, togetherness. The sign manifests dynamics.

Picture 64. Signs on the end wall of a building. [36]

Picture 65. Latvian pattern signs in the overview of the Eastern-Latvia creative service centre "Zeimuļs". [6]

Nowadays in Rēzekne an innovative object was built in the centre for the urban-space development and the creative service centre of Eastern-Latvia municipalities, which would attract young people and a new age would be started in Latgale

architecture. In the competition the offered proposal by SAALS architects Rasa Kalniņa and Māra Krūmiņa was acknowledged as the best one. The authors were inspired by the landscape – the medieval hillfort with its castle ruins, but the victory was gained due to the gentle approach to the complex historical place. On September 1, 2012 one of the most peculiar buildings in Latvia was opened (Picture 65): a monolith concrete structure made as a green valley which contrasts with the prismatic volumes of the classrooms – "pencils" stuck into the grass – two towers coated with wooden boards for pupils and youth's diverse rooms. Yellow, brown, greenish and pink sign patterns painted in colours typical to Latgale.

Conclusions

Latvian nation, being situated in the European culture-space, has cultivated its life wisdom, language and culture, it has created own identity, setting freedom, justice, honesty, solidarity, family, work as its main principal values. Sign symbols manifested the world perception, vision and aesthetic ideals, applied for a particular ideological purpose in order to preserve the awareness of belonging to the native land, people and create a shield against strange powers and the misery brought with them and ideological manipulations, trying to eliminate independence of Latvian consciousness and spirit of sovereignty. Everybody took care of themselves, relatives and the society's common benefit in compliance with their own abilities, treated their neighbours, country, environment, nature and future generations well. Sing symbols, which are the most ancient and laconic form of information and energy expression, were closely connected with the meaning and impact of the object, they were placed in certain places and they affected or emphasized the object's architectonics. The decorative pattern of the objects often complied with good advice, good wish, protected from the evil. Repeating the sign symbols several times, an ornament was created, which in translation from the Latin work *ornamentum* meant decorations. The mutual arrangement, sequence and placement of the decorative pattern had a great importance. Later the pattern was included in chains of changes, and arrangements of ornaments started to differ in the ethnographic regions. The ethnographic symbols expressed the sense of national beauty in the environmental and farmstead building creation.

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THE MUSIC OF CHINESE CALLIGRAPHY
(Paper, Artworks, Live Performance)

Topic: (Art, Calligraphy, Music,...)

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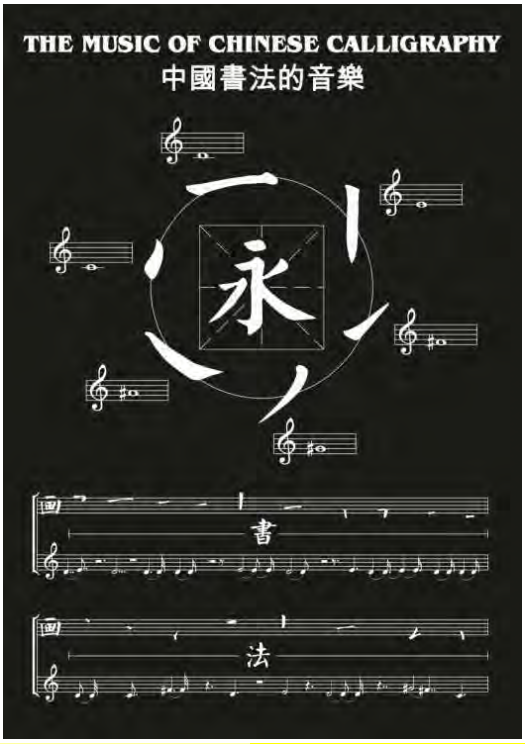
Abstract
Chinese Calligraphy is usually defined "silent but having musical harmony".
In the East Calligraphy and Music are both considered as major arts.
There are many similarities between Calligraphy and Music, and they go beyond the concept of "harmony"; acoustic quality is like the quality of hand-written lines, intonation is like accurate writing skill, volume is like writing intensity, tone range is like the comparison of writing changes, tempo is like pause and transition when writing, and rhythm in music is like partial or entire arrangement of calligraphic works, also calls "rhythm" in Chinese. Both in Music and Calligraphy the expression is given by a temporal sequence of well-defined acts. In the case of Music we have a sequence of notes that compose a melody, while in the case of oriental calligraphy we have a sequence of "strokes" that make up the character and, gradually, the calligraphic work. Both Music and Calligraphy require a very long practice and great precision during the execution. In Calligraphy as well as in musical interpretation, there's no remorse: each and every brush stroke, as well as each every note, cannot be retracted once executed. And, in both cases, the art is an interpretation via an instrument, which is not only the vehicle of the artist's psyche, but also influences the artist's hand.

"Musicalligraphy Project" aims at combining Calligraphy and Music to create something new between the two. Starting from a set of pre-defined rules it is possible to match "fundamental calligraphic strokes" to "musical notes" - obviously respecting their respective "lengths or durations". Chinese characters are thus transformed into corresponding musical melodies and, consequently, entire calligraphic artworks do define their corresponding musical compositions.
These musical compositions are usually transposed in **"musicalligraphy performances":** while the calligrapher writes Chinese characters on a scroll, a musician plays the music of those characters on the stage.



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Key words: Chinese calligraphy, Music, Art
Main References: ------

The Music of Chinese Calligraphy

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1. What is Chinese calligraphy?

Calligraphy is one of the most beautiful of all the arts that have been cultivated in the East. It originated in China and spread from there to all countries that use Chinese characters. It is difficult to say in a word just what forms the basis for the beauty of the calligraphy of the East, but the greatest factor in producing this beauty is no doubt the construction of the Chinese characters themselves.
Chinese characters began as primitive pictographs, diagrams depicting things. From these pictographs of natural objects, another kind of character developed: the ideograph. The early pictographs were concrete signs, while these ideographs were symbolic, showing relative position, number, or expressing other relations. The combination of the concrete and the symbolic is the base from which all other varieties of characters developed.

Every character includes three elements: form, sound, and meaning. Whatever type of character it is, it will possess all three. But perhaps the most arresting of these three elements is the form - the remarkable graphic-design quality of the Chinese character. The fact that Chinese characters not only developed from but retained through time their pictorial or diagrammatic forms indicates just how central the element of visual form is in the Chinese character. Each era produced its own particular variations in form, and as these forms became established and were employed in writing, various styles of these forms were to develop. The appearance of these styles marked the first emergence of calligraphy as an art, the art of writing beautifully.

Fig.1- Brush, ink, paper and inkstone, called “The Four Treasures of the Study -

Fig.2- Copy of Wang Xizhi's Lanting Xu, the most famous

2. Calligraphic scripts

Chinese calligraphy has a three-thousand-year history. During these years the historical process of transformation of calligraphy has produced 5 forms:

- Seal Script (*Zhuanshu*)
- Clerical Script (*Lishu*)
- Running Script (*Xingshu*)
- Cursive Script (*Caoshu*)
- Regular Script (*Kaishu*)

Fig.3 - Seal script

Seal script is an ancient style of writing Chinese characters that was common throughout the latter half of the 1st millennium BC. It was still widely used for decorative engraving and seals in the Han dynasty. The *clerical script* is popularly thought to have developed in the Hàn dynasty and to have come directly from seal script. Clerical script characters are often "flat" in appearance. The *running script* approximates normal handwriting in which strokes and, more rarely, characters are allowed to run into one another. The *cursive script* is a script with drastic simplifications. Entire characters may be written without lifting the brush from the paper. Sometmes strokes are modified or eliminated completely to facilitate smooth writing and to create a beautiful, abstract appearance.

The regular script is one of the last major calligraphic styles to develop, emerging during the Hàn dynasty and maturing in the Tang dynasty. As the name suggests, the regular script is "regular", with each of the strokes placed slowly and carefully, the brush lifted from the paper and **all the strokes distinct from each other**.

Chinese characters are basically logograms constructed with strokes. Over the millennia a set of generally agreed rules have been developed to determine the right order of the strokes. Namely the writing of the characters should be economical, with the fewest hand movements to write the most strokes possible. This promotes writing speed, accuracy, readability and, above all, an aesthetic guarantee for the beauty of the character.

Therefore, the affirmations that each character is made of a single “right” succession of strokes and that the character written in regular form consists of a sequence of distinct strokes, has led me to the choice the **regular script** for my work with music and calligraphy.

Fig.5 - Clerical script

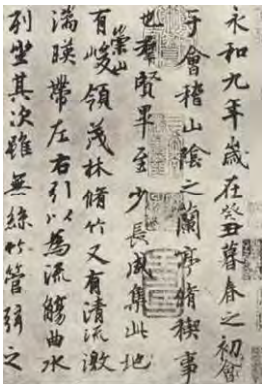


Fig.6 - Running script

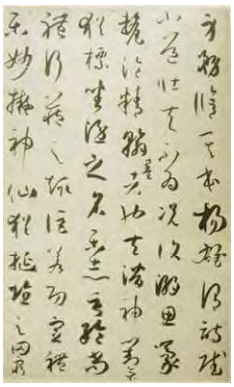


Fig.4 - Cursive script

Fig.7 - Regular script

3. Relationships between Calligraphy and Music

Since ancient times in the Eastern world both, calligraphy and music, have always played the role of major arts.
In many aspects, a calligraphic work can be compared to a musical work. Each calligraphic stroke (in "regular script it corresponds to the sign made between the initial contact of the brush with the paper and its final lift) is like a note on the pentagram, each character (composed of a well-defined sequence of calligraphic strokes) is a succession of notes interrupted with pauses that are equivalent to the non-written between strokes.
Other similarities can be found in comparing the acoustic quality of music with the quality of the calligraphic strokes, the musical intonation with the calligraphy accuracy, the volume with the writing intensity, musical tones with calligraphic forms, the alternation in writing that determines a rhythm with the musical rhythm.
So, in the same way as a great musician brings his music to high values of harmony through his own phrasing, his pitch and rhythm, a great calligrapher reaches the same artistic harmony through the rhythmic movement of his own brush and allowing us to talk about " Music of Chinese Calligraphy ".
Both, in music and calligraphy, the expression is given by a temporal sequence of well-defined acts. In the case of music we have a sequence of notes that compose a melody, while in the case of Chinese calligraphy we have a sequence of "strokes" that make up the character and, gradually, the calligraphic work.
Both, music and calligraphy, require a very long practice and great precision during the execution. In calligraphy as well as in musical interpretation, there's no remorse: each and every brush stroke, as well as each every note, cannot be retracted once executed. And, in both cases, the art is an interpretation via an instrument, which is not only the vehicle of the artist's psyche, but also influences the artist's hand.
"Musicalligraphy Project" aims at combining calligraphy and music to create something new between the two. By matching "fundamental calligraphic strokes" to "musical notes" - obviously respecting their "lengths or durations" – it arrives at a transformation of Chinese characters into a corresponding musical melodies and, consequently, of calligraphic artworks into corresponding musical compositions. These musical compositions are usually transposed in "musicalligraphy performances" during which the calligrapher performs his calligraphy simultaneously with the musician who performs the music score obtained by the calligraphy itself.

MUSIC	CALLIGRAPHY
sound quality	stroke quality
intonation	calligraphic accuracy
volume	writing intensity
musical tones	calligraphic forms
musical rhythm	alternating of strokes and pause = calligraphic rhythm
sequence of well-defined acts to generate music	sequence of well-defined acts to generate calligraphy
long practice and great precision during the execution	long practice and great precision during the execution

4. Musicalligraphy Project

4.1 From Chinese character to musicalligraphic score

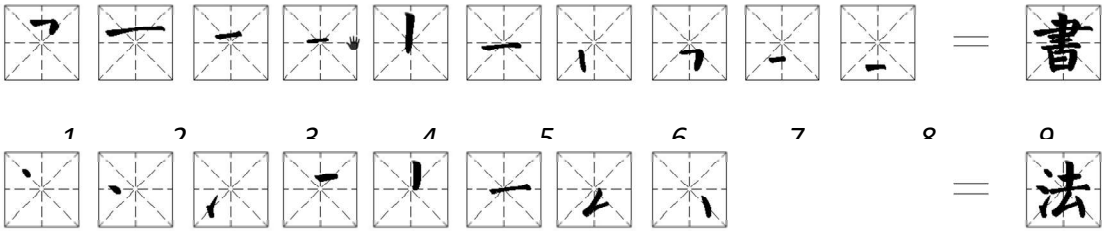
Starting from each character that make up a calligraphic work and, more specifically, from each calligraphic stroke and relative blank spaces between strokes, I can build, through “unique relationships” between strokes and notes, a composition of contemporary music.
These “unique relationships” connect in first instance "fundamental calligraphic strokes" and "fundamental notes" belonging to an appropriate musical scale.
In this first phase of the project, the fundamental strokes chosen are 6 (in contrast with other theories belonging to the calligraphic chinese culture) and are strokes that do not involve sharp variations of direction. Obviously it is possible to choose a different number of fundamental strokes and then a corresponding musical scale (for example, 8 strokes and an eight-note scale).
In agreement with the number (6) of fundamental strokes chosen, I have utilized an esatonal musical scale.
Obviously also the blank spaces between the strokes have fundamental importance because they will produce the relative musical rests.
In doing so, the only harmonious and correct sequence of calligraphic strokes that make up the Chinese character will produce a unique musical melody in which the duration of each musical note will be tied to the length of each calligraphic stroke and music pauses will be linked to the non-written gaps between a stroke and the following.

4.2 Sequence of strokes and Blank spaces and their measurement

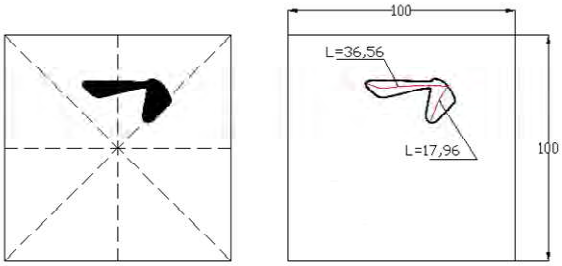
STEP1: Realization of a calligraphic work in regular script.

Fig.8 - The two characters of *Shufa* -

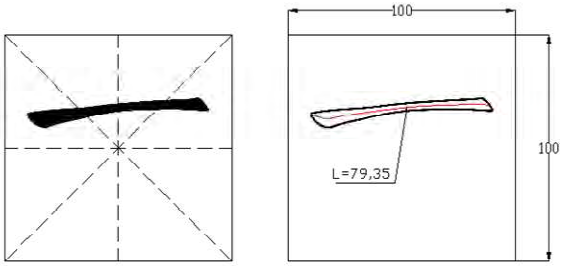
STEP2: Identification of the sequence of the strokes.



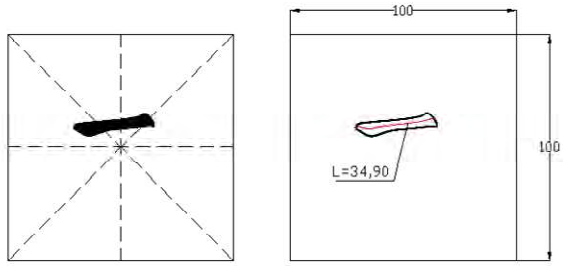
STEP3: Measurement of the length (mm) of the strokes (red line) in 



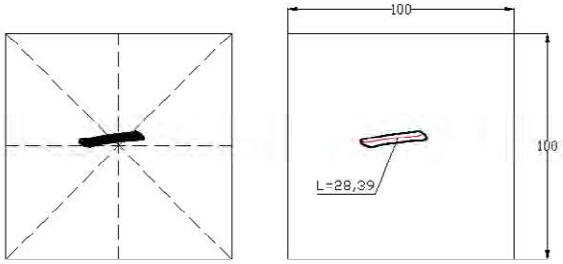
Stroke 1



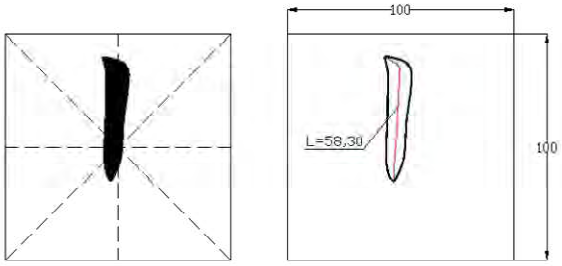
Stroke 2



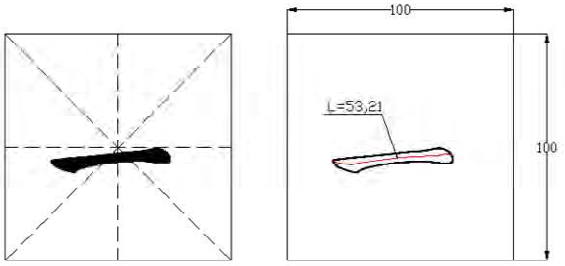
Stroke 3



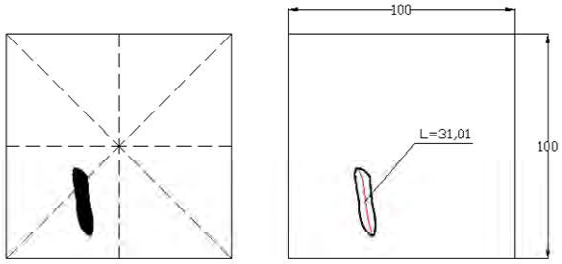
Stroke 4



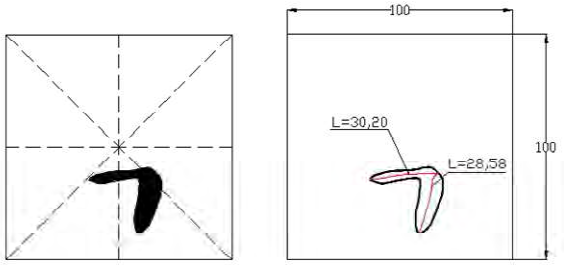
Stroke 5



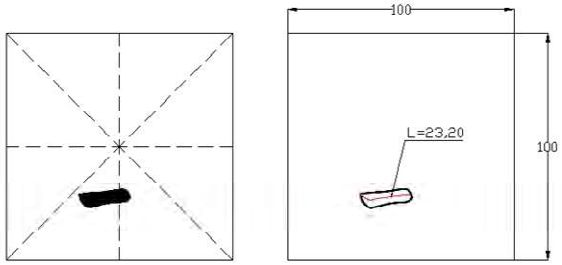
Stroke 6



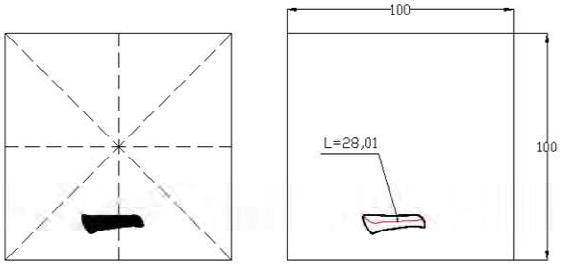
Stroke 7



Stroke 8



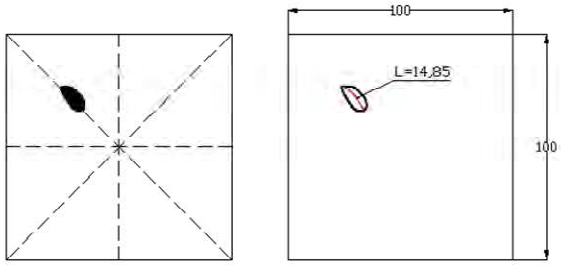
Stroke 9

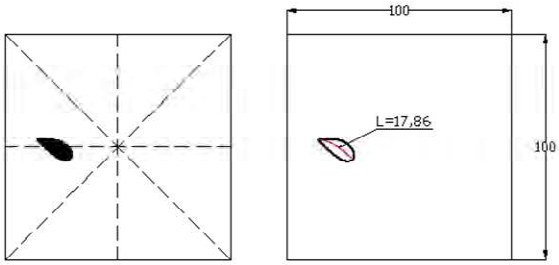


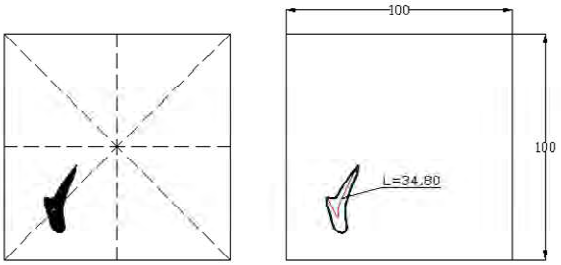
Stroke 10

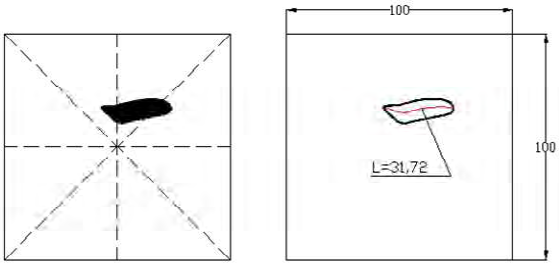
character

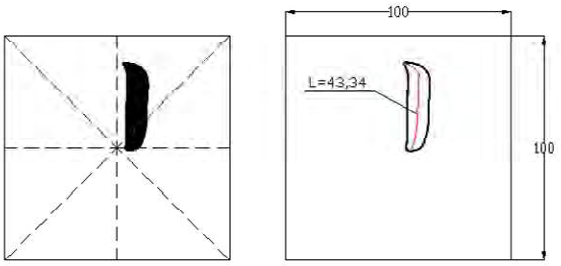
Measurement of the length (mm) of the strokes (red line) in character 



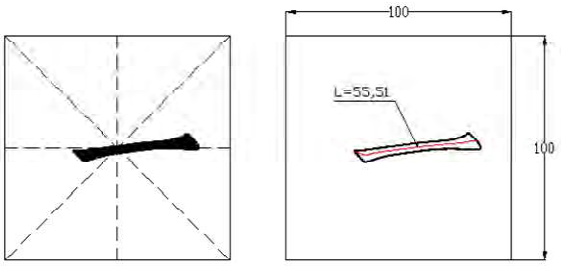




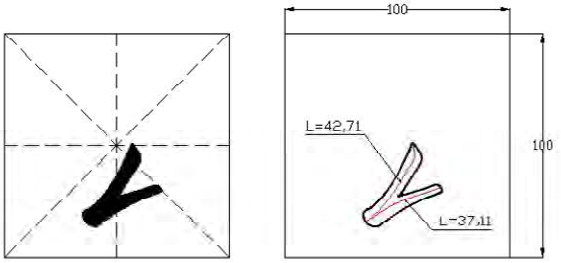




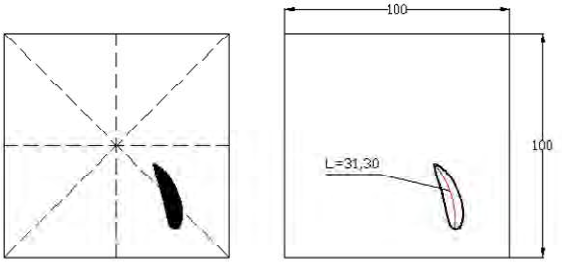
Stroke 5



Stroke6

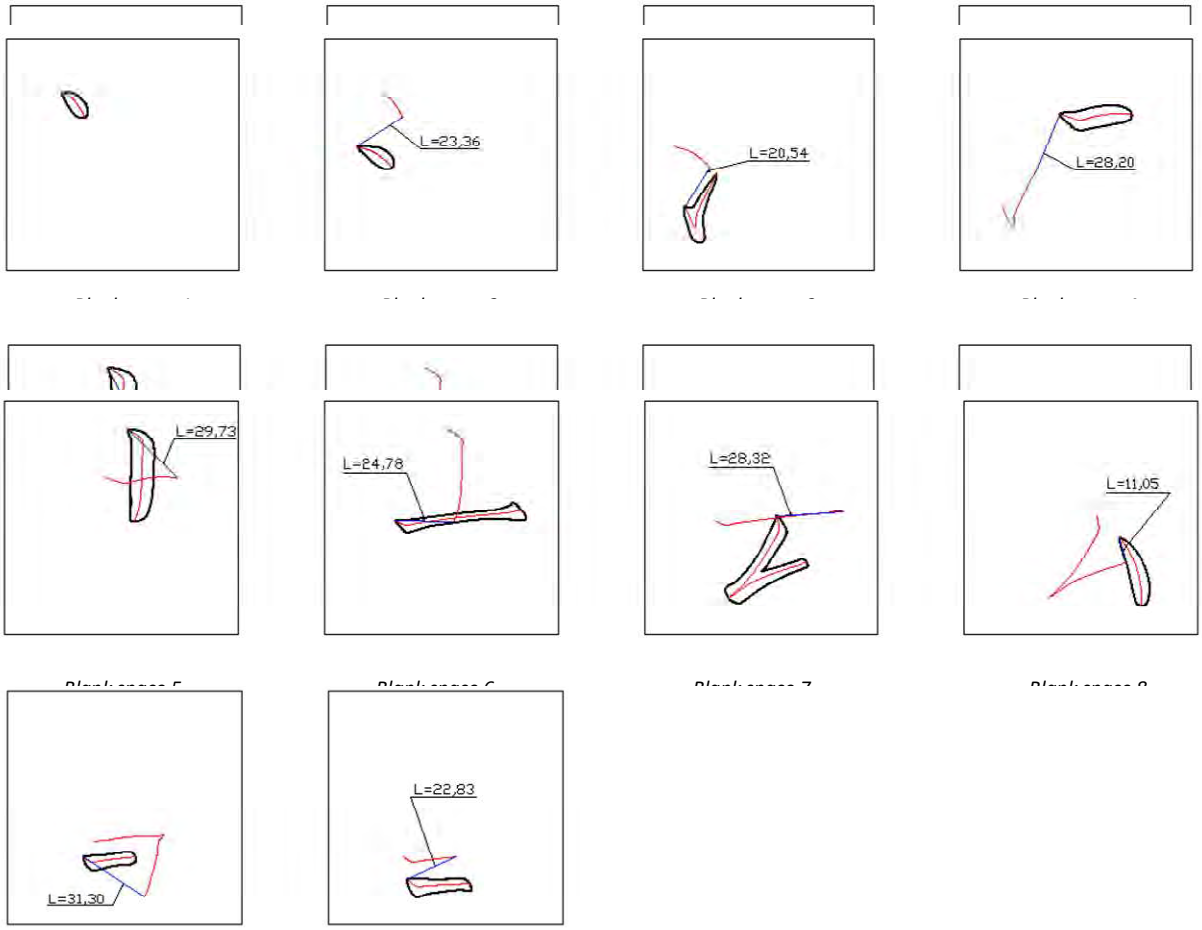


Stroke 7



Stroke8

Measurement of the length (mm) of Blank spaces (blue line) in character 



Measurement of the length (mm) of Blank spaces (blue line) in character

4.3 Normalization of the lengths (strokes and blank spaces) 

Strokes:

NS = Number of Strokes **SLS** = Sum of Lenghts of the Strokes

MLS = Medium Lenght of Strokes = **SLS/ NS**

LS= Lenght of Stroke

NLS = Normalized Length of Stroke = LS/ MLS

Blank Spaces:

NBS = Number of Blank Spaces **SLBS** = Sum of Lenghts of Blank Spaces

MLBS = Medium Lenght of Blank Spaces = **SLBS/ NBS**

LBS = Lenght of Blank Space

NLBS = Normalized Lenght of Blank Space = LBS/ MLBS

4.4 Correspondences between lengths

Strokes and musical notes NLS = 1 ➡ 

Blank spaces and musical rests NLBS = 1 ➡ 

As a consequence of this choice in the relationships between geometric and musical lengths, all measured lengths of the different strokes and blank spaces will assume consistent musical values proportionally.

4.5 Correspondences between fundamental strokes and musical notes

Which and how many are the foundamental strokes? Through history different theories have been developed:

Emperor Zhang (Later Han Dynasty) = **14 types of strokes**
Lady Wei (272–349) (Eastern Jin Dynasty) = **72 types of stroke**

The classification of the great calligrapher *Wang Xizhi* (303–361) written in the book "*The eight components of the character Yong*" is today the most generally used in the practice.

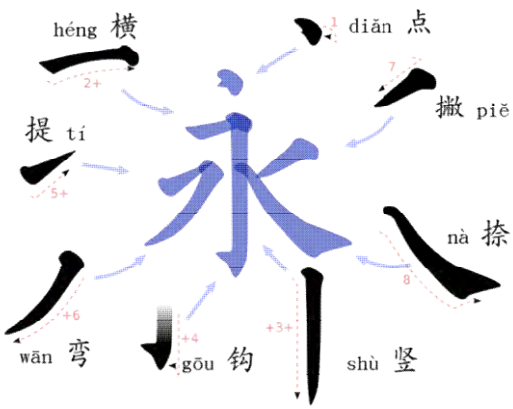


Fig. 9 – The eight components of the

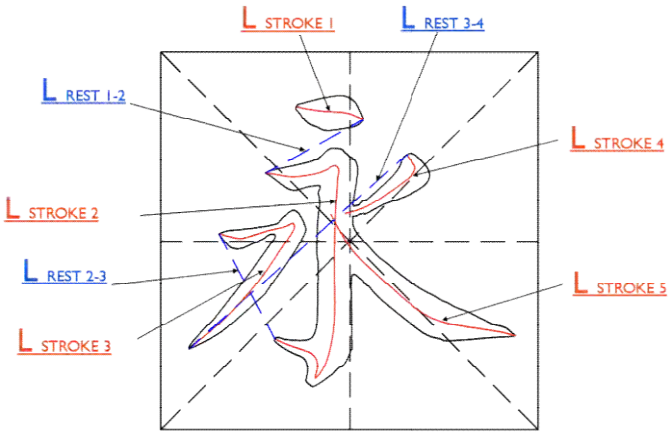


Fig. 10 – Character Yong – Strokes and

In my work, the choice of the number of fundamental strokes, derived from the model of *Wang Xizhi*, is reduced to 6. In fact there are 6 strokes so-called "simple" that do not involve rapid changes in direction in carrying them out.

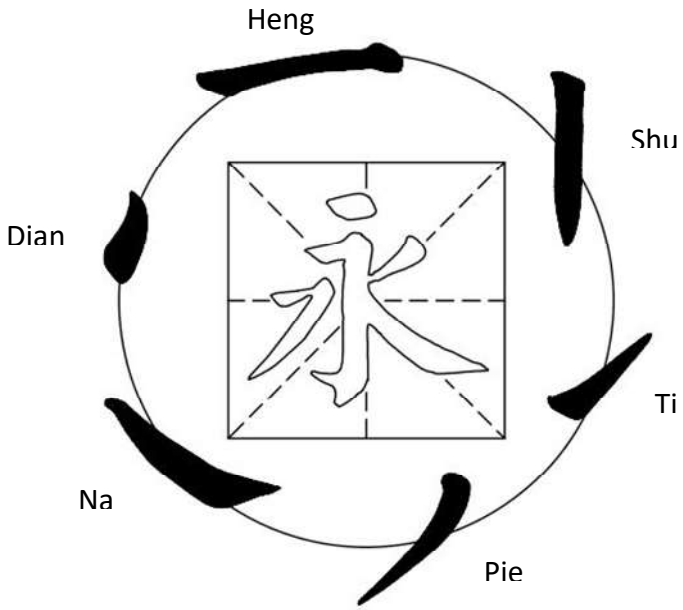


Fig. 11 – The six "fundamental strokes" derived from the

Since the fundamental strokes choose in my theory are six, it follows that is convenient to use a musical scale with 6 notes (exatonic music scale) and set a direct correspondence stroke-note. The succession of strokes used is the same as that in the scheme of Wang Xizhi, then the stroke "Diǎn" (first stroke) coincides with the first note of the scale used (example C scale).

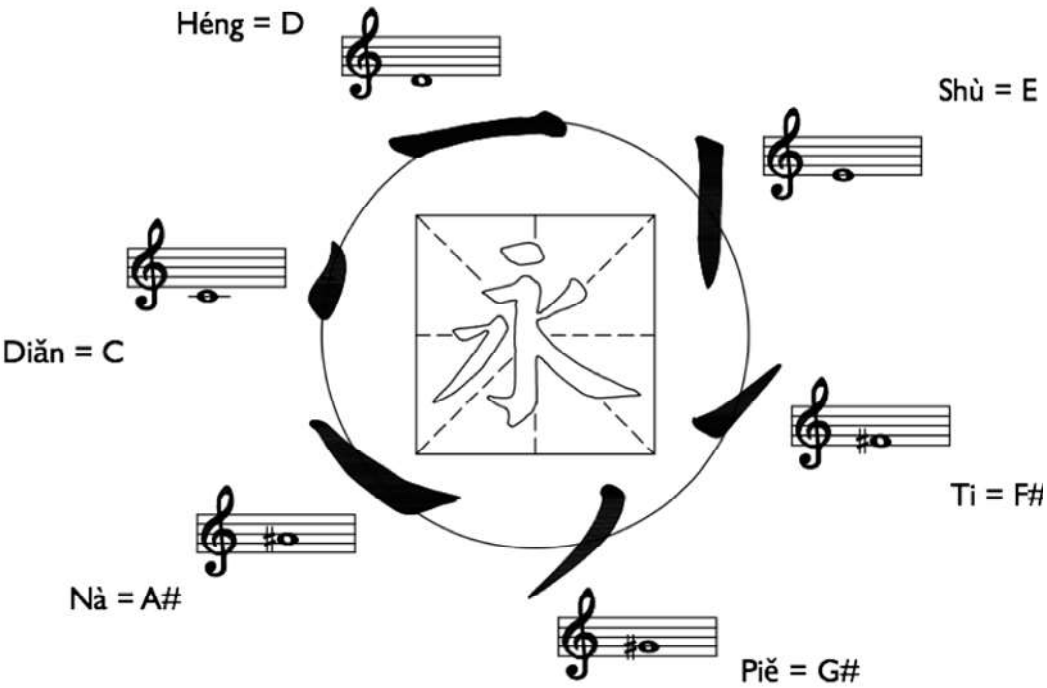
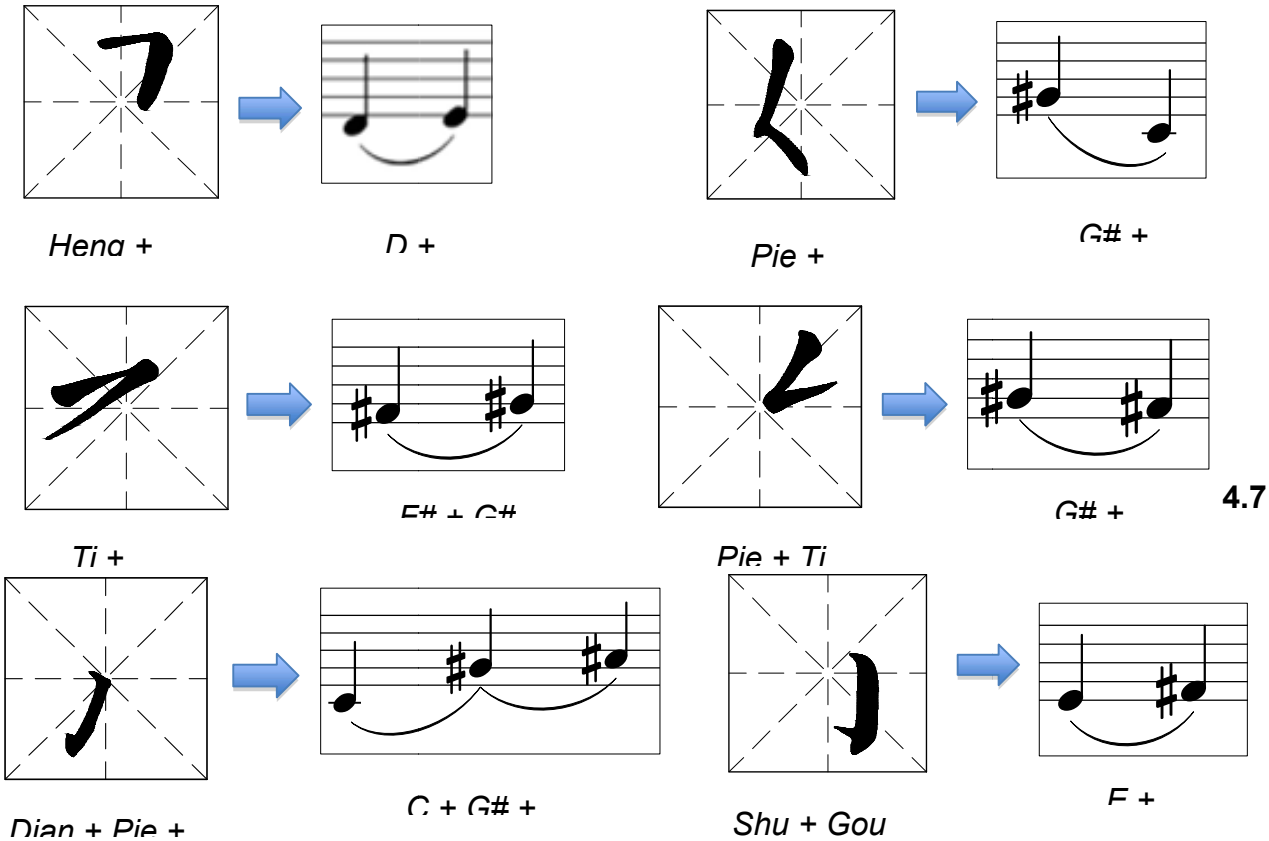


Fig. 12 – Correspondence between the six fundamental strokes and the six notes

4.6 How to process non-fundamental calligraphic strokes?

The “other” strokes (non-fundamental strokes) will be considered as arising from fundamental strokes. Since, non-fundamental strokes, can be considered as a continuous sequence of fundamental strokes executed in a single calligraphic gesture and the musical correspondence generated will be a sequence of musically linked notes.
Below you can see some examples of “calligraphic events” that will appear in the phrase with 8 characters.



4.7

Musicalligraphic score

In the musicalligraphic score we have two parallel music lines in which both, calligraphic and musical events, evolve at the same time. This gives the sense of the deep link between the two artistic forms.

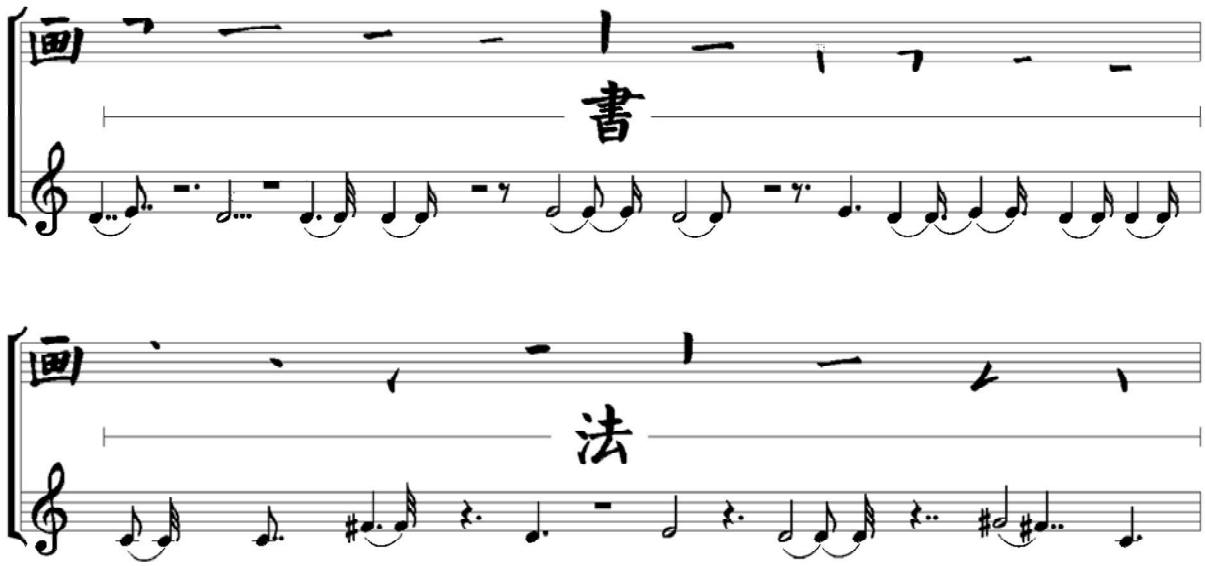


Fig. 14 – Musicalligraphic score of the characters书法

5. An 8-character phrase: 千里之行始於足下

This work was presented in "2013 World Calligraphy Biennale in Jeollabuk-do" - Korea. In this context, where the greatest exponents of oriental calligraphy show their masterpieces, my work "千里之行始於足下" has aroused great curiosity and stimulated several questions about the meaning of it.
From a graphical point of view, the work present in the upper part the eight characters of the title in seal script and, in the underlying part, the score on two lines with the unfolding in parallel of the calligraphic and music part.

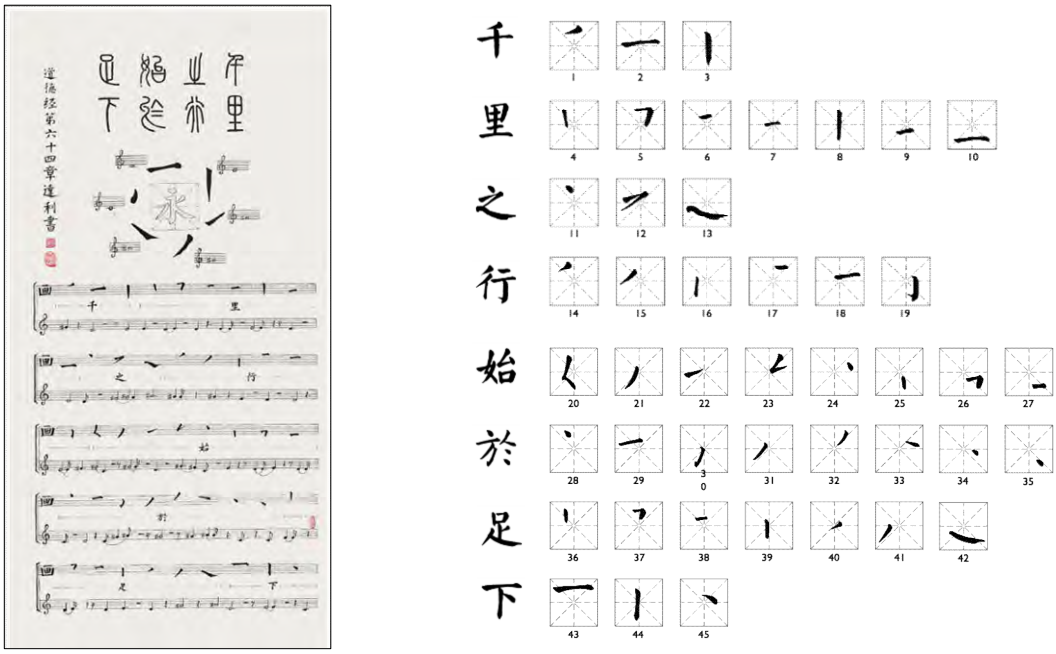


Fig. 15 – Work presented in World Calligraphy Biennale and sequence of

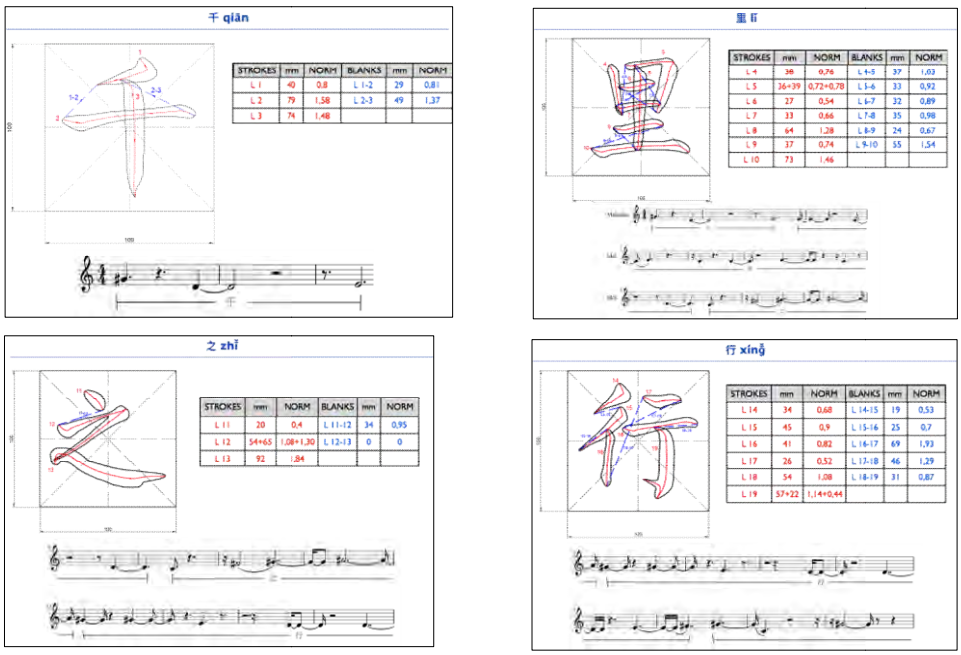


Fig. 16 – Measurement of the length of strokes and blank spaces in 千里之行 and

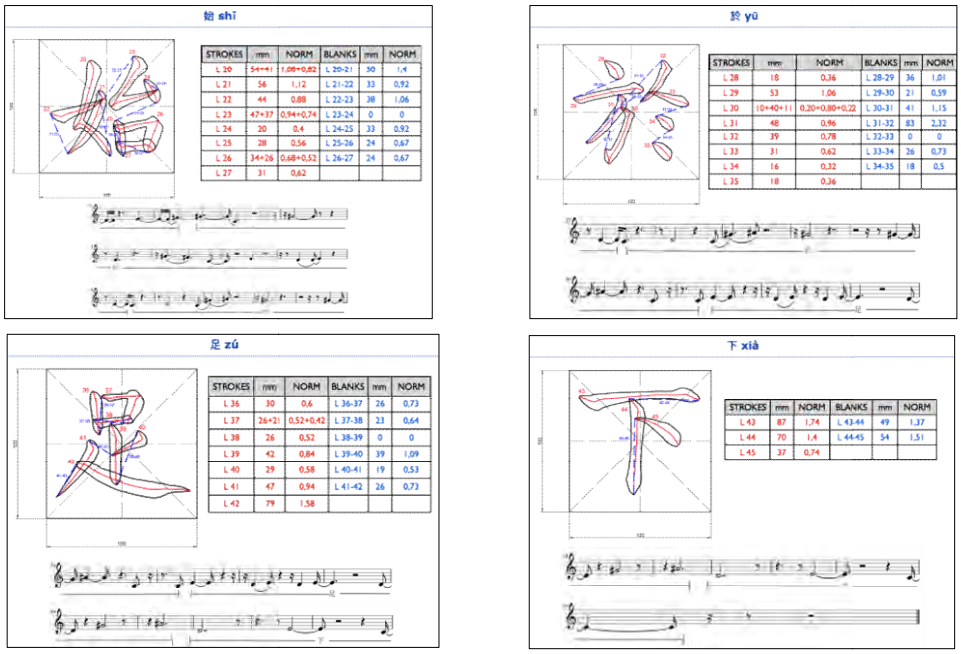


Fig. 17 – Measurement of the length of strokes and blank spaces in 始於足下

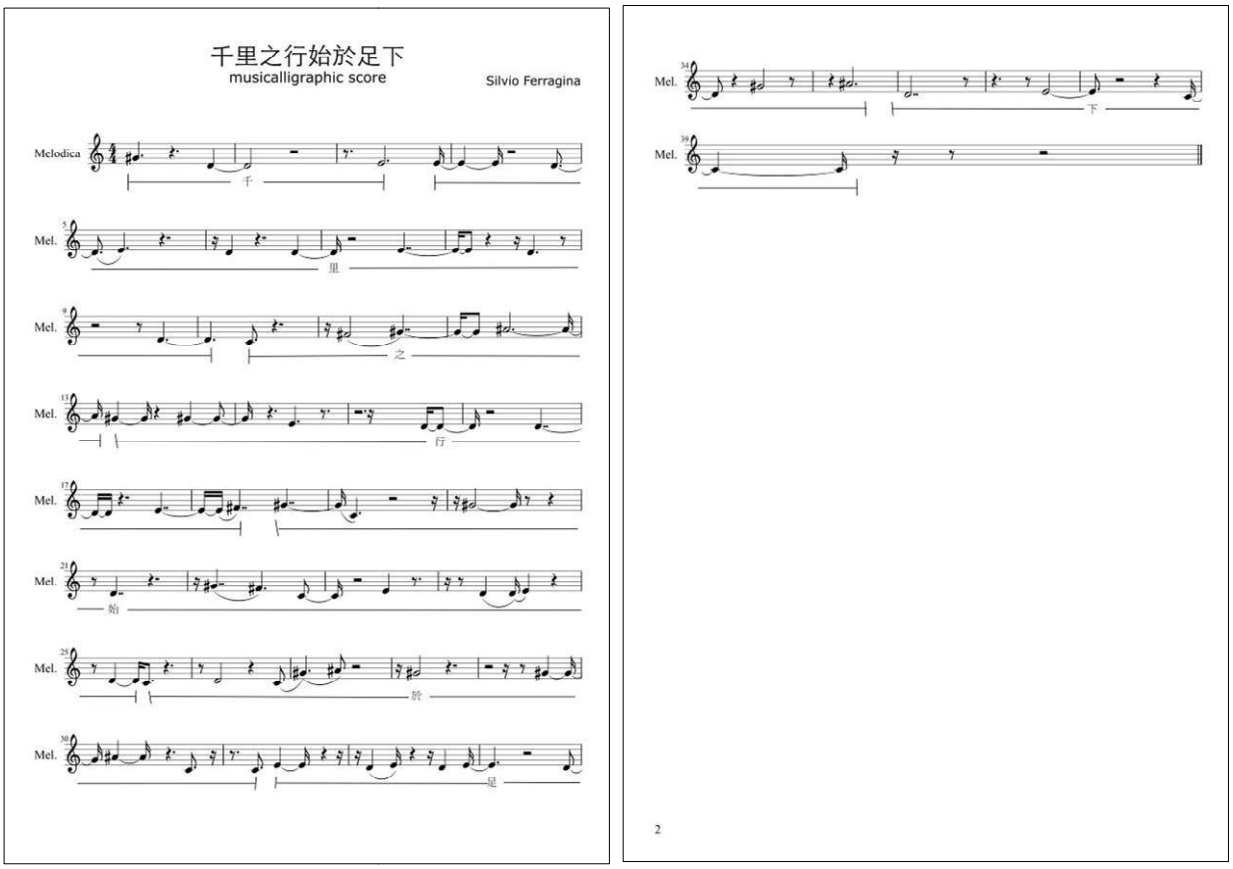


Fig. 18 – Musicalligrafic score of 千里之行始於足下

6. The Hangzhou event at "Zhejiang Conservatory of Music"

Fig. 19 – Musicalligraphy performance in Zhejiang Conservatory of Music in Hangzhou – China – October 2016 - Poster of the event "The Music of Chinese Calligraphy, and

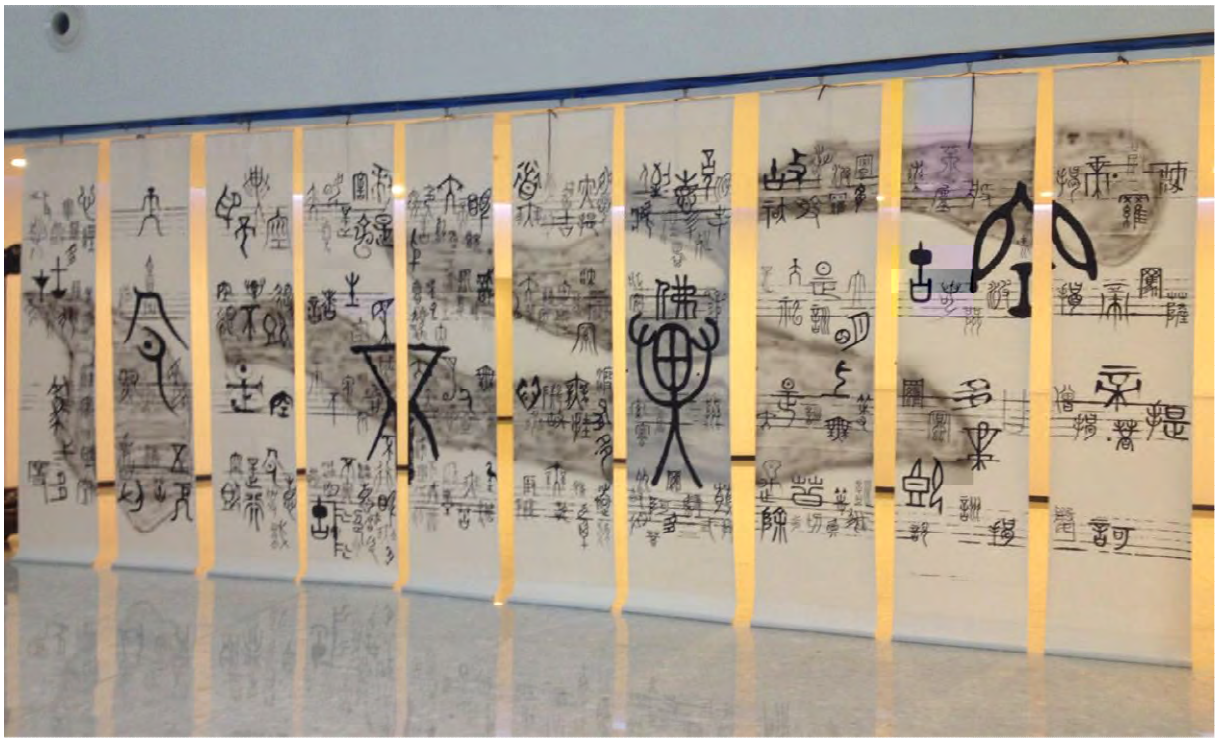


Fig. 20 – Exhibition and Musicalligraphy performance in Zhejiang Conservatory of Music in Hangzhou – Images of the Heart Sutra - 700x300 cm - China – October

Fig. 21 – Musicalligraphy performance in Zhejiang Conservatory of Music in Hangzhou – Silvio Ferragina (brush) and Sandro Cerino (flute) – China – October

Fig. 22 – Musicalligraphy performance in Zhejiang Conservatory of Music in Hangzhou – Cover of the Musicalligraphic score of 16 characters of the Heart Sutra -

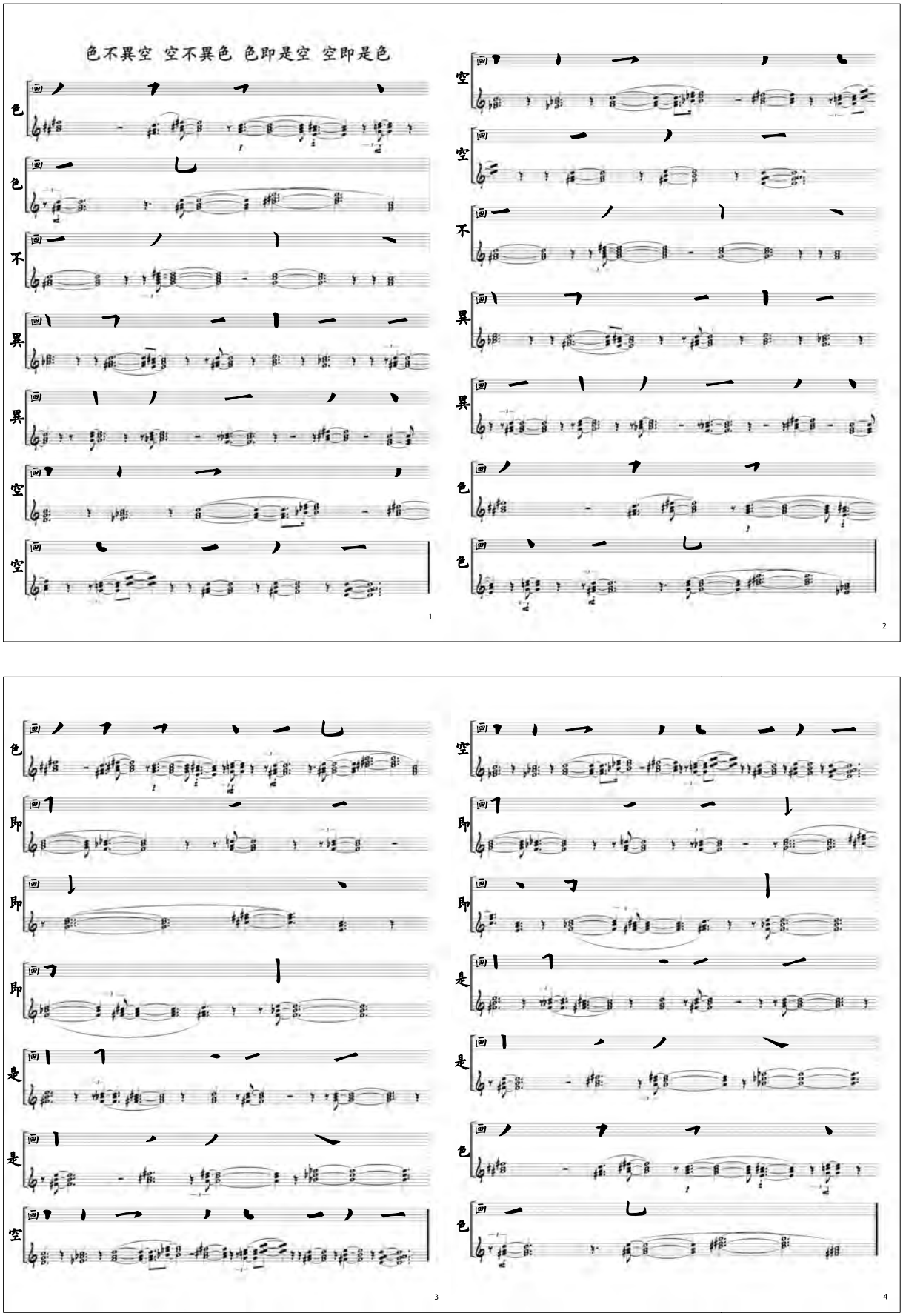


Fig. 23 – Musicalligraphy performance in Zhejiang Conservatory of Music in Hangzhou –

SYMBIOTIC INTERACTION IN/WITH ARTIFICIAL ECOSYSTEMS

Paper, Installation

Interactive Audiovisual Installation

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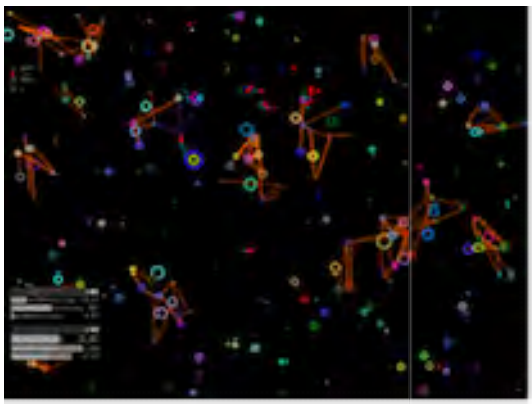
Abstract
Natural biological workspaces offer prime examples of emergent functionality from symbiotic interaction amongst different species. We take inspiration from nature for designing human-machine interaction protocols featuring life-like complexity.
In this light, our paper develops a comparative discussion of responsive vs. interactive art. By way of example, we discuss the conceptual ground and implementation of a recent interactive audiovisual installation called *Crickets*. Our system interfaces an artificial agency with the grounded world through computer vision. Truly interactive systems are characterized as affording a life-like, unpredictable though coherent sensorial experience. We take inspiration from the science of complex dynamical systems, the process of biological reproduction and the theory of enactment. The notion of emergence is key; the agency develops complex spatiotemporal patterns from simple interactions amongst constituent components. The human participant is actively engaged in an anticipatory process; a rewarding experience issues from the appreciation of relative uncertainty and unpredictability in system behavior.



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Key words: dynamic system, interaction, emergence

Main References:
[1] Peter Beyls, "*Life-like Behaviour in a Gestural Interface for Interacting with Sound", Proceedings of CMMR, Sao Paulo, Brazil, 2016*
[2] Peter Beyls and Andre Perrotta, "*Rainforest, An Interactive Audiovisual Universe*", CHI2016 Proceedings, San Jose, CA, ACM 2016

Towards Symbiotic Interaction in/with Artificial Ecosystems

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Premise

This paper develops a comparative discussion of responsive and interactive art. By way of example, we discuss the conceptual ground and implementation of a recent interactive audiovisual installation called Crickets. Our system interfaces an artificial agency with the grounded world through computer vision. Truly interactive systems are characterized as affording a life-like, unpredictable though coherent audiovisual experience. We take inspiration form the science of complex dynamical systems, the process of biological reproduction and the theory of enactment. The notion of emergence is key; the agency develops complex spatiotemporal patterns from simple interactions amongst constituent components. The human participant is actively engaged in an anticipatory process; a rewarding experience issues from the appreciation of relative uncertainty and unpredictability in system behavior.

1. Introduction

Natural ecosystems like rainforest are intrinsically complex in terms of morphology and behavior because innumerable active components are engaged in continuous processes of interaction. Living species coexist and co-evolve in a sustained common biotope generating perpetual novelty. Complex spatiotemporal patterns materialize spontaneously from interlocking processes; for example, the sound of the forest emerges as an articulate dynamical pattern blending anticipation and surprise in a human participant. In addition, ecosystems exist as complex hierarchical structures themselves spawning behavior at a higher level. A forest is thus seen as a complex adaptive system sustaining the development of hierarchies of signals and boundaries still holding many mysteries [3, p11]. According to Holland, four categories are relevant to all signal/boundary systems: diversity, recirculation, niche and co-evolution. Diversity follows from internal constraints and the interaction of species in a struggle for survival. Recirculation of resources from organism to organism creates complex patterns in morphology and behavior. Our implementation loosely follows the adaptive signal/boundary systems framework in the constructionof

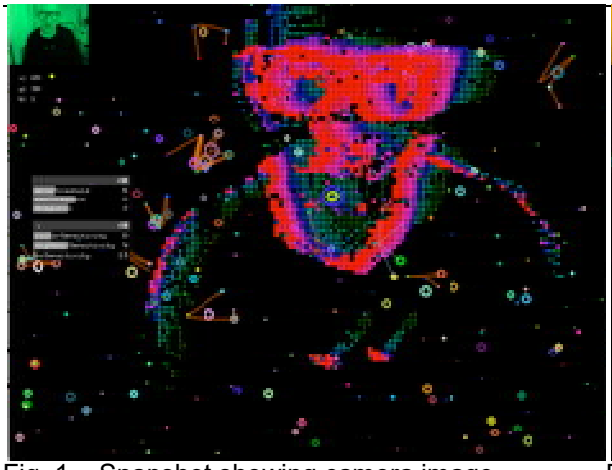

Fig. 1. Snapshot showing camera image, processed image, particle agency, and parameter editor.

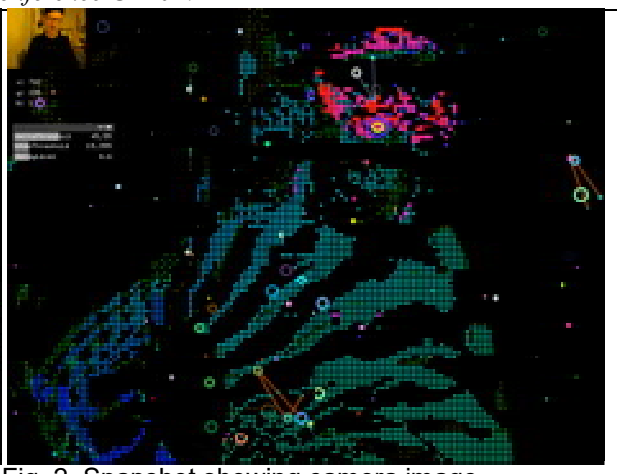

Fig. 2. Snapshot showing camera image, processed image, particle agency, and parameter editor.

a hybrid reality system; the artificial world and human participant(s) coexist in a shared higher-level compound environment. Also, Crickets builds on earlier work, including *Living Gestures* [1], and *Rainforest* [2] - a large-scale interactive installation where the notions of coexistence, mutual influence, emergence and autonomy underpin systems design. However, Crickets suggest a more private, complex single user experience. Unpredictable waves of audiovisual patterns emerge – nevertheless the impression of coherent behavior subsists: balancing anticipation and surprise contribute to a strong engaging experience.

In this light, let us briefly compare the creation process of (1) artificial structures and (2) living structures as found in nature. In general, explicitly engineered artificial structures are designed top-down, exploiting unambiguous knowledge through symbolic representations. Such structures are brittle facing unpredictable impact. Most often, explicit engineering implies a predefined goal. When turning to natural artifacts, things are very different: nature creates complex hierarchical structures bottom-up, life emerges spontaneously from the enactment of simple components. According to the theory of enactment, first advocated by biologists Maturana and Varela, living systems continuously recreate the required components and their hierarchical organization in order to remain alive [4]. Therefore, natural systems behave autonomously by adapting gracefully to unpredictable challenges.

What can we learn from examples of adaptive interaction in biological workspaces? Symbiotic interaction amongst living species implies mutual benefit in terms of chances for reproduction and survival. Some creatures in nature develop deeply cooperative behavior: consider the symbiosis between the sea anemone and the clownfish as an exceptional example of interconnectivity between different plants and animals in their common environment. The fish seeks to hide in the plant as to find protection from predators, in addition, the fish eats the algae in the plant while the sea anemone needs protection from competition with algae. So both anemone and fish develop an intimate relationship based on the principle of rewarding coexistence. We suggest to turn to such inspiring instances of complex biological behaviour to design augmented forms of human machine interaction.

In conclusion, predictable engineering structures are created through explicit instructions. In contrast, natural living structures emerge through construction – the

constructive effect of many contributing forces. In addition, in terms of its design, Crickets is not engineered from unequivocal instructions but adapts a strategy of speculative computing; the focus is mobile and a functional system gradually emerges from active experimental programming. Inspired by the theory of enactment we may rethink interactive art systems. Let us first address the global nature of interactive systems according to a collection of underpinning keywords.

2. Implementation

Crickets is implemented as three concurrent processes (1) a distributed artificial agency and (2) a computer-vision component, both written in C++ (OpenFrameworks [6]) and (3) an audio component implemented in SuperCollider [5]. Processes communicate via Open Sound Control.

The agency holds a variable collection of agents, particle-like objects, characterized by 2D position, energy level, angle of movement, angle delta, status (awake or asleep), gender (4 options), neighbor sensitivity, level of attraction to human activity, survival chance and reproduction chance. Agents locally interact and dissipate energy by configuring themselves into temporal clusters. In addition, the centroid of the intensity of human activity in the analog word is relayed to the agency; agents, when awake, move toward this temporal zone of influence. Given a critical mass of agents in a particular area, they will create offspring according to a variable reproduction table accommodating non-binary gender. Agents gradually disappear depending on the history of their interactions and the energy they spent. Dynamic visualization documents global systems behavior and signals the moments in time when individual agents interact. In addition, the moment when any two agents connect, a sound is heard reflecting features of the agents in question – a Frequency Modulation synth object is instantiated in SuperCollider; agent energy, velocity and angle of movement are mapped to FM parameters.

A small camera captures outside activity in a low resolution, maps intensity of activity in a color scale and stores the result in a self-fading memory structure. The rationale is to capture movement in time (in a time frame from one to several seconds) rather than stationary snapshots. We are interested in the quality/complexity of spontaneous body language and its dynamic visualization.

3. Discussion

Crickets suggests an interactive experience rather than a responsive structure, there is no clear-cut relationship between internal and external behavior. Humans interact as participants in a non-transparent interface since we avoid trivial mappings in favor of expression of influence over otherwise autonomous system behavior. From simple local interactions between agents we get global emergent functionality: variable hierarchies of emergent spatiotemporal patterns.

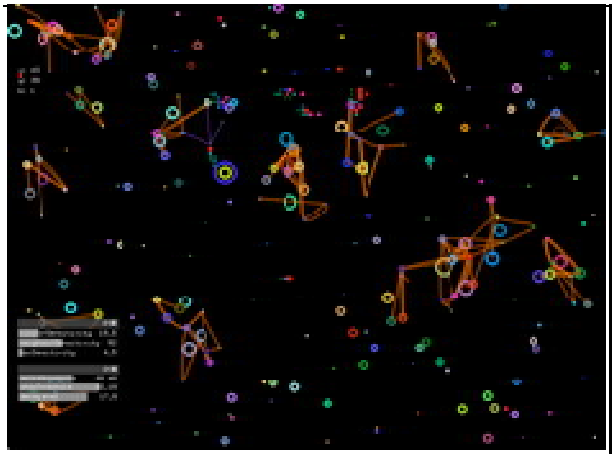

Fig 3 Snapshot documenting particle clustering and parameter editor.

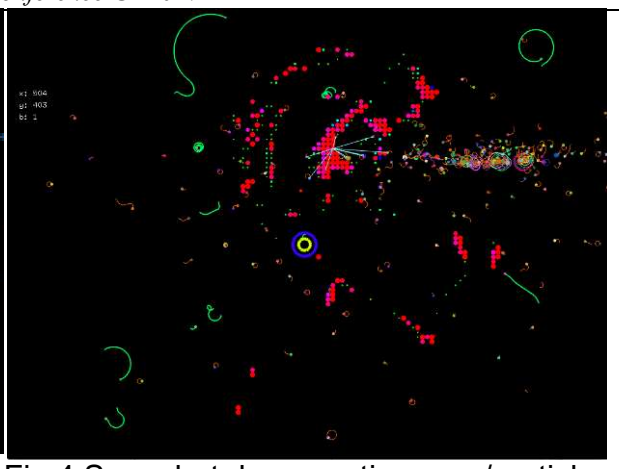

Fig 4 Snapshot documenting user/particle attraction and particle interaction.

Figures 1 to 4 display snapshots of the running system. Fig 1 and 2 provide an impression of the picture-processing algorithm: a low-resolution grayscale version of the live camera image is captured in a rectangular array; gray values are mapped to a HSI (hue, saturation, intensity) color model using the complete color spectrum. Three parameters condition the behavior of the vision procedure: (1) deltaThreshold, showThreshold and decayLevel. In case the absolute difference in image intensity between the current and previously captured frame is higher than the DeltaThreshold, the image memory array is incremented – if not, values in the memory array are decremented in proportion to the decayLevel parameter. When the memory array is shows on top of the particle world, array values below the showThreshold parameter are not displayed. Note the GUI sliders are only used to explore the system's behavioral scope and they are not displayed under normal operation. Parameters self-adapt within a particular range of values as to accommodate external under- or overstimulation.

Life-like qualities are reflected in the emergence of spatiotemporal patterns. Agents contain a simple form of parametric self-representation and exchange information with their neighbors and the environment i.e. the human interactor. Actors' functionality follows from the integrity and relationships between their instance variables. Long-term complexity follows form the multi-gender reproduction process. This procedure is self-sustaining and self-critical since both the number of offspings and their diversity (the quality of the breeding process) influences the fitness of the reproduction process. Somehow metaphorically, we introduced the concept of enactment to view the notion of (1) autonomy as a system that regenerates its components and their organization and (2) structural coupling as a way to explain emergent patterns as byproducts of the systems' interaction history. We shall further develop this orientation in future work.

Merging dynamic visualization of emergent structures and real-time sonification contributes to an engaging experience of a life-like artificial world. In contrast to virtual worlds conceived as computer games, the work reported here excludes explicit goals. It aims to connect abstract scripted virtual life forms with grounded individual and social life forms 'on the other side of the screen'. Also, Crickets is adaptive and gracefully accommodates from vigorous to extremely subtle human activity. The interaction paradigm explored here leaves the human participant with a variable degree of understanding; global behavior cannot be explained from the observation of local events. A particular mix of meaning and mystery acts as a source of rewarding human-

machine interaction; the idea of interaction itself is extended into a profound, machine mediated aesthetic experience.

Future research will address the full potential of symbiotic interaction in cultural rather than biological workspaces. A first step is the development of the notion of aesthetic survival - how machine and human performers subsist in a common habitat while sharing life through mutual creative decision making.

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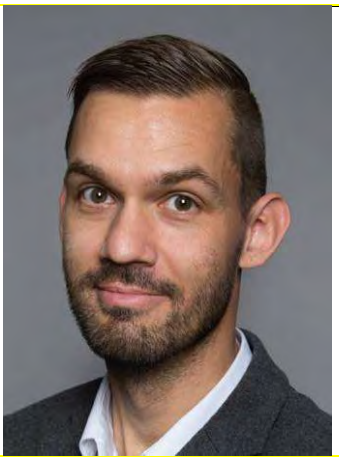

DECONSTRUCTION/RECONSTRUCTION: A PEDAGOGIC METHOD FOR TEACHING PROGRAMMING TO GRAPHIC DESIGNERS

(Paper)

Topic: Graphic Design, Teaching, Programming

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Abstract
Being code-literate is considered a crucial ability in today's society. Permeating through all parts of contemporary culture, this view is also influencing the education of graphic designers, prompting students to recast their existing skills to fit the medium of the code and educators to develop new courses that help build this literacy. The convergence of graphic design and code to form an interdisciplinary field is making a strong case for programming and computational thinking to be part of any contemporary graphic design curriculum.

However, most graphic design students perceive programming as an abstruse skill they will never be able to master, and have a hard time trying to connect the activity of programming with the essence of their trade; crafting visual artifacts. While many attempts have been made to teach fundamental programmatic principles, most fail to produce little more than bouncing balls or awkward matchstick men in harsh color schemes. To an audience, who tend to equate a lack of aesthetics with a lack of relevance, neglecting the importance of the visual quality causes them to lose interest. As graphic design educators, how do we combat this? How do we convince graphic design students that learning to code is indeed a long-lasting and worthwhile addendum to their skill set? How do we capture the students' interest and keep them engaged long enough for them to experience first hand how code-driven generative, parametric design systems can radically transform the way they think about, discuss and execute graphic design?

This paper proposes and describes one possible solution; a hands-on, experiential pedagogic method, *deconstruction/reconstruction*, designed to target graphic design students as informal end-user programmers who use code to create visual output. As its theoretical underpinning, the method builds on constructionist learning theory where students draw their conclusions through active, creative experimentation and construction of a meaningful product. The method aims to establish a safe, forgiving and explorative learning environment in which graphic designers can learn programming as naturally as they learn typography, color theory, visual semantics and similar fundamental skills of their trade. Seeking to contextualize programming into a domain familiar to the students, the method relies on pre-existing graphic design specimens as its main material, allowing students to direct their attention towards learning how to program instead obsessing over aesthetic issues.

The *deconstruction/reconstruction* method has been tested in a number of courses taught to undergraduate graphic design students with little to none prior programming experience. This paper reports successes and shortcomings of the method through a selected number of student examples from these courses.

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Key words: design education, graphic design, creative coding, generative, parametric, design system, Processing

Deconstruction/Reconstruction: A Pedagogic Method for Teaching Programming to Graphic Designers

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Abstract

This paper proposes, describes and exemplifies a hands-on, experiential pedagogic method, *deconstruction/reconstruction*, specifically designed to introduce graphic design students to programming in a visual context. The method uses pre-existing commercially applied graphic design specimens as its main material to contextualize programming into a domain familiar to the audience. Observations of the method used in teaching are discussed, and its potential evaluated based on feedback provided by the students.

1. Introduction

Being code-literate is considered a crucial ability in today's society. Permeating through all parts of contemporary culture, this view is also influencing the education of graphic designers, prompting students to recast their existing skills to fit the medium of the code and educators to develop new courses that help build this literacy [1, 2, 3]. However, most graphic design students perceive programming as an abstruse skill they will never be able to master, and have a hard time trying to connect the activity of programming with the essence of their profession; crafting visual artifacts. Although many attempts have been made to teach programming to a visually oriented audience, most of them use seemingly random layouts, bouncing balls or simple characters in monochrome color schemes (e.g. [4, 5, 6]) to illustrate programmatic principles. To an audience, who equate a lack of aesthetics with a lack of relevance, neglecting the importance of the visual quality causes them to lose interest. To encourage graphic designers to explore programming as a creative tool, it is vital that new teaching strategies be developed, tailored to fit how this specific audience acquires new knowledge. In a contribution towards building computational literacy among graphic designers, this paper proposes and describes a hands-on experiential pedagogic method, deconstruction/reconstruction, specifically designed to introduce programming in a visual context.

2. Background and influences

For nine years I have taught introductory programming classes to undergraduate graphic designers at The Danish School of Media and Journalism. During this time, I have observed some recurring critical issues that negatively affect student retention, engagement, and learning outcome:

- Students find it hard to relate the activity of programming to their line of work.
- Students feel intimidated by the prospect of working with mathematics, logic, and structure.
- Students respond poorly to a lack of aesthetic quality in the output produced by their code.
- Students are easily distracted when asked to consider aesthetic issues. They quickly obsess over design-related issues, forgetting that their primary goal is to learn how to program.
- Students lack a starting point for their knowledge construction. As novice programmers they spend their time in the bottom half of Anderson and Krathwohl's Taxonomy [7], not yet in a position where they feel confident about programming to be creative with it.
- Students respond negatively to passive auditorium lectures and abstract, verbal explanations.
- Students are deterred by strange syntax and indecipherable error messages.

Seeking to alleviate these issues, I decided to develop a new pedagogic method specifically tailored to accommodate the learning needs of my students. To inform the design of the method, I summarized my observations into a set of guidelines:

- The link between programming and crafting of visual artifacts must be clearly visible.
- The output of the programming exercises must be visual
- The output must possess an aesthetic quality that makes it useful and sellable at a professional level.
- Students must be given an "object-to-think-with" [8], a cognitive artifact to serve as a link between their pre-existing internalized mental structure ("how to create graphic design") and the formation of new abstract knowledge ("how to program").
- Students must be given a fixed goal to provide a clear focus. Also, a fixed goal can serve as a measuring stick allowing students to continuously evaluate their progress.
- Students should not be asked to consider aesthetic issues to keep them focused on learning how to program.
- Mathematics, logic, and structure should only be taught when the students encounter a need for it, preferably by letting the students investigate the topic themselves, guided by the teacher.
- Students must be given the same material to encourage sharing of knowledge and discussion around a common base.
- Students must be actively engaged in the task of programming to build hands-on experience.
- Students must work in a programming environment that provides a low threshold (easy entry to usage for novices), high ceiling (powerful facilities for sophisticated users), and wide wall (a small, well-chosen set of features that support a wide range of possibilities) [9].

I chose to build the method around the recreation of pre-existing design specimens. This decision resolved several issues at once: It established a direct link between programming and design, introduced a relatable "object-to-think-with" that doubled as a fixed target, thus eliminating the risk of students losing focus by being having to make aesthetic choices.

Constructionism was chosen as the theoretical foundation of the method. Among other things, constructionism let students use the information they already know ("how to create graphic design") as a foundation for acquiring more knowledge ("how to program") in a different domain. Also, constructionism holds that learning happens most effectively when students are active in making external artifacts they can reflect upon and share with others. Finally, constructionism prescribes that the teacher must take on a mediational role as opposed to an instructional role, assisting students to individually understand problems in a hands-on way.

Guzdial [10, 11] suggest that teaching programming needs to be contextualized and meet the needs of the learners. The target audience is intended to merely be “programming tourists,” [12], thus a rigorous adherence to “correct” Computer Science terms was abandoned in favor of a terminology that better helped students build cognitive models of programmatic principles. Another key factor in favor of contextualization is to make apparent the usefulness of programming in the student's profession.

A term introduced by Papert [8] and later popularized by Wing [13], Computational Thinking deals with thought processes involved in formulating a problem and expressing its solution(s) in such a way that a computer—human or machine—can effectively carry out [14]. Key principles in Computational Thinking are:

- Decomposition (breaking down a complex problem into smaller, more manageable parts)
- Pattern recognition (looking for similarities among and within problems)
- Abstraction (focusing on the important information only, ignoring irrelevant detail)
- Algorithms (developing a step-by-step solution to the problem, or the rules to follow to solve the problem).

These principles influenced the design of the method and are embedded in the activities therein.

Finally, the work of Stahl [15] also informed the design of the method. According to Stahl, transforming tacit preunderstanding into a computer model happens in a series of successive steps. In his discussion, Stahl, among other things, suggests a taxonomy of classes of information [15, pp. 178-183]. This taxonomy greatly inspired the design of the method to be a number of sequential steps divided into two distinct phases.

3. Method described

The deconstruction/reconstruction method consists of two successive phases, deconstruction, and subsequent reconstruction. Each phase has three steps. Activities associated with each step are briefly described in figure 1. A detailed account of how the method is applied in practice is given in section 4 of this paper.

Phase	Step	Activity	Material	Domain
Deconstruction	1	SELECT Choose a pre-existing graphic design product specimen to be deconstructed from the sample set provided by the course instructor.	Paper and pen	Graphic Design
	2	DESCRIBE Make detailed notes about immediately visible visual components, e.g., shapes, typography, colors, scaling, rotation, grids, rhythm, and repetitions.		
	3	ANALYZE Identify and formalize invisible components, e.g., interconnections, math, logic and rules required to control the design system and make it behave as desired.		
Reconstruction	4	CONVERT Convert notes from steps 2 and 3 into code that replicate the chosen specimen. Use the original specimen as a visual reference to guide and evaluate the process.	Code	
	5	EXPLORE Modify the variables in the design system to create alternate versions of the original specimen.		
	6	TINKER Modify (and possibly break) the code to create radical mutations of the original specimen.		Computer Science

Figure 1: Schematic overview of the deconstruction/reconstruction method.

The purpose of the deconstruction phase is to keep the students in their comfort zone by letting them rely on their pre-existing knowledge of graphic design principles and terminology to deconstruct an existing design product to form the basis of the reconstruction phase. The purpose of the reconstruction phase is to let students discover programming as a practical craft acquired by incremental conversion of their notes from the deconstruction phase into code, thereby constructing a self-contained design system capable of reproducing the chosen specimen, and acting as a platform for playful discovery through manipulation of variables and the code itself.

As the student completes each step, he/she gradually shifts from using their existing skills in a familiar domain (Graphic Design) toward acquiring new skills in an unknown and unfamiliar domain (Computer Science).

Material

As its main material, the method uses pre-existing commercially applied graphic design specimens. Examples of these are posters, packaging, logos, typography, signage, bank notes, stamps, etc. Specimens are handpicked by the teacher based on their ability to be deconstructed, meaning that they must exhibit distinct visual characteristics indicating that an underlying system or set of rules has played a key role in their creation. Specimens should be easily replicable using geometric primitives, basic linear transformations (e.g., translation, rotation, scaling) and control flow statements (e.g., decision-making, looping, branching). A selection of suitable specimens that meet these criteria is shown in figure 2 to provide an idea of the visual genre.

Figure 2: A selection of specimens suitable as material for the method.

Figure 3: Poster by Enzo Mari (1963)

4. Method exemplified

In this section, the activities associated with each step of the deconstruction/ reconstruction method are discussed using Enzo Mari's 1963 poster "Arte Programmata: Kinetische Kunst" [16] (figure 3) as example. Processing [17], a popular Java-based language for learning how to code within the context of the visual arts, is used as the programming environment.

Step 1: Select

Guided by his subjective aesthetic preference, a student, Peter, chooses the Arte Programmata poster from the set of specimens provided by the teacher.

Step 2: Describe

Taking notes using pen and paper, Peter describes the poster's immediately visible components:

- "The poster is portrait format."
- "The background color is brown."
- "The upper part of the poster contains one 5x5 grid of black squares with inset spacing taking up the entire width of the poster excluding a border margin."
- "Each black square contains one white square of varying size."
- "The white squares increase then decrease in size while forming a spiral pattern."
- "The white square is fixed to the lower right corner of the black square."
- "The lower part of the poster has a white all-caps title spanning the entire width of the poster excluding the border margin + an additional black text set in a small font size aligned to the left."
- "Separating the 5x5 grid and the typography is a small white logo aligned to the left."

Peters observations are described using graphic design terminology familiar to him. Embedded in his description are clues about features that he must consider in his code (e.g. "square," "grid," "border margin," "inset spacing".)

Step 3: Analyze

Still using pen and paper as his material, Peter identifies and formalizes the underlying math,

logic and rules needed to construct the poster. In the previous step, Peter loosely described a spiral pattern of oscillating white squares. In this step, he must make additional considerations to explicitly describe this spiral pattern: Is it rotating left or right? Does it go inside out or outside in? Where are its starting and ending points? Also, looking at the oscillating squares: How many oscillations? What are the minimum and maximum size? What principle is used to calculate the rate of change in size: Sine waves? Linear interpolation? Exponential change? These observations do not translate into simple built-in commands. They require rules to be established and algorithms developed. To formalize a thing like oscillation, something that is otherwise easily (but imprecisely) verbalized, Peter is forced to look into mathematics of oscillating functions, realizing that even a seemingly simple thing like oscillating movement can be accomplished using many different techniques all of which ultimately affect the visual style of the output. No code is written yet, although, during his research, Peter comes across a pseudocode spiral algorithm that helps him understand how spiral patterns are constructed in a two-dimensional grid.

Step 4: Convert

In this step, Peter launches Processing, as he transitions from paper and pen to code. By using his notes from previous steps as starting point, Peter gets an idea of what his program must contain and do. Sampling the original artwork, he converts colors from broad descriptions to specific color codes ("Brown" = `#5A4531`, "White" = `#F7F1E5` and "Black" = `#000000`). Squares are drawn using the built-in `rect()` command. The 5x5 grid is constructed using two nested `for()`-loops representing x-coordinates and y-coordinates respectively. To correctly place the black and white squares, functions like `pushMatrix()` and `popMatrix()` in conjunction with `translate()` is used. Investigating the `sin()`-function, Peter chooses a sine wave moving from 0 to π to achieve the oscillating white squares. In search of a way to mimic the spiral pattern, Peter modifies pseudocode found online to fit his needs. The typography can be made either as text or inserted as an image. Painstakingly recreating complex typography letter by letter serves no point; also, students might get distracted from programming when trying to correctly identify, download and install the font. Therefore, in this example, Peter was asked to simply cut out the original typography as a separate image using Photoshop, and insert it into his program as a static image. As Peter converts his notes from steps 2 and 3, he gradually constructs a program capable of recreating the original specimen. Besides acting as an "object-to-think-with," the original poster also doubles as a visual reference used by Peter to measure his progress and evaluate the behavior of his program.

Step 5: Explore

In this step, Peter must produce alternative versions of the original poster without modifying his code. By only changing variables, in this particular case using Processings "Tweak Mode," instant feedback is provided allowing for real-time exploration of the solution space inherently described by the code. A set of Peter's possible alternatives to the original specimen, obtained by tweaking the variables in his code, can be seen in figure 4.

Figure 4: Alternative versions obtained by tweaking variables.

Step 6: Tinker

Having gained an understanding of the "mechanics" of the code, Peter begins modifying the code itself. Now, more radical solutions emerge. The result of Peters' tinkering with his code as well as continued tweaking of the variables can be seen in figure 5.

Figure 5: Alternative versions obtained by modifying code and tweaking variables.

5. Method used in teaching

I used deconstruction/reconstruction method in two introductory programming courses taught at The Danish School of Media and Journalism. Participants were classes of 20-24 undergraduate graphic design students (ages ranging between 21-33 years, 50/50 gender ratio) with little to no prior programming experience. The aim of the courses was to equip the students with sufficient cognitive and practical skills to enable them to conceive and execute custom made code-driven design systems. The deconstruction/reconstruction method was used as a recurring daily exercise in the first week.

As prescribed in the method, I chose a sample set of 20 pre-existing graphic design specimens from a curated collection [18]. The entire set of specimens made available as handouts and

digital files to the students is shown in figure 6.

Figure 6: The collection of chosen specimens taped to the blackboard in the studio provided a quick visual overview.

Step 1: Select

Initially, choosing a specimen was a simple matter of personal preference and daily mood. Later, the students' choice was influenced by their newly acquired skills. If they had learned how to make a two-dimensional grid, students tended to choose a specimen that would allow them to reuse this programmatic feature in addition to posing a new challenge.

Step 2: Describe

The students felt confident as they began to describe their chosen specimen. Trained observers of graphic design, students had few problems describing the immediately visible components. Perhaps overly confident in their own ability to memorize their findings, I found it necessary to stress the importance of noting all observations on paper. Students spontaneously developed the habit of using Photoshop's eraser and cloning tool to remove all design components besides the background and typographic elements. This provided an authentic background to import in step 4 to make the output look almost identical to the original specimen.

Step 3: Analyze

Students began leaving their comfort zone when asked to explicitly describe the math, logic, and rules of their chosen specimen. Certain relations and behaviors were easily described using basic mathematical principles (e.g., sine/cosine, Pythagoras, linear transformations) while others relied on formulas or phenomenon one could not expect the students to know beforehand (e.g., Fibonacci series, recursion, moiré). I assisted the students in researching any formulas or techniques they might need to recreate the specimen, being careful not to provide explicit answers. This step provided a great opportunity to for the students to practice and utilize Computational Thinking principles as discussed in section 2 of this paper.

Step 4: Convert

Launching Processing and converting notes into code, students gradually discovered how

variables, arrays, functions, classes, as well as other programmatic building blocks, helped them extend their static system to become a fully functioning, dynamic system capable of replicating the original specimen. This step was – without a doubt – the most challenging step for the students. They spent the majority of the time working on the daily assignment completing this step, slowly grasping programming logic, structure, looking up syntax in the language reference, and tracking down bugs.

Step 5: Explore

In this step, students used Processing's 'Tweak Mode' to manipulate variables with instant visual feedback. They would bend, stretch and inevitably break their programs. Immersing themselves in playful experimentation, students kept generating new variations from the seemingly infinite number of possibilities, always curious to discover what output their system would generate next. Students were asked to capture a visual log of their progress to show the extent of the visual diversity that their system was capable of producing. Examples from a students' visual log are shown in figure 7.

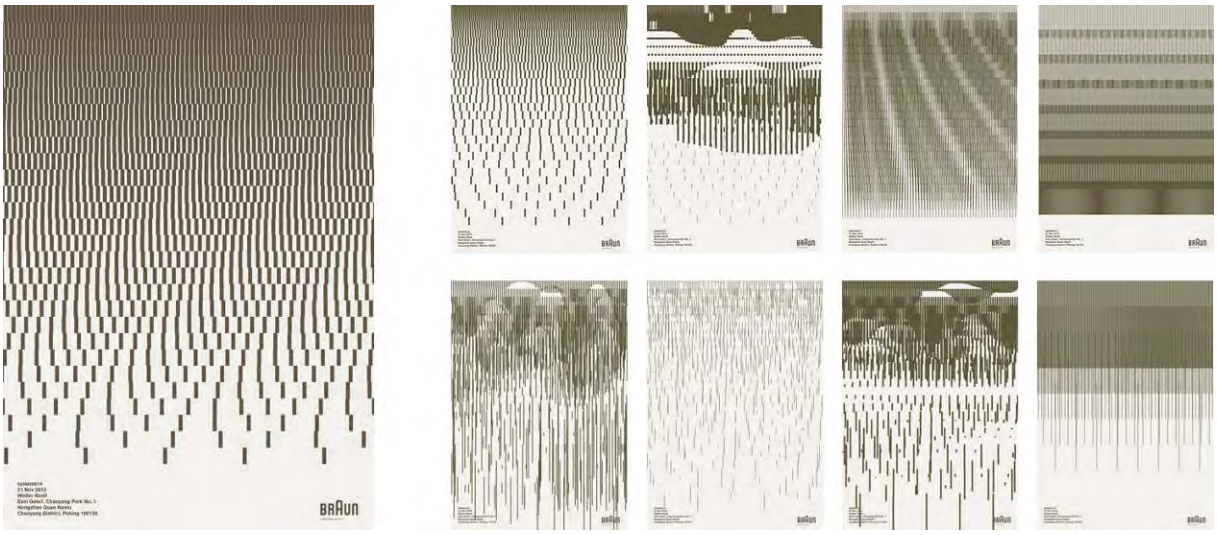

Figure 7: A students attempt at recreating the original specimen (big image, left) [19] using code, and his subsequent experiments modifying the identified variables and the code itself to produce radically different versions (small images).

Step 6: Tinker

Spurred on by their active experimentation in step 5, students began to modify the code itself. Through this process, students discovered that code, although immaterial and intangible, still possess plasticity and is highly malleable. Their confidence in their abilities grew, and this kind of tinkering and hacking was encouraged to support their urge to experiment. This step gave occasion to discuss topics like version control, optimization and advanced debugging.

Most students managed to work through steps 1-6 in one day (= 7 hours of scheduled and supervised studio time). On a few occasions, students gave up trying to complete the daily assignment. This was mainly due to issues arising in step 4 as a result of their lack of experience.

True to constructionist learning theory, students were asked to share their experiences with fellow students, currently trying to solve the same specimen. This had them verbalize and explain how they had arrived at a solution, further anchoring their understanding of what they did.

6. Concluding remarks

In this paper, a pedagogic method for teaching graphic designers programming in a visual context has been outlined and put into practice. Supported by an overall positive student response expressed in follow-up plenary interviews, the method appears as a promising way of introducing graphic design students to programming in a visual context.

The idea of contextualizing programming using pre-existing graphic design specimens was well received. Students entered their programming course with skepticism and anxiety, but introducing the deconstruction/ reconstruction method and explaining how it relied on familiar and well-known material defused the student's immediate aversion to code. The students also appreciated being given a real-life case as a starting point and step-by-step method to guide their learning process.

Though praised by the students, it can be argued, that repetitiously remaking work done by other graphic designers does not stimulate them to synthesize their knowledge into new independent creations. While this might be true, the deconstruction/reconstruction method is primarily designed to keep students engaged and motivated while introducing them to the nuts and bolts of programming. If students, by the rote learning and repetitive practice implicitly inscribed in the method, manage to cognitively link visual patterns with basic programmatic techniques, they have established a solid basis for taking full advantage of the creative potential of computational media in their future line of work.

To further put the social and learning-through-sharing ideas of constructive learning theory in play, one possible future improvement would be to make the deconstruction phase group-based to incite discussion and make problem-solving a more verbal exercise. Moving to the reconstruction phase, shifting to individual work will still allow for a personal hands-on experience with programming. Having multiple students working individually in parallel to implement a jointly deconstructed specimen will further increase the chances of students helping and learning from each other.

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Tatsuo (right) and Daniel (left).

RAPID BIOGRAPHY IN A SOCIETY OF EVOLUTIONARY LOVERS

(Paper and Installation)

Topic: Narrative, Evolution, Simulation, Psychology

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Abstract

Love and sex are popular topics of human's interests widely common in any period in the history and at any place on the earth. These words have been employed for the subjects of any forms of artistic activity such as poem, novel, play, movie, painting, sculpture, music, and so on. Love itself is made up of relation between persons attracted each other. As you can see from the fact that the word "beauty" is typically applied to women, it can be assumed that attractiveness is one of the origins of aesthetics from a viewpoint of evolutionary psychology [1].

For a scientific research to seek the origin of beauty, we developed an agent-based simulator of society of evolutionary lovers. A population of thousands of agents lives in a two dimensional virtual world where they are roaming around. Each agent has its own physical appearance and psychological preference as the sex-influenced hereditary traits. It approaches another agent whose appearance matches its preference. If two agents are attracted each other and stay together in enough time, the female agent may bear a child if the sexes are different. Since the correspondence between sex and appearance is not clearly assigned a priori, half of the couples are homosexual in the initial population. However, the appearance and preference are evolved toward sexual dimorphism, separation of the traits between male and female, thanks to the advantage of heterosexual mating for successful reproduction. To make mating easier, we allow an agent to propose its lover to receive the response of acceptance or refusal. The other traits are also introduced such as activeness, fickleness, tolerance, compromise, and so on.

This simulator is useful not only for a scientific research but also a form of generative art that presents huge number of biographies of agents rapidly. It produces approximately sixty stories of individual lives per second, since it has an ability to simulate one year of virtual world in one second of throughput time for six thousands agents. The system picks up six sample agents to display and announce the life events, such as birth, love, proposal, separation, and death. When a sampled one passed away, another new born agent replaces it. Each agent is called its name randomly assigned from the list of English names for boys and girls.

In the installation, the two dimensional view of the virtual world and the texts of life events are dynamically displayed on the screen, and some of the texts are read loud using speech synthesis by the computer. It sounds sometimes hilarious and sometimes impressive. Human life is a series of happiness and sadness. You may be moved by such stories even though the computer generates them automatically.

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Key words: generative story, biography, evolution, love and sex

Main References:

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Rapid Biography In A Society Of Evolutionary Lovers

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Premise

We developed an evolutionary-ecological simulator for a scientific research in order to seek the origin of beauty from a viewpoint of evolutionary psychology, which simulates a large number of human lives for longer than some tens of centuries for some thousands of individuals as the population size. It generates a lot of biographies rapidly, and it becomes effective for the viewers when each individual is given its own name as same as humans, and summary of each life is read loud by the computer. We extended the system so that it picks up a number of sample individuals from the population, displays their life events, and reads some of those sentences and summaries as many as possible utilizing a speech synthesis by the computer, under our intention to turn it to a piece for automatic generative art. The ratio of homosexual couples is 50% in the early phase because there is no clear correspondence between appearance and gender. However, the appearances and the preferences are gradually getting separated between male and female thanks to the advantage of heterosexual mating for reproduction, supported by the genetic encoding as sex-influenced hereditary traits. We are hoping this piece provides an occasion to audience to rethink their lives typically on the human relation and gender diversity among lovers and families.

1. Introduction

Love and sex are popular topics of humans' interests widely common in any period in the history and at any place on the earth. These words have been employed for the subjects of various forms of artistic activities such as poetry, novel, play, movie, painting, sculpture, music, and so on. Love itself is made up of relation between persons attracted each other. As you can see from the fact that the word "beauty" is typically applied to women, it can be assumed that attractiveness is one of the origins of aesthetics from a viewpoint of evolutionary psychology [1, 2].

For a scientific research to seek the origin of beauty, we developed an agent-based simulator of society of evolutionary lovers. A population of thousands of agents lives in a two-dimensional virtual world where they are roaming around. Each agent has its own physical appearance and psychological preference as the sex-influenced hereditary traits. An agent approaches another one whose appearance matches its preference. If two agents are attracted each other and stay together in enough time, the female agent may bear a child if the partner is a male. Since the correspondence between gender and appearance is not clearly assigned a priori, half of the couples are homosexual in

the initial population. However, the appearance and preference are evolved toward sexual dimorphism, separation of the traits between male and female, thanks to the advantage of heterosexual mating for successful reproduction. To make mating easier, we allow an agent to propose its lover to receive the response of acceptance or refusal. The other traits are also introduced such as activeness, fickleness, tolerance, compromise, and so on.

The simulator is useful not only for a scientific research but also a form of generative art that presents huge number of biographies of agents rapidly. Each biography is a series of life events described by simple sentences with individual names randomly assigned from the list of English first and family names. Though it has no rhetoric for impressive representation, it sounds interesting that inspires a type of sympathy to the life of agent.

In the installation, the two-dimensional view of the virtual world and the texts of life events are dynamically displayed on the screen, and some of the texts are read loud using speech synthesis by the computer.

In the following sections, some details of visualization and speech synthesis are described after a design overview of the simulator.

2. Overview of the Simulator

As similarly as the pioneering works of evolutionary ecological simulation in the field of artificial life, such as PolyWorld [3], the environment is a square shape of two-dimensional Euclidean space with continuous Cartesian coordinates surrounded by four walls. Some hundreds of still objects are randomly placed, and some thousands of agents are roaming around inside of this virtual world. Each agent has its own state of position and age. It gets older by a constant portion of month for each simulation step. The maximum life span is 120 years and it is divided into three periods of child, adult, and elderly ages, where the boundaries are 16 and 50 years old for example. Each agent may be killed in a probability in each step that is predefined following the population statistics issued by Japanese government [4]. The characteristics of individual agent are specified by its own genetic codes inherited from its parents which includes appearance, preference, and other parameters for action selection. The following sections describe overviews of movement, mating between agents, genetics, and control. The detail specifications including the mathematical model and embedded tools for statistical analysis will be available in another literature [5].

2.1 Movement

Each agent has a vector of the velocity to be modified in each step by adding a force vector synthesized from factors of both attraction and repulsion. It is discounted by a friction at the same time. It is always affected by repulsion forces from walls, objects, and the other agents in order to avoid the collision, but attraction forces are different depending on the age. When the agent is a child, it intends to follow its mother, but it starts approaching another attractive agent when it became adult. It just intends to keep staying together with its mutual lover if exists, after it became elderly. The position of the agent is revised in each step using a simple Euler method by adding the velocity vector to the current value of the position. Because the attraction forces are inversely proportional to the distance to the target agent, mother or lover, and the repulsion forces are inversely proportional to the square of the distance to the obstacle, an agent usually

moves towards its target agent but soon escapes from a nearby obstacle when the distance becomes short.

The degree of attractiveness is measured basically as a similarity between the agent's preference and the target's appearance, but the physical distance is also an important factor to select which agent is the best. It is often better to choose an acceptable one nearby than the best beauty in a distance. An adult agent always tries to find the best target in the observable area, within a constant distance from the agent. Measuring the attractiveness as a weighted geometric mean between the matching degree and the physical closeness. The weight is a hereditary trait encoded on the gene as described in the section 2.3.

2.2 Mating and Reproduction

If two agents mutually select each other as the best target to love, or if the target agent accepted a proposal, the relation between two agents is established. If the relation continues for enough time and the genders of the agents are different, the female agent may become pregnant under the predefined probability depending on the age. The probability is high until the middle of adult period, but it decreases toward zero at the boundary of elderly age. The highest value is depending on the population density on local area around the agent to avoid the population explosion and extinction. A baby agent is born after ten months passed at the adjacent location with the mother.

The attractiveness is not affected by gender, but to avoid incest, an agent ignores its parents, brothers, and sisters as a candidate to love. An agent sometimes gets to love an object since the still objects placed in the world are also potential candidates by the appearance of their color.

The probability to propose the best one depends on the activeness, and the probability to accept the proposal is proportional to the tolerance. If the receiver of the proposal already has a mutual lover, it might accept it if the fickleness is high. It also depends on the fickleness whether the agent proposes an attractive target even when it has a mutual lover. If the proposal was refused and the proposer is graceful enough, it memorize the target agent to prevent from proposing it again until it is forgotten. These parameters of characteristics are encoded on the genes as described in the next subsection.

2.3 Genetics

Each individual agent has its own genome including five elements on appearance and preference for each and eight elements affecting the behavior. Each element is represented in a real number within a range from 0 to 1. Three out of five elements for appearance and preference are the color components of red, green and blue. The others are plumpness and aging in the look. For a female agent, the plumpness is temporary changed when it is pregnant. If the value of aging is high, the agent looks older than it is. If the value is low, it looks younger. The aging value for preference indicates how old target the agent prefers in observation. The elements on behavior include love-hate threshold, fickleness, duration necessary to deepen the relation, distance bias for compromise, activeness of proposal, tolerance to accept proposal, gracefulness to give up retrial of proposing, and maximum speed of movement.

A genome consists of double of these genes as they are sex-influenced, that is, one side manifests when it is male, and the other side manifests when it is female. When a

new genome for a child is organized, the element for each locus is a mutant of the gene randomly selected from the same locus in the genome of either mother or father. The mutation is made by adding or subtracting a small random number to or from the original value.

2.4 Control

The simulation software is equipped not only with graphical user interface for manual control by the user, but also with a software interface that enables another application software to send a command to the simulator and to receive data as the response if necessary. This functionality is useful to conduct a large number of trials automatically with a variety of parameter settings and different random number sequences. For a scientific research, it is important to conduct such simulation in an enough number of times to induce statistically feasible consequences. At the same time, it is also useful for a purpose of installation as an automatic art. We developed a control application to realize the iteration of initialization of the parameter settings, periodical changes of display, and restart after tens of minutes passed, as described in later section 5. It also accepts an interruption by the user for emergency stop. As the application software runs on macOS, the communication between the applications is implemented utilizing Apple events. Therefore, it is relatively easy to develop a controlling software in the scripting language, AppleScript.

3. Visualization

Visualization is important in general for any types of computer simulation to show what happens in the process. As an automatic art using the computer, this piece shows who is doing what in the virtual world especially concerning the love and mating. Figure 1 shows a typical example of screen image where the left side is the two-dimensional distribution and movement of objects and agents, the trend graph and density distribution of statistical indexes are displayed at the right bottom, and the sentences describing the life events of six sampled agents are printed at the middle right part of the screen. The sentences are shown not only as scrolling texts at the right side, but also displayed in the balloons attached to the agents in the distribution part at the left side. The background color of the balloon is same with the title bar of scrolling area. The top part of the right side is also a scrolling text of summaries of individual lives that is added when a monitored agent passed away. The arrangement is designed suitable for an ordinal full HD screen of 16 by 9 as the aspect ratio.

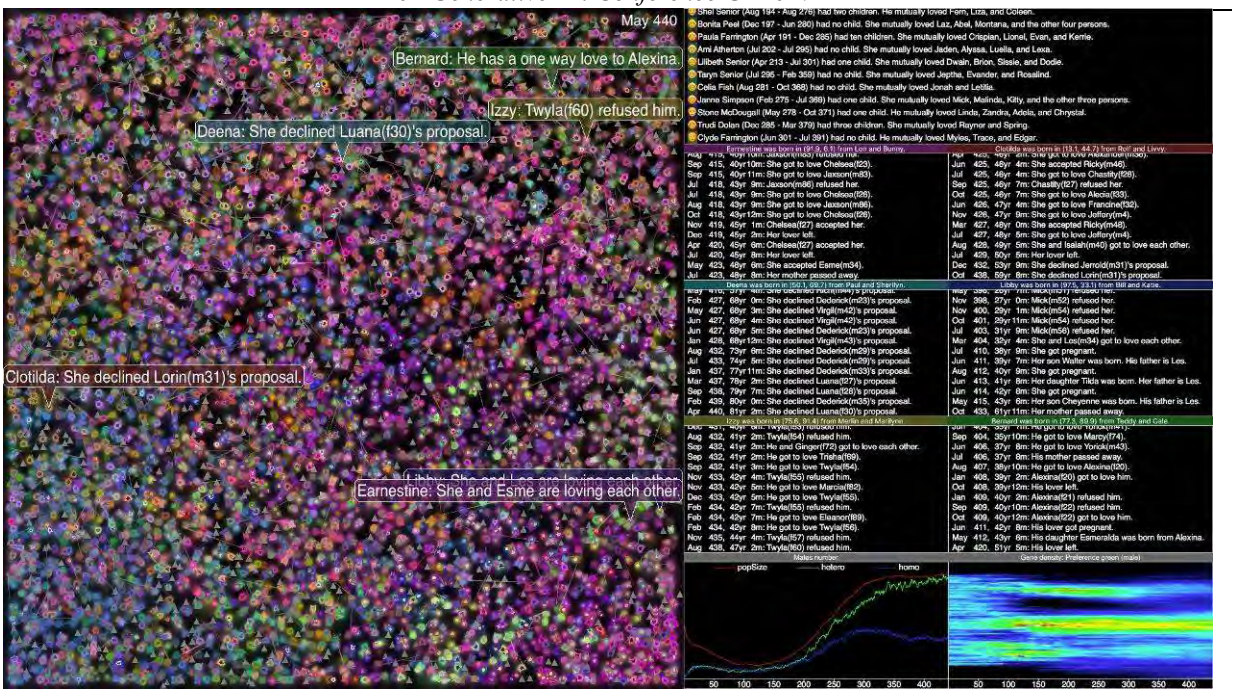

Figure 1. *A typical example of a view of the screen.*

The following part of this section describes the detail of each part of the screen, and the design of extra monitor that allows the visitors to browse the individual biography using a tablet terminal connected via Wi-Fi.

3.1 Agents

Each individual agent is rendered on the screen as a shape with two colors, the outer color is the appearance and the inner color is the preference, as shown in Figure 2. A male agent is drawn in a shape of arrow head, and the female agent is in a round shape. The aspect ratio is determined from the plumpness. It is drawn in a small size when it is a child, and gradually grows up until it reaches the age of adult. The color becomes gradually darker after it enters the elderly age. It rotates following the moving direction if it has no lover, but are facing the lover if exists regardless of the movement direction.

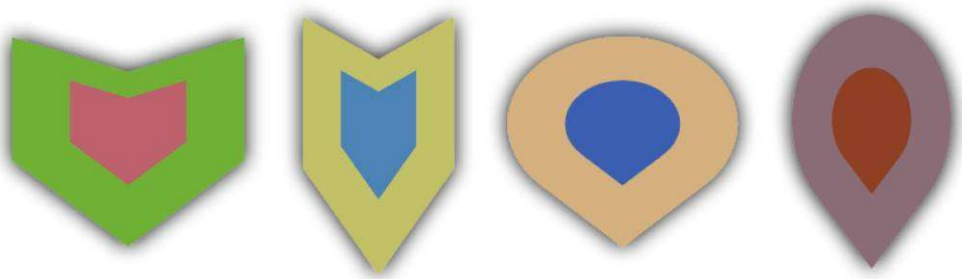

Figure 2. *Examples of agent figures in visualization. The two shapes in left side are male agents, and the two in right side are female agents.*

If an agent has a lover, it expands the right arm toward the target. The edge of the arm is shaped sharply as it points the target when it is a one-way love. If they are loving each other, the edge becomes round and it looks as if they are hugging. The color of an arm is a gradation of the appearance color at the shoulder and the preference color at

the fingers with half transparency. Figure 3 shows another example of a screen shot where the view of the distribution is zoomed.

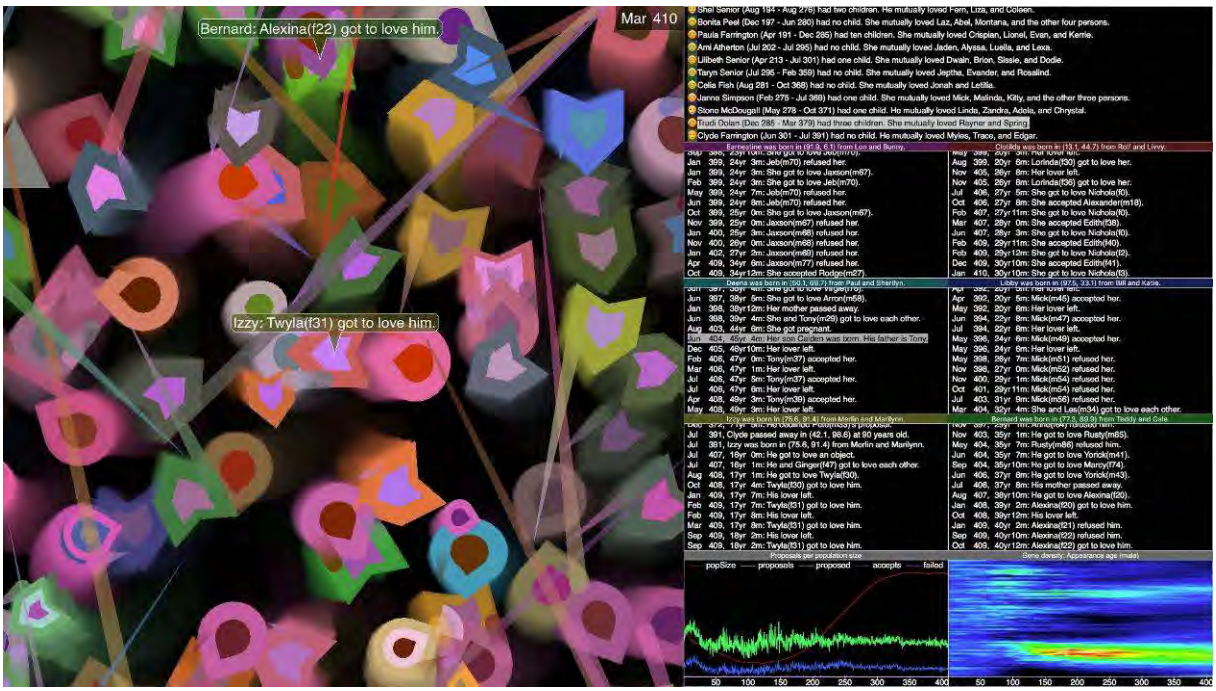

Figure 3. *A sample screen shot with zoomed display.*

3.2 Monitoring the Life Events

The life events to be described in the monitor are concerning birth, love, being loved, proposing, being proposed, acceptance, refusal, separation, birth of its child, and death. If the name is Tom, the sentence of his birth is “Tom was born from John and Mary,” for example. The events of an individual is shown in a separated scrolling text area from the others as shown in Figure 1 and 3. The sentence of its birth is drawn in the title bar of the area with unique background color in order to make it easy for a viewer to identify the agent displayed in the left side. A summary sentence is added when a monitored individual passed away in the area of top right part of the screen is “Tommy Smith (Jan 1023 - Sep 1102) had two children. He mutually loved Mary, Jane, and Kathy,” for example.

The name for each agent is randomly assigned from the list of English boy and girl names gathered from the internet [6]. The family name for the summary is also chosen from a similar list [7], but it is randomly assigned only for the initial population, and it is inherited to the children from the mother or the father. The mother’s family name is always inherited if the father has left or gone when the child is born. Because the number of girl names we gathered is larger than boys’, the names common in both boys and girls, such as Alex and Chris, were omitted from the list of girl names. To prevent from occasional overlaps between first and last names, the overlapped names, such as Bennett and Lee, were also omitted from the first names lists. In the current implementation, the system contains 921 boy names, 1,377 girl names, and 1,199 family names.

3.3 Browsing the Individual Biographies

The biographies generated through out the simulation process provide interesting narratives for the visitors. To allow them to appreciate these life stories, we added a functionality to save the life events in a separated file of HTML format for each individual. The list including the links to individual profiles is also organized and revised when a monitored individual has gone. By storing these files in a directory for the contents of web server running on the same machine that the simulator is running, the visitors can browse the biographies by operating the separated tablet terminals through Wi-Fi connection. Figure 4 is a sample screen image on the tablet terminal. When the visitor touch a name in the list shown in the left side, its biography is displayed at the right side with the background color same with the color shown in the simulator. The image of agent's shape is also shown in the background. A emoji face is attached to each item in the list to make it easy for visitors to recognize the death age and gender. Since this is a web application viewable from modern web browsers, it is also possible to enjoy it using a user's smart phone and a web browser on user's PC.

Figure 4. *A sample screen image of the biography browser on a tablet terminal.*

4. Sound Effects and Speech

The system synthesizes sound effects and speeches similarly to the visuals. Three types of sounds start when the corresponding events occur in the displayed part of the virtual world. The events include birth, proposal, and death. These events correspond to the sounds of a baby cry, a human voice telling "I love you," and a funeral bell, respectively. The adult and elderly agents probabilistically express their emotion by happy laughters when they have mutual lovers, and by sad sighs when they are alone.

The human voices are selected depending on the gender. We employed license-free sound samples available from the internet. The sounds are modulated in various playback speeds, and are played back mixed all together. It sounds a noise when the whole of the world is displayed, but it becomes clearly recognizable when the display is zoomed. The balance between two audio channels, left and right, is also helpful to identify who are making the sounds.

The system also produces sounds of speech that reads the sentences loud. The displayed events are generated too fast to read them all, some of them are chosen to be spoken by referring the importance. Birth and death are recognized more important than proposals in the current settings. Behind the spoken events happened on the six sampled agents, approximately sixty stories of individual lives are produced for each second, since it has an ability to simulate one year of virtual world in a second of throughput time for some thousands of agents under the settings where three simulation steps are interpreted as one month.

The summary sentences are also read loud in another audio stream in louder voice. It is usually possible to speak them in time, and sometimes it needs wait for the next sentence. During the summary is being read, the speech volume of life events is suppressed in half.

The speech synthesis is realized using a programming framework embedded in the operating system on the computer. In macOS 10.12, a number of high quality voices for a variety of English accents in both male and female are available for speech synthesis. The voice is changed for each 30 seconds in turn. To give a time for the voice of events to be recognizable, a 5 seconds pause is inserted before a next voice for summaries begins. The pitch of the voice is modulated higher when it reads happy events, such as birth of child and a start of loving each other, and modulated lower when a sad event happened, such as refusal of proposal and death of agent.

5. Exhibition Scenario

The simulation process itself has no limit of continuation for arbitrary number of steps. However, because it is interesting to watch the dynamical transition in the early phase from a random population to a relatively stable distribution, it is better to exhibit a reputation of limited length of simulations each of which uses different random number sequence. As Figure 5 illustrates, the population size rapidly decreases just after beginning, since most of individuals with random genome has no ability of successful reproduction. Some are trapped by an object as a target of their love. Some are hating all of the other agents even if they are proposed. But usually, some of the others find their partner and produce their children successfully. It is not always because the population might not include any agents that would succeed. In such a case of extinction, the simulation process stops and restarts again with a newly initialized population. We limited a single simulation process to 72,000 steps. It is possible to run faster but we allocated 30 steps per second in order to make the animation smooth. It means that a single simulation takes 72,000 / 30 / 60 = 40 minutes. This duration corresponds to 2,000 years in the virtual world. The average life span of an individual agent is approximately 85 years and the number of sampled agents is six, therefore the total number of sampled biographies is about 2,000 / 85 × 6 ≒ 141, listed in the browser described in section 3.3 at each end of a single simulation process.

To show the spacial distribution and movement of agents both globally and locally, the display iteratively changes the visible area from the whole to a local part. The cycle time is 40 seconds or so. When it zooms up, the area is selected so that a sampled agent is placed at the center of the frame if possible. If the focused agent moved toward the edge by which the frame edge violates the border of the world, the frame stops shifting from the boundary. When the focused agent died, the youngest sampled agent replaces it as a subject to be traced. The scale of zooming magnification is determined so that the sound effects generated by the visible agents are clearly recognizable for viewers, referring to the local agents density.

All of these transition including zooming in and out is controlled by a script code as described in section 2.4.

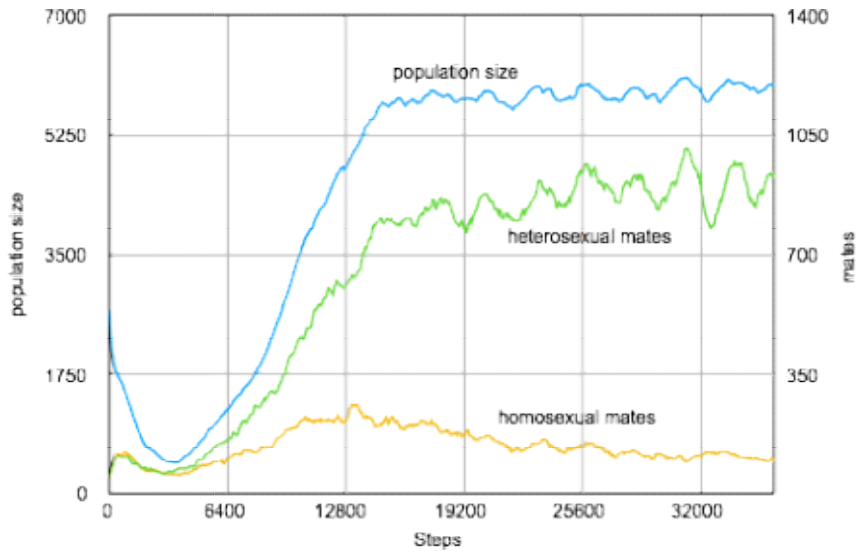

Figure 5. *A sample of time evolution in population size and the number of mates.*

6. Concluding Remarks

We developed an individual-based evolutionary simulator that imitates a long term human evolution focusing on a mating strategy by introducing a genetic mechanism of sex-influenced traits concerning appearance and preference. And we extended it so that it produces a huge number of individual biographies rapidly. By the graphical visualization of agents' distribution, movement, and relations; and by letting the system read the sampled life events loudly using a speech synthesis; it became possible to provide the viewer an occasion to enjoy a lot of unique narratives. It sounds sometimes hilarious and sometimes impressive. Human life is a series of happiness and sadness. You may be moved by such stories even though the computer generates them automatically.

Of course, there are many aspects to be added to the current model in order to fill the gap toward reality. As several researches related to the mating strategy of humans have been conducted in the field of anthropology, cultural studies, human evolution, and psychology, such as [8], the other interesting features to be considered include resource gathering, possession, protection, investment, and fighting to solve a conflict between individuals. Social aspects are also important for humans, such as cooperation, group conflict, ethics, social norms, and so on. From a viewpoint of gender studies, it must be

interesting to add some features that lead asymmetrical relation between male and female. It will be possible to produce more interesting biographies when some of these features are implemented in the simulator.

We are hoping this research and development will provide a path toward our scientific understanding on aesthetics, gender diversity, and mutual understanding among different cultures, in near future.

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Robert Spahr

TITLE : Scholars on a Picnic: Dada m'dada. DaDa mhm dada Da *(Paper)*

Topic: (Arts Practice and Pedagogy)

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Abstract part 1
This paper will explore the live performance of *Scholars on a Picnic: A Generative Ballet in Three Parts* through the lens of generative arts practice, algorithmic art, chance procedures and Dada montage. I will discuss the ways in which *Scholars on a Picnic* utilizes the theory and practice of Dada, and live performance as developed by Oskar Schlemmer at the Bauhaus, as well as looking specifically at the philosophical writings of the absurd by Albert Camus.

"If the world were clear, art would not exist." -- Albert Camus

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Key words: Chance Procedures, Dada, Bauhaus, Philosophy of the Absurd

Main References:

[1] Albert Camus, "*The Myth of Sisyphus*", Hamish Hamilton, London, 1955
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Scholars on a Picnic: Dada m'dada. DaDa mhm dada Da

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Premise

"If the world were clear, art would not exist." -- Albert Camus

This paper will explore the live performance of *Scholars on a Picnic: A Generative Ballet in Three Parts* through the lens of generative arts practice, algorithmic art, chance procedures and Dada montage. I will discuss the ways in which *Scholars on a Picnic* utilizes the theory and practice of Dada, as well as looking specifically at the philosophical writings of the absurd by Albert Camus.

1. Collaborative Live Art Performance

As a visual artist, I began my career making work using traditional processes of sculpture using wood, metal, casting and assemblage. As I became focused on the process of making art rather than the product, my work then began to shift between disciplines such as performance, installation, video and object-making as well as using the Internet as a space filled with media objects that flow in a stream of information to be used as found objects that can be juxtaposed, assembled and deconstructed. My current artistic practice also explores my interest in auto-generated work, computer coding and network culture, as well as an iterative generative process involving painting, drawing, printmaking. I will now outline the collaborative live art performance entitled *Scholars on a Picnic: A Generative Ballet in Three Parts*, and then discuss the methodology of using chance and indeterminism in relation specifically to the Act 2 Entre'acte of *Scholars on a Picnic: A Generative Ballet in Three Parts.*

Scholars on a Picnic: A Generative Ballet in Three Parts, is a live performance that incorporates chance, algorithms and game play to determine its parameters. In the post WWII period two very different games were developed that demonstrate the precarious position we find ourselves in at the start of the 21st Century, stuck between possible world destruction (auclear annihilation, climate change) and the potential peace (universal income, racial, religious and gender equality). We take as our starting point, the game La Conquête du Monde (The Conquest of the World) or as it was later called, Risk, the Game of Global Domination, which was developed in the late 1950s by writer/filmmaker Albert Lamorisse. Our second influence comes from the World Game or World Peace Game, an educational game developed by Buckminster Fuller in 1961 to challenge the notion of dominant nation states and to create solutions to problems like over population, world hunger, and now climate change. Our ballet is situated within the struggle between these two opposing possibilities, between brute force of capital/power and the peaceful sharing of resources and education, that are played out as both individual dilemmas and a societal call to arms. Our three protagonists, each representing a different philosophical approach to artistic/scholarly practice. I will be the 21st century dadaist, and my fellow performers Jay Needham, the ecological composer and Michel Leigh the feminist historian. We interact within the performance space using predetermined movements based on rules of play as we move through the two game concepts. Sounds are programmed using algorithmic processes incorporating chance and indeterminism to coordinate and determine who moves, how and for how long. Each of the three acts of the ballet are associated with specific historical moments in time, Act 1 Setting out the Picnic - The Battleground, 1755 to 1945, Act 2 Entre'acte - The Free-for-All, 2017, Act 3 Food Coma - Peaceful Slumber, 1957-1970.

2. Chance, Uncertainty and Contingency

"There is no such thing as chance. A door may happen to fall shut, but this is not by chance. It is a conscious experience of the door, the door, the door, the door."
(From *Lieschen* by Kurt Schwitters)

The Act 2 Entre'acte of *Scholars on a Picnic: A Generative Ballet in Three Parts*, uses chance as a generative process organize the composition of live art events. There is uncertainty as to the sequence of events, as the work develops it;s own composition based on the laws of chance. Act 2 Entre'acte bridges the Dada anger and frustration at the chaotic global destruction of post-WWI Europe, and our burgeoning neo-Dada anger and psychological stresses of our present age of Brexit, the presidency of Donald J. Trump, rampant nuclear proliferation and climate change. We find ourselves in an continual state of alertness, sleeping less due to overwork and insomnia. We live in a time of false memories and fake news, where elected officials can repeat the lies so often we begin to forget the truth. What was a radical juxtaposition of images in a Dada photomontage has become the mundane method of acquiring knowledge in our daily existence as we experience the overload of networked information sending waves of data to our laptops, tablets, and cell phones. We live in a world today that seems to be organized by the cynical rules of the game of Risk, and not the optimism of Fuller's World Game. In 1917, Dadaist Jean Arp composed a collage by shuffling torn scraps of paper, and gluing them down just as they fell. [1]

Jean (Hans) Arp
Untitled (Collage with Squares Arranged according to the Laws of Chance)
1917. Torn paper, 19 1/8 x 13 5/8" (48.5 x 34.6 cm)

This work created according to the Laws of Chance, calls into question long-held assumptions about artistic authorship, originality and skill. This work is made from a process that embraces uncertainty to create a contingent object. Today the events of our daily lives feel absurd, random, uncertain and contingent. As Gabrielle Buffet-Picabia, the first wife of artist Francis Picabia, said of Dada, " The ability of the unconscious to reconcile opposites is nowhere so evident as in Dada, for within a periphery of nonsense the ridiculous and the profound were made to evince each other: "Dada wished to destroy the reasonable frauds of men and recover the natural, unreasonable order. Dada wished to replace the logical nonsense of the men of today with an illogical nonsense. That is why we beat the Dadaist bass drum with all our might and trumpeted the praises of unreason... Dada like nature is without meaning. Dada is for infinite meaning and finite means." [2] The ballet *Scholars on Picnic* achieves a similar experience of this Dada cognitive dissonance of living in a world of logical nonsense while simultaneously wanting to replace it will illogical nonsense.

3. Chance Methodology

There are three methods of chance that I have used in my auto-generated visual art that has influenced the chance procedures in the development of the ballet, *Scholars on a Picnic.* I create digital collages by scraping the web using computational algorithms organized under the umbrella concept of *Cruft,* to then take apart, juxtapose, recycle, and interrupt the relentless flow of media on the Internet to reveal a relationship in which we don't simply consume media, but are also consumed by it. Chance is used in three different ways to auto-generate these *Cruft* .

3.1 Random Event / Selection

Using the Internet as a large database of flowing information, my work simple goes out to the network and selects images, audio files or text from specific web sites. The constantly changing information inherently makes the scraped media a random event. For this example I will use the source image for an auto-generated work entitled *Darkling Cruft (an eye on dangerous).* The computer program that generates this work captures an image every hour from surveillance cameras watching the streets of New York City. By the nature of a constant video feed, this selected image will always be random with various people and vehicles within the frame.

Randomly selected source image from a New York City CCTV camera.

3.2 Mutation / Transformation

An analogy to a Darwinian form of evolutionary mutation, several source images are digitally manipulated and transformed into an animation. Nature itself is structured on indeterminacy, from evolutionary processes to the Heisenberg uncertainty principle in quantum mechanics which states that the more precisely the position of some particle is determined, the less precisely its momentum can be known, and vice versa.

Started in 2017 with daily updates at 47 minutes past every hour
Source: CCTV Cameras in the City of New York

http://www.robertspahr.com/work/darkling/

3.3 Iterative Processes

An iterative process where either a digital or analog image is used as a starting point for a repetitive round of exploration and discovery. With each generation of new work,

surprises develop, and with continued repetitions there is a risk of boredom. Pushing through this boredom, and continuing iterations can sometimes produce a new state of mind which can reveal new avenues of inquiry that were not at first apparent.

Erebus: Watching the Dreams of Others #1
Woodcut print, 7" x 7"
2017, Signed and dated on the back.

http://www.robertspahr.com/work/erebus/

4. Contingent Moments

The chance processes in both my recent auto-generated work and those generating compositional structure in the ballet *Scholars on a Picnic* create a contingent art object

and live art experience. There potential as art is in flux and this fluidity reflects our false memories, fake news, and a world where facts are contingent. This art work becomes a residue documenting this contingent moment as we bear witness to the breaking news coming out of Donald Trump's White House. In the age of Trump, there is no other news. “There is but one truly serious philosophical problem and that is suicide. Judging whether life is or is not worth living amounts to answering the fundamental question of philosophy. All the rest - whether or not the world has three dimensions, whether the mind has nine or twelve categories - comes afterwards. These are games.” [3] There are so many distractions; reality TV; social media; and the 24/7 cable news cycle and we are in information overload as we experience a global psychological crisis. A crisis that the philosophy of “the absurd” seeks to describe. A world where we tend to seek a meaning to life, searching for it’s inherent value, only to discover our inability to find any.

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Michele Leigh

TITLE : Scholars on a Picnic: Feminist Coloured Glasses
(Paper)

Topic: (Arts Practice, Pedagogy and the Archive)

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Abstract part 2
This paper will explore the live performance of *Scholars on a Picnic: A Generative Ballet in Three Parts* through the lens of feminist critique. Borrowing from feminist scholars like Jaqueline Millner and Vicki Callahan, this paper will unpack the ways in which *Scholars on a Picnic* utilizes and creates an archive of sounds, images, texts and movement that at display, as Millner puts it, "the contemporariness of the past and its infinite malleability." It is through this concept of infinite malleability that this paper examines the potential of generative arts practice to expand our understanding of feminist scholarship in the arts and feminist arts practice.

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Key words: feminist, Arts Practice

Main References:

[1] Jaqueline Millner, "*Future Feminist Archive*", University of Sydney, Sydney, Australia, 2015.
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Scholars on a Picnic: Feminist Coloured Glasses

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Premise


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This paper will explore the live performance of *Scholars on a Picnic: A Generative Ballet in Three Parts* through the lens of feminist critique. Borrowing from feminist scholars like Jaqueline Millner and Vicki Callahan, this paper will unpack the ways in which *Scholars on a Picnic* utilizes and creates an archive of sounds, images, texts and movement that at display, as Millner puts it, "the contemporariness of the past and its infinite malleability." It is through this concept of infinite malleability that this paper examines the potential of generative arts practice to expand our understanding of feminist scholarship in the arts and feminist arts practice.

Wearing My Feminst Coloured Glasses

It is time to return to what feminism has to tell us.
It is time to make the case for what women have to
say about the perils of our modern world.
Jacqueline Rose, 2014 [1]

As a feminist film scholar and historian, I spend a significant amount of my time searching in archives and working to recuperate the contributions women have made to art and culture. I am particularly interested in the power of feminine/feminist aesthetics in arts practice to unseat traditional hierarchies to create a space, however liminal, where dialogues can be opened, boundaries can be pushed, and change can be enacted. The live performance "Scholars on a Picnic: A Generative Ballet in Three Acts" does just that, it calls attention to the 'perils of our modern world' and most importantly, it creates a space for dialogue and potential for change.

"Scholars on a Picnic" is a collaborative event between myself, the feminist historian and my fellow performers, Robert Spahr, the 21st century dadaist and Jay Needham, the ecological composer. Our scholarly/artistic voices come together, sometimes in opposition to each other and sometimes in harmony, in a generative ballet that both evokes the past (the Bauhaus Triadic Ballet, Ballet Mecanique, and Meyerhold's biomechanical theatre) and promises a new type of experience for the 21st century. The ballet can be understood in two ways; 1) in relation to the underlying games of Risk and the World game, and 2) in relation to the archive that it utilizes and generates.

Game Play and History

The underlying premise of the ballet, the story as it were, is based loosely on two important games developed in the middle of the 20th century: the game of *Risk* developed in the late 1950s by French writer/filmmaker Albert Lamorisse (perhaps best known for his award winning 1956 short film, *The Red Balloon*); and the *World Game* developed by American architect/designer/inventor, Buckminster Fuller in 1961. Each of the act is occupied with one of the games and is underpinned by historical connections and the rules of the individual games.

The first act is centered on Risk and is marked by the development of nation states, the growth of the military industrial complex, the rise in global power, the consolidation of wealth in the hands of the few, as well as the gradual and systematic disenfranchisement of the working classes. Grounded historically within the 18th - 20th centuries this period signifies for me a time when female voices were ignored or out right silenced.

The Entr'acte is marked by our present moment in history and is plagued by perpetual war, retrograd politics, economic extremes, fake news, and information overload. This period is cacophonous and chaotic, requiring strong, loud voices to be heard above the din.

The final act returns to the game play of the World Game, which focuses on sharing resources, distributing wealth, protecting the environment, and in general putting the preservation of species, humanity and the planet before material excess. While historically situated in the later part of the 20th century, this part of the game play is also forward thinking, and hopeful.

The power in these themes and historical underpinnings is that they too follow the generative prescriptions of the ballet, as well as, the generative aspect of game play itself. Feminist scholar Vicki Callahan notes "… envisioning temporality as a nonlinear, multidirectional flow of information rather than a singular reductive and evolutionary stream of apodictic data" is the key to creating/sharing new modes of understanding. [2]

Just as a game will never be played the exact same way more than once, the ballet relies on generative processes and chance to create a historicity that is neither fixed nor linear. “Thus, history should not be seen as a static entity but rather a process of ongoing conversation with the materiality of the moment.” [3] The generative aspects of the games and the ballet, allow for a dynamic understanding of history that is powerful in its ability to open a space for dialogue.

The Archive Generates the Ballet

The second key element to understanding the ballet is the concept of the archive. Like Callahan, Jacqueline Millner suggests a skepticism of linear time and she notes that potential for doing history differently lies in the use of the archive, “for the archive insists on the contemporariness of time and its infinite malleability,” in other words the archive is an infinitely generative tool. [4] The ballet is comprised of multiple archives, collections of sounds, images, movements and objects that are combined with the computer generated algorithms. The collections/archives generate the movements of the ballet, at the same time that they are generated by the algorithms, they create a continuous feedback loop.

In its ability to generate new material and its maleability, the archive becomes a source of feminist possibility. Each of the characters in the ballet have an archive of sounds which dictate his/her movements. The sounds which dictate my movements come from a variety of sources both personal and inspirational. They include snippets froms music, films and speeches that have in some way impacted my life. For instance, there are clips of dialogue and sound from Vera Chytilova’s 1966 film *Daisies*, a film which gives voice to two young women caught in between generational discord during the Prague Spring.

Also included are clips from the activist/feminist punk band, Pussy Riot, these women literally and figuratively put their art and their lives on the line to protest Vladimir Putin and his administration (for which they received two years in prison). Other inspirations sources include works by singers like Aretha Franklin and Annie Lennox, as well as women who have impacted by life as politicians, scolars, feminists, sush as: Shirley Chisholm, Laura Mulvey, bell hook, and Jane Gaines.

My character’s archive is comprised of sounds that have meaning to me, to my past, present, and future. As Millner remarks, “the archive occupies the threshold between public and private, a key feminist focus.” [5] The conflation of public/private is further conflated in the performative aspect of the ballet, which also combines gestures and movements that are at times both the intimate and personal and at other times public and distant.

Vicki Callahan, notes “The archive becomes in this context not the last edifice standing

in a received history, but a dynamic agent of change and a space of becoming." [6] Through is use of game play, generative algorithms and archival sources (personal and public), *Scholar's on a Picnic* illustrates the potential of generative arts practice to to open dialogues, to expand our understanding of feminist scholarship in the arts and feminist arts practice.

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Jay Needham

TITLE : Scholars on a Picnic: Risk Ecology and the Songs of Ants

(Paper)

Topic: (Arts Practice and Pedagogy)

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Abstract part 3
In this paper, the composer will outline the origins and telos of the musical score conceived for *Scholars on a Picnic: A Generative Ballet in Three Parts.* Hints of a pastoral turn and a post-industrial utopia abound in Fuller's conception of The World Game and the composer will present what post-modern influences were brought to bear on the creation of the sounds and how generosity and empathy were used as a generative tool for composition and play.

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Key words: *Music, composition, ecology, empathy*

Main References:

[1] Fuller, R. Buckminster "The World Game: Integrative Resource, Utilization Tool" Southern Illinois University, Carbondale, Il 1971.

Scholars on a Picnic: Risk Ecology and the Songs of Ants

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Jay Needham, MFA

In this paper, the composer will outline the origins and telos of the musical score conceived for *Scholars on a Picnic: A Generative Ballet in Three Parts.* Hints of a pastoral turn and a post- industrial utopia abound in Fuller's conception of The World Game and the composer will present what post-modern influences were brought to bear on the creation of the sounds and how generosity and empathy were used as a generative tool for composition and play.

It is 1970 and there is a broken piano in the basement of the house. The upright is old and smells as though it has been through many floods, count the rings of lime and mildew that have etched up along the base. I am seven years old and I develop an affinity for the instrument, its singularly odd tuning, missing ivories and heavy weight. I place my head onto the black enamelled surface in order to hear the resonances of the instrument more acutely and as I play, I hear the wooden strides of the action amid the soft counter rhythms of the felts, the interior of the system. In among the sustained notes are other ecologies of resonance, moments of distinct interaction that blend and sing briefly before they fade.

I am staring at crushed lava stone, a coffee collared pumice that is ochre toned, rusted. The rocks are splayed out very evenly on the back lawn, there is something almost lunar about them… maybe it's the hard light in the Phoenix Valley, as if the sun belt is just that, a band of concentrated photons focused on drying up all the military retirees in the area. This is the visual tableau for my listening, all done from behind a mid-century window wearing oversized headphones. The reel to reel unwinds time on two wheels that rotate in a synchronous spell, a radar ping, a creaking fracture, communications static and a long droning sound that I imagine is a whale. I'm in my grandfather's office in 1977, listening to the recorded sounds of the Nautilus, the first nuclear powered submarine navigating under the polar ice in 1958.

The score for Scholars on a Picnic: A Generative Ballet in Three Parts is a personal parable that describes my own cultural shift in music from that of performing music to creating and experiencing sound [1]. As the narrative accounts describe above, my own acts of western music making on a damaged piano connect to my listening of the sounds of the Cold War as introduced to me by my Grandfather. A similar sonic progression from the framework of the classically melodic to the territory of modernist abstraction is also at play in the games of Risk,
The Game of Global Domination (by writer/filmmaker Albert Lamorisse in 1957) and the World Game (or World Peace Game) developed by Buckminster Fuller in 1961. While Lamorisse's game of Risk regenerates border conflicts set in the time of the Napoleonic wars, Fuller's World Game is designed to generate an exchange of the world's resources for the common goal of achieving world peace.

Music and sound for *Scholars* will be performed as a sound montage across 3 acts and will include musical phrases, figures, samples and processed sound from specific eras in musical history with each act having its own specific grouping of sonic referents. Act 1, Setting out the Picnic - The Battleground, will feature music that is derived from such composers Anton Reicha, François-Joseph Gossec and Pytor Ilyich Tchaikovsky. The music for Act 2, Entre'acte The Free-for-All will be comprised of sounds that represent dense, chaotic and dissonant sounds that refer to the creation of false memories, fake news and the sleepless condition of today's contemporary lifestyle. Inspired by the traditions of Dada, Russolo's noise and the serialism of Luigi Nono and Pierre Boulez. Finally, sound for Act 3, Food Coma - Peaceful Slumber is derived from the sonic optimism present in the electronic music of the 1950's and 1960's including composers such as Pauline Oliveros, Otto Luening and Raymond Scott.

From an artist's perspective, Fuller's World Game can be looked at as an eco-compositional tool. The whole earth of it might just sound like jazz. The proposition of sharing the world's resources is about taking great risks together and that leads to the creation of an ecology of risk.

"I next saw that if that could be done then, the theory of John von Neuman's war gaming, which holds that ultimately one side or the other must die, either by war or starvation, is invalid. Therefore, I saw that we had a heretofore unconsidered alternative way to play the world game in which as with mountain climbing, the object would be to find all the moves by which the whole field of climbers would win as each helped the other so that everybody successfully reached the mountaintop and all returned safely to its base. This is a mathematically permitted alternative of game playing but it has never been played in any of the war games of the great nations of the earth." [2]

Also in play within the risk ecology are all the actors who join with you to share the resources of the picnic, the ants. The artist opens a briefcase full of referential items. This briefcase is also used in the performance of Scholars on a Picnic and that seems ironic at first, but you are accustom to the notion that objects from the everyday will appear to you as symbols. A special microphone is placed near the ants, whose numbers are now increasing. Just under the sound of the slight breeze, you hear it, a gritty whine that is slightly out of the range of your hearing. On pause in a space

between music and sound, you listen for clues. Hearing the ants sing will make you sleepy. This is peace.

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Yiannis Papadopoulos

TITLE **TIMAEUS: Three-dimensional Illuminated Media Augmented Sculptures** ***(Paper)***

Topic: ***Art***

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Abstract. TIMAEUS is a digital art studio environment that enables creation of personalised 3-dimensional sculptures built with expanding spherical volumes or interconnected tetrahedra and possibly other atomic blocks in the future. These sculptures can be customised with media, e.g, pictures, videos and music which are overlaid or seeded in the sculpture. Media can represent memories or more generally facts, including live internet feeds, that can be used to create artistic narratives in space. Such facts are embedded in the sculpture and can be experienced in different ways with the capability of zooming in and out, rotating, viewing from different angles, and applying sounds and soundtracks. Sculptures are hollow and translucent. They can be illuminated, and the space that they enclose can be viewed internally.

TIMAEUS incorporates generative components. Features of images, videos or music can be algorithmically extracted and used to modify the shape or movement of a perpetually mutating or dancing sculpture where these media have been applied.

We are currently designing a study in art therapy of dementia patients where TIMAEUS will be applied. One hypothesis is that artistic memory sculptures can both aid reminiscence and create a much needed sense of well-being. Reviewing one's life in an artistic manner may help to place fragments in perspective as well as work out gaps and conflicts. This could nurture feelings of relaxation through artistic creation and of stronger more coherent self.

TIMAEUS was inspired by the homonymous Platonic dialogue and its geometric, atomic cosmogony and cosmology. The above image is of a relief created in TIMAEUS in a style which is reminiscent of sumptuous Byzantine silk fabrics and which, we hope, connects this paper to the Byzantine art for which Ravenna is renowned.

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Key words: generative sculpture, dementia art therapy

TIMAEUS: Three-dimensional Illuminated Media Augmented Sculptures

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1. Introduction

In this paper, we discuss the background, inspiration and current state of Timaeus, a digital art studio environment that enables the creation of personalised 3-dimensional sculptures built with expanding and interconnected volumes of atomic blocks.

Timaeus sculptures can be customised with media, e.g, pictures, videos and music which are overlaid or seeded in the sculpture. Media can represent memories or more generally facts, including live internet feeds that can be used to create artistic narratives in space. Such facts are embedded in the sculpture and can be experienced in different ways with the capability of zooming in and out, rotating, viewing from different angles, and applying sounds and soundtracks. Sculptures are hollow and translucent. They can be illuminated, and the space that they enclose can be viewed internally. TIMAEUS incorporates generative components. Features of images, videos or music can be algorithmically extracted and used to modify the shape or movement of a perpetually mutating or dancing sculpture where these media have been applied.

We are currently designing a study in art therapy of dementia patients where Timaeus will be applied. One hypothesis is that artistic memory sculptures can both aid reminiscence and create a much needed sense of well-being. Reviewing one's life in an artistic manner may help to place fragments in perspective as well as work out gaps and conflicts. This could nurture feelings of relaxation through artistic creation and of stronger more coherent self. Timaeus was inspired by the homonymous Platonic dialogue and its geometric, atomic cosmogony and cosmology.

Figure 1 shows a relief created in Timaeus in a style which is reminiscent of sumptuous Byzantine silk fabrics and which, we hope, connects this paper to the Byzantine art for which Ravenna, where the conference takes place, is renowned.

Figure 1. Tribute to the Byzantine art of Ravenna – a relief created in Timaeus

In section two we provide relevant background on digital and generative art and its applications to art therapy in particular reminiscence and dementia. In section three, we highlight the potential for generative art. In section four we discuss the inspiration and state of Timaeus, and finally in section five, we draw conclusions and discuss further work.

2. Digital and Generative Art & Therapy

Groysman reminds us of the original meaning of "téchnē" (τέχνη), the Greek word for art, which was used to refer to both art and technology at the time [1]. It is well established that for ancient Greeks, the expression, imagination, creation, aesthetics, beauty, thought and emotions which are integral to "téchnē" "were not confined to "fine arts". But is this connection between technology and art relevant in today's technological age, and how?

Jones notes that computers were a liberator technology for artists, in the same way as video and television had been before [2]. One recent strand of digital art has become known as generative art. Monro [3] cites Philip Galanter's widely circulated definition of generative art as "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 then set into motion with some degree of autonomy contributing to or resulting in a completed work of art" and notes that computers, or even machines, do not have to be imperatively present in the creation of generative art.

In this paper, we focus on the potential of digital and generative art for art therapy, through the implementation of an art studio that enables therapeutic expression within the creation of personalized, customisable and generative sculptures. One particular application of this is the creation of "memory sculptures" for reminiscence in the context of art therapy of dementia patients.

Multimedia

Conventional and digital media and multimedia, are generally present in art and reminiscence therapy systems and they appear as an essential element of this approach. As an example, Tony et al. report Hellen Bonny's Guided Imagery and Music method, in the 1970s, aimed for self-development work where music may be selected and images may be used for building a metaphorical dialogue with the therapist [4]; or the inherent presence of media in the Antunes definition of reminiscence therapy for dementia, in "the use of life events, photos, music and other supports" to remember the past and promote dialogue [5].

Several authors report on the benefits of the use of multimedia, e.g. on helping to engage patients and improve communication. Elements such as texts, photos, videos, music and songs, possible to use in the work of day-care settings, can provide entertainment and recreational experiences; they can be used as a vehicle for reminiscence conversations [6]. Alm et al. report that staff enjoy more pleasant caregiving experiences [6] and Peterson describes patients creating digital images and movies, with the advantage of unnecessarily getting "messy during their art therapy treatment" [7]. In addition, Carswell et al. report enhancements in wellbeing and brain stimulation [8], and Blandford et al. explain that high satisfaction with the use of multimedia in reminiscence results in "strong tendency towards repeated use" [9]. Noticeably, it is also reported that there is a strong preference for personal, in contrast with generally themed materials [9].

Lazar et al. assert that "access to rich and engaging multimedia reminiscence materials", helps the clients to "participate in social interactions and take ownership of conversations, and that there is also a resulting reduction of barriers due to motor deficits" [10]. Antunes makes a comprehensive listing of several existing applications of multimedia in the context of dementia: like multimedia biographies, where the caregivers collect materials that are then continuously displayed in a device at the client's home; or Portrait, purposed for nursing homes and day care centres; and computer-assisted reminiscence therapy, with personal photographs, and photographs taken from public places known to the patient and playlists of songs they can relate to, where the carers noticed that the clients had increased focused time, in comparison with non-digital media; or the use of YouTube in group therapy sessions, where caregivers can set playlists that will work as reminiscing triggers, and where the patient's enjoyment was visible; and Friendcrafting Memories, a web application with an

interface resembling a bookshelf where the patients can choose to open themed books about people, places, and interests; or Friendsourcing and Remember-Me, that use the functionalities of social networks to collect reminiscence materials; and even the use of virtual reality, providing immersive experiences that transport the client to familiar places [5].

Taking into account the differences between dynamic and static media, Blandford et al. state that "dynamic media, like video, can provide more context than static media, such as photos" [9]. Media can also be linear or non-linear. Linear media, like a song or a movie, has a beginning and a point of completion. Non-linear media incorporates continuity within the possibly endless complexity and can also be beneficial in art therapy.

A multimedia-game synthesis

One area little explored in the area of therapy is that of "games". It is important to look at games as they can provide a very rich non-linear multimedia interactive experience. Games also introduce advanced computerized functionalities such as cinematics, physics, and artificial intelligence. It is therefore plausible to consider that digital games might add value to the digital approach to reminiscence and art therapy. There are indeed a few examples of the use of digital games in this therapeutic context. Alm et al., for instance, mention the creation of computer game prototypes, developed in consultation with patients and carers, where there was no competitive element, nor finishing point, and that did not rely on memory for successful play, nevertheless resulting to a joyful and engaging experience for players [6].

Further Gamification

This leads us to the topic of gamification, to the definition of its meaning, and to the understanding of why and how it is used. Mesárošová and Hernández observe that the concept of gamification was introduced in 2002 by Nick Pelling, a game designer [11]. A way of thinking that involves the application of concepts of computer games in social contexts, taking the dynamics of games and implementing them in real life, converting tedious tasks in playful activities and, in general, application of game mechanics to any situation, idea or project [11]. Gamification includes current research that involves games and health is growing. Shapil et al. observe that, for instance, in cognitive rehabilitation, there is great heterogeneity of impairments to address and cost-effective ways for game creation are desirable [12].

The answer to the question of why gamification is relevant may be reduced to the ideas of fun and usefulness. For instance, software vendors have adopted it to increase customer engagement [13]. Research in gamified training, illustrated by examples such as medical serious games, has been applied to surgery and infection prevention and to increase dexterity [14]. Also in Odontology and Nursing, in areas such as diagnostics, decision-making, treatment protocols and risk and pain management [15]. Moreover, and importantly for this research, gamification is being applied to Medicine and Psychology therapies, because it may have the potential to address "difficulties associated with sustained engagement in behaviour change strategies". Psychologists may use well-established tasks to train specific cognitive abilities, benefiting from the transformation of routine tasks into playful activities [14]. As another example, Ricciardi and De Paolis report the use of several physical rehabilitation serious games, that were perceived by the patients as a credible training approach [15].

Overall, there seems to be an interesting potential for computer games to become a compelling medium to create engagement in healthier lifestyles, and in learning and teaching [13]. In mental health, Agmon et al. provide some evidence that suggests positive impacts on depressive symptoms, cognitive performance and mental health related quality of life [16].

3. Towards a generative-game synthesis?

Generative cinema, generative photography or painting provide good examples of possibilities that are realised when jumping from one simpler to a more complex medium that incorporates a degree of autonomy. This observation has led us to consider that digital games for art therapy could be greater than just non-linear media, and more than an interactive multimedia synthesis. By thinking about the general architecture of Timaeus, we considered the possibility of generative art components in gamification of art therapy.

The possibility for a generative art synthetic game emanates from the diversity of its organics. Modern digital games, from the view of a game engine, provide real-time functionalities in varied domains: real-time graphics and sound that can be enriched with generative algorithms; generative poetry can take the shape of generative game narratives; music, text, voice, cinematics, 2D and 3D imagery and shapes, etc. The digital game has the potential to be a synthesis of a vast panoply of generative art forms. Such forms could be integrated, unified. Pushing it to the limit, even mechanical generative systems can be reproduced within a game through its physics engine, inputs, and outputs such as screens, printing, and 3D printing. However in this synthesis new generative forms may also emerge, that are not necessarily a mere sum of the previous. This is the case of new forms of generative sculpting/design that are addressed in this paper. Such is the case of generative time, flow, and control – through the game's AI engine – and also of an overall Generative Play.

Play and Art Therapy

This concept of Generative Play reconnects us with Generative Art Therapy. Whilst discussing contemporary art, Sweeney emphasized the pivotal meaning of Play in deriving pleasure from Art, making a mention to Plato who considered that pleasure "does no good or ill" itself but it is important and conditioned to do good by other factors such as virtue and practical wisdom [17]. This sense of Play is also present in Hayes look into the role of the creative arts in dementia care. Hayes reminds us that "when we play we do not question the validity of what we do or make", hence resulting in a joyful experience for patients and the staff [18]. This, in turn, can have a therapeutic effect especially if contextualised properly. Play is important in this kind of therapy that is person-centred in quality experiences [18]. Killic focuses on the delicate nuances that might exist between play and game, by noting that the obtrusiveness of rules of the latter might invalidate the first [19], which seems a wise and important consideration in the design of serious games.

4. TIMAEUS Art Studio

Inspiration from Plato

The Platonic dialogue of Timaeus has inspired the conception of the homonymous art studio. The dialogue develops a geometric cosmogony in which the world, much like the

mosaics of Ravenna, is composed of atoms which in the dialogue are considered to be shaped as the five perfect solids discovered by Plato. Apart from its literary value and an example of dialectic argumentation, the dialogue provides extraordinary insight into later scientific discoveries in the field of chemistry and biology which have discovered harmonious, often geometrically perfect, structures in the fabric of matter. Note that the system that we develop effectively aims to construct memory worlds from atomic units and entities.

Timaeus also contains the original reference to the myth of Atlantis, the lost city or lost continent depending on which narrative one reads out of the many stories created in centuries of literary speculation that followed Plato. The myth makes a relevant connection to the loss of memory and therefore the topics of reminiscence and dementia that we wish to address. Moving beyond this obvious connection, modern psychological and neuroscientific theories suggest that memories are continually reconstructed on the fly as opposed to being recalled. This is precisely what happened in the case of the myths surrounding Atlantis, but it is also how memories are recreated in an artistic fashion within the Timaeus art studio.

Creation of artefacts, moments, memory sculptures

Timaeus as an art studio is envisioned to be a digital game for art therapy, providing an interactive audio-visual experience for generatively augmented expression and creativity that can be used for reminiscence and life review with dementia patients, care staff, and artists.

The Platonic inspiration provides an opportunity for bringing a philosophical dimension to the project with links to geometry. The game should provide, with simple interactions designed to address problematics such as loss of sight and dexterity, an imaginative environment for the generatively augmented expression of ideas, memories, and thoughts, through the creation of sculptures collated with sounds, images, videos and other media, and illuminated. Despite its unique technological advances on the links drawn with art and therapy, the underlying action of creating reminiscing artefacts is an established therapeutic methodology, including in digital form, in reminiscence therapy for dementia, and is well documented in Thiry's doctoral thesis [20]. This is a work that was focused on a specific type of reminiscing, described as "a process that may involve many 'turns' and that produces a personal legacy artefact".

Thiry observes that artefacts may be scrapbooks, memoirs, oral histories, photographs, newspapers, letters [20]. In a functional view, artefacts may be created to remember or to share and be remembered or just "because it is pleasurable in and of itself" [20]. To remember traveling, for instance, in that moment or in the future, or to share with a grandson a personal journey, stories and knowledge the patient feels that should be preserved for younger generations [20]. In terms of therapy practice, Thiry reports that "artefacts have emerged as an important aspect of reminiscences with older adults" and that despite "HCI researchers have explored a variety of different approaches to the creation and use of personal legacy artefacts" however "very little attention has been directed to how personal legacy artefacts might be created and authored" [20].

In terms of patients' requirements regarding technological approaches to the creation of personal legacy artefacts, Thiry mentions the desires expressed by the users of the greatest simplicity possible, in the software, and also a preoccupation with the possibility that the technologies might later become obsolete and their legacy lost [20]. This information is very valuable for this research because it strengthens a justification

for possibly including 3D printing of the memory sculptures in the workflow.

Besides looking into Thiry's work in what concerns digital reminiscence and artefact creation, the research task of Timaeus also looks into the artfulness of such artefacts and the creative experience and joy that is more related to art therapy. Here, another strong inspiration and reference is the work of ArtCare in bringing workshops of non-computerised reminiscence "using poetry, art, music and handling objects" into the interior of hospitals, to "inspire staff, patients and visitors" [21]. This research considers doing precisely this, but in a technological, and possibly ubiquitous way. In the same line with Cognitive Dynamics work of combining reminiscence activities and art therapy "to validate Alzheimer's patients in their current state, helping to honour their life stories, restore and preserve their sense of self", improving the patients' communication and expression, concentration, attention and ease of care [22].

The above is the current stage on experiments with the creation of a software that enables innovative ways of producing art, namely handmade therapeutic generative art, through a system in the form of a touch-based game that facilitates the augmented expression through the creation of transparent 3D sculptures, drawing, texturization, illumination and semantics and may help to reflect the patients thoughts and facilitate reminiscence and life review exercises. The present features of TIMAEUS are:

- **Moment/Memory Sculptures**
- Painting
- Sculpting
- Multimedia 3D Collage (picture, audio, video, illumination)
- Control of variables for generative art exploration

The studio is already in a developed state. Figure 2 displays an example of a memory sculpture created in Timaeus. A colourful painting by abstract artist Roberto Bono (http://www.arteutile.net/) is covering the surface of the sculpture, Hanging within and on the boundary of the curved space there are personal images forming an internally illuminated 3D collage that can be navigated both internally and externally.

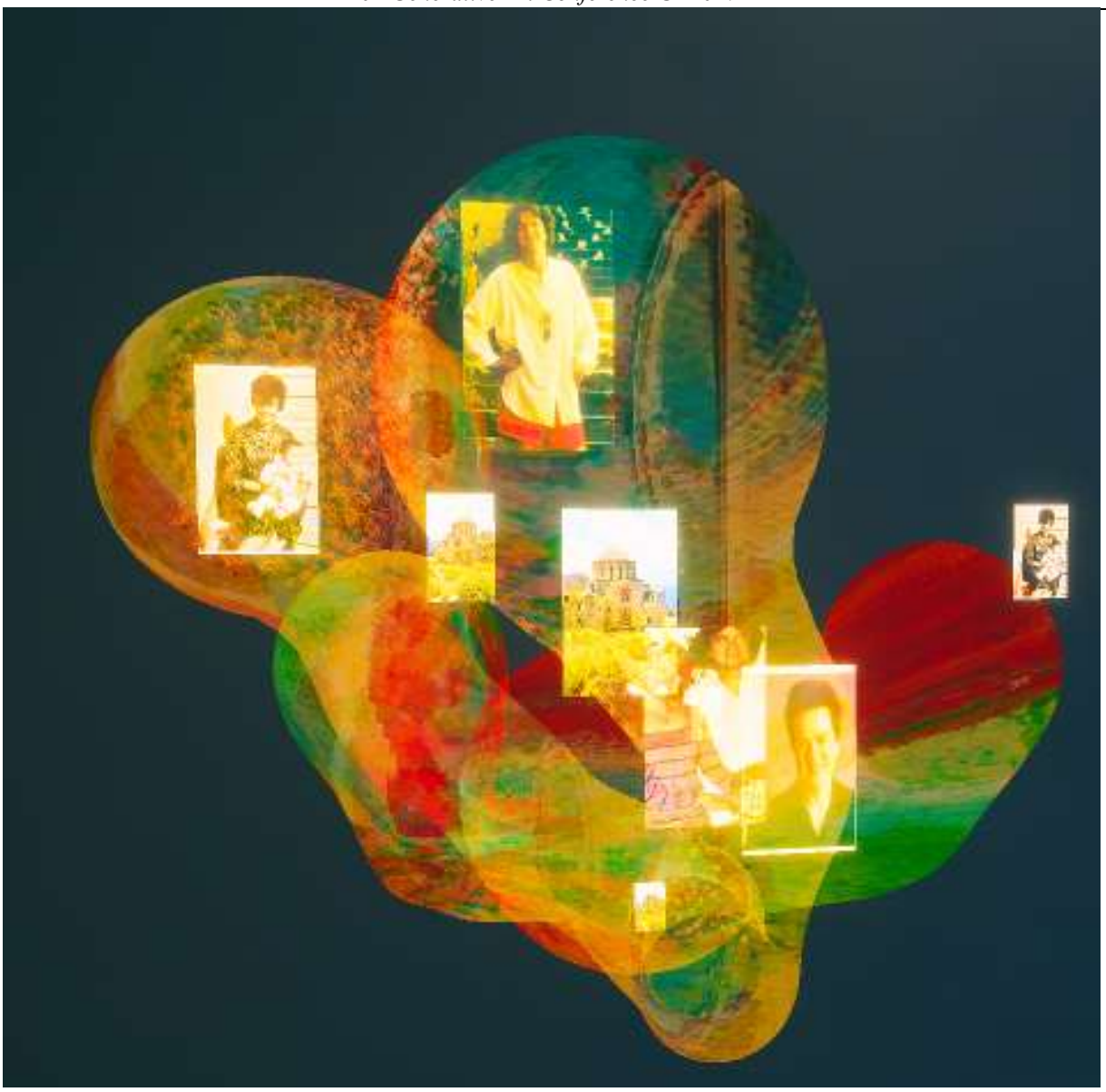

Figure 2. Memory sculpture created in Timaeus

Dancing Sculptures

As an exercise on the many possibilities for generativeness we have picked music as an example of input that can be processed to then create a generative effect on a sculpture under design. This processing, done via Fast Fourier Transformations (FFT), results in a dynamic sculpture that has a constant, editable shape, which also floats in the air as a result of sine and cosine fluctuations of surface shape that correspond to the results of the FFT. By enabling this function, the player creates a sculpture that can be constant but that at the same time reconfigures itself to the variations of the frequencies of the music. While sculpting, the shape comes back, and then it floats again, so there is a perceived sensation of dancing with the sculpture.

Thinking in terms of complexity, and in a parallel with Soddu's New Naturality, the sculpture is fed with an "always differing flow of information" [23], in this case, derived from the soundtrack, that then is dependent on the player's interaction. Still in that parallel, possibly more interesting sculptures could be achieved if, instead of simple surface sine and cosines, more complex design decisions were made regarding the shape. As to emergence, the dynamic feeling of "dancing with the sculpture" emerges from this generative exercise.

5. Future Work

Timaeus is already at the stage where case studies are being put in place. However, work is needed to improve the efficacy of this art studio and the work it intends to support.

Firstly, the current user experience design is further being developed in collaboration with domain experts in the field of dementia. We are currently considering including interaction possibilities such as natural input and language so that we can maximize the therapeutic applicability of Timaeus.

Secondly. Timaeus opens the possibility to provide augmentation in creation, in a way that, inabilities to draw, paint, and sculpt, or limitations such as the loss of dexterity may be surpassed, in an overall beneficial and expressive experience. This involves concepts such as cognitive amplification, augmentation or prosthesis. Augmenting in disability is a challenge transversal to assistive technologies for the elderly, considering that "computers may have the potential to augment human cognitive processes in ways that could be beneficial" [6]. Peterson reported that "a computer's ability to capture and amplify even the smallest movement made art therapy treatment available to those with limited mobility" [7] and Astell notes that an important goal when developing technologies for people with dementia should be in building on, maximising and extending retained abilities and mitigating the natural cognitive limitations [24]. Very relevant for this study, Sauer mentions how important that opportunities for creative expression are for those with dementia, who might have seen the erosion of other abilities of self-expression and mastery eroded [25].

Finally, we are working with experts, therapists, staff, and patients in memory clinics, to address safety and compliance with medical regulations.

6. Acknowledgments

We would like to thank Fredrik Lindh and Chris Conway for the kind clarifications.

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FORM FOLLOWS ALGORITHM: Differentiation of Chladni Patterns Through Mathematical Functions in Processing

(Paper)

Topic: Design

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Abstract

First introduced by Ernst Chladni in 1787, Chladni Plate refers to geometries resulted from different frequencies of sound (Hans, 2001). It has been observed that solid particles (such as dust, sand) scattered over the square plate given the vibratory "Chladni Plate" underneath form nodal lines, nodal points and patterns. Chladni has investigated the behavior of sound waves through an experiment setup, in which material type, size of the plate, frequency of sound were used as variables. Further to his studies, approaching Chladni Patterns through logical and mathematical expressions has led to exploration of various patterns.

This study aims to address whether the mathematical expressions developed based on the frequency of sound be used effectively for the pattern in the digital environment. In the literature there are remarkable numbers of studies focusing on merely visualization of mathematical formulas. Therefore, the computational approaches derived from two-dimensional wave equation and frequency lead to similar visual results in some extent. However, the motivation of this study is not reproduction of Chladni Patterns, instead develop generative design approaches departed from initial patterns.

Derived and inspired from Chladni Patterns, this study aims to contribute to the algorithmic visualizations of Chladni patterns in computer programming environment through replacing trigonometric expressions and variables by other mathematical functions. Those trigonometric expressions and the variables can be changed and differentiated by means of graphical user interface that we have developed in Processing environment. Further to input-dependent visualization of Chladni patterns, the same interface also allows user to explore agent-based visualization possibilities. In the scope of this study, the outcomes of the pattern generation will be discussed in the context of complexity, unpredictability, and divergence of the patterns in correlation with the replacement of the variables.

Bourke's (2003) definition for wave movement in Chladni plate was used as a basis formula:

$$\cos(n*\pi*x / L) * \cos(m*\pi*y / L) - \cos(m*\pi*x / L) * \cos(n \pi y / L) = 0 \qquad (1)$$

In the scope of this study, the parameter of linear length (L) is neglected in the formula (1). Main contribution of this study can be considered as the interactive user input panel for generation, manipulation and differentiation of Chladni Patterns.

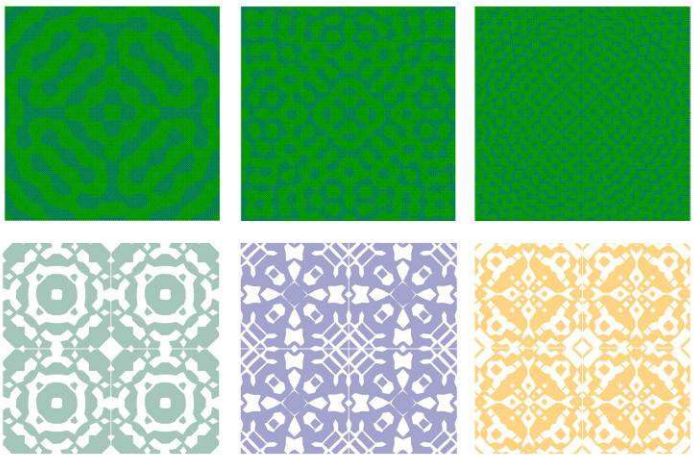

Figure: Pattern examples generated from algorithm.

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Key words: Chladni patterns, generative pattern, cymatics, algorithmic approaches.

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Form Follows Algorithm: Differentiation of Chladni Patterns through Mathematical Functions in Processing

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Abstract

Derived from and inspired by Chladni patterns and cymatics, this study aims to contribute to the algorithmic visualizations of mathematical functions in computer programming environment which has led to exploration and creation of various patterns. Mathematical operations which derived from periodic functions associated with different variables to control patterns. Software called Cymatify is introduced which developed in Processing. Cymatify allows users to generate patterns by modifying mathematical functions and variables. In the scope of this study, outcomes of the pattern generation will be discussed in the context of complexity, unpredictability and diversity of the patterns.

Keywords: Chladni patterns, cymatics, periodic functions, pattern generation, Processing, graphical user interface (GUI), software.

Introduction

"If you want to find the secrets of the universe, think in terms of energy, frequency and vibration." Nikola Tesla

The idea of creating patterns based on mathematical formulas emerged from examining the study of Chladni patterns. "First introduced by the German physicist Ernst Chladni in 1787, Chladni patterns refers to geometries resulted from different frequencies of sound" [1]. Chladni has investigated the behavior of sound waves and wave phenomena through an experiment setup where patterns emerge when solid particles scattered over a resonated plate in different frequencies [2] (*Figure 1*).

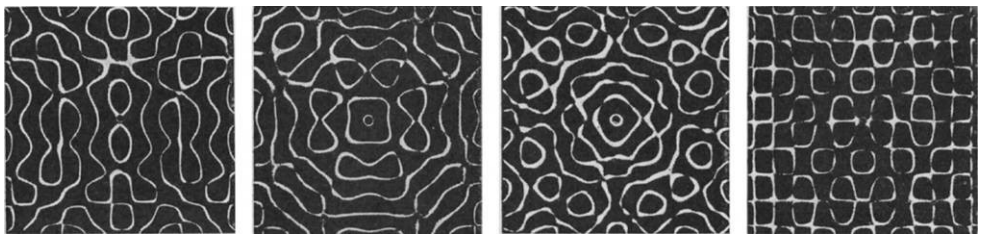


Figure 1. Chladni figures on square plates (Colwell, 1936, p. 4)

Emerged figures vary depending on the material type, size of the plate and the frequency of sound were used as variables in the experiment setup [3]. Chladni patterns

are organic, complex, continuous and intricate figures which can be expressed with specific mathematical formulas. Studies conducted in this area are commonly based on the mathematical formula proposed by Robert Colwell [4] (1).

$$W = \left\{ \begin{array}{l} (\cos k_m a + \cosh k_m a)(\cos k_m x + \cosh k_m x) \\ + (\sin k_m a + \sinh k_m a)(\sin k_m x + \sinh k_m x) \end{array} \right\} \quad (1)$$

There are various digital simulations for visualizing Chladni patterns in digital environments. Main intension of these studies is to investigate and digitalize Chladni patterns as they emerge in physical environment. Therefore, they are similar to each other in terms of appearance, diversity and complexity. The purpose of the study is to propose a digital pattern generation framework based on the fundamentals of the Chladni patterns rather than mimicking or re-creating them. The wave phenomenon underlying reason of the emergence of Chladni patterns are investigated to this end.

Figure 2. Sound wave

Figure 3. Surface wave in water

Wave refers to the movement of a particle which follows a specific route [5]. There are various types of wave in the physical environment which we can exemplify with sound waves, string waves, radio waves, light waves, water waves etc. [6] (*Figure 2, 3*). In this study, wave type that is particularly emphasized is *sound wave* as it is in Chladni patterns. It is a must to define the wave phenomena with the mathematical expressions in digital environment to create the proposed framework. Sound waves are simply defined as sinusoidal plane waves which characterized by frequency, amplitude, speed of sound and direction. For this reason, waves can be described with the periodic functions. “In mathematics, a periodic function defines as a function that repeats its values in regular intervals or periods. The most common examples are the trigonometric functions, which repeat over intervals of 2π radians. Periodic functions are used throughout science to describe oscillations, waves, and other phenomena that exhibit periodicity” [7]. In this context, periodic functions are used as the fundamental mathematical basis in the study (*Figure 4, 5*).

Trigonometric functions	Non-smooth functions	Sinus-like functions	Vector-valued functions
Sine	Non-smooth functions	Trochoid	Vector-valued functions
Cosine	Triangle wave	Cycloid	Epitrochoid
Tangent	Sawtooth wave	Clausen function	Epicycloid
Cotangent	Square wave		Limaçon
Secant	Cycloid		Hypotrochoid
Cosecant	Tangent		Hypocycloid
Exsecant	Cotangent		Spirograph
Excosecant	Secant		
Versine	Cosecant		
Vercosine	Exsecant		
Coversine	Excosecant		

Figure 4. List of various periodic functions

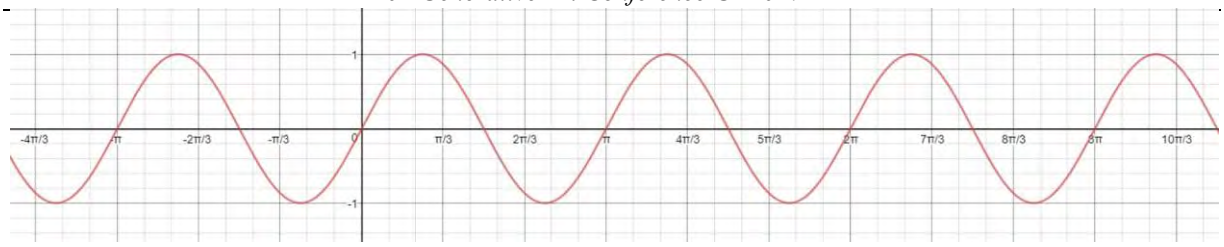


Figure 5. Sine wave is an example of periodic functions

The motivation of this study is to develop a pattern generation tool with an interactive, graphical user interface which users can generate and manipulate diverse patterns. Our hypotheses are, it is possible to generate patterns by visualizing periodic functions and infinite amount of patterns can be generated with Cymatify. In this manner, it is aimed to develop a software for generating patterns in the scope of proposed framework. We argue that the more we diversify the periodic functions the more various patterns can be generated. By using various periodic functions for figure generation, diverse and different patterns are expected to encounter than the original Chladni patterns. Outcomes will be discussed in the context of complexity, unpredictability and diversity of the patterns.

Related Works

Derived from Greek word '*kyma*', cymatics investigates wave phenomena and it is used to express the form of the responses of sound in diverse frequencies. In cymatics, Hans Jenny points out that "Typically the surface of a plate, diaphragm or membrane is vibrated, and regions of maximum and minimum displacement are made visible in a thin coating of particles, paste or liquid" [1]. Diverse patterns generated on the plate deriving from the geometry of the plate and the frequency values. In this sense, Chladni patterns can be classified as a part of a study of cymatics. In this part, cymatics and Chladni pattern studies will be examined.

Within a study about cymatics from Penn State University in 2014, a matrix and several control points are defined as a pattern generation system, and a morphology is presented with the effect of simulated waves. Generated matrix is deformed by various wave frequencies in the study conducted in the *Grasshopper* environment. Patterns are transformed into more complex figures by adding different wave functions into the algorithm [8]. Another approach which "Grasshopper" is used to visualize cymatics patterns is developed by Mohamed Dawod in 2014 [9]. Also, in 2014, a *Cymatic Display* medium is designed by Machine Histories to generate waveforms by the real time data from Audi's social media campaign [10]. This study is consisted from combination of physical and digital examination of cymatics. Patterns are generated in a physical experiment setup by the real time digital sound data.

Various studies are published by Albert Callejo between 2007 and 2008 to generate and animate Chladni patterns in *C++* and *Processing* environment [11]. In these studies where exciting results were obtained, the natural formation framework of Chladni patterns is followed by Callejo. In a study conducted by Enrique Zeleny in 2008, *Wolfram Alpha* computational knowledge engine is used to visualize Chladni patterns. This study aims to create software which allows people to manipulate and create several patterns. In this sense Zeleny's approach is considerably similar to ours. But in contrast to his work, our approach is to propose a new generation framework besides

creating software. As he mentioned on his study, his approach is based on the Colwell's formula mentioned on the introduction part [12].

Similar to related works, we used the fundamentals of the study of cymatics. Apart from the examined studies, our goal is to investigate the differentiation possibilities of Chladni patterns. Moreover, another goal in our study is to design an interface which include users in this investigation process.

Cymatify: A Pattern Generator

In the Chladni's experiment, patterns are emerged as a result of relocation of the physical particles which are provoked by the vibrated metal plate by the sound waves. In contrast, in the digital environment, a direct connection is established between the sound waves and the digital particles. Main goal is to inform the digital particles by the sound waves coming from preset source points. This information includes the new location data, designated by the waves, for the points. Basic trigonometric periodic functions such as sine, cosine, and tangent are used to simulate sound waves in digital environment. Patterns are formed as a result of the displacement of those points *(Figure 6)*.

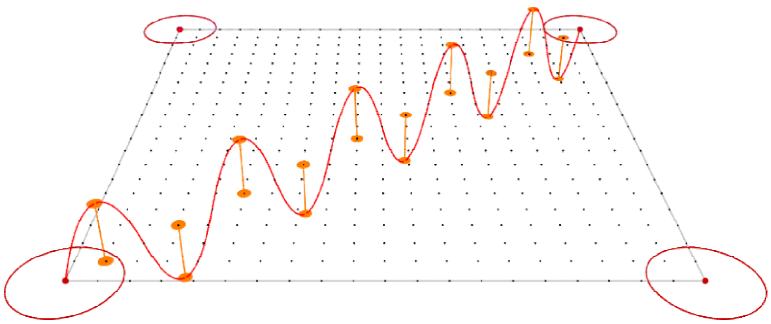


Figure 6. Matrix, source points, and a sine wave from a source

Processing 2.2.1 which is an open source programming software is used to digitalize the proposed pattern generation framework. Integrated graphical user interface allows users to create and manipulate various patterns. In this section methods and procedures will be explained, user interface will be introduced, and the outcomes will be discussed.

Method and Procedure

In order to achieve the pattern production, the proposed framework should be digitalized. For this purpose, the framework is defined as an algorithm in the Processing environment. The basis of the algorithm is consisted of a 2D matrix which each unit corresponds to a point on the coordinate system. Therefore, the number of columns and rows determines the *density* of the points. These points are the basic components that enable patterns to be produced. Generation occur as a result of the interaction of these points with various mathematical operations. In this context, it is possible to define these points as a *digital particles* which refer to the solid particles in the Chladni's experiment. The corner points of the matrix are defined as *source points*. Source points represent the origin points of the mathematical operations to be used in the pattern generation process. These mathematical operations define the *waves* which consisting of a combination of periodic functions and several variables. One of the variable is *distance*

between the source points and the matrix points. In this context, *distance* cannot be directly manipulated due to its dependency on the location of the matrix points. By calculating the distance for each point, it is possible to determine the motion of the matrix points affected by the waves going out from the sources. The other variable is *frequency* value. Frequency defines the repetition of the periodic function in a unit of time. This variable can be directly manipulated in contrast to the d*istance* variable. Finally, the combination of the *frequency* value, the *distance*, and the *periodic function* forms the mathematical function (*Figure 7*). This mathematical function is applied on each point of the matrix. In the end, the operations determine the new locations of the points which resulted as emerge of the patterns *(Figure 8)*.

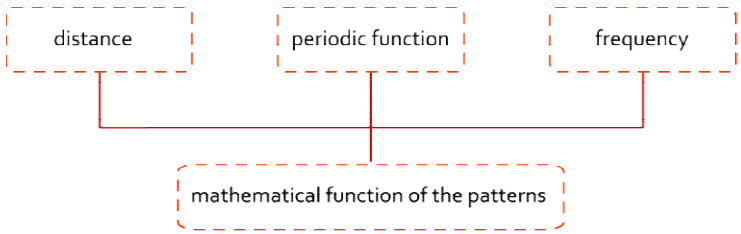


Figure 7. Creation the basis mathematical formula

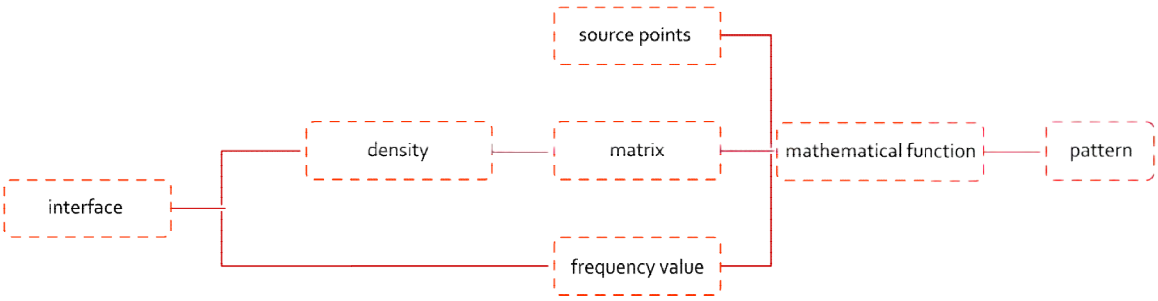


Figure 8. Pattern generation process

User Interface

Proposed interface of the software is consist of two parts. A window for displaying patterns and a menu for manipulating variables. In the menu part, there are 7 buttons placed to manage the type of the function (1), frequency value (2), size of the grid (3), the density of the grid (4), and color of the patterns (5) for generating and manipulating patterns. Users can choose and modify these variables with left-click or scroll through the buttons. Stroke button (6) can be used to stroke each grid in the pattern. Stroking patterns makes difference in low densities. Also, the interface allows users to export their generated patterns as PDF files. The program automatically creates a folder named as PDF, saves those files by automatically naming them as users click the export button (7), and assigns files a name according to date when patterns are created which include the year, month, day, hour and minute. (*Figure 9*).

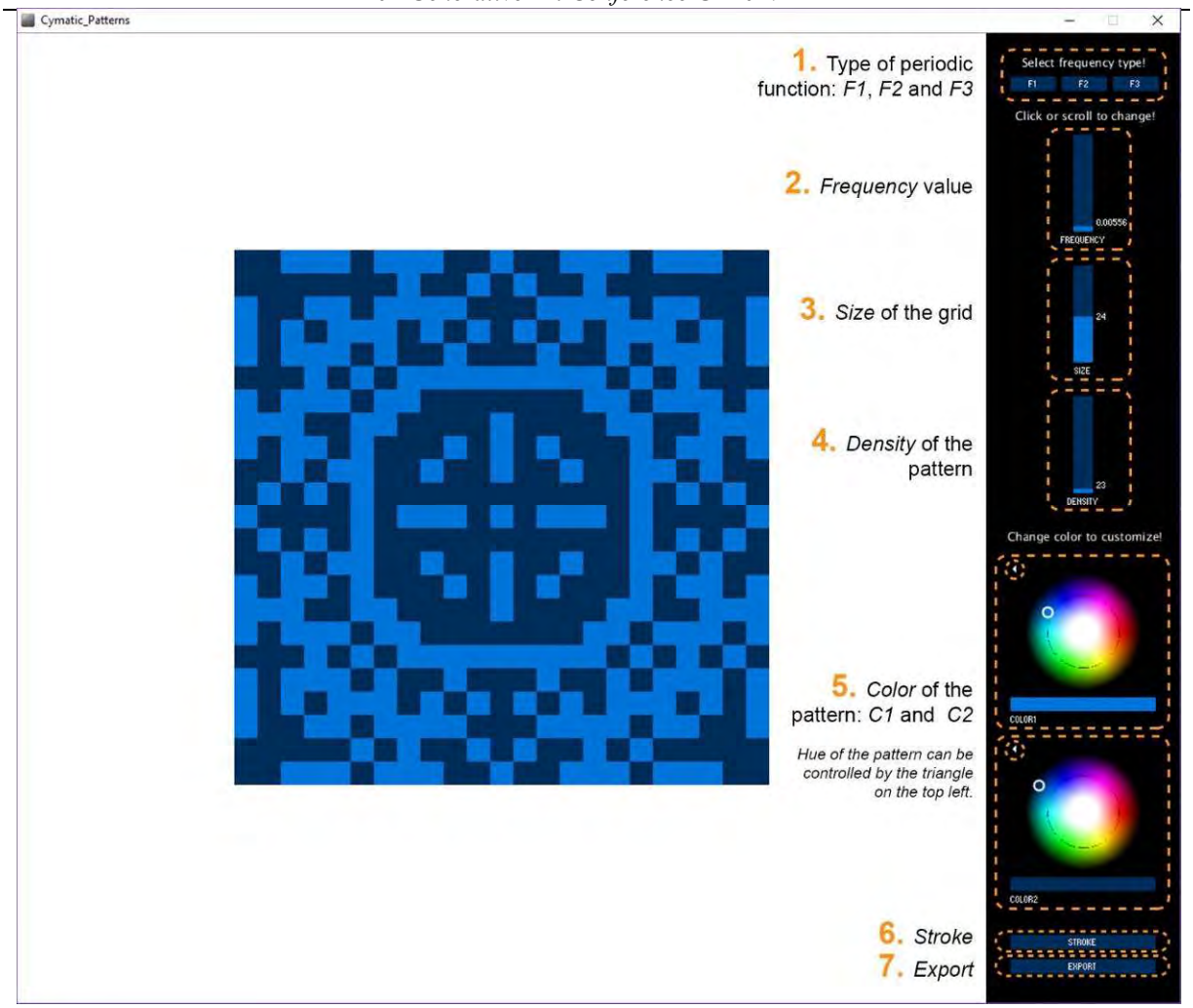


Figure 9. Introduction of the interface of Cymatify

Frequency type is used to change the type of periodic function in the mathematical expression. It allows users to make more distinctive manipulations on patterns. These periodic functions are predetermined in the algorithm. For this reason, the frequency type can only be manipulated by modifying the source code. Users are able to switch between 3 types of different mathematical functions which are expressed as *F1*, *F2*, and *F3*. *Frequency* slider controls the frequency value in the periodic function. *Size* slider gives users ability to change the size of the pattern. *Density* slider allows users to increase or decrease the number of rows and columns in the grid. As the density increases, the pattern complexity increases accordingly, and vice versa. *Color wheels* are responsible for the color of the patterns. *C1* and *C2* color wheels allow users to control the colors of the negative and positive areas separately. Cymatify allows users to create customized patterns by modifying the defined variables according to their intentions and function or place to be used.

Outcomes

In this section, various generated patterns through using Cymatify is presented (*Figure 10*). Generated patterns show that how making minor changes in variables can affect the diversity of the emerged figures. This variety among patterns reveals the importance

of the precision of the variables. In the interface, to ensure precision 5 decimal places are used for generating intricate, different and infinite quantity of patterns.

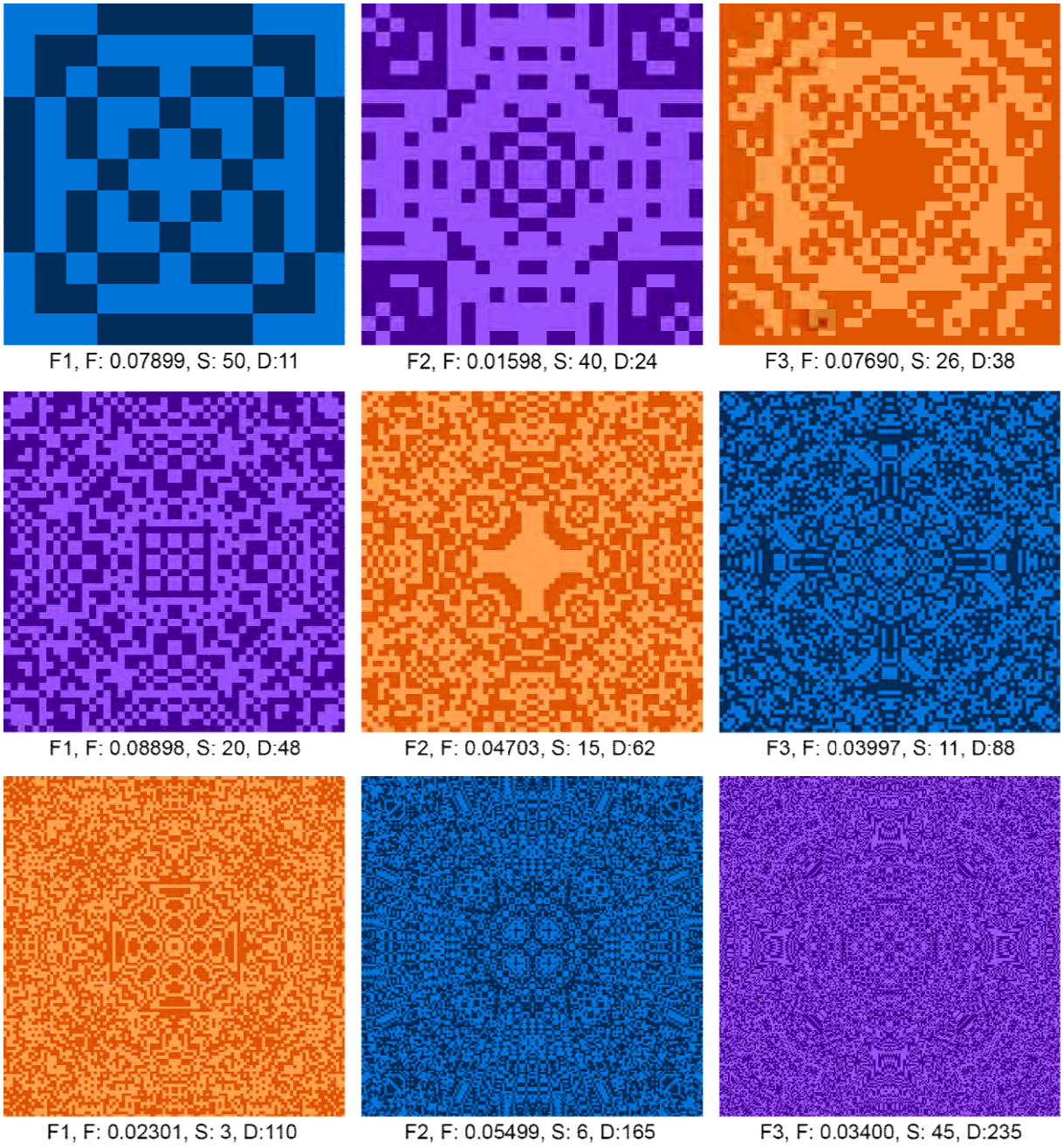


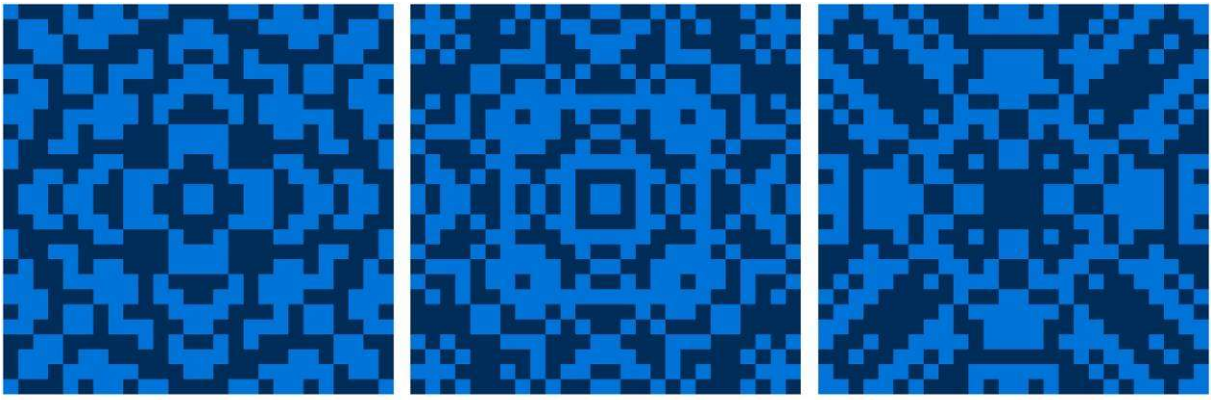
Figure 10. Outcomes are sorted in order to frequency and density values increasing from left to right. F1, F2 and F3: Frequency type, F: Frequency value, S: Size of the pattern, D: Density of the pattern

Results and Discussion

In this study, a novel pattern generation tool introduced with the Chladni's experiment as a source of inspiration. The underlying fundamental of the Chladni patterns is the wave phenomenon. It is possible to differentiate from Chladni patterns with the visualization of this phenomena within the proposed framework. Using periodic functions is a decent way to realize and visualize this phenomena. It is possible to create unique and intricate patterns in different complex structures. The resulting patterns can be varied by manipulating the *density* and *frequency* variables, and different combinations can be

derived by the users. Furthermore, pattern variation can also be differentiated by diversifying the *periodic functions* in the source code of the software.

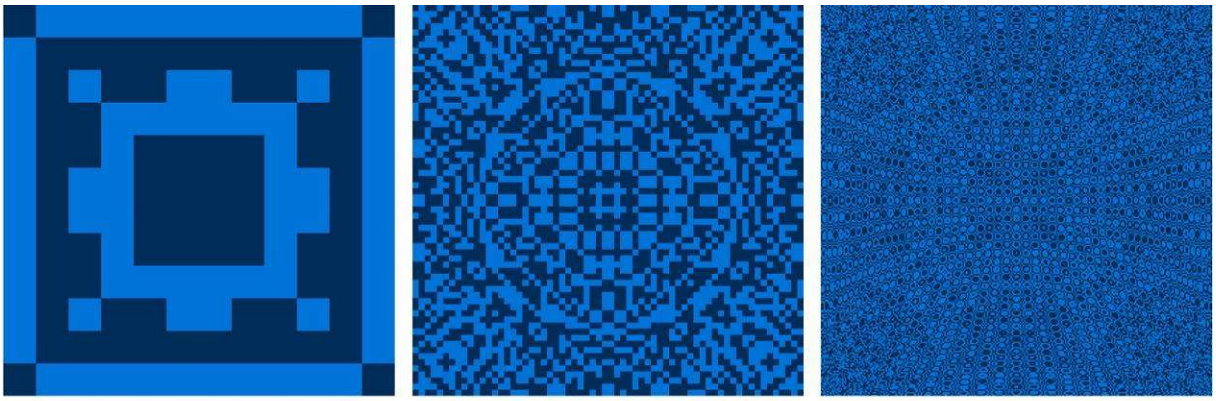
It is observed that the software is capable of producing infinite amount of diverse patterns hence the variety created within the periodic function. Changing frequency types, F1, F2 and F3, means changing the type of the periodic function which leads emergence of completely different patterns even though every variable is the same but frequency type (*Figure 11*). Moreover, infinite amount of patterns can be created by changing the *frequency* and *diversity* parameters since they have high precision for setting values. We can say that our two hypotheses are justified by the reasons mentioned above.



F1, F: 0.00302, S: 28, D: 26 **F2**, F: 0.00302, S: 28, D: 26 **F3**, F: 0.00302, S: 28, D: 26

Figure 11. Values of the patterns variables are the same but frequency type

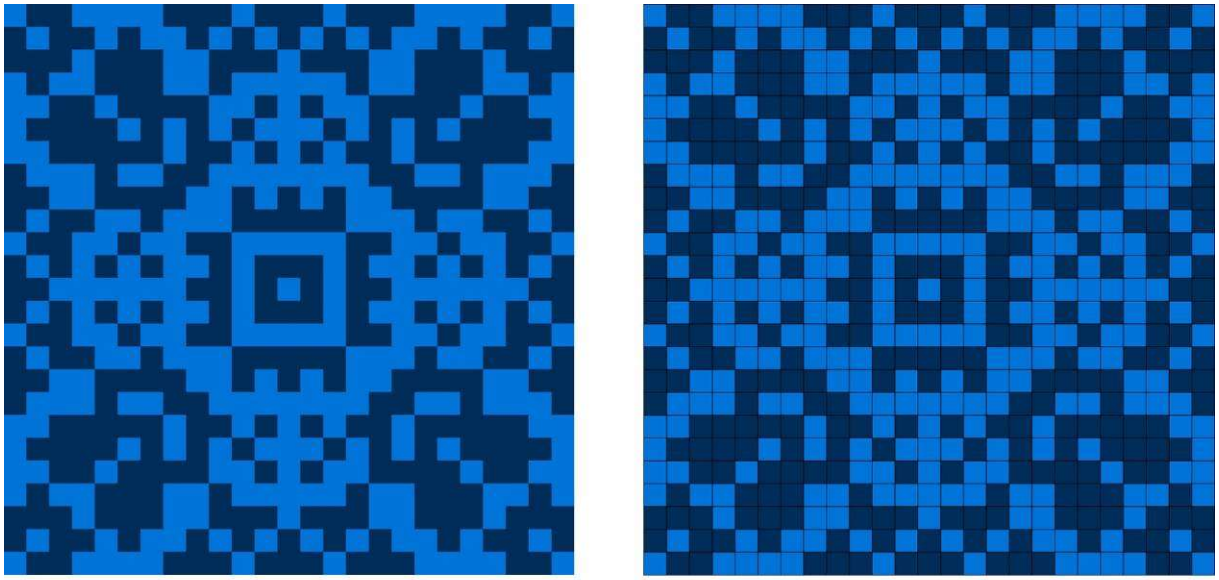
As a result it is possible to discuss outcomes of the pattern generation in the context of complexity, unpredictability, and diversity of the patterns. The variations within the created sequences can be provided by the variables on the interface. It is concluded that each manipulation on the provided variables are resulted as emerge of a pattern with a different appearance. Therefore, it is possible to argue that each variation on the functions and the variables has direct effect on the diversity of the patterns. Another point that is determined is, as the matrix size increases, which is represented as *density* in Cymatify, the complexity of the patterns increases (*Figure 12*). Each change in the mathematical function, frequency and density causes the generation of unpredictable patterns. In this context, it is correct to say that each variable is directly related to the unpredictability of the resultant product.



F1, F: 0.06500, S: 2, **D: 12** F1, F: 0.06500, S: 12, **D: 64** F1, F: 0.06500, S: 2, **D: 295**

Figure 12. Values of the patterns variables are the same but density

In the interface, by using stroke button black lines drawn around the each grid of the pattern (*Figure 13*).

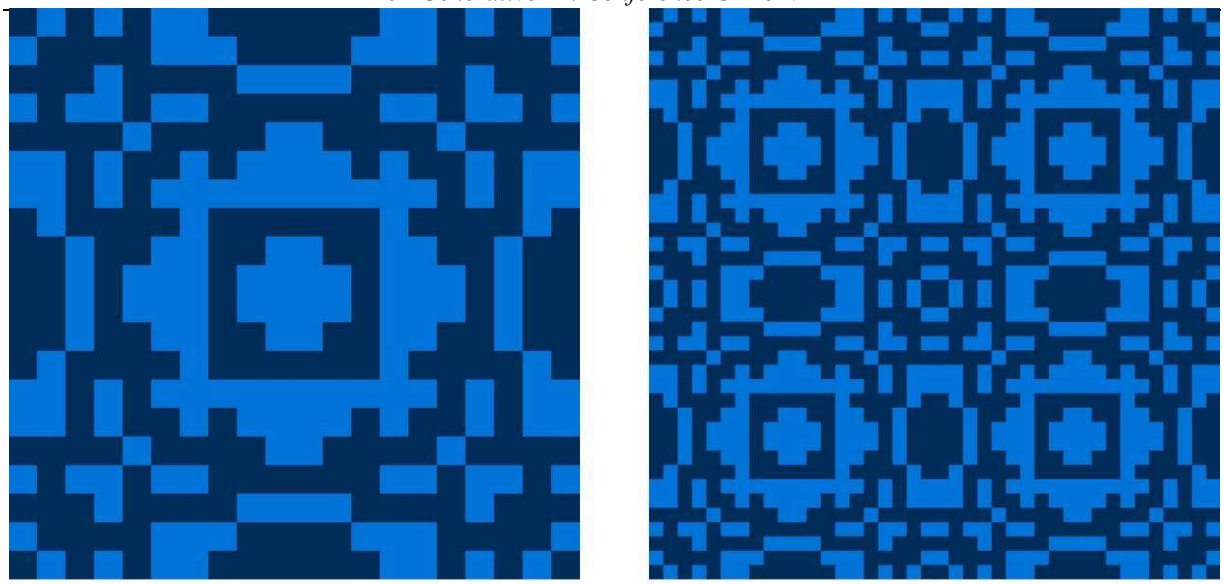


F1, F: 0.00719, S: 37, D: 25

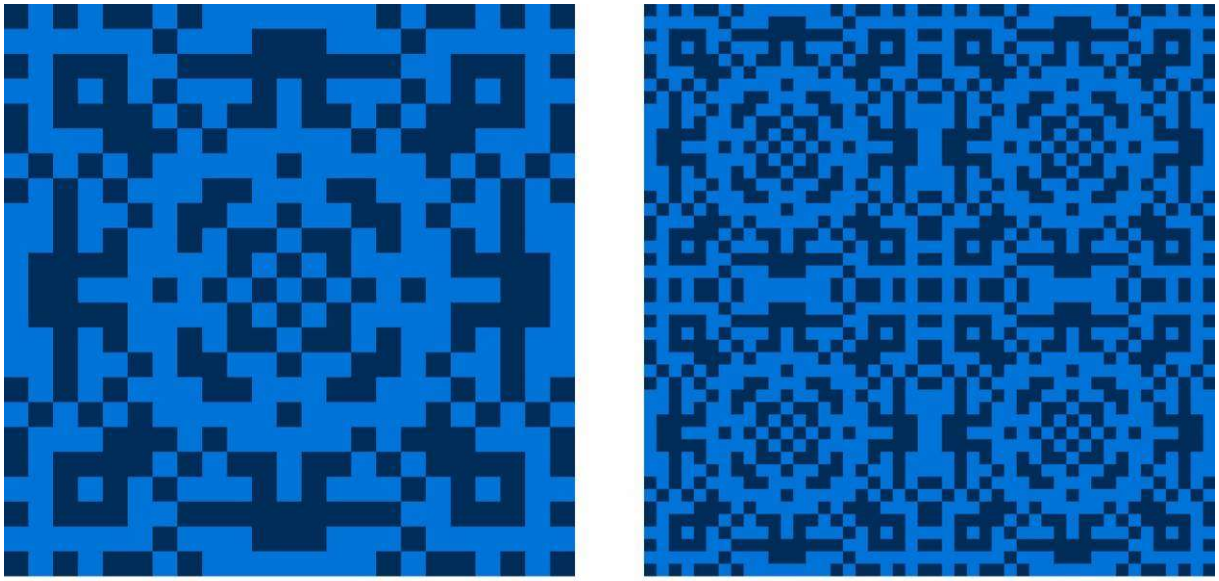
Figure 13. Difference between non-stroked and stroked patterns

Outcomes obtained from Cymatify are continuous patterns. Generated patterns showed continuity when brought side by side (*Figure 14*). Also, unnoticeable new patterns emerged in the intersection between the coupled patterns (*Figure 15*). This shows us variety can be increased by bunching patterns together.

Chladni patterns are usually produce under similar experimental conditions and digitalized with similar approaches. A few amount of diversity can be achieved by changing a small number of variables with limited values. For this reason, similar results are obtained as a result in the previous experiments and simulations. Thanks to the pattern generation framework introduced, it is possible to create complex, diverse and unpredictable patterns. Even if the proposed framework is based on a similar approach, due to the proposed differentiations in mathematical definitions, it is possible to achieve far more diverse and much more complex results. With the introduced software, unlike the Chladni patterns, it is possible to achieve an infinite number of patterns with the multiple combinations.



F1, F: 0.07000, S: 45, D: 20



F1, F: 0.03687, S: 45, D: 23

Figure 14. On the left, single pattern. On the right, pattern is copied 4 times

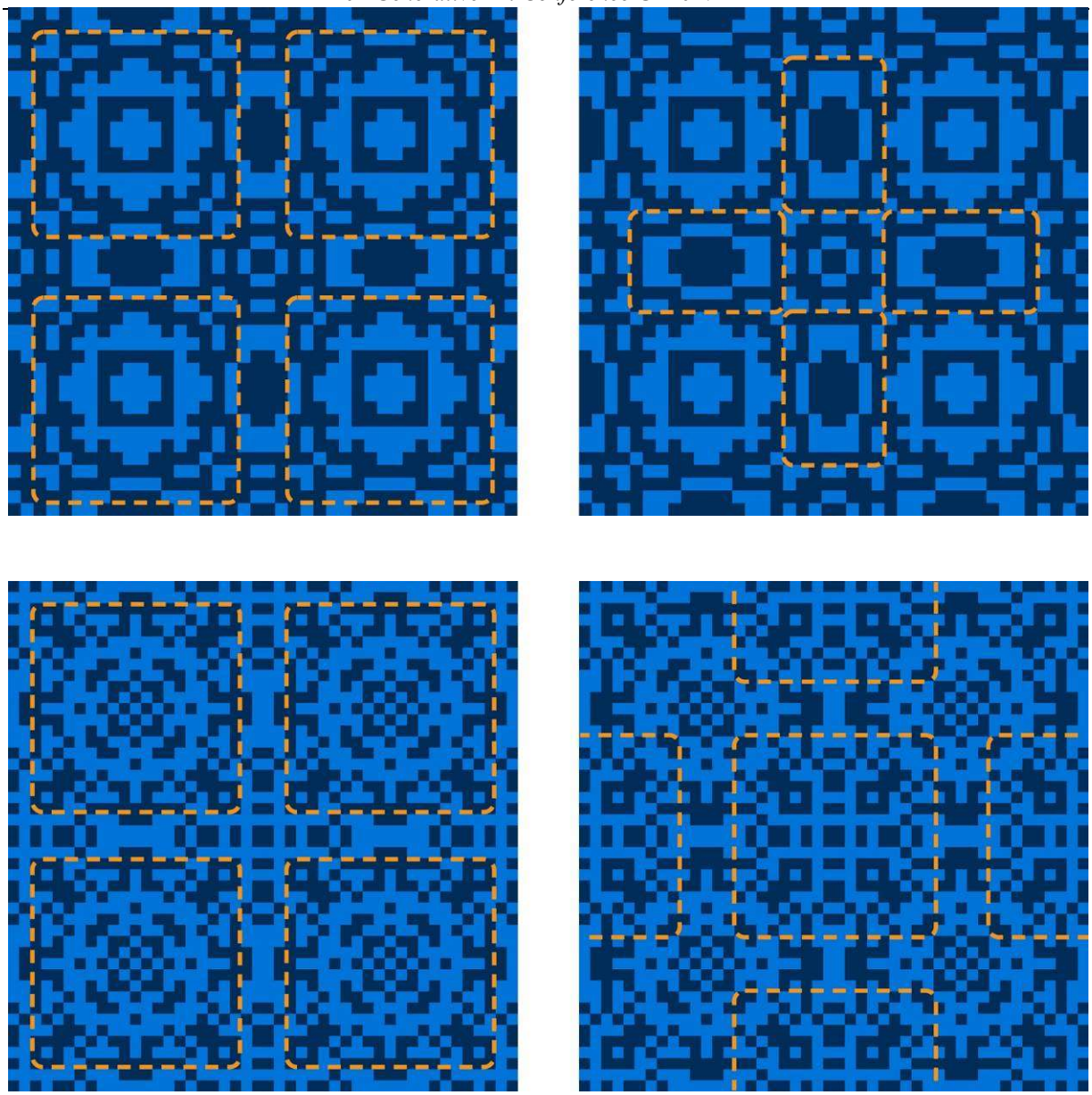


Figure 15. Existing patterns are on the left. Emerged new patterns are on the left

Future Works

It is determined that the one of the most dominant reason on the diversity of the patterns is the variations periodic functions. In this phase of the study, only a few *trigonometric periodic functions* is operated in the algorithm. In the future studies, it is aimed to increase the variety of periodic functions. It is predicted that different patterns can also be obtained by *Sinus-like, Non-smooth*, and *Vector-valued periodic functions*. It is planned to integrate more complex functions into the algorithm such as *Fourier series*.

This study includes two-dimensional pattern production in a 2D plane. As a next step, it is aimed to modify the algorithm in order to produce 3D patterns. In this context, we are carrying out various studies. By using the 3D modeling program *Rhinoceros* and the *Grasshopper* plug-in, proposed pattern generation method has been reconstructed in the 3D environment (*Figure 16*). It is predicted that various sectors such as architecture, product design, interior design and so on can benefit from the patterns that emerged as

the result of this study. In addition, since these 3D patterns will be defined in the digital environment, it will also be possible to physically manufacture them easily by using devices like CNC and 3D printer (*Figure 17*).

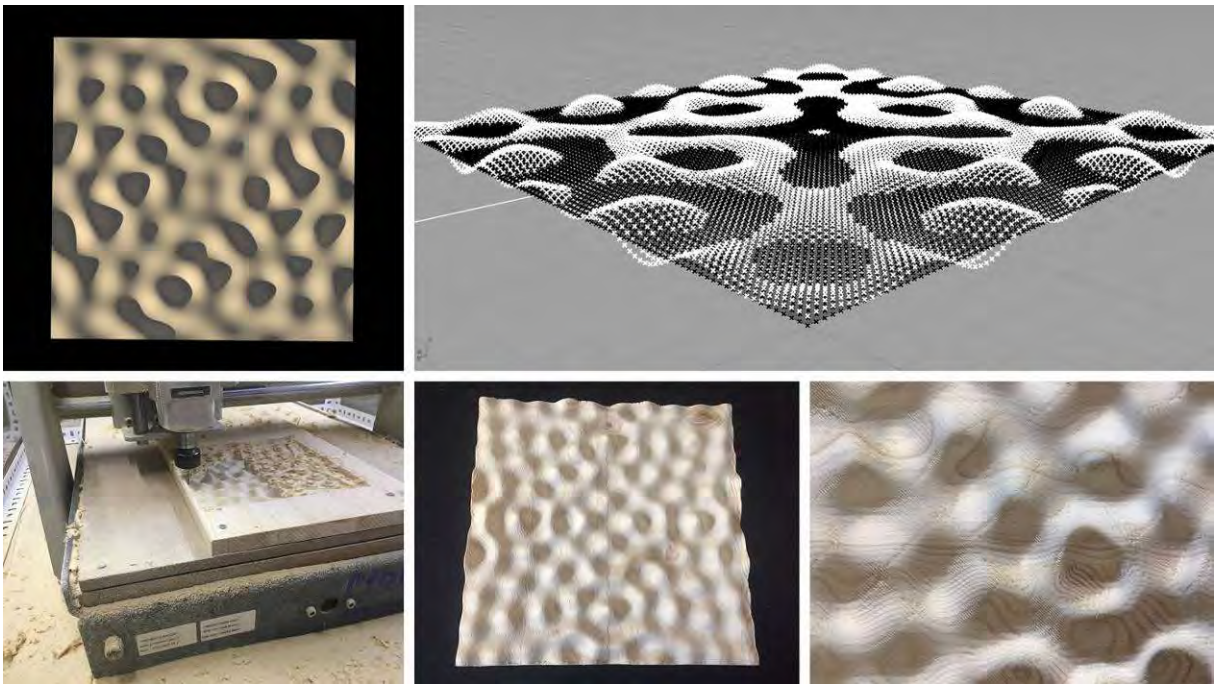


Figure 16, 17. Top: Digital 3D patterns. Bottom: Manufactured patterns by CNC

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BLURRY BOUNDARIES: QUERIES ON BOUNDARY PHENOMENON BY USING DOPPLER EFFECT

(Paper)

Topic: (Architecture)

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Abstract

Architecture has always been related to the concept of enclosure and boundary. It can be considered as a mediator that separates 'inside' and 'outside' and establishes the relationship between these two situations. People who inhabit in the environment are being continuously shaped by physical, cultural, and social fictions. Boundaries are the ones that affect relationships of people and environment by separating or surrounding them. In a broader sense, architecture has been attributed to the form, the ending, containment, the building shell or the wall of the room. Concurrently, architectural space has been considered as a void which has nothing in it. However, there are also 'materials' such as air, gas, fire, sound, magnetic effects, light which intentionally or unintentionally fill this void. The perception of people cover multisensory and complex interactions, beyond receiving merely visual stimuli from the space. So It is possible to say that the 'boundary' is an abstract line without actual thicknesses. The boundary between body and space is either widely assumed as the skin/contour or represented with a circle shape of agent-based computational models. We argue that investigation of the relationships between body and space in terms of architectural representation which might bring new dimensions to boundary phenomenon. This study aims to introduce a Doppler-inspired interactive boundary visualization and its comparison with the kinesthetic monitoring of full body movements.

Motion tracking and capture of hand and body movements became not only possible but also feasible by the advances in sensor technology. Different than the existing studies on 2D and 3D visualization of body movement, this study aims to introduce a series of experimentational visualization of body-dependent boundaries in space. Main aspects of Doppler Effect such as observer-source dependency, change in motion, change in direction were inherited. In addition of this, the wayfinding mechanism of bat was utilized as a source of inspiration. The body is assumed as a dynamic agent and a source of light beam (vector) generator. Real time body-space interactions will be mapped onto 2D planar surface. Visualization experiments are generated in Processing interface by using Kinect XBox 360 Sensor.

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Key words: architecture, boundary, visualisation, modeling

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Blurry Boundaries: Queries on Boundary Phenomenon by Using Doppler Effect

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Abstract

This study introduces findings and outcomes of an experimental research based on a Doppler-inspired visualization process. Doppler Effect, by definition involving dimensions of time, velocity, direction, space-observer relations and wave provided provided a basis for the initial assumptions of the experiments. The body of a person in a space is considered as a source of doppler wave. The events consisting of movement are defined as the impact area of the event. Physical surfaces are assumed as reflective and nonreflective constraints. Therefore, the way doppler effect is abstracted, while waves are spreading out from a living source, space plays a crucial role to characterize the perceptual aspect. Moreover, theoretical foundations of the experiments were fed from Toyo Ito's flow and blurry architecture concepts. The experiments lead primarily new understandings about the boundary concept. With the aim of expanding the potential meanings and definitions of boundary concept, in order to investigate the changing relations between subject-event-space diagram-based scenarios and rule-based approaches were developed in Processing environment.

1. Introduction

Architecture has always been related with the concept of enclosure and boundary. It can be considered as a mediator that separates 'inside' and 'outside' and establishes the relationship between these two situations. People who inhabits in the environment are being continuously shaped by physical, cultural, and social fictions. Boundaries are the ones that affect relationships of people and environment by separating or surrounding them. Tschumi opposes the idea of reducing architecture

into merely space and form [1]. As event, action or what happens in space are also related to architecture. Especially in the modern era, when the boundary phenomenon has begun to be questioned in Cartesian forms, it has been a controversy in the architectural literature as a phenomenon frequently mentioned. Therefore, Le Corbusier has used the prime geometries as design elements due to their clarity which can be easily perceived, Mies van der Rohe has made architectural planning studies concerning total space search with less restrictive architectural elements, Wright has worked on designs that question internal-external relations. A vast number of studies have been investigated the concepts of transparency, inter-space, massive fluidity, topological and topographical relations.

In this manner, architecture has been attributed to the form, the ending, containment, the building shell or the wall of the room. Concurrently, architectural space has been considered as a void which has nothing in it. However; the perception of people cover multisensory and complex interactions, beyond receiving merely visual stimuli from the space. There are also 'materials' such as air, gas, fire, sound, magnetic effects, light which intentionally or unintentionally fill that void. In his “Blurring Architecture” text, Toyo Ito conceptualizes the elements of “blurry architecture” in three items:

1) The responsive architecture as a designed artificial which takes components of natural environment such as light, water, wind, into account;
2) A room which provides an extent of flexibility to change its program
3) Architecture seeking for transparency and Homogeneity [2].

Toyo Ito approaches the phenomenon of “boundary” in relation with the metaphor of “floating” [2]. According to Ito, human inhabits in nature and society through the experience of/experiencing bodies and the perception of 'inside' and 'outside' over the body can be considered as the floating of water [2]. The body is neither inside nor outside, at the connection point; it can be expressed as "floating" if we fill the void at this connection point. Ito describes this approach as “blurring architecture”[2]. Blurring architecture defines a kind of soft architecture image that does not yet have a definite shape. The physical description of this situation can be achieved by a soft limited architect responding to natural aesthetics (light, water, wind) or by a transparent and homogenous structure suitable for program changes of a space [2].

In physics, the boundary is not a static field, is a layer moving between the two fields. This layer occurs as a result of energy differences which depends on various states such as temperature, pressure, density. Philippe Baylaucq's high-resolution thermal camera shoots (Figure 1) in “ORA” film, can be considered as an example of how to define a gradient interconnection between energy differences in terms of an artistic interpretation[3]. The scenes in the film involve a second layer of gradient colours surrounding the dancers' bodies and the colours form a thermal space informed by synchronously moving dancers in the same area. Sean Lally points out the gradient light of a street lamp in a dark street as an example to boundary state of the energy [4]. As Lally highlight that people feel safe when they enter an area which is restricted by the light, even though there is no physical obstacle. As an experience of this situation, the series of interactive installation 'Transcending Boundaries' by teamLab can be exemplified [5]. The 'Transcending Boundaries' (Figure 2)

installation, by only differentiating the qualities of light, led audience to perceive and question the limit of space.

Figure 1: A screenshot from ORA [3] Figure 2: Event based visualization [5]

The energy change, the flow of the energy and the concept of entropy have been approached by various scholars [2-8]. Beesley emphasizes that current developments in technology may allow to create a completely new built environment typology using thermal, acoustic, chemical and electromagnetic energy [7]. In the context of boundary concept in architecture, Beesley criticizes the conventional assumption of boundary which is reduced into the basic shapes of 'circle or sphere'. He argues that, the conventional assumption of boundary effects the way people perceive and comprehend the space. However, the position of an individual continuously changes, the perception of spatial relations as well. Beesley suggests a form that represents a permeable area surrounding the individual. This form is more of a twisted form that surrounds the world around the individual as a network [8].

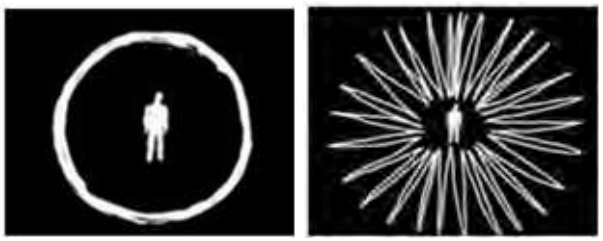
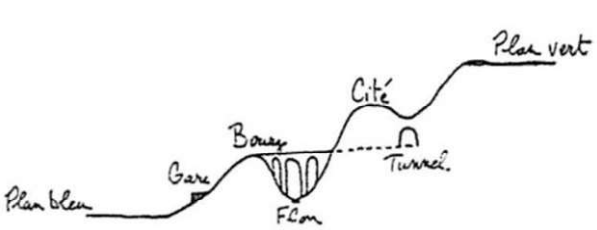


Figure 3: Beesley's boundary descriptions [8].

In 'Earth moves: The furnishing of territories' book, Bernard Cache writes "*Our brain is not the seat of a neuronal cinema that reproduces the world; rather our perception are inscribed on the surface of things as images amongst them*" [9]. The view of our surroundings can be considered as a reflection of our interpretation of them. Therefore, our way of seeing is crucial to the understanding of space, architecture, territories and everything else. This is why Cache concerns about expanding the limits of our understanding of the space. Images could always be read as abstract mathematical elements and relatedly all physical elements can be simplified into pure geometric forms in some extent. For instance, to redefine a landscape, Cache interprets that all the variations of the landscape can be converted into geometric shapes. Further to this assumption, he translates a vector that projects onto an abstract line of the terrain [9]. He draws an inflection in between points (Figure 4).



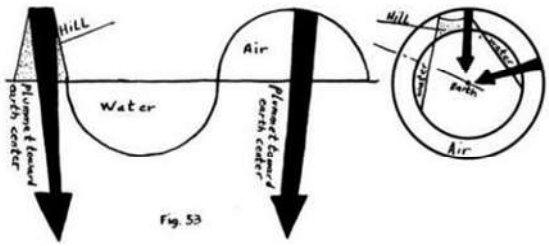
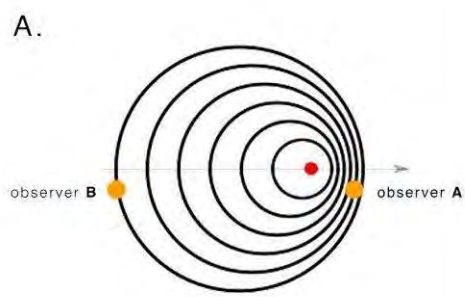


Figure 4: Louve city definition of Bernard Cache [9]. Figure 5: Earth, water and air drawing by Paul Klee [10].

Reading our surroundings without identity allows for the infinite change and creative possibilities that might push potential developments [9]. Accordingly, re-reading the concept of boundary between the self and the space through different modes of abstraction is essential to gain new understanding. Similar to Cache, in 'Pedagogical sketchbook', Paul Klee describes the world, nature, naturalness, everything on earth, water, air, dimensions of human body with moving lines (Figure 5) through a free creation of abstracted forms [10].

In the light of these discussions we argue that investigation of the relationships between body and space in terms of architectural representation which might bring new dimensions to boundary phenomenon. The way one abstracts the ongoing spatial and motion-based relations in the world would be a key action to enrich thought, imagination and the design ideas as well. Therefore, this study aims to introduce a Doppler-inspired interactive boundary visualisation process and discuss the potentials and limitations of the outcomes in the context of their contribution to understanding of boundary concept.

2. Doppler Effect and Boundary Phenomenon



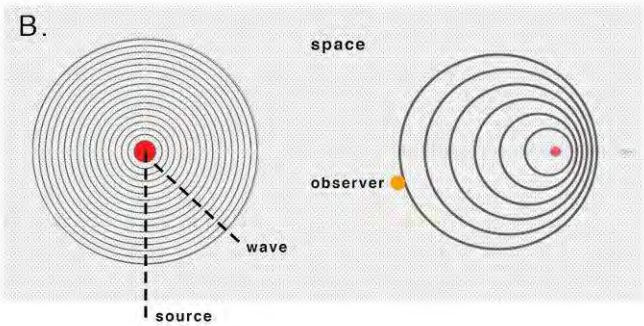


Figure 6a: Doppler effect

Figure 6b: Waves radiating from the source and motion of source

In the scope of this study, the doppler effect has been approached as as initial concept to manifold the affordances of boundary phenomenon. In a broader sense,

the Doppler Effect refers to perception of light and sound signal phenomena which emerges from relationship between the signal source and the observer. By mathematical definition, the signal moves closer is perceived as being higher than it actually is, whereas that same signal moving away will be perceived as being lower (Figure 6a) For the formation of the doppler effect, a signal source in movement, an observer and spatial (space and time) relations between them are required (Figure 6b).

In order to get a better understanding, the components of doppler has been divided into components as a preliminary assumption. These components (i) space, (ii) observer, (iii) wave lead to a parametric ground which can be elaborated in different directions. In other words, during the digitalization process of boundary phenomenon in experiments, the variables and assumptions on doppler effect was used. The doppler effect is considered metaphorically as a spatial agent. The metaphorical consideration of doppler effect allows to explore new the relationships between space and boundary.

2.1 Defining Space in Terms of Its Geometrical Limits

In a broader perspective, the term space conveys the meaning of a place that encapsulates the events. Relatedly, the concept of encapsulation needs to be unfolded in terms of the limit of a space defined by a borderline or a threshold. In the scope of the experimental process, space refers to the physical surfaces encapsulating an event. The digital layers which might augment the notion of space were neglected. Therefore, space is considered as a border line or an obstacle, that does not allow some specific actions to pass through from inside to outside (Figure 7a). To give example, concrete walls of a room which limits the transition of light can be considered as spatial boundary.

Shown in Figure 7a, encapsulating surfaces are taken as in-situ boundaries. Threshold in Figure 7b demonstrates a spatial extension of an event, without having a border. Instead the threshold value which is represented by changing radii values representing the distance from the source of event. Therefore, the threshold value is considered as depth that shows spatial extensions of event. Threshold is determined by range of waves and it extends through spatial extensions of event. In that manner, the depth of threshold demonstrate the areas of all possible actions covered.However there is no any certainty about depth of threshold if it is evaluated as abstract notion. It is a re-definable / re-coded concept/ structure and any decision can be applied on it various contex.

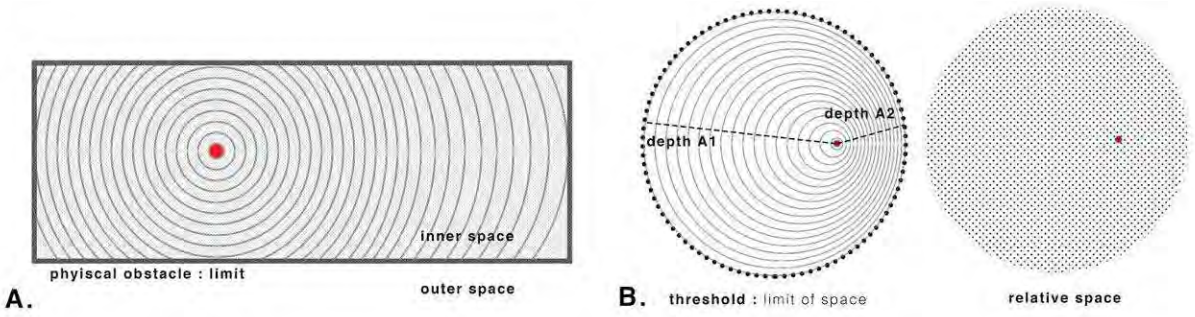


Figure 7a: Space definition in context of obstacle and 7b: Threshold

To exemplify, Sean Lally's street light description can be mentioned [4]. Lally illustrates street lights as light sources illuminating dark[4]. He mentions that lights fall on ground[4]. In that case, ground becomes obstacle or boundary. He adds that the transmission of energy levels high to low can be easily read, between too lightened through darkness there is a threshold that divide space as where is lightened and dark[4]. Another example is shown in Figure 8 regarding the interactions among the bodily event, wave and encapsulating interfaces. When the boundary concept grounded on a real space (where is physical obstacle), that mixture (unity) reveals the interfaces of encounters. A body grounded in public or private space, reading the maps of events inevitably employs the cultural (socio-political and economical) problematics in terms of body and this investigation can turn to cultural study. Surfaces can respond to the waves in different ways. In this study the behavior of the surfaces are limited to :reflective and nonreflective surfaces.

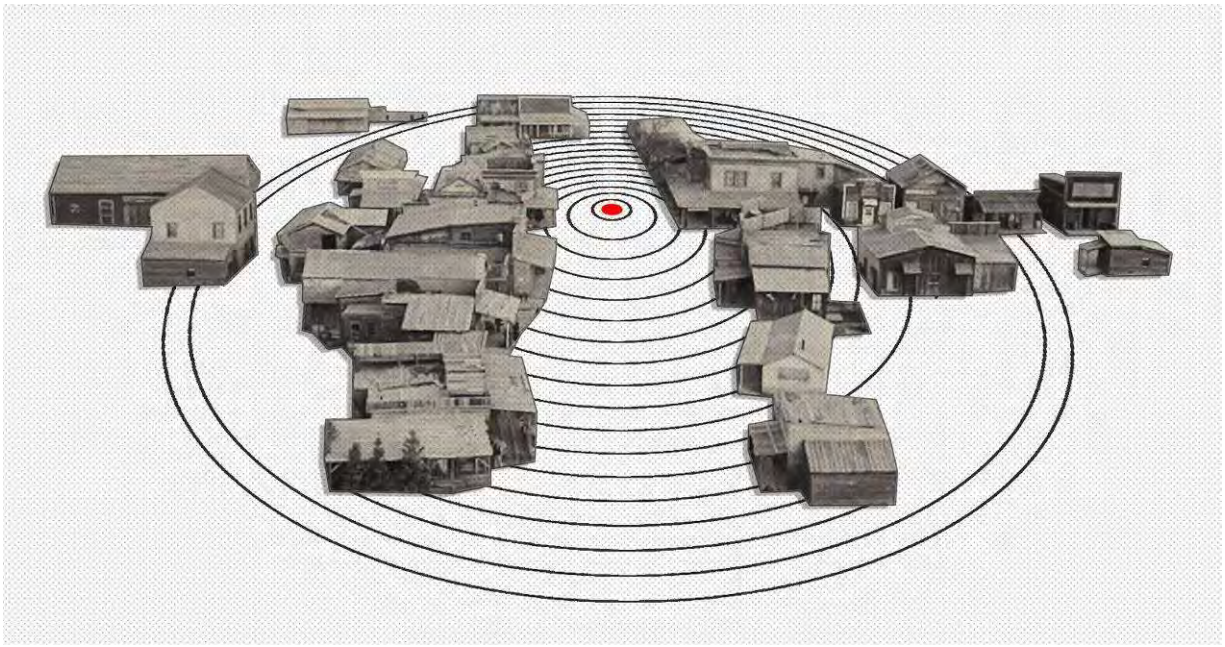
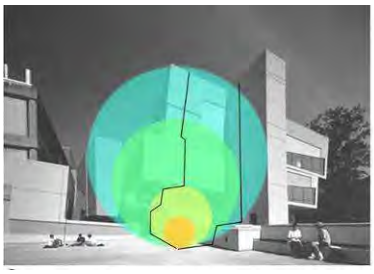


Figure 8: Grounding bodily event in real space

2.2 Sources of wave: The deconstruction of Body

A source of wave is represented as a second component of doppler effect. In the theoretical ground, the source of wave indicates to the body. As it was mentioned in the previous section, the existence of body (itself) inevitably grounds on public and private space within political situations and in the urban scenes, as an example relations between grey/ green areas sizes and mostly everything can easily demonstrate to us how the environment respect to the body. We argue that, the body and the scales play crucial role to broaden the context of that boundary investigation. While body can be noted as the one to generate waves itself, also body parts (like hand, head, feet) can be considered the generator as well. The encounter between the body and physical environment (which are manmade and nature) indicates the sense of scale of the environment in which the events take place. Accordingly, mapping the movements of either one part of the body or taking the human body as a whole provide an opportunity to digitalize relationship between body and space. Today, motion tracking and capture of hand and body movements became not only possible but also feasible by the advances in sensor technology. Different than the existing studies on 2D and 3D visualization of body movement, this study aims to introduce a series of experimentational visualization of body-dependent boundaries in space. Main aspects of Doppler Effect such as observer-source dependency, change in motion, change in direction were inherited.

Apart from those, and different than doppler effect, self-triggered wave generation mechanism is proposed. Within self-triggered wave generation mechanism, as it is shown in Figure 10, further to the intersection of the waves and encapsulating surface, new waves are considered to start. A diagrammatic section-based expression is shown below (Figure 9, Figure 10):



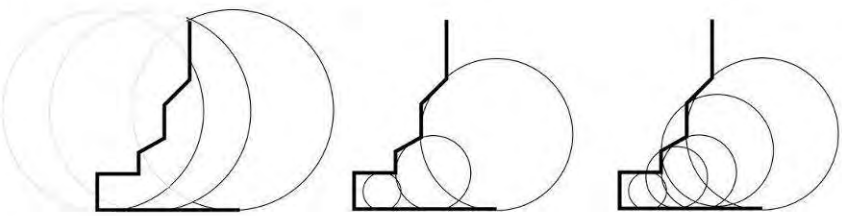


Figure 9: Visualization of doppler as a packing element

Figure 10: Diagrams of section based variations

3. Experimentation

The research of blurry boundaries is conducted by a series of experiments. Experiments are evaluated from basic to complex structure step by step to understand fundamental question how the waves of bodily event possibly behave inside the encapsulated space. In other words, while the human body assumed as a source of wave, how/if changing boundaries of the potential events can be mapped and visualized in different ways. Experiments are performed in terms of space, rules and events specification. Evaluation process of experimentations is stated with diagram based scenario through slow computing and it is finished with implementations.

3.1. Diagram based scenario

Visualization of the doppler effect and exploration the relations was the crucial stage of the experimentation. Diagram-based scenario stage aimed to foster creative ideas and divergent thinking regarding the speculations on the concept of boundary. Photoshop was used as tool for colleges to see fast visual effects, apart from sketching. In this way, analysing the possible opportunities and parameters sets in two scenario. First scenario approaches the notion of doppler effect through shape and colors in terms of visual and formal character. The source of doppler was represented with a point. Based on the assumption of simultaneous execution of different events in a space, multiple doppler sources were used (Figure 11). Further to the initial abstractions, the second scenario focused on real-time interaction and implementation. Body parts were considered as a source of doppler wave and, movement of body assumed as a initiator of doppler waves in 3D space (Figure 12).

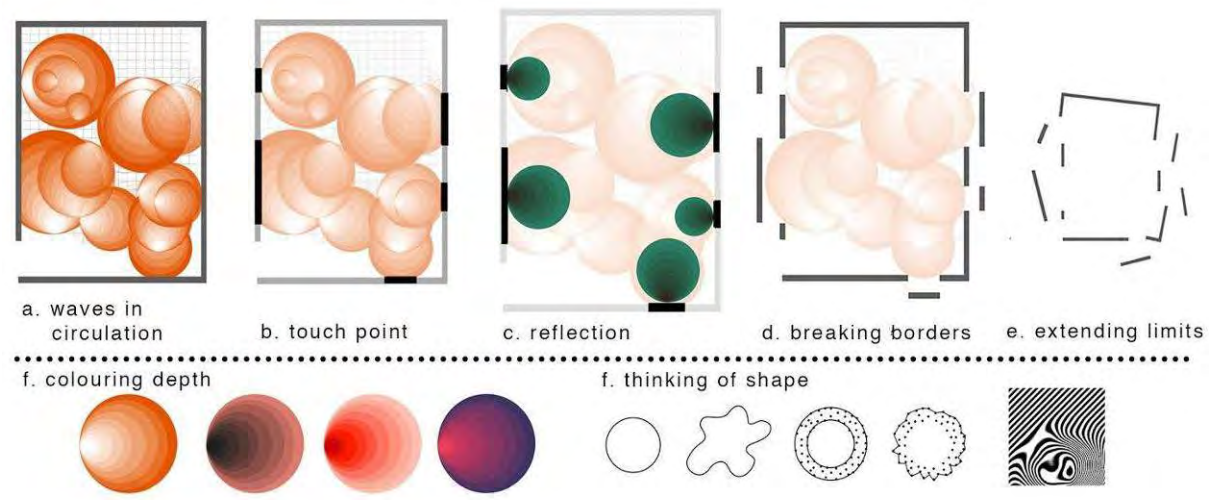


Figure 11: First formed scenario

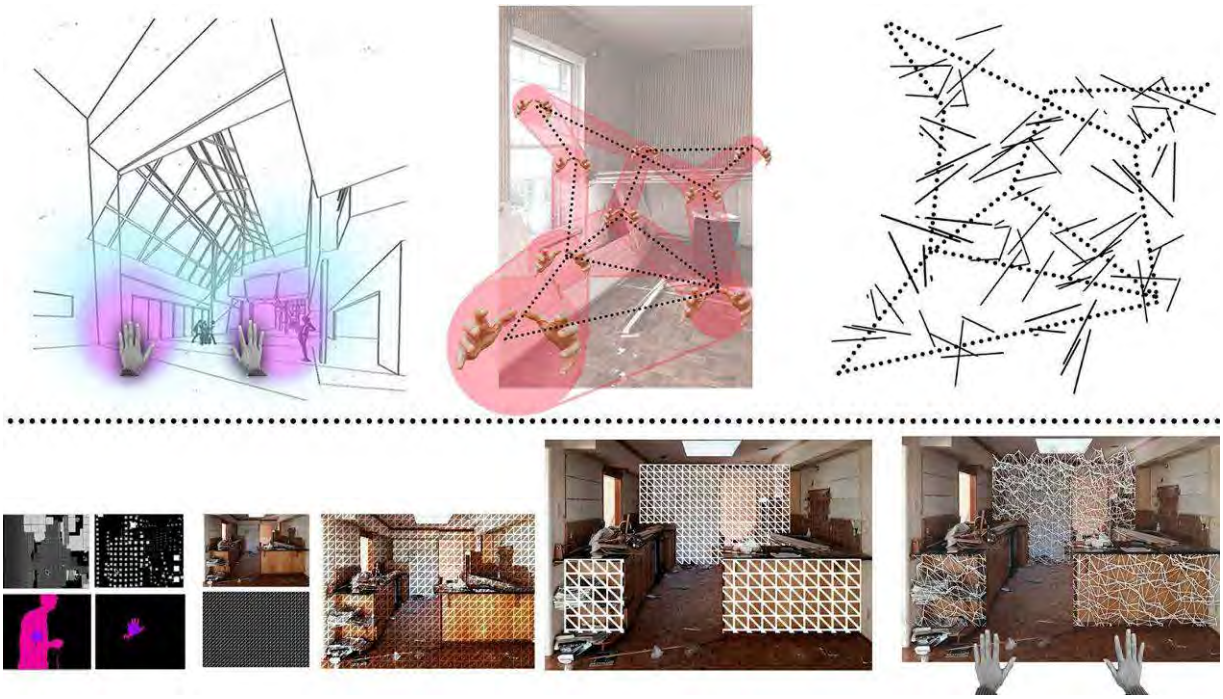


Figure 12: Visualizations for three dimensional space scenario

3.2. Slow Computing

3.3.

Further to the scenario development, the assumptions on the doppler effect were translated into Processing environment through rules and algorithmic structures. This stage can be considered as a bottom-up process in which each consideration has been converted into programming codes and tested. Instead of focusing on instant and working outcomes in Processing, this process has focused on generation of rules, relations and event specifications.

3.3.1. Space

"Impact area" and "encapsulated space" were the basis of the assumptions for space, as it has been previously explained in section 2.1. Impact area refers to a self-triggered wave generator (body) and the encapsulated space is a boundary which consists of reflective and nonreflective surface layers. In addition, regular shape and indented-irregular shape were examined within form of the encapsulated space.

3.3.2. Rules

Five rules are defined to explore boundary situations in relation with the surface typology of a fictional or real space (Figure 13).

Rule 1 - The first rule involves continuously wave generation. The waves are considered to spread out from a center point towards outside as circles. The period parameter affects the distance between consecutive waves.

Rule 2: Whenever a wave (circle) touches (intersects with) a surface, stop growing. Rule 3: After Rule 2, shift the center of growth of a wave to the intersection point of the wave and the surface.

Rule 4: Whenever a wave intersects with a surface, generate new centers (center of wave).

Rule 5: Apply perlin noise to the wave. In other words, from a certain distance affect the radii of the impact area.

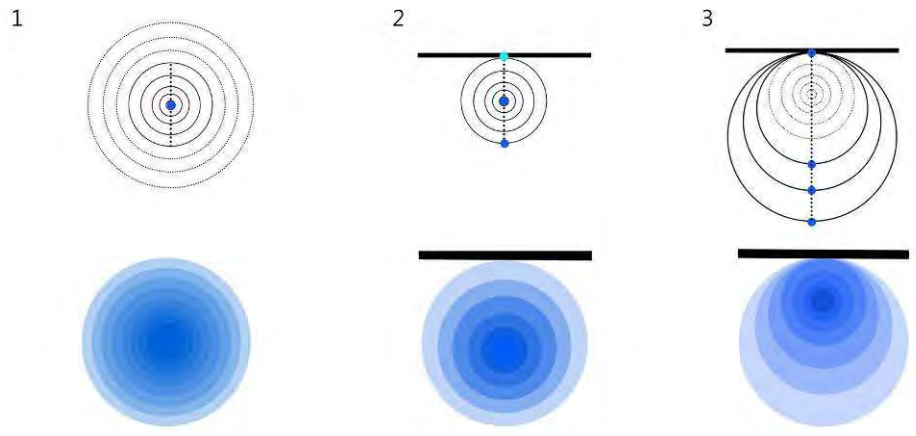


Figure 13: Visualization of the first three rules

3.3.3. Event

Conception of event leads the exploration of the limits of wave diffusion in space. Events involve the movements of the source without having any directional purpose. It is assumed as a continuous motion with a consistent direction with certain paths. In the scope of the experimentation, two paths were examined: Simple/linear path and multiple/connected paths. While the linear path involves simple motion, the multiple/connected path involves more complex potentialities (Figure 14).

3.3 Experiments

In this stage, different visualization techniques were tested to unfold potentials of the experimentation. Circles representing the impact area of the source way, Pink square explores limits of radiuses, Orange square are illustrates both the directions of impact area which is perpendicular to the path and how impact area fills the different levels of voids in space. Touching points of waves on the surfaces are demonstrated with red arrow (Figure 14).

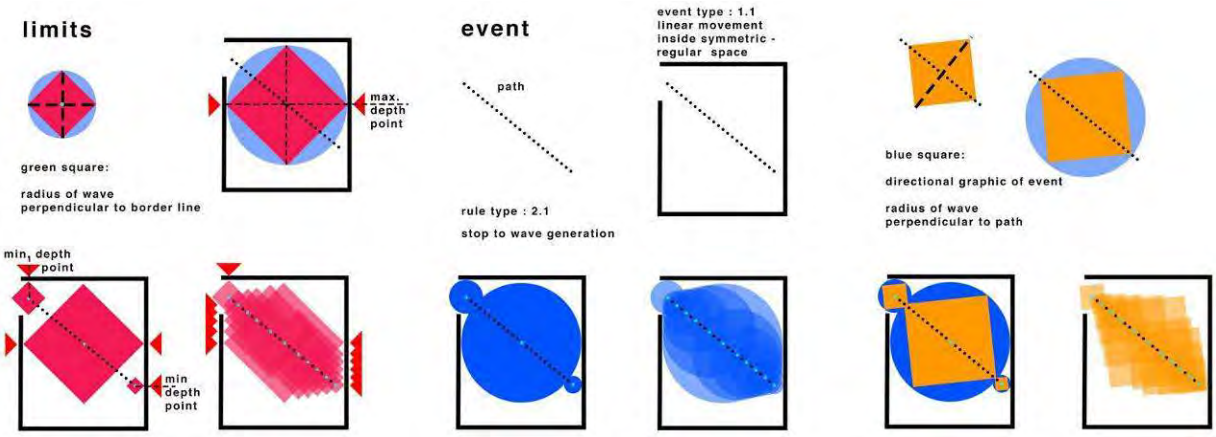


Figure 14: Experiments in defined spaces

3.3.1 Experiment - 1

The first experiment focused on the source of wave which represents the impact area, nonreflective surface and encapsulated regular shape spatial properties, Rule 1 and Rule 2 as an interaction mode and linear path event (Figure 14).

3.3.2 Experiment - 2

This experiment have same specification/ parameters with Experiment-1 yet only difference is choosing the encapsulated irregular space rather than encapsulated irregular space(Figure 15).

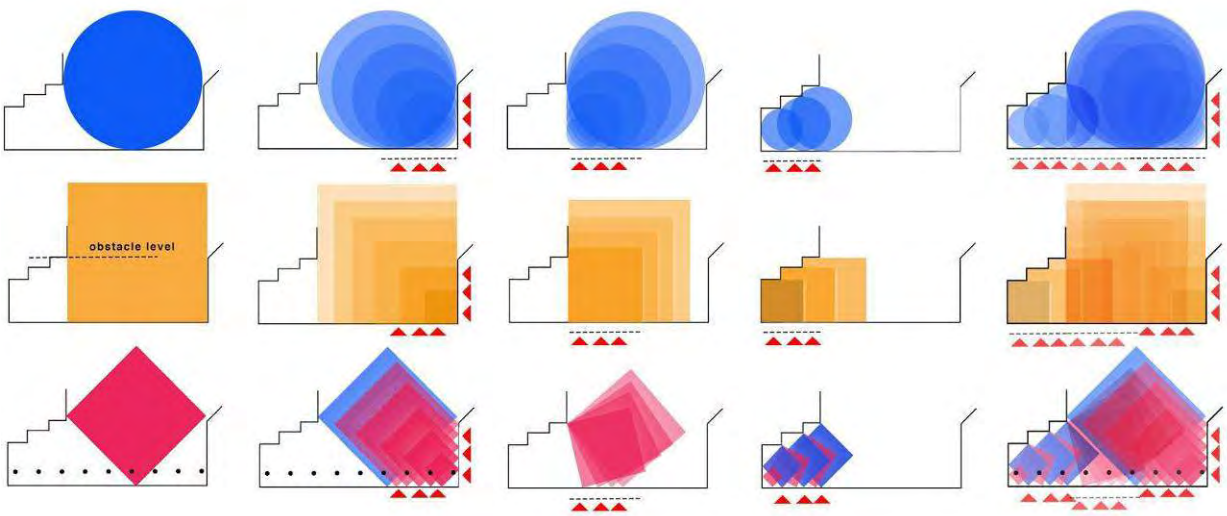


Figure 15: Experiments in irregular formed spaces

3.3.3 Experiment - 3

Further to the bottom-up explorations in Experiment 1 and Experiment 2, Experiment

3 can be considered as a top-down process in which sample programming codes

[11] are decoded and adapted to the context of the study. Kinect 360 was used for motion capturing and Processing was used for visualization in Experiment 3. During 2D visualization, kinect camera was used as top view camera. The body was assumed as a dynamic agent and a source of light beam (vector) generator. Real time body-space interactions were mapped onto 2D planar surface. The algorithm schema of the code is shown in Figure 16 below:

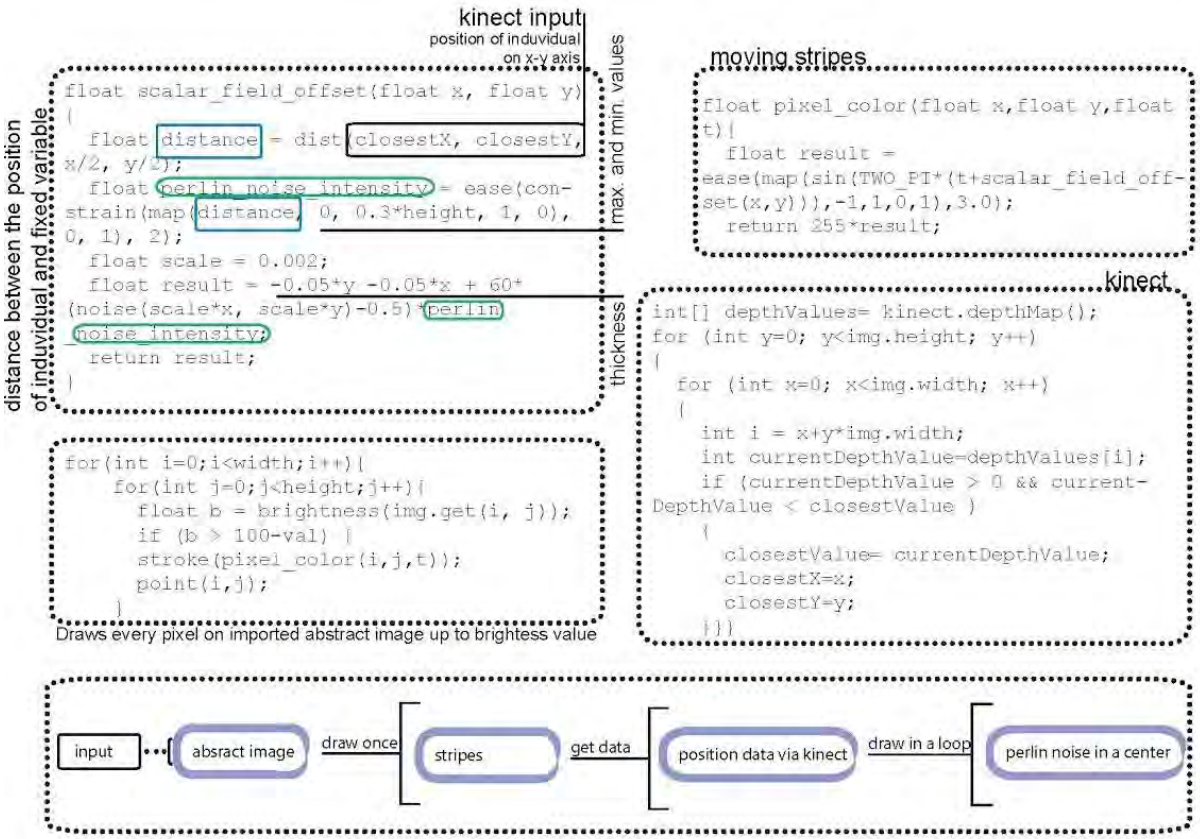


Figure 16: Flow of the program

The variables of the code consist of number of the people, the location (X, Y) of the people, speed of the movement, spatial constraint (encapsulating surface), frequency of the wave (time-depended), stripe value and perlin noise. The time-dependent frequency value is also linked to the speed of the movement. The stripe value refers to the distance between two waves and it is related with the speed. In addition to these variables, perlin noise is used for generating more natural effect on the Processing outcomes. The perlin noise allows an opportunity to restructure doppler waves.

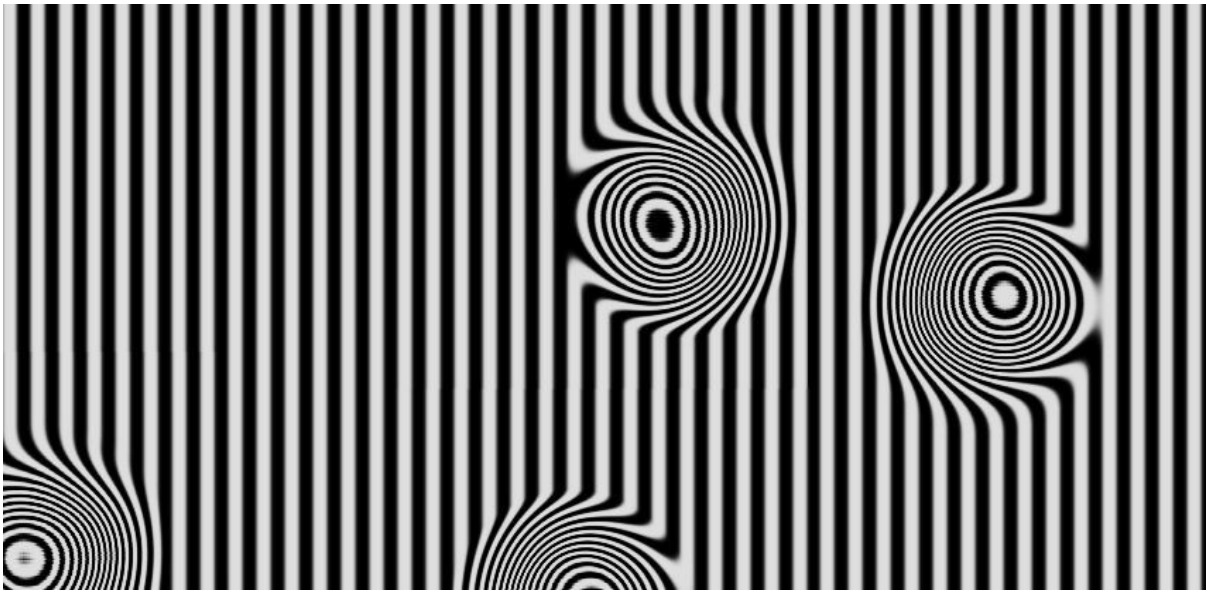


Figure 17: Abstract visualization of motion without any stimulant

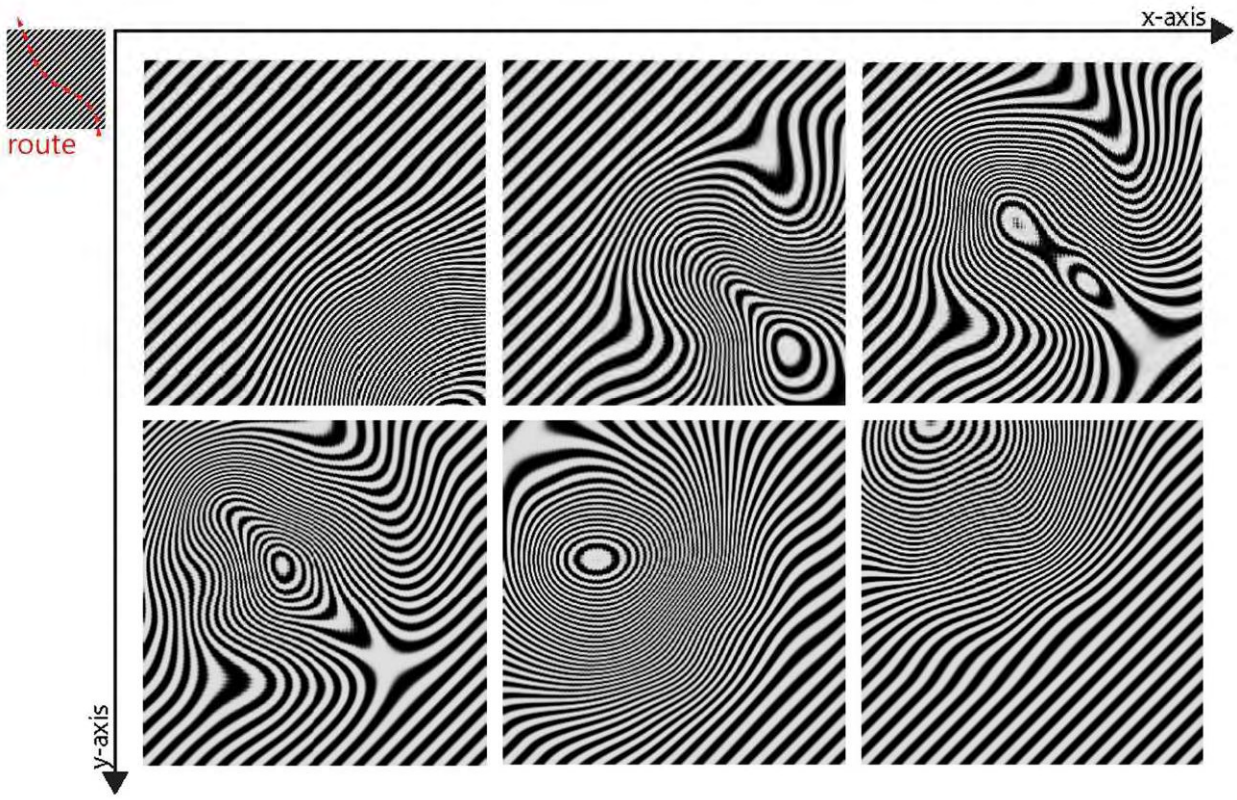


Figure 18: Motion on a route

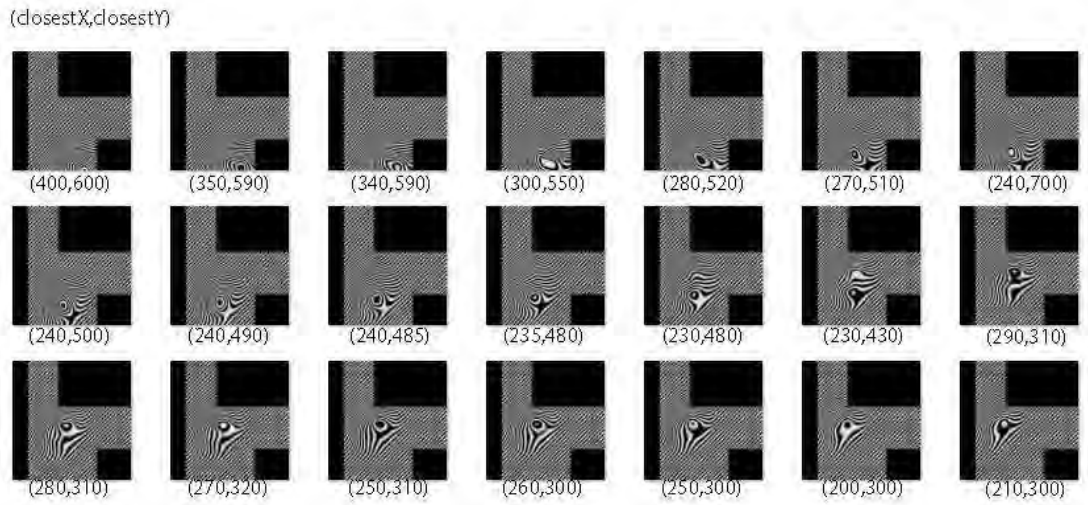


Figure 19: Results on different positions of individual

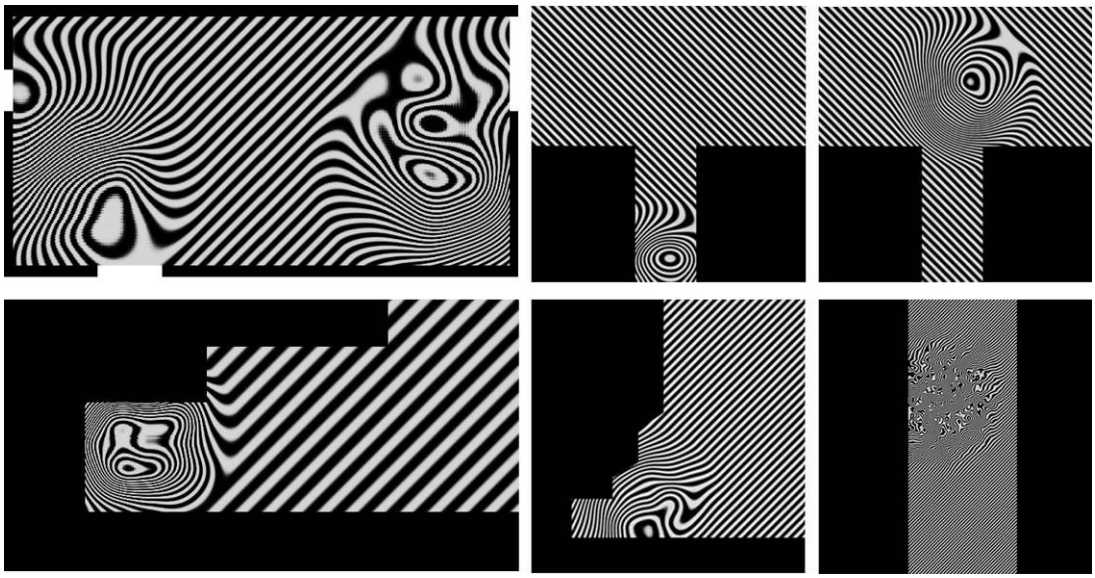


Figure 20:Variations on fitting to space

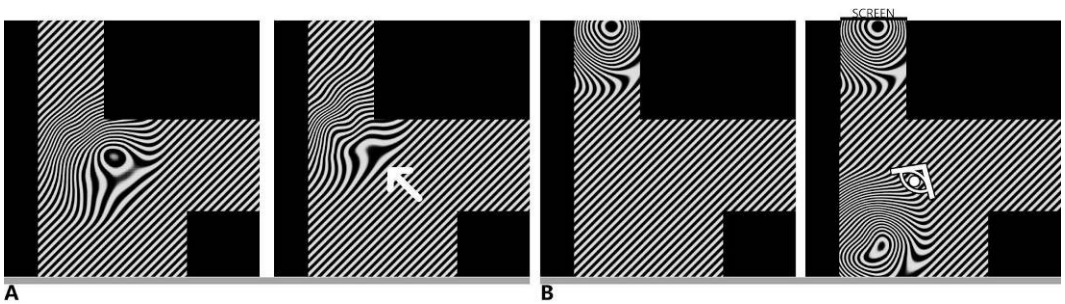


Figure 21a: Change of boundary perception through wind

Figure 21b: Change of boundary perception through an interface

4. Concluding Remarks and Discussion

In this study, mathematical definitions of the doppler effect have been examined as an initial departure point. The concept of boundary, relatedly the changing relations between subject, event and space have been investigated through diagram-based scenarios and a series of visualization experiments in Processing environment. Insights derived from the experiments show that the doppler-inspired approach has potential to be used in generating visuals on:

Impact area: Apart from the representation of body in a closed space through basic geometries (Figure 11), wave-based representation might lead more reflective (Figure 10), reflexive and relationally complex outcomes (Figure 17-21).

Event maps: It is possible to generate different event maps based on real-time or retrospective usage of motion capture data. Therefore, doppler-inspired approach has potentials to achieve blurry traces of the events.

Holistic reading of fragmented/discrete events (Figure 17-21).

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ARTWORKS

Cosmic Birth
Artwork (Poster 50x70)
Topic: Art, Digital Art, Graphic Design, 3D, Procedural Generated, Hybrid Fractal
Author:
Alfredo Monaldi "Hurricane"
Italy, recently graduated Graphic Designer at the Academy of Fine Arts of Macerata with a thesis about Postdigital Aesthetics, Glitch Art, Generative Art and Vaporwave Art movements.
Personal Site: http://facebook.com/hurry.art

Abstract
Since the dawn of time we took from the world around us visual grammars to express ourselves, our thoughts and needs but also to impress and share a feeling. Crawing to reach others, driven by our inner search for beauty, artistic practice is what makes us humans. Wether we look at geometric patterns carved into stone, typical of the Paleolithic
art or we jump forward in time to the first Oscillons made by
Ben F. Laposky in 1953, Generative art has always been a distinctive artistic experience that connected us, our tools, math and nature together.
Being fond of Graphic Design and digital practices I wanted
to learn how contemporary software-driven generative art can approach fields like concept art, illustration and visual design, how the endlessness of natural-like fractals could be used in new solutions. Thanks to our modern techniques and tools used within a generative context we can achieve communicative and artistic solutions never seen before, allowing us to exploit ordered and disordered systems both in 2D and 3D dimensions to explore new ideas and concepts. This is a piece I called "Cosmic Birth". It was achieved with a 3D hybrid fractal and 2D post-production. 3D fractals are a range of chaotic equation-based objects usually derived or formed from the Benoit Mandelbrot set.
The set can be visualized in two different "pure" 3D visualizations that inherit the same characteristics of the mathematic equation: the Mandelbub (discovered by Daniel White and Paul Nylander in 2009) and the Mandelbox (discovered by Tom Lowe in 2010). The hybrid fractal is a 3D fractal presenting both of those two parameters combined in different ways that can "grow" into an infinite number of ways and combinations. This generation and transformation is called Mandelmorphosis. This is the technique I used to generate a fractal "cloud" of matter around a central point of light in a 3D space, resembling a star emerging from a Nebula in a beam of light.

amonaldi95@gmail.com

Key words: 3D, Fractal, Hybrid, Light, Cosmic, Star, Universe, Pathos, Ray, Generative, Digital, Art, Mandelbub

Main References:
www.chicagospace.org
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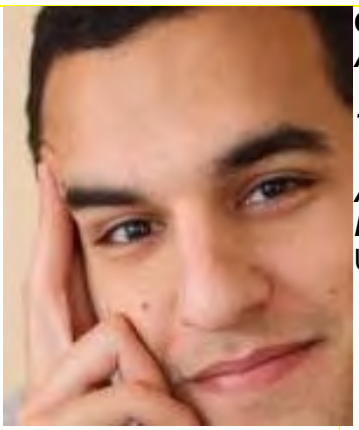

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Company / The Company I Keep
Artwork

Topic: Art

Author(s):
Barak Chamo
United States, New York University, ITP

Abstract
"Company" is an exploration of human connection, identification and empathy that leverages generative artificial intelligence to synthesize imagery. The complete technique for production includes portrait photography, neural network training and generation and dynamic image processing on display.

By training a generative neural network with the faces of my close friends and acquaintances, I want to produce a series of images of our combined selves as a representation of our relationship and impact on each other. This generative process yields a semi-realistic, almost impressionistic, depiction of our "intersected identity" that is inseparable and indivisible.

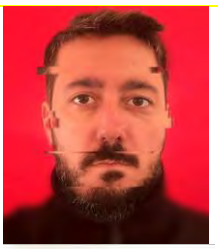
By display the figures on presentation monitors and not print I will be able to modify and animate the degree to which the two identities impact the "intersected" one, almost like gene dominance in biology, morphing the figure's makeup over time.

At the same time, this series is also an attempt to explore cultural diversity in a new and visual way. All depicted share a
common half, myself, while having a distinct and varying "other" half. I want to leverage this sense of connection between all figured to explore the representation of different cultures, races, and ethnic groups in visual art and in society.

If time and resources allow, I would like the piece to be accompanied by an interactive installation in which the audience could explore how they themselves "intersect" with others. I believe this experience will provoke a sense of empathy and connection with others that are different than you, by seeing yourself as them as your own "intersected identity".

email/address

Key words: generative, neural network, identity, visual art



TITLE: ***Degenerative Cultures: Corrupting the Algorithms of Modernity (Artwork with Artist Presentation)***
Topic: Art, Science & Technology

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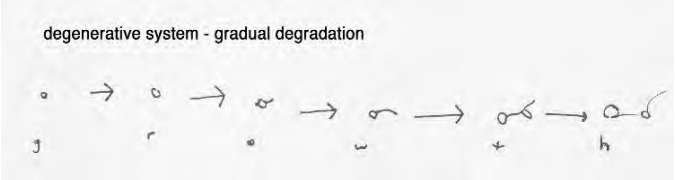
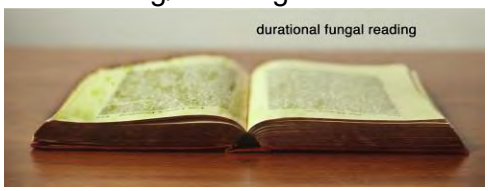
The League of Imaginary Scientists
United States, California State University San Marcos
csusm.edu/sofa/about-dept/faculty/solomon.html
imaginaryscience.org

Abstract
Degenerative Cultures: Corrupting the Algorithms of Modernity
Cesar Baio and Lucy HG Solomon/LOIS present a degenerative fungal installation that disperses spores and degrades culture. Human societies comprise a biological culture raised on Earth, with a substrate as the global ecosystem. Inarguably, human societies are destroying this ecosystem, resulting in a massive loss of data in the form of species extinctions and environmental devastation. This work permits the opposite flow of information degradation or data loss, allowing nature to disrupt human cultures – in the form of knowledge. A book is the substrate for fungi, whose spores propagate and corrode text, which is essential for storing/restoring human culture.





Degenerative Cultures: Corrupting the Algorithms of Modernity presents a physical book that is host to a fungal colony. Fungal spores consume the book, spurring the algorithmic degradation of cultural data. This book is the substrate for micro cultures, advancing a fungal censoring of human cultural knowledge and generating realtime audiovisual data of the fungal reading. This media element remixes and breaks down in content-complexity in response to the progression of the autonomous fungal system – an entropic feedback loop between culture and nature.
Cesar and LOIS present an autonomous system of data degeneration, with regular readouts of a fungal colony redacting human-based culture. An invisible network of fungi establishes the bases for an Internet of natural things, or a natural "Internet of things," at odds with most human knowledge systems. This fungal network escapes Internet protocols and evades electronic interventions. It is a global system that evolves through propagation and corruption. **Nature, including human nature, is unpredictable. Like fungi, we naturally disrupt.**

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Key words: autonomous systems, natural data, fungal system

Main References:
[1] Underground Signals Carried through Common Mycelial. Networks Warn Neighbouring Plants of Aphid Attack
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O. Feinerman and A. Korman. *Proc. Intl. Conf. on Distributed Computing and Internet Technologies*, LNCS 7753, 1-18, 2013.

Degenerative Cultures: Corrupting the Algorithms of Modernity

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Premise

A book is host to fungal growth, which both deletes text and tweets degenerating messages about nature and culture.

Figure 1 Book as substrate for fungal culture

Fungi form a natural Internet, sending signals and connecting nodes through mycelia. This

project combines the Internet of Natural Things with the Internet in a “bhiobrid” fungi-digital system that permits a feedback loop between human and microbiological cultures.

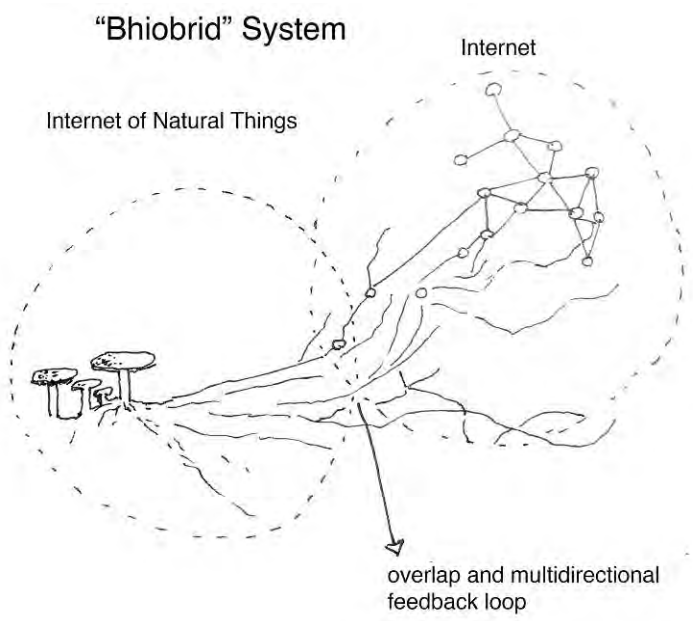

Figure 2 “Bhiohybrid” system of interconnected networks

The fungus disperses spores and thereby degrades culture. Spores drift across text, redacting as the fungus grows. This fungal censoring of books results in fungal tweets and retweets by human twitter users. The algorithmic scaling of the biological culture’s growth and resulting censoring of human culture generate a continuous series of fungal tweets. The retweets circle back into the fungal system in a feedback loop between these natural and technological networks. An automated readout of the fungal twitter feed documents one culture’s consumption of another: in this case, nature’s consumption of human culture.

A book becomes the substrate for a culture of microbiological organisms, whose spores propagate and in turn corrode the text. Books, as symbolic objects, are the storage vaults of human knowledge. Indeed, for most human societies, everything that we know is stored in text. Even when updated as computerized versions of this knowledge dataset, text is still the basis for this knowledge and is ultimately essential for both storing and restoring human culture.

If one considers human societies as a biological culture on Earth, our substrate is the global ecosystem. Incongruously, human societies consistently destroy this substrate, resulting in a massive cumulative loss of data in the form of species extinctions and environmental devastation. *Degenerative Cultures* accommodates the opposite flow of information degradation or data loss and allows nature to disrupt human cultures through the degeneration of text.

1. Cross-*Cultural* Interactions

Human societies destroy nature. Fungi destroy books. Cesar and LOIS present an autonomous system of data degeneration, with regular readouts of a fungal colony redacting human-based culture. Human and microbiological interactions underlie and drive

the installation's algorithmic functions.[1][2] These include the autonomous actions of fungi, which result in textual redactions, bot-driven fungal tweets with computerized readouts of those, as well as viewer interactions.

The biological cultures' growth obscures the text, which is tracked and catalogued as data points. This data is scaled against the length of the text, resulting in tweets by the growing biological culture, aided by algorithmic computer processing. These fungal tweets are printed on a continuous readout as a sort of poetry of degenerative cultures.

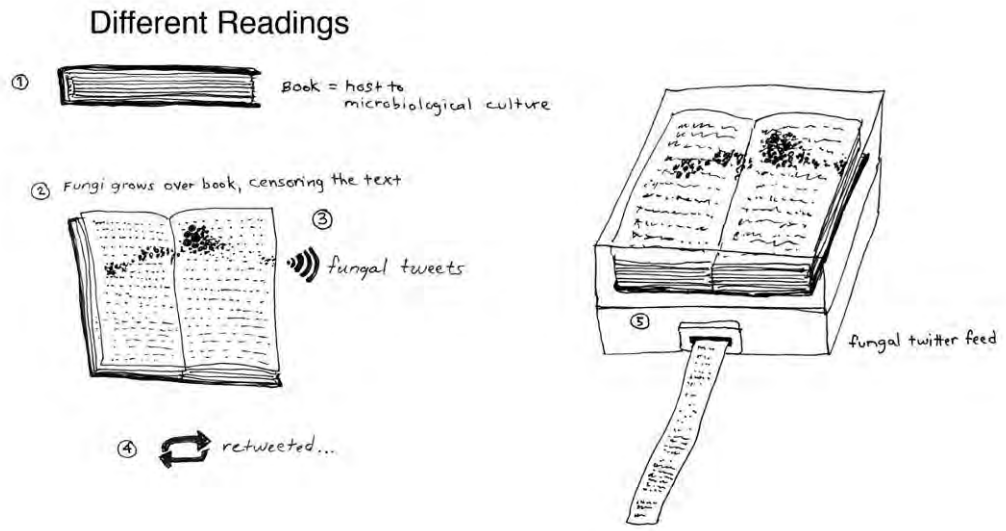

Figure 3 Model for fungal reading, redaction, and tweeting

The visual feedback of the fungal tweets is accompanied by audio that likewise tracks the text's redaction. Each of these generative outcomes can be influenced by humanity. Through in-person interactions, viewers can choose to contribute to the microenvironment in which the fungus grows, influencing the microorganisms' growth and further obscuring the text. This viewer interaction challenges the paradigm of culture vs. culture and inserts human beings as part of the natural system.

1.1 Degenerating Nature and Culture

Based on the corruption of data, *Degenerative Cultures* looks critically at how technology changes nature. Through landscape design and geo-engineering, human cultures seek to dominate nature. This domination can be viewed as a corruption of nature. Within the installation, the microbiological culture degenerates text in the form of a physical book and digital documents (i.e. human culture). As the living entity consumes and degenerates the book, Internet documents likewise become degenerated. At the same time, the fungus grows.

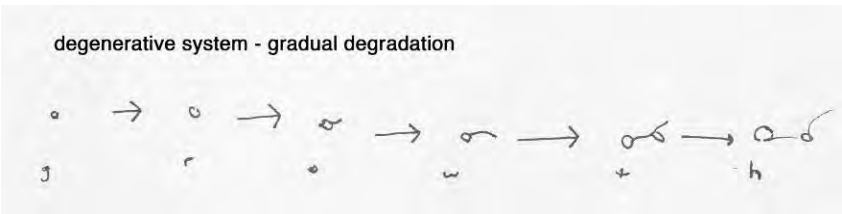

Figure 4 Degeneration of substrate equates growth of fungus

More often, throughout history, human societies are corrosive through the domination and mechanization of nature. Outliers in this are cultures for which nature is the dominant force. In a 2008 lecture to visiting artists and scientists, University of Lapland rector Mauri Ylä-Kotola described his decision-making process: “We follow the wisdom of the reindeer.” University policy is made according to reindeers, whose wisdom underlies Sami tradition.[3]

Some of the more direct pathways between different peoples and nature are themselves eroding. The Anishinabekwe scientist, Robin Wall Kimmerer, laments the loss of a connection to nature (and loss of language): “My first taste of the missing language was the word Puhpowee on my tongue. I stumbled upon it in a book by the Anishinaabe ethnobotanist Keewaydinoquay, in a treatise on the traditional uses of fungi by our people.” “Puhpowee,” she explains, “…translates as ‘the force which causes mushrooms to push up from the earth overnight.’ As a biologist, I was stunned that such a word existed. In all its technical vocabulary, Western science has no such term, no words to hold this mystery.”[4]

Degenerative Cultures alludes to this language loss. The book that is the substrate is literally eaten by microorganisms. The text is destroyed in a physical sense, and this destruction is visible through the redaction or disappearance of legible text on the surface of the pages. This data corruption is further articulated by algorithmically generated tweets and the automated readout of those tweets. Data does not last forever; nor does nature in its current form.

1.2 The Substrate

One selected substrate for the fungal reading is Studies in Landscape by G. A. Jellicoe. This text, published in 1960, documents the human desire to tame, shape and control nature, and within it Jellicoe examines global landscape traditions.[5]

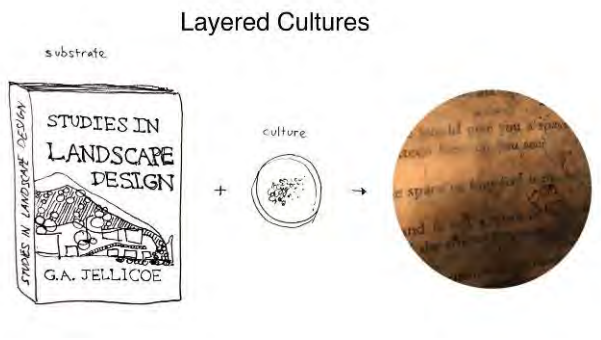

Figure 5 Text on nature and culture as a substrate

Jellicoe considers the Garden of Eden a paradise where unmitigated nature becomes a jungle. He recognizes that “the whole of architecture was based on suppression rather than the enlightenment of the individual spirit…” He posits an idealized garden, one that “would remind us also that we are always a part of nature and would tune us to that delicate response to nature which has almost passed from our experience.”[5]

Jellicoe quotes biologist Julian Huxley, who identifies the following as obstacles to human fulfillment: "'the extermination of wild life, over-mechanization, the boredom of mass-production and conformity, the spoiling of natural beauty, the destruction of cultural traditions.'" Jellicoe concludes: "Modern civilization is in fact tending to produce an environment that is contrary to the natural condition of man and therefore against his ultimate happiness and welfare." This positions humanity and nature as diametrically opposed cultures: "Western man set himself to adventure upon and conquer the resources of nature." [5]

2. Internet of Natural Things

An invisible network of fungi establishes the basis for an Internet of Natural Things, or a natural "Internet of Things," at odds with most human knowledge systems. An Internet of Natural Things exists: fungal spores communicate.[6] This fungal network is one that escapes Internet protocols and evades electronic interventions. It is a global system that evolves through propagation and corruption. The artists are interested in how this natural network is connected with the actual Internet and human communication systems. By creating a conduit for fungal tweets, Cesar and LOIS cross these dual lines of communication and open up this question: how are we – humanity, technology, and nature – connected?

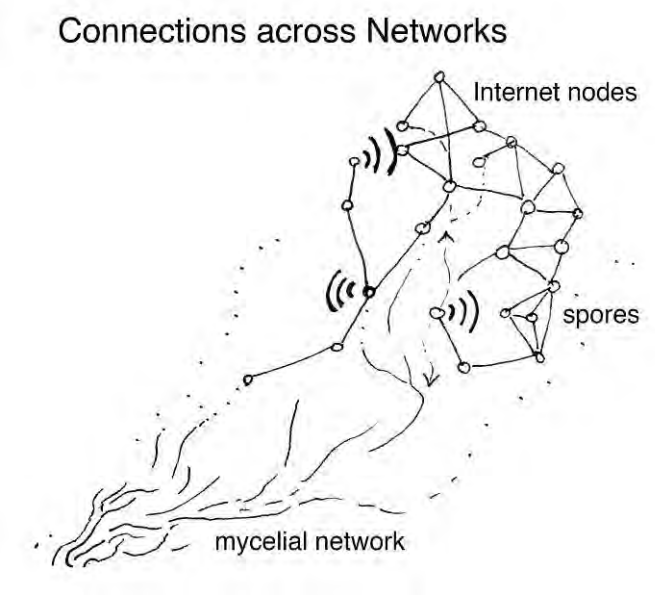

Figure 6 The Internet of Natural Things and the Internet

Likewise, the artists ask: Can fungi access the Internet? The project crosses the Internet of Natural Things with the Internet, integrating a biological network and a digital network. Through this intersection, the fungus has access to the Internet.

2.1 "Bhiobrid" Network

The collaborating artists combine fungi – the Internet of Natural Things – with the Internet in a "bhiobrid" fungi-digital network. This integration of the fungal network and the Internet results in a bio-triggered evolutionary network. The premise is that natural and technological networks coexist and are integrated through their shared space and

environment. The natural network is analog, relying on a fungal network of growth based in soil and propagated through air. The technological network operates underground and in the air, similar to the airborne spores and mycelial networks, some of which connect across geographic spaces.[7]

Within the Internet there are different nodes, which are connected through links. When microorganisms are the actors that make these links, we have a “bhiobrid” system in which microbiology ends up making real decisions that impact the Internet. This influence is articulated by the different connections that are made within the network – connections triggered by biological entities across a digital network.

The resulting “bhiobrid” network invites the participation of fungal and human authors and allows for the intersection of these cultures. The Internet typically serves human interests; human beings are not in general responsive to signals across a mycelial network. This is not to say that human beings are not biological entities or that we are excluded entirely from nature’s network. Within the art installation, tactile interactions by viewers reinforce the inherent connection between the human viewer to both networks. Human beings are part of the “bhiobrid” system. We exist in this layered network.

2.2 Circular Feedback Loop

In the feedback loop between the Internet of Natural Things and the Internet, the growing microbiological culture tweets text from digital documents and from the physical book that acts as a substrate. A bio-digital transducer transfers digital information to biology and back. The growth of the fungus determines the content of the tweet. A sensing system tracks the fungal growth, and the tweets devolve to reflect the fungal censoring of the text. As the microbiological culture advances and the physical text becomes illegible, the tweets also degenerate.

Within the fungal redaction and tweeting system there is cooperation between nature and technology. The fungus cooperates with a bot, the automation of which determines the corruption of digital files in response to the fungal redaction of the physical book. The growing microorganisms cover letters and words, and the fungus tweets. These tweets become a timeline of the death of the book. At the same time, the fungus exists in a physical space and interacts with digital network. There is information coming in and coming out. As a result, the exchange of human knowledge and knowledge from nature takes place in the “bhiobrid” network.

By incorporating Twitter to send information consumed by the fungus, the project integrates the analog and the digital. The fungus degenerates information, disrupting the data laws of the book and also the digital information of accessed text files. Mold eats an old book, and an algorithm destructs digital documents within fungal tweets. Viewers who retweet these messages spread them as digital spores on the Internet.

3. Connections and Projections

By maintaining separate networks humanity preserves the same myth of modernity that for many centuries has dictated how we interact with the world. Despite advances in technology, humanity still does this in more or less the same way that we did five or six hundred years ago. The project draws on texts that examine concepts of modernity, such as geometry and perspective, which human societies have applied to nature. In the

historical gardens of Italian villas and in the future of geo-engineering, there is a lack of disruption of these basic tenets of modernity. Though humanity now possesses more technology and continuously sparks innovation, we maintain these conventions. *Degenerative Cultures: Corrupting the Algorithms of Modernity* enacts disruption in order to generate new directions.

4. Antecedents

The project has a basis in Cesar Baio's work incorporating the playful disruption of systems and LOIS' data performances of nature. Cesar and LOIS ask: Are disruptions to algorithms natural? And is nature's degradation a form of data loss? In their various bodies of work, Cesar Baio shows that disruptions to algorithms are indeed natural to autonomous systems, while LOIS replicates degradative datastreams sourced in nature. *Degenerative Cultures: Corrupting the Algorithms of Modernity* demonstrates an autonomous system of competing cultures, one derived from humanity and the other from nature.

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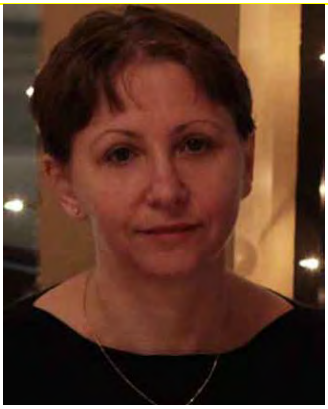

TITLE: Evolving C-Plants
(Interactive Artwork, Art)

Topics: computational art, evolutionary art

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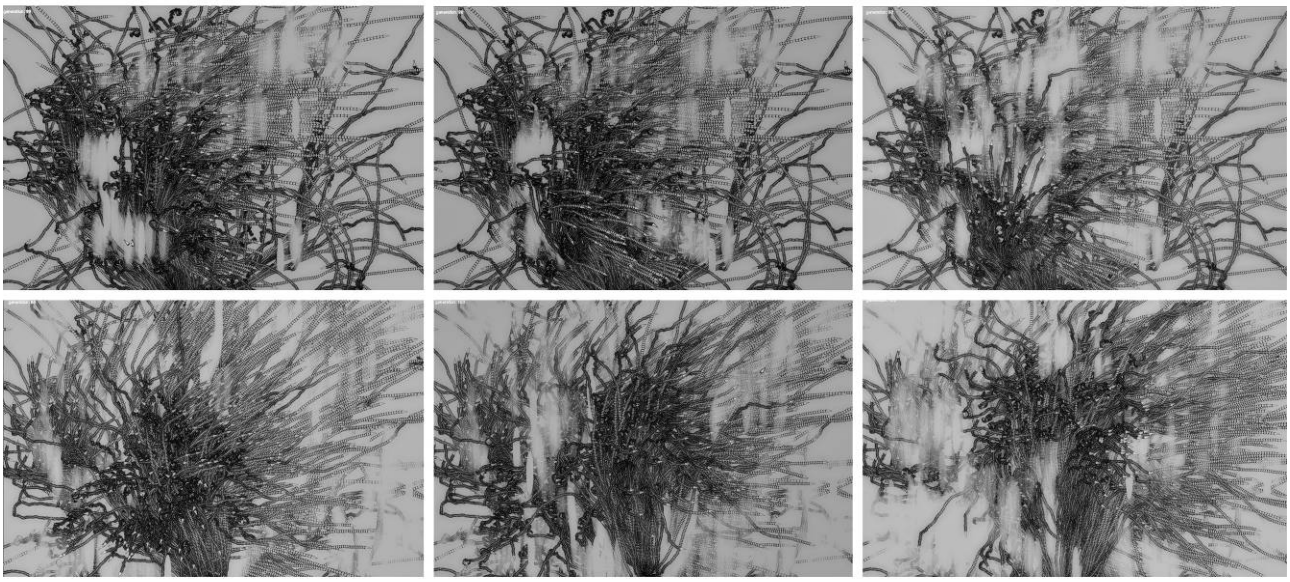
Evolving C-Plants (Computational Plants) is an experiment in adaptive drawing based on GA (genetic algorithms) computational paradigms. C-Plants come to live as visual structures that aggregate in time from traces generated by a population of artificial agents in movement. Drawing agents evolve motion paths that adapt in response to reconfigurations of structural zones in the artificial medium, which can be manipulated by the artist or can be left in fixed positions. Therefore, in this experiment of adaptive drawing, artificial agents evolve drawings in relation to environmental changes controlled by the artist. Aesthetic concepts are expressed in the adaptive drawing system by designing and activating the environment in which the artificial drawing agents live and evolve.



Evolving C-Plants. Still frames from interactive computational artwork by Daniela Sirbu.

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daniela.sirbu@uleth.ca

Key words: computational art, computational creativity, evolutionary algorithms, genetic algorithms, software art, generative art

Main References:

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ANALOGIES: When I Draw a Song for a Film
Artwork (Installation)

Topic: Art

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Abstract

This project was sparked by acknowledging the distinctive joy with which I associate certain songs to the films where I had heard them and vice versa, in recalling the films for certain songs played in them. Although we all share this associative pleasure, its affinities and qualities are highly individual.

From the initial pool of about 50, I selected 31 independently produced songs with the strongest associative links to the films in which they appear as diegetic or non-diegetic music, and I visualized these songs using the mechanical energy of their own sounds. The acoustic medium can be air or water, or a solid material of the speaker driver whose vibrations incite lateral forces that are absorbed by the speaker cabinet. However, a free-standing speaker driver will move sideways while playing so it can be used for drawing.

I played the selected songs over a light, down-facing wireless speaker with a pen attached to the side. This setup does not aspire to the accuracy or reproducibility of scientific experiments. Rather, it is essentially generative and flexible, allowing for complex creative decisions on the type of pen and paper, pen angle and pressure, and pen-speaker bond. It was tuned up to repetitively produce similar drawings of the same song.

Each drawing was created by playing a single song. The drawings were scaled up to reveal their visual dynamics and printed in high resolution, with one cursor marking the origin and another marking the center. One composite print of all 31 drawings centered geometrically and one composite print of all 31 drawings aligned to the starting point will be presented at this exhibition.

Analogies was inspired by a number of generative art projects, especially by Mary Ellen Bute's *Abstronic* (1952), William Anastasi's *Subway Drawings* (1968/1970), Yoshimasa Kato & Yuichi Ito's *White Lives on Speaker* (2007), Evan Roth's *Graffiti Analysis* (2010), Stefan Tiefengraber's *Delivery Graphic* (2013-2014) and Mogens Jacobsen's *Probabilistic Audio Dice Roll* (2015).

The project is dedicated to the work of Paul Schrader who summed it up with the observation: *The more I've made films and written, the more I realize that less and less you need to do, and that telling people stuff, or preaching to people, is really not what we should be doing in the arts. What an artist should be doing is investigation through implication and association*.

Project web page: http://dejangrba.dyndns.org/analogies/index.html.

Left: *One Time One Night* (Los Lobos, 1987) [*Colors* (1988)]; Right: *Stroll On* (The Yardbirds, 1966) [*Blow-Up* (1966)].

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Key words: generative art, sound art.

Main References:

[1] Dejan Grba, *Avoid Setup: Insights and Implications of Generative Cinema*, Leonardo Volume 50, Number 4, August (2017): 384-39.
[2] Paul Schrader, Blu-Ray audio commentary to *Hardcore* (1979), Twilight Time, 2016.

Analogies: When I Draw a Song for a Film

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1. Project Description

1.1 Concept

Analogies explore the blending of unrelated cognitive paths into the matrices of new meaning through abstraction, comparison and analogy-making [1]. The project was sparked by acknowledging the distinctive joy with which I associate certain songs to the films where I had heard them (not necessarily for the first time) and vice versa, in recalling the films for some songs played in them. Although we all share this associative pleasure, its affinities and qualities are highly individual.

From the initial pool of about 50, I selected 31 independently produced songs with the strongest associative links to the films in which they appear as diegetic or non-diegetic music. I discarded the composed film scores and the musicals, in which the associations are trivial, more calculated and less open for idiosyncratic affect.

1.2 Procedure

I visualized the songs using the mechanical energy of their own sounds. Sound is a vibration that propagates as a wave of pressure and particle displacement through a transmission medium. The medium can be air, water or solid material of the speaker driver whose expansion/compression creates a set of lateral forces that are absorbed by the body of the loudspeaker. Separated from the loudspeaker casing and played loud enough, a speaker driver will move sideways so it can be used for drawing. Lars Hansen based his project *Spiderbytes* [2] on this phenomenon, but never went beyond a well-rounded proof of technical concept.

I drew *Analogies* by playing specific, precisely contextualized music over a light, down-facing wireless speaker with a single pen attached to its side. This asymmetrical and unstable setup does not aspire to the accuracy and reproducibility of scientific experiments. Rather, it is essentially generative and flexible, allowing for complex creative decisions on the type of paper and pen, pen pressure and angle, and strength of the pen-speaker bond. It can be tuned up to repeatedly produce similar drawings of the same song.

Each drawing was generated by playing a single entry from a playlist of all 31 songs with matched volumes. The originally produced drawings range from 25 to 125mm in length so they were scaled up to 270% in order to reveal their visual dynamics and graphic subtlety.

1.3 Motivation

Analogies were inspired by a number of generative and sound art projects, especially by Mary Ellen Bute's *Abstronic* (1952), William Anastasi's *Subway Drawings* (1968-1970), Yoshimasa Kato & Yuichi Ito's *White Lives on Speaker* (2007), Evan Roth's *Graffiti Analysis* (2010), Stefan Tiefengraber's *Delivery Graphic* (2013-2014) and Mogens Jacobsen's *Probabilistic Audio Dice Roll* (2015).

The project is dedicated to the work of Paul Schrader who summed up its approach with the observation: *The more I've made films and written, the more I realize that less and less you need to do, and that telling people stuff, or preaching to people, is really not what we should be doing in the arts. What an artist should be doing is investigation through implication and association* [3].

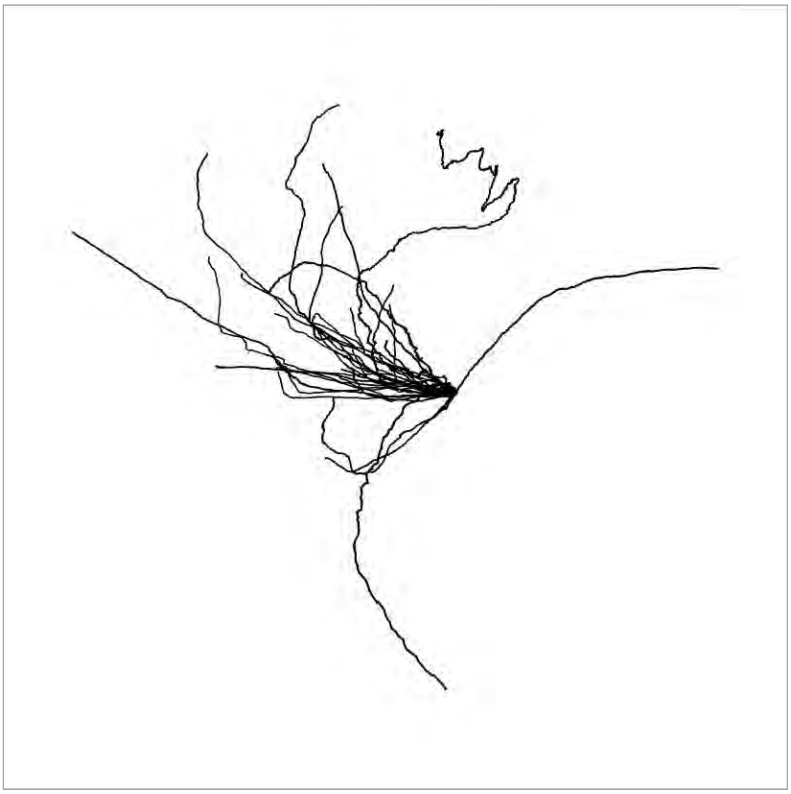
1.4 Installation

The initial installation set features framed drawings in a linear arrangement following the playlist order from right to left. The songs play continuously on the wall-mounted tablet over the speakers, and the visitors can select and run any preferred song. The projected video documents the drawing process and presents the film instances of all songs.

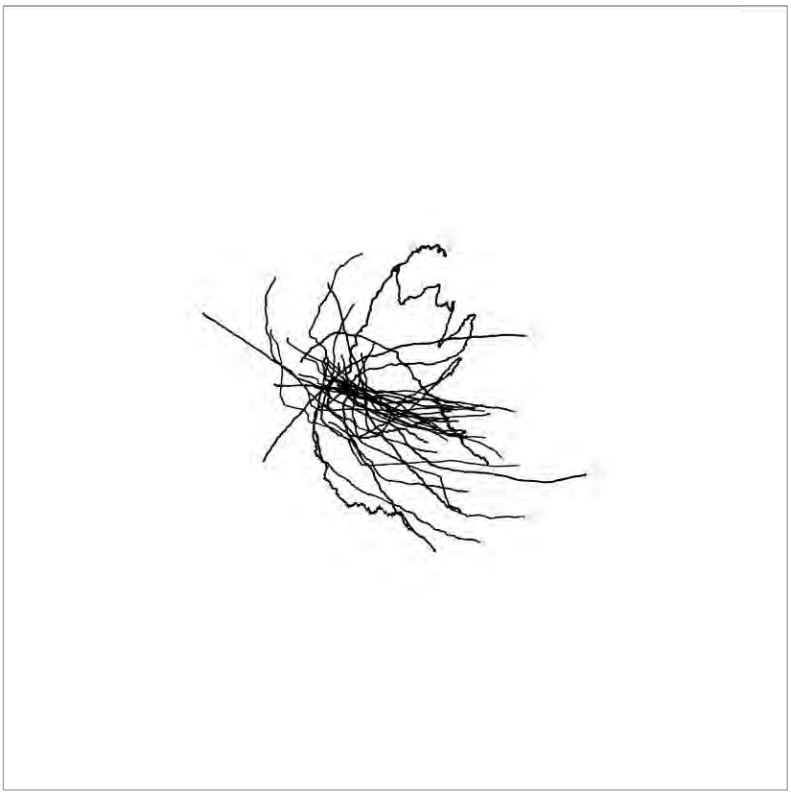
At GA2017, the installation features two images that summarily represent the project: a composite of all drawings aligned to their origin point (Image 1), and a composite of all drawings aligned to the relative center (Image 2).

Alternatively, the installation features the animations of the two image composites, with respective soundtracks: one created by mixing all 31 songs aligned at the beginning, and one by mixing all 31 songs with aligned mid-time points.

2. Images



1. Dejan Grba, Analogies 1-31, Origin Point Composite.



2. Dejan Grba, Analogies 1-31, Relative Center Composite.

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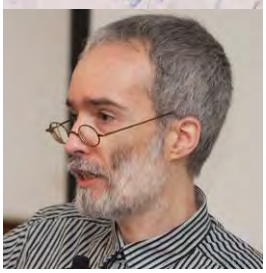

TITLE: APPROXIMATION THEORY
(Artwork and artists' presentation)

Topic: Visual mathematics

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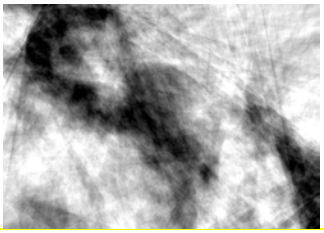
Abstract
Approximation Theory is an art-research project in visual mathematics and data aesthetics. It consists of a series of prints that visualize the mathematical idea of approximation. The methodology used in the work involves the choice of a set of fixed dictionaries or databases of images. Each dictionary has its own distinctive quality. For instance, some consist of linear or curved elements generated procedurally. Other dictionaries might consist of more complicated images, such as frames from movies or Chinese characters. Any other image can then be reconstructed as a weighted superposition (linear combination) of all or some of the images in the dictionary.
There exist mathematical procedures that identify how to superpose a given subset of images from the dictionary in a manner that most closely reconstructs or "approximates" the source image. The character of the approximation depends on two kinds of factors: qualitative and quantitative. The qualitative aspect has to do with the character of images in the dictionary, for instance whether they are linear or curved. The visual quality of the approximation depends in part on the visual qualities of the images in the dictionary. The quantitative aspect has to do with the number of images from the dictionary that are used in the reconstruction. The more images are contained in the dictionary, the closer the approximation.
Our work uses source images drawn from the 1936 Summer Olympics. These images express a fascination with the human form, and one of our main concerns has to do with the representation of the body in an algorithmic age. The reconstruction of these source images with different dictionaries allows for a visual comparison of the dictionaries' characters. The following image uses a dictionary that consists of rectilinear elements in order to produce a reconstruction (right) of a single source image (left).



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Keywords: Approximation Theory; Visual Mathematics.
Main References:
Cheney, E. W. (1998). Introduction to Approximation Theory. Providence, RI: AMS Chelsea Publishing.

Approximation Theory

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Abstract. Approximation Theory is an art-research project in visual mathematics and data aesthetics. It consists of a series of prints and videos that visualize the mathematical idea of approximation.

1 Description

Approximation Theory is an art-research project in visual mathematics and data aesthetics. It consists of a series of prints and videos that visualize the mathematical idea of approximation.

The methodology used in the work involves the choice of a set of fixed dictio- naries or databases of images. Each dictionary has its own distinctive quality. For instance, some consist of linear or curved elements generated procedurally.

Figure 1 A few images from the rectilinear dictionary

Figure 2 A few images from the curvilinear dictionary

Other dictionaries might consist of more complicated images, such as frames from movies or Chinese characters.

Figure 3 A few images from the Chinese dictionary

Any other image can then be reconstructed as a weighted superposition of all or some of the images in the dictionary. For instance, this source image from the 1936 Summer Olympics can be reconstructed by superposing a selection of

3840 images (each of them of the “linear” dictionary).

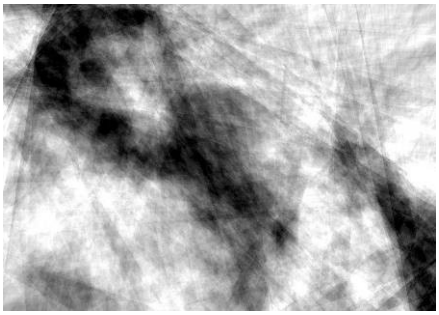


Figure 4 An image of a swimmer and a reconstruction of it

There exist mathematical procedures that identify how to superpose a given subset of images from the dictionary in a manner that most closely reconstructs or “approximates” the source image.

The character of the approximation depends on two kinds of factors: quali- tative and quantitative.

The qualitative aspect has to do with the character of images in the dic- tionary, for instance whether they are linear or curved. Figure 5 shows an image and three reconstructions obtained using the three dictionaries shown in Figures 1–3. While the three results resemble the original, each has its own distinctive personality.

The quantitative aspect has to do with the number of images from the dic- tionary that are used in the reconstruction. The sequence of digital prints in Figure 6 shows several reconstructions of one source image using progressively larger selections from the same dictionary.

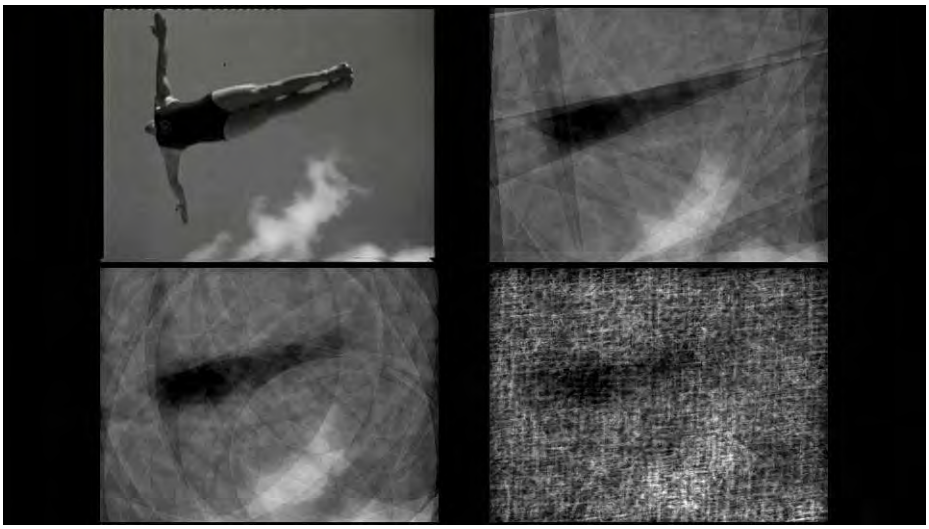
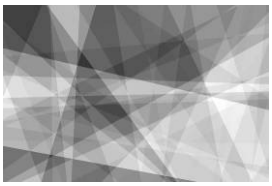
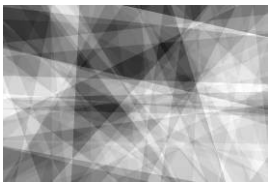


Figure 5 Three reconstructions with different dictionaries





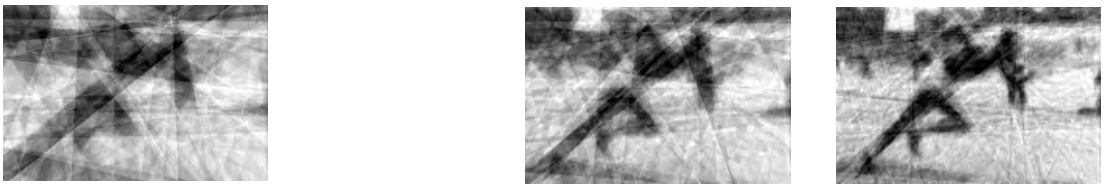


Figure 6 Reconstructions using 30, 60, 120, 360, 720, and 1920 images from the dictionary

Our work uses source images drawn from the 1936 Summer Olympics, as shot by director Leni Riefenstahl. These images express a fascination with the human form, and one of our main concerns has to to do with the representation of the body in an algorithmic age. The images are also drawn from an age where the threat of fascism was very real, and manifested itself in the cult of the body. We are also confronting a growing sense of populist authoritarian- ism around the world. Our response to this threat is to reassert the value of rational analysis and the integration of art, science, and cultural critique. An

additional reason to choose Riefenstahl's movie is that it naturally provides a diverse, yet thematically coherent, collection of short clips, rich in movement. The reconstruction of these clips with different dictionaries allows for a visual comparison of the dictionaries' characters.

This project can be exhibited as a set of prints that explore different as- pects (both qualitative and quantitative) of mathematical approximation the- ory, together with videos that compare different reconstructions. The number of prints and videos can be adjusted to take into account venue and equipment constraints.

2 Mathematical Approximation

This section contains a more detailed description of mathematical approxima- tion theory, and can be skipped.

The idea of approximation underpins many aspects of digital technology, including machine learning, computer vision, and digital image and sound pro- cessing. In many of these applications, it is vital to replace a complicated function (for instance, one that is expensive to compute or tedious to describe) by a simpler one. Digital data compression, for instance, often involves the replacement of image or audio data by a shorter description. Approximation theory aims to find the best approximation of the desired input.

The context of approximation theory is the following: there is a target func- tion f which we want to approximate with another function g to be selected from within a set S of approximant functions. The main problem is that of estimating how good this g can be, that is, how small can the error of replacing f by g be. This problem presupposes a way of measuring this error (usually a distance in a space of functions where both f and g live). In addition, it depends on both the target function f and the set of approximant functions S. This dependence has both quantitative and qualitative aspects.

On the quantitative side there are parameters, such as the dimension of the linear space spanned by S (typically, when S spans a finite dimensional linear space) or the radius of S (typically, when S is a closed ball in a linear space, possibly of infinite dimension).

On the qualitative side there are factors such as the kind of functions in S (e.g., polynomials, radial-basis functions, splines, etc.) and the quality of the function f itself (how smooth it is, how rapidly it oscillates, etc.).

Our project is an experimental exploration of the quantitative and qualita- tive aspects of approximation.

Intuitively, a digital image can be viewed as a position or a point in a space of possible images. More precisely, an image of N (grayscale or "black-and-white") pixels is identified with a vector of N real numbers in the interval $[0, 1]$, with 0 being black and 1 being white. Our target function (for instance a photograph that we wish to reconstruct) is a point in this N-dimensional vector space. A set S of approximant functions is a subset of the unit cube in this space. In other words, S is a set of N-pixel images (the "dictionary").

Any target image is to be approximately reconstructed as a weighted sum (linear combination) of a selection of images from the dictionary. Intuitively, we can think of this procedure as a superposition or mix of

brightened or darkened versions of the various images in the dictionary. By changing the intensities of the images in the dictionary in appropriate ways, the resulting combination will resemble approximately the target image. The “appropriate ways” of mixing the dictionary are determined automatically by mathematically projecting the target image onto the subspace spanned by the images in the dictionary.

The quantitative side mainly involves the number of images to be used in any approximation, i.e., the size of the dictionary. We might choose to employ only a relatively small subset of images in the dictionary. As the number of images employed decreases, the fidelity of the resulting reconstruction also decreases, and vice versa.

The qualitative side involves the kinds of images to be included in the dictio- nary. Our project explores how the use of different kinds of images (for instance geometrically abstract frames consisting of lines or checkerboards, photographs of different locations in the world or still frames from classical films) affects the visual quality of the reconstruction.

We are currently exploring the use of advanced mathematical tehcniques, such as $\pounds_1$-minimization, affect the visual character of the result.

TITLE
Hueue (Artworks)

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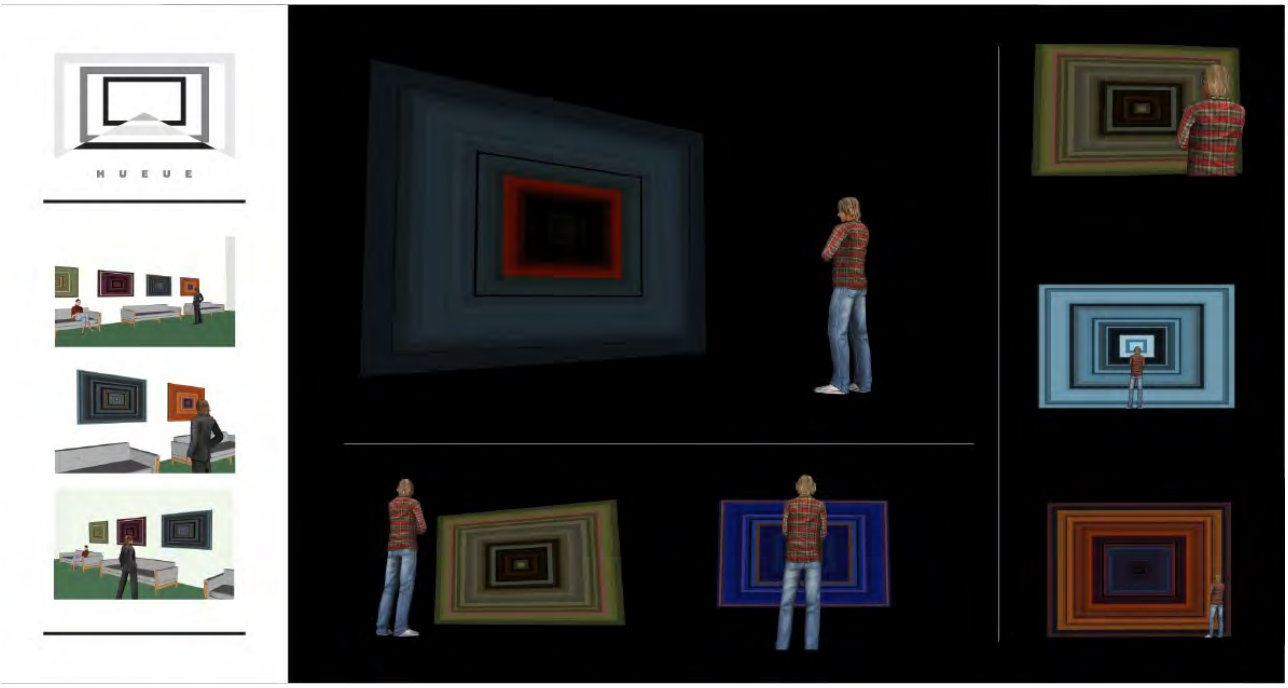
Abstract
HUEUE aims to capture the colour story of a movie and present it in an accessible time frame of a minute. Movies at their simplest are colour, sound and motion.

HUEUE aims to distil any movie into these basic forms and generate a unique form of escapism, bring the audience on a journey into the movie itself.

HUEUE creates a tunnel effect. The effect indicates an impression of a portal. This is intended to give life to the escapism and create a more concrete feeling of the journey with the aid of sequential colours flowing from the movie. The audio is condensed creating a pitch shift, simulating the Doppler effect. All these elements create an experience that accelerate the viewer into the escapism and further into the movie.



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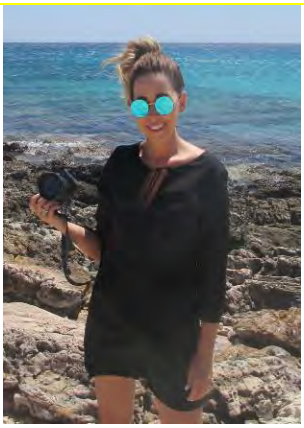
ceks@waikato.ac.nz

Key words:
Visualisation, movie, colour, animation



Hypnos
(Artwork)

Topic: Art

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Abstract

An ongoing interest in temporality has led me to explore the concept of oblivion or forgetfulness. In Greek mythology Lethe was one of the five rivers of the underworld. Also known as the river of unmindfulness, the Lethe flowed around the cave of Hypnos and through the underworld, where all those who drank from it experienced forgetfulness. In my most recent work, I have moved from underwater to above water to depict the expanse of the sea in relationship to land or horizon, and human or bird. The underlying theme is that of instances of being in a state of precarious limbo. I refer to my human and avian subjects as *The Oblivion Seekers* and they are frequently depicted between freedom (flight) and safety (land) with the turbulent sea the uncertain suspension that they must navigate between the two. They occupy a kind of liminal space. It is this in-between space of protracted temporality that I am interested in revealing.

Hypnos consists of 6,500 photographs taken at 2 second intervals to create a Moving Image. The compiled photographs are then over-painted to create the shift in light and texture. I use light to convey a sense of duration of time or perhaps timelessness. For example, in some instances in *Hypnos*, the time of day is unidentifiable … fluctuating between sunlight and moonlight … stars in the sky and sun on the waves. Spatial references are also manipulated ... with sky becoming sea ... and sea becoming sky. Some events occur over and over, however seemingly at a different time of day or night, thus causing the viewer to question their relationship to linear or non-linear time. *The Oblivion Seekers* are searching for a space where time is suspended, where they can hover in limbo, and temporarily push memory and knowing into oblivion. *Hypnos* depicts one of those places.

30 minutes continuous looping.

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Key words: Temporality, Technology and Art, Non-Linear Time, Moving Image.

Main References:

[1] Timothy Barker, "*Time and the Digital*", University Press of New England, New Hampshire, 2012.
[2] David Rodowick, "Giles Deleuze's Time Machine", Duke University Press, North Carolina, 1997.
[3] Christine Ross, "*The Past is the Present; It's the Future Too - The Temporal Turn in Contemporary Art*", Bloomsbury Academic, New York, 2013.

TITLE ***Un_Habit.tants #muoverciper:ar_muovere***
Installation
San Felice, Poster
Topic: Art, social insertion activities

Author(s):
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Portugal, licentiate from FBAUL 2009
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Città Solidale
www.cittasolidale.it

Abstract
" This existence of ours is as transient as Autumn clouds
To watch the birth and death of beings is like looking at the movement of a dance
A lifetime is like a flash of lightning in the sky
Rushing by,
Like a torrent down a steep mountain" From the Lalitavistara sutra

Città solidale is a cooperative that manages, amongst others, housing services for people with disabilities; in 2015/2016 I assisted its operators as a volunteer (SVE). According to the UN directives, one of the priorities while structuring social health care services directed to people with disabilities is self-determination. In collaboration with Città Solidale, social cooperative, I devised an umbrella strategy that would be beneficial:
»to reinforce the communication between the fives communities under its management;
»to the development of the social insertion activities and further the possibilities to unveil the guests power of self-determination;
»to the expansion of Città Solidale´s community engagement in accord with a transparency policy.

In order to develop the intergroup relations of the five communities, one operator from each community was assigned as responsible for uploading content in the Città Solidale Facebook page. In researching about the power of self-determination of the guests we devised a social insertion activity that joined one operator with one guest in front of the computer, aiming that the individual with impairments could approach the virtual world through Facebook- this activity had specific modalities according to the guest and the community in which he resided. These two factors is what I define as the triggers of the generative process. The notion of collaborative construct can be hard to disentangle from a generative process, I sustain that the output of this system is closer to the latter.

"Si è dura la vita mia è una ruota che mi trattiene in spazio sempre uguale" Città solidale´s guest, using an augmentative alternative communication method: supported typing- serves as an example to attest the richness of this project, but the activity of supported typing is done by an external consultant and has no direct link to my influence in the communities.

The installation proposed consists of: two printed photographs from the very early stage of my volunteer program; one print with the username and password of the profile "Is this an art project?"- profile that can publish live video on the "Is this an art project?" page; 500 stickers "Find us on
: www.facebook.com/isthisanartproject"; the printed and plastified #muoverciperfarmuovere sign that was used in the campaign for the San Felice project; an album of selected photos put together by the operators of Città Solidale that aim at describing the one year of Facebook experience.
Obviously this is a subject matter that has to be dealt with the utmost sensibility.
The installation aims to provoke a reflection on one's self-determination on today's virtualized contemporary reality.

I conclude with two quotes that summarise this enterprise.
"I need to produce great ideas, and I believe that if I were commissioned to design a new universe, I would be mad enough to undertake it" Giovanni Battista Piranesi
"In the moral plane, that is the one that matters, you only lose if you stop fighting." Francisco Salgado Zenha

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Key words: Community engagement, self-determination, transparency, reality–virtuality continuum, net

Main References:
[1] Josephine Bosma, "*Nettitudes*", NAi Publishers, Amsterdam NL, April, 2011

Community engagement, communication strategy, Elena Vettore 2016

"Si è dura la vita mia è una ruota che mi trattiene in spazio sempre uguale" Città solidale´s guest, using an augmentative alternative communication method: supported typing- serves as an example to attest the richness of this project, but the activity of supported typing is done by an external consultant and has no direct link to my influence in the communities.

Panel at Aracelinsieme 2017, Vicenza, Città Solidale

Digital sketch from Città Solidale´s post, 29.09.2017

The installation proposed consists of:
1) two printed photographs from the very early stage of my volunteer program;
2) blackboard written the username and password of the profile “Is this an art project?”- (a profile that can publish live video on the “Is this an art project?” page);
3) 500 stickers (“Find us on: www.facebook.com/isthisanartproject”);
4) the printed and plastified #muoverciperfarmuovere sign that was used in the campaign for the San Felice project;
5) an album of selected photos put together by the operators of Città Solidale with the purpose of describing the one year Facebook experience.

The installation presents the opportunity to reflect on one´s self-determination regarding today's virtualised contemporary reality.

Città Solidale office 2016

Operator and Davide Trevisan


EVENTO SOLIDALE
SAN FELICE
FESTA
02/07/2016
ARACELI
BORGO SCROFFA, 14
VICENZA
città solidale
vi invita al primo evento solidale
SAN FELICE
16:30 - CONCERTO Ambaradan
pianoinfinitocooperativasociale
17:30 - ZUMBA GOLD con Cindy Gomez
cindy88.zumba.com
19:00 - PRESENTAZIONE CITTÀ SOLIDALE
www.cittasolidale.com
cittasolidalevicenza
21:00 - CONCERTO IN2
IN2
22:00 - Impossibile Banda d'Ottoni
Impossibile.banda.di.Ottoni
Dal 02/07/2016 al 06/07/2016
Mostra curata dall'Associazione 22:37
22e37.wordpress.com
#muoverciperfarmuovere
città solidale
BCC
22:37

ONE-TO-ONE
(Kinetic Sound Installation)

Topic: Music

Authors:

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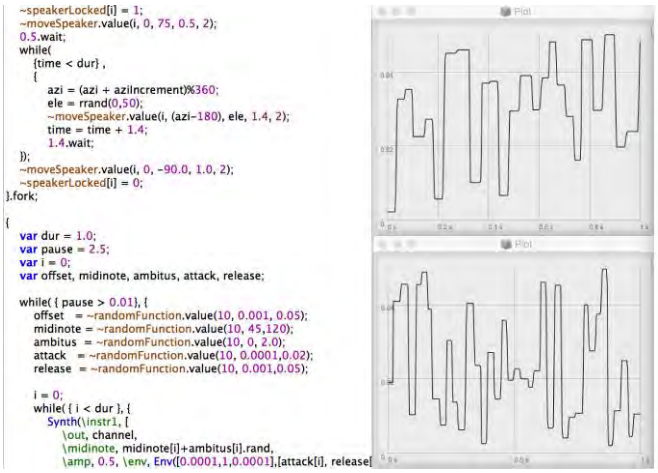
Abstract
The installation *One-To-One* consists of two movable speakers that are placed at head height on stands. The appearance of the speakers is very technical, all mechanical and electronic elements are candidly shown without any covers. Nevertheless, we easily tend to anthropomorphize these speakers and regard them as beings that can move their heads, gaze in different directions, and express themselves acoustically. The Installation *One-To-One* addresses this irrational appreciation: the two speakers face each other and seem to be engaged in a discussion.

The sound production is entirely computer-generated: all sound synthesis parameters are controlled algorithmically, partly by random processes, partly by several deterministic cyclic patterns that run at different speeds. The resulting sounds are abstract, yet they resemble spoken utterances in a very peculiar way. All sounds are combined with a movement to emphasise in a simple but effective way the intended humanisation of the speakers.



```
~speakerLocked[i] = 1;
~moveSpeaker.value(i, 0, 75, 0.5, 2);
0.5.wait;
while(
    {time < dur} ,
    {
        azi = (azi + aziIncrement)%360;
        ele = rrand(0,50);
        ~moveSpeaker.value(i, (azi-180), ele, 1.4, 2);
        time = time + 1.4;
        1.4.wait;
});
~moveSpeaker.value(i, 0, -90.0, 1.0, 2);
~speakerLocked[i] = 0;
}.fork;

{
var dur = 1.0;
var pause = 2.5;
var i = 0;
var offset, midinote, ambitus, attack, release;

while( { pause > 0.01}, {
    offset   = ~randomFunction.value(10, 0.001, 0.05);
    midinote = ~randomFunction.value(10, 45,120);
    ambitus  = ~randomFunction.value(10, 0, 2.0);
    attack   = ~randomFunction.value(10, 0.0001,0.02);
    release  = ~randomFunction.value(10, 0.001,0.05);

    i = 0;
    while( { i < dur }, {
        Synth(\instr1, [
            \out, channel,
            \midinote, midinote[i]+ambitus[i].rand,
            \amp, 0.5, \env, Env([0.0001,1,0.0001],[attack[i], release
```

Fig. 1: Screenshot depicting stochastic control functions

Fig. 2: Kinetic speaker objects.

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Key words: sound installation, sound synthesis, kinetic installation, algorithmic composition.

Daniel Buzzo

The Time Machine:
a Multiscreen Generative Video artwork
Topic: (Art, temporality, video, phenomenological experience)

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Abstract
'The Time Machine' is a multi-screen, high-performance, generative video art installation based around multiple low cost computer platforms. Using algorithmic selection of palindromic loops of time-lapse video the work contrasts the external, machine perception of time with our internal, phenomenological experience of it. The video feeds, recorded from around the world, tick and tock backward and forward creating a polyrhythmic, 12 screen time-piece. The images loop back and forth on each screen of the installation, creating a large polyrhythmic clock of high definition, full colour motion. Each screen detailing a passage of time from around the world, captured, frozen, forward and reverse. The time-lapse loops slowly switch, selected from over a thousand separate pieces by generative algorithms on each host computer. Creating a Time Machine reflecting the world, gently rocking back and forth with a myriad of sub-cadences, confronting the viewer with the unanswerable challenge of comprehending time.

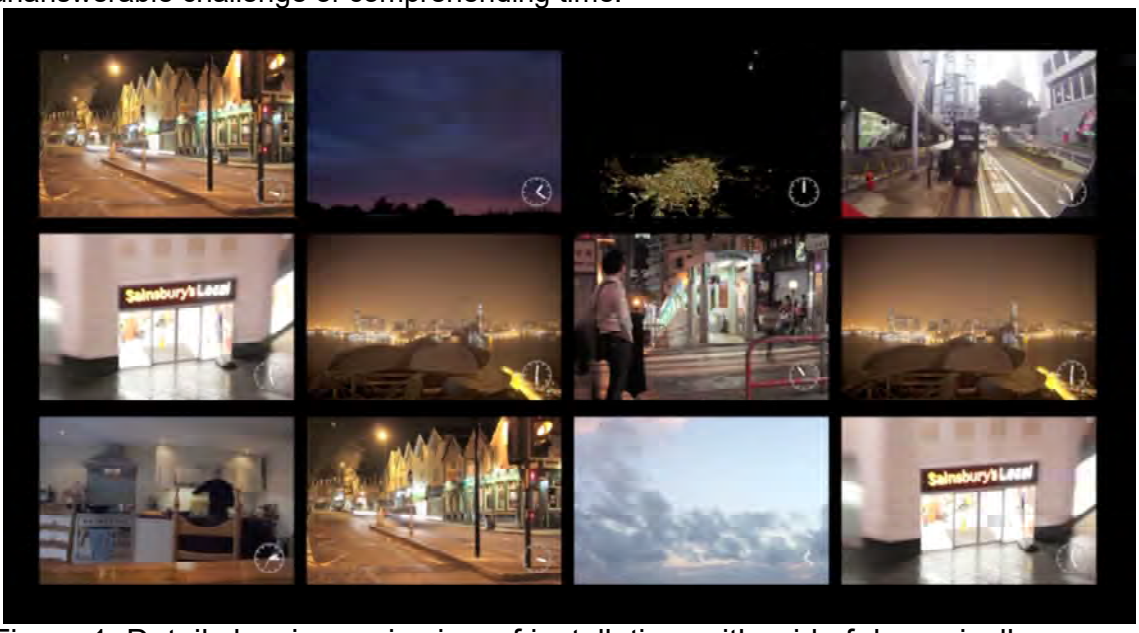

Figure 1: Detail showing main view of installation, with grid of dynamically generated, palindromic time lapse video loops

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Key words: time, temporality, generative video, installation

Main References:

[1] Kevin Birth. 2012. Objects of time: How things shape temporality. Palgrave Macmillan. 211 pages. https://doi.org/10.1057/9781137017895
[3] Edmund Husserl. 1991. On the phenomenology of the consciousness of internal time (1893-1917). Springer.
[4] Jonathan Martineau. 2015. Time, Capitalism and Alienation. Brill. http://www.brill.com/products/book/time- capitalism- and- alienation
[5] N. Munn. 1992. The Cultural Anthropology of Time: A Critical Essay. (1992), 93– 123 pages. https://doi.org/10.1146/annurev.anthro.21.1.93
[7] Buzzo, D. (2016) What do we know of time when all we can know for real is now? In: Reyes-Garcia, E., Chatel-Innocenti, P. and Zreik, K., eds. (2016) *Archiving and Questioning Immateriality: Proceedings of the 5th Computer Art Congress.* Paris,
France: Europia Productions, pp. 438-443. ISBN 9791090094239

LIVE PERFORMANCES

BrainArt
Live Performance

Topic: Art, Design, Technology, Programming

Author(s):
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Abstract
BrainArt was born from the idea to explore how art was perceived by the general public as a physical interactive installation. Using a hacked portable EEG (Electroencephalogram), users would wear the EEG and be under the influence of audio and video stimuli. Their brains, naturally would respond and brain waves would be detected, interpreted and mapped through a proprietary software into visuals.
The installation was transformed into a performance where a subject uses the EEG and generate art that has peculiar characteristics: unique, personal and involuntary. Many insights keep coming from BrainArt performances (previously shown in the US, Mexico, Brazil, Spain, India, UK, Ecuador and Colombia), with audiences raising questions like: Can I generate art without being aware of what I'm generating? Who's the author: the artist that wrote the code, the designer that came up with the seed imagery, the musician that inspires with his (her) music or myself, as the "owner" of the brain activity triggering in a unique way the variables of BrainArt?
The BrainArt performance is designed to be under 3 minutes, with a local musician (or musicians) and the author, followed by a talk on tech, hack and collaboration.

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Key words: art, creative technology, EEG, performance
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Feed Gesture
(Live Performance)
Topic: Music & Art.
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Dr. Mark Zanter composer/performer
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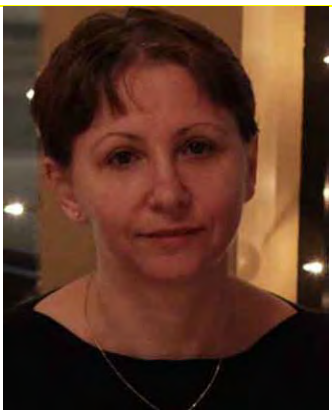
Abstract
***Hands Fed the Roots* Brigid Burke 2017:** *Hands Fed the Roots* is based around 4 spaces in 4 movements. Each depicting an element taking you on a complex interactive journey. **Echo** - cavernous empty space with emphasis on reflection the use of synthesis and acoustic reverbs is the emphasis of the sounds **Ping** - mirrors and glass with the audio from the clarinet and guitar transformed into brittle percussive sounds **Layers** - books stacked, opened in boxes exploring layers of lines with infinite textures
from the audio **Pulse**- a collection snap shots of abstract people with the audio forming layered rhythms in distorted rapping voices, transformed by clarinet and guitar. The creative process evolves from reflection upon these rooms.
Hands Fed the Roots is an audio-visual performance work for clarinet, guitar and real-time electronics with live video feed and pre-recorded visuals. The conversation between the clarinet, guitar, electronics and visuals will be intricate and thought provoking as the work progresses through each of the rooms. *Hands Fed the Roots* imagery is based on the performer's interactions conversing with abstraction and realism of the rooms.
FAZES Brigid Burke 2017
This work is a collaboration resulting in an integrated sound and video work that fuses multiple Bass clarinets, guitar, dance, layered digital images, glass plates, film footage and digital sound. The sounds have been stretched, effected and multi tracked numerous times. The dancer (Sela Kiek) merges with glass fused images of a slow moving figure.
These multi-layered projections ripple and blur as the dancer performs small gestures in and out through the fused glass. The acousmatic sound reflects the dance, by means of multi-layered drones and partials of covering the whole spectrum of timbre and texture. *FAZES* takes you through a dream world of line imagery that evokes senses of fantasy, intellect and desire through the movement of the distorted figure and clarinet sounds.
The way Vladimir Suchanek *Dreams and Realities. Grafika.* Prague: Akropolis*,* 1997 describes reality and a dream expresses my ideas and how *FAZES* should be interpreted:
...when my prints meet with a sensitive viewer, who is excited by the same angle of view on the world, at the events and their objects, which has the same joys and concerns, he might find in them an echo of his own ideas, dreams and feelings….
The focus is on dream and reality that explores a monochromatic feature of the human form of women's limbs.



brigid@chariot.com.au

Key words: improvisation, music, composer, multi media artist, clarinet soloist, visual artist, film maker, peformance artist, installation artist, printmaker modular form and signal processing.



TITLE: The Wanderings of Linear A-Creatures
(Live Performance)

Topics: adaptive drawing, live performance

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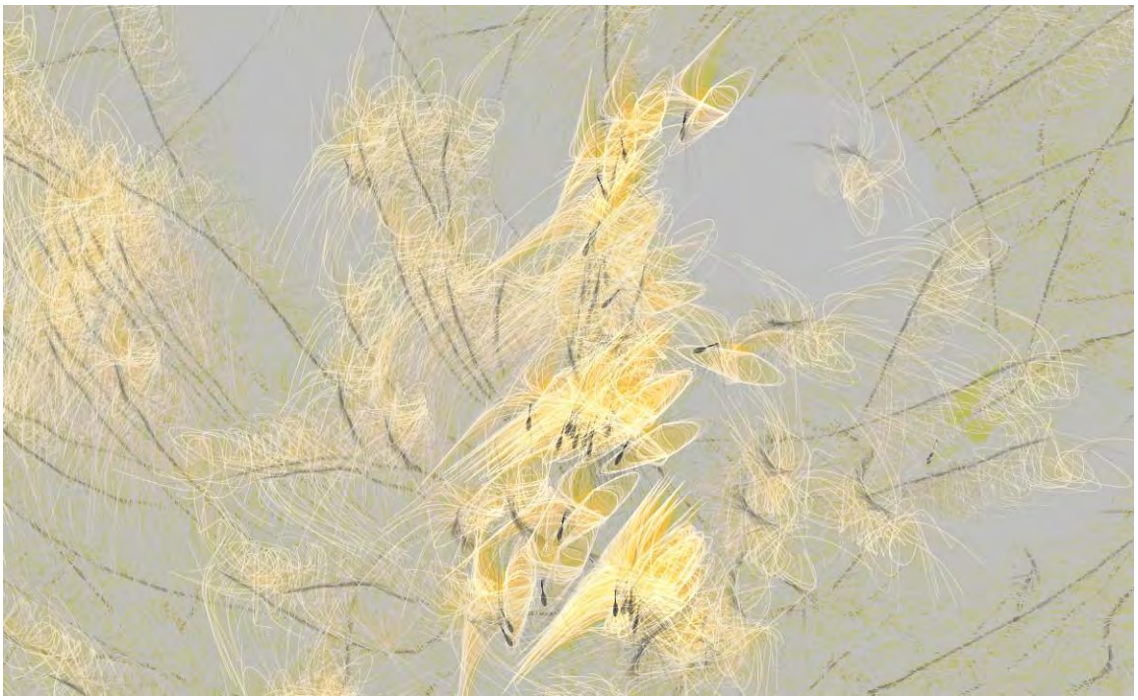
Abstract
The Wanderings of Linear A-Creatures (Artificial Creatures) is an adaptive drawing piece that allows creating artwork interactively as live performance. The audience is taken into a virtual space where artificial creatures with linear formal qualities interact with environments reconfigured live by the artist. Through adaptive drawing, visual structures are evolved interactively in ecosystems driven by aesthetic principles. Drawings are generated through the activities or movement of A-Creatures. The artist's intervention leads the environmental dynamics in relation to which the A-Creatures adapt for aesthetic fitness.



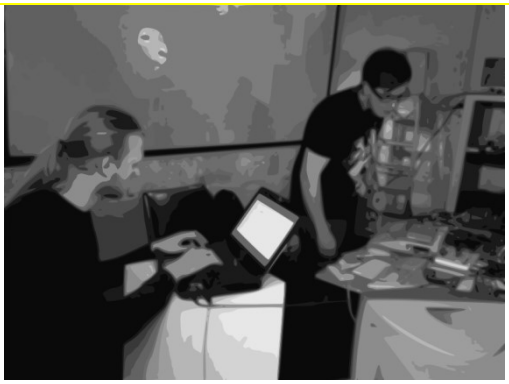
The Wanderings of Linear A-Creatures.Still frame from adaptive drawing artwork by Daniela Sirbu.

Email:
daniela.sirbu@uleth.ca

Key words: computational art, computational creativity, evolutionary algorithms, genetic algorithms, software art, generative art

Main References:

[1] Braitenberg, Valentino. *Vehicles. Experiments in Synthetic Biology*, Cambridge Massachusetts MIT Press, 1986.
[2] Daniela, Sirbu and I. Dumitrache. 2017. "A Conceptual Framework for Artificial Creativity in Visual Arts." IEEE IJCCC International Journal of Computers, Communications, and Control 12(3):381-392, ISSN 1841-9836, June 2017, DOI: http://dx.doi.org/10.15837/ijccc.2017.3.2759.



tabula rasa musica
(Live Performance)

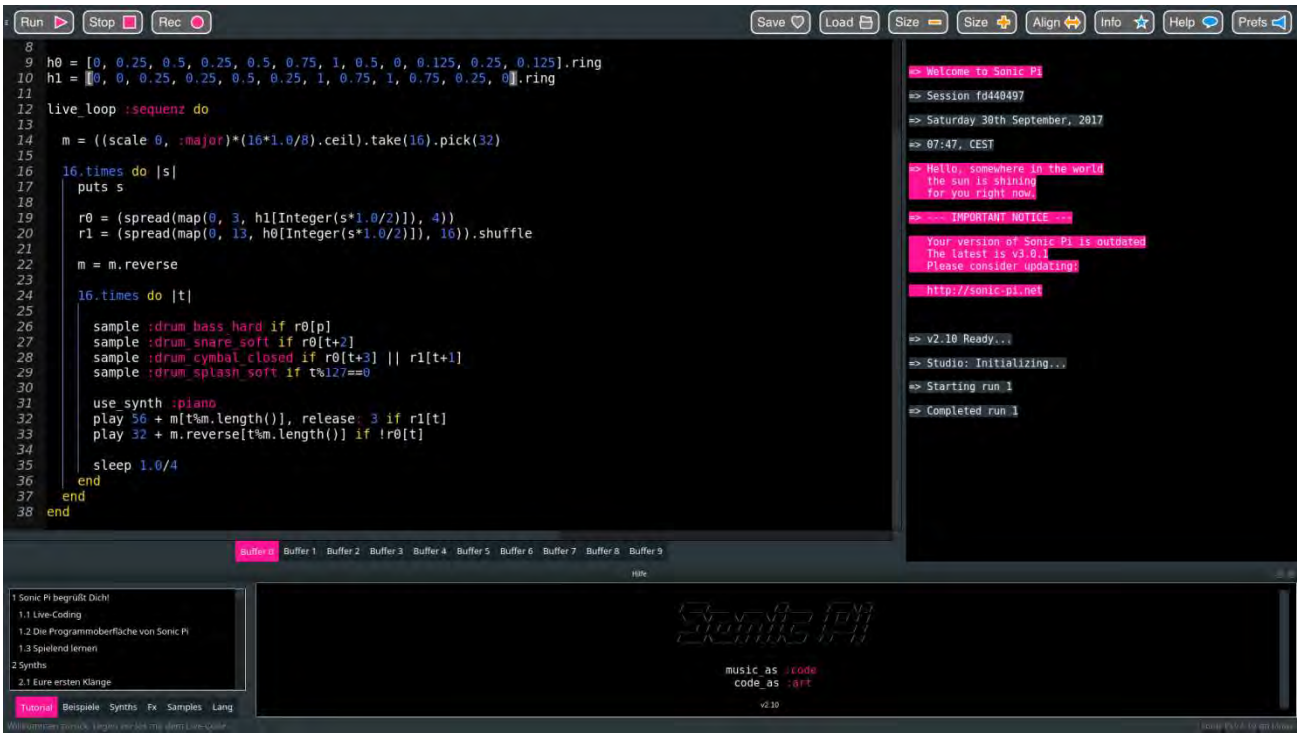
Topic: Generative Design, Music

Author(s):

labora media
Germany
www.labora.media

Abstract

“labora media” is a group of artists and their mobile laboratory to create interactive media in real time with their own developed instruments, as independent as possible.

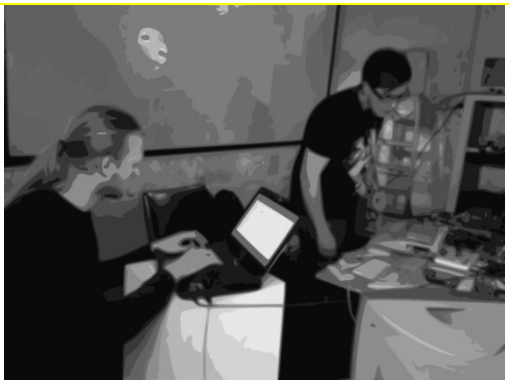


“tabula rasa musica” is a method to develop generative music via live coding.

Starting with nothing, coding a static beat, expanding with dynamic methods and ending up with automatic sequencing to generate different songs in one performance. Nothing more, nothing less. Maybe endless playing music.

info@labora.media

Key words: live coding, generative music



Generative Kampfkünste
(Live Performance)

Topic: Art, Generative Design, Teaching

Author(s):

labora media
Germany
www.labora.media

Abstract

“labora media” is a group of artists and their mobile laboratory to create interactive media in real time with their own developed instruments, as independent as possible.

“Generative Kampfkünste” or in English “Generative Fighting Arts” is a generative concept of using universal code of practice, individual skills and situational opportunities to defend yourself or others against destructive interaction in daily or extreme situation.

Based on generative designed lessons, the trainer set up steps of practice by selecting themes, place, training partners, usable skills and weapons, tempo and duration.

steps of practice :

- basic exercise : Training modular part of healthy and protective movement without challenging

- free exercise : Training and combining movement with clear roles of attacker and defender

- free fight : Using trained skills to prevent, control and finish possible attacks of all fighting partners

Following this respectful way, students learn to explore, train, verify, evolve and also teach individually physical and mental skills of themselves and their partners.

This extensive construction of unpredictable situations and behaviour let people train as realistic as possible and let them create and express their own peaceful art of fighting.

info@labora.media

Key words: self defence

TITLE
Groovy Racket

Topic: Live Performance, Music Audio Visual

Author:
Dr. Mark Zanter, USA, School of Music, Marshall University, www.marshall.edu;
Dr Brigid Burke Australia, Independent Artist, www.brigid.com.au

Abstract
This performance proposal features three works for electric guitar, live processing, clarinet and live video to be performed by Dr, Mark Zanter, Marshall University, USA, and Dr. Brigid Burke, Melbourne, AU. Approximate time 20 minutes.

Groovy (2017) a work for electric guitar, fixed media, live processing, and video uses additive techniques that generate the form and textural density of the work. Live video accompanies the performance. https://soundcloud.com/markzanter/groovy
Racket (2017) for electric guitar, live processing and live video, explores/maps physical gestures that are tropes of electric guitar performance using them to generate musical events, explore pure sonic content in varied musical contexts, and find potential meanings—intentional or accidental—to throw light upon their interpretation in social contexts.
Gestures I (2010) for any two instruments is an indeterminate/improvisational work employing modular form. The work was generated by fib, and pi numerical sequences applied to pitch, rhythm, and formal domains. This performance will be the premiere.

Biography:
Dr. Brigid Burke:
Brigid is an Australian composer, performance artist, clarinet soloist, visual artist, video artist and educator whose creative practice explores the use of acoustic sound and technology to enable media performances and installations that are rich in aural and visual nuances. Her work is widely presented in concerts, festivals, and radio broadcasts throughout Australia, Asia, Brazil, Europe and the USA. Dr. Burke has earned degrees from the University of Tasmania, and the University of Melbourne. More information can be found at: www.brigid.com.au

Dr. Mark Zanter:
Mark Zanter, composer/performer, has received commissions from many artists in the U.S. and abroad. His compositions have been featured on radio broadcasts, concerts, and festivals in the U.S.A., Brazil, and Europe. Dr Zanter has received awards from ASCAP, AMC, ACF, Meet the Composer, WV Division Culture, WVMTA; and *Lament and dream* for string orchestra, piano and percussion received special distinction for the ASCAP Rudolph Nissim Prize. He currently serves as professor of music at Marshall University.

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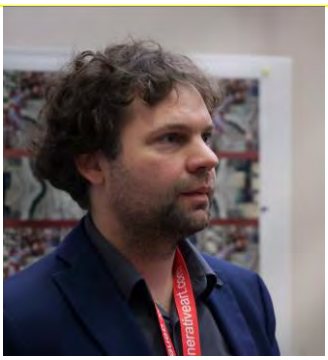
Huntington, WV 25755

Key words: improvisation, modular form, signal processing, gestural mapping, fib, pi, BHZ



TITLE : The old manor house. The intersection of drawings, sounds, and animation.
Live Performance

Topic: Art, Architecture,

Author:
Slawomir Wojtkiewicz
Technical University of Bialystok
Faculty of Civil and Environmental Engineering,
The Eugeniusz Geppert Academy of Art and Design in Wroclaw
Faculty of Painting and Sculpture
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Abstract
Generative Art as a form of media art allows for interesting, autonomous artistic activities, as well as an artistic practice in which the artist creates a system described eg by natural language.
The definitions of generative art, although fairly precise, permit the free treatment of its features to obtain the intended artistic effect. The term understood in this way allows us to go beyond the language of media art, generated only by machine, technology, computer, and combining it with traditional artistic techniques. In this way, generative art becomes a medium for certain attitudes where the artistic goal remains the same regardless of the tools used in the work.

The presented art performance exploits the capabilities of individual media to describe the specified reality of the surrounding world. The point of reference is the history of the transformations of the Polish manor house. The Polish manor house in history played the relevant role in identification unique space of architecture and cultural landscape of Poland. He formed language of the identity of settle place and regional culture. The historical-social form of architecture of the Polish manor house is understood as the code of the cultural landscape of north-eastern Poland. In the postwar years, this code was consciously and painfully blurred by destroying the cultural-spatial and landscape relationship. Its consequences are evident today in the form of loss in many cases the characteristics of the place and consequently the degradation of space.

Submitted art live performance is an inspiration of contemporary history of a manor house in order to achieve an interesting art image, animation, sound. The presented movie uses drawing, sound, animation as a tool and a means of artistic expression.
Post-cage animation and the suggestiveness of hand-drawing art is a pretext for the artistic activity resulting from the phenomenon of the role of a manor house in the history of Poland. This all seems to be a source of inspiration in the creation of my art using various media. Deriving from the base of existential philosophy the artwork combines contemporary and traditional tools in the creation of art.

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Key words: regional architecture, sound, hand-drawing, video art, animation

Scholars on a Picnic: A Generative Ballet in Three Parts

TITLE : Scholars on a Picnic: A Generative Ballet in Three Parts
(Live Performance)
Topic: (Art, Ballet, Music, Sound, Image, Spoken Word)

Author(s):
Michele Leigh
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Jay Needham
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Robert Spahr
USA, Southern Illinois University, Dept. of Cinema & Photography www.robertspahr.com

Abstract
Scholars on a Picnic: A Generative Ballet in Three Parts, is a live performance that incorporates chance, algorithm and game play to determine its parameters. Drawing from a rich history of generative arts performance, such as Fluxus and Happenings, this performance will offer a unique experience and include the audience in its generative practice. In the post WWII period two very different games were developed that demonstrate the precarious position we find ourselves in at the start of the 21st Century, stuck between possible world destruction (military, climate) and the potential peace (universal income, racial, religious and gender equality). We take as our starting point, the game La Conquête du Monde (The Conquest of the World) or as it was later called, Risk, the Game of Global Domination, which was developed in the late 1950s by writer/filmmaker Albert Lamorisse. Our second influence comes from the World Game or World Peace Game, an educational game developed by Buckminster Fuller in 1961 to challenge the notion of dominant nation states and to create solutions to problems like over population, world hunger, and now climate change. Our ballet is situated within the struggle between these two opposing possibilities, between brute force of capital/power and the peaceful sharing of resources and education, that are played out as both individual dilemmas and a societal call to arms. Our three protagonists, each representing a different philosophical approach to artistic/scholarly practice, will interact with the the performance space (designed to look like a picnic tablecloth and by extension a game board) in movements that are predetermined (much like the pieces on a chessboard) and based on the rules of play as we move through the two game concepts. Sounds, representing each of the protagonists, will be programmed and coded to play randomly, determining who moves, how and for how long. Additionally, the performance will rely on chance and audience participation, through the rolling of dice to add aspects like sound, imagery, and interactivity to the performance.
Act 1 Setting out the Picnic - The Battleground
Act 2 Entre'acte - The Free-for-All
Act 3 Food Coma - Peaceful Slumber
Protagonist 1 – Robert Spahr, media artist, Dada m'dada. DaDa mhm dada Da
Protagonist 2 – Jay Needham, sound artist, post-modernist with a briefcase of referential items.
Protagonist 3 – Michele Leigh, scholar-historian, feminist coloured glasses

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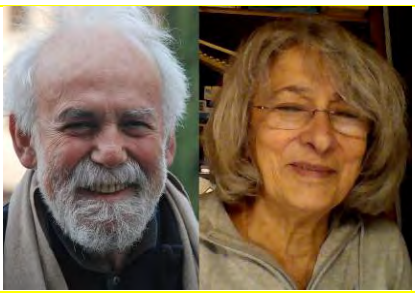
Key words: live art, algorithmic art, RISK, World Game



The Generative tongue, an *infinite* nudging
(Live Performance)
Topic: Art, Architecture, Poetry and Music

Authors:
Celestino Soddu
Enrica Colabella
Generative Design Lab Politecnico di Milano
www.generativedesign.com

This performance is an homage to Dante, the father of our mother tongue, generated by*"La Divina Commedia"* The only tongue, over the entire world, from the artwork of a poet completely generated. This is a unique extraordinary reference point for all lovers of Generative Art. Through an original generation of 3D Ravenna *futuring past* mosaic-architectural scenarios by C. Soddu, we want to give also an homage to Ravenna, that. preserves the tomb of Dante and the most beautiful mosaics in the world.
In this live performance, the generative process is not linear and works by nudging new visions into infinite remembering scenarios. The passage from a first open visionary generation of mosaic buildings runs following the memory traces of the past steps made by people during centuries on the floor where the labyrinth in Ravenna Basilica of St. Apollinare Nuova is. This imaginary discovering traces generates our vision toward a collective path of remembering, following the ancient art of connecting different fields as architecture, poetry and music as a new organic resonance of the infinite Mosaic beauty. Where each fragment in its uniqueness works collectively for the whole result, as a song that we can only intend by heart. The same structure of elements generates an organic path open to improvisation. If the nudging act is the mother effort for her son birth, in similar way poets generate words for the commune maternal voice of life. E. Colabella gives a poetic homage to Dante and Eliot, great *philosophical poets,* with 4 generative quatrains*:*

The Angel intimate painting by Dante

"Dante's imagination is visual ... it is visual in the sense that he lived
at a time when men still saw visions ... We have only dreams **…".** *Eliot*

"Dante once prepared to paint an Angel", *wrote Eliot.*
"It is sure; Dante painted his intimate Angel". Then we can say, following the Eliot poem.
More, you can put this question: "Why did Dante paint an Angel?"
In reality, he described in his Commedia thousands of angels:

An incredible lighted visionary Paradise figuration,
Through rhythmical emotional sounds, hidden between his poetic words.
"Dante painted an Angel," Eliot sings. "He painted his Angel ***with great tenderness*** *too"*
We add with emotion. "For ***whom to please?"*** *Nudging an answer.*

With impersonal time in his voice, Eliot ***whispers****:* ***"Beatrice".***
And, reflecting by open points of view, he decides to sing with ardour
That he prefers to see the intimate Angel of tenderness,
Painted by Dante, than ***"to read a fresh inferno".***

Oh ambiguous complexity of words, oh intimate discover of poetry,
Welcome at the open desco of song tenderness without time!
Where the intimate beauty of the Angel by Dante unveils "Four Quartet" too, as a shining site,
Generated by the splendor of evergreen laurel trees, for an infinite nudging toward beauty.

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enrica.colabella@polimi.it

Key words: futuring past - generative tongue- visionary imagination

Main References:

Dante,*"LaDivinaCommedia",http://www.filosofico.net/ladivinacommedia.htm*
T. S. Eliot, "*Four Quartet*", http://www.davidgorman.com/4Quartets/

XX Generative Art DVD

All the images of mosaics are from Ravenna, that we thank for the fine hospitality

GA2017

Italy, Ravenna 13, 14, 15 Dec. 2017

Conference, Exhibition and Live Performances:
MAR, Museum of Art in Ravenna
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www.gasathj.com

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