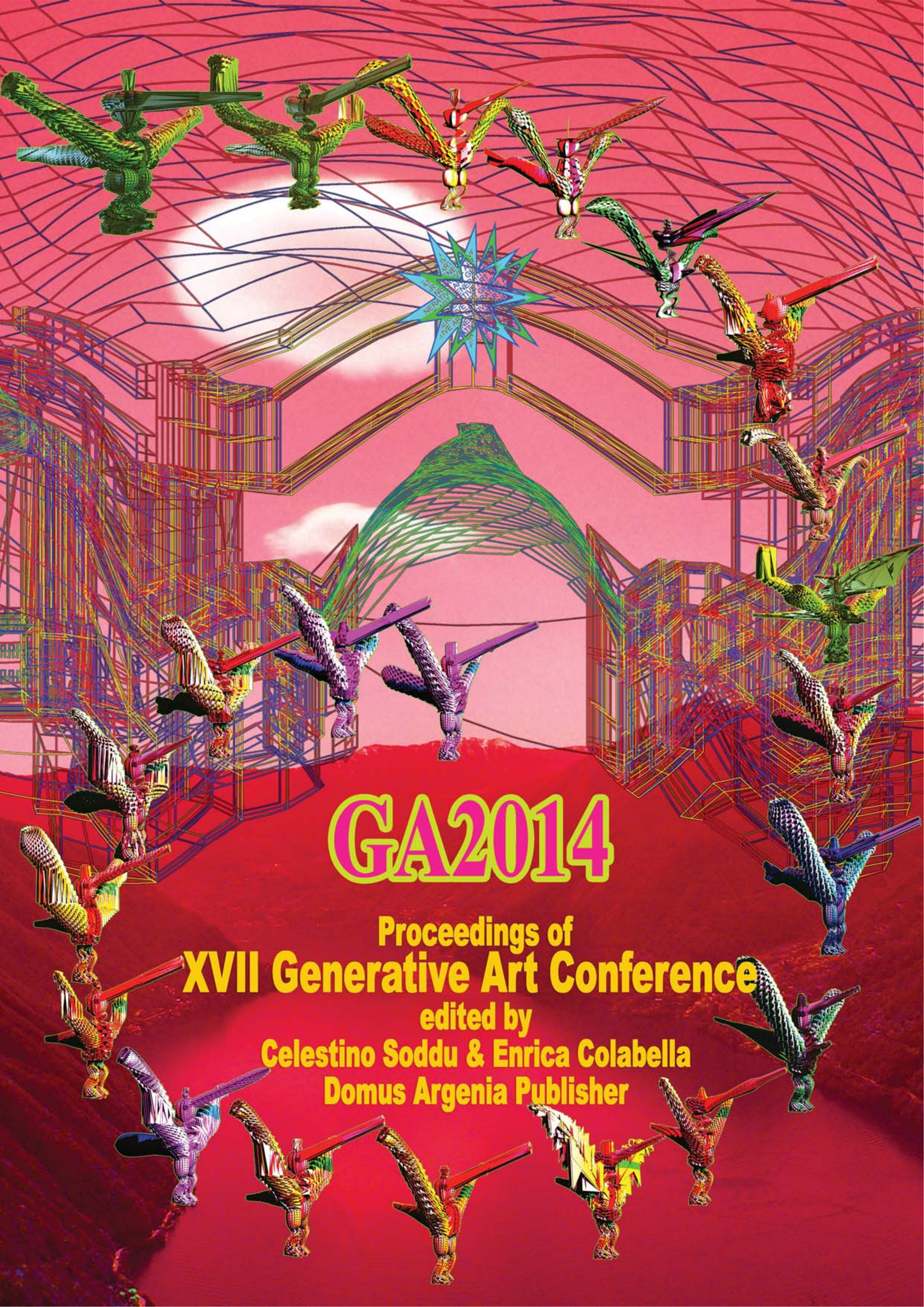

GA2014

Proceedings of
XVII Generative Art Conference

edited by

Celestino Soddu & Enrica Colabella

Domus Argenia Publisher

In the 1st and 4th cover an anamorphic perspective from inside a baroque cathedral and a sequence of birds, all generated by Celestino Soddu.
The DVD images of generated birds are unique, all different, and dedicated to each participant to GA2014

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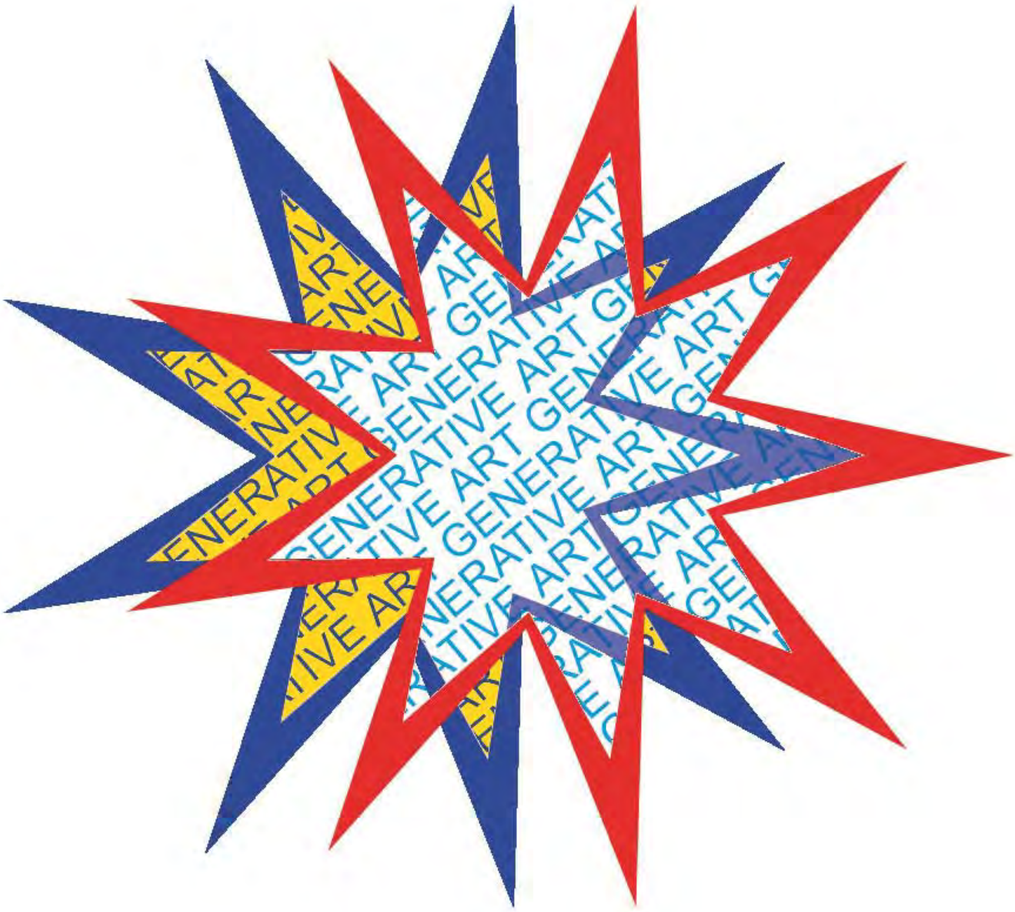

GENERATIVE ART 2014

GA2014, XVII International Conference
Rome, 16, 17, 18 and 19 December 2014
Conference at Tempio di Adriano
Exhibition at the Gallery of Angelica Library
Live-Performances at Cervantes Gallery

Proceedings

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

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Artworks, Installations and Posters

Live Performances

Generative Art Cloud

From 16 years we worked for building Generative Art Cloud, together with a lot of our friends that have actively participated in the past GA conferences, exhibitions and live-performances.

We all are proud of this mirroring identity. But sometimes we discover ourselves alone in a sea of omnipresent simplifications and of reductive and generic definitions of our approach to science and art. But in these 16 years, for a long time, we have discussed which are the characters and the identity of this group, by performing thoughtful meetings, with an happy open mind and sometimes also with hard contrasts, but always in respect to the nature of complexity in Generative Art approach.

We are an open group that was formed and it still exists because we have discovered in progress how to meet for exchanging ideas and for putting in discussion our more advanced artworks and performances. In this way it is formed something strongly identifiable: Generative Art. Generative Art was a little child in 1998 and now has spread all over the world. We all wanted, with hard motivation, to perform our participation to Generative Art conference each year for discussing and for exchanging their ideas. So we continue on looking to the future with hope, by trying to do our best.

This annual meeting is not in fact only an academic conference as so many others over the world. We know very well many of these conferences, where the main aim is to extend the field of electronic art to all the multiple possible approaches, dividing crowds of different people in a lot of different sub-topics and sessions without any possible scientific exchange. Art is a site of connections, not of differences. Generative Art meeting is instead a conference among people that are identified or they try to be identified in the generative approach to art and science. For many different reasons, during these meetings, many for us have tried to write a definition of Generative Art, by defining the potentiality and the distinctive characters of it. It might happen also in the future, if someone will discover a new course of our river. This doesn't happen in other conferences. Our annual meeting is unique in the international panorama also for this reason. GA conference, together with our experimental work in Art and Science, has founded Generative Art and the participants are proud to be identified as Generative Artists.

Following Futurism, the art movement more closed to GA for reason of time after Renaissance, we can try to identify some points:

We want to sing the unstoppable process of ideas and the progressive dynamics of creating Art.

Two are essential elements of GA:

1 - the strength of a generative thought

2 - the interpretative logics, written in algorithms, able to represent the characters of our contemporary world.

As Generative Artists we:

- move from static forms to dynamic transformations, performing our artwork as process and not only as result;

- manage the complexity of our vision, step by step, with progressive increasing identity by running not-linear systems for their unique multiple results;

- perform our artist identity in a recognizable style as a poetic process, able to generate artworks/variations with recognizable imprinting;

- can represent our idea with a progressive process before any possible results;

- our artworks are software able to generate variations.

Actually technology works by exalting only itself in art. We want, instead, to exalt ideas as imaginary products that are able to produce the construction of multiple, sudden and unpredictable results also through the unpredictable use of the technology, using a logic brought to the extreme paradoxes.

Starting from more than one century ago the mass production of all equal objects, from housing to industrial objects, over all word grews. After that, the technological imprinting degenerated in author, project and subjective creativity death. In contrast of this dark vision we proudly find again with GA the uniqueness and recognizable vision of every generative artist, his hard strength in project and in ideas, following ancient Maestri.

We don't want to hymn technology but the man that knows how to use it for pursuing his own vision, useful for the progress of human life.

Beauty is in the continuous transformation of the past into the future and our generative algorithms work by telling operatively this progressive vision.

Still today the innovation has been mainly a market of opportunisms. We want go beyond the commercial software and the homologating technologies for finding again our creativeness in writing progressive algorithms and in building our generative engines.

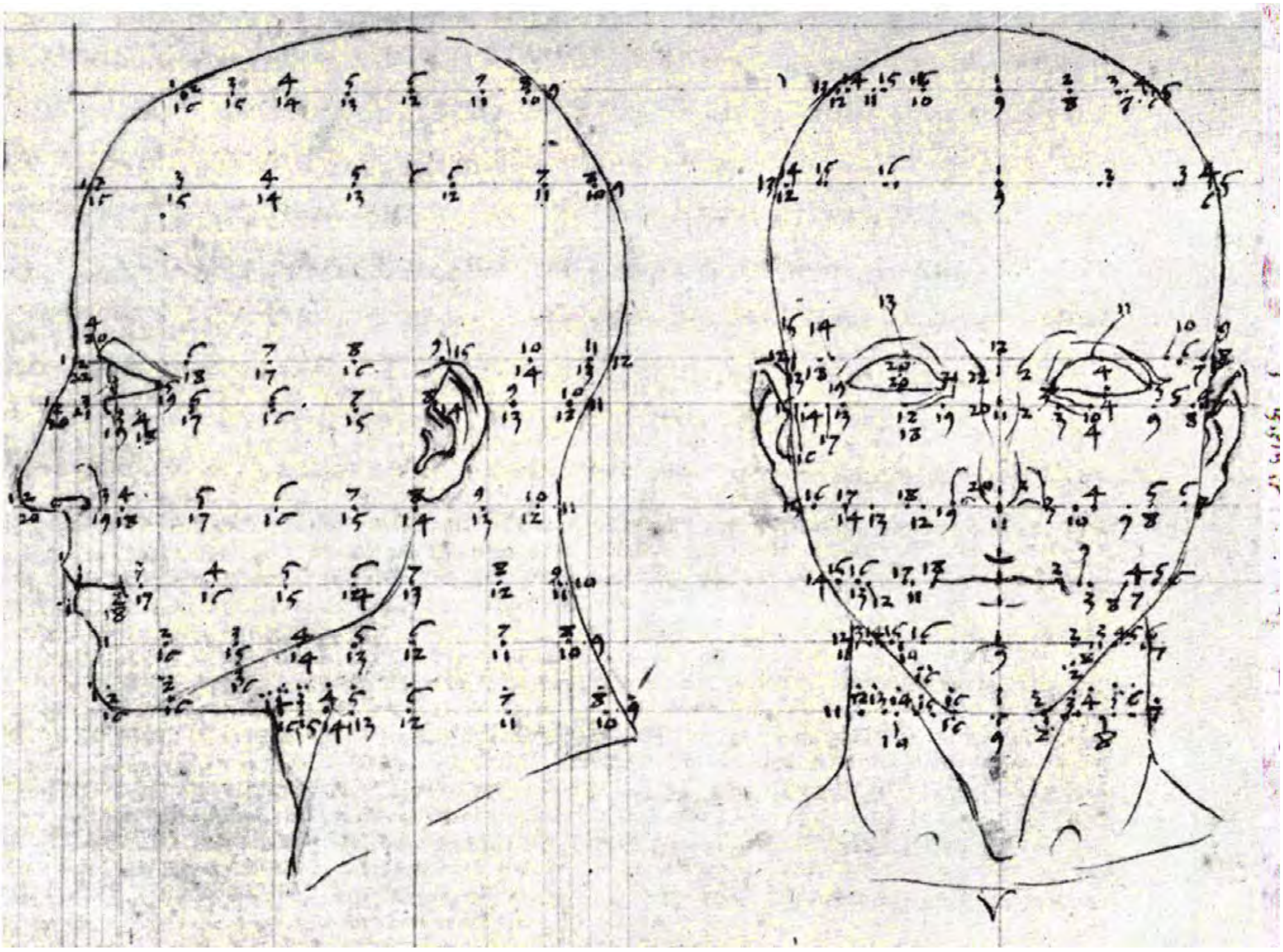
There are people among us that have lived the first advent of the digital era by founding again, in their really personal process of discovery, the pride to generate the possible, by pursuing their own vision. For youngest generation there are some problems about their getting easily fast results. But these often are not able to perform experience of knowledge. We hope that they too can generate the possible pursuing of their own vision, by producing their first generative results with conscience, following our or others experiences, but with the main aim of destroying the thrones of the homologating technologies.

So we will still meet again for discussing on how to draw progressive paths toward the infinite.

Roma, 16 December 2014

Celestino Soddu and Enrica Colabella

Chairs of Generative Art Conference



PAPERS

Celestino Soddu

Generative Art Geometry. Logical Interpretations for Generative Algorithms

Topic: Generative Art Theory, Architecture, Design

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www.gasathj.com
www.generativeart.com
www.generativism.com

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[2] E. Colabella, C.Soddu, "*Il Progetto Ambientale di Morfogenesi*", Leonardo, Milan, 1992

This paper tries to identify the creative processes of Generative Art that brings to the construction of dynamic procedures of transformation, generative algorithms, by departing from interpretative logics. This construction becomes possible through a dynamic approach to Geometry. In fact, overcoming the logic of the figures and related rules, this approach opens to the logic of the progressive processes and to the dynamics of transformation inside the geometric space.
This dynamic use of Geometry can be performed crossing again the revolution operated by Piero della Francesca, by Brunelleschi and by Leonardo da Vinci. This Renaissance revolution founds on the convergence between Art and Science and on the discovery of the Perspective Logic.
Quoting Decio Gioseffi, "The perspective has been the first mathematical (in systematic and univocal terms) formalization of a "physic" law indefinitely "extensible", of general validity and general verifiability".
The perspective, also in the first geometric tools structured by Brunelleschi, is a logical form of representation of the space that allowed, for the first time, to represent the infinite. The Perspective performs the representation of the infinite identifying a point of view. This means that the complexity of the space is scientifically investigable through the subjectivity of an observer and his Logical Interpretations. The scientific search, in fact, can follow too the same interpretative way pointed out by the perspective. Until now, as shown by Einstein and his logical interpretation of the universe through the theory of Relativity, together with Max Planck and his quantum theory that is a different logical interpretation of the universe. Both theories are useful and true, also if so in contrast one each other. The points of view are different but the matter is the same.
Generative Art pursues this interpretative approach. And it does it redrawing its tools starting from the main one, the Geometry. *The interpretative logics, activated by Generative Art, build parallel, multiple and progressive paths of dynamic transformations. These are managed through algorithmic logics*.

The *Generative Geometry* really becomes one of the main tool of Generative Art because it is able to logically represent the interpretation of the author performing his artworks in the endless multiplicity of the possible variations.
Writing Generative Algorithms is representing and investigating the existing environment from different and progressive logical points of view, tracing the rules for transforming the past in the future.

Fig.1 Generative Ship, C.Soddu 2014 over the image of Hokusai, 1830.

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Keywords:
Generative Art, Generative Geometry, Generative Algorithms, Transformation, Logical Interpretation

Generative Art Geometry.
Logical interpretations for Generative Algorithms.

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Abstract

This paper tries to identify the creative processes of Generative Art that brings to the construction of dynamic procedures of transformation, generative algorithms, by departing from interpretative logics. This construction becomes possible through a dynamic approach to Geometry. In fact, overcoming the logic of the figures and related rules, this approach opens to the logic of the progressive processes and to the dynamics of transformation inside the geometric space.
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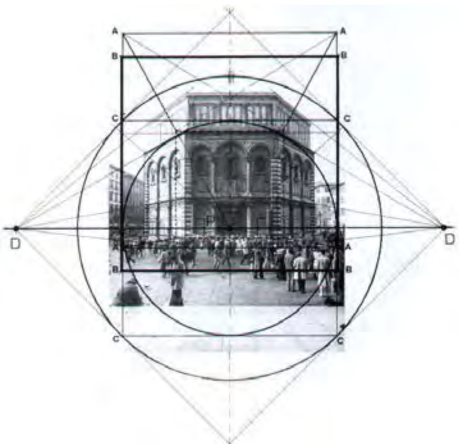


The "formella" of Brunelleschi interpreted by P.A.Rossi indicated that Brunelleschi made a peculiar, not casual choice of a point of view, with a distance from Battistero equal to the side of a cube involving the architecture and the optic cone, indicated by the circle, able to have a correct perspective. This was the approach for defining the structure of perspective the "perspective tool".
Paolo Alberto Rossi, "La scienza nascosta", (the hidden science).

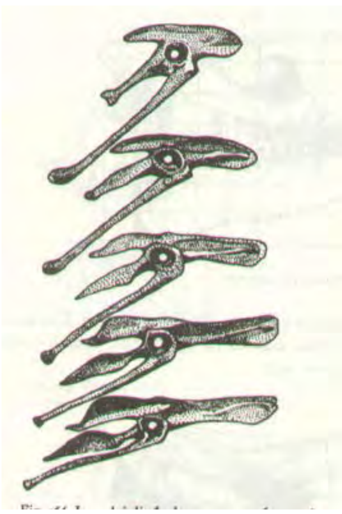
Quoting Decio Gioseffi, "The perspective has been the first mathematical (in systematic and univocal terms) formalization of a "physic" law indefinitely "extensible", of general validity and general verifiability".
The perspective, also in the first geometric tools structured by Brunelleschi, is a logical form of representation of the space that allowed, for the first time in human culture, to represent the infinite. The Perspective performs the representation of the infinite identifying a point of view. This means that the complexity of the space is

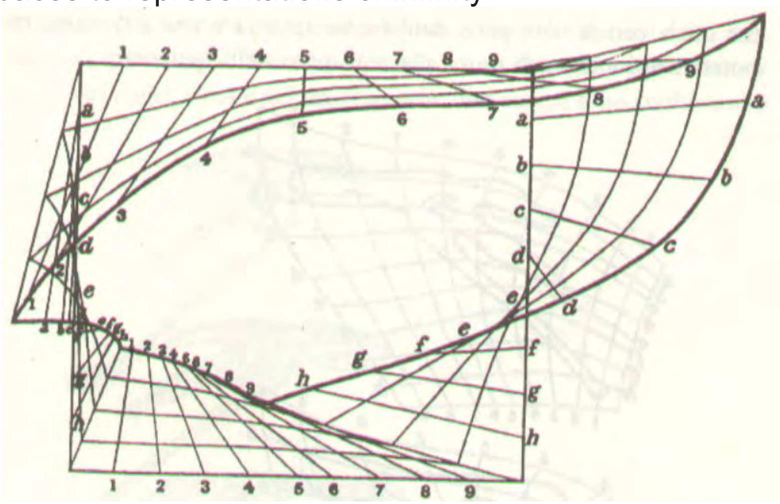
scientifically investigable through the subjectivity of an observer and his Logical Interpretations. The scientific search, in fact, can follow too the same interpretative way pointed out by the perspective. Until now, as shown by Einstein and his logical interpretation of the universe through the theory of Relativity, together with Max Planck and his quantum theory that is a different logical interpretation of the universe. Both theories are useful and true, also if so in contrast one each other. The points of view are different but the matter is the same.

Generative Art pursues this interpretative approach. And it does it redrawing its tools starting from the main one, the Geometry. **The interpretative logics, activated by Generative Art, build parallel, multiple and progressive paths of dynamic transformations. These are managed through algorithmic logics.**
The Generative Geometry really becomes one of the main tool of Generative Art because it is able to logically represent the interpretation of the author performing his artworks in the endless multiplicity of the possible variations.
The act of writing Generative Algorithms is representing and investigating the existing environment from different and progressive logical points of view, tracing the rules for transforming it from the past into the future.

The generative geometry

Geometry is one of the main fields involved in the construction of the generative algorithms. Not only for architecture, design and visual art, but also for music and poetry.
Since Generative Art moves from static forms to progressive transformations, Generative Geometry should be considered as the main tool for managing dynamic processes of transformation. Generative Geometry moves from geometric figures to the representation of dynamic logic processes, from measures to dynamic proportions, from measurable figures to measures related to a point of view, from representations of limited spaces to representations of infinity.

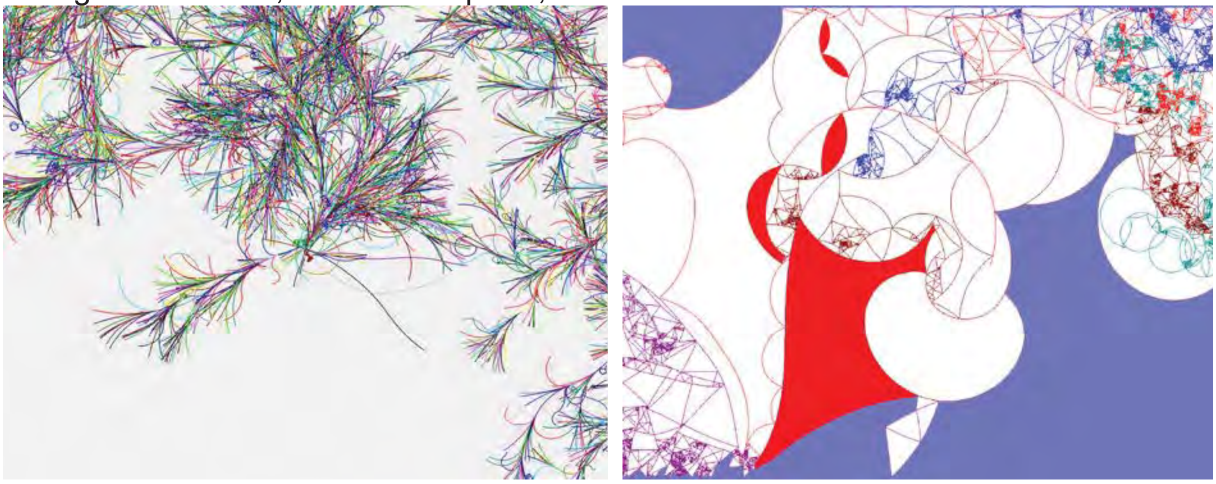




The transforming progressive process from Archaeopteryx to Apatornic following the Logical Interpretation of D'Arcy W. Thompson, "On Growth and Form", Cambridge Univ. Press, 1961. The Geometric structure is considered in analytical way following Durer, as a series of deformations. But I like to interpret, with generative geometry, his analytical tables, like the one in the image: a transforming process could be identified because the image looks like a *"perspective" representation.*

Exemplifying, such potentialities could be represented by the passage from axonometric representations to perspective views, the only ones that logically represent the infinity. But not only. The Generative Geometry is much more.
The construction of generative and geometric algorithms founds more specifically on logical interpretations of what fascinates us, by fixing our point of view. It's also a way to represent our main references, our preferred results of the past: the work of our main masters. Not copying them but interpreting them as results of a possible progressive process of transformation able to perform the quality that we appreciated. The aim is to construct procedures able to bring our design process in reaching such qualities.
Not analyzing these qualities but identifying which quality we like to transfer to our artworks, which quality corresponds to our own vision. This goal is performed by clearly identifying the point of view and the objective.
Operationally we are not doing copies of forms that interests us for the construction of a code, of a rule that represents our hypothesis: "how" we can construct events with the character that we like. And we will try to use these rules for managing the progression from the existing events to the possible ones; in other words for designing or making art. The logical-geometric interpretation of our imaginary of reference, of the works of our masters, of what fascinates us, is the core of the construction of a generative engine and of our creative tools.
In my generative design I have had a preference for the specific field of 3D space, also because my main sector of interest is architecture. But the Logical Interpretation of Geometry starts from one-dimension and two-dimension events as Kandinskij points out in "point, line and surface". We can find the more simple experimentations of using interpretative logics and managing the progressive dynamics when we construct lines through the generation of progressive points governed by rules. If our reference is the curve structured by Kandinskij, we can build an algorithm that defines, in progression, the following point through the progressive transformation of some parameters able to point out the verse, the dynamics of variation of the bending and the points of catastrophe where the direction suddenly changes, the progressive acceleration, the dynamics of variation of the thickness, etc.
We will never succeed in representing the famous line by Kandinskij (also because we don't like to copy it but to generate a kind of lines fitting similar aims) but we will produce a whole series of lines that represents the character that mostly interests us. The aim is to represent this characterized line with a transforming rule able to always turn a point into a different line but every time belonging to the same species of lines. So we have built a simple generative algorithm. And we have also represented an "ideal" line as a whole possible dynamic representations of a point in relationship to the precedents and the following ones. *An Idea is "generatively" represented only when this "representation" can produce endless variations of the same event, all belonging to the same character.* As, in Nature, a sequence of very different olive trees are all recognizable as olive tree. Variations are infinite because there is no limit to variations of individuals belonging to a species, of representations of the same objects belonging to the same logical interpretation but changing the point of view.
Increasing the complexity of our approach and moving over the simple one-

dimension geometry, we can build other algorithms able to define other dynamics of transformation. We can use them in the transforming process from a point to a line, from a surface to a solid, but also in each possible process from a dimension to the following one.
Remaining on two-dimensions, if we, for instance, have as reference the refraction of the light in a prism of glass, we can write an algorithm that, when our progressive line meets another line with particular colour, it defines how it breaks in a series of divergent lines that, after the "impact", will have autonomous life.



On the left a generation of lines that break themselves in a series of different lines when they impact with another lines with selected colours. On the right generation, a line inverts its angle of growing when impacting with another line. (simple experiments by C.Soddu with his soft).

But, as it appears obvious, we are already moving toward an increase of dimensions. The acceleration already points out another dimension that can be represented in various ways.
The simpler three-dimensional generative process is the logic of cellular automata, when this kind of process is activated in the three-dimensions.
It is difficult to imagine the final result of these progressions even if we can foresee of it, but we can predetermine its character: nothing is left to random and all depend on the spatial topological location of the first events and of the adopted rules.
We can talk, in this case, of a progressive logic, of a first kind of generative approach to geometry. But it foresees an intrinsic difficulty to manage own spatial vision and the characters of each possible result. For doing that it is necessary to experiment and to find connections among the adopted rules and the character of the results. This search is possible because the logical sequence of the transformations is fully controlled by the rules. Even if we can surprise of unpredictability, and sometimes of the unexpected beauty of the results, this happens without using logical random but only varying the mutual initial positioning of the events.
And here a fundamental aspect of generative processes appears: the use of random parameters. Firstly we need to clarify that the use of random for the initial data as the positioning of the first events in a process of cellular automata or the first points in the construction of lines through the logical progression of points, are really different from the creation of random forms and the subsequent choice of the form that casually can emerge.

This difference can seem meaningless but it is fundamental.
1. The use of casual data as beginning of the transforming process is similar to the logical consideration of an existing and unpredictable environmental context in which to activate a progressive process totally managed by well defined transforming rules able to interact with unexpected events.
2. The use of random parameters in the construction of formal results is an aesthetical blind search instead of following own vision identifying us as author. It defines an approach that seeks the emergent form from a process totally deprived of controls. It pursues the "death of the project", "the author's death", quoting R. Barthes, with the impossibility to recognize the author vision and identity.

The first type of approach with using different initial data is also a characteristic of my generative software: I manage the oneness of the results and the relative variations using an initial data that always changes: a number that synthesizes date and time of the beginning of the process. Then everything happens without randomness but the results, also being recognizable as belonging to my own vision, are absolutely unique and unpredictable.

Generative Geometric figures

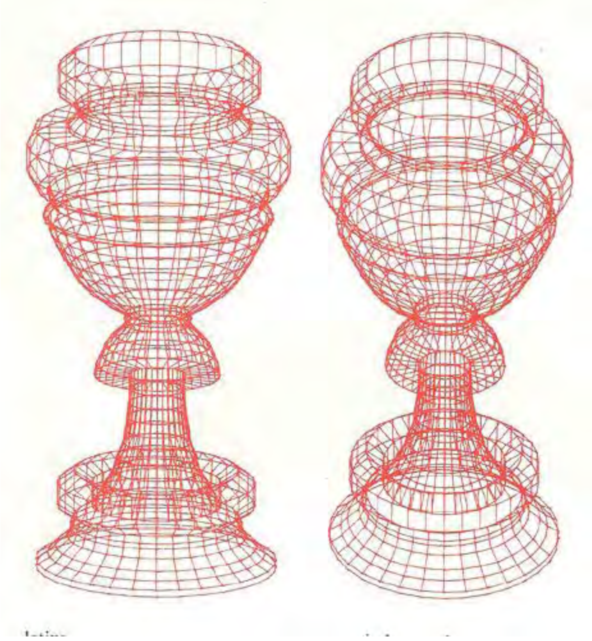
We need to go over the cellular automata, that are only a particular even if extremely meaningful study case of transforming process without random. The generative geometric logics are founded upon different logical interpretations of the same geometric entities. In the generative geometry, for instance, a cube is never the same geometric event, but it depends on the logic adopted for generating it.

It could be generated defining an algorithm representing a dynamic series of solid that can go from the tetrahedron to the sphere. Or with an algorithm generating solids with two shapes existing in an orthogonal axle. Or with an algorithm representing the dynamic series from a cylinder to a triangular prism, and so on.
And we could nearly define a endless series of logical interpretations of a cube that would bring to a series of solid of generative geometry that, in the construction of the generative algorithms, they totally behave in different way.

This is the base of the generative geometry.
If the Geometry is defined as "*part of the mathematics that studies the space and its figures*" **we could define the Generative Geometry as "*part of the mathematics that studies the dynamics of the spatial transformations and the progression of its figurations*."**

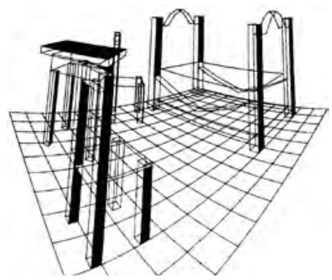
Generative Perspective Geometry

But Generative Geometry would be a sterile branch if there was not the perspective. It is not a case that the perspective, and its first logical form identified by Brunelleschi, has been a revolution in science. The identification of a logic perspective, or rather of a based logical structure of points of view and observed events, allowed a scientific approach based not only on deductive analysis but also to Logical Interpretations whose multiplicity is based on the points of view. The first and fundamental aspect of this "scientific innovation" has been to discover that these logical interpretations are able to acquire the infinite and "to measure it" giving an essential impulse to the human knowledge.



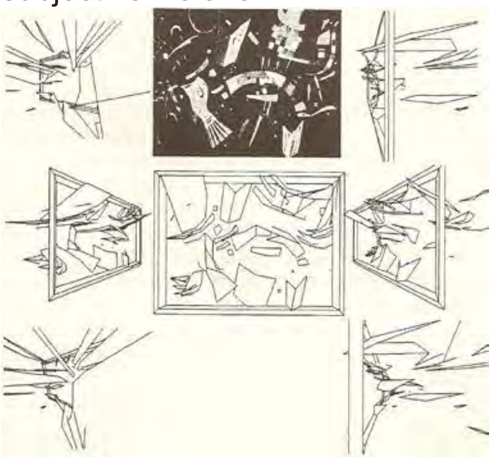
The calyx of Paolo Uccello, attributed also to Piero della Francesca in a logical perspective computer reconstruction by Celestino Soddu, 1985, printed at pen plotter.
The reconstruction, quoting Carlo Ludovico Ragghianti in Critica d'Arte n'8, 1986, follows the very particular geometrical approach to perspective by Brunelleschi, interpreted with algorithms ad hoc.
This algorithmic approach was one of the first perspective scientific software in the world. The study and the articles made by C.L.Raggianti, P.A.Rossi and C.Soddu, was part of the research "Art Processes and Visual Objects Computer Analysis" developed in the International University of Arts in Florence.

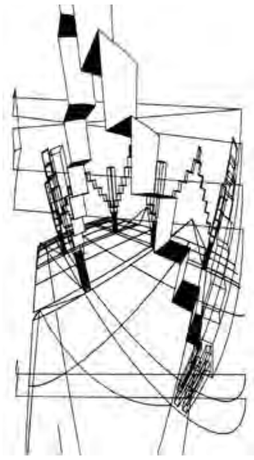
The logical interpretations of spatial events could use different points of view and different perspective logics. These are not limited only to the perspective of Brunelleschi but they can also involve other perspective logics as the curved perspective, the anamorphic ones and the inverse perspective of Florenskij, as well as the three-dimensional representations of events with more than three dimensions. We can start from simple examples. The choice of the point of view and the logical structure of the perspective, identifying a peculiar logical interpretation of the space, can define the character of the artwork and the vision of the artist. Two examples are very eloquent. The "Flagellation of Christ" by Piero della Francesca and "the room" of Van Gogh.

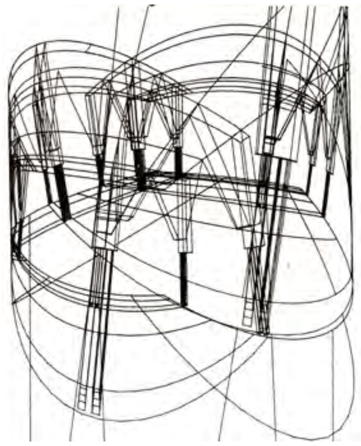


"Flagellation of Christ" by Piero della Francesca and "the room" by Vincent Van Gogh. On the right a reconstruction of the room with a curved perspective from another point of view but with the sight toward the ceiling as the original image.

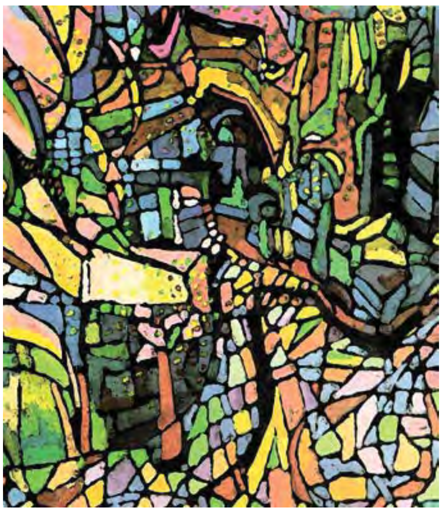
In both these artworks the perspective image is paradoxical, absolutely particular and hardly verifiable in the reality. Also if they both seems to be "normal" at the first sight. In the "Flagellation" the observer is very low, almost to the floor, and he looks toward the direction of the flagellated Christ. From that position he could not see in full the three figures, being these, of fact, out of an acceptable optic cone; he would see only the low part of the dresses. Instead, forcing the geometric structure of the perspective the three figures are fully represented. The use of this point of view constructed an estranging image but geometrically "correct". And in this it reflects and renders explicit the interpretative logic of Piero. In the room of Van Gogh (C.Soddu, "The not Euclidean image", Gangemi Publ. 1986, and C.Soddu, “L'idea di spazio nelle rappresentazioni d'arte“, (the space idea in art representation), in “Critica d'arte“ magazine, n.16, 1988.) the perspective seems, at first sight, a normal perspective of the room seen by a standing observer. But the vertical lines converge upward. Since the observer is standing, taller than the bed and of the chair, these lines should converge downward instead. This converging is estranging because, to find again this possibility in a correct perspective image, or however in a "photographic" view, we must imply that the observer is, as he appears, more high then the objects but, at the same time, he looks upward. The whole room, therefore, would be seen with the tail of the eye while the observer (Van Gogh) is looking at the ceiling (that is not represented in the artwork) and the whole image of the room would be, in a certain sense, out of a "normal" optic cone. This posture represents, through the perspective logic, the discomfort, the character and the vision of Van Gogh. In the use of an "impossible" perspective image we can find something in common between Piero della Francesca and Van Gogh. Both have used the perspective geometry to clearly communicate a strong subjective vision of a "normal" spaces. And this has produced a spatial order strongly interpreted but, also if impossible, logically correct. It shows how the perspective science can communicate subjective visions.





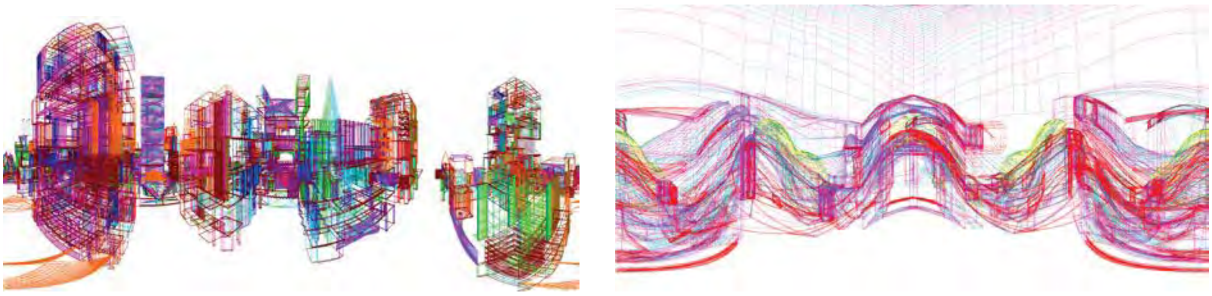


1st Image, a 3D logical interpretation of a Kandinskij artwork (C.Soddu, 1987) and (2nd-3rd image) some unusual perspective images made forcing the algorithms of the perspective. When the distance change beyond its "natural" limits, if we use algorithms following the logical approach of Brunelleschi the image break itself and some elements move from one side to the other of the sheet. This happens in a different way when forcing the algorithms of curved perspective. (C.Soddu, "Not Euclidean Image", 1986. (4th image)The same approach in one of mine oil painting (C.Soddu, "Guggenheim museum NYC", 1986) where the image is reconstructed using a spherical anamorphic logical interpretation forced

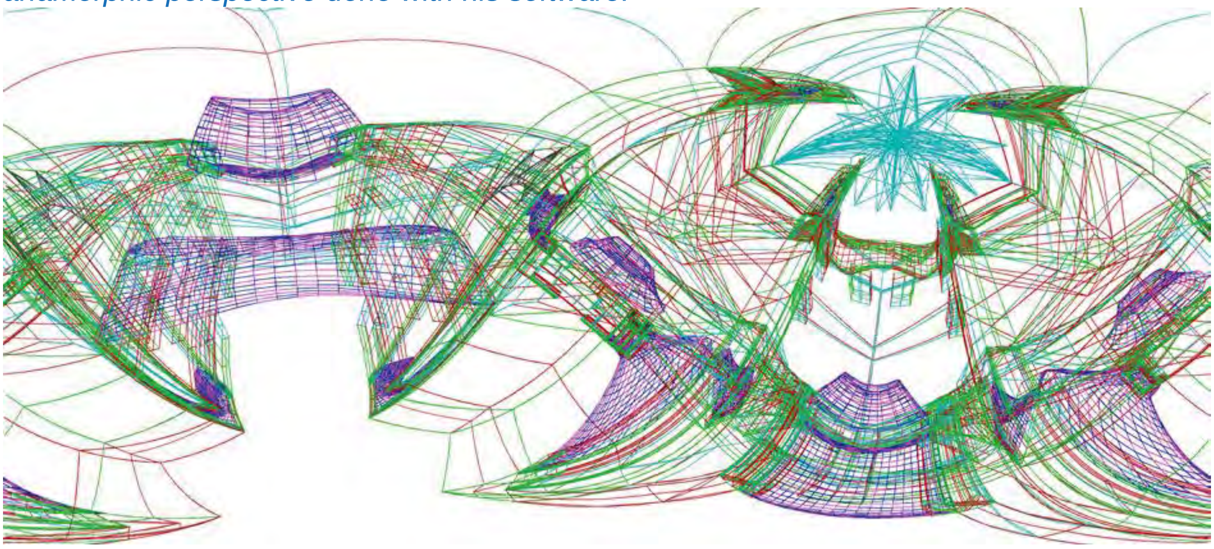


beyond the limits of this type of perspective..

The logic to represent the events identifying points of view and observed events has allowed to build different perspective logics. While the perspective of Brunelleschi and Piero della Francesca identifies an observer and an observed point, other perspectives as the cylindrical and spherical anamorphic perspective, of which I have built in 1986 the algorithmic sequences, identifies one point of observation and a linear (cylindrical) sequence or a surface (spherical) of observed points.



In these cylindrical anamorphic perspectives, representing a generated city and the interior space of a generated cathedral, the observer is in the centre of a cylinder constructed by the image wrapping the cylinder. This is the reason why the left border and the right border of the images coincide. The observer can rotate his sight looking at all possible directions. The anamorphic structure of the image answers to these different sight with a "correct" perspective image by straightening the curved lines in the perception. C.Soddu, total anamorphic perspective done with his software.



In this other total anamorphic perspective of a generated architecture the sight is oriented to the dome (and, in the other side to the floor, being a 360 degree sight. C.Soddu, software "totale" 1988.

This is the first possibility to go over the Brunelleschi perspective going over an axiomatic visual direction, opening to not Euclidean geometries. But it's possible to go ahead. The inverted perspective, identified by Florenskji in the Russian icons, inverts the direction between observer and observed point. Here, contrarily of the anamorphic perspectives, the points of view become manifold while the observed point returns to be unique. And this is indicative of the peculiar use of Russian icons: a multiplicity of people (points of view) looking at the same event, the face of the Saint. ("Perspective, a Visionary Process: The Main Generative Road for Crossing

Dimensions", C.Soddu, Springer, 2010)

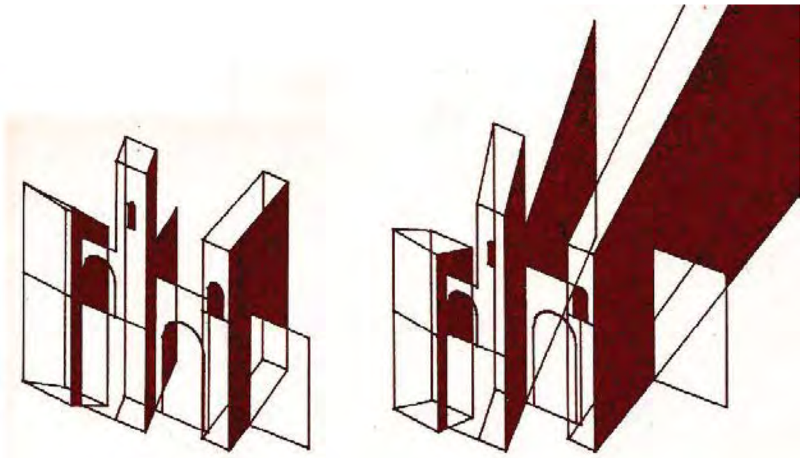
As Florenskij argued, the Russian icons have a inverse perspective. It's possible to understand this inverse perspective because you can see, in the same time, the two ears of the Saint as we look from the inside of the head, or from the inside of a cube where the image is anamorphically projected (top fig.). The Inverse perspective is focused by Florenskij saying that we only see the eternal surface of the objects. In this case the image (botton fig) is the same but the cube is inverted and we look to its external surface.

This approach using different perspective logics and the related construction of generative algorithms opened the possibility to "logically" interpret in different way the same event. The different points of view, all together, can refer to possible variations of the same logical interpretation, opening to the generation of endless possible results, endless individuals of the same species, recognizable through the same logical interpretation.

This is a way to collect our creative investigations, making them executable inside our generative software. It is possible to do that without creating a database but with generative algorithms. They, using as input different "points of view" are able to generate multiple variations. The interesting aspects of this type of generative approach are two: each result is different but each result is recognizable by the same logical interpretation, that is by the same "vision". In this way the "author" can be expressed, and the style too. This is the reason why my generative software have a lot of pages of statements. I added them step by step by following my design activityduring the last 30 years.

This "change of point of view" is normally used by artists, designers and architects and it is of great utility in the creative process. As example, today I got a step of my project, of my artwork. Tomorrow I go back to my work and, to go on, I turn the sheet

on the other side and, doing that, I easily continue to draw. Making this simple gesture, changing the point of view, I can open new possibilities and I go on expeditious pursuing my vision and managing the complexity and the ability of my artwork to answer to different and multiple requests. Why not to manage the same possibility in a generative software? We can do that by using the generative geometry for constructing our algorithms.
In the generative process, and inside the algorithms, it's possible to perform this possibility and more. I can represent my event through a perspective representation and then I can perform the reading of this "virtual image" as a 3D object represented using a different point of observation. This can be performed according to my logical interpretation, as happened in the medieval artworks by Simone Martini. He made different representations of medieval cities. But when he represented each building, he done it with different points of view. I discovered that it's possible to interpret these points as belonging to a 3D line: a virtual path showing the discovery of the medieval town. It runs from the outside to inside thecity wall. In other terms Simone Martini has used the selective variation of the points of view as way to represent the fourth dimension in a two-dimension image. (C.Soddu, "L'immagine non Euclidea", "the not Euclidean Image", Gangemi Publisher 1986)

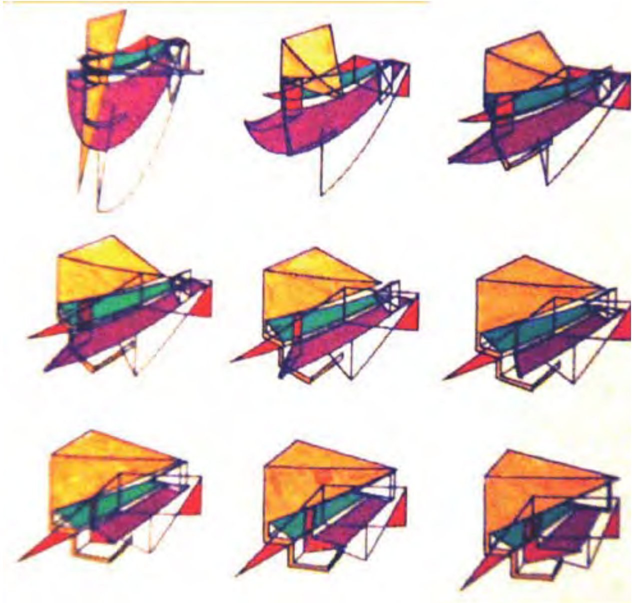



Simone Martini, tempera on panel, 1328. Looking at the different buildings it's possible to verify that each building seems to be represented with a different perspective view. This "interpreted" points of view create a 3D line from outdoor to inside the medieval city. We can interpret it as a representation of the 4th dimension in the two-dimension image. In the right image two frames of the transforming sequence of the solids following the path of points of view. C.Soddu, "L'immagine non Euclidea", "The not Euclidean Image", Gangemi Publisher 1986.

My opinion is that Simone Martini used, for drawing his artwork, the Generative Geometry. And it's possible to find this type of approach in Giotto too, and in some medieval artists living before the systematization of the perspective tools made by Brunelleschi.
If this process is used in the creation of the space, the form of every three-dimensional solid transforms itself in progress, assuming different results and performing events that have characters fitting the vision of the author. Spatial orders and characters that are logically reproducible through algorithms because the

process is repeatable.

Balla, "Mio istante del 4 Aprile 1928 ore 10 piu' due minuti". 1928

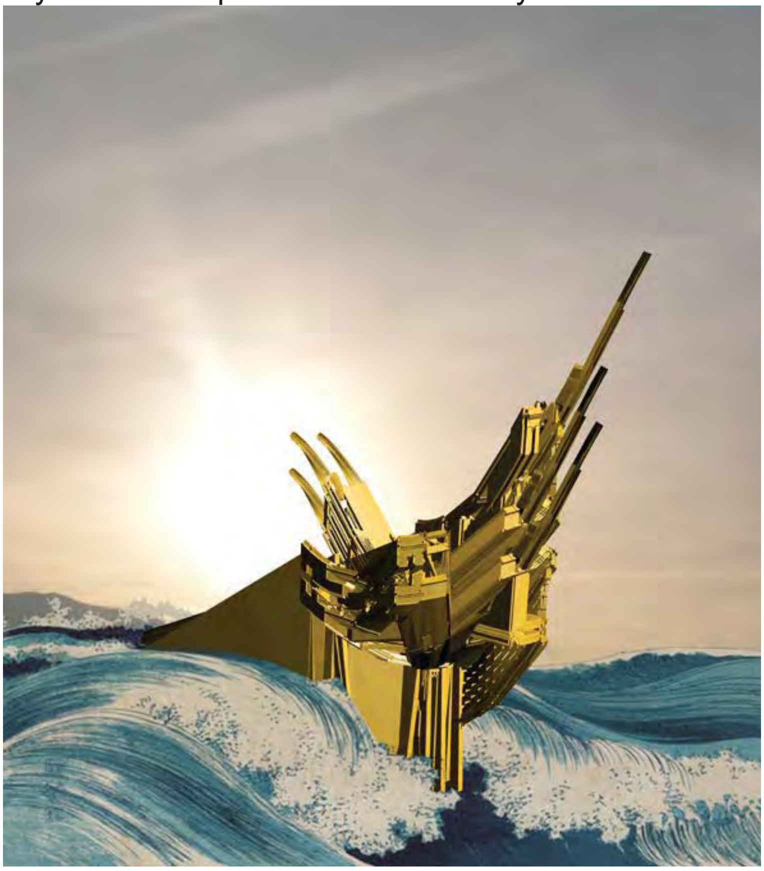


Moving from the image as canonical perspective to a not Euclidean perspective and going back. If we read the not Euclidean perspective (first image of the sequence), as Brunelleschi perspective we can have a completely different object with rounded solids. C.Soddu, 1986.

More. We can try to read a canonical perspective as it was a curved, not Euclidean, perspective. ("The not Euclidean image", example of Balla, C.Soddu, Gangemi Pub. 1986) This generative process can produce complex solid events that reflect our spatial vision. In that case the results are rounded solids where the curved lines are strongly controlled by an intrinsic harmony, the same harmony of the previous squared solid but different fascinating. Logics are mathematically describable, therefore the construction of these generative algorithms is easily prosecutable, together with the objectives and to the characters that they intend to pursue.

Following the same approach, a reverse perspective of a cube, for example, can be read as canonical perspective assuming that it is a 5 sides prism. The increasing from 4 to 5 sides transform the solid in a generative way moving from a logical geometric interpretation to another one. ("Perspective, a Visionary Process: The Main Generative Road for Crossing Dimensions", C.Soddu, Springer)
This is the Generative Art Geometry. The hard core is constituted by the logical sliding among different representations, among different spatial dimensions.
In fact, another possibility can be performed by sliding from a dimension to another. The base is moving from two dimensions to threereading a two-dimensional image as was three-dimensional and vice versa. But also managing through interpretative logics the passage from three to four dimensions, from the cube to the hypercube by reading this last event as three-dimensional.

The creative world of Generative Geometry is extremely wide, and above all it can fit the own vision. It can logically reflect our uniqueness of creative people, it is the logical world where we can identify and develop our vision as our style.



On the left a generated baroque cathedral, together with a UFO and a car, all generated with Argenia software, C.Soddu 2013. In the right image a Generated Ship in a Japanese Sea, C.Soddu, 2014. The sea is done interpreting the image of Hokusai, 1830. The ship is the result of a generative process with a progressive geometrical transformation using the same baroque algorithms but going over the predefined limits of these algorithms. Every personal tool is made for going beyond the default limits. As it's possible by using Generative Geometry.

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Abir Acharjee

Paper: **Geometric Evolution and Optimization of 'The Oval'**

Abstract:

Computational freedom and emergent design tools are leading to geometrically challenging forms in the field of architecture. Designers are able to work with more complex geometries and design variations. The challenge lies in defining these geometries into buildable components with constraints in construction techniques, materials and cost. Designing with construction logic helps to avoid geometric post-rationalization.

Geometric abstractions of mathematical descriptions form an inherent part of computational design. These applications and tools in architecture attempt to solve a combinatorial problem like modular facades or generate pattern for surfaces.

This paper takes the project "The Oval" in Limassol, Cyprus, as a case study to explain the integrated design process of form development to rationalization of the design geometry, leading to a modular cost effective solution. It focuses on the use of computational approaches towards the design enabling the alignment of the design geometry with the design intent at every stage and embed constructional rationales. It further researches on developing optimized paneling solution for this class of geometry.

Topic: Architecture

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Form Generation, Rationalisation & Panelisation of The Oval

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Keywords:
Generative Design, Parametric modeling, Rationalization, Paneling, Geometric Optimization.

Geometric Evolution and Optimisation of "The Oval"

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Abstract

Computational freedom and emergent design tools are leading to geometrically challenging forms in the field of architecture. Designers are able to work with more complex geometries and design variations. The challenges lies in defining these geometries into buildable components with constraints in construction techniques, materials and cost. Designing with construction logic helps to avoid geometric post-rationalization.

Geometric abstractions of mathematical descriptions form an inherent part of computational design. These applications and tools in architecture attempt to solve a combinatorial problem like modular facades or generate pattern for surfaces.

This paper takes the project "The Oval" in Limassol, Cyprus, as a case study to explain the integrated design process of form finding to development of the design geometry, leading to a modular cost effective solution. It focuses on the use of computational approaches towards the design enabling the alignment of the design geometry with the design intent at every stage and embed constructional rationales. It further researches on developing an optimized paneling solution for this class of geometry.

Keywords: Computational Design, Parametric modeling, Rationalization, Paneling.

1.0 Introduction

Concept design explores visions from sketching to massing and then to defined geometry, which eventually defines the building components. This sometimes results in a process of post-rationalization. A well-informed design solution takes into consideration the construction logic and modularity at an early design stage. In this approach the building geometry is developed with an awareness of the details.

Computational approaches help to generate, visualize and evaluate spatial properties of the built environment. The notion of controlling geometric systems through parametric design has become a route for complex designs. Parametric modeling transforms the design process into an experimental series of actions that allows the discovery and analysis of unfamiliar opportunities. The model generates several variations for taking design decision and helps the transition from computational geometry to the materialization of the design.

2.0 Approach

The emerging digital tools are enabling designers to deal with more in-depth analytical design thinking and approach. They have a strong influence in designing forms and resolving complexities derived from concepts, site constraints, construction limitations and cost. It helps in the iterative evaluation process for the design options. The geometric descriptions allow for higher control of the design and achieve the required aesthetic expression. It helps in negotiating design options with competing disciplines. The combination of intuitive visual programming with the robustness of parametric design, offers unprecedented fluidity throughout the development of a project.

a b c

Figure 1. Concept development

The original concept was based on a pebble form (Figure 1a,b,c). Initial studies involved the formation of a generative model (Figure 2b) and analyzing this form with respect to the spatial and planning data. The concepts have been created in conjunction with the architectural team. Solutions have been devised that meet the architectural and structural requirements. This paper contains discussions of the form finding, geometric approach, design development and further research on paneling solutions.

3.0 Concept Development

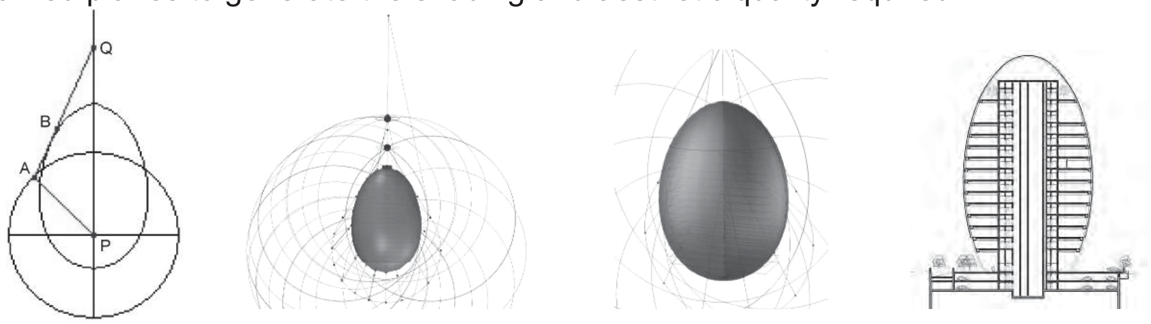
Atkins was commissioned the Concept and Schematic design of this 80 meter tall office tower. I assisted the Design Director at all stages from form-finding to final deliverables for his vision of this oval form. Initially in the concept design I was responsible for the geometry, envelope and facades. Later was responsible for the full project deliverables at the schematic design stage.

The concept of pebble form was approached by developing an egg curve using the mechanical egg curve algorithm (Figure 2a). The site and project constraints defined the final volume.

3.1 Mechanical Egg Curve

Point A (Figure 2a) moves in a circular path around point P and Q is another variable point in a line passing through P. Point B is a variable point collinear and in-between A and Q. The position of the point B describes an egg shaped curve as the point A rotates 360 degree.

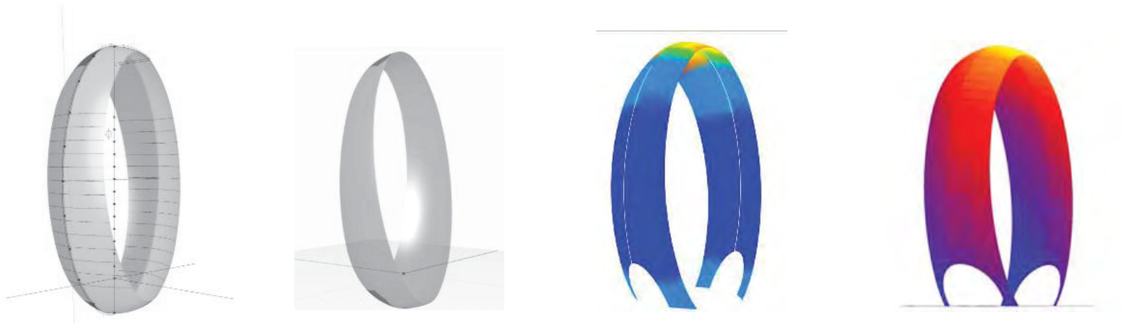
Initial studies involved generating a range of volumes with this logic transformed along translated and rotated planes (Figure 2b,c). Once a simplified volume meeting area requirements is achieved (Figure 2d), it was sliced in the middle (Figure 3a) to have a sharp change in curvature, producing a differentiating line of shading between the two halves of the shell. It was then sliced from both sides (Figure 3b) with inclined planes to generate the shading and aesthetic quality required.



a b c d

Figure 2. Mechanical Egg curve algorithm(a) and form finding (b-d)

This initial form was a double curved surface with more curvature towards the top of the envelope (Figure 3c) due to the inherent nature of the egg form.



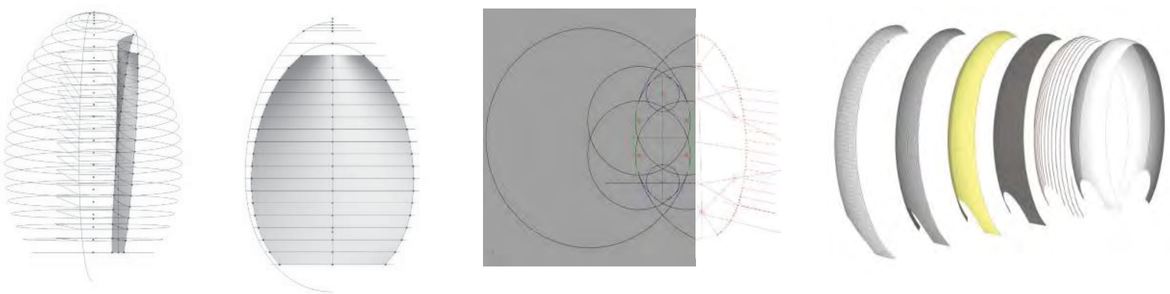
a b c d

Figure 3. Development and Analysis of the shell

The changes in curvature needed to be nominal towards the side for accommodating the areas and viewing angles from the floors. The variables in the parametric model helped to satisfy the area requirements, aesthetics and integrate structural solutions. Several iterations of the slice angle with solar analysis (Figure 3d) of the shell along with aesthetic judgements, produced the final form.

3.2 Geometric approach

The process of iterations of the geometry was informed by rationales and geometric implications at all stages (Figure 4a,b). To create a standardized approach to this non-standard surface, the surface was initially created as a combination of several parametrically controlled torus patches. The egg cross section of the form was realised using eight circles with tangential continuity, at the points of required structural joints (Figure 4c). Circle centres were derived after simple iterative loop of a function to minimize the distance from the original curve respecting the specific tangent points and satisfying the floor areas within a range.



a b c d

Figure 4. Analysis of surface, rationalisation, structural layering

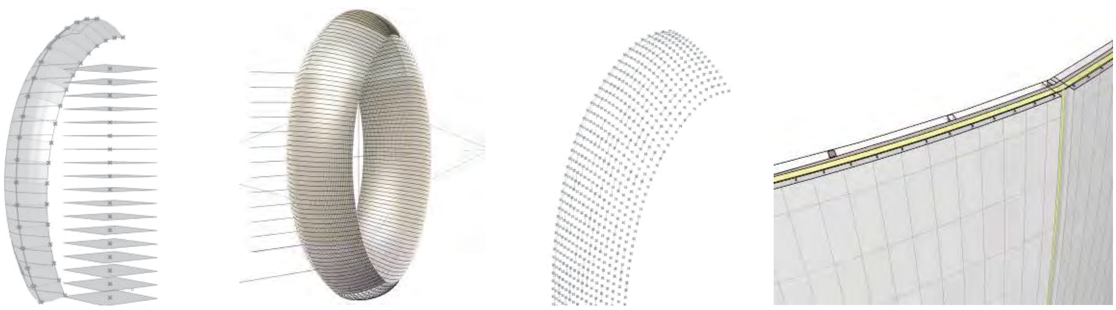
The top of the tower host a sky restaurant, so the curvature of this part was further reduced to accommodate the volumetric requirements and provide openness to the space. The oval cross section in the other direction was formed with three circles with tangential continuity. Since the shell geometry influenced the structural layers within the shell, the geometric relationship between structure and exterior facade were explored (Figure 4d). Two layers of panels, outer and inner layer, needed to be evaluated which required a paneling solution.

3.3 Panelisation Strategies

The paneling solution is generally achieved by using a tessellation algorithm to break the geometry into required subdivisions. The general approach is a top down methodology in which the surface is explored with regard to its global topology. For minimizing the overall cost planar quadrangular panels were preferred over planar triangular and bent panels. In contemporary construction, flat panels in general, have several advantages over warped panels, including productive time, manufacturing cost, durability and maintenance.

The full unsliced surface geometry was taken for the paneling. The edge line panels follows the slice line of the form and needed to be sized accordingly. Several paneling solutions were developed, some of these were based on the globally curved facade-locally planar panels, some were globally curved facade-locally stepped and others were based on the globally curved facade-locally planar with adjustable divergences, where divergence refers to the gaps between panels. The aim was to go with planar quadrilateral panels. Analysing constructional support system for the panels and aesthetic requirements, the panel size required was around 1350 (length) and 450 (width).

A torus patch can be subdivided into rows of flat quadrilateral panels. In the initial formulation, eight parametrically controlled torus patches combined to form the outer panelled surface geometry. However, within each strip there were variations in the panels as per the inherent nature of torus form.



a b c d

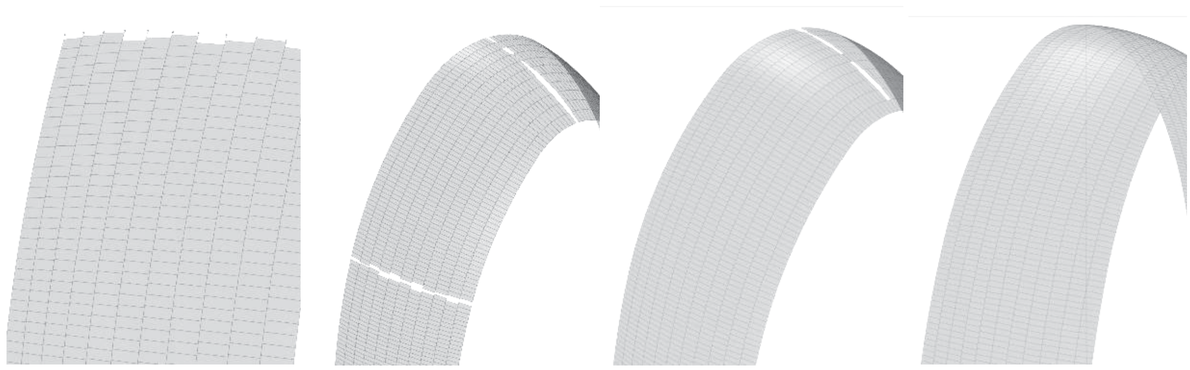
Figure 5. Variations in slice angles

3.4 Panel Optimization

In the previous solution, each torus panel strip had a number of variations as the panels start from centre of the tower and proceed towards the edge. The main aim of the optimization was to minimize the number of panel variations in the surface. The algorithm developed was broken down into a couple of simplified routines dealing with specific issues. The central cross section curve, which we derived earlier from eight arcs is taken as an input. Since the form had one symmetry axis, we had to deal with only five curvatures, which are treated one at a time. For each of the curvatures, the respective curve is taken and an iterative loop is used to generate the geodesics for that curvature.

The curve of any one curvature is taken and a conical surface is defined with its base on this curve and apex lying on the vector passing through the curve centre, normal to its base plane. A variable plane parallel to this base plane is defined to intersect this conical surface. An optimization loop of a minimizing function is set up to get the intersection curve on the conical surface which is at a specified distance of panel length and it closely matches the curvature in the other direction. This curvature match is done by taking a cross section curve following that curvature in other direction and dividing them into points. Then the distance of the intersection curve on the conical surface from the corresponding point is obtained. Minimizing this distance to zero, gives the closest match. Since both the curve planes are parallel, so we get a conical strip with width equal to the panel length and which closely follows the curvatures on both directions. Taking this new curve, the above steps are repeated to generate its corresponding next curve. This is repeated till the full curvature in the other direction is covered. Repeating this for all the five curvatures the required geodesics are generated.

Next step was the formation of the panels. Taking a pair of consecutives curves, equal walking steps were taken on the first curve to place points. For each of these points a corresponding nearest point was searched in the other curve. The four points generated by walking two step forms a panel.



a b c d

Figure 6. Variations in slice angles

This process continues for the remaining length of this curve pair. Next this second curve and its neighbouring counterpart curve are taken and again for these two curves the previous approach is taken to form the panels. This continues for all the curves in this curvature. Then the curve in the next curvature is taken and the above routine continues. This repeats for all the different curvatures.

For each curvature, while taking a pair of curves, several walking approaches along the curves was experimented with mainly two line of approach. In the first approach (*Figure 6b)*, curves in different curvature are taken one at a time with the walking process stopping at the end of each curvature . In the second approach (*Figure 6d)* all curves in one cross section loop are treated as a single composite curve for walking without stopping at the curvature change points. Other experiments included taking three curves in one quadrant as a composite curve (*Figure 6c)* and looking into ways of making simple proximity decisions at the top end points.

3.5 Paneling analysis

A control over the panel variation was achieved and analysis of the panel types indicated a significant reduction in the number of panel variations. Geometric results were evaluated against construction conditions. The panels formed with such technique are all planar within a tolerance of 5mm as there tend to be slight negative curvature at the top where the curvature is minimum (*Figure 7a)*. The panels are staggered from each other accommodating the panel sizes (*Figure 7b,c,d)*.

In the first approach when dealing with individual curvatures, similarity in panels are achieved with few irregularities at the curvature transition areas. In any one curvature, as we go from a large to small radius of panel strip, the panels tends to get smaller, however when working with very large curvatures, like this form, taking small steps allowed to distribute the differences to get uniform panel sizes and the number of panel types are minimum. In this first approach, all panels are planar within a tolerance of 3mm.

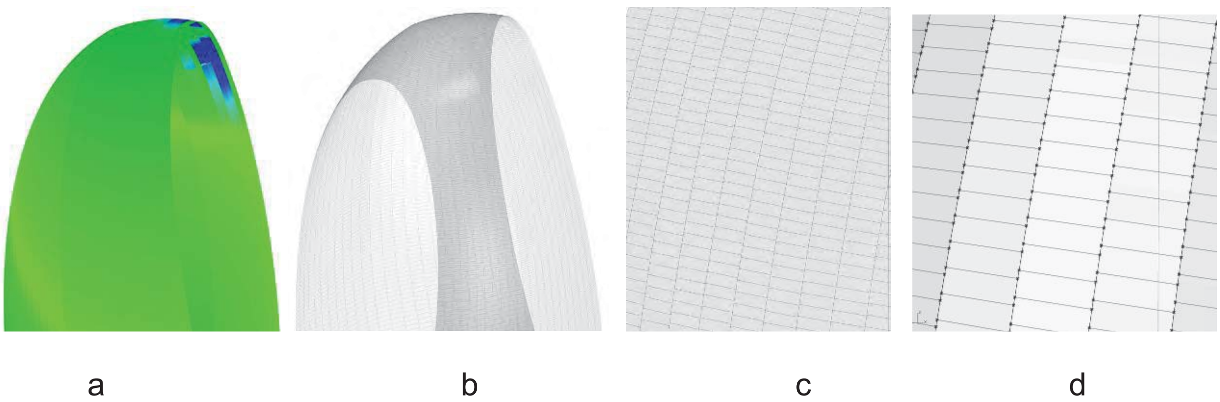
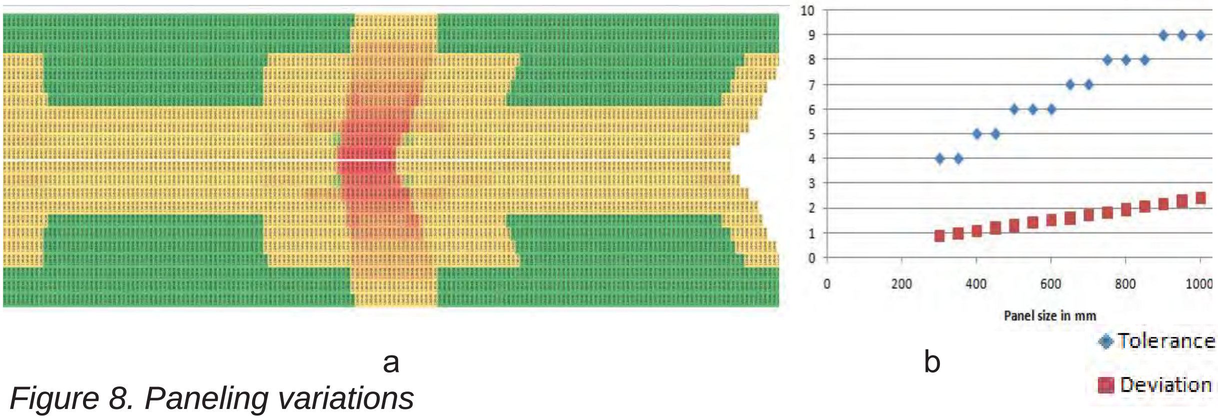


Figure 7. Curvature analysis and Panelled surface

In the second approach for the paneling, we start walking from the lowest point in the ground level of one side and loop through the full composite curve. This approach provides no irregularities at the areas of curvature change and planarity of the panels was achieved within a tolerance of 5mm with the curvature change of the panels being minimum. A control over the panel similarity is achieved within a specified range (Figure 8a) with slightly more panel types than the previous approach. There are some irregularities at this bottom area on the other side where it joins back. Since the full geometry was taken for paneling, this part of the shell is below ground, so it creates no issue in this case. Further investigation is required as to how the paneling end edges wraps up with the starting edge line for other designs which are continuous.



a b

Figure 8. Paneling variations

Keeping the panel length constant, experimenting with the step distance (panel width) from 300 to 1000 mm (Figure 8b) shows that as the panel width increase there tend to be minor angular deviations of the panel and the overall planarity is achieved within a tolerance of 9mm.

Taking into account the overall structural as well as material behaviors, this approach can lead to trade off the number of panel types depending on the required aesthetic of the visible edge quality for the design.

4.0 Discussion

Architecture stands as a product of hybrid processes in which traditional and digital methods merge with computational freedom and emergent digital tools. In a digital environment, Architects are able to customize one's own tools and realize design intensions more rationally. Using these tools from the early design stage offers unprecedented fluidity throughout the development of a project.

Every design problem now demands custom approaches, tools and analysis. This paper demonstrates the cohesive use of computational approaches in the design process from concept development to the final design. It explains the gradual development and strategies to support the design intentions at all stages. It further researches on different strategies to the paneling solution for the envelope. These approaches support the design process across several disciplines and can be further investigated for specific needs in materialization of the design.

5.0 Acknowledgements

I am grateful to Atkins (Architecture, Design & Engineering) for the support in this research. I would like to sincerely thank the Design Director of this project for his guidance and support. I would also like to thank the design team members for the discussions during the project.

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7.0 Image credits

Figure 2a. Mechanical Egg Curve. [image] Wikipedia < http://www.mathematische-basteleien.de/eggcurves.htm >

Alejandro Lopez Rincon

Artificial Drawing *(Paper, Live Performance)*

Topic: Animation Technique and Interactive Video

Authors:
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Main References:
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Abstract:
We call our project artificial drawing because we try to emulate using artificial intelligence (random search and genetic algorithms) the procedure by which humans draw. The question is: how do we draw? Following a series of concepts we extracted from the drawing technique we inferred basic rules which could be programmed into a computer.
For the first step we consider we only have two colors: black and white. The first rule is to extract an outline; we do this by making an analysis of the contrast between each colour. If the pixel colour is very different to the subsequent color, then we consider it a black pixel, in the other case a white pixel. This idea comes from the drawing technique, when we wish to extract the forms of an image or a real life.
Considering the difference in colours for the construction of images by contrast is not something new, and does not requires a complex algorithm. Our innovation is to try to construct the drawings by a series of lines (that we will call elements) similar to the technique in the drawings of Egon Schiele.

The reconstruction of the drawings by a series of elements allow us not only to make the drawing, but to make the whole path as to how reproduce an image similar as if it was drawn by hand. In this context, a drawing becomes a series of lines.

We took this idea a step further and having defined our elements as particles with a position in time, we can animate a sequence as to how to draw an image. Or we can make an interactive video in which each frame sequence is decomposed into a series of elements.
This allowed us to make a presentation in which the user can "play" with the lines during the video sequence. In other words, the user using a touch screen interface can stop the video and then change the position of the lines , and when the user releases the screen the lines came to the original position.
In our research the most difficult part is to construct the lines. In order to do this, we use genetic algorithms including the EASEA[1] library to find where the lines should be positioned.

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Artificial Drawing

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Introduction

Art therapy has been proven to improve the quality of life in cases at nursing homes and suffering from dementia. It allows to improve the capacity of the senses and improves the independence of the patients [1]. Better still, in the absence of a cure in the foreseeable future for dementia patients, art therapy has been proven to be a tool to evaluate and improve communication with the patients [2]. For example, in [3,4] the authors made an application to use mandala drawings as a tool to measure the severity of psychological disorder. Art therapy has been proven useful for patients suffering from Alzheimer disease. Improving the mood of both patients and caregivers [5]. There are several associations working along the subject, in France ARTZ[6].

Using the available web resources, such as WebGL and cloud resources we want to create a web-based service capable of giving interactivity and functioning for art therapy. To achieve this goal we want to make an interactive interface where the subject can "play" with a series of video sequences as an interactive movie. The particles are moved by the subject at will. Similar interfaces exist for children with motor and mental disadvantages as the ones sold by AZ toyz[7].

This application was created from the idea of trying to imitate how human beings draw [8]. The basic idea is we take a video sequence, separate the frames (into images) and then, convert each frame into particles that can be manipulated. The particles are actually lines with an initial point, and ending point arranged to give the impression of reproducing the original image. Similar work can be seen in the project ArtiE-Fract[9,10].

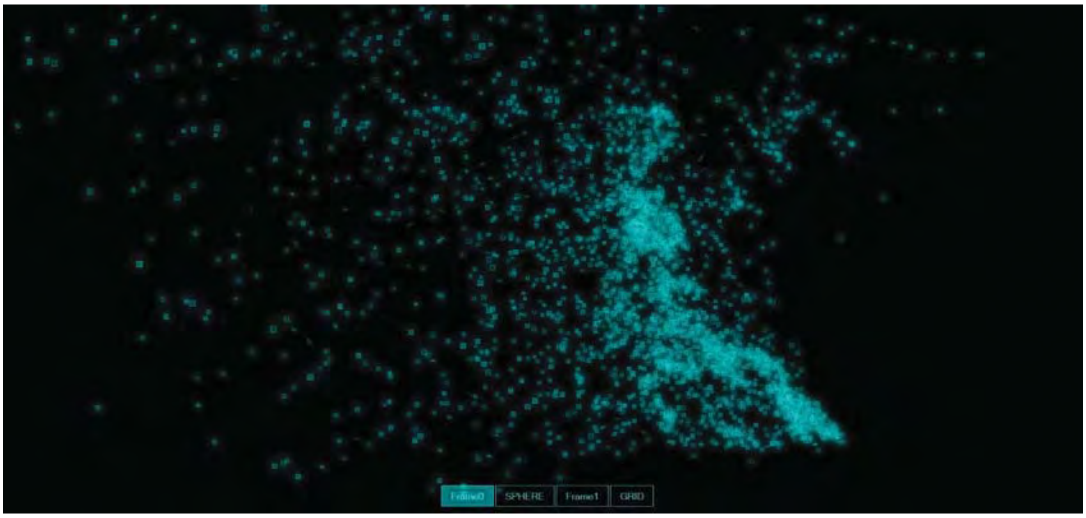


Figure 1 Example of web based application.

Why is it important to try to approximate computer graphics to emulate hand-made drawings? As mentioned in [11]; with great rendered computer graphics we expect perfection. Whereas from simple drawings we communicate easier abstract ideas. In this work we want to mimic how humans draw. For example, if we take into consideration the following hand-made drawing (Fig. 2) we can see this drawing is made from a series of pencil strokes as seen in the detailed view from Fig. 3.

Figure 2 Hand-made drawing.

Figure 3 Detail of the drawing.

From Fig. 3 we can see that a line is composed by a series of lines. There are similar works trying to imitate real pencil strokes. For example in the work from [12] they made a similar work by trying to approximate the lines made by human using an algorithm to stylize the images. Other works [13] use a given library and they retrieve the pencil strokes to try to emulate the drawing.

Once we have the list of positions for the particles, we can manipulate them, "play" with them and the particles will return to the original position. A similar interactive presentation was presented in the Van Gogh Museum for the painting Van Gogh's Starry Night Interactive by Petros Vrellis [14].

In this research we do not apply a mathematical rule to apply the drawing of a line based on the color of each pixel. We create an algorithm which compares an image line by line to the image we want to reproduce. For example in the Fig 3 we show how particle by particle we approximate to the original drawing.

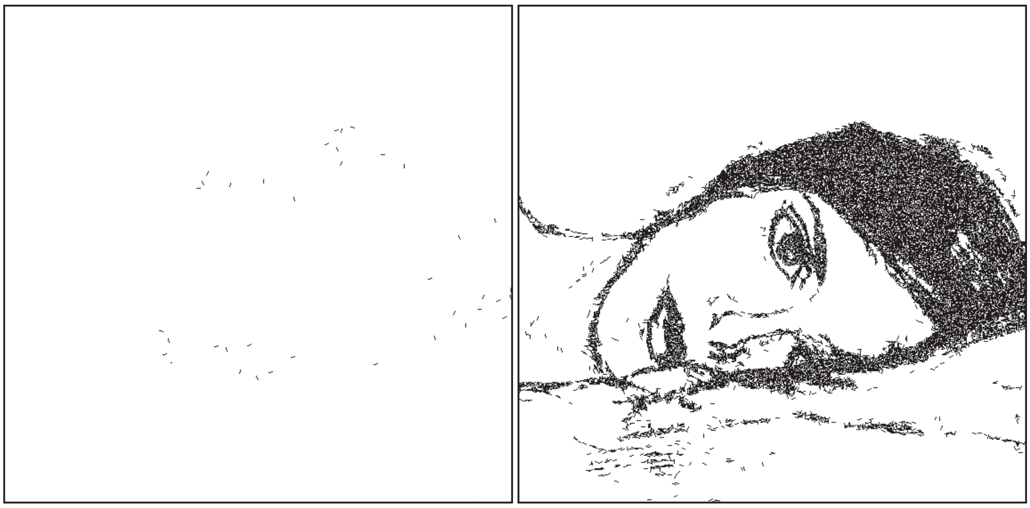


Figure 4 Drawing by 50 Particles (left) and 10,000 particles (right).

The problem we face is how to create the series of particles. For this purpose, we used random search by creating a series of images with a line in a random position, and compare it to the original to see if it was closer to the image we want to reproduce. This approach takes a lot of time, therefore we went to more complicated techniques using genetic algorithms to look for the position of the particles.

To implement the GA techniques we use the library EASEA. EASEA (EAsy Specification of Evolutionary Algorithms) is an Artificial Evolution platform that allows to implement evolutionary algorithms and to exploit the massive parallelism of many-core architectures in order to optimize real-world problems (continous, discrete, combinatorial, mixed and more (with Genetic Programming)) [15-18].

Methodology

For our research we tested 2 different methodologies of treating an image. In both applications we treated the image to only have black and white. In Fig. 5 we have the original image and in Fig. 6 the high contrast in black and white version to apply the algorithms. The first rule is to extract an outline; we do this by making an analysis of the contrast between each colour. If the pixel colour is very different to the subsequent colour, then we consider it a black pixel, in the other case a white pixel. This idea comes from the drawing technique, when we wish to extract the forms of an image or a real life.

Considering the difference in colours for the construction of images by contrast is not something new, and does not requires a complex algorithm. Next, we transform the image into 3 matrixes of the size of the image.

Figure 5 Original Drawing

Figure 6 Black and white image.

The matrixes are for the Red, Green and Blue (RGB) value. Each matrix value is the value of the pixel in that position for the RGB component. The posible values vary from 0 to 255. For the case of black and white we will have that all of the matrixes are the same, and we will only have two possible options, for the [*x,y*] pixel we will have:

Black R[*x,y*],G[*x,y*], B[*x,y*]=0,

White R[*x,y*],G[*x,y*], B[*x,y*]=255.

In the firt approach we create a line with a fixed length (5 pixels) and a random position and random angle. To make the line we use the Bresenham algorithm as implemented in [19]. We use this algorithm because it uses integer matrix for the representation of the image which makes it easier to translate it to several languages and plataforms.

We create 100 images with different lines and compare them to the original image. For the first run the best image becomes the temporal image. To compare it to the original image we use the following cost function:

$$cost = \sum_{i=0}^{m}\sum_{j=0}^{n}(|R_o[i,j] - R_c[i,j]| + |G_o[i,j] - G_c[i,j]| + |B_o[i,j] - B_c[i,j]|) \qquad (1)$$

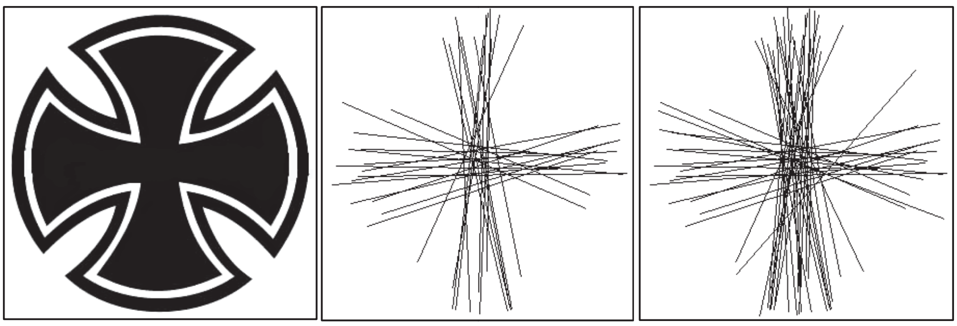
where

$$m = height\ of\ the\ image,$$
$$n = width\ of\ the\ image,$$
$$R_o, G_o, B_o = original\ image\ matrices,$$
$$R_c, G_c, B_c = calculated\ image\ matrices.$$

If any of the 100 images has a lower cost than the temporal image, then we have a new temporal image.We repeat this procedure several times. For example for the Fig. 6 we will have the following creation of particles.

Figure 7 Drawing by 50 particles (top left), 500 particles (top right), 5,000 particles (bottom left), and 10,000 particles (bottom right).

The second approach is to create the particles by choosing two random points and then make a line. For this approach we use the EASEA library and the cost function from Eq. 1. We have 100 individuals in the population, and 30 generations. The parameters to search are the beginning point *x, y* and ending point *x, y* positions.



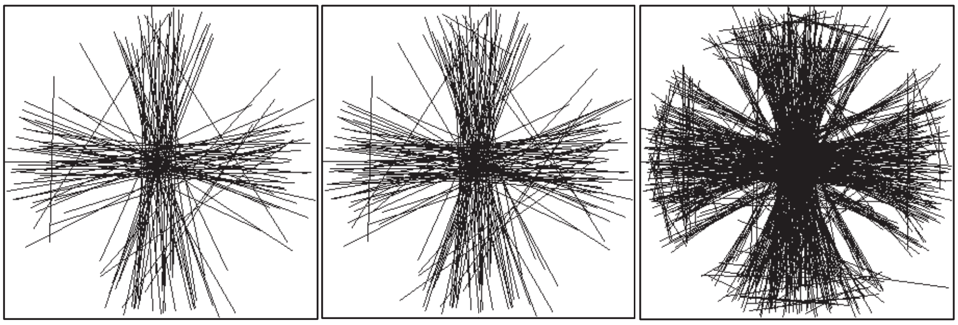


Figure 8 Reproduction of the image. Original picture (top left), 20 particles (top middle), 40 particles (top right), 100 particles (bottom left), 150 particles (bottom middle), and 300 particles (bottom right).

Applying this methodology to the Fig. 6 we get the following result, we added the original image for comparison.

Figure 9 Original Image (left) , and reconstruction 1,000 particles (right).

Finally, as we have the particles we use either WebGL or other visualization technique for example a C# application to move the particles. In

http://www.itsamazigh.com/Resonance/Hope/ArtificialDrawing.html

there is an application for two processed images for 1000 particles using WebGL. The particles change from one position, to the other and also predefined positions as shown in Fig. 10.

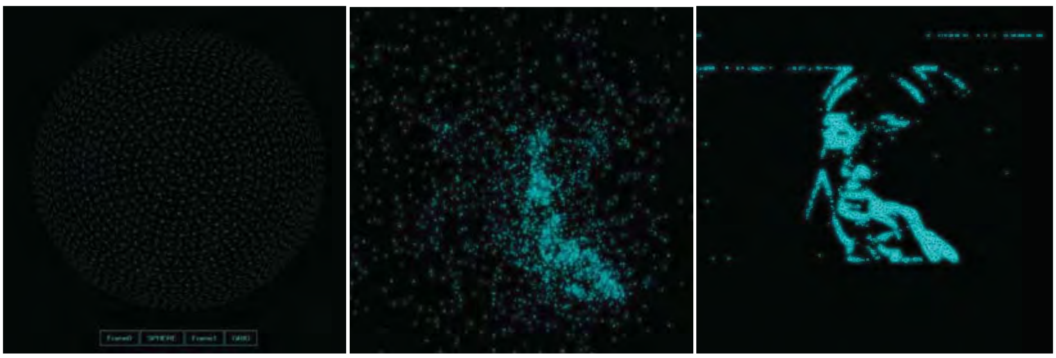


Figure 10 WebGL application for 100 particles. Sphere position (left), transition from sphere to frame (middle), and frame (right).

For these applications and both approaches, the particles are saved with the following format:

var table3 = [0,0,5,0,

822,565,827,564,
817,565,822,566,
976,592,971,594,
991,578,992,583,
986,571,981,571,
1036,612,1037,617,
1018,611,1013,610,
....

giving the beginning and ending point of each line.

Conclusion and Future Work

The tests show that creating the particle system for an image depends on the available resources and for each frame step can take several hours. With a computer with Intel(R) Core(TM) i7-2860QM CPU @ 2.50Hz and 8.00 (RAM) the construction time is around 8 hours. The time varies depending on the image.

To display the particles in a web based interface or an application is not computationally costly. The computational cost is in transforming a full video sequence into a series of particles. For example a 3 minute sequence with 30 fps (frames per second) will take around 43,200 computational hours.

To speed-up our algorithms we are going to add more non-linear constraints to the creation of particles; for example identification of 2d geometric primitves as in [20]. The next step is to start making some tests with individuals to see the application as art therapy which is our main objective.

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Annex EASEA Code

```
/*____________________________________________________________

Template for an EASEA evolutionary algorithm for easea v1.0.3
_____________________________________________________________
*/

\User declarations : // This section is copied on top of the output file
#include <fstream>
#include <string>
#include <iostream>
#define M_PI 3.14159265358979323846
#include <math.h>
#include <ctype.h>
#include <cstring>
#include <sstream>
#include <cstdlib>
#include <stdio.h>

int **Rmat;
int **Gmat;
int **Bmat;

int **Rmattemp;
int **Gmattemp;
int **Bmattemp;

int **RmatLine;
int **GmatLine;
int **BmatLine;

int M=0;
int N=0;
```

```
\end

\User functions:

int strtoint(std::string text) {
        int a;
        std::stringstream stream;
        for(int b = 0; b < text.size(); b++) {
                if(!isdigit(text.at(b))) {
                        text.erase(b, 1);
                }
        }
        stream<<text<<std::flush;
        stream>>a;
        return a;
}

void readMatrix(char *name, int** &Transfer, int &M, int &N)
{
        std::ifstream file(name);
        std::string str;
        std::getline(file, str);
        M=strtoint(str);
        std::getline(file, str);
        N=strtoint(str);
        Transfer = new int*[M];
for(int i = 0; i < M; ++i)
   Transfer[i] = new int[N];

        for (int i=0; i<M; i++)
        {
                std::getline(file, str);
                std::string word;
                std::stringstream stream(str);
                for (int j=0; j<N; j++)
                {
                        std::getline(stream, word, ' ');
                        Transfer[i][j]=atoi(word.c_str());
                        //std::istringstream os(word.c_str());
                        //os >> Transfer[i][j];
                }
        }
        std::cout << "Matrix loaded"<< "\n";
}

void printMatrix(int **matrix, int rows, int cols, char *name)
{
        FILE *f = fopen(name, "w");
        if (f == NULL)
        {
                printf("Error opening file!\n");
                exit(1);
        }
        fprintf(f, "%i\n", rows);
        fprintf(f, "%i\n", cols);

        for (int i=0;i<rows;i++)
        {
                for (int j=0;j<cols;j++)
                {
                        fprintf(f, "%i ", matrix[i][j]);
                }
                fprintf(f, "\n");
        }
        fclose(f);
}

 void SwapNum( int &x,  int &y)
    {
        int tempswap = x;
        x = y;
        y = tempswap;

    }

void Line2(int x, int y, int x2, int y2,
        int** &Rmat, int** &Gmat, int** &Bmat,
        int r, int g, int b)
    {
            int x0 = x;
        int y0 = y;
        int x1 = x2;
        int y1 = y2;
            if (x0<0)
            {
                    x0=0;
            }
            if (x0>N)
            {
                    x0=N-1;
            }
            if (x1<0)
            {
                    x1=0;
            }
            if (x1>N)
            {
                    x1=N-1;
            }

            if (y0<0)
            {
                    y0=0;
            }
            if (y0>M)
            {
                    y0=M-1;
            }
            if (y1<0)
            {
                    y1=0;
            }
            if (y1>M)
            {
                    y1=M-1;
            }

        bool steep = abs(y1 - y0) > abs(x1 - x0);
        if (steep)
        {
          SwapNum( x0,  y0);
          SwapNum( x1,  y1);
        }
        if (x0 > x1)
        {
          SwapNum( x0,  x1);
          SwapNum( y0,  y1);
        }
        int deltax = x1 - x0;
        int deltay = abs(y1 - y0);
        int error = -deltax / 2;
        int ystep;
        int yt = y0;
        if (y0 < y1) ystep = 1; else ystep = -1;
        for (int xt = x0; xt < x1; xt++)
        {
          if (steep)
          {
            //plot.SetPixel(new Point(y, x));
            Rmat[yt][ xt] = r;
            Gmat[yt][ xt] = g;
            Bmat[yt][ xt] = b;
          }
          else
          {
```

```
          Rmat[xt][ yt] = r;
          Gmat[xt][ yt] = g;
          Bmat[xt][ yt] = b;
          //plot.SetPixel(new Point(x, y));
        }
        error = error + deltay;
        if (error > 0)
        {
          yt = yt + ystep;
          error = error - deltax;
        }
      }


    }

int getCost2(int a,int b, int c, int d)
{


        int temp=0;

        for (int i=0; i<M; i++)
        {

                for (int j=0; j<N; j++)
                {
                        RmatLine[i][j]=Rmattemp[i][j];
                        GmatLine[i][j]=Gmattemp[i][j];
                        BmatLine[i][j]=Bmattemp[i][j];

                }
        }

        Line2( a, b, c, d, RmatLine, GmatLine, BmatLine,0, 0, 0);

        for (int i=0; i<M; i++)
        {

                for (int j=0; j<N; j++)
                {
                        temp=temp+abs(Rmat[i][j]-RmatLine[i][j]);
                        temp=temp+abs(Gmat[i][j]-GmatLine[i][j]);
                        temp=temp+abs(Bmat[i][j]-BmatLine[i][j]);

                }
        }


 return temp;
}

\end

\Before everything else function:
{

        readMatrix(const_cast<char *>("Rmat.matrix"),Rmat,M,N);
        readMatrix(const_cast<char *>("Gmat.matrix"),Gmat,M,N);
        readMatrix(const_cast<char *>("Bmat.matrix"),Bmat,M,N);
        readMatrix(const_cast<char
*>("Rmattemp.matrix"),Rmattemp,M,N);
        readMatrix(const_cast<char
*>("Gmattemp.matrix"),Gmattemp,M,N);
        readMatrix(const_cast<char
*>("Bmattemp.matrix"),Bmattemp,M,N);

        readMatrix(const_cast<char
*>("Rmattemp.matrix"),RmatLine,M,N);
        readMatrix(const_cast<char
*>("Gmattemp.matrix"),GmatLine,M,N);
        readMatrix(const_cast<char
*>("Bmattemp.matrix"),BmatLine,M,N);

        cout<<M<<endl;
        cout<<N<<endl;
        //Line2( 300, 300, 0, 0, Rmat, Gmat, Bmat,0, 0, 0);
        //printMatrix(Rmat, M, N, "Rmat2.matrix");

}
\end

\After everything else function:

//std::cout << (*population) ;

cout <<(population->Best->serialize())<<endl;
string str=population->Best->serialize();

        string word;
        stringstream stream(str);

                getline(stream, word, ' ');
                int d=atoi(word.c_str());
                getline(stream, word, ' ');
                int c=atoi(word.c_str());
                getline(stream, word, ' ');
                int b=atoi(word.c_str());
                getline(stream, word, ' ');
                int a=atoi(word.c_str());


cout << a << "\n";
cout << b << "\n";
cout << c << "\n";
cout << d << "\n";

Line2( a, b, c, d, Rmattemp, Gmattemp, Bmattemp,0, 0, 0);
printMatrix(Rmattemp, M, N, "Rmattemp.matrix");
printMatrix(Gmattemp, M, N, "Gmattemp.matrix");
printMatrix(Bmattemp, M, N, "Bmattemp.matrix");
\end

\At the beginning of each generation function:{
}
\end

\At the end of each generation function:

\end

\At each generation before reduce function:
 //cout << "At each generation before replacement function called" << endl;

\end

\User classes :
GenomeClass {
 // need to declare the genome here
 int a, b, c, d;
}
\end

\GenomeClass::display:
        printf("%i %i %i %i\n",Genome.a, Genome.b, Genome.c,
Genome.d);
//printf("%f \n",Genome.a);
\end


\GenomeClass::initialiser : // "initializer" is also accepted
 // the genome to initialise is known as "Genome"
 Genome.a=random(0,N);
 Genome.b=random(0,M);
 Genome.c=random(0,N);
 Genome.d=random(0,M);
\end

\GenomeClass::crossover :

int cost=getCost2(parent1.a,parent1.b,parent1.c,parent1.d);
child.a=parent1.a;
child.b=parent1.b;
```

```
child.c=parent1.c;
child.d=parent1.d;

int costTemp=getCost2(parent1.a,parent1.b,parent2.c,parent1.d);
if (costTemp<=cost)
{
child.a=parent1.a;
child.b=parent1.b;
child.c=parent2.c;
child.d=parent1.d;
cost=costTemp;
}

costTemp=getCost2(parent1.a,parent2.b,parent1.c,parent1.d);
if (costTemp<=cost)
{
child.a=parent1.a;
child.b=parent2.b;
child.c=parent1.c;
child.d=parent1.d;
cost=costTemp;
}

costTemp=getCost2(parent1.a,parent2.b,parent2.c,parent1.d);
if (costTemp<=cost)
{
child.a=parent1.a;
child.b=parent2.b;
child.c=parent2.c;
child.d=parent1.d;
cost=costTemp;
}

costTemp=getCost2(parent2.a,parent1.b,parent1.c,parent1.d);
if (costTemp<=cost)
{
child.a=parent2.a;
child.b=parent1.b;
child.c=parent1.c;
child.d=parent1.d;
cost=costTemp;
}

costTemp=getCost2(parent2.a,parent1.b,parent2.c,parent1.d);
if (costTemp<=cost)
{
child.a=parent2.a;
child.b=parent1.b;
child.c=parent2.c;
child.d=parent1.d;
cost=costTemp;
}

costTemp=getCost2(parent2.a,parent2.b,parent1.c,parent1.d);
if (costTemp<=cost)
{
child.a=parent2.a;
child.b=parent2.b;
child.c=parent1.c;
child.d=parent1.d;
cost=costTemp;
}

costTemp=getCost2(parent2.a,parent2.b,parent2.c,parent1.d);
if (costTemp<=cost)
{
child.a=parent2.a;
child.b=parent2.b;
child.c=parent2.c;
child.d=parent1.d;
cost=costTemp;
}

//second batch
costTemp=getCost2(parent1.a,parent1.b,parent1.c,parent2.d);
child.a=parent1.a;
child.b=parent1.b;
child.c=parent1.c;
child.d=parent2.d;

costTemp=getCost2(parent1.a,parent1.b,parent2.c,parent2.d);
if (costTemp<=cost)
{
child.a=parent1.a;
child.b=parent1.b;
child.c=parent2.c;
child.d=parent2.d;
cost=costTemp;
}

costTemp=getCost2(parent1.a,parent2.b,parent1.c,parent2.d);
if (costTemp<=cost)
{
child.a=parent1.a;
child.b=parent2.b;
child.c=parent1.c;
child.d=parent2.d;
cost=costTemp;
}

costTemp=getCost2(parent1.a,parent2.b,parent2.c,parent2.d);
if (costTemp<=cost)
{
child.a=parent1.a;
child.b=parent2.b;
child.c=parent2.c;
child.d=parent2.d;
cost=costTemp;
}

costTemp=getCost2(parent2.a,parent1.b,parent1.c,parent2.d);
if (costTemp<=cost)
{
child.a=parent2.a;
child.b=parent1.b;
child.c=parent1.c;
child.d=parent2.d;
cost=costTemp;
}

costTemp=getCost2(parent2.a,parent1.b,parent2.c,parent2.d);
if (costTemp<=cost)
{
child.a=parent2.a;
child.b=parent1.b;
child.c=parent2.c;
child.d=parent2.d;
cost=costTemp;
}

costTemp=getCost2(parent2.a,parent2.b,parent1.c,parent2.d);
if (costTemp<=cost)
{
child.a=parent2.a;
child.b=parent2.b;
child.c=parent1.c;
child.d=parent2.d;
cost=costTemp;
}

costTemp=getCost2(parent2.a,parent2.b,parent2.c,parent2.d);
if (costTemp<=cost)
{
child.a=parent2.a;
child.b=parent2.b;
child.c=parent2.c;
child.d=parent2.d;
cost=costTemp;
}

\end

\GenomeClass::mutator : // Must return the number of mutations
```

```
  if (tossCoin(0.4)){
    Genome.a+=random(-10,10);
    return 1;
  }
  if (tossCoin(0.4)){
    Genome.b+=random(-10,10);
    return 1;
  }
  if (tossCoin(0.4)){
    Genome.c+=random(-10,10);
    return 1;
  }
if (tossCoin(0.4)){
    Genome.d+=random(-10,10);
    return 1;
  }
 return 0 ;
\end

\GenomeClass::evaluator : // Returns the score as a real value
        //IndividualImpl::printOn(std::cout);

        double temp=getCost2(Genome.a,Genome.b,Genome.c,
Genome.d);

 return temp;
\end

\User Makefile options:
\end

\Default run parameters :     // Please let the parameters appear in this
order
 Number of generations : 10   // NB_GEN
 Time limit: 0                               // In seconds, 0 to
deactivate
 Population size : 100
 Offspring size : 50% // or a xx%
 Mutation probability : 1      // MUT_PROB
 Crossover probability : 1     // XOVER_PROB
 Evaluator goal : minimise     // maximise
 Selection operator: Tournament 20
 Surviving parents: 50      // Percentage or absolute
 Surviving offspring: 50    // Percentage or absolute
 Reduce parents operator: Tournament 10
 Reduce offspring operator: Tournament 10
 Final reduce operator: Tournament 7

 Elitism: Strong                             // Weak or Strong
 Elite: 1
 Print stats: true                                // Default: 1
 Generate csv stats file:true
 Generate gnuplot script:false
 Generate R script:false
 Plot stats:false                                 // Default: 0

 Remote island model: false
 IP file: ip.txt                            // List of IP:PORT of islands
to send individuals to
 Server port : 2929
 Migration probability: 0.33   // Probability of sending an individual per
generation

 Save population: true
 Start from file:false
\end
```

Andrea Wollensak
Bridget Baird

Ph(r)ase Transition: A Generatively Constructed Interactive Visual and Poetic Environment ***Artwork/Paper***

Andrea Wollensak

Bridget Baird

Topic: Interactive Art, Data Visualization

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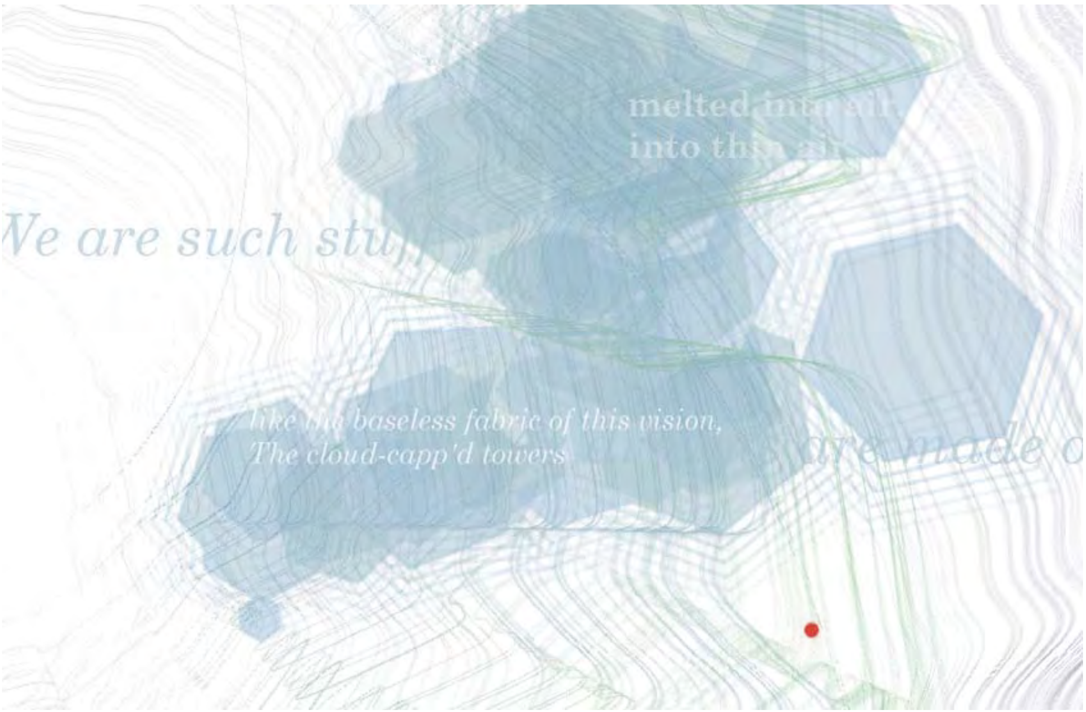
The Nature of Code 1st ed.

Abstract:
The state change from solid to liquid is an example of a phase transition in a thermodynamic system. Similarly imagined, a poetic phrase transition might be exemplified by a semantic or typographic state change affecting the meaning or lexical representation of text fragments. Within the interactive generative environment we have developed, both types of transition are interwoven in the visualization of iceberg data, water currents, and poetic phrases that appear and evolve. Hexagonal iceberg forms take their initial position and size from International Ice Patrol (IIP) iceberg sighting data. After being spawned, they exhibit slow melting and drifting behaviors that can be interactively accelerated and influenced by the movement of an observer using the Microsoft Kinect motion-sensing camera. Simultaneously, poetic textual phrases can be spawned, evolving with a set of related but distinct behaviors, and interacting with both the iceberg representations and the user's virtual representation within the environment. User interaction re-locates the phrases and changes the meaning. The system explores interaction that both generates and eliminates through the transitioning between states.



Still image from "Ph(r)ase Transitions: A Poetic Generatively Constructed Environment"

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Keywords:
Generative, Visualizing Data, Digital Poetics, Processing

Ph(r)ase Transition:
A Generatively Constructed Interactive Visual and Poetic Environment

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Abstract

The state change from solid to liquid is an example of a phase transition in a thermodynamic system. Similarly imagined, a poetic phrase transition might be exemplified by a semantic or typographic state change affecting the meaning of lexical representations of text fragments. Within the interactive generative environment we have developed, both types of transition are interwoven in the visualization of iceberg data, water currents, and poetic phrases that appear and evolve. Iceberg forms take their initial position and size from International Ice Patrol (IIP) iceberg sighting data. After being spawned, they exhibit slow melting and drifting behaviors that can be interactively accelerated and influenced by the movement of an observer using the Microsoft Kinect motion-sensing camera. Simultaneously, poetic textual phrases are spawned, evolving with a set of related but distinct behaviors, and interacting within the environment. User interaction re-locates the phrases and influences the reading of the texts.

1. Background and Motivation

The authors have been working collaboratively on a number of interdisciplinary projects under the auspices of the Ammerman Center for Arts and Technology at Connecticut College (New London, CT, USA). The mission of the Center is to facilitate creative collaboration and experimental investigation at the intersections of Arts and Technology, forging interdisciplinary partnerships and creating opportunities for students and scholars to think outside of disciplinary boundaries.

Over the last ten years, the authors have worked on several interactive and generative audiovisual installation pieces featuring poetry, video processing, sound and audio processing, virtual reality exploration and intelligent agent-based software. The current work developed from, and extended, research on the northern arctic environment.

To begin with, we established a set of core guiding principles that would govern our investigation. These included:

1. Interest in explorations that visualize environmental data and in working with The International Ice Patrol Center in New London, CT which is part of the United States Coast Guard Academy

2. Development of agent based models applied to generative visual art that are representations of iceberg data

3. Incorporation of contextually sensitive poetic text that iteratively develops and is responsive to user movement

2. Visual Elements and Prior Work

The work *Ph(r)ase Transition* evolved from a prior work entitled *Drifting*, that was exhibited at a gallery exhibition titled *Between Solid and Liquid: Constructed Landscapes* at the Konstepidemin in Gothenburg, Sweden during May 2014. The motivation for *Drifting* was to combine a dynamic visualization of iceberg data with gestural recognition interactivity based on the use of a Kinect sensor. During the realization of that work, a number of possible data sources for iceberg data were considered. The most prevalent form of available data is in the form of sighting data, and consists of position, size, shape and sighting time. These datasets are available per year for geographical areas in which icebergs drift, such as the Grand Banks of Newfoundland. There are also a few datasets involving tracking of individual icebergs, showing their movement patterns, but, in general, these are dated and harder to obtain.

Figure 1. Icebergs in Disko Bay, Greenland (Getty Images).

During the course of the work, the authors established a working relationship with the United States International Ice Patrol (IIP), a branch of the U.S. Coast Guard. The IIP's mission is to monitor the iceberg danger near the Grand Banks of Newfoundland and provide the iceberg information to the maritime community. The IIP was established as a direct result of the tragic sinking of the RMS Titanic in 1912. Greenland glaciers calve thousands of icebergs each year with an average of 500 drifting south to threaten transatlantic shipping. IIP iceberg data is entered into a computer model that uses ocean current and wind data to predict iceberg drift and deterioration.

In order to best combine the interactive Kinect sensor with the iceberg data, the Java-based Processing visual programming language was used, as it provides a robust and flexible platform for generative 2D and 3D graphics, and has good support for the Kinect using open source libraries. An iceberg dataset with over 6000 sightings from 2011 was used as the basic for the iceberg visualizations. The data includes an ID for each iceberg, sight time, latitude and longitude, sight method, size and shape of iceberg.

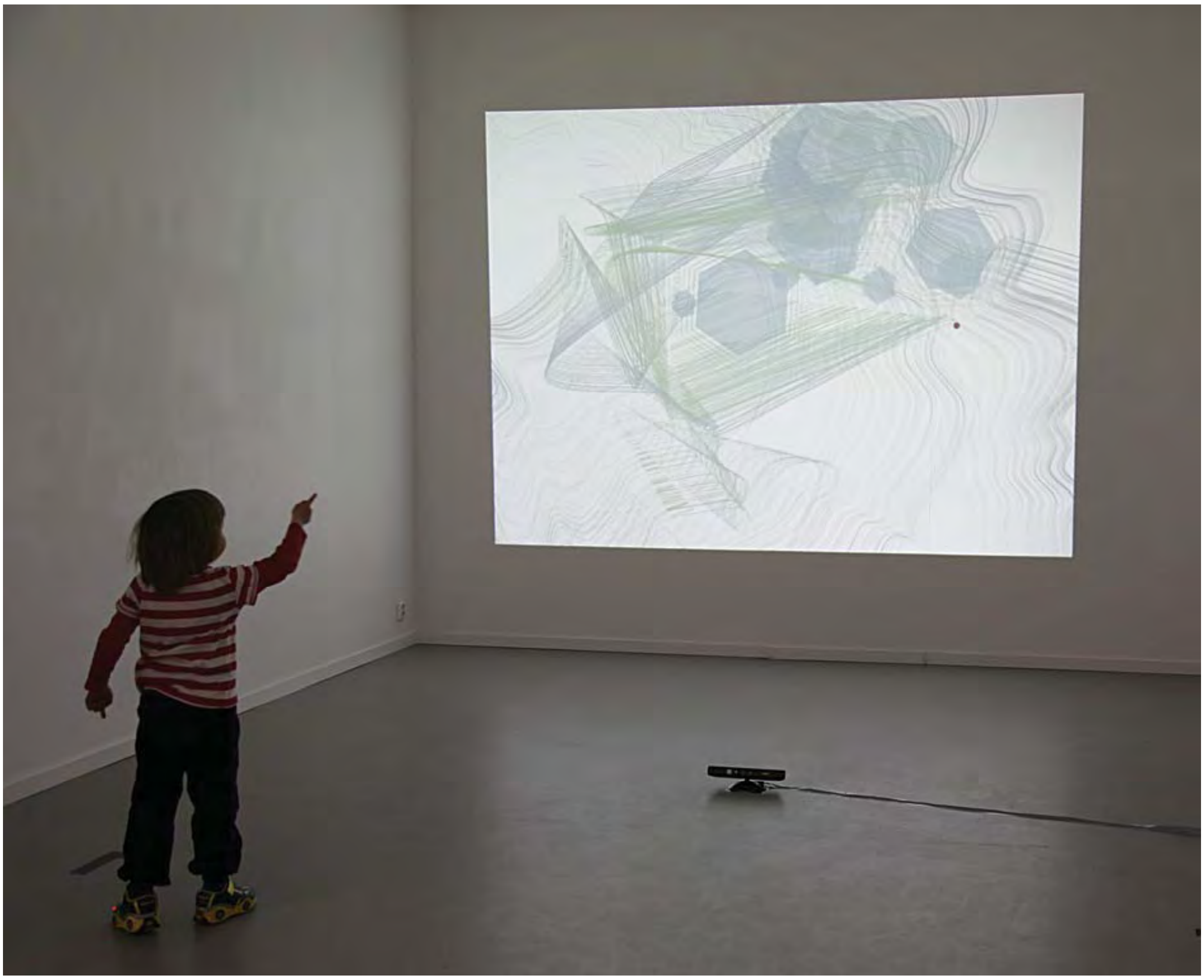

Figure 2. "Drifting" interactive visualization work on exhibit at Konstepidemin Gallery, Gothenburg, Sweden. May 2014.

To create an engaging interactive work, the authors experimented with a number of visual elements, ultimately deciding on a background of undulating current textural lines combined with hexagonal iceberg forms with linear outlines. Icebergs are spawned from the 2011 sighting dataset using the position and size parameters. These icebergs are spawned with the virtual environment, they slowly shrink and fade using a behavior that connotes gradual melting.

For the interactive engagement, the gestural recognition is depicted with a red dot that influences the currents and, as proximity to the icebergs increase, accelerates the ‘melting’ behavior of the icebergs. For many participants in the installation in Sweden, the accelerated melting caused by user intervention reminded them of issues related to global climate change and many wished to avoid melting the icebergs any faster. To the authors, this response to the work was an interesting discovery.

3. Overall Structure and Generative Art Processes

The background of the virtual environment includes undulating currents upon which the icebergs randomly appear. These icebergs may be represented by either hexagonal forms or text fragments. Interaction may occur with either a Kinect motion-sensor or with keyboard arrows. This interaction affects both currents and icebergs. The icebergs move and evolve even if there is no interaction. (figure 3).

Figure 3. Screenshot of “Ph(r)ase Transtion”

The parameters of the iceberg sighting data were used to control the size, opacity, color, location and evolution behavior of all icebergs, whether represented by text fragments or hexagonal forms. A set of visual and interactive behaviors was developed for the textual and hexagonal icebergs as well as the water current representations. With regard to the Kinect or keyboard ‘paddle’ interaction, the behavior was classified into two modes of behavior: default ‘uninterruped’ behaviors when the paddle was far way, and ‘intentional’ behaviors when the user is deliberately trying to interact with the text fragments, hexagonal forms and water currents by moving the paddle towards and near these objects in the environment.

Text Elements

Drifting was conceived of as an evolutionary work. In considering the next direction of the work, we sought a less literal representation of the visual iceberg forms and melting behaviors. Towards that end, we decided to experiment with the typographic and semantic properties of poetic text fragments. We selected excerpts from the following:

- Shakespeare's *The Tempest* and *Antony and Cleopatra*
- *Snow-Bound: A Winter Idyl* by John Greenleaf Whittier
- Numerous poems by the contemporary poet Ansie Baird
- *The Moment* and *The Waking* by Theodore Roethke.

These poetic texts were chosen because they each included phrases depicting modes of transition, the environment and natural forces, the northern landscape and light, and the human condition. Additionally, these texts worked well in combination, with a variety of interesting readings occurring when the passages were juxtaposed and recombined.

Below are two sample text passages:

Our revels now are ended. These our actors,
As I foretold you, were all spirits and
Are melted into air, into thin air.
And like the baseless fabric of this vision,
The cloud-capped towers, the gorgeous palaces …
—Spoken by Prospero in Shakespeare's *The Tempest*

I would like you to believe
The oceans are kind,
Keeping each island afloat
In all weather. You will
Be to each other a kind of
Island, separate and entire.
Together you will gather
Tide-tossed shards
In your hands.
— Ansie Baird's poem "*I Would Like to Tell You*"

We parsed the poems down to phrases using a generative approach both as the mechanism to break down the phrases and also for the order in which these phrases appear. Additionally, each time the program runs or is reset, a different author is randomly chosen.

Generative elements in Processing

The program is written using the Processing software and includes many generative and random elements. The following is a summary of elements as codified by the software:

- Water currents are initially set up in a generative manner.
- The author of textual icebergs is chosen randomly from the list of chosen authors.
- The appearance of a particular iceberg is generated randomly from the dataset although the position and mass of that iceberg is determined, within small fluctuations, by the dataset.
- The program randomly decides whether a given iceberg will be hexagonal or textual; greater probability is assigned to the appearance of textual icebergs.
- Textual icebergs acquire their phrases through a generative process that both divides phrases and shuffles the order in which those phrases appear.
- Textual icebergs are randomly assigned one of two behaviors. One of those behaviors causes the iceberg to grown larger and lighter and thus transition from a solid to a gas. The other behavior causes the iceberg to transition to a smaller and more dense phase.
- The textual icebergs that transition to a smaller, denser state will either disappear entirely or acquire a permanence and immortality; these choices are determined randomly.

4. Behaviors

The behaviors of the three elements (typographic, hexagon forms, and line currents) in the “Ph(r)ase Transition” environment are dynamic both in their uninterrupted and intentional states. In the uninterrupted state all of the elements gently undulate as if they are suspended, but controlled by a larger force. Uninterrupted, the environment continues to acquire poetic text and hexagonal forms, creating a layered and thick environment where poetic phrases appear on top of the hexagonal forms and the linear elements. Poetic texts may grow larger and evaporate or may get smaller and more dense and some of them will disappear entirely. The hexagonal forms will very gradually evaporate.

Using the Kinect or keyboard, the intentional behaviors create an active gestural space where the poetic phrases move, many growing in size and becoming transparent. The hexagonal forms also continue to accumulate and as the user gets close to the hexagonal forms, the forms reduce more quickly in size and disappear rapidly. The line (current) elements continue to gently move and are reshaped as the user interacts with them.

The eventual disappearance of all the hexagonal forms, in contrast to the permanence of some of the textual forms expresses a belief about the power of poetry. In contrast to the ephemeral nature of ice, some words, even though they grow out of the imagination and seem to have no physical embodiment, do possess a certain kind of immortality. This current project makes use of virtual environmental interaction to more broadly reflect the role of human influence in transitions, weaving together the melting of icebergs and the recombination and displacement of poetic texts to suggest some deeper visual and semantic relationships in play.

Typographic Behaviors

The position of the poetic text in the environment is determined by specific longitude and latitude coordinates from the iceberg sighting data. The font size and color represents different sizes of icebergs from the sighting data.

	size	opacity/color	location/change
no paddle	sizes determined by iceberg data _extra small _small _medium _large _extra large	_initially randomly determined to become lighter (opacity) & larger, or darker (opacity) & smaller _color determined by data	_no large movement just slight current movement
paddle	_paddle does not affect size of font	_paddle does not affect opacity or color _some small sized phrases disappear, others are not affected by paddle	_ nudged in direction of paddle movement _can be nudged again after a period of time _some small phrases do not move

Figure 4. Typographic qualities for uninterrupted and intentional behaviors

The poetic text is randomly generated and, in its uninterrupted state, some texts continue to expand and lighten, a gesture representing the phase transition state from liquid to gas. Other texts become smaller but increase their opacity.

With Intentional behaviors (use of paddle), the poetic text can be moved within the environment and off of the screen. Figure 4 shows the typographic behaviors with and without the interaction. The use of the paddle allows the user to relocate poetic phrases, and dissolve some phrases all together. There are random smaller phrases that do not move, that may disappear, and some may stay in the same position, size and opacity.

Hexagonal behaviors

	size	opacity/color	location/change
no paddle	_sizes determined by iceberg data with slow decrease in size	_transparency increases slowly	_slight current movement _small forms have more noise movement
paddle	_paddle affects the rate of size reduction	_paddle increases the rate of transparency	_paddle has no effect of movement of forms

Figure 5. Hexagonal qualities for uninterrupted and intentional behaviors

In addition to poetic phrases, the hexagonal forms also are visualizations of iceberg data. The hexagonal forms appear in different sizes, with differing numbers of outlines. When the user approaches the hexagonal forms (intentional behaviors) the forms begin to get smaller and more quickly disappear, a gesture representing the melting process of ice, phase transition from solid to liquid. All of the hexagonal forms have slight movement in both states and the smaller forms have a faster, more nervous movement.

Currents behaviors

	size in length	opacity/color	location/change
no paddle	_no effect	_no effect	_slight undulating movement
paddle	_paddle affects shape of lines	_no effect	_lines move in direction of paddle, then slowly return to original location

Figure 6. Current (lines) qualities for uninterrupted and intentional behaviors

The line elements in the environment represent the currents of the water. They move gently without any interaction, providing a ground and dimensionality to the visual field. When the user interacts within the space, the directions of the lines are pulled by the paddle but eventually return to their original state.

5. Summary and Future Directions

This collaborative work of generative art is a poetic visualization based on scientific data from the International Ice Patrol. It uses the flexibility of the digital to create a more randomized, unpredictable and interactive interpretation of the IIP data. This work makes use of virtual environmental interactions to more broadly reflect the role of our influence in transitions, weaving together the melting of icebergs and the recombination and displacement of poetic texts to suggest a deeper visual and semantic relationship at play.

Additional plans for this environment are to give the user more control over the movement and placement of the poetic phrases. We envision this project as an outdoor interactive installation accessible by a larger public.

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http://www.navcen.uscg.gov/

Ben Baruch Blich

Paper : **Twisted bodies: annihilating the aesthetic**

Topic: Architecture

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Abstract:

The claim that architecture is designed for people is not extravagant, as they both occupy architectural spaces and serve as the scale for their design. That is, the human being and body "consume" and, at the same time, delineate architecture.

Vitruvius (1st century BC) is rightly believed to be the first theoretician who saw in the human body not only the means but also the aim of architecture. In architectural practice this body has since been perceived as a paragon of excellence and presented mostly as an analogy of perfection and beauty, of a good gestalt and coherent form.

However, in this article I will raise questions about the maimed body in pain, its twisted and not-beautiful shapes. Has the contemporary idea of architecture addressed this body as well?
I will introduce the problem, examine its origins and bring examples where the body is analogous to what is abject, distressed and in pain--all this in an attempt to argue that abjectness is inseparable from our lives.

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Keywords:
Architecture, Vitruvius, the Modulor (Le Corbusier), Learning from Las-Vegas, the Uncanny (Freud), Théodore Géricault, Franko B.

Twisted bodies: annihilating the aesthetic[1]

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An abstract

The claim that architecture is designed for people is not extravagant, as they both occupy architectural spaces and serve as the scale for their design. That is, the human being and body "consume" and, at the same time, delineate architecture. Vitruvius (1st century BC) is rightly believed to be the first theoretician who saw in the human body not only the means but also the aim of architecture. In architectural practice this body has since been perceived as a paragon of excellence and presented mostly as an analogy of perfection and beauty, of a good gestalt and coherent form.
However, in this article I will raise questions about the maimed body in pain, its twisted and not-beautiful shapes. Has the contemporary idea of architecture addressed this body as well? I will introduce the problem, examine its origins and bring examples where the body is analogous to what is abject, distressed and in pain--all this in an attempt to argue that abjectness is inseparable from our lives.

The body-architecture analogy

In recent years various disciplines have shown a resurgent interest in the human body. Always at the forefront of scrutiny, mainly in the arts and sciences, the human body has become a topic of intense debate today also in other fields, such as fashion, industrial design, communications, architecture and, of course, in the classic disciplines of psychology, anthropology, sociology, economics; even literary studies and philosophy resound widely with questions about the status of the human being and body. This emphasis on bodily aspects raises a vast range of questions. Is the rekindled debate merely a revision of what was once debated but later somehow neglected and forgotten, or is this our natural, yet to be exhausted, curiosity eager to probe deeper at a propitious time? Does the preoccupation with the body spell discontent with its roles in many of the disciplines that should have highlighted its share in the definition of the modern human being's status? Or does the return to the body represent a refreshing, previously unknown, point of view after longstanding, deeply ingrained sexual stereotypes have been discarded?

Though we will be unable to offer an unequivocal answer to all these questions, facts

[1] I want to thank Beatrice Smedley for translating and editing this paper.

seem to defy arguments. Thus, one cannot deny that today the body stars in more disciplines than 20 years ago, and even architecture, which boasts a long tradition of focus on the body, has returned once again to this topic, raising new speculations that seemed fantastic and inadmissible a mere generation ago.

Architecture is, indeed, a special case. It does not examine the human being as a body, nor does it claim to present the human body as do the visual arts, fashion, photography, film, and certainly not as do post-modern theories on the connections between the body and sexuality. Still, architecture does deal extensively with the human being, in particular his body,[1] and the publications honoring the body and its connections with architectural values are not fewer than in other disciplines.

If this is how matters stand, and analogous lines run between architecture and the human being, what is, then, the connection between architecture and the human body or, to refine the question, is the reference to the body immanent to architecture, a sine qua non if we are to understand its intentions, or does this analogy serve the pedagogical purpose of better explaining the architect's working process?

I would like to argue that the analogy between architecture and the human body is not fortuitous and certainly not trivial, nor does it merely teach us how to read an architectural work. Architecture and the body are two sides of the same coin: on the one hand, architecture views the human being as its purpose, that is, people populate architectural spaces--cities, their squares, streets and buildings that make up the human environment--and, as such, are the natural consumers of architecture, which plans, designs and builds for them. On the other hand, architecture uses images of the human body to justify its contents as paragons and examples of harmonious and proportional structures, but also as a measure for creating a proper and commendable environment suitable to human needs. Notable examples that address the human body include, of course, Vitruvius, whom I will discuss further below, and Le Corbusier who has designed numerous buildings in Europe, mainly during the fifties collaborating with Nadir Afonso (an architect and an eminent artist) using the 'Modulor' - a 'housing unit'[2] as a principle of proportion. In these two examples,[3] although distant in both time and their visions of the human being,

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1. A broader scope of the issue is discussed in *Flesh and Stone: the body and the city in Western Civilization* written by Richard Sennett, W. W. Norton and company, 1994. See especially chapter 8 'Moving bodies' in which William Harvey's revolution in anatomy and its influence on city planning, is presented.

2. In French 'Unite d'habitation' also literarily translated as 'housing unity'.

3. One more example worth noticing is Orlan's *MesuRAGEs* project in which she lies on a floor of a building, marks with a chalk her body, repeating her action till the floor is full with a display of Orlan-corps. See a detailed review in *Carnal Art: Orlan's Refacing* by: C. Jill O'Bryan, University of Minnesota press 2005, p. 8.

the body and architecture function on two distinct levels, with a one-way analogy stretching from architecture to the human body, which serves here as a sort of schema for the architectonic structure. Against this example one can pit the post-modern architectural conception that refers to the body's connotations and not only its limbs, as does Ayn Rand in her novel *The Fountainhead*. Rand describes the limbs of the toned, virile body of the architect Howard Roark as though they were quarried from rock; it is on them he models his buildings. Although there is no direct connection between architecture and bodily features, the very drawing of such an analogy points to a reversal in the architectural view of the human body: from the body as a model--for Vitruvius and Le Corbusier--to an interpretation of the body as a metaphor for the building's power, as evident in the collection of projects *Stud: Architecture of Masculinity*,[1] which discusses images of the masculine body in architecture.

The "affair" between architecture and the body, isn't new, then, and Vitruvius was, as noted, the first to refer to the human body and the human being himself as a means that offers architects working methods he deemed crucial if architecture was to serve its aims properly. His treatise *On Architecture* features a hefty compendium of instructions on how to build well-proportioned and properly scaled buildings.
The following quote eminently describes the classical architectonic paradigm, which, trickling into the discipline, has become a timeless model:

> Proportion consists in taking a fixed module, in each case, both for the parts of a building and for the whole, by which the method of symmetry is put into practice. For without symmetry and proportion no temple can have a regular plan; that is, it must have an exact proportion worked out after the fashion of the members of a fine-shaped human body".[2]

Let us examine Vitruvius' central claim implied in this passage. First, however, I must refer the reader to a similar position held in the 5th century BC by Aristotle, who claims that an indispensable code underpins a well turned out tragedy that imitates well the characters' lives. The tangents drawn between art and an external factor aren't new, then. Vitruvius is following an already paved road when he uses the human body to establish standardization in architecture. Let us consider the analogy Vitruvius draws between architecture and a 'fine shaped human body' rather than the human body as such. The emphasis on 'fine-shaped' raises the question of what underlies the choice of such a human being, rather than any other,

1. Joel Sanders (ed.), *Stud: architecture of masculinity,* Princeton, 1966. See also George Dodds and Robert Tavernor, *Body and Building: essays on the changing relation of body and architecture,* MIT press 2002. Susan Bordo, *The Male body: a new look at men in public and in private,* Farrar, Straus and Giroux (New York), 1999

2 Vitruvius, *On Architecture,* translated into English by Frank Granger, Harvard U. press, 1932, p. 159

as analogous to architecture. Are only the proportions of a fine-shaped human being suitable to the temples the Roman architect envisions? What about the person who does not diet and work out every morning, whose bodily proportions are not those Vitruvius set down in his treatise? Are the proportions of an unattractive person not sufficiently human? Furthermore, did Vitruvius' world teem only with perfectly proportioned people, and, therefore, he required the architect to imitate the perfect body as a basis of standard proportions? Or did Rome display the very opposite, people with regular human rather than ideal proportions, and, to correct this flaw, at least in architecture (as Renaissance painters were to do later), Vitruvius set the ideal body as a model, shunning the body structures of regular people. All these questions share yet another question, namely, why Vitruvius chose the human body at all rather than another external factor for his architectural instructions.

Vitruvius' analogy, certainly not trivial but informed by the view that set the human being and his body at the center, was already drawn in the 5th century BC by the ancient Greeks. They addressed the human body from every possible point of view, investing it with a wide range of meanings that were to animate its perception and description throughout Western culture. Quite plausibly, ancient Greece played this role because, unlike in the Middle Ages, no distinct disciplines had yet emerged, such as religion, myth and mythology on the one hand, and painting, sculpture, theater, philosophy and science, on the other. No pure disciplines free of mutual influences existed in ancient Greece, and the myths, the central axis of daily life, were actually the language of artists, playwrights, philosophers and scientists. In poetry, fiction and even the visual arts, such as painting and sculpture, this self-evident influence requires no justifications, but when the language of mythology is used in the sciences, especially anatomy, a rather developed field in ancient Greece, an explanation is called for: must an anatomical description leave the body untainted by defining and descriptive concepts of the period? Must the scientist ignore the culture he lives in, the beliefs of his contemporaries, their religious principles, myths and mythology and examine the object of his study objectively without any apparently external connections or influences? Is the demand for objectivity possible or an unquenchable yearning? These questions, which inflected the attitude of ancient Greeks toward the human body, defined the latter much as did Vitruvius, although his conception of the body transcended its mechanical system of organs and invested it with a metaphoric meaning. To illustrate this point we will return to ancient Greek art, theater and mythology, which illuminate the human body from two angles: the concrete body moving within the space and time of the play's characters and the eternal body transcending concrete time and space as a symbol of balance (or imbalance) between the human being and his fate.

Sophocles' tragedies are a case in point. The first play in the trilogy tells of Oedipus the King, the cause and effect of the moral imbalance that stems from his very existence as a human being, despite his bravery, wisdom and cleverness. A mortal who solves the riddle of the Sphinx, he unsettles the status quo between the gods and people, paving the way for a chain of transgressions that began with his birth, his abandonment, feet bound, on the mountain, his marriage to his mother and the birth of his four children, and up to the grim end when he plucks out his eyes and is banished from his country. At each of these stages the human body is the ground where the drama of unsettled mythical balance unfolds: between the gods' metaphysics and human life, between the cosmic order and the triviality of earthly events, between the concrete body and the metaphoric body. Nor is the human body absent in the trilogy's third play, where Antigone asks to bury her brother in defiance of King Creon's decree that forbids his burial because he betrayed Thebes. This is not the place to examine the complex conflict between loyalty and treason, between the king's decree and Antigone's flouting of the law, though we should point out that the entire play revolves around a dead human body that functions as a central image in the disturbed balance between the royal decree and Antigone's conscience, between death and Antigone's fate.

Not only tragedies but comedies, too, address the body. Aristophanes' *Lysistrata*, written probably in 411 BC during the Peloponesian wars (430-404 BC) between Athens and Sparta, is among the famous. In the play Lysistrata tries to convince the women of Sparta and Athens to abstain from sexual relations with men to make them stop the war. In the best of Greek writing tradition, Aristophanes does not forgo graphic descriptions of both male and female sexual organs and erotic scenes verging on pornography in order to portray human weaknesses and steer bodily passions into the ideological conflict between Athens and Sparta. Many mythological stories flash through the lines, such as the myth of creation and the birth of Gaia's and Uranus' children, the story of the Amazons, and, of course, all the stories about the gods' seductions and betrayals.

But the ancient Greeks looked at and learned about themselves not only in the theater. The much more accessible arts of painting and sculpture presented the bodies of women and men not only as ornaments or aesthetic expressions. Set in a mythic context, the paintings of women and men depicted impossible imaginary situations. This may be why for the ancient Greeks art mediated between mythology and daily reality, between the metaphysical and the physical, serving as a sort of shield for the individual. It is not fortuitous that Aristotle lists catharsis as an important element of tragedy, as it is the only way to see in art allusions to daily life and so-called realistic scenes, even if these are hard, though relevant, to our lives.

In this sense Aristotle was the first, if not the most rigorous, theoretician who understood that art was not only an aesthetic but also a pedagogical activity. Art seeks to present the imaginary, the desirable rather than the extant at a particular moment, to highlight the probable[1] rather than only concrete reality as such. Art, then, infuses an apparently trivial reality with an ideational, sublime dimension that rhymes with the gods. The implied tone in Aristotle's claim that the artist must present the universal through the particular and set down the concrete as he highlights the general truth is noteworthy, as it opens the door to metaphoric representations--key mediators in the complete presentation of the concrete.

Vitruvius was well aware that art played this role, whose application in architecture was not fortuitous nor devoid of historical context. His argument isn't, therefore, trivial, if only because in those times, too, the body's arena was not exhausted by the circumscribed field of anatomy but symbolized, more than anything else, the Zeitgeist that was to peak in the Renaissance. After all, ancient Greece, Rome and Renaissance Florence, too, were swarming with fat and thin, tall and short people, not to speak of the variously disabled. Nevertheless, Vitruvius and the architects of the following generations ignored these variations and exhorted young architects to learn from the image of the perfect, ideational human body that thrived in their wild imagination or, at least, in the world of Platonic ideas.

Surprisingly enough, the theories of Vitruvius resonate even today among contemporary architects, despite the shifts the images of the human body have undergone in art and science. An unusual example in this context is the fascinating work of the architect Le Corbusier who, unlike his colleagues, boasted he was able to and really did infuse the theory of Vitruvius with a modern meaning when he built, inspired by him, what he termed "the Modulor"--a house adapted to the average human body--with the intention of harmoniously organizing his environment inside and outside his home. Located in Marseille, the apartments feature units with proportions adapted to each family member: the rooms for adults are larger than those for children, the proportions of the family living room differ from those of the bedroom and kitchen, etc. Yet for Le Corbusier, says Anthony Vidler, "the body acted as the central reference"[2] and is considered the last, to some extent even pathetic, if not tragic, survivor among a community of architects who remained loyal to the model proposed by Vitruvius, and although some architects look to the human body for inspiration, most, certainly unlike Vitruvius, perceive the body as a

1. "It is evident, however, from what has been said, that it is not the function of the poet to relate what has happened, but what may happen, - what is possible according to the law of probability or nescessity." Aristotle, *Poetics* IX 1, translated by: S. H., Butcher, *Aristotle's theory of Poetry and Fine Art,* Dover publications, 1951.

[2] Anthony Vidler, *The Architectural Uncanny: essays in the modern unhomely,* MIT press,1994, p. 90.

metaphor.

Vidler attributes the rift between classical architecture, in which the building's adequacy is based on the analogy to bodily proportions, and an architecture free of Vitruvian anthropomorphism, to Edmund Burke, the 18th-century Irishman, known also for his religious stance precisely during the Enlightenment, which has tried to throw off the shackles of religion and tradition. Despite his religious-ethical world view, Burke sees in the human being a limited creature subject to the evolutionary laws of nature rather than to divine powers. There is a reason why we hear Burke anticipate the later Charles Darwin, who saw nothing sublime either in the human being but studied him as yet another link in nature's random evolution. Against this background, as general and sketchy as it may be, Vidler's quote from Burke's famous treatise *Philosophical Inquiry* expresses staunch opposition to the analogy between architecture and the human body. Burke disdains the Vitruvian human being, claiming that

> To make thus forced analogy complete, they represent a man with his arms raised and extended at full length, and then describe a sort of square… It appears very clearly to me, that the human figure never supplied the architect with any of these Ideas…. Men are very rarely seen in this strained posture; it is not natural to them; neither it is all becoming… Certainly nothing could be more unaccountably whimsical, than for an architect to model his performance by the human figure, since no two things can have less resemblance or analogy, than man, and a house or a temple".[1]

Burke's rejection of the analogy dear to Vitruvius and the advocates of proportion who walked in his footsteps unsettles the foundations of the Aristotelian theory that evaluated art by its ability to create sublime, imaginary realities. Instead, art is to be grasped through the human senses, that is, it passes muster as good art if it elicits feelings. If we apply this claim to architecture we realize that Burke does not remove the body from the debate on the discipline's nature, but against the perfect, sublime body depicted in Leonardo da Vinci's famous drawing, he pits the body as it is--the subjective body moving through architectural spaces, with its sensations and impressions as the measure for the building's nature and value.

[1]Burke, E., *Philosophical Enquiry into the Origins of our Ideas of the Sublime and Beautiful,* p. 100 cited from Vidler 1994, p. 72. The same passage is cited in the *Opening Statement* by Deborah Hauptman (ed.), in her *The Body in Architecture,* Rotterdam: 010 Publishers, 2006. Introducing Burk's challnge of the Vitruvian body in the very first page of her book is of no coincidence, stressing the point that Architecture should not be based on 'a forced analogy, namely, the ideas of regularity, geometry and proportion as deriving from the human body and being considered the *efficient cause* for beauty in architecture'.

The advent of the ugly and distorted

Burke's critique of Vitruvius seeped deeply into architecture, whose quest has shifted increasingly to emotion and surprise, often at the expense of functionality. Salient examples would be the works of such architects as Daniel Libeskind (The Jewish Museum in Berlin), Frank Gehry (Bilbao), I. M. Pei (Javits Convention Center in New York), to mention only a few of the current star architects who seem to have carefully read Burke's brief observation that the test of art, including architecture, is its ability to call forth emotions: fear, anxiety, dread and, of course, empathy, joy, etc. In this context Robert Venturi's well-known book *Learning from Las Vegas*[1] (1972) is noteworthy, as it takes issue with Bauhaus sterility in favor of an architecture that conveys the spirit of the place and, therefore, strikes deeper chords than the universal pretentiousness suggested by buildings aiming at the proportional and the sublime without any reference to their time and place.

It is in this vein that we are to read many theoretical works on architecture with ample references to theoreticians who, were it not for the turnabout in architecture, we would have hardly seen their traces in this discipline: Sigmund Freud, Luce Irrigaray, Judith Butler, Andrew Benjamin, Anthony Vidler, Umberto Eco, Tali Hatuka and Rachel Kallus,[2] who have ushered in a new approach to the twisted, ugly, aching, sexual body.

As a gambit to all these, I must refer to Freud's famous essay *The Uncanny* (1919), where he analyzes a feeling that is neither fear nor anxiety but a special emotion that stems from the repression of a childhood experience of dread. Among the many examples he includes the dread triggered by automatons moving in space, the recurrent appearance of an object, event or person in our regular surroundings or on our itineraries, such as a certain number in various contexts, or the sudden looming of a person we just thought about, getting lost in an unknown city, and even identical twins, who offer no apparent reason for the discomfort and even dread such identical doubling elicits. Finally, Freud lists as uncanny also certain literary and dramatic characters and events. The ugly, the distorted and the disproportional encountered in art do not elicit fear or anxiety but, rather, discomfort and at times even an uncanny sense that they are about to unsettle the social order.

To continue Freud's idea, we could say that the sense of uncanniness is contrary to the emotion elicited by the beautiful, the sublime, the harmonious and the proportional. The latter offer an experience of pleasure and tranquility, whereas the

[1] Robert Venturi, Denise Scott Brown, Steven Izenour, *Learning from Las Vegas: the forgotten symbolism of architectural form,* MIT press 1092

[2] Tali Hatuka and Rachel Kallus, "Body", Rachel Kallus and Tali Hatuka (eds.), *Architectural Culture: Place, Representation, Body,* Resling, 2005, pp. 243-254 (in Hebrew)

crippled, imbalanced, wounded call forth discomfort and even dread without any apparent reason. Still, in many cases, something beautiful and harmonious can also provoke dread if presented exaggeratedly with surprising elements.

I have chosen to open with Freud because two brief passages in his essay refer to architecture. I have already mentioned finding oneself in an unfamiliar street in an unfamiliar city: here the dread stems from the tourist's sudden disorientation as he is looking for his hotel yet returns over and over to the same street he wants to leave behind. The second example is our own home when the lights suddenly go off and we grope in highly familiar hallways but are hard put to find our way in the dark. Both cases elicit a sense of uncanniness and disquiet, not because a figure or an object suddenly appeared in our environment or because a jarring sound burst from an unknown source. We experience uncanniness because our place has become distorted and different, and the familiar and predictable are suddenly unclear.

In line with Freud's concept of the uncanny, we could say that from the mid-19th century modern art has aroused feelings that had certainly not been experienced by art viewers in previous centuries. The very reference to non-sublime body images flouts every aesthetic principle prevalent thus far. The aching, the ugly, the dismembered, the bleeding--all these defied the symmetrical, harmonious body, shedding a critical light on the past with a slice of concrete life in all its grotesque and tragic aspects. This transgression also meant to constitute a new but actually familiar image of the human body ever since--ailing, aching and bleeding--though art, literature, theater and architecture had blurred, if not concealed, its representation. Does this omission stem from the dread elicited by gruesome sights? Has the body in pain been hidden by the fear that it might be perceived as trivial and banal compared to the unequalled sacredness of Jesus' martyred body? Could the image of the sick, distorted body have changed the very order of such fields as architecture, which used the healthy, harmonious and symmetrical body as a paradigm for a gestalt worthy of imitation?

With these questions in mind, let us examine the body images that emerged in the wake of the French Revolution and whether modern architecture has been mindful of the shift in body images or has remained loyal to the Vitruvian vision of architecture as an imitation of the beautiful body.

Images of the fragmented body in modernism

I first became interested in body images in art after reading Linda Nochlin's[1] short

[1]Linda Nochlin, *The body in pieces: the fragment as a metaphor of Modernity,* Thames and Hudson, 1994

book *The Body in Pieces*. Its much more enticing subtitle specifies what the title implies, who the body pieces belong to and in what context they are discussed. Indeed, *The Fragment as a Metaphor of Modernity* not only reveals the book's tenor but also explains how to spot modernity, which, the author claims, "invented" fragmentariness. That is, the consummate expression of modernity can be found in the body's depiction in art: the greater the fragmentariness, the firmer the body's status as image and metaphor, and, as such, it enhances modernism. Nochlin locates the rift between traditional art and modern art during the French Revolution, and, strange and morbid as this may sound, she considers the guillotine a device that "ushered in the modern period, which constituted the fragment as a positive rather than a negative trope".[1]

Loss, fragments, the dismembered body are the most apt counter-arguments against "the nostalgia for the past," Nochlin writes, and, in this sense, the emergence of body parts is to be interpreted as the deliberate destruction of whatever is connected to tradition and to what we wrongly perceive as vandalism in the creation of new, unbiased images in art. The guillotine was the first modern mechanical means of execution that stripped the execution of its punitive aspect, turning it into an icon of modernism that purged society of the burden of the old world. While we shudder at the sight of the guillotine and the executions during the French Revolution, in those years they were perceived as a dramatic change in the politics of punishment. If, up to the revolution, the treatment of the convict's body was driven by fundamentalist motives, that is, the restoration of the old order, as in Socrates' case, or selfish motives (kings executed political rivals), never had people been executed, as during the French Revolution, in the name of the Enlightenment and the promotion of humane values, such as freedom, equality and brotherhood. Not surprisingly, artists from all the arts praised and documented the guillotine as the first soldier fighting for lofty values, and the results of executions--heads, hands, legs, etc.--were presented as symbols of progress rather than mere expressions of cruelty or terror.

Indeed, many paintings feature a severed head held by a revolutionary, recalling paintings of David holding Goliath's head or of Judith beheading Holofernes (the latter by Artemisia Gentileschi, 1635). Despite the time gap and horror, in both cases the severed limb is meant to elicit not only revulsion or dread but also positive connotations. Once the dismembered body settled as a legitimate display in art, the door opened, mainly from the 19th century onward, for many artists who saw the body in general, but also their own, as a ground to express social, national and existential values. Let us recall that during the French Revolution, when both France

[1] Ibid. p. 8

and Europe were plagued by social and political disorder, quite a few members of the middle class used the circumstances to tout libertine ideas. Contrary to traditional society, which venerated the family and social status, the revolution granted, mainly to men but also to quite a few women, the freedom to meet in cafés, bars and pubs. Free to consume, among others, luxury, fashion and pornographic literature, many, as noted by Margaret C. Jacob[1], became aware of their erotic body, of their passions and appetites, which could at last be quenched.

People suddenly discovered that life was not underpinned only by ideas, values and religion, that there were bodies and objects, that the human being had a body whose behavior did not depend on the soul only. The body turned out to be a historical entity but, unlike most other objects, not to speak of the ideas, values and laws by which we live, it has not undergone changes and upheavals in its appearance and functions, nor has it become more sophisticated. Throughout history the human body has remained constant: a complicated, complex system of organs and limbs, whose deviation from normative functioning is perceived as an unusual event, leaving us powerless before the body's overall definition. If anatomical changes did occur, they were external and artificially introduced in order to police the body and restore its normative functioning.

Our insights about the body's essence call for, then, the solution of the following paradox: on the one hand we are aware of the concrete private body, which, as noted, has not changed and will most probably not change dramatically in the future; on the other hand, we cannot ignore the body images depicted by scientists, theologians, philosophers, artists, playwrights, writers and poets, but also architects, who do look at the physical body yet build around it images that do not dovetail its concrete existence. Given this paradox between the concrete body and its images, we cannot but ask where the body is, and which of the above possibilities describes it better. The human body seems to be an enigma: since we have a body, it is accessible and familiar to everyone but its definition in a historical context, the attendant images, the philosophical and psychological dilemmas it raises in the arts and sciences indicate that the body is a "chameleon-like concept" that functions in our discourse as both a physical object and a metaphor. It was Théodore Géricault, in the fledgling years of modernism, who offered the most arresting metaphorical expression of dismembered, scattered human limbs. In a series of paintings of severed limbs he underscored absence, setting hands, legs, heads next to each other

[1] M. C., Jacob, "The materialist world of pornography", in: Hunt, L., (ed.), *The Invention of Pornography: obscenity and the origin of Modernity 1500-1800,* New York 1993, pp. 157-202, See especially p. 159

as though in an anatomical display of lifeless body parts devoid of context and meaning, as though they were mere limbs bereft of any address or identity, limbs that belonged to no one in particular, lacked history and could not explain what they were doing and how they entered the painting.

Théodore Géricault, *Severed limbs*, 1818

Many artists who came of age with the French Revolution, among them Théodore Géricault, painted the maimed human body. Without memories of the revolution, these paintings would have hardly been accepted. In 1816 Géricault painted also an execution in Italy, wounded soldiers lying on a cart (1818) and a man with a leg prothesis standing in front of a Louvre guard. As noted, these paintings offered harrowing depictions of the guillotine and of France's status and situation in the wake of the Napoleonic wars, as though to remind us that against Napoleon's imperial image (he had been painted by Géricault himself) were pitted human shards as a historical warning of a leader's hubris, a leader who disdained no means to glorify himself. These paintings, says Nochlin, are a reminder for art historians who address the human body only from the iconographic point of view, ignoring its physical, aching and tormented corporeality, which represents, as in the above example, events in the history of France. Nochlin's claim would have been tenable had Géricault been the only one to paint such sights at the time. In this case we would have had to interpret his paintings as historical documents rather than as a metaphorical expression of the human condition. But since Géricault did not work in a vacuum, and since quite a few artists of that period and even later used the body as a central theme in their work, we could hardly accept uncritically Nochlin's claim that this is not iconographic painting. The artists of the French Revolution, as well as those of the 20th century, such as Cindy Sherman, Franco B, Orlan, the Chapman brothers and others, whose work we will examine further below, would not have won such acclaim and legitimacy were it not for the shifts in the vision of the human body with the emergence of scientific materialism several years prior to the French Revolution. This is not the place to expand on this subject, yet it should be noted that scientific materialism emerged concomitantly with the spreading of Protestantism and, later, Calvinism.

There were not only essential theological differences between Catholicism and the surge of Protestantism and Calvinism. The new radical Christian movements, in particular, exerted a marked influence on science and, therefore, on the definition of the human body in the arts. Science saw this turning point in the work of William Harvey[1], who studied the function of the blood vessels, heart and heart valve structure and defined them contrary to the then prevalent approach influenced by Galen, who had written about the structure of the human body and even drawn sketches, now lost. A Platonist, Galen had described the circulatory system in spiritual terms--oxygenated blood carried "vital spirits," whereas the blood returning from the body lacked them.

As it often happens in science and, of course, also in art, the paradigm for a turning point does not originate in the field itself but is animated by external factors. One influential paradigm was philosophy, which, at least in the period under discussion, was closer to science than it is today. Indeed, materialism is usually seen as straddling the religious turning point and philosophical positions, from Thomas Hobbes, through René Descartes and up to Julien de la Mettrie[2] (1709-1751), a physician and philosopher who is, I believe, the most pertinent to our context: in his book *L'Homme Machine* (1748) he mocks the Platonic view, stating that the human being is a machine. De la Mettrie expands here the thesis about the human body elaborated by Descartes, who may have been among the first to propose the machine as a model for understanding the body but, as a rationalist, he remained loyal to the soul's role and God's centrality. De la Mettrie bypasses these two elements but, fearing persecution by the Church, he uses Descartes' reference to God as a ploy that would enable him to publish his work.

De la Mettrie wrote works on dysentery and asthma, and when *L'Homme Machine* was published a coalition of Protestant and Catholic priests protested his view that

Man is so complicated a machine that it is impossible to get clear idea of the machine before-hand and hence impossible to define it. For this reason, all the investigations have been in vain, which the greatest philosophers have made *a priori*, that is to say, in so far as they use, as it were, the wings of the spirit. Thus it is only *a posteriori* or by trying to disentangle the soul from the organs of the body, so to speak, that one cam reach the highest probability concerning man's own nature, even though one can not discover certainly what nature is.[3]

[1] See an extensive discussion on Harvey's contribution to the understanding of the cardiovascular system in: Jonathan Miller, "The Pump, Harvey and circulation of the blood", in: J. M. Bradburne (ed.), *Blood, Art, Power, Politics and Pathology,* Munchen 1990, pp. 149-155
[2] Julien Offray de la Mettrie, *Man a Machine,* La Salle, Illinois 1961
[3] Ibid. p. 89

In other words, the materialist de la Mettrie seeks to replace the Platonistic, non-empirical research methods prevalent until Harvey's time with scientific materialist methods that treated the human body as a machine not driven by the soul.

It is not clear whether Hobbes', Descartes' and, later, de la Mettrie's materialism directly influenced the artists of their times, but the very circulation of this theory in many intellectual venues at the time must be given its due in a discussion of the body's place in the visual arts. I cannot review here the entire baroque period, which seems to have responded more than any other to materialist principles, but paintings by such artists as Caravaggio *(The Crucifixion of St. Paul*, 1601), Rubens (*Descent from the Cross*, 1611) and, especially, Rembrandt's painting *The Anatomy Lesson of Dr. Tulp*,
1632, which depicts a guild of surgeons headed by Dr. Tulp operating on the just executed young criminal Aris Kindt, leave no doubt about the sharp divergence from the Vitruvian, that is, beautiful, human being worshipped 150 years earlier, during Renaissance.

Rembrandt, *Doctor Nicolaes Tulp's Demonstration of the Anatomy of the Arm* (1632)

It is in this vein that we are to look at the works of Géricault, and although I don't know whether he had read de la Mettrie's *L'Homme Machine*, the very reference to the human body and its parts indicates that the physician's work was known and had somehow reached the painter's doorstep. Because, if any visual representation does loyally depict de la Mettrie's thoughts about the body's materiality, it is in Géricault's morbid paintings. Let us recall that in those years, when he painted these paintings and *The Medusa's Raft* (1818-19), Mary Shelley published *Frankenstein* (1818), which blends pseudo-medical anatomical descriptions with the typically romantic desire for immortality.

Still, the force of Géricault's works lies not only in the depiction of severed limbs but in the highlighted absence, the disappearance of the concrete body, with the remnants as sole testimony to its existence. Do Géricault's paintings anticipate Jean Baudrillard's idea of simulacra? Do they foresee the condition of the postmodern human being, whose life is steered by an invisible hand? Though these were probably not Géricault's thoughts, one can easily read his works also a prologue to the works of many artists, such as Man Ray, Gilbert and George, Cindy Sherman, Maurizio Cattelan, Vanessa Beecroft, Sally Mann's corpse photographs, Dinos and Jake Chapman, Sigalit Landau, Robert Maplethorpe, and such performance artists as Ron Athey, Franco B and Orlan. All these represent the simulacra, the remnant or the ersatz of the concrete, so much so that the real connection with the reality to which they are doomed is lost. They all share, then, the dilemma between concreteness and fantasy, between the object as it was meant to be - complete, full, apparently extant - and what the artist actually presents, what seems, at least at first sight, partial, a remnant, an allusion from which we are to infer the complete narrative.

Does not the reference to the body in the works of these artists conceal an unruly desire to look at the *I*, at any *I*, even the homely, and don't the gaze at the distorted and ugly, the scouring of the body and its remnants aim to breach body images in order to reach out to the concrete, to the true? To answer these questions I will examine three notable artists whose work features the body as a central theme. While their place in postmodern art and their influence on many other artists is indisputable, I would like to show that individually, and certainly as a group, they created body images that resonate in other fields as well, including architecture.

Cindy Sherman, Franco B and Orlan

The artists Cindy Sherman, Franco B and Orlan may not be innovative in setting the body at the center of their work. Already in the 1960s and 1970s quite a number of artists, such as Marina Abramovic, Chris Burden and Joseph Beuys staged similar body performances.[1] Still, there is something new in Sherman, Franco B and Orlan, manifested in their vision of the body not as a means to rebel against earlier, traditional, art, which dealt with the beautiful, the aesthetic and the artistic object. On the contrary: unlike the artists of the 1960s and 1970s, which were the first to use the body to chart a new artistic path, Sherman, Franco B and Orlan have been seeking a new reading of the body itself or, rather, to restore a long since abandoned reading of the body and to present what is abject, aching, rejected and twisted as an inextricable part of our lives. Of these three Orlan is the most extreme with the live broadcast of her surgeries.[2] The various objects inserted under her facial skin distort

[1] An extensive overview of the subject can be found in Tracy Marr and Amelia Jones, *The Artist's body*, Phaidon 2000

[2] Quoting Orlan: Carnal Art open 'a new Narcissistic space which is not lost in its own reflection… So I can see my own body suffering … look again, I can see myself down to my entrails… a new mirror stage', in: Kate Ince,

her image in a sort of simulation of plastic surgeries people undergo to improve their looks. On the other hand, Franco B, who also cuts into his living flesh, offers once every few months a performance of blood dripping from his veins. In this sense Cindy Sherman is the only one of the three not to slash or change her body through real bodily intervention; at most, she disguises herself in her works, creating a fascinating gallery of figures from the repertoire of Hollywood films and sights glimpsed in New York.

In a video of her early work, in which she stages herself in scenes reminiscent of 1950s films, but also in later, more mature, works, where she disguises herself as imaginary figures, Sherman repeatedly raises the question: "Where, then, is the real Cindy Sherman?" Where is the real Cindy Sherman realized--in simulacra, in the artificial look she has created, or in the flesh-and-blood person living her daily life in New York? If so, where, then, is the simulacra? In art, which reveals Cindy Sherman's real passions and desires, or in daily life, which forces her to curb her passions and desires and abide by cultural principles set down by others? To which arena--the one called art or the one called reality--are we to ascribe truth values? And what is the body's place in this story? Is it invoked because it is physical, a concrete object that cannot be disowned and, as such, enables concrete reference, as to other objects surrounding it, such as a chair, table, etc., or does this object's ontological status differ from that of others and, therefore, raises questions about identity, memory, consciousness, which are not the share of regular available objects? Would it be correct to say that Sherman, like other artists who address the body, expresses dichotomies that haunt contemporary culture but were already discussed by Aristotle: concreteness / fantasy, reality / simulacra, true / imaginary?

These questions emerge more poignantly in Sherman's last works from the 1990s, in which she has replaced costumes with dummy parts--hands, legs, faces--to stage morbid scenes reminiscent of horror movies. I will first address her work and show that the body images she has created are neither fortuitous nor trivial, and that their influence on the conception of the human being as a whole and on disciplines touching on the visual arts, such as architecture, helped shatter several mainstream views.

Throughout her artistic career Sherman has used herself as the central theme of her works. In her early works from the 1970s she photographed herself in urban environments, her attire evoking film noir and Hollywood classics. Only in the 1980s do we notice a shift with her imitations of horror film scenes, later echoed in the

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Orlan: Millenial Female (Dress, Body, Culture), Oxford 2000, p. 49. For a broader discussion on Orlan's works, see C. Jill O'Beryan, *Carfnal Art: Orlan's Refacing*, University of Minnesota press, note especiallychapetr 2:
'Looking inside the Human Body'.

dramatic scenes featuring medical dummies and twisted dummy parts. Indeed, after presenting herself as a pig, she photographed vomit and scraps of used clothes; starting in the 1990s she has used dolls as a sort of simulation of the human being and his condition in modern society.

Cindy Sherman, untitled, 1992

While Sherman was not the first to include dolls in her work--Man Ray preceded her with a series of dummies in erotic, at times rather provocative, postures--the very reference to the body as a still life, and not just any but a doll imbued with all our cultural connotations, paints its use in somber colors. Sherman replaces the concrete body with slashed, twisted, maimed, injured dolls. In some works the dolls look at us, laughing madly and grimacing, at times they look at us straight, horrified by what is happening around them. Almost all the works refer explicitly to sex, pornography and death, with special emphasis on the face, sexual organs, severed hands, legs and gaping bellies. Here and there figures wear masks sported in S&M clubs and marginal communities, flaunting body parts with various accessories inserted in them. The abject, disgusting, repulsive, compounded by distortions and crippleness, offer a highly painful visual experience reminiscent of Géricault's, Man Ray's and even Maplethorpe's works. Still, there is a vast difference between Sherman and other artists who address the body in their work, if only because she uses artifacts rather than real body parts, which animate her work with a hysterical aspect that reflects sweeping despair and loss of humanness brought about by the nihilism we are steeped in. In an interview she stated that her works are not meant to please and comfort. On the contrary, they seek to wake up, "to bite" and elicit self-awareness about the place of the distressed, tormented, aching body as an archetype of modern life and its demands for considerable level of alienation. The shocking effects and added value of this series stem from its intensity, which elicits in the sensitive viewer familiar with art history a self-reflexive response about the body's and his own place vis-à-vis the raw erotic images of these staged photographs.

Elizabeth Smith rightly compares this series to Francisco Goya's well-known work *The Sleep of Reason Produces Monsters* (1797), which depicts what may happen when human logic falls asleep: the sinister forces hidden just beneath the surface would burst out and settle among us like familiar family members. It is generally assumed that in this work Goya meant to herald the advent of surrealism, but in our context, g despite the distance in time, there is no doubt that Sherman, too, also sees the rotesque as a faithful expression of our *Zeitgeist*. The twisted body is a metaphor for the culture, politics and fragmented life typical of modernity and its nihilism, cynicism, competitiveness and lack of values.

While Sherman expresses her insights through the fantastic realities she builds with dummies, Franco B[1] goes one step further. In his performances he exposes abjectness, distortion and ugliness with his own body, as though sacrificing himself in the very presentation of what is despised, bleeding, wounded and maimed.

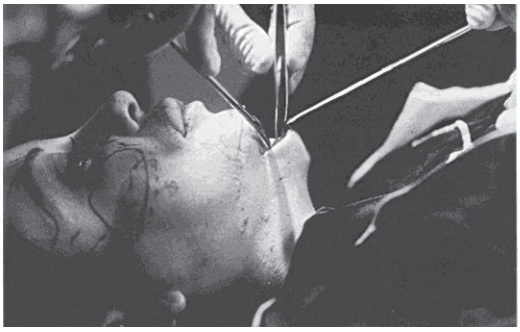
Franco B 1998

Most of Franco B's works are very hard to watch, as they touch on sights we would rather avoid. In a television interview he said that his performances touch the raw nerves of the bourgeois who averts his gaze from wretched cripples, beggars, AIDS patients, homeless, refugees from the East, foreign workers, singers and musicians in subway stations, servants, home cleaners and cab drivers who roam the streets of the

big cities in the thousands yet are hardly noticed.

[1] See Susan Hiller's paper "Part of what art is about is to find ways of beginning to say things about the darkness of culture" in: *Franko B*, Block Dog Publishing, no pages indicated. For a much more elaborated analysis of Franko B's works in the context of Carnal Art, see Fransceska Alfano Miglietti "About wounds", in *Extreme bodies: The Use and Abuse of the Body in Art,* Skira, pp. 17-41

In Franco B's work, the bruised, wounded, twisted, aching, punctured, tortured body wallowing in its own blood functions as a lighthouse whose beacon reaches out to our bleak culture. Perhaps, through his performances, he wishes to help us, the viewers, to imagine the evil that may be yet our share in the future. Perhaps he is writing the looming apocalypse on his body, now that the illusions about the eternity of Western culture--with everything it implied about the future of the human species--were shattered. Franco B's performances are unsettling and haunting, his chalk-white painted body casts a spell on the viewer, its shocking self- sacrifice recalls ancient myths in which humans and their body parts were sacrificed to appease the gods. To top it all, Franco B the Catholic believer grants his body sacred status, evoking Jesus' body, and his bleeding veins raise associations familiar to every Westerner. All these elements dialogue with the familiar past and the alienated present, with quite a few clichés about the tragic axis of the modern human being who, despite progress, is unable to escape his body in pain. The very use of the body as a medium, with emphasis on pain and abjectness, is certainly not the only factor that has influenced postmodern architecture, but I have no doubt that the legitimacy Franco B has enjoyed in presenting the ugly and the twisted has sent ripples through other disciplines too, including architecture.



Orlan, *The second mouth*, 1993

Franco B's self-flagellation and Orlan's surgeries function not only as metaphors, they have also deeply affected our conception of human essence. Invasive body performances have triggered an epistemological upheaval not only in the concept "body" but also in the latter's very way of being. For Orlan the body is not a means of artistic practice; she has turned her body and public surgeries, broadcast live throughout the world, into the very purpose of her artistic practice. Facial changes made with a surgical scalpel (it should be noted that only Orlan's face, but never her body, is operated on) offer, on the one hand, a new reading of the concept identity when surgical metamorphosis "grants" a new identity. On the other hand, Orlan's work suggests that the body is flexible and can be changed any time, that the face is not cast in stone, it is neither sacred, nor beautiful, nor something wrongly perceived as the ideational blueprint of the human body, but a sort of appearance, a battlefield that teaches us about our life. The predilection for pain and distortion in art, for ugliness and the body's decay, its presentation by Sherman, Franco B and Orlan as an assemblage of fragments, a random, trivial collection of limbs--all these indicate to what extent the body, though deemed sacred, is actually a *material* like any other, and hurting it desecrates nothing but only offers a new channel of addressing it. As noted, Orlan is far ahead of the others, as she uses plastic surgery to create natural distortions permanently marked on her face. Instead of correcting and embellishing, as the consumption culture of plastic surgery urges us to do, Orlan uses the same technique and surgical scalpel to offer a subversive reading of the hankering after beauty, perfection and eternal youth. This inversion reflects a cultural ambivalence: people sway between the desired imaginary body and the material body living here and now or, specifically, between Orlan's slashed face expressed in art and the yearning for the perfect face and beautiful body touted in ads. Orlan is, then, the mirror image of our consumption culture and, showing the ugly and distorted other, even if deliberately and artificially created, she offers an alternative to what is perceived as beautiful and perfect.

Epilogue

Can we translate Orlan's, Franco B's, Cindy Sherman's and many other artists' vision of the body into architectural language? Can the twisted and ugly be applied to architecture? Is the Vitruvian analogy valid also when body images do not even skirt the ideational body? Would it be correct to say that the conception of space, envelope and structure in postmodern architecture has been influenced by the aforementioned artists' vision of the body? If so, can the Vitruvian analogy between the body and architecture predict, over and over, architectural "fashions," or is it a pedagogical tool meant, at most, to elucidate and help us better understand architecture without claiming that it deals with factually determined laws? I cannot offer a reply to these questions within the scope of this article, but there is no doubt that Vitruvius' intuition is neither trivial nor lacking implications for contemporary architecture. A considerable number of buildings sport an innovative, revolutionary expression of architectural principles--structure, space and envelope--that challenge prevalent views. It is enough to look at the buildings of Frank Gehry, I. M. Pei, Daniel Libeskind, Zaha Hadid and many others, who, even if they have not been directly influenced by the sweeping shifts in artistic body images, have, for the most part, defied traditional conceptions in architecture and created dissonances that could not have been realized during Vitruvius' times, when body images were slanted toward beauty, harmony and perfection.

Bin Umino
Asako Soga

Paper: Automatic Composition Software for Three Genres of Dance Using 3D Motion Data

Topic: Dance

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Abstract:

This paper reports on automatic composition software for dance that use 3D motion data captured from performances of professional dancers. The purpose of our project is to develop useful tools in dance education and creation such as a self-study system for dance learners and a creation-support system for dance instructors and choreographers. The software can generate short choreographies of three genres of dance: hip-hop dance, contemporary dance, and classical ballet.

The authors label the method of automatic composition as analytic-synthetic choreography, where the dance movements are segmentalized along a time axis into short elemental motions and synthesized them to generate new movements. Both the elemental motions and the automatic composed movements are instantly simulated as 3D animation.

The method is applied to develop the automatic composition software that is expected to use as e-learning tools for dance learners and instructors. After investigating the characteristic features of each dance genre, three systems with motion data archives and automatic composition algorithms were devised to generate short dance sequences for dance learners.

The software for hip-hop dance automatically generates 32-count dance sequences for beginners using a simple algorithm with mirroring and repetition of selected elemental steps (Fig. 1). The software for contemporary dance automatically generates short dance sequences for beginners using a more complex algorithm using a narrative structure with four parts that originated in ancient Chinese poetry (Fig. 2). The software for ballet automatically generates 16-count petit allegro *enchaînements* (a combination of several ballet steps for lessons) for elementary-level female dancers using a highly complex algorithm with four groups of elemental ballet steps (Fig. 3).

Experiments to evaluate the usability of the software were conducted with experienced dance instructors. From the result of experiments, we verified that the software's usability was acceptable.

Fig. 1. Example of automatic composition for hip-hop dance

Fig. 2. Example of automatic composition for contemporary dance

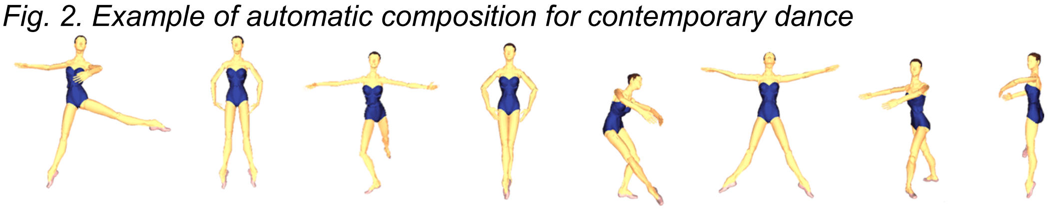

Fig. 3. Example of automatic composition for classical ballet

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[1] Bin Umino, Asako Soga, Motoko Hirayama, "*Feasibility study for contemporary dance e-learning: an interactive creation support system using 3D motion data*", Proc. of International Conference on Cyberworlds, 2014

[2] Bin Umino, Jeffrey Scott Longstaff, Asako Soga, "*Feasibility study for ballet e-learning : automatic composition system for ballet enchaînement with online 3D motion data archive*", Research in Dance Education, vol.10, no.1, pp.96-107, 2009

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Keywords:
dance performance, choreography, 3DCG, motion capturing, e-learning

Automatic Composition Software for Three Genres of Dance Using 3D Motion Data

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Abstract

This paper reports on the development of three automatic composition systems for dance that use 3D motion data captured from the performances of professional dancers. The systems can generate short choreographic works in three genres of dance: hip-hop dance, contemporary dance, and classical ballet. The authors label the method of automatic composition as analytic-synthetic choreography, where the dance movements are segmentalized along a time axis into short elemental motions and synthesized them to generate new dance movements. Both the elemental motions and the automatic composed movements are instantly simulated as 3D animation. After investigating the characteristic features of each dance genre, motion data archives and automatic composition algorithms were devised. We experimentally evaluated the usability of our software and verified its acceptability for hip-hop dance and ballet.

1. Introduction

This paper describes a new method of dance choreography that uses 3D motion data that were captured from performances by professional dancers. We name our method analytic-synthetic choreography, as explained in Section 2, and applied it to develop automatic composition systems for three genres of dance: hip-hop dance, contemporary dance, and classical ballet.

We have been working on computational dance study using 3D motion data for more than ten years [1-5]. This study forms part of our broader project whose goals include developing useful software in dance education, creation, and appreciation for the learners, instructors, choreographers, and audiences of dance performances. It introduces three types of software that allow users to create and simulate short choreographies of three dance genres.

There are some related works on computational dance study. Some research used dance notation and developed software applications [6, 7]. With these software, users can simulate already captured or precisely described dance animation. However, it is difficult to use these applications to compose original dances. Some research developed human animation systems using motion clips with GUI and a tangible interface [8]. With this software, composing choreographic works is difficult because it previews animations after editing the sequences. Our method allows users to compose new dance sequences easily and preview them immediately.

A dance simulation system using 3D motion data with handwritten sketch inputs was recently developed [9]. 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.

2. Analytic-synthetic Choreography

The basic concept of our method is to segmentalize dance movements performed by professional dancers into short elemental motions and synthesize them as building blocks to generate new movements. Both the elemental motions and the synthesized movements can be simulated easily and instantly as 3DCG animation with a CG avatar. We call this method analytic-synthetic choreography.

In general, the history of dance in the 20th century as a performing art has two main choreographic trends: expressive methods and structural methods. Expressive methods use feelings, emotions, or narratives to establish the choreography. Structural methods use movements or concepts of movement structure. These two methods are not necessarily in conflict, but legendary 20th century choreographers Isadora Duncan (1877–1927), Martha Graham (1894–1991), and Pina Bausch (1940–2009) created their works basically with the former methods, while Merce Cunningham (1919–2009), Lucinda Childs (1940–), and the early William Forsythe (1949–) created with the latter [10, 11]. We were inspired by the latter group of choreographers and analytic-synthetic choreography is an extension of their ideas.

In analytic-synthetic choreography, the segmentalization of dance movements can be done in two ways. First, in whole-body segmentalization the dance movements are separated into basic whole-body movements along a time axis. Second, in body-part segmentalization the whole-body movements are articulated to extract the body-part motions.

Similarly, the synthesis of dance movements can also be done in two ways. First, several whole-body movements can be selected and combined in a row on a time axis to generate a short dance sequence. For example, when three movements denoted by A, B, and C are selected, the system can generate ABC, BAC, ACBA, CBCAAB, and so on. Second, part of a whole-body movement can be replaced by a body-part motion. For example, when a stamping forward movement with waving arms is selected, the system can replace the arms by folding them in front of the body. The movements overlap on the time axis unlike in the first way. We call these whole-body synthesis and body-part synthesis.

This paper introduces three types of automatic composition systems using whole-body segmentalization and whole-body synthesis. Although these systems do not use body-part segmentalization and body-part synthesis, these methods are still very powerful and promising for automatic composition, which will be discussed in Section 6.

3. Motion Data and Body Structure

The 3D motion data of dance movements were captured from performances by professional dancers using optical motion capture systems and a magnetic motion capture system. Three different types of dance were selected. Hip-hop movements were captured through cooperation with an award-winning hip-hop dancer. Contemporary movements were captured from a leading contemporary dancer and dance choreographer in Japan. Ballet movements were captured from performances by two professional ballet dancers.

Figure 1 shows capturing scenes using motion capture systems. The dancers had more than 30 markers on their bodies, and the 3D coordinates of each marker were picked up for 120 frames per second.

Figure 1. Capturing scenes using motion capture systems

The various formats for motion capture data are not always standardized. We created an original 3D human model to describe the dance movements [1]. Figure 2 shows a diagram of the structure of the human body that was used to create 3DCG dance animation in our research project. It is based on the “H-anim” standard, which is an international standard for Humanoid Animation proposed by the Web3D Consortium in the 1990’s and standardized by the International Organization for Standardization (ISO) [12].

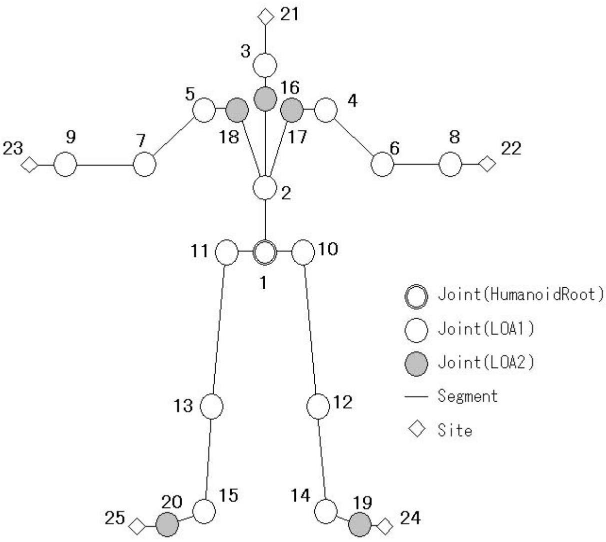

Figure 2. Human body structure for dance movements

Human joint positions are defined as 89 joints in H-anim. Since the data from motion capture systems usually have 15 to 20 joints, 14 joints were selected as our model based on Level of Architecture 1 (LOA 1) of H-anim. We added the neck, shoulder, and toe joints, which are based on Level of Architecture 2 (LOA 2), to rectify the model for dance movements. The model has hierarchical structure with 20 joint objects, 20 segment objects, and five site objects. The center joint is called the “HumanoidRoot”. Figure 3 shows the human body hierarchy of the standard model for a dancer.

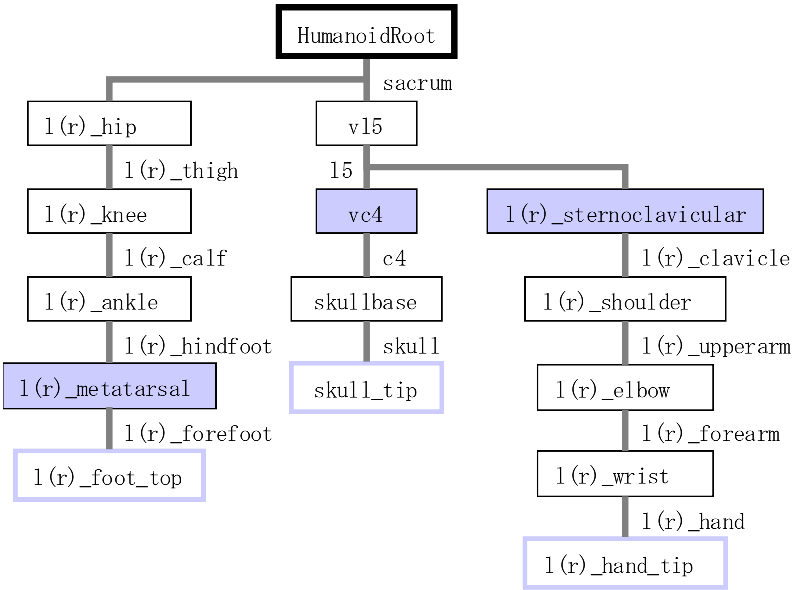

Figure 3. Human body hierarchy for dance movements

The motion data of dance movements we uses have 30 frames per second. They consist of two types of information: rotation and traveling. For each joint in each frame, there are 20 bits of rotation information, which is represented as quaternions. In addition, for each frame, there is one piece of traveling information of the HumanoidRoot joint. The traveling information is represented as a three-dimension vector.

4. Automatic Composition Systems

Automatic composition systems have been developed for three dance genres to actualize a method of analytic-synthetic choreography. In the initial stage of this research, we targeted elementary-level dance learners as users of the systems, which are intended for dance beginners and their instructors.

For each dance genre, a motion data archive and automatic composition algorithms were devised according to the characteristic features of the genre. Each archive stores a set of short motion clips which were created by whole-body segmentalization from the motion data of the dance movements. Then each algorithm, which defines the particular sequencing laws, is designed to generate dance sequences by whole-body synthesis. According to the algorithm, some motion clips are selected from the archive and synthesized into a new dance sequence that can be performed by elementary-level dance learners. The synthetic result is immediately displayed as 3DCG animation with a CG avatar on a tablet or a notebook PC. Figure 4 shows an image of the automatic composition systems.

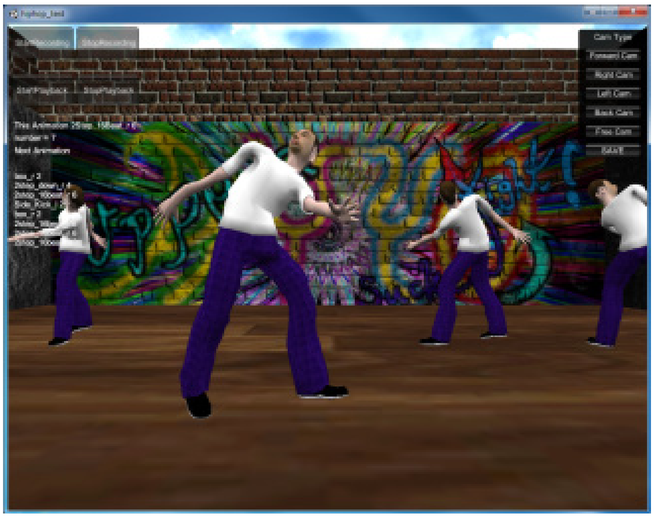

Figure 4. Image of automatic composition system for hip-hop dance

4.1 Hip-hop Dance

Hip-hop dance emerged in the late 1960's as part of Hispanic and African-American street culture in the United States and is typically performed to hip-hop music. The genre includes a very wide range of dance styles, such as breaking, locking, and popping. Its physical techniques continue to develop [13].

After an investigation of hip-hop dance with experienced hip-hop dance instructors, we identified a number of its characteristic features. Beginners of hip-hop dance need to learn many elemental steps and practice them to the rhythm of the music at the same tempo. The timing of steps is constrained relative to the music such that a step is not allowed to carry over from one musical bar to the next. In elementary-level lessons, most elemental steps have two or four counts. The order of the elemental steps is not strictly constrained so that any step can be succeeded by another step. A motion data archive and an automatic composition algorithm for hip-hop dance were created based on these features [5].

The motion data archive has 44 types of elemental hip-hop steps that are frequently taught in elemental-level lessons, such as box step, cross step, crab step, side kick, and the body wave. The durations of all the steps are unified in four counts (four beats). A mirroring motion clip of each type was created so that the archive stores 88 four-count motion clips.

We devised an automatic composition algorithm that generates 32-count dance sequences. Eight slots are arranged, and the system randomly fills them with four-count clips. Repetition of the same motion is allowed, but the algorithm has a constraint on the maximum number of repetitions, so a 32-count dance sequence has at least three different types of elemental steps. Figure 5 shows a transition diagram for creating hip-hop dance sequences. Figure 6 shows an example of a generated sequence.

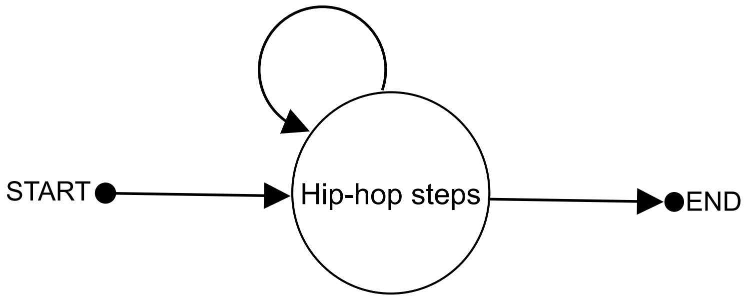

Figure 5. Transition diagram for hip-hop dance sequences

Figure 6. Example of a hip-hop dance sequence (from upper left to lower right)

4.2 Contemporary Dance

It is difficult to define contemporary dance because its territory is continuously spreading, but the term became popular in the 1960's in western countries. This genre is a successor of modern dance, which emerged at the beginning of the 20th century. Contemporary dance has been one of the most dominating performance genres of dance art in the 21st century. It has no common or standard manner of choreography, and it assimilates any dance style to exploit its artistic territory, such as classical ballet, jazz dance, Butoh dance, and worldwide ethnic dances [10, 11, 13].

After investigating contemporary dance with a Japanese contemporary dance choreographer who is also a university teacher, we identified a number of its characteristic features. In contrast to hip-hop dance, contemporary dance has inherently no elemental steps that beginners need to learn, although there are some movement methods such as the Graham technique, the Limón technique, the Forsythe technique, and GAGA. Contemporary dance instructors and teachers have individually their own teaching method for elementary-level lessons. The timing of dance motions is not constrained by the music, and motions are frequently allowed to carry over from one musical bar to the next. The duration of step units also varies widely. Similar to hip-hop dance, since the order of steps is not constrained, any step can be succeeded by another step. A motion data archive and an automatic composition algorithm for contemporary dance were created based on these features [4].

To capture dance motion data, a Japanese contemporary dance choreographer performed her own elemental movements that she usually teaches in her elementary-level university lessons. The movements included both steps and motions without steps. The motion data archive has 53 elemental contemporary dance movements, such as contraction, neck roll, arm swing, side dive, and jump forward. The duration of the movements varies widely. The 53 movements are categorized into five families: 22 body-part motions, 14 balance motions, five jump motions, four pivot motions, and eight floor motions.

We next devised an automatic composition algorithm that generates about 15-second dance sequences for beginners. To create a well-organized sequence that provides intriguing practice for beginners, we used a well-known structure of Chinese and Japanese narratives that originated in ancient Chinese poetry that consists of four parts: introduction, development, turn, and conclusion [14]. The turn part is the climax of the narratives in the structure.

The algorithm consists of the order of the arrangement of four parts and a number of selection constraints using the categorization of movements. The system arranges the elemental movements in the order of turn, conclusion, introduction, and development. First, a movement is selected from other motions than the body-part motions for the turn part. The movement in the turn part can appear only once in a sequence. Second, for the conclusion part, a movement is selected from other motions than the off-balance motions and the motion that was already selected in the turn part. Third, for the introduction part, a movement is selected from other motions than the jump motions and the movements already selected. Finally, for the development part, movements are selected repeatedly from other motions than the movements already selected until the sequence has sufficient duration. The algorithm allows the conclusion part to be omitted. Figure 7 shows a transition diagram for creating contemporary dance sequences. Figure 8 shows an example of a generated sequence.

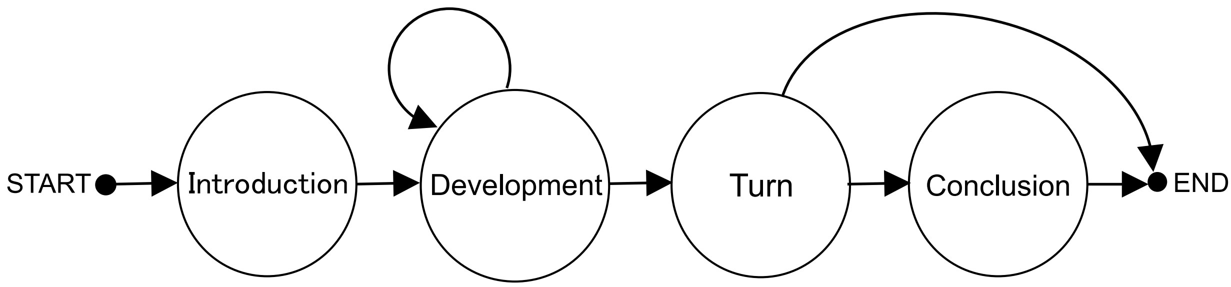

Figure 7. Transition diagram for contemporary dance sequences

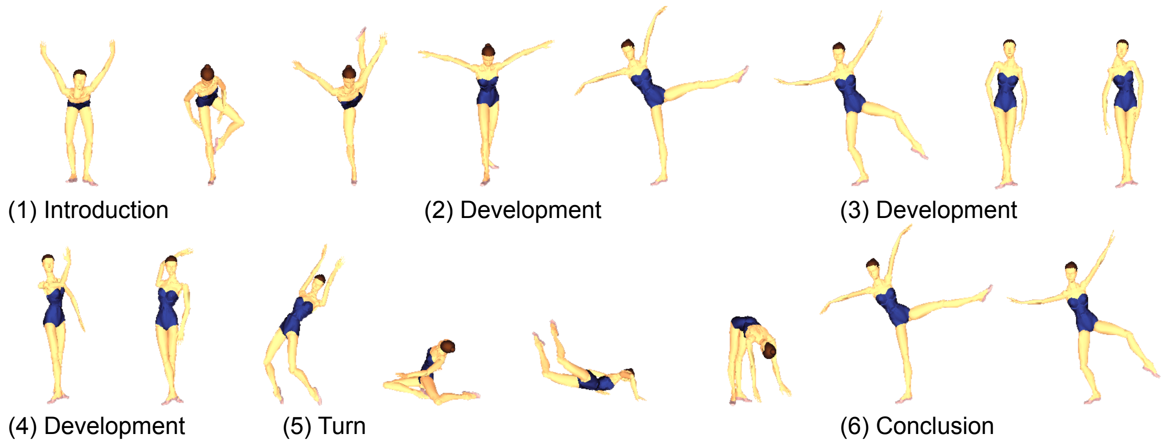

Figure 8. Example of a contemporary dance sequence (from upper left to lower right)

4.3 Ballet

Ballet originated in the Italian Renaissance courts of the 15th century and its basic technique was established in the French courts of the 17th century. It became widespread in most modernized countries in the 20th century and has been globally influential as the fundamental dance technique of many other genres of dance. It has different teaching methods, such as the French method, the Cecchetti method, the Vaganova method, and the RAD method, but the genre has a widely common standard of movements and a strict canonical manner of choreography in contradiction to the unrestricted manner of contemporary dance [13].

After an investigation of ballet with experienced ballet teachers, we identified a number of its characteristic features. Beginners of ballet need to learn many elemental steps and practice them to the rhythm of the music at the same tempo. The timing of steps is constrained relative to the music such that a step is never allowed to carry over from one musical bar to the next. These features are similar to hip-hop dance, but ballet has a much stronger standard and stricter rules than hip-hop. In elementary-level lessons, most elemental steps have one count whose duration is shorter than hip-hop. Ballet has its own vocabulary based on French terminology that is used around the world. The order of elemental steps is closely constrained based on its conventions. A motion data archive and a set of automatic composition algorithms for ballet were created according to these features [1, 2, 3].

To capture the dance motion data, experienced ballet teachers exhaustively enumerated the ballet steps that are required for elementary-level female *petit allegro* in ballet schools. All the steps were captured from performances by professional ballet dancers. The motion data archive has 215 elemental ballet steps. The most steps have one count, but some have two to four counts or a half count. The 215 steps are categorized into the following four families:

Allegro steps: quick movements without rotation, ex., *sauté, changement, assemblé, glissade, jeté, sissonne fermée.*

Rotation steps: turns around the dancer's vertical axis, ex., *pirouette en dehors, pirouette en dedans, chaînés, piqué en dedans*.

Transition steps: movements that usually link other step families or part of a necessary preparation, ex., *chassé, pas de buorrée, pas de basque.*

Fragmentary steps: short motions used to generate a seamless series among the other families, ex., *demi-plié*, changing the supporting leg.

The authors also enumerated 84 basic foot poses that can be either the beginning or the ending pose of elemental ballet steps. The beginning and ending poses of each of the 215 steps are identified as one of the 84 poses.

We devised a set of automatic composition algorithms that generates 16-count female *petit allegro* ballet sequences or "*enchaînement*". To create a well-organized sequence that adheres to ballet conventions, we used the constraints of musical phrasing, transitions between steps, and transitions between step families. First, the constraint of musical phrasing requires that a step is never allowed to carry over from one musical bar to the next. The system selects steps one by one to comply with this constraint. Second, the constraint of transitions between steps requires that the ending pose of the previous step becomes the beginning pose of the next step. The system uses the 84 poses to comply with this constraint. Third, the constraint of transitions between step families requires a natural and organic structure that obeys the artistic conventions of ballet. The system uses the four families to comply with this constraint. Figure 9 shows a transition diagram for creating a *petit allegro enchaînement*.

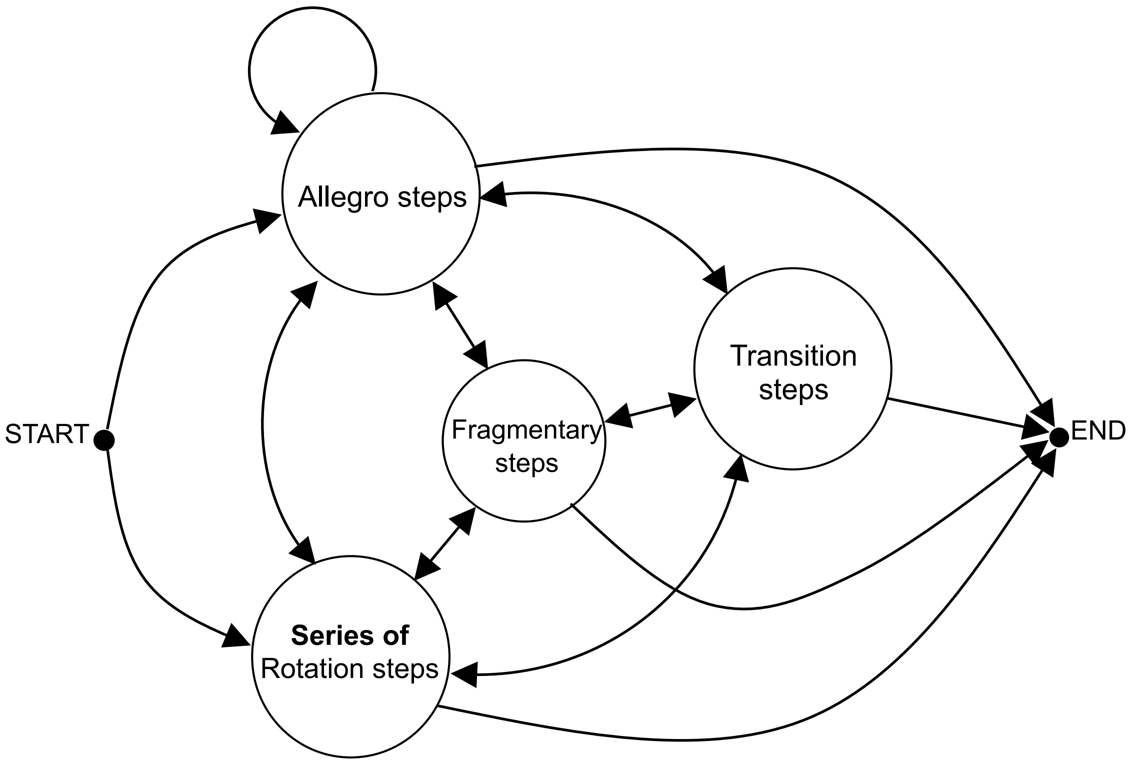

Figure 9. Transition diagram for ballet sequences

Regarding the steps in the rotation family, the algorithm allows only one rotation step in the immediate succession at the elementary-level (i.e., no double turns).This rotation step is always preceded by a preparation action. There is an option to follow the rotation step with a short recovery action; otherwise the next step must be from a different family. An additional overall rule in the algorithm for rotation steps also places another constraint: only one set of rotation steps can occur in a single *enchaînement*.

Furthermore, the algorithm has a constraint on the starting and final poses of the sequence. Any *enchaînement* starts with the 5th position of the feet and ends with one of three possible poses that were identified by the ballet teachers as appropriate final positions. The *enchaînement* duration was restricted to just 16 counts (four bars in four-four). The system selects steps repeatedly based on the algorithm until the sequence has 16 counts. Figure 10 shows an example of a generated sequence.

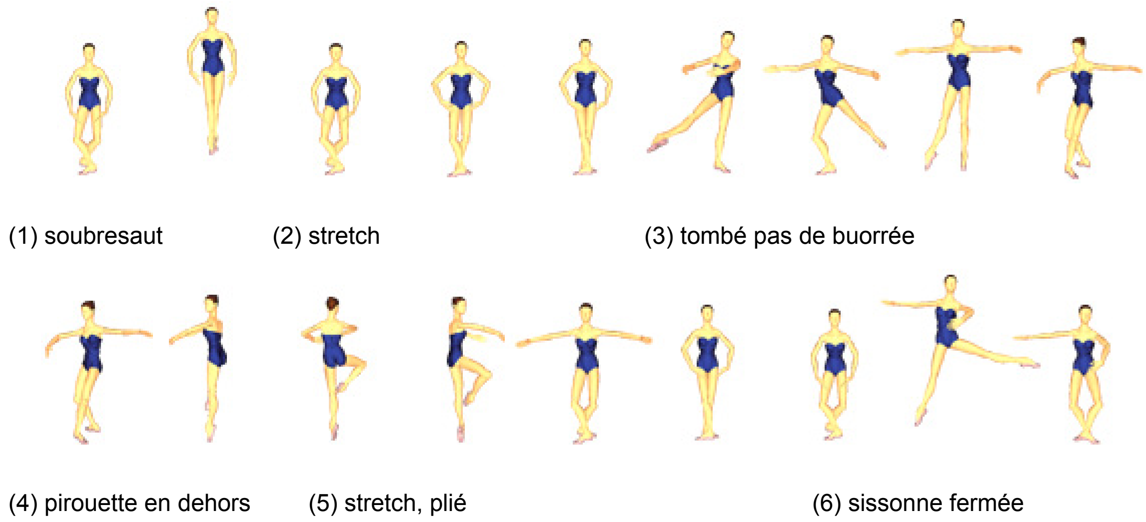

Figure 10. Example of a ballet sequence (from upper left to lower right)

5. Experiments

Experiments were conducted to verify the usability of the two systems for hip-hop dance and ballet. Experienced instructors and expert teachers of the two dance genres evaluated a group of the dance sequences for elementary-level dance learners that were generated by the automatic composition systems. An evaluation experiment of the contemporary dance software has not been conducted yet.

5.1 Hip-hop Dance

A group of 25 hip-hop dance sequences was composed automatically by the software. An expert hip-hop teacher who has been teaching for eight years evaluated the usability of each one. The level of usability was rated on a scale from 1 to 5. The result of the ratings is shown below.

1. Inappropriate for a hip-hop lesson	0
2. Upper limit for an advanced lesson	0
3. Appropriate for a normal advanced lesson	7
4. Upper limit for an elementary-level lesson	13
5. Appropriate for a normal elementary-level lesson	5

72% of the ratings considered the sequences appropriate for an elementary-level lesson either at the limit of upper level or at normal level. No sequence was considered to be inappropriate for a hip-hop lesson.

5.2 Ballet

A group of 20 female *petit allegro enchaînements* was composed automatically by the software. Five expert ballet teachers evaluated the usability of each one. The level of usability was rated on a scale from 1 to 5. The number of total ratings of the 20 *enchaînements* by the five teachers was 100. The result of the ratings is shown below.

1. Inappropriate for a ballet lesson	8
2. Upper limit for an advanced lesson	5
3. Appropriate for a normal advanced lesson	22
4. Upper limit for an elementary-level lesson	30
5. Appropriate for a normal elementary-level lesson	35

65% of the ratings considered the *enchaînements* appropriate for an elementary-level lesson either at the limit of upper level or at normal level. Only 8% of the ratings considered the *enchaînements* generated by the algorithm to be inappropriate for a ballet lesson. Five *enchaînements* were evaluated as inappropriate by a single teacher, and another one was evaluated as such by three teachers.

6. Conclusions

Three automatic composition systems for three dance genres were developed using 3D motion data. The software is designed to generate short dance sequences for elementary-level dance learners using a method of analytic-synthetic choreography. Two evaluation experiments were conducted for the systems of hip-hop dance and ballet. As a result of the experiments, we verified that the software is useful for elementary-level dance learners and their instructors and teachers.

With respect to contemporary dance, we uncovered a crucial fact for automatic composition during our research. In this study, we used the method described whole-body segmentalization and whole-body synthesis (Section 2). However, body-part segmentalization and body-part synthesis must be used for contemporary dance, because whole-body methods are likely insufficient to satisfy the requirements of contemporary instructors and teachers. Contemporary dance always requires the discovery and innovation of new dance movements, but whole-body methods cannot generate any movements other than those stored in the motion data archives. The body-part methods are more productive and adaptable for contemporary dance.

In future work, we will amend the software by augmenting the user interface, increasing the motion data archives, and upgrading the algorithm of automatic composition. We are focusing on the automatic composition software for contemporary dance that actualizes body-part segmentalization and body-part synthesis of analytic-synthetic choreography.

Acknowledgements

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Phantom Limb – Hybrid Embodiments for Dance (paper)

Abstract:

Phantom Limb is a dance project that employs simulation-based techniques to extend and alter a dancer's bodily characteristics and movement capabilities. It does so by representing physical and virtual bodies and their movements as actuated mass-spring systems and artificial neural networks. This unified representation of dancers and generative artefacts permits the creation of hybrid embodiments whose morphological, behavioral, perceptual and aesthetic aspects manifest on stage as acoustic and visual co-presence. This publication describes the conceptual motivation, preliminary technical implementation, and initial experiments in designing relationships between natural and synthetic forms of corporality.

Topic: Dance

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Semi-autonomous corporeal structure that extends from a skeleton representation of a dancer's tracked body

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Keywords:
Dance Performance, Hybrid Embodiment, Mass-Spring Simulation, Artificial Neural Networks

Phantom Limb – Hybrid Embodiments for Dance

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Abstract

Phantom Limb is a dance project that employs simulation-based techniques to extend and alter a dancer's bodily characteristics and movement capabilities. It does so by representing physical and virtual bodies and their movements as actuated mass-spring systems and artificial neural networks. This unified representation of dancers and generative artefacts permits the creation of hybrid embodiments whose morphological, behavioral, perceptual and aesthetic aspects manifest on stage as acoustic and visual co-presence. This publication describes the conceptual motivation, preliminary technical implementation, and initial experiments in designing relationships between natural and synthetic forms of corporality.

1. Introduction

The project Phantom Limb is a collaboration between the two authors and the choreographer Muriel Romero. The project forms part of an ongoing research initiative entitled Metabody [1]. This initiative deals with the development of creative technologies and artistic productions that exemplify strategies for promoting cultural diversity and idiosyncrasies. Phantom Limb specifically addresses this thematic context by experimenting with simulation-based technologies that allow dancers to modify their morphological appearance and behavioral capabilities. This modification is based on the representation of a dancer's natural bodily properties via the same computational abstractions that are employed for the simulation of artificial bodily structures. This abstraction integrates the structural and behavioral properties of natural and simulated body parts into a unified form of hybrid embodiment. The idiosyncratic qualities and capabilities of a particular hybrid embodiment is then as much the result of the dancer's subjective properties and activities as it is of the peculiarities of the simulated body parts.

2. Background

The realization of Phantom Limb is inspired by a long standing tradition within performance art. Historical precedents include the artists Loïe Fuller, Oskar Schlemmer and Alwin Nikolais. Loïe Fuller became famous through works such as the *Serpertine Dance* [2]. A central element of these works are very wide costumes whose flowing movements extend and amplify the activities of the dancers (Fig. 1, left). Oskar Schlemmer's *Triadic Ballet* treats the human body as an artistic medium that is transformed by the costume into a geometric object [3] (Fig. 1, middle). Alwin Nikolais explored in works such as *Imago* or *Kaleidoscope* how costume-based distortions or extensions of a human body structure affect the dancers movement possibilities [4] (Fig. 1, right).

Figure 1. Examples of Costume-Based Body Modifications in Performance. Form left to right: Serpentine Dance by Loïe Fuller (1891), Triadic Ballet by Oskar Schlemmer (1922), Imago by Alwin Nikolais (1963)

Figure 2. Examples of Robotic Body Extensions in Performance. From left to right: Third Hand by Stelarc (1980), Connected by Gideon Obarzanek (2011), Exoskeletal by Christiaan Zwanikken (2014)

Among the more recent examples that are relevant in the context of this publication are works by Stelarc, Gideon Obarzanek, and Christiaan Zwanikken to name just a few. Those works employ robotic structures as actuated mechanisms that extend a human body. Stelarc is famous for his often drastically invasive body modifications. In his *Third Hand* project, a mechanical hand is attached to the artist's right arm and controlled via EMG signals from various muscles in his body [5] (Fig. 2, left). In *Connected* by Gideon Obarzanek, a dancer is connected via strings to a grid-like sculpture that has been built by Reuben Margolin [6] (Fig. 2, middle). The structure transforms the dancer's activities into undulating movements and contortions. The work *Exoskeletal* by Christiaan Zwanikken employs a robotic body-extension suit that comprises a mechanically actuated boar skull [7] (Fig. 2, right).

Within the field of Artificial Life, those projects that model morphological and behavioral properties of life-like entities via integrated simulation-based approaches are highly relevant for this project. For the sake of brevity, we describe only three by now classical examples. In the *Evolved Creatures* project by Karl Sims, bodily topology and control algorithms of artificial creatures are evolved concurrently in order to improve their capabilities for locomotion or for competing for food sources [8] (Fig. 3, left). The focus of the *Artificial Fishes* project by Xiaoyuan Tu and Demetri Terzopoulos lies on the realistic simulation of the fishes' appearance, movement and behavior. A high level of realism is achieved via a combined modelling approach that simulates the hydrodynamic properties of water, the animals' muscular structure, as well as their perceptual and cognitive capabilities [9] (Fig. 3, middle). In the art context, the *A-Volve* project by Christa Sommerer and Laurent Mignonneau is interesting in that it realizes an artificial ecosystem, whose creatures can be interactively created and shaped by visitors. The movement and behavior of these creatures is automatically derived from their shape properties [10] (Fig. 3, right).

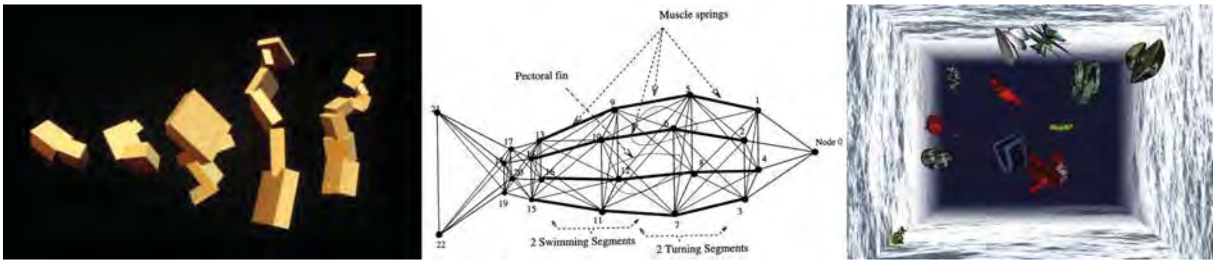

Figure 3. Examples of Artificial Life Simulations of Life-Like Creatures. From left to right: Evolved Creatures by Karl Sims (1994), Artificial Fish by Xiaoyuan Tu and Demetri Terzopoulos (1994), A-Volve by Christa Sommerer and Laurent Mignonneau (1997)

3. Software

The software environment for Phantom Limb consists of several applications for simulation, video tracking, visual rendering, video mapping, sound synthesis, and audio spatialization. These application run in parallel and exchange information and control data with each other via the open sound control protocol (OSC).

3.1 Simulation

The simulation software which has been custom developed in C++ is responsible for modelling the actuated virtual body extensions. The simulation functionality is divided into several parts: body architecture, mass-spring simulation, propulsion simulation, collision detection and resolution, numerical integration, neural network simulation, sensing and actuation.

3.1.1 Body Architecture

The body architecture part of the simulation manages the topology of the virtual body extensions. Each extension consists of one or several so-called body segments that are organized into tree like structures. Both the computational representations of the dancers' physical bodies that are derived from video tracking and the virtual body extensions are structured in such a way. The simulation takes care of translating the various body segments into corresponding mass-spring systems and of preserving their connectivity and directional constraints (Fig. 4, left).

3.1.2 Mass Spring Simulation

The mass-spring simulation (Fig. 4, middle) models spring tensions forces according to Hooke's law. In addition, it also simulates a directional restitution force that pushes springs towards a preferred rest direction which is relative to the direction of the preceding spring. Finally, all the mass points experience a damping force that is proportional and opposite to their velocity. The body architecture is represented within the mass-spring simulation as linear or branching sequences of springs. Successive springs within a sequence share their respective mass points (Fig. 4, left).

3.1.3 Propulsion Simulation

The propulsion simulation implements a physically rather contrived way of calculating forces that cause body segments to propagate through space. These forces are derived from the mass points' relative velocity with respect to the direction of their corresponding springs (Fig. 4, right). The propulsion force points in a direction opposite to the spring and its length is proportional to the dot product between the velocity difference between mass point 1 and 2 and a vector that is perpendicular to the spring's direction. Furthermore, a damping force is calculated that opposes the movement of a body segment and thereby imitated the viscosity of a surrounding medium. The damping force is the sum of two vectors. The first vector points into the direction of the spring. The second vector points is a direction that is perpendicular to the spring. The length of both vectors is proportional to the dot product between the velocity of mass point 1 and the vector perpendicular to the spring.

3.1.4 Neural Network Simulation

The simulation software allows the construction of time-delayed recurrent neural networks. The characteristics of these networks is as follows. Signals and activity levels are represented as continuous values whereas time is discrete. Signals propagate with a time delay and attenuation factor in between interconnected nodes. Signals that arrive concurrently at a node are passed through a transfer function that adds the node's gain and decay values to the sum of the incoming signals. The output of this function determines the node's activity level. This value is then passed through a step function that serves as threshold in order to determine if the node should produce an activity spike. If the node's activity level exceeds this threshold, the node fires, its activity is reduced by a preset amount, and the node enters a refractory period during which it cannot fire again (Fig. 5).

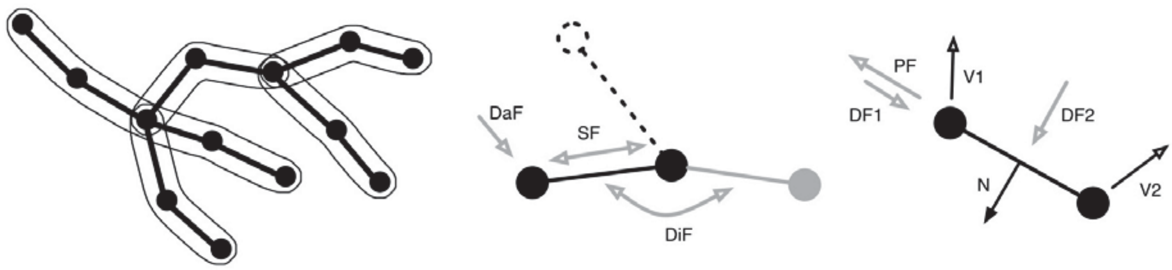

Figure 4. Body Architecture, Mass-Spring and Propulsion Simulation. Left: Schematic depiction of a corporeal structure consisting of multiple branching body segments and its corresponding mass-spring representation. The mass-spring system is depicted as black lines (springs) and black circles (mass points). The body segments are depicted as black outlines. Middle: Depiction of mass-spring forces. Forces are shown as grey outlined arrows (DaF: damping force, SF: spring force, DiF: directional force). The currently evaluated spring and its mass points are depicted in solid black. The preceding spring is depicted in solid grey. The current spring's rest direction and length is depicted as dashed black line. Right: Depiction of propulsion forces. Forces (PF: propulsion force, DF1: damping force vector 1, DF2: damping force vector 2) are shown as grey arrows. mass point velocities (V1: mass point 1 velocity, V2: mass point 2 velocity) are shown as black outlined arrows. The spring normal direction (N) is depicted as black filled arrow.

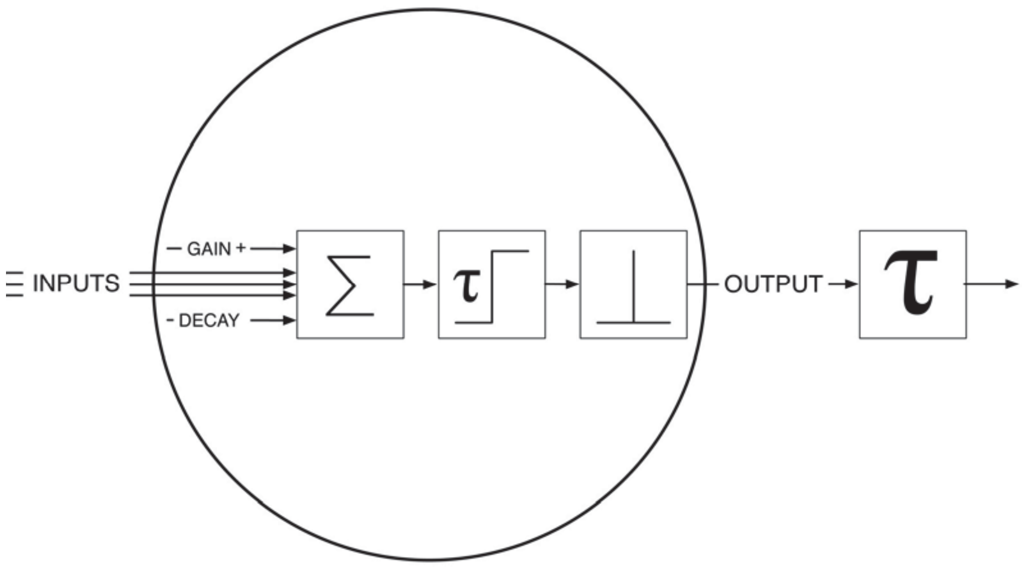

Figure 5. Neural Network Simulation. The graphical symbols in the schematic depiction of a neural node are (from left to right): Summation of input signals, gain

and decay, refractory period limit and activity threshold, output signal spike, signal propagation time delay.

3.1.5 Sensing and Actuation

The activity of the neural network can affect the properties of the mass-spring system and vice versa. This functionality is realized via the implementation of sensing and actuating elements. Each of these element is associated with a spring and a neural node. A sensing element maps a property of its spring into an activity value of its neural node (Fig. 6, left). An actuating element maps the activity of its neural node into a property of its spring (Fig. 6, middle). At the moment, the following sensing and actuation elements exist: Length sensors map the deviation of a spring's length from its rest length into a neural activity. Directional sensors do the same for the deviation of a spring's direction from its rest direction. Length motors map neural activity into a new rest length for a spring. Directional motors map neural activity into a new rest direction for a spring. An example body extension with its neural network, sensors and actuators is shown in Fig. 6, right.

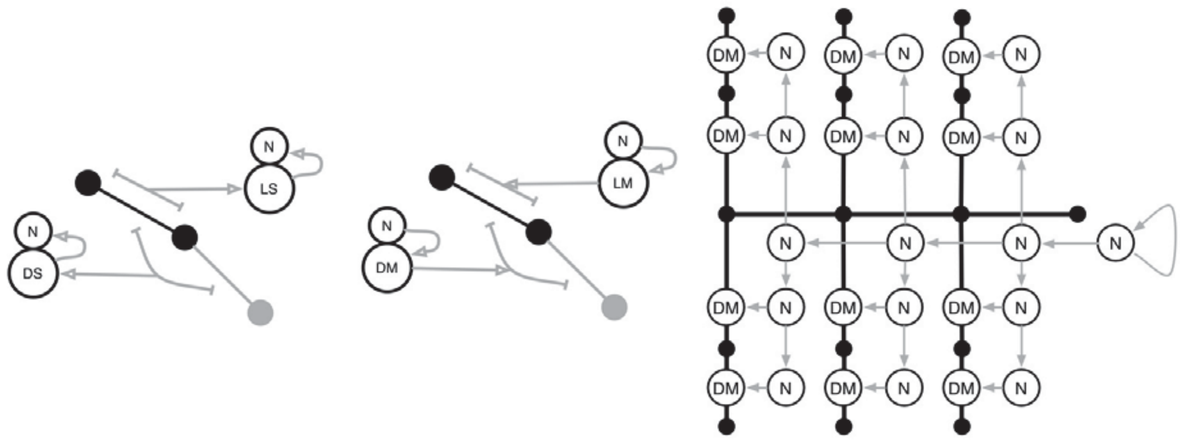

Figure 6. Left: schematic depiction of sensors. A directional sensor (DS) maps a spring's directional deviation into an activity level of a neuron (N). A length sensor (DS) maps a spring's length deviation in a neuronal activity level. Middle: schematic depiction of motors. A directional motor (DM) maps a neuronal activity into a spring's rest direction. A length motor (LM) maps a neuronal activity into a spring's rest length. Right: manually designed neural network and directional actuator system for a multi-arm body extension.

3.1.6 Collision Detection and Resolution

The simulation provides means to define bounding volumes to which individual body segments can be assigned. These volumes are constructed from 2D contours that are extruded into the Z-direction. A volume consists both of a hard limit surface and a soft limit region. In addition, a volume can act as an outer boundary, preventing body segments from leaving a particular region, or it can act as inner boundary, preventing body segments from entering a particular region. Bounding volumes can either be hand designed or automatically derived from the video tracked contours of one or several dancers (Fig. 7). The collision detection and resolution mechanism applies to mass points that try to traverse a hard limit surface. If such a collision is detected, the corresponding mass points are instantaneously repositioned onto the limit surface. If the mass points enter a soft limit region, a force is applied to gradually push to them back. This force is proportional to the depth of the mass point's penetration into the soft limit region.

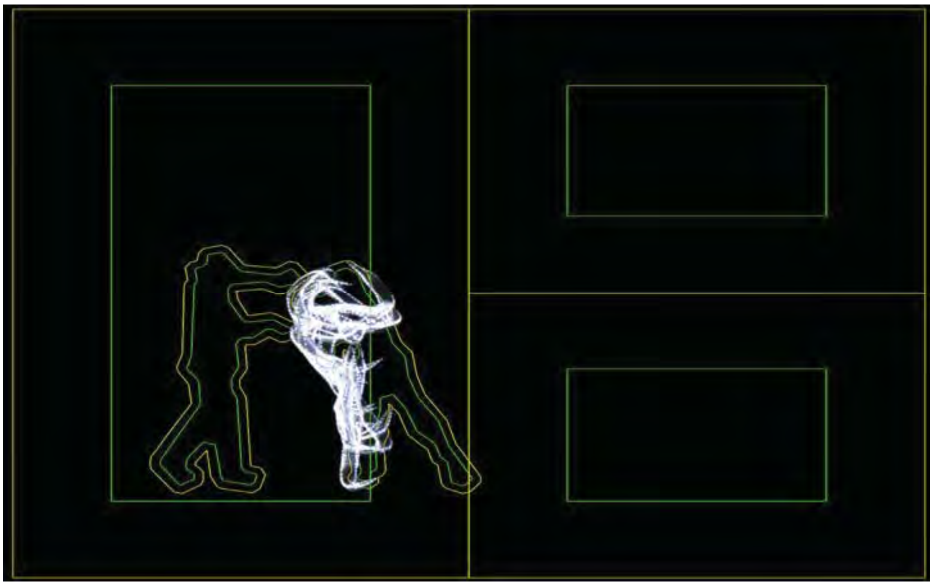

Figure 7. Bounding Volumes. Multiple bounding volumes can delimit the simulation space. Here, two of the volumes are derived from the tracked contours of the dancers. The other three volumes are static and aligned to screen regions on stage. A simulated body extension is constrained within one of the dancer's body contour. The hard limit surface is depicted as yellow outline. The soft limit region extends from the green outline to the yellow outline.

3.2 Tracking

The interaction between dancers and simulated body structures is based entirely on video tracking. For this task, three different video tracking applications are running in parallel. A custom developed tracking software derives body contours of dancers from a distance image obtained from a Kinect camera. These body contours are used to create dynamic bounding volumes within the simulation. An Eyesweb-based software patch calculates body centroids of dancers from a distance image obtained from an additional Kinect camera. Based on these centroids, skeletal representations of the dancers' bodies are created and mapped into corresponding structures within the mass-spring simulation. The mapping is based on a spatial transformation of the skeletons' joint positions from tracking space into mass point positions within simulation space A proprietary tracking software that forms part of the Motion Composer System [11] is used in combination with a Asus depth camera and an industrial gigabit ethernet camera. The combination of the very low latency response of the ethernet camera with the depth image of the Asus camera allows for fast interaction with the sound material and the simulated creatures. This tracking software detects higher level expressive features as well as low level features. The high level features include a set of gesture, the low level features consist of width, height and activity. The output of the tracking software is used to control the properties of the body extensions and the medium within which they move.

3.3 Hybrid Embodiment

The representation of the dancers' bodies as mass-spring structures within the simulation environment plays a central role for the integration of simulated and natural bodies into a hybrid form of embodiment. On a purely mechanical level, the springs constituting the virtual body elements can be interconnected with the springs representing a dancer's skeletal structure by assigning some of the former springs to mass points that are directly controlled via the dancer's tracked body centroids. Based on this purely physical connection, the dancer's movements propagate mechanically through the mass-spring system and thereby cause a movement of the simulated body structure. An additional and more elaborate level of behavioral relationship between dancers and their virtual body extensions can be realized by creating shared neural networks. For each of the springs that correspond to a skeletal representation of a dancer's body, a directional sensor can be added. These sensors control the activities of their associated neurons which then propagates through the neural network. If some of the neurons within this network are part of actuators that control the rest length and rest direction of the springs in a virtual body extension, then the dancer's movements translate into behavioral changes of the virtual body extension. Figure 8 depicts two examples of a neural network that is associated with a dancer's mass-spring representation and a virtual body extension. The image on the left depicts a branching body extension that is mechanically attached to the left hand of the dancer's skeleton. Here, the neural network is extremely simple and therefore, its parameters can be easily tuned by hand. The image on the right depicts a short linear body extension that is not physically attached to a skeleton. Here, the neural network consists of multiple neurons, sensors and actuators which are organized into several fully interconnected layers. While this network has a much greater potential of generating interesting behavioral relationships between dancers and body extensions, the large number of parameters render a manual configuration unfeasible. For this reason, these types of networks have been automatically configured via evolutionary adaptation.

3.4 Video Rendering and Mapping

The simulated body extensions are transformed into polygon meshes by extruding a circular circumference along a three dimensional Bezier spline whose control points are derived from the body segments' mass point positions. These polygon meshes are then rendered both as wireframe structures and texturised surfaces that are then composited into a final video image. This image is passed via the Syphon texture sharing mechanisms [12] to a custom developed video mapping software. The mapping software provides the means to subdivide and align different image sections to physical screen locations on stage.

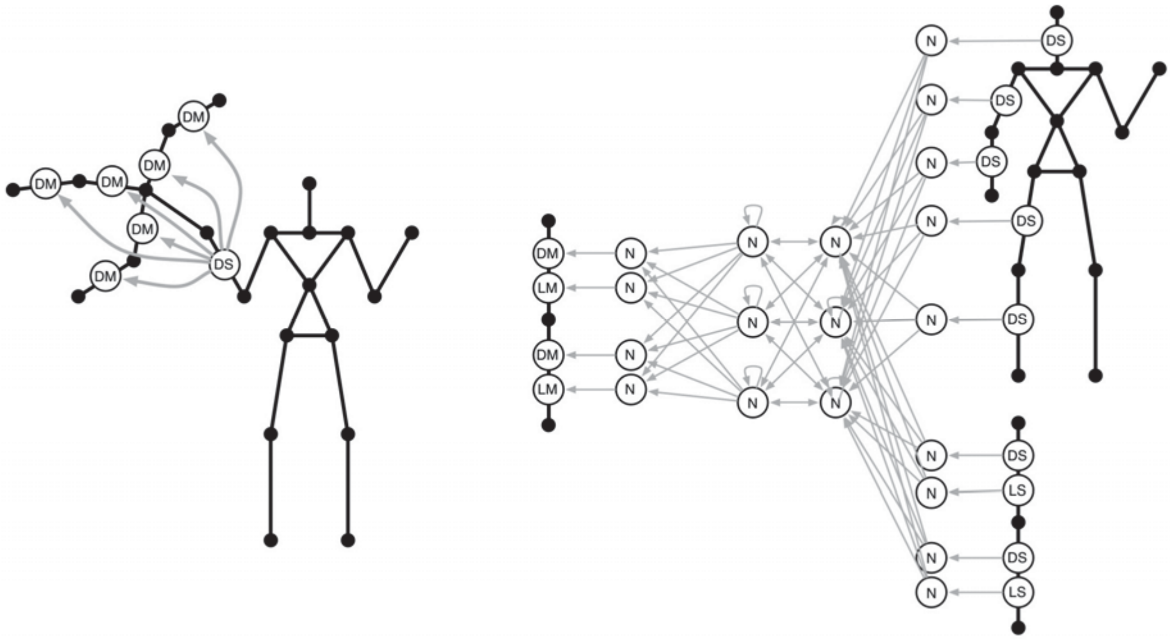

Figure 8. Combination of a Dancer's Skeletal Representation with a Virtual Body Extension. The schematic representation depicts the mass-spring system of the dancer's skeletal structure and the virtual body extension as filled black circles (mass points) and black lines (springs). The directional sensors (DS), neurons (N), length motors (LM), and directional motors (DM) are depicted as black outlined circles. The neural connections are depicted as grey outlined arrows. In the right image, the body extension is depicted twice (once as providing sensory input only and once as receiving motor output only) in order to achieve a cleaner representation of the neural network.

3.5 Sound Synthesis and Spatialization

Four types of sound synthesis approaches are used: an original extended form of dynamic stochastic synthesis, subtractive synthesis, additive synthesis, and granular synthesis. The sound synthesis as well the generation of the musical structures are implemented in the programming environment Supercollider. Some of the dynamics between the virtual body extensions and the dancers are also controlled from within Supercollider using stochastic patters that introduce mutations in the configurations of the body extensions and their attachment to the skeletal representation of the dancers. The synthesis algorithms are controlled by the simulated body structures in a variety of ways. A straightforward approach is to map the vertical and horizontal position of each mass point that make up a body segment to the frequency and spatial position of the resulting sound. The mapping of the coordinates movement of the mass points results in interesting musical phenomena that range from unisons to highly complex clusters. This approach of translating branching graphical elements into musical structures has a famous historical predecessor in Iannis Xenakis *arborescences* [13]. A more sophisticated mapping approach is used in the case of dynamic stochastic concatenation synthesis [14]. In this model, several waveforms generated by stochastic functions (the so-called *gendys*) are juxtaposed. This results in sounds of a more granular quality. The structure of each gendy is connected to the structure of each spring within a body segment, thereby mirroring the spring's shrinking and expanding. Of particular musical interest are the harmonic structures that emerge from those springs which are connected to joint positions of the dancer's skeletal representations. In this situation, the dancer's human body proportions generate waving chords that are transformed according to the choreography of both the natural and virtual bodies.

4. Performance

4.1 Stage Setup

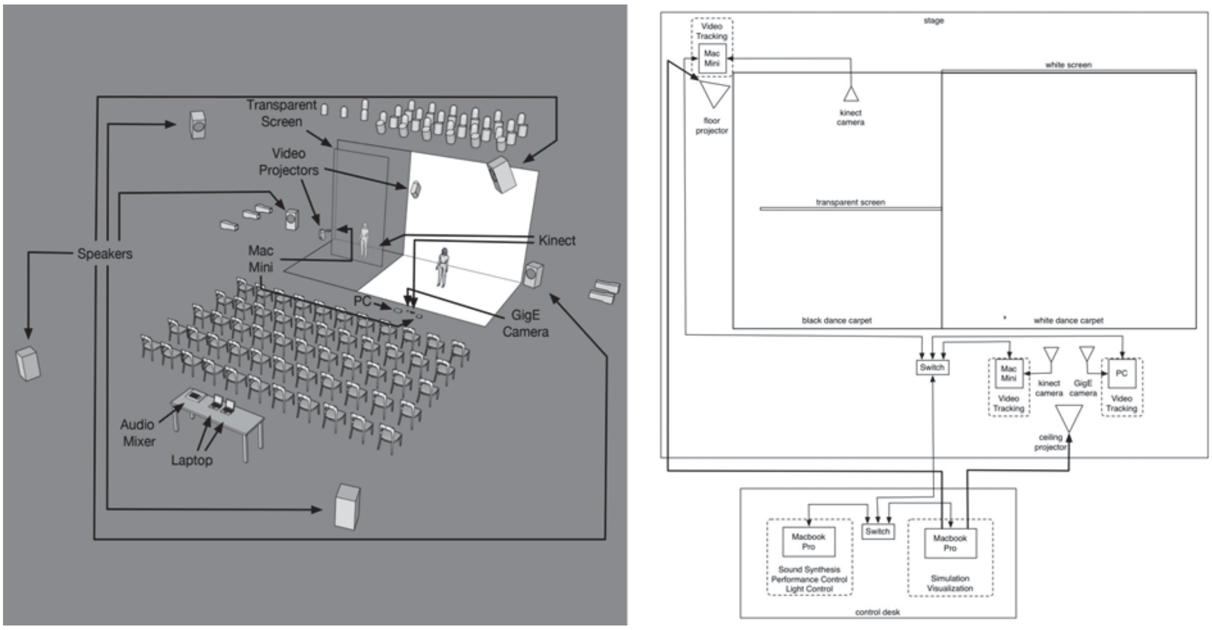

Figure 9. Stage Setup. The image on the left depicts a 3D representation of the stage. The image on the right show a schematic depiction of the hardware used on stage.

So far, the Phantom Limb project has resulted in two dance performances that were shown at La Casa Encendida in Madrid. For these performances, the stage setup was designed to emphasize from the audience's point of view our concept of hybrid embodiment. An acoustic and visual setting was created that allowed the appearance of the dancers to be overlapped with a rendering of the virtual body extensions. A central element of this setup is a transparent video rear projection screen [15] which hangs from the ceiling in front of a dancer. The dancer is tracked by a Kinect camera that is situated behind her. The visual rendering of the simulation is projected from a video projector that is placed at an acute angle onto the screen in front of the dancer. The dancer's tracked skeleton and the graphical rendering of the virtual body extensions are aligned in such a way that they match in position in size from the point of view of the audience. By controlling the intensity of the projected image and the illumination of the dancer, the combined visibility of the dancer and the virtual body extensions can be adjusted to give raise to a mixed appearance.

The right half of the stage consists of a vertical front projection screen that is placed at the back of the stage and a white dance floor in front of it. Both the screen and the floor are projected on via a ceiling mounted video projector. Additional tracking cameras are placed at the center in the front of stage. The audio setup consists of six speakers. Two of them are placed in the back corners of the stage. An additional two are hanging on each side above the audience. And the last two speakers are placed on the side behind the audience. A 3D rendering of the stage setup and a schematic representation of the stage hardware setup are depicted in Figure 9.

4.2 Choreographic Scenes

The choreography for the Madrid performance is divided into several scenes, each of which highlights a particular idea how to relate the dancers' bodies and behaviors to the simulated body extensions. In the following text, six of these scenes are briefly presented.

In scene 1 (Fig. 10, left), a hand-like structure is projected on a transparent screen in front of the dancer. The structure is physically attached to a dancer's skeletal representation. In addition, a simple neural network (Fig. 8, left) allows the dancer to control some of the structure's shape properties. Throughout the scene, the number and position of the body attachments changes.

In scene 2 (Fig. 10, right), a multi-segment structure (Fig. 8, right) is projected in front of the dancer. Depending on the movement of the dancer, the structure fractures and dissociates into multiple freely moving fragments or re-coalesces and re-attaches to the dancers body.

In scene 3 (Fig. 11, left), the same multi-segment structure is projected on the transparent screen. But this time, the creature is physically and visually dissociated from the position and skeletal structure of the dancer. The connection between dancer and the simulated segments is based on relating the degree of opening and contraction of the two body structures.

In scene 4 (Fig. 11, right), a large multi-segmented structure is projected on the white screen in the background of the dancers. The structure is not attached to the dancers' skeletal representations but envelops their body contours. The enveloping effect is temporarily interrupted when the dancers quickly move away from the structure.

In scene 5 (Fig. 12, left), another large multi-segmented structure is projected on the white screen. Contrary to the previous scenes, the structure is not associated with any dancer and behaves as an autonomously moving creature.

In scene 6 (Fig. 12, right), a large number of smaller structures are projected on the white screen. These structures are dynamically created by the dancer whenever she accelerates very quickly. After a certain time, the structures disappear. While the structures exist, they move freely across the screen but the rhythmicity of their movement is coordinated with the dancers' movements.

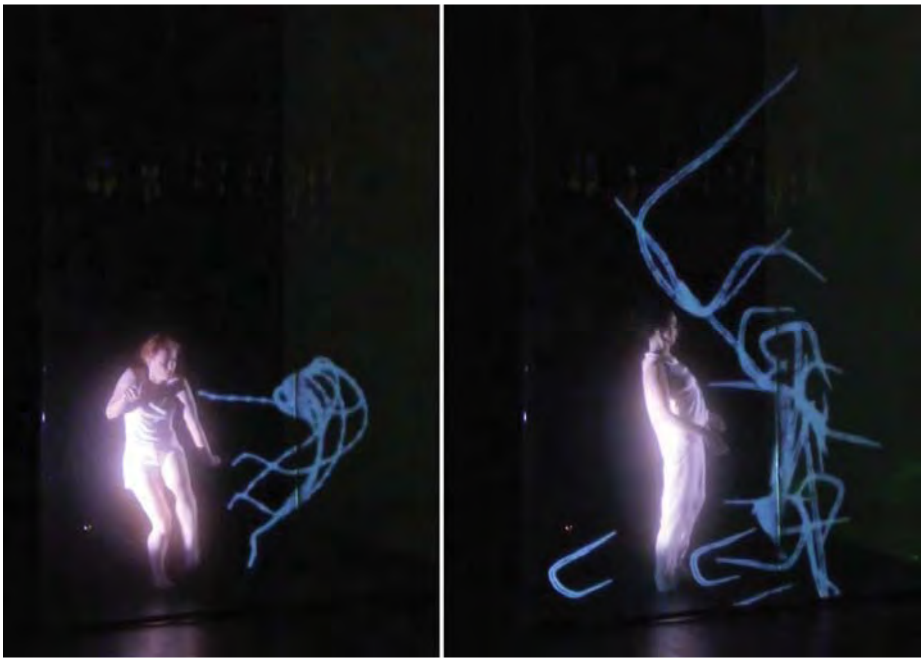

Figure 10. Scenes from a Dance Performance. Left image: Scene 1. Right image: scene 2.

Figure 11. Scenes from a Dance Performance. Left: Scene 3. Right: scene 4.

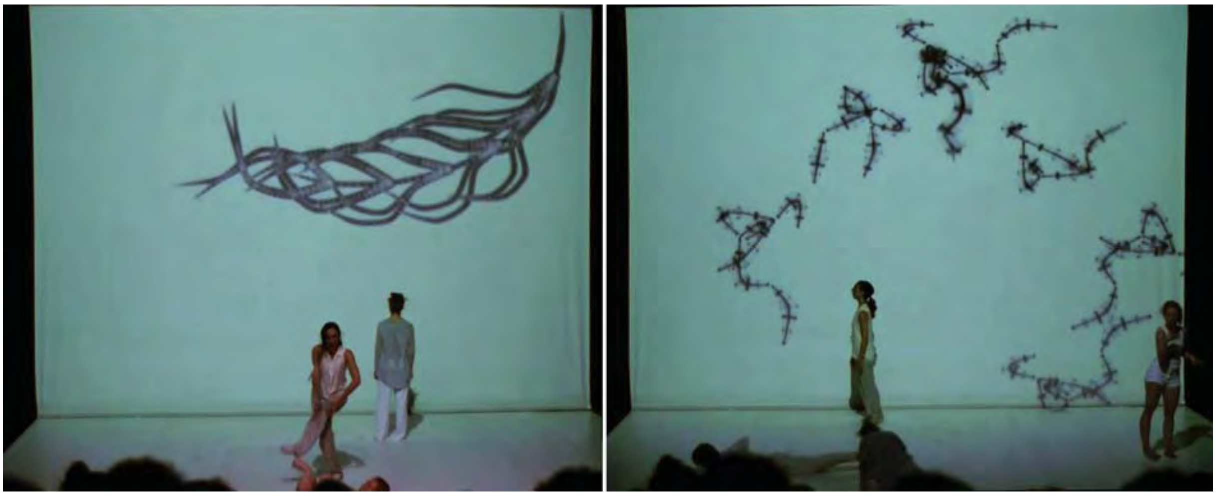

Figure 12. Scenes from a Dance Performance. Left: scene 5. Right: scene 6.

4. Conclusion and Outlook

The main goal of the Phantom Limb project is to experiment with hybrid forms of embodiment in dance. Our approach consists of establishing a simulation-based augmented reality situation on stage. This situation allows virtual body extensions and the dancers' physical bodies to merge into composite corporeal structures whose morphological and behavioral properties deviate significantly from a normal human body. As part of this project, a set of technical tools has been developed that comprises custom developed simulation software, several video tracking systems, audio and video synthesis and spatialization tools, and video screen setups. These tools have allowed us to develop and present some initial performance ideas in the form of a dance piece. The piece has served as a valuable testbed for our ideas and technologies and helped us to outline future improvements and research directions. One of the issues that we would like to address in the short term concerns a certain lack of complexity in the behavioral relationships between dancers and their virtual body extensions. So far, most body extensions respond to the dancers' movements via simple reflex type reactions. In order to achieve less direct and more diverse forms of behavioral relationships, it might be useful to modify the fitness functions that control the artificial evolution of the body extensions. Rather than to reward simple activity synchronization or movement distance, the fitness function could be based on Laban Movement Analysis [16]. Some possibly suitable quantifiers for this analysis system have been proposed by Antonio Camurri and his coworkers [17]. As a further goal, we would like to experiment with additional than purely visual and acoustic means of providing feedback to the dancers about the activities of the virtual body extensions. One possibility would be to employ wearable actuators that can generate tactile sensations. Such a sensation could for instance be triggered when a simulated body segment collides with the hard limit surface of a bounding volume. As part of a rather long term outlook, it would be interesting to combine our simulation-based approach with robotic means of extending a dancer's body with artificial body extensions.

To summarize, we believe that our research which combines ideas and methods from artificial life, generative art and dance provides ample opportunities to explore new forms of choreographing the human body. By creating and manipulating hybrid forms of embodiment, the performers bodily identity can be transformed into a plurality of morphological and behavioral differentiations and possibilities. The fluid transition between these various bodily manifestations creates a level of malleability that helps to transform a dancer's body characteristics into an expressive medium. As such, our approach continues a tradition of artistic works that experiments with the construction and alteration of the human body.

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Enrica Colabella

Generative Artist *behind* machine
Paper

Topic: Art theory and philosopy

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[1] Roberto Longhi, "*Piero della Francesca*", Sansoni, Fi, 1927/1962

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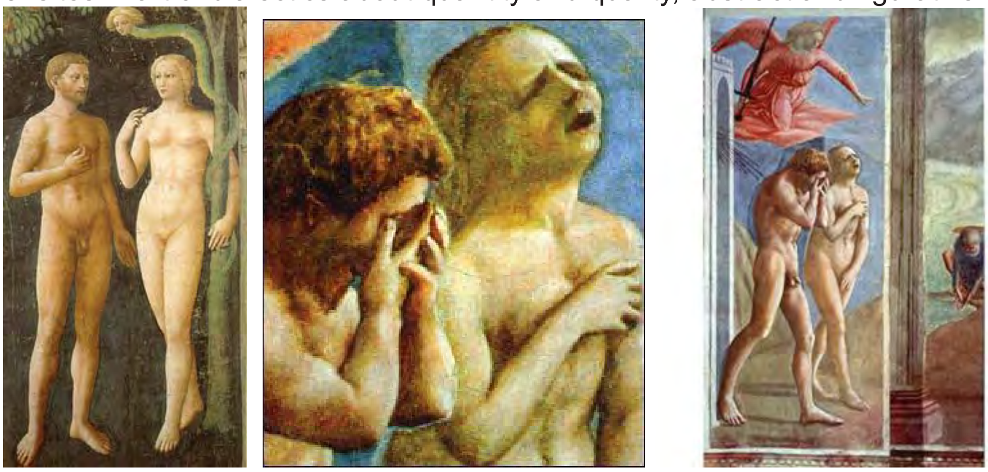
Abstract:

Sapere aude!/ Dare to know!
Orazio, (Epistole I, 2, 40)

The main aim of this paper is to identify difference and similitude in characters of generative artists, after more than 20 years of experience in different fields on GA processes.

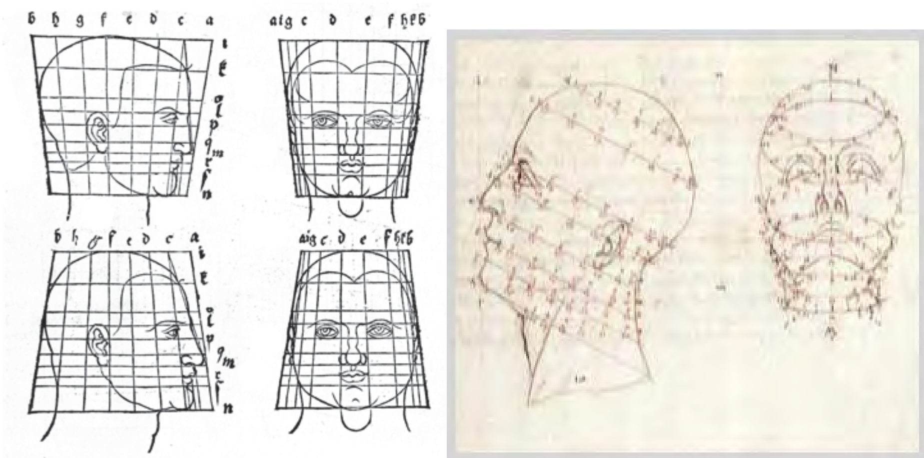
Investigations about:

1. relationship between computers and creativity following the hypothesis that the knowledge process might run toward a *flat* vision in young digital users.
2. the need of scientific references for re/discovering from past generative tools and engines for preserving the cultural human vision in 3d, as a character of our evolution as species. Main reference: the invention of perspective, the first experimental science for painting and architecture.
3. sites in art of dialectics about quantity and quality, abstract and figurative.



Adam and Eve by Masolino in absence of perspective and Massaccio's perspective in humanistic vision in Cappella Brancacci, Florence.

About perspective:



Differences between Durer analytic approach in illustrating heads circumscribed with a box and for movement the use of plans and elevations and a drawing of heads by Piero della Francesca with the definition of endless logic interpretations, all belonging to the same head configuration.

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Keywords:
Perspective, logic interpretations, quantity and quality, abstract and figurative.

Generative Artist *behind* machine

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The main aim of this paper is to identify difference and similitude in characters of generative artists, after more than 20 years of experience in different fields on GA processes.
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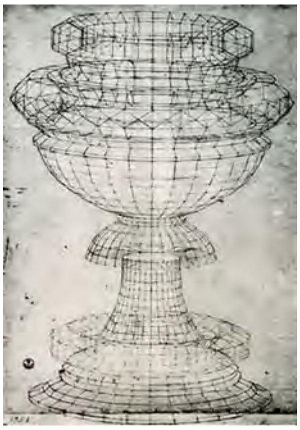
1. relationship between computers and creativity following the hypothesis that the knowledge process might run toward a *flat* vision in young digital users
2. the need of scientific references for re/discovering from past generative tools and engines for preserving the cultural human vision in 3d, as a character of our evolution of species.
Main reference: the invention of perspective, the first experimental science for painting and architecture
3. rediscovering dialectics about *quantity and quality, abstract and figurative* in art

Premise:
Ars sine scientia nihil est
Jean Vignot, 1392



Attributed to Paolo Uccello or Piero della Francesca Study of a Chalice, *c 1450 – 1470, pen and brown ink over ruled stylus and compass, 349 x 243 mm, Uffizi*

In our digital time the main character of an artist might be *generative.* It depends by this main condition in using the attribute generative:
in the significance in which art becomes a way of reaching a complete synthesis as possible between the disappeared past and the alive real.
This significance follows also the scientific using of biologic world.

1a: Ars

GA is the art of connections. More logic connections are you able to perform, more you are crossing complexity. Connections are generated from the 3 main structures of our heart: *Memory – Intellect – Will.*

So a process is generative when from the starting point to the results it is able:

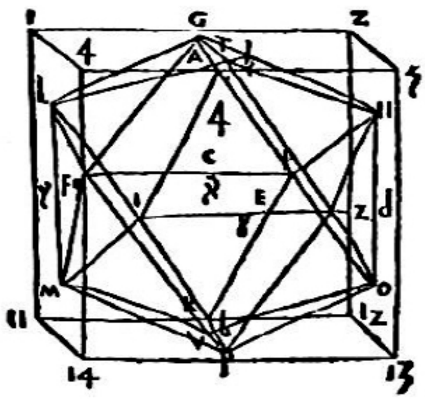
1 - to structure impressions as an open artificial *memory* system, through the definition of aims by gaining through tools in open dynamic connections.

2 – to perform an idea/code as a possible first expression in evolution.

Designing a software*, intellect* is able to perform the translation from impressions as an idea into expressions as variations.

3 - *Will* is necessary for gaining emotions in people hearts. Will is the main tool of connections. More will we should be able to put on our table of work, more we might gain emotions in art users.

1b: Scientia



Woodcut: Perspective study,
Piero della Francesca, De perspectiva pigendi, *c. 1480*

The first experimental science is perspective, by following *Decio Gioseffi* **[1].**

It might be that perspective was known to artists before *Brunelleschi* time of Renassaince. There are a lot of studies around this hypothesis. It is real possible, being perspective a tool following a *natural vision* for representing reality.

But the great invention by *Brunelleschi* with his *tavolette* (small tables)) and by *Piero della Francesca* with *"De perspective dipingendi*" applied in his wonderful drawings and artworks were able to define a new experimental science.

In the Italian 400, *Piero* is the inventor of "*La Pittura Chiara"*, as the site in which the light of day seeps and seems to disperse the opacity of symbolic color. *Piero* is called *the poet of shapes*; his poet's task, as *Bonnefoy* says in *"Afterword",* is to turn the works of the self *"into the flame that consumes them, and to love, first and foremost, the light from this flame".*

He defined methodology and tools useful for endless representations with infinite inside. In this way our imaginary vision can be strongly connected with reality in transfiguration; by performing drawings with our imagination too inside

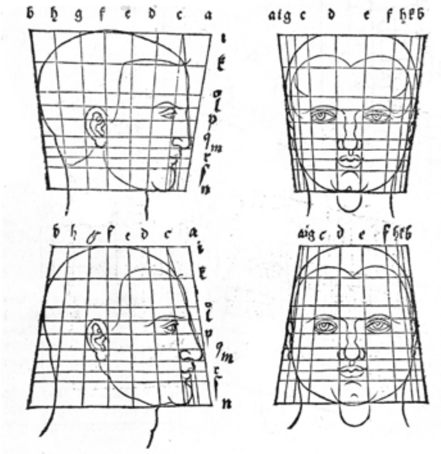
1c: Il *Disegno,* an ancient tool for art

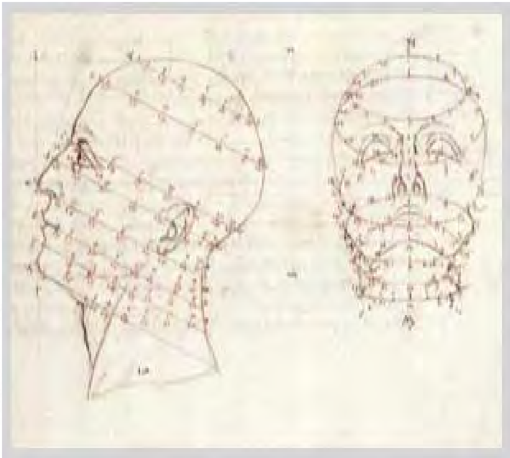
Il Disegno is the Italian word for drawing. It is a more complex term, able to connect drawing and design. About the significance of *disegno,* the Tuscan painter and architect Giorgio Vasari wrote in the II edition of *"Le vite dei più eccellenti pitturi, scultori ed architettori".* 1568:

"...Seeing too that from this knowledge there arises a certain conception and judgement, so that there is formed in the mind that something, which afterwards, when expressed by the hands, is called disegno, we may conclude that disegno is not other than ***a visible expression and declaration of our inner conception and of that which others have imagined and given form to in their idea."***

In this words it is very clear the structure of a generative process that is complex for the reason that it starts from the world of imagination as an idea for becoming *real* through words and drawings, that we translate in algorithms for machines. These are *neo-logoi*, able in representing the transformations of past in an adaptive resonance caching the chromatic variations of vision. This generative procedure follows the *green endless* variations of Nature in the different seasons in the cosmic tour. With this procedure the generative artist qualifies that art starts by the act of perceiving connections. So the investigation with will and curiosity is the basis of his identity building.
The great master is *Piero della Francesca*. He is the great connector of endless ambiguities, of the multiple interpretations and of the ancient tools that coexist more and more with *neo-logoi*, for disclosing them in the evidence of their representations.
This happens in his artworks as in "*the stolen letter"* by Poe, left in evidence, without ambiguity, neither any clear or dark and without deceptive artificial shadows.
Everything in *Piero* is represented in a shine of endless beauty, real generator of wandering, closed to hand and infinitely distant, He performs a drawn pictorial reality as mirror of infinite, that it is in each of us. This complex procedure is represented by *Piero,* that is a collector of the human science of the numbering from Pythagoras until his own time, faithful custodian and shiny visionary experimenter of the poetics of the geometric forms. *Piero* connects the science of the space with the logos, where the meaning is not the dominion of the space but the purity of the sound.
The sound produces ideas, that take forms following the generative concept defined by *Leopardi in Zibaldone:*
" An idea, without words or way of experience, escapes us or it errs around us in the thought as indefinite or bad known also to us, that have conceived her. With the word she takes shape and almost visible sensitive and circumscribed form."
We thing by speaking.
Our thought formalizes it with words.
In *Piero's* artworks the infinite generative purity of the sound of word is veiled among the folds of spaces of harmony.

2 - Quantity versus Quality





1 – Durer, analytic definition of quantity 2 – Piero della Francesca, visionary definitions of quality

Differences between Durer analytic approach in illustrating heads circumscribed with a box and for movement the use of plans and elevations and a drawing of heads by Piero della Francesca with the definition of endless logic interpretations, all belonging to the same head configuration.

2a - Over "Divide et impera"

By over classing a rhetoric question of power, Decio Gioseffi in in his paper "Filippo Brunelleschi and the Copernicus turning. The geometric formalization of Perspective. The beginning of the modern science" talks about the role of perspective's discover for the foundation of the modern science. He defines this role as immensely greater in front of the opinion of several people. It is the first mathematic systematization of a "physic" law that can be extended indefinitely, of general validity and verifiability.
But n ' 600 century we see that the division between values quantitative as real at all effects and qualitative as subjective considered of any scientific value , was yet performed by Boyle, Locke and Galileo. In this vision of the world it is considered real only what is miserable as a quantity. More to this division is added the great synthesis made by Newton in "*Philosophiae Naturalis Principia Mathematica",* 1687; where, *de facto,* **quantity** becomes what is explicable with a mechanic model. We have to wait a long time for the fusion between quantity and quality after an hard and complicate iter for gaining appreciated verifiable results toward the middle of the last century . When it is very important to focus that various sciences, that in past time were divided and not related, tried to perform connections in new sites, passing the secular antithesis. **This synthetic vision becomes as a revolution in the concept of machine.** We can assign the data of 1943 when the collaboration between the physiologist *Arthur Rosenblueth* and the mathematicians *Julian Bigelow* and *Norbert Wiener* gives as result the paper "*Behavior, Purpose and Teleology",* published in *Philosophy of science* **[2].** It is with this well known paper that was founded cybernetics or the science of government with the fundamental results:

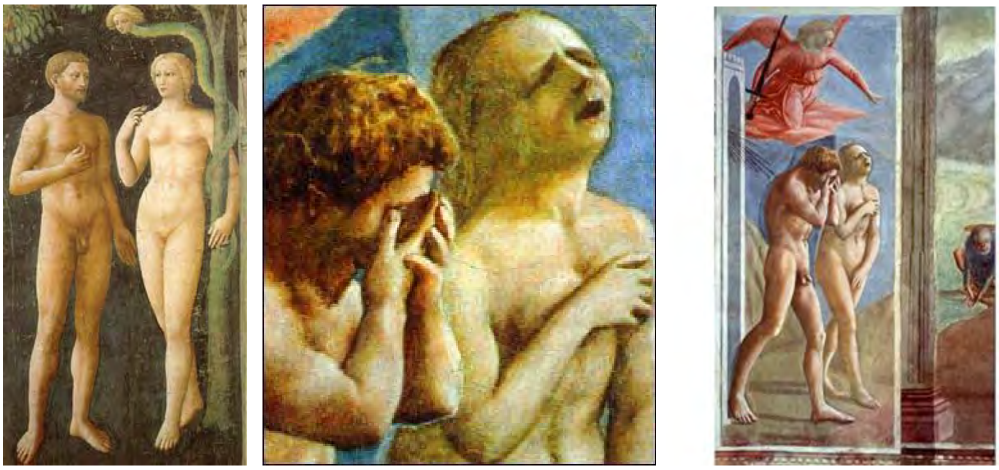
1- Cybernetics enters in a new site different from that qualitative of biology and from that quantitative of mechanicism

2- The control of every machine is founded on the information's quantity

3- The organization becomes auto-organization in base of the possibility that have the effects in back aging with causes.

The same mathematics changes and also logics is putted in discussion. Ashby wrote:"Man doesn't think logically but **dynamically**"". The effective operation of the machines of new type does not allow anymore a distinction able to generate an insulating process between quantity and quality. Once the quantity becomes seen as its process of evolution, quality becomes an integrant part of every organization both natural and artificial.

2b - Abstract/figurative from Masaccio until Cezanne



Adam and Eve by Masolino in absence of perspective and Masaccio's perspective in humanistic vision in Cappella Brancacci, Florence.

Masaccio made a real revolution in painting by performing people and space as Vasari defined " *Sembrano reali, quanto il vivo (They looks real as the alive)".* His life is very short, he lived only 27 years, but he leaved an indelible sign in art. All artists of his time and for many centuries, Michelangelo too, went to see his revolution in Cappella Brancacci for learning how to apply at the best the new science..
This painting was defined by Longhi "*una folgorazione fiigurativa"(a figurative lightining)*; for the contrast between abstract and figurative .Here they became a clear and indelible sign of the complexity in art.

.
With Veermer, Cezanne was a great follow of Piero science. His poetic art in painting is prefigured in " *An unnown masterpiece*. Here Balzac had foreseen that painting could happen to overcome itself in something gigantic of which nobody was able to discover the significance. Balzac is the poet of life. *The human comedy* is the identification of the eternal human characters in the same abstract vision of the identical as an human coding, that repeats singularity in infinite variations. And it is this identical, coding that is represented in *An unnown masterpiece* . **The identical human coding is not figuration but abstraction**. So it is the code of every

character of his comedy that as in the real life meets similar and dissimilar for representing a comedy of which the artist is the craftsman as mirror of the true life. The angling of the vision continually changes, at times it overlaps to the character when the intensity of the emotion is strong, at times it is distant, at sidereal distance when extraneousness is strong and the coldness and the indifference dominate the feelings of the artist. This crossing the variations from the intensity connected to the author *proximity* performs the character of the poetic result in **art. Only this variability of the distance in time and in space it is performed about the human life**. It is enough here quoting *Infinito* by Leopardi, for finding again in our vision the memory and the infinite in our imaginations; as an endless music with the timbre variations.. Their performances are expression of the endless variability.
About Cezanne, Longhi sets Piero as his main reference for his main phase, almost a watershed, of a way of painting that he defined *"of perspective synthesis of the form and of the color"* Longhi,(idem, pag.76) and that he defines "Paul Cezanne, the greatest artist of the modern age" Longhi. (idem, pag. 106).
IN ART ABSTRACTION IS THE WORD THAT IDENTIFES THE MATHEMATIC PROCESS SURRENDING THE RESULT. The dialects that open the beginning of ‘900 abstract against figurative is the result of the lost of the center in science of the human vision toward a false emphasis of technology, that become the new center with money of humanity.

“Art is the Queen of all sciences communicating knowledge to all generations of the world”
Leonardo da Vinci

3 – The characters of a generative artist

1 - Computers and words sounds
Computers are necessary, but they are not enough for gaining a *really* generative art expression.. After having focused our ideas as logics, we can translate in algorithms our first steps of discovering possible new representations of the world.
Ideas are totally abstract. So it is very not congruous to a generative system to perform them only as algorithms especially if we stay in the starting point of our generative experience around a new investigation.
Algorithms are logic interpretations. They are the translations in computer language of geometric matrices. These tools are very ancient and very useful for identifying the process since its origin, ,in fact we can call them in a better more open way numbering structures as generating tools for performing our idea/vision.

Je ne peux entendre la Musique de l’être
Je m’ai reçu la pouvoir de l’imaginer.
Yves Bonnefoy, Dans le leurre du seuil (1975) **[4]**

3a - How to become today a generative artist.

The main condition is that other people recognize you generative as artist. You may affirm: ” I am a generative artist”, but for experts this is not enough. But where and how is it possible to recognize *really* the generative attribute of quality in an artist?
1 – By performing aims as characters.
Without aims it is not possible to design tools for gaining the prefixed aims.

2 - By generating *neo-logoi*
Words in a generative structure follow their most adaptive significance. They are sounds for performing characters. Musical sounds in open systems, but real tools for a performing aim.
We can delaine three main sub-conditions for performing *neo-logoi, as tools for our times:*

1- to work following scientific procedure
2- to be visionary, open and adductive
3- to gain results following a poetic vision

These conditions perform the main structure of a generative process. Here random works but not as protagonist. Every result is fixed in the artist memory as a precious element of experience. The image of this generative process might be a tree performed from a double direction. One is performed starting from heart, as we said, between ***memory, intellect, will;*** the second direction is connecting with the first through an abstract structure between ***vision; memory; imagination*****. Memory works as connector of the double structure.** It is delineated in progress a working process between *impressions* and *expressions* for generating *emotions*. So the main aim in a GA process is to generate emotions and the main tool is *the performance of a singular emotional vision*, so as always the work in art is performed. If we go back in Renaissance we see Leonardo working at the beginning of his experience in art at the *bottega of Verrocchio* for learning tools and methodology but in the same time for focusing clearly in his mind in his own vision, as a *poetic point of view* in progress.

3b - The language of a generative artist is mathematics
This is the only one that machine can understand. So numbering is the main structure of a creative mind exercise for generating artworks. But numbering are in primis sounds. Sounds run in a creative mind connecting fragments of visions, from memory, walking with imagination, fixing them in a "*digital reality".* These processes are able to connect also differences between disciplines, in a discovering that can start also from words for performing an algorithmic structure.
Generative is an artist able to experiment a transformation from past to a new vision of world, following an open adaptive character performed in mind as the main aim of his expression process. In our digital technology time, the challenge is in affording computer devices for generating our poetic recognizable vision.
.A GENERATIVE ARTIST performs *an artificium* as expression of his own impressions following an emotional tonality.
This is not a question of figurative or abstract art. The process of recognizing belongs only to the expression of a poetic vision or not. We perform our singular *"poetic"* vision of the world around us in our infancy. This is performed as a singular proper expression of the impressions that gained our mind in singular adaptive way, learning us in recognizing *the reality* all around our vision.. This is the quoting of the so many reminds to our infancy time expressed by a lot of poets, scientists and philosophers.
So if we procede in fractal way from reality to art, we can affirm that each generative artist build a specular artificial world following his singular impressions encoded in infancy. In art is not a question to recognize reality or to see an abstract result. Each result in art is also abstract, because it belongs to a singular hidden vision of reality as a singular code, expressed at different scales.
Vision; memory; imagination work with their 3 sisters: a mirroring memory with

will and intellect. We can see these words metaphorically as a river on which the generative process might run sometimes on calm transparent waters. other times on dark stormy ones, but following always a possible direction of experimentation. This needs two important tools:
1 a vision performed in characters by gaining with an idea/ code/hypotheses
2 logical interpretation, abductions from the real world expressed by concrete tools for performing rules of connections between elements of the generative process.

4 - The generative process, experiences

. Following *Yves Bonnefoy*, we can affirm that*..." word does not save, sometime it dreams..". "For this reason we have always preserve and spread the principle of hope, that is the heart of life. Poetry is the hope in the language".*

So we can define generative an artist able to collect experiences following a performing vision for focusing in progress knowledge and responsibility in answering to the human aesthetic needs.
But it happens that when all are artists, as easily it can be affirmed in our time shaped only by the dominion of the appearance, nobody is an artist. This deduction doesn't belong to the true reality. The art changes techniques, tools, poetics, but a need inextricable of the human mind remains as a not cutting necessity in expressing our tale with figures, words, sounds as the impression of our own vision of the reality.
It is art **the necessity to translate the reality in thing,** for escaping things out of the frailty of life, as precariousness that any technology and scientific discovery can never compensate, living in every human being the conscience of his own precariousness

Abstract and figurative in a whole: ***poetry in prose***

The origin of the main structure of a generative art process is identifiable in the structure of ***poetry in prose.***
This is very ancient. It can be discovered in the structure of the fable. The sounds of voices in fables telling are able to perform the children minds as full of imagination. Fables configure a double site: one connected to real world, the second one able to describes an imaginary world, but able to configure the reality. This is strongly similar to the creative process in generative art. It tales the connection between a possible vision as idea/code to an open algorithmic structure. This connecting is able to generate a set of endless variations There is ***a similarity*** between the open system of the voices of telling and the variations of a generated reality . What is strongly identifiable is the code of tales, able to repeat variations during century of the same fable telling. . I investigated about the code of fable in my GA paper "*Mater Matuta"*: **.[5]** This fable process was systemized as popular voice connected to poetry in French, 1664, in *Maximes* by Francois La Rochefoucauld . This work opened a new line for preserving in written works the popular sapientia, able to be generate similar but always in new ways during centuries. Poetry in prose are also *"Le operette morali "* by G. Leopardi, *performed as a connection between myth and real world.* This process is still alive today in globalization, by preserving cultures through their mater

tongue.
This double center of the connection between real vision and imagination performs all the opera by Piero della Francesca. He was the most important author of performing logic geometric structure as experimental science over all the world. His structure art is very similar to the art of poetry in prose. I selected one great example for describing the complexity of the world by *Piero: La Flagellazione*, the most discussed site in art as mystery able to generate endless interpretations, also for mathematical questions.

Piero della Francesca, *"La Flagellazione"*

Talking about this work but with reference to the whole painting by *Piero*, the poet *Bonnefoy*, has spoken of "*strategy of the enigma"* .
Longhi to his students proposed *…""Here it is the intent to arrange in front of you, in the space, a construction of human bodies immovable that is in architectural relationship*… " (Longhi, idem pag. 77).
Longhi spoke of "*the rest of the color"* (Longhi, idem pag. 79) *for intending that the color, in Piero, never has the tendency to offer a convulsive and dramatic vision of the world, but on the contrary a serene vision, consequential from the idea that a rationality and a beauty cosmic, absolute, unperturbed dominate on it and they direct the events of it, also those more dramatic and bloody.*
"Therefore,by writing , by painting and by calculating, Piero is a real theorist. His same painting does not show a theory of style or a practice of it, but it expresses the whole of his technical, scientific and philosophical knowledge, that founds it".
The monumentality of the characters of *Piero* is not aching and heroic as that of *Masaccio.* They are serene and situated in a context of rational and spiritual harmony of the world. The world painted by *Piero* is *"a new world , in front of the frescos by Masaccio"* (Longhi, idem, pag.420), a world where the perspective is not an arm with which man, hopelessly heroic, tries to affirm himself in the world ,but that in which, found again the serenity. He accepts the laws of the world, of the cosmos, of the universal reason.
This incredible small picture was rediscovered after many centuries, in 1839, in the sacristy of the Duomo of Orvieto by *J. D. Passavant,* but only in 1860 was restored in Italy, losing the significance of the script for possible interpretations: *" Conventur in unum*". In our time after a lot of studies on this Piero's artwork, the truth of his great

authority inside the perspective science in painting is well known over all the world. *Venturi, Longhi, Berenson, Ragghianti, Battisti, Kemp, Gombrich* and many others scientists, historic writers and artists dedicated to *Piero's* opera very interesting studies and books.
In my humble interpretation, *Piero* described also the double structure of fables. One, on the right, is the description of the reality of his time. On the left, the second part is the vision of the sacred world in J. Christ flagellation. The quoting : *"Conventur in unum*" might be a demonstration of this hypothesis configured by me. So I can affirme that Piero is also the great translator of the art of fable telling into the science of painting. Piero is the father of all generative artist, for his great science that connected all the scientific knowledge on poetics, on geometry and on all sectors of mathematics from *Pitagora, Averroè* until Franciscan knowledge with his incredible unique attitude to art and science. It is not possible to talk of art without science, as *Piero* teaches to us still today.
The writer Aldus Huxley in *" The best Picture"* defines "*La Resurrezione" by Piero* as the best painting over all the world, by defining it *"an experiment of composition so strange and so winner from the beginning*". With these words he recognizes the complex science that is possible to discover in infinite congruous interpretations.

La resurrezione by Piero, fresco, S. Sepolcro

Going Forth by day, Bill Viola, 2002

the art of the Game, Michael Brown

From cinema to digital technology
The ancient structure of fable was still alive with the advent of cinema.
In the first public exhibitions cinema created only shock in its visual configuration. Insofar the vision was always correlated by the music that a pianist elaborated on a preexisting musical trace. The vision collective image and *alive* music shaped an artificial world but strongly connected with the reality by reminding to the tales world .
A sonorous poetic vision of great beauty. With the sonorous in movie the relationship

changed completely. And with the new technologies it is performed a total new site of communication, where rules of connections are very arbitrary.
1 - In *B. Viola* video-tapes exhibition in Getty Museum at LA, 2002, the plasma video-panels is defined by the same dimensions, proportions, frames, compositions, colors of *Piero*. A video quotes explicitly *The Resurrection.* This is a great experimentation of technological tools. The main aim is to render alive the artwork, by using real persons and environment. This process works by gaining the perfect reproduction of the reality of the *Flagellazione* as quantity, but missing an abstract interpretation as quality, In fact the perspective complex system designed by *Piero* as hidden structure by discovering Is not interpreted. In the video projection on a wall, reminding to *Piero's fresco,* the movement gain spectators in a new world as a game cloned from art, without emotion. The inquietude is the only feeling able to destroy any imaginative interpretation. The video is a new reality where only technology is the winner. To experiment in art is really very important, but to discover a poetic similarity is the heart of every experiment.

2 -Browne painted this tribute to Eric Cantona based on *Piero's* painting.
Only a double game!

5 - A letter to a young artist:
I am imagining a young generative artist on his table behind his machine, trying to realize a generative process. His computer looks like a dish on his table waiting for some food. He can catch around, for putting down the most easy and fast food, by copying and pasting data for gaining a randomly solutions for his hungry moment.
But sorry hungry for what? Is art a necessity of his as real tool for his surveying? Or is he trying to full empty spaces of his mind for trying to give a significance to his life, that can be acclaimed from other people. So it seems that a GA process can gain a fast recognized result, spending time in a random exciting way. Appearance, this is only an appearance.
A moment of exaltation, without any trace. No art is gained.
But thanks to *the lighting birds*, it might be that the process of discovering a poetic sound is opening a window in a small site of his heart.

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Francesco E. Guida

Generative Visual Identities. New scenarios in corporate identity. *(Paper)*

Topic: (Design)

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Abstract:
In the **communication design** field, main applications of a generative approach are for information graphics and flexible visual identities. Looking to recent practices we can observe cases of **visual identities** – that can be defined as **dynamic** or **post-logo** – that present a completely opposite approach compared to the traditional production in the field of **corporate image**. The use of visual languages that are more fluid and expressive, variable, context related, processual, performative, non-linear, consistent are now preferred to the usual and static repetition of a logo or an imposed series of rules [1]. The classical structure of corporate identity – a subject representation through a series of primary and subsidiary visual elements which has in the manual his book of rules – is reactivated by the use of meta-design tools and processes that can be compared to the transition from closed to open systems.
Galanter [2] affirmed that generative art refers to any practice where an 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. This definition emphasizes the artist proactive role in the definition of rules or guidelines that allow the production of multiple solutions consistently to the framework [3]. This is the same in the generative design practices, that look to be something more than just a generation Y passion.
In generative design practices, the user of computer and ready-made digital tools (professional softwares) becomes the programmer of **personalized digital toolboxes** – often developed by using Processing, VVVV or java-script codes –. This approach deeply changes the design process and the perspective of practitioners, introducing the idea of a **new craftmanship**. Technical issues remain in the background, abstraction and data parameters come into the foreground. This new scenario in the creative and design process empowers the designer [4], freeing he from the constraints of predefined computational tools, and promoting creative freedom in the construction of visual metaphors [5].
The aim of this paper is to argue this recent evolution in the field of visual identities and in the wider area of communication design practice. by showing a series of case histories as well as presenting the results of some experimental projects.

Example: generative visual identity for a micronation (experimental project developed by M. Posani, G. Ponzetta, E. Sciolto, coordination prof. F. E. Guida)

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Keywords:
Communication design, visual identity, corporate identity, post-logo.

Generative Visual Identities. New Scenarios in Corporate Identity.

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Introduction

In design processes the use of computer and related tools, as we can define softwares, it is today an extended practice in conceiving and producing forms. Mainly designers, architects, as well as artists, use proprietary softwares (or closed source softwares), that limit the possibilities to the ones provided by package developers. Those limitations have been effectively underlined by the expression “form follows software” [1, 2], which make evidence to the need by the creative world people to experiment all **open source programming codes possibilities**. Reas [3] expressed well this way of thinking: “Proprietary software products are general tools designed for the production of specific types of forms (…) To go beyond these limitations, it is necessary to customize existing applications through programming or to write your own software”. A direction that Galanter [4] already summarized therefore: “It was seemingly inevitable that soon after the adoption of the computer by designers as to manual tool for CAD, to there would follow the adoption of genetically inspired algorithms for the creation and selection of variations”.

In these words is indicated by the fact a course recorded for about ten years in many areas of design and in particular in **the field of communication design**. And that it is proper to the so-called Generation Y (those born between 1980 and 1996), for which the use of technology is natural if not obvious [5]. The intriguing present scenario sees **graphic designers** using more and more programming in the definition and construction of **visual identity** projects whose results are characterized by variability, flexibility, dynamism and multiplicity of forms. The peculiarity of this phenomenon, besides the use of programming, is the definition of a formal genetic code, a system of basic rules and management of the forms themselves. This premise allows to bind to a similar phenomenon –as we will see in follow– the term of generative design.

The aim of this paper is to argue this recent evolution in the field of **corporate identity** and visual identities and in the wider area of **communication design practices**, by showing a series of case histories as well as presenting the results of some experimental projects.

1. On the definition of Generative Design

The definition of Generative Art by Galanter [4] 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". This emphasizes the proactive role of the artist in defining those "evolutionary" rules –as are called by Soddu [6]– or guide-lines that allow the production of multiple solutions consistently to a framework [5]. It is possible to observe this approach in several cases of **Generative Design**. When this approach is applied to a visual identity system, the designer defines a system of rules more or less variable on the basis of parameters that can produce multiple formal variations, not at all predictable. This is consistent to the very first definition given by Soddu on Generative Design "as a morphogenetic process using algorithms structured as not-linear systems for endless unique and un-repeatable results performed by an idea-code, as in Nature" [7, 8].
Again Galanter [9] affirmed, "generative art happens when the artist give some part of control to another system so as the result would differ from an art creation of spontaneous decisions of an artist." In the field of Generative Design, this other system can be represented by programming codes or customized computerized machines. That –according to Manovich [10]– generate multiple formal solutions, to set up automation, repetition, scalability and variation processes. Systems that must be considered like facilitation tools of a creative act, as they allow to spend more time in experimentation, research, production; and the final result can be more satisfying for the designer as well as consistent to the design ambitions and requests [3].

The designer is not anymore just the user of ready-made digital tools, becoming himself programmer of **customized digital toolboxes** by using open source codes like Processing or VVVV. That changes not only the design process but the role of the designer himself. As far as technology support is relevant, technical matters are relegated in the background on behalf of abstraction and data parametrization that means on behalf of a meta-design level. The use of programming in creative and visual communication design processes "empowers the designer, freeing he from the constraints of predefined computational tools, and promoting creative freedom in the construction of visual metaphors" [11]. The designer part becomes the one who defines parameters to generate forms not losing sight of a visual identity system main task that is to identify and to make recognizable an organization [2].

2. Tradition and Innovation in Corporate Identity

In the communication design field, main applications of a generative approach are for information graphics and flexible visual identities. Looking to recent practices we can observe cases of visual identities –that can be defined as fluid [12], dynamic or post-logo– that present a completely opposite approach compared to the traditional production in the field of corporate image. The application and repetition of a logo (the unique sign of identification of an organization) following precise rules is a conventional and traditional practice method. There is now an opposite practice that prefers the use of a more fluid and expressive visual languages "characterized by variability, context-relatedness, processuality, performativity, non-linearity, coherency ..." [13].

An innovative way of thinking and practicing that reflects the evolution of the brand field as in the words of Boylan and Cox, designers at the well-known brand design agency Wolff Olins [14]: "the brand is no longer a single neat and tidy logo that you stick in the same place every time. Our thinking of brand has moved on. The brand is the platform, the brand is flexible, the brand is a place of exchange, and it is not fixed, so there is not one logo. There is recognisable form and recognisable communication and behaviour, but it's not one type of constrained and fixed thing”.

The representation of an organization –as it is with a traditional corporate identity approach– by a series of primary (the logo first among others) and subsidiary elements, whose prescriptive expression is the manual [15, 16-17], is revitalised by the adoption of formal building tools and processes nearer to meta-design matrices. That is a change from closed (e.g. logo-centered) to open systems [18].

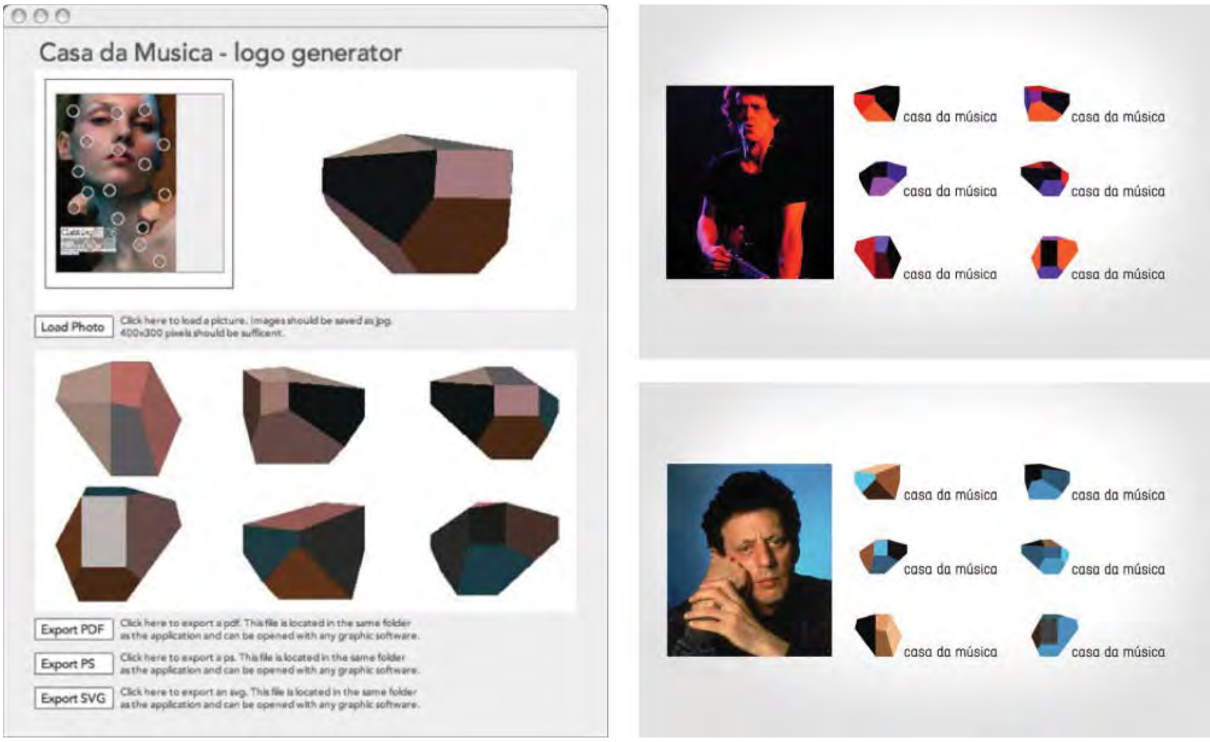
The designer can use programming not only in the two or three spatial dimensions, but also in the fourth, the one of time. Time modifies the image's appearing not in a controlled way, but in a programmed way. This approach –not new but actual, considering that already in mid-60s there were cases of flexible visual identities [19]– is closer to divergent thinking that are interested in the production of multiplicity and variety then to the convergent and pragmatic thinking. It is possible to affirm that this is an approach closer to a soft one (as it was for Peter Behrens designing everything for the former AEG) then to an hard one, centered on the manual as a technical and bureaucratic tool [20].

3. Logo-Generators

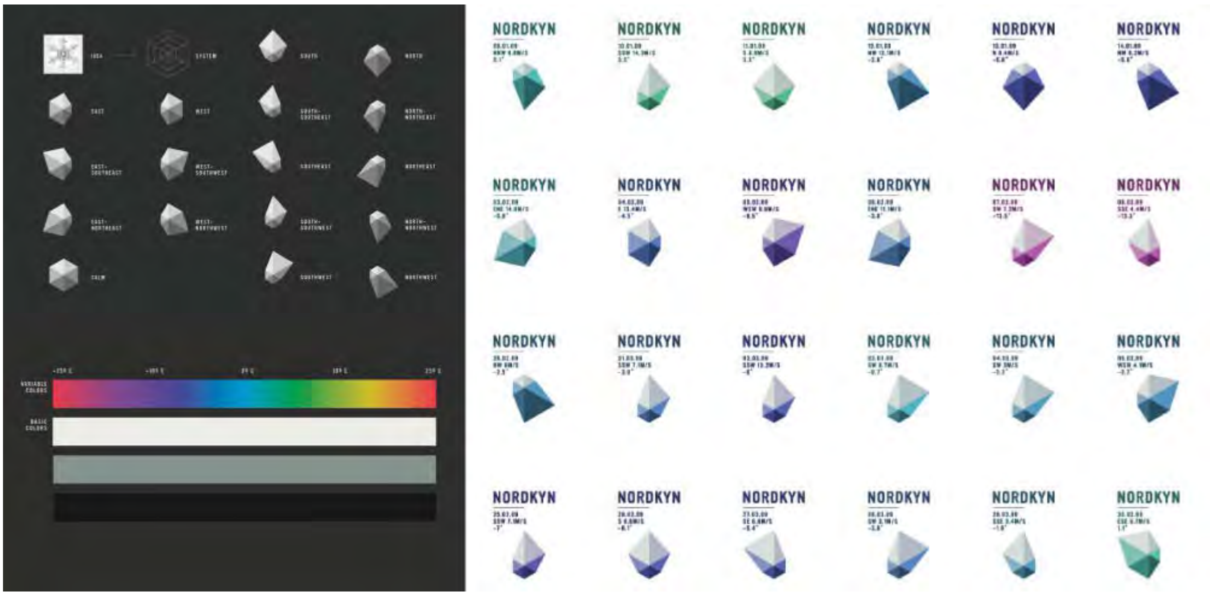
In consideration of (all of) the above, observing the international practice it is possible to identify some case histories of logos or visual identity systems that match this idea of brand's multidimensionality suggested by Boylan and Cox [14]. The trend is the design of **toolboxes**, called **Logo-Generators**, that allow to manage a finite number or not of a sign variations to use as identification sign. Variations are managed following a strong meta-design approach: the design of the process is preferred allowing control on the whole visual identity. What is relevant in this process is the design of the “control knobs” that generate variety and guarantee the identity permanent elements [18].

Chronologically the logo-generator for the Casa da Musica [21] is one of the very first. It works on six versions of a basic sign, necessarily inspired by the Rem Koolhaas's design of the building, showed from different perspectives. Through the different views of the building, 17 facets are defined – from those a 17-point color-picking mechanism is created as customized software. That allows to select from images the colors of the sign to be used in the various communication matter for particular events or the staff (e.g. business cards). The logo changes in every application and media and the colors change too.

The Casa da Musica organizes and hosts several music events –from jazz to classical, to contemporary styles– for different kinds of audiences. The personality of the organization is not static, nor can be the identity or the image. The software offer an endless variety of solutions both for the audience and for those who have to manage the identity every day.

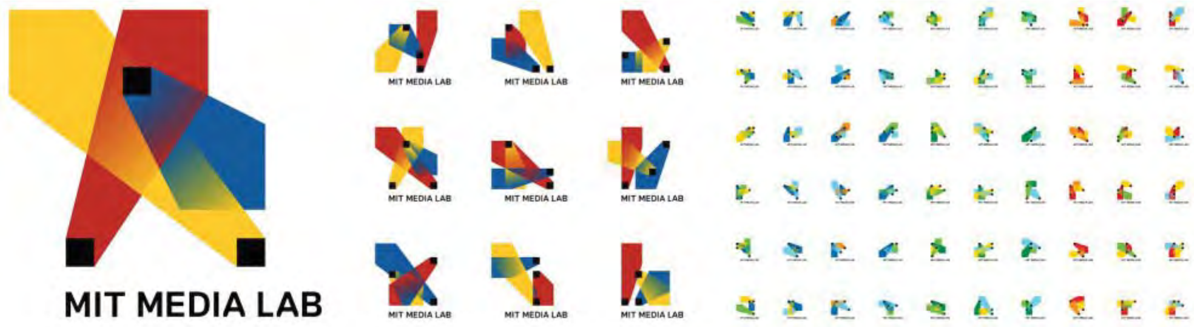


Logo generator –developed using Processing– for the Casa da Musica, Oporto (Portugal), design S. Sagmeister, 2007.



Logo variations for the Nordkyn place brand project by Base Design, Norway, 2009.

Another is the one for the Nordkyn peninsula, not far away from the Arctic Circle, home to two municipalities – Gamvik and Lebesby – in the county of Finnmark, Norway. The two cities have developed a common place branding strategy. Neue Design (2009) based the visual identity on two main ingredients [22]: a payoff, “Where nature rules”, and weather statistics from the Norwegian Meteorological Institute. A feed of weather statistics affects the logo to change when the direction of the wind or the temperature changes. On the website, the logo updates every five minutes. A logo generator has been developed where Visit Nordkyn staff can download the logo to the exact weather conditions of that particular moment. As affirmed by Neue Design [23] “Nordkyn is truly a place where nature rules, even over the visual identity”. Because of the random climatic parameters it is not possible to control all shape variations, although the primary one is based on a strict geometric grid. “When the input is generated by live information, the identity reflects the world it is living in and adapts according to its real-time input, it becomes alive” [24].

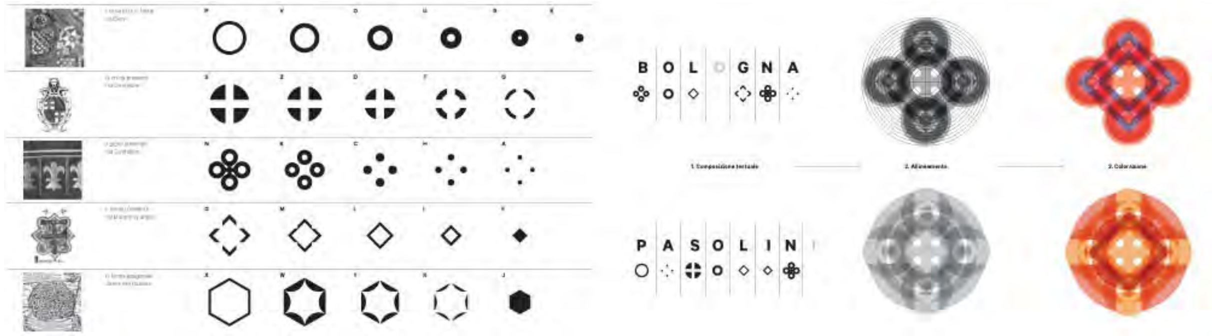


Logo variations for the Mit Media Lab, design by Thegreeneyl, 2011.

For sure the algorithm based logo for the Mit Media Lab (Thegreeneyl, 2011) [25] it is one of the most well known. His unique character is reflected in the logo design: each of the three shapes stands for one individual’s contribution. The three shapes combined create a new shape, representing the outcome of the research process in a constant redefinition of what media and technology mean today. The algorithm allows to create a unique logo for each faculty, every member of staff and all students. A custom web interface was developed to allow each person at the Media Lab to choose and claim their own individual logo for their business card, letterhead and website as well as a custom-designed animation software which makes it possible to create custom animations for any video content the lab produces [24]. In this case the sign is based on intangible values and variations depend on the people of the staff that generates and use the sign itself.

Index Urbis visual identity designed by FF3300, 2010.

There is still a certain number of cases that can be quoted. To point Italy on a hypothetical design world map it is possible to mention two of these. The first is Index Urbis designed by the Puglia based studio FF3300 (2010) [26] for the Festa dell'Architettura di Roma (the Rome Architecture Festival). A software has been developed to translate in a sign the town complex morphology, to show architectural elements of different ages that coexist in the same spaces, or to visually synthesize Rome's multiplicity and variability. “There is no final result, but just a continuous sequence of phases" [26]. The sign that changes in every application it is typographic, a variable logotype.



Basic elements of the visual alphabet and set of rules for logo arrangement, "è Bologna" city brand, design Matteo Bartoli and Michele Pastore, 2013.

The other one is very recent city brand for Bologna (2013), designed by Matteo Bartoli and Michele Pastore [27]. The visual system is based on a visual alphabet in which the single letters are replaced by geometric abstract signs inspired to a typical Italian historical imaginary. In this way, the richness of elements and tangible and intangible values –that can be typically referred to an Italian town– are translated. The forms freely take up again some figurative archetypes of the Italian city and more precisely of Bologna [28], such as walls, brick mosaic, the lily and the heraldic cross. Through a customized online software (available at http://ebologna.it/) it is possible for everyone to write what "Bologna is" ("è Bologna"). As the two designers affirmed this is "not just an adaptive and flexible visual system, […] but participatory too" [27].

4. An experimental practice

An annual work –consistent to the professional and experimental design scenario described above– has been launched for the 2013-14 bachelor's Communication Design Studio. The aim was to design visual identity systems for places, organizations and events rendering the richness, the multidimensionality, the multiplicity of the aspects, the eventual context-relatedness. The class has been organized in about fifteen groups, each having a specific subject to work on (e.g. nation branding, sports event, currency system, political party, and so on). First each group has to define the whole concept and the organization of the subject, his aims, his values through targeted research; then to design the visual system, defining appropriate communication channels, tools and applications.
Each group had to develop his project defining parameters and rules of the visual identity variations to be programmed by using the open source code VVVV. It is useful to describe two of those results, in order to demonstrate the richness of this area of design experimentation.

The visual identity for an invented hacker micro-nation located in the Westman Islands –a series of small islands sited south of Iceland–, is mainly based on two elements: the **Vegvisir** (the ancient Icelandic magical stave intended to help the bearer find their way through rough weather) inspired an alphabet; the **glitch** (the bitmap images failure) inspired the graphic elements of coordination.

The Westman Islands nation's brand identity and the flexible nation's flag (right). Design by Mariagloria Posani, Giulia Ponzetta, Emanuele Sciolto, 2014.

The Vegvisir-inspired elements are used to arrange the basic symbol of the nation and to write customized codes to use as customized fiscal codes. A specific **tool-box** has been designed and prototyped to write and print the visual code. The tool-box is composed of an on-screen writer called Muninn and of a printer named Huginn (the two ravens that fly all over the world and bring information to the god Odin).

On-screen writer and printer for the Westman Islands nation's brand identity. Design by Mariagloria Posani, 2014.

The glitch inspired elements are used in two ways. First, to arrange the visuals of printed and digital applications. And as a digital nation's flag that is shaped through a particular sound-reactive generator: two central rectangles change on sound volume and tone variations; a series of disturbing pixels increase and arrange themselves following the ground noise. The overall elements give a visual representation of a participatory democracy.

Nyvold logo variations and in use for a display mobile device application. Design by Marco Biasibetti, Mara Cominardi, Sergio Corini, Andrea Croci, 2014.

The other experimental project is the one for an health-care organization that produces drugs inspired to the archaic alchemy. This company is called Nyvold, from the two Icelandic words "ny" and "völd" that stands for "new powers". The logo basic shape refers to the philosopher's stone, and it is designed as a two-dimensional decahedron. Through a customized digital tool-box that converts parameters on body temperature, heartbeat and skin hydration the logo becomes three-dimensional mixing three geometrical shapes and the three basic colors. The logo variations show real-time feeds related to drugs users' physical changes, and it is used as a portable device display infographics. In this way, the logo visualizes temporary contacts between the subject that produces (the organization itself) and the drugs' users (the organization stakeholders).

5. Conclusions

Comparing the practices in visual identities it is possible to observe that until all the '90s there are no significant innovations in the transition from the analog age to the digital one –the "age of transition" as named by Baule [29]–. Today it is possible to notice some changes.
Traditionally, when have to design a logo or a visual identity system, graphic designers reduce contents and values of an organization through signs by using professional tools. In the past those were pencils, photos, scissors and so on, then the very first photo and layout softwares. In both cases results were visual artifacts where it was not possible to observe significant evolution, in terms of visual language, it matters not what tool was used.
Today results can be devices to produce and generate visual artifacts. Graphic designers have to define still the set of rules and a framework to shape a visual identity, but more evidence is to give to the designed tool that manages the shape. The real evolution it is in the use of the digital tools, not anymore in a passive way but in an active way. Graphic designers can build their digital tools basing them on design and esthetic needs. Innovation is in the creative process, instead of in the

final result [4], is in the “way to live our own creativeness” as affirmed precisely by Soddu [6].

In terms of merely formal shape, the use of photo, vector or layout digital editors, has not produced innovative results comparing them to previous ones. Rules and elements of a visual identity are the same: a logo (defined both in black and white and color versions, positive and negative versions), a set of basic colors (most of the times two), a set of basic typography and so on. Visual elements are strictly organized, based on a series of sharp rules of use and combination.

Small changes happen with the use of some transparency effects to suggest links to the digital world by using liquid and immaterial shapes. Another one is the trend of making three-dimensional logos by using shades and gradients –not anymore incisive of what could be obtained in the past by using an airbrush. The designer is creatively and stylistically forced by the digital tools available solutions; tools that simulate and reproduce precisely and limitless analog tools and procedures.

It is then quite evident that what has been described in the previous pages has to be observed more as an innovation in terms of design procedures and processes then of pure formal shapes. Although it is to say that it is possible to observe in most cases a sharp use of simple and clear geometric shapes.

Observing the practice it is possible to notice that a generative oriented approach to visual identity is particularly effective and idiosyncratic to those kind of organizations that need to communicate using different tones of voice turned to different kind of stakeholders and users. Or to represent the multidimensionality of their personality as a value to share (to be intended as a multiplicity of contents and operation). Most of these organizations operate in the fields of cultural or public interest, or manage places or cities.

The use of programming and a generative approach allows to build tools and, once a set of rules is defined, to obtain unexpected results. Donald Schön called this approach as “reflective practice” [30]: that means having in the design practice an experimental approach in the research of procedural and formal solutions. Where experimentation means what Teal Triggs [31] has defined as “a way of trying something out, of playing. It is about innovation, but it is not always formulaic nor is there an established set of rules. Positioned within a more scientific context, experimentation is a process by which a hypothesis is tested under controlled conditions to discover an unknown effect. In both cases, experimentation is a legitimate research method”.

Through those considerations emerges that the communication designer (what was the graphic designer of yore) needs a new knowledge that produces a new expertise. A profession, whose prestige has been destabilized by softwares’ circulation and easy to use interfaces and functions, that acquires a new knowledge through a methodological and technical cross approach. To do so, the communication designer has to act as an artisan as has been defined by Sennet [32].

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COURCHIA Jean-Paul

The painter's doubts: from Balzac to Ramachandran.

Topic: art and science

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"Arts' mission, is not to copy nature but rather to express it". This quote successfully summarizes Balzac's essay, from 1831, le chef d'oeuvre inconnu (the unknown masterpiece) (1). Our study will investigate whether this question has managed to find a cognitive answer. VS Ramachandran describe ten principles of art : peak shift, perceptual grouping and binding, contrast, isolation, perceptual problem solving, symmetry, abhorrence of coincidence, repetition, rhythm and orderliness, balance and metaphor. We posit that an answer to Balzac's interrogation can be elicited from Ramachandran's work (2). Balzac, under Delacroix's vision, exposes two approaches: the german school, emphasizing drawings and lines famously illustrated by Holbein and Durer; the venetian school, on the hand, is based on color and light as seen in Le Titien, Véronèse, Giorgione's works. As Fenhofer argues in Balzac's essay, lines are meant to disappear. This is already true in nature, and lines are still used by artists in order to juxtapose two entities with different lighting. Outlines are bound to disappear with proper use of color, "you artists fancy that when a figure is correctly drawn." This concept has been studied at the neuronal and cognitive level. Differentiated brain cells exist for the perception of, among other things, color, depth and form. Furthermore, several studies on eye movements have confirmed that human vision are drawn towards lines, contrast and boundaries. David Hubel and Torsten Wiesel (1979) originally pointed out that this principle might reflect specific cells in the visual pathways that are stimulated by edges and thus indifferent to homogeneous regions. For Ramachandran, the rule of isolation lies in proper use of colors and not lines in order to make any item stand out. This was the plight of the impressionist movement who favored colors over lines. Impressionism has proved that mere sketches can elicit the same, if not more, emotions than a colored photograph. "Look you, youngster, the last touches make the picture. Porbus has given it a hundred strokes for every one of mine. No one thanks us for what lies beneath. Bear that in mind." Coveying what Ramachandran refers to as "rasa" (i.e. the essence of things) is what Balzac, through Frenhofer, shows us. The essence of the work can cross the boundary of the canvas by a "peak shift" which exaggerates both form and color. All these parameters will in the end guide the artist who is constantly torn between representation and expression, lines and color. Cezanne, on his journey towards modernity, is an eloquent example of this struggle eventually pushing the boundaries to the edge of the abstraction. Cezanne had to first jag the edges before making them disappear completely.

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Keywords: eye movement, brain, perception.

The painter’s doubts: from Balzac to Ramachandran

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There is a little book written by Balzac, in 1831, entitled “The unknown masterpiece” (1). Honoré de Balzac is a French writer, novelist, playwright, literary critic, art critic, essayist, journalist and even a printer. Balzac’s oeuvre is one of the largest in French literature with 91 published novels and short stories. He organized his work within a larger ensemble: “The Human Comedy”. This book is a short book, with a contradictory title, with three main characters: Porbus, Nicolas Poussin and Frenhofer. They ask a single question about art: How to give art, a lifelike movement? The scene takes place in 1612 in France; Porbus a famous painter is in his studio. The young Nicolas Poussin, a young aspiring novice artist, comes to visit Porbus studio. On his way up to the studio he meets Frenhofer, Porbus’ master. He has been for 10 years in the process of creating a work of art that he does not want to expose until perfected. Poussin offered his mistress, Gillette, to Frenhofer as a model in order to complete the work. Gillete reluctantly consents. When the work of art is done, Poussin and Porbus came to see the masterpiece, but they did not see the “beauty” that Frenhofer talked about. They only see colors upon colors… Porbus finds out the next day that Frenhofer has died after burning all of his artworks. Frenhofer represent in Balzac’s book, “The God” of the pictorial failure. There is another painter known as a fail painter, Paul Cézanne. In the book “Conversation with Cézanne”, we see that Cézanne identified himself as Frenhofer. Picasso will do the same. Zola will, like Balzac write a book about painting: “The Masterpiece”, he will describe a failed painter. Cézanne recognized himself in this book and will be angry with Zola. This will be the end of their friendship. But Zola has seen something of a programmed failure, failed to revitalize what is painted. What is the meaning of art? Art is trying not to reduce painting to a fruitless attempt, to imitate things, to copy, but rather to make them the vector of expression (2). “Arts’ mission is not to copy nature but rather to express it”. This quote successfully summarizes Balzac’s essay. “The aim of art is not to copy nature, but to express it. You are not a servile copyist, but a poet!" cried the old man sharply, cutting Porbus short with an imperious gesture. "Otherwise a sculptor might make a plaster cast of a living woman and save himself all further trouble. Well, try to make a cast of your mistress's hand, and set up the thing before you. You will see a monstrosity, a dead mass, bearing no resemblance to the living hand; you would be compelled to have recourse to the chisel of a sculptor who, without making an exact copy, would represent for you its movement and its life". An as the painter has a doubt, the writer has the same doubt, this is why Balzac is sensitive to the painter's problem. Balzac will not describe a character by using words, but he will try to make it "feel" to us. It is the first advice given to a young writer: "show me don't tell me". It is the Frenhofer ambition, which will, costs him his life … Porbus is only able to copy. Frenhofer will criticize the work of Porbus. On one side the picture is a success: "…when a figure is correctly drawn, and everything in its place according to the rules of anatomy, there is nothing more to be done", "…fill in the outlines with due care that one side of the face shall be darker than the other", "At a first glance she is admirable", "The perspective is perfectly correct, the strength of the coloring is accurately diminished with the distance". On the other side the picture is a failure: "Your good woman is not badly done, but she is not alive", " that she is glued to the background, and that you could not walk round her", "An image with no power to move nor change her position", "I feel as if there were no air between that arm and the background", " I could never bring myself to believe that the warm breath of life comes and goes in that beautiful body", and "Your creation is incomplete". What Frenhofer ask to the painter is to "capture the invisible". And this is a very hard task. In the movie made from the novel, "La belle Noiseuse", Michel Piccoli, in the role of Frenhofer will says "…every time I finished my canvas, I think that I should still make an effort, try to go to the end of myself, take the risk! ..." There is a risk in trying to catch the invisible. For Balzac through Frenhofer there should be 3 main things: First, the dilution of the line under the impact of the color, this is the confrontation of the drawing and the line, and the color. It is the opposition between Ingres and Delacroix. The line appealed to the mind, to the intellect, the color appealed to our emotions. For Porbus: "…for me painting is the line ... something clean, finished" for Frenhofer "…but there are no lines in Nature, everything is solid. We draw by modeling, that is to say, that we disengage an object from its setting; the distribution of the light alone gives to a body the appearance by which we know it." In a previous study we showed that Cezanne had followed this rule to let the color imposes the form. Matisse will find, with paper cuts outs the solution to get free of the line. Second, Frenhofer will use a glossary of straightness accuracy, telling us that the technique is not sufficient: "You artists fancy that when a figure is correctly drawn, and everything in its place according to the rules of anatomy, there is nothing more to be done", and " The perspective is perfectly correct, the strength of the coloring is accurately diminished with the distance". The entire unknown masterpiece turns around something unspeakable, which cannot be said, expressed. The spark, the genius, must be soluble in the work. Third, The lines should be diluted, but not completely there must be a remaining of drawing. In this way, the artist will try to give movement with fixity. Cezanne will say "…treat nature by the cylinder, the sphere, the cone…" but maybe the painter should directly seize the human form and go directly to the essence?

Vilayanur S. Ramachandran is a well-known Neuroscientist, director of the Center for Brain and Cognition at the University of California, San Diego. He will see the aesthetic from a scientist's viewpoint. He defined nine laws of aesthetics (3): grouping, peak shift, contrast, isolation, perceptual problem solving, abhorrence of coincidences, orderliness, symmetry, and metaphors. With those laws he is trying to explain how artists generate aesthetic in the brain. One of the main functions of early vision is to discover and delineate objects in the visual field. By grouping, we will have successive stages through our visual “what” pathway in the temporal cortex. Through our limbic system we will have an emotional feedback until we recognize the form in front of us. The Peak shift effect: art will always tend to be a sort of exaggeration of the reality. Nikolaas Tinbergen an ethologist, (Nobel Prize physiology, 1973), studied the field of supernormali stimuli. He showed that female herring gulls have a red spot underneath their beaks, which is a target for gull chicks to peck at when they want to be fed. In an experience even a red line on a stick will produce not only the same effect on the gull chicks, but even more. Ramachandran will say that the exaggeration linked to the principle of discrimination of the forms. And it is the same in caricature and art in general. Ramachandran will conclude that the point of art is not realism, the purpose of art is not copying reality, is exaggeration, hyperbole, distortion of realism to please the brain. Picasso and Matisse created distortion. They liberated us from realism. But you cannot just make distortion and call that art! It needs something else. Indian artists use the word RASA for the artistic capturing of the essence; RASA is the soul, the spirit of something. Ramachandran says that the artist must apprehend the very essence of something to evoke specific emotion in the viewer’s brain. Contrast, without contrast, there is no form. Isolating a single module leads to attention. Ramachandran took again the concept of David Hubel and Torsten Wiesel (Nobel price physiology, 1981). They showed that sketches are very effective because cells in your primary visual cortex, where the earliest stage of visual processing occurs, only care about lines. Perceptual problem solving is making a more attractive object, if it is less visible, causing pleasure in the recognition of the non-immediate.

In conclusion, it seems that aesthetic visual reaction to beauty seems a rich, multidimensional reaction. The aesthetic emotion has historical parameters and symbolic development and it will be our culture that will be able to do something with the “experience of beauty” that affects us. Balzac will say, “The role of art is not to imitate, but to express nature”, Ramachandran will say, “The purpose of art is not copying reality is exaggeration, hyperbole, distortion of reality to please the brain”. Balzac will conclude, “The work of art must be the essence of the masterpiece” Ramachandran will conclude, “Rasa is capturing the very essence of something to evoke specific emotion in the viewer’s brain”.

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Janusz Rębielak

STRUCTURAL SYSTEMS GENERATED FOR VARIOUS ARCHITECTONIC PURPOSES

Topic: Architecture

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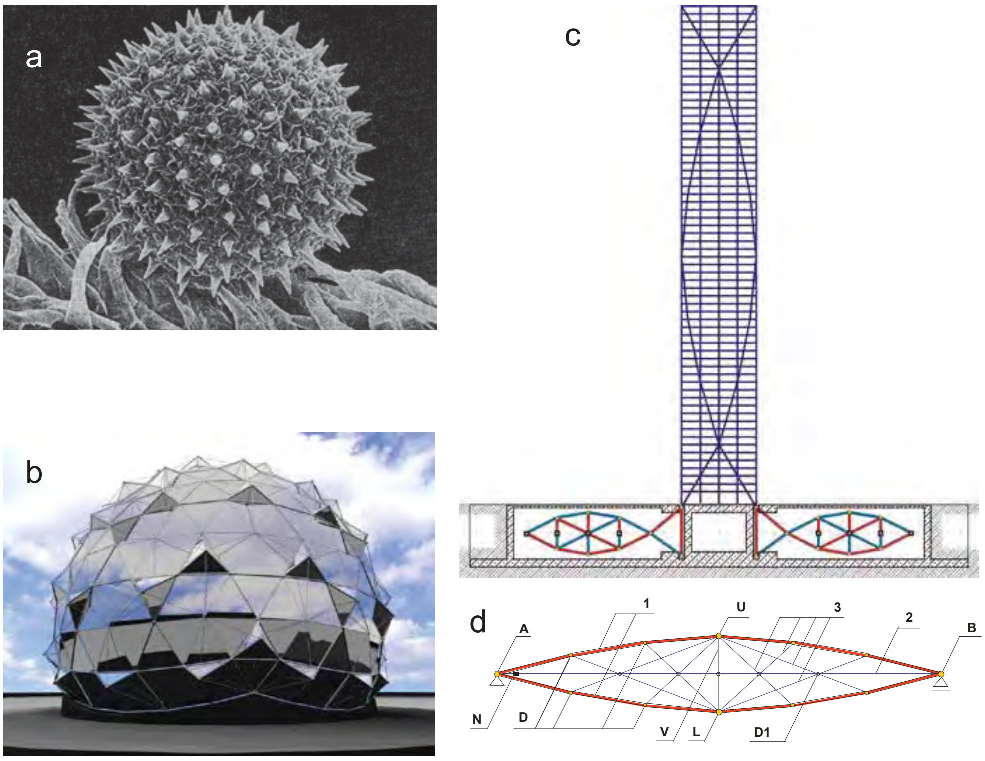
Abstract:
Basic structural rules have to be taken into consideration during shaping of various types of systems designed as the support structures of roof covers or tall buildings. Large span roof structures should be very lightweight, that is why systems composed only of tension members are often applied for these purposes. They are very efficient however because of e.g. architectonic reasons they are not appropriate for most investments. It explains the recent popularity of tension-strut systems in various types of roof covers. Rules of shaping of these systems are shown on examples of spatial structural systems recently developed by the author [1,2]. Among others very similar rules are used for shaping systems of lightweight roofs having e.g. forms of geodesic domes, patterns of which resemble forms of some natural ocean micro-creatures like for instance chosen shapes of radiolaria. Another structural system, called lenticular girder, can be applied in design of tall buildings. Pattern of the tree root system was one of the inspirations during procedures of shaping of the combined structural system of foundation, which is devoted for heavy loaded building located e.g. on earthquake areas. Application of numerical models of these structures enhances efficiency of design processes of these structural systems.



Images of a) selected kind of radioraria, b) geodesic form of certain structure, c) vertical cross section of proposed combined structural system of tall building, d) example of newly proposed structural system of the lenticular tension-strut girder

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Keywords: Space structure, roof cover, tall building, numerical model

Structural Systems Generated for Various Architectonic Purposes

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Premise

During process of the design of the structural system of a building there have to be taken into account numerous and complex aspects. In all the cases the safety and the reliability of the system constructed by the possible small energy consumption in connection with the reasonable financial expenses are the main, principal requirements. The contemporary computer techniques together with an appropriate software make the design processes very fast and efficient. All these sophisticated tools are based on elementary rules of mathematics and theory of structures. Application of these rules are visible in shapes of the nature's creatures, patterns of which are always valuable inspirations for architects and engineers.

The paper presents some selected examples of the structural systems invented earlier or recently by the author. These systems are aimed to be the main bearing structures for various types of roof covers and for tall buildings.

1. Structural systems for roof covers

One of the most structurally efficient systems of roof covers are the geodesic domes, see Fig. 1a, initially invented by Walter Bauersfeld, then developed and popularized by Richard Buckminster Fuller [1]. Some patterns of them have their counterparts in forms of the sea creatures called *radiolaria*, see Fig. 1b.

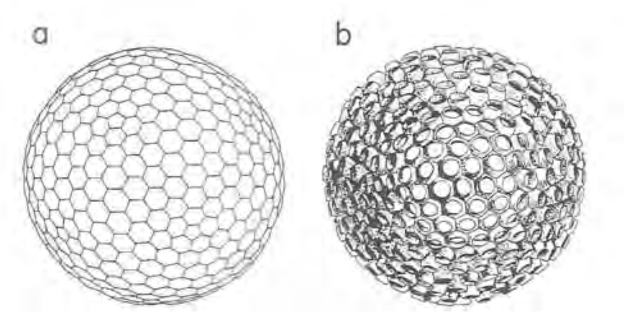

Fig. 1. a) An example form of the geodesic hexagonal grid with several pentagonal meshes, b) scheme of skeleton of one of the radiolarian species

Geodesic domes are mostly design and constructed as a specific types of the spatial trusses, due to which - and among numerous other reasons - they are very effective structural systems for these types of roofs. Covers of large spans have to be built by application of the double- or multi-layer spatial systems.

1.1 Group of the VA(TH) tension-strut systems

Space frames built of struts have been considered in the middle of XX century as the very modern and economic solution for construction of large span roofs [2]. Rapid changes of economic conditions in the building industry have caused a significant evolution in ways of the design of structural system towards application in them the possible big number of the tension members [3, 4]. The hanging roof systems and the inflated membranes are the most lightweight structural solutions but because of architectonic reasons they not always can be applied in the roof structures. Tension-strut system are nowadays consider as the most convenient technical solutions for numerous forms and types of the roof covers [5]. A specific group of the VA(TH) tension-strut systems was invented by the author, see Fig. 2 and Fig. 3 [6].

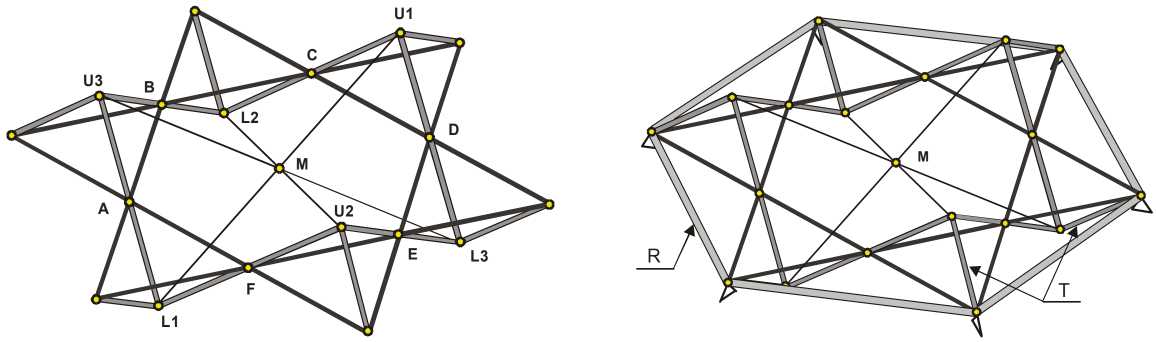

Fig. 2. Schemes of a simple structural configuration of components in the inner space of the VA(TH)No2 tension-strut structure

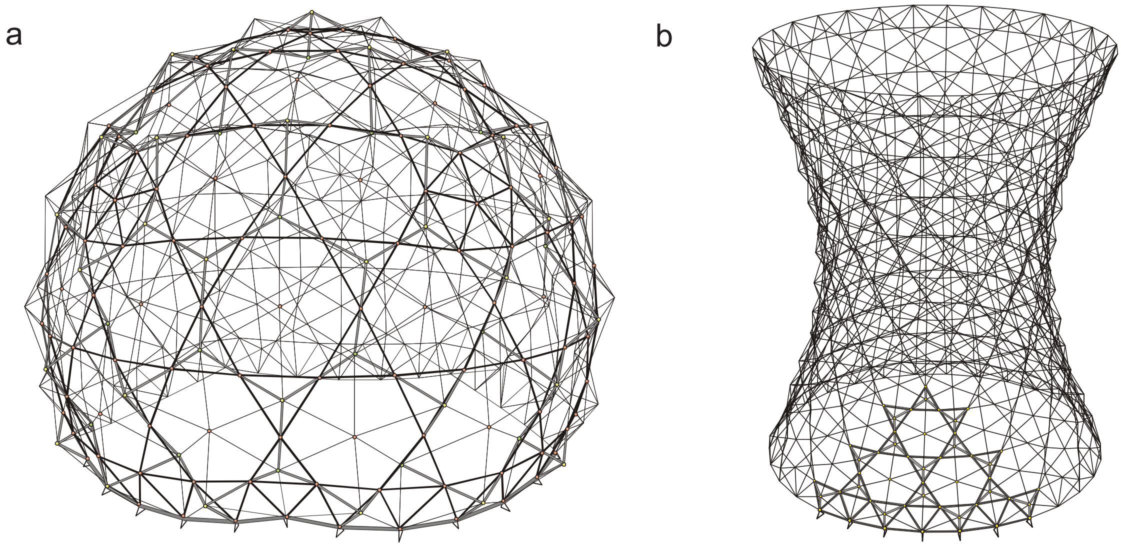

Fig. 3. a) The geodesic form of the VA(TH)No2 structure created over the fifteen faces of the icosahedron b) hyperbolical form of the VA(TH)No2 structure

The point of the structural concept of this group of the support systems is that the single layer grid of the compression bars is supplemented by means of oppositely directed tetrahedron bar modules, arranged respectively onto inverse sides of the grid. The top vertices of these modules are suitably connected by means of tension members used for the pre-tensioning of the system and the whole structure is fastened in the perimeter ring. The unusual feature of these types of structural systems is that the single layer grid, supplemented by bars and tension members, creates a three-layer space structure. In this manner is built an unique type of spatial system, having nodes located at three levels, which obtains characteristics of the double-layer tension-strut structure. The VA(TH) group of the tension-strut systems can be applied in designing of various types and forms of spatial structures. For instance, they can be the main support structures of flat covers, roofs designed as barrel vaults or geodesic domes, see Fig. 3a, or roof structures having the forms of a paraboloid hyperboloid. This group of structural systems can take shape of hiperboloid of one sheet, see Fig. 3b, and moreover these systems can built each type of form of the roof surface and they can be spaced over optional shape of the basis projection of the cover.

The VA(TH)No2 tension-strut structure was proposed by the author to be a support structure of the central building of the Geo Centre designed by himself for the Wrocław University of Technology, see Fig. 4.

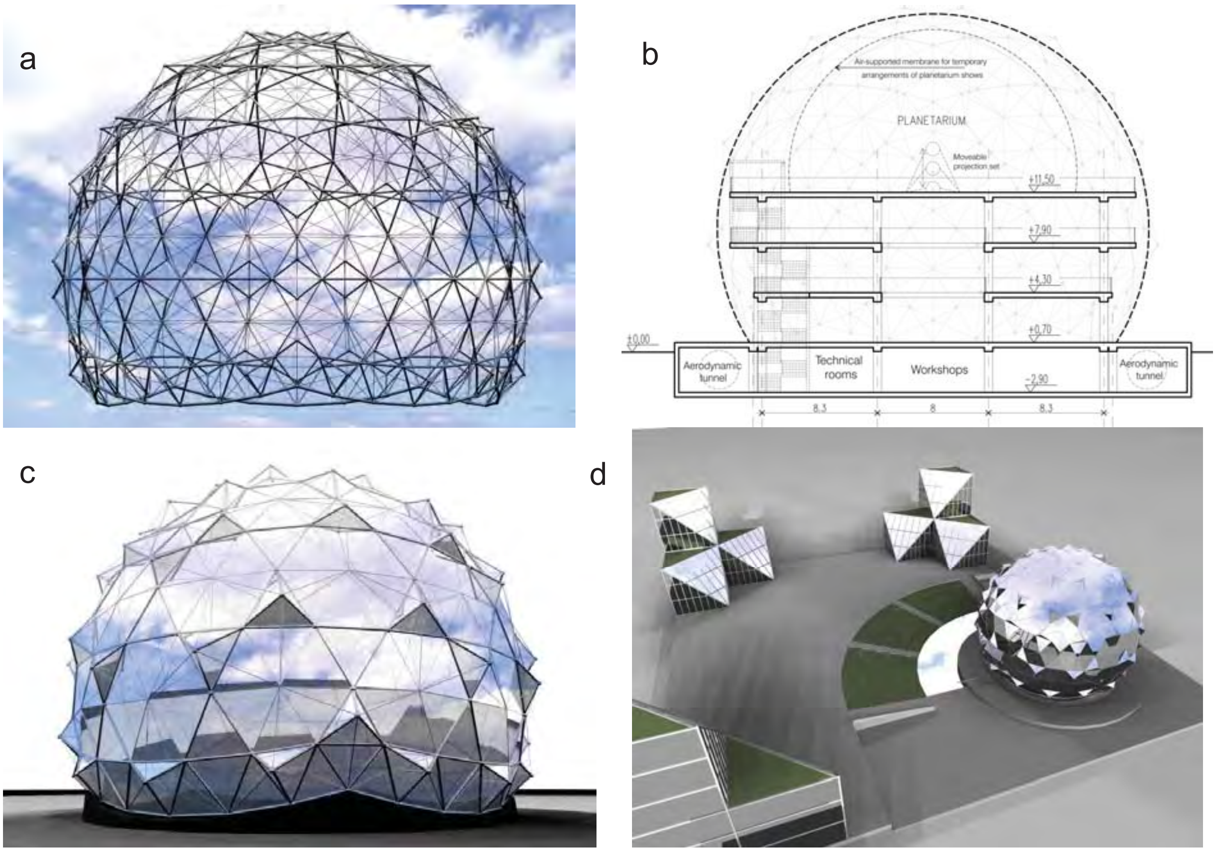

Fig. 4. a) View of the VA(TH)No2 tension-strut structure, b) vertical cross-section of the main pavilion of the Geo Centre, c) view of the structure with the glass panels cladding, d) bird view of the whole Geo Centre

The Geo Centre was proposed as the integration forum for the students, academic staff and visitors of the new part of the University. Diameter of the central geodesic structure equals only about 32 meters because its geometrical dimensions are limited by the urban regulations assumed for this part of the Wrocław city. The tension-strut structure geodesic dome was aimed to be a subject for the long term testing of behave of such a system under numerous types of loads and for testing of various types of cladding systems. In the top area of the dome is located a multi-purpose hall, which can be sometimes arranged as the Planetarium, below are placed research laboratories and in the basement were designed technical workshops together with the wind tunnel.

1.2 Special forms of the lenticular girders

Basic rules of theory of structures, as it was previously mentioned, can be very helpful as an inspiration for the processes of shaping of very effective structural systems. An example of such applications can be the trajectories of the main stresses in the free-ends beam, see Fig 5a, which patterns were inspiration for defining a new type of the lenticular girder, see Fig. 5b [7, 8].

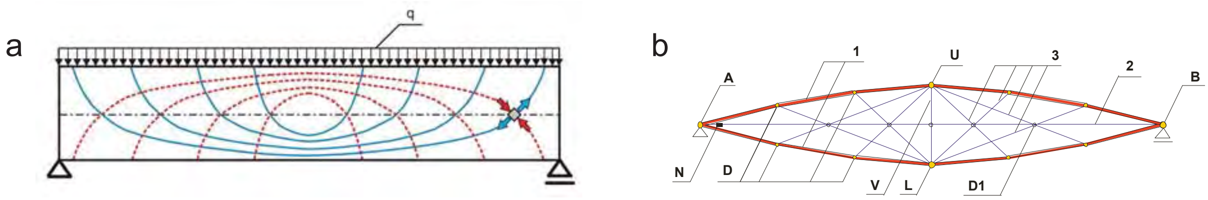

Fig. 5. a) Patterns of trajectories of the main stresses in a simple beam, b) scheme of the basic form of new type of the lenticular girder

The point of this structural system is to use the possible big number of tension members and the possible small number of compression members in a lightweight form of a girder, which can be able to transmit load forces applied at any direction to its structural nodes. Because it consists of tension and compression members the system requires a suitable pre-stressing. The planar structural configuration presented Fig. 5b has some spatial counterparts, exemplary forms of which are presented in Fig. 6. These spatial shapes of the lenticular girder can be applied for designing of numerous and various forms of the roof structures, see Fig. 7.

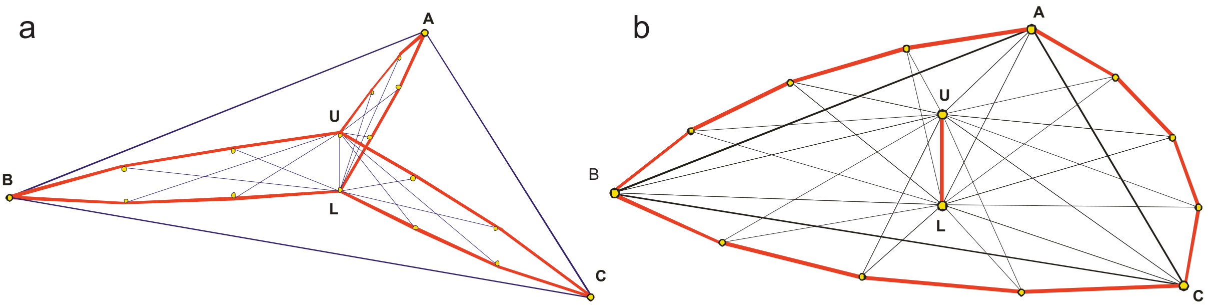

Fig. 6. a) Spatial form of new type of lenticular girder called system MT, b) another form of this girder called system D

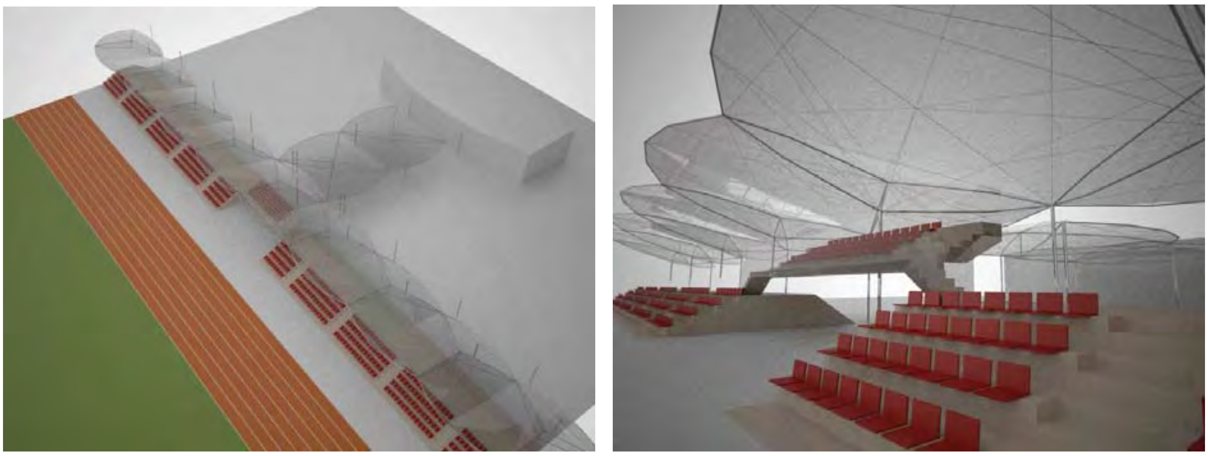

Fig. 7. General views of the stands cover designed for a small stadium in Złotów

The spatial of system MT of the newly proposed type of lenticular girder has been applied in the conceptual design of the lightweight and semitransparent roof cover spaced over stands of a sport stadium in Złotów, in north of Poland.

2. Structural systems proposed for tall buildings

The task of design and construction of the tall buildings is always a challenge to architects and engineers. The complexity and difficultness of this problem increases significantly when the tall building has to be located on subsoil of small load capacity or in the seismic areas. The horizontal load is the dominant type of loads obligatory taken into account during design of the safe structural system of a high-rise building, which at the same time has to have two contradictory features. It has be very stiff but on the other hand it should be to some degree flexible [9]. The below presented examples of such systems have been invented by the author by inspirations of shapes of the biologic structures as well as the inspiration of the trajectories of the main stresses in the free-ends beam, see Fig. 5a, and form of the Michell beam [10].

2.1 Systems of circumferential space structures

Inspiration for working out of this group of systems were conclusions coming from comprehensive analyses of the thermal strains of structures of the tall objects and analysis of the vertical cross section of a corn stalk.

Structures of the very tall objects are subjected not only to the vertical and horizontal loads. By increasing of the height the impact of the thermal load may also play a significant role. Differences of temperature between vertical columns located inside space of the building and columns arranged along perimeter of the tall building can be sometimes quite big, what causes their various lengths. In the structural systems called *tube* or *tube in tube* the problem is relatively easy solved by suitable connection of the floor girders, above the 20th storey, to the perimeter columns. In the last decades the double-layer space frames are proposed to be the main parts of the bearing systems of the high-rise buildings, see Fig. 8 [11].

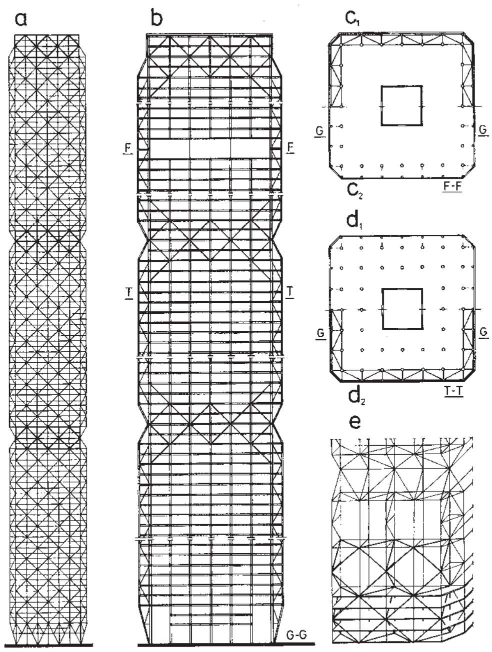

Fig. 8. General schemes of a structural system of a tall building shaped as a special form of the circumferential bearing space frame

This structural system is created by means of three segments vertically positioned each on other. A single segment contains 36 typical storeys, what implies that the whole building should have 108 storeys but in fact the real number is slightly smaller. Double-layer space frame vertically arranged along perimeter is the main bearing system of this building. The two adjacent segments are connected together by means of horizontal disks designed in form of the multi-layer space frame. External layers of the vertically positioned circumferential structures are devoid of members on levels of central layers of these disks. Due to this structural configuration strains of a single segment should have a significantly reduced impact on level of strains acting in members of the adjacent vertical segments.

2.2 Combined structural system of the tall building

The proposed structural systems of the combined foundation and the combined structural system of the tall building make possible to design and to construct a very stable and relatively inexpensively foundation structure, which can obtain an extremely large horizontal surface and can be placed not deeply beneath the terrain level. It can be a very solid support structure for the tall building placed on very weak subsoil and at the same time located in seismic area [12]. The author has invented these systems by inspiration of shapes of creatures existing in the nature, like for instance the very effective root system of a tree, see Fig. 9a, and again the patterns of stress trajectories in the free-ends beam. The combined structural system of the tall building, scheme of vertical cross-section of which is shown in Fig. 9b, can be characterized at the same time by the previously mentioned two contradictory features. It is very stiff but on the other hand it can be to some degree flexible. This system can also be applied for the design of the mega-structures, see Fig. 10a.

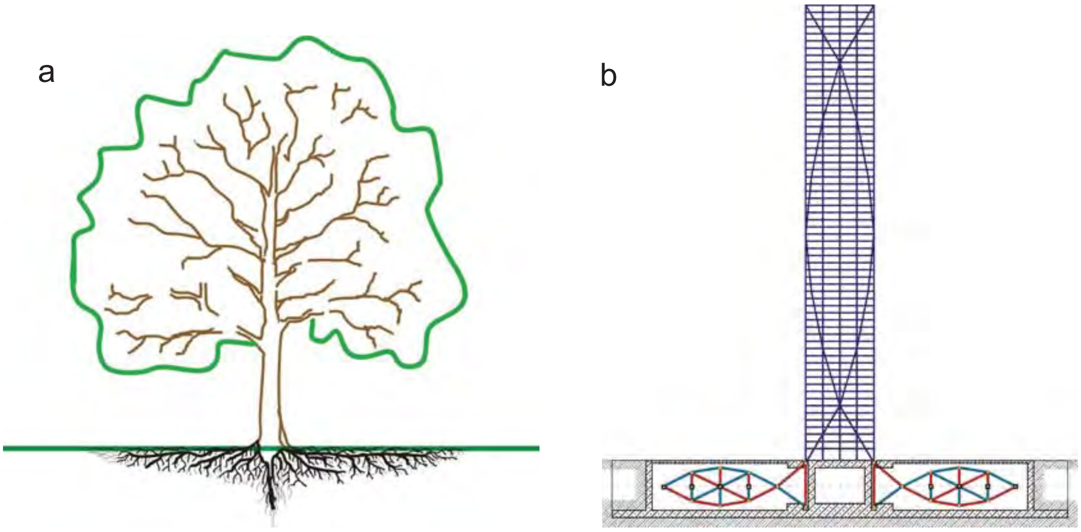

Fig. 9. a) Simplified scheme of the root system and structure of a tree, b) scheme of the main vertical cross-section of the combined structural system of a tall building

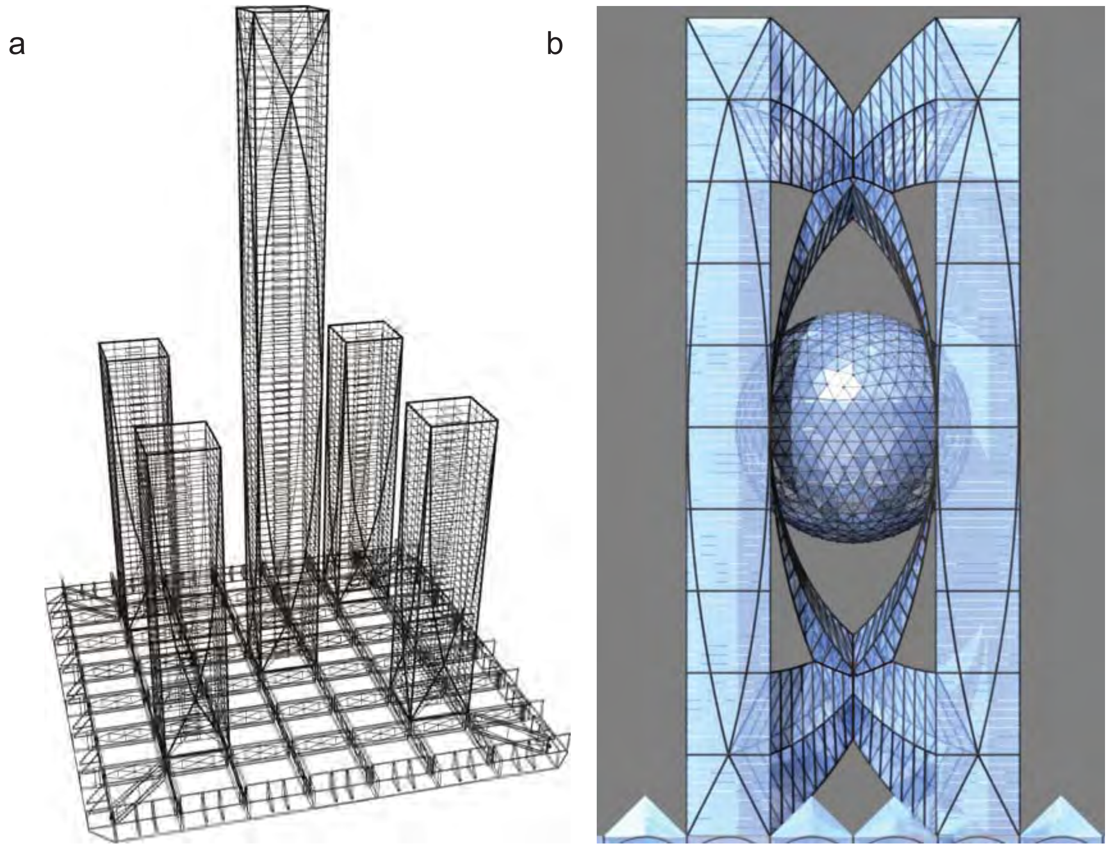

Fig. 10. a) Example of form of a mega-structure based on system of the combined foundation, b) typical elevation of the complex GeoDome Sky Towers

The surface of the combined foundation is theoretically unlimited. The combined structural system was applied by the author in the conceptual project of the building complex called the GeoDome Sky Towers located in the south part of the city of Wrocław, in the south-west region of Poland, see Fig. 10b. It is composed of four towers, each of them contains 80 storeys of the typical height equals 4,50 meter. The horizontal base of this complex is shaped in form of the combined foundation, which is of the height equal to 18,00 meters and it is placed directly on the subsoil level. The total height of this complex equals slightly more than 380 meters. The system of combined foundation can be applied not only for the new buildings but also for the existing objects and it can be used for straighten the previously inclined houses. One can to state that the combined structural system proposed for the whole building has a big develop potential.

Closing remarks

Structural systems, shaped in an appropriate way, are very helpful in processes of generating of the interesting and individual architectonic forms of buildings designed by means of them. Stable, efficient and economic shapes of the building structures can be generated by suitable application - during crucial stages of their design - of basic rules of the theory of structures as well as the inspirations of structural forms existing in the nature.

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Jie WU, Guangxi CHEN, Yinan ZHANG

The Digital Re-design of Chinese Traditional Customs in Teaching Practice *(Paper)*

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Topic: Design

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Abstract:

The Chinese traditional culture is now facing the difficulty of inheriting the past and connecting the contemporary society after the historical fault age. In our teaching Practice, we wanted to explore the innovative design concept and the possibilities of interaction for the revival and dissemination of Chinese traditional culture with the help of contemporary digital interactive technology, integrating the traditional culture with the modern life.

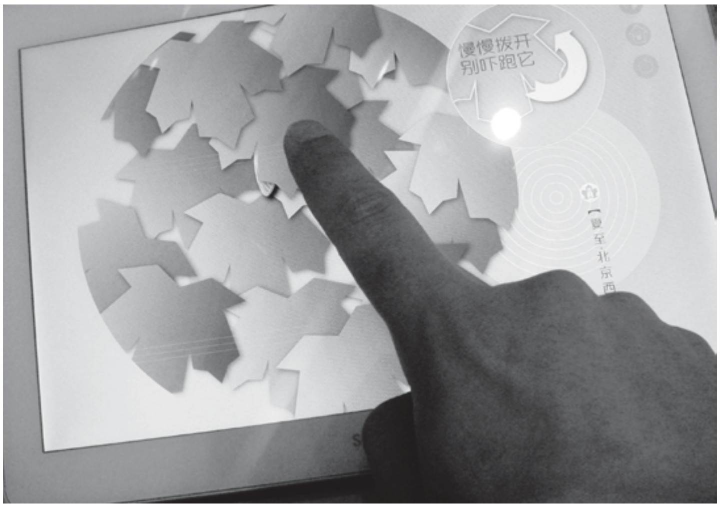

Image of The game ,Seeking the Cicada in the Summer Solstice:

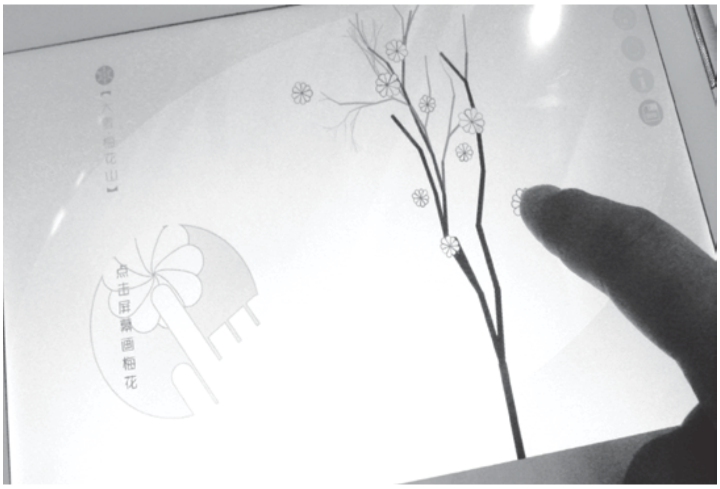

Image of The game, Painting Meihua (Flowing Plum) in the Great Sno

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Keywords:
Digital media, Chinese traditional customs, Interaction, Re-design

The Digital Re-design of Chinese Traditional Customs in Teaching Practice

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Abstract

The Chinese traditional culture is now facing the difficulty of inheriting the past and connecting the contemporary society after the historical faultage. We wanted to explore the innovative design concept and the possibilities of interaction for the revival and dissemination of Chinese traditional culture with the help of contemporary digital interactive technology, combining the traditional culture to the modern life and the technology to the cultural content. The technical approach included Android application design and programming, the generative fractal and random algorithm and game design. The re-design of culture involved filtrating the traditional custom and extracting the visual and audio elements.

Keywords

Digital media, Chinese traditional culture, Interaction, Inheritance and dissemination

1.Background

1.1 The Chinese national strategy of the cultural revival

On the domestic aspect, the government of China has announced *the Cultural Industry Revitalization Planning* in 2009, putting the revival of culture industry onto the schedule as a direction of the national development strategy. Since the development of culture backs up the economy, and a sustainable society needs not only the sustainable economy but also the sustainable culture, it becomes a new type pf society with the innovation ability.
And on the international aspect, China has become an important member of the world and more and more nations are in need of knowing the Chinese traditional culture, especially the contemporary culture manner and custom, in order to understand China better and faster to develop trade and communication.

1.2 The international tendency of the cultural development with the help of digital media technology

There has been an international tendency in which digital interactive media plays an important role in disseminating culture and knowledge. During the Shanghai 2010 EXPO, countries all over the world built up their stages to present their own culture, economy, design, science and technology as comprehensive national strength, on which the digital image and interactive media were widely adopted to deliver the information more directly and vividly. Besides, the digital museums have shown great advantages in representing and inheriting the history and culture of different countries, which is far beyond the capability of the past media.

The ubiquity of tablet PC and mobile terminals has brought new user experience and media design possibilities. Different countries are now preparing and deploying the future textbook and the digital renovation of teaching model. For instance, Apple released 3 new products into the textbook market in the January of 2012, including iBooks Author, iBooks2 and iTunes U. The first two can enhance the reading experience of textbooks while the last one can be used for music and movie playback, course organization, course inspection and credit check which has been adopted by 100 universities. And 5 days after the release, the download of iBooks Author was beyond 600,000 while that of iTunes U was over 3,000,000. The South Korea authority also made the commitment in July, 2011 that more than 2 billion US dollars should be allot to the development of digital textbooks and that schools should provide tablet PCs for reading this kind of textbooks in 2015.

The international tendency of the cultural dissemination with the help of digital media technology relies not only on the innovation of technology, but much more on the combination of technology and the actual content and requirement of culture and education, which calls for a high-level integration of technology, art and content.

1.3 Research significance

On the above-mentioned background of national strategy and international tendency of development, the inheritance of Chinese traditional intangible culture requires innovative dissemination more than protection, which gives it a progress of merging into the contemporary life and then makes it the foundation stone for China’s development into an innovative society in the future.

2.Education practice

2.1 Education goals

Due to the condition mentioned above, the unit of Chinese culture research and re-design was bent into the education research and practice of the digital media design course in the College of Design and Innovation, Tongji University, based on the digital media technology background and tools, which aimed at presenting the daily manner and custom in modern China to the youth and foreigners interested in this topic with the newest dissemination tools, innovative design concept and the interactive design method.

We hoped to integrate the culture content into digital technology in this research, not only building the foundation of further research and practice but also searching for a new cross-discipline professional training model which included two aspects:

(1) The integration of tradition and contemporary life:

The existing research had focused on the inheritance of tradition while our research focused on the impact from the tradition on the the contemporary era and the ways of assimilating and creatively passing the tradition to the young generation.

(2) The integration of technology and culture:

Even though in the computer science field, there were a few attempt involving the Chinese traditional culture, they were far away from satisfaction in visual effect and aesthetics. And in the culture research field, in spite of the will of using new media to present culture content, the final results were lacking in creativeness due to the constrain of technique and poor understanding of the new media. So that our research wanted to find the complementary between the two fields.

2.2 The entry point of the education theme: the 24 solar terms

The Chinese public have started to realize the importance of the traditional culture and custom to the daily life and self-recognition as the level of income and standard of living keep rising. The exploration, trim and protection of traditional culture and custom have shown up, leading to the return of ‘old custom’ to the public life which is not simply recurrence but re-construction based on the modern economy and the contemporary aesthetic and ethos. Meanwhile, some ‘new custom’ has been springing up because of its closeness to the public and its incorporation with business.

There were different themes in our education research and practice such as traditional manner, daily folk, Chinese medicine concept and provincialism. The results were spread via the Internet and exhibition.

We chose the 24 solar terms as our education theme and example of this paper. The 24 solar terms are the experience of time measurement and agriculture guidance since the ancient China, which are also the represent of Chinese traditional culture. The 24 solar term are determined by and named after different phenological phenomenons and agriculture activities all over a year. And different kinds of custom and folk culture unfold along the timeline with the 24 solar terms.

All sectors of the society has paid much attention to the traditional culture of solar terms. There are introducing publications and videos, apps connecting health maintenance to solar terms and non-governmental organizations promoting community activities with related knowledge and information.

2.3 Technological means

Our education research and practice involved two kinds of media: video image and interactive game, which showed their own features and needed different disseminating channels.

The Video image which presented traditional custom could be divided into two types, film shooting and computer animation. The former one could be displayed via television and video websites such as documentary series, which showed facticity because it recorded the current condition of the custom as documentation. And the latter one could be spread through the Internet because of its condensity of time and information which suited the requirement of modern dissemination. And it also gave the creator a lot of freedom by permitting different selection, exaggeration and ridicule.

However, the video image still had some disadvantages. Firstly, it put the audience to the position of pure receiver as in communication studies. The audience could only follow the timeline of the video linearly, even though they may have their own preference of the content and may want to skim or go deep. Secondly, it lacked of participation during and after the communication. The audience may be interested during the play of the video, but could not experience or do further research of the traditional custom based on the information acquired in the video, which resulted in shallow impression.

The interactive game made up of these deficiencies though. The nature of interactive game required the audience to participate in the process of dissemination, understanding the content of game playing and the concept of custom and culture step by step as asked to. And it was also possible to construct non-linear story-telling by pausing, linking, clicking and jumping back. The web links inside of the game may extend to process of dissemination to help the interested audience find channels for further learning.

The following of this paper introduces the education research and practice with the theme of the 24 solar terms and the form of digital interactive game.

3. A re-design of the custom of the 24 solar terms

This re-design was a set of interactive games based on the custom of the 24 solar terms in Nanjing, combined with the regular exhibition of Nanjing Folk Museum. Figure 1 shows the icons designed for the games. The following is two of the games.

Fig. 1. Icons of the games of the 24 solar terms

3.1 The game of the Summer Solstice: finding the cicada

The elder generation experienced the activity of catching the cicadas with a bamboo pole, at the end of which a spider web was attached. This game aimed at helping the modern citizens review this cozy old activity. (Fig. 2,3,4)

The game was programmed with Processing and Android tablet. The player needed to take the volume of chirping as a clue to find the cicada with the help of volume bar as visual feedback, then to tilt the tablet to change the viewpoint and find the position of the cicada using the built-in gyroscope. Tapping and dragging on the screen to rotate the leave covering the cicada. The speed of rotating the leave was calculated. Rotating too fast beyond the threshold resulted in the cicada fleeing and the player had to start search again. However, if the speed of rotation was within the threshold and the leave was fully removed, the cicada was found and the player won the game.

Fig. 2. The game of the Summer Solstice: finding the cicada

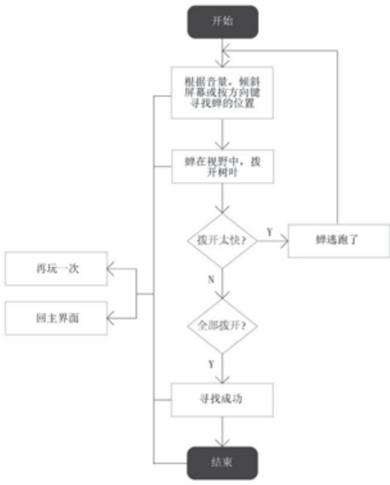

Fig. 3. The flowchart of the game: finding the cicada

Fig. 4. The instructions of the game: finding the cicada

3.2 The game of the Great Snow: drawing the wintersweet

There is a hill named after the flourishing wintersweet all over it in Zhongshan Scenic Area, Nanjing. And ancient Chinese women always painted a branch of wintersweet before entering ‘the coldest 81 days of the year’, which included nine flowers each made up of nine white petals. Everyday as doing the facial makeup, they painted a petal into red with rouge. And after all the petals were painted, the coldest 81 days passed into spring and the white wintersweet seemed like red apricot flowers.

This game was to help the player get their own wintersweet branch by digital generative algorithm with Processing and Android tablet. The painting could be saved in the device as desktop image as well as printed out.(Fig. 5, 6)

The first tapping point determined the horizontal position where the branch grew and the direction of dragging determined where the branch mainly grew to. Then the following nine tapping drew nine flowers which randomly differed in size and rotation angle. And the stroke weight and opacity of the filling color of the petals were also random to vividly mimic the natural flower. The branch and the flowers all could be canceled or restated if not satisfactory.(Fig. 7)

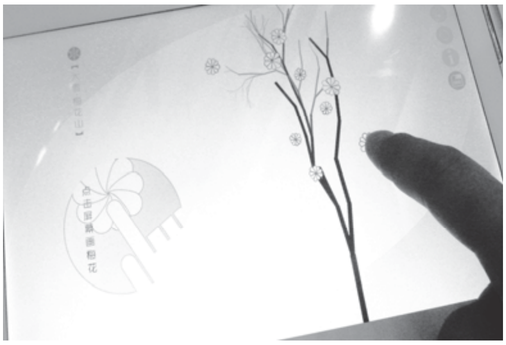

Fig. 5. The game of the Great Snow: drawing the wintersweet

Fig. 6. The painting generated in the game

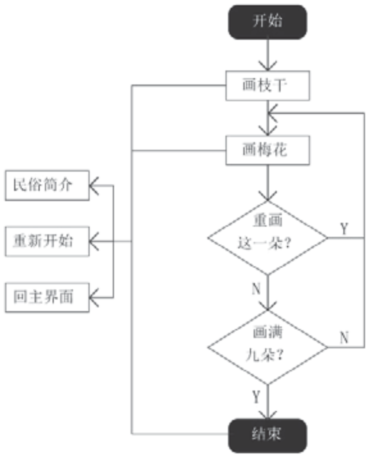

Fig. 7. The flowchart of the game: drawing the wintersweet

4. Epilogue

In this digital media era, interaction and gamification present new challenges to the dissemination of culture content: the combination of interaction and cultural education should benefit each other. Further more, the balance between the entertainment of game and the preciseness of education should be achieved to form real edutainment.

How to make full use of the advantages of interactive media, especially the mobile terminal, to inherit the traditional Chinese culture and custom and even to form the new custom is a meaningful field worth further research. And the possibilities of the combination among the custom of the 24 solar terms, the interactive media and technology also need more exploration.

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Jônatas Manzolli

Unfolding Stones: Interactive Music Dialoguing with Digital Immersion and Augmented Cognition

Topic: (Music)

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Abstract:
Nowadays, new technologies emphasize interaction and novel music interfaces and alternative forms and modes of interactive media have been realized. The digital era is promoting interaction between audiovisuals, music and improvisation in virtual and mixed reality spaces. In such époque, it is necessary to expand not only our familiarity with new technologies, but mainly to develop a critical and revitalized understanding revealed in new dialogues between Art and Science. Have we again *"stones"* in our hands - the computer technology? As the primitive man was stimulated by the images and sounds from the stones, we might be stimulated, by mixing the virtual and real worlds, to understand the integration of the brain and the body with such yet unpolished technological tools. These developments raise fundamental questions regarding the role of embodiment as well as the environment and interaction in live interactive composition focusing on our understanding of the man-machine interplay [1]. The dynamic organization of sound material in real time, adds new dimensions to musical information and to its symbolic representations. Further, for studying music cognition in its fullness and understand its processes of discovery and creativity, it is necessary to examine how the brain and body work together in the solution of such complex problem [1]. Our methodology follows this path: "*while an agent and a group of agents are interacting all multimodal signals produced by the agent(s) are shared in a network, captured and analyzed in real time and/or stored for future off-line manipulation, remotely or locally*. Our aim is to create a live interactive composition system in which the physical space, light, sounds and images are integrated in a broad notion of musical instrument. Thus we combine multimodalities using interactive media to unfold live performance in line with improvisation and audiovisuals such as re(PER)curso (2007) [2] and the Multimodal Brain Orchestra (2009) [3] (see figure 1). We understand music performance as re-creation and not merely reproduction of a work and we aim to enlarge the countless possibilities to correlate sounds, visual material and text, as presented in minDSounDS (2014). Finally, we argue that a theory of mind, including one of creativity and aesthetics, will be critically dependent on its realization as a real-world artefact because only in this way can such a theory of an open and interactive system as the mind be fully validated.

Figure 1: Performance of the Multimodal Brain Orchestra

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Keywords:
Music, Man-Machine Interaction, Multimodal, Cognition, Creative, Network

Unfolding Stones: Interactive Music Dialoguing with Digital Immersion and Augmented Cognition

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Abstract

Nowadays, new technologies emphasize interaction and novel music interfaces and alternative forms and modes of interactive media have been realized. The digital era is promoting interaction between audiovisuals, music and improvisation in virtual and mixed reality spaces. Have we *"stones"* in our hands - the computer technology? As the primitive man was stimulated by the images and sounds from the stones, we might be stimulated, by mixing the virtual and real worlds, to understand the integration of the brain and the body with such yet unpolished technological tools. This article presents a conceptual discussion articulating interactive music composition and computer creativity. It is also introduce the idea of using interactive media as laboratory to study creativity and to mediate the creation of artworks. We introduce previous interactive performances and *minDSounDS*, a performance to be presented at the Generative Art 2014 Conference.

Introduction

With the advent of new technologies that have emphasized interaction and novel music interfaces, alternative forms and modes of interactive media have been realized. These developments raise fundamental questions regarding the role of embodiment as well as the environment and interaction in live interactive composition focusing on our understanding of the man-machine interplay. In addition, it emphasizes a more situated and externalist view of performance and composition.

In parallel, music representations have evolved from symbolic notated pitches to expressions of the internal organization of sound. This can be observed in the extended instrumental techniques developed from the 1940's onwards up to the more recent compositional strategies that have emerged from the "new interfaces for musical expression". The dynamic organization of sound material in "real" time, however, adds new dimensions to musical information and to its symbolic representations.

In such époque, it is necessary to expand not only our familiarity with new technologies, but mainly to develop a critical and revitalized understanding revealed in new dialogues between Art and Science.

This article is organized as follows: first we present a conceptual discussion articulating interactive music composition and computer creativity, it is based on two recent chapters published in "*Language, Music and the Brain: A Mysterious Relationship*" [1][2]. Next we introduce the idea of using interactive media as laboratory to study creativity. It follows a philosophical point of view based on the idea that acquiring knowledge from experience is an important evolutionary accomplishment. This observation leads the concepts of *Presence* [12] and Abduction from Charles S. Peirce [3]. To exemplify our perspective, previous artworks are presented, such as described in [5][6], and the article finishes with the description of minDSounDS, a performance to be presented at the Generative Art 2014 Conference.

THEORETICAL VIEW POINT

Sounds and images interact with the human cognitive system since the primitive man struck two rough and unpolished stones and he thought about mastering the power of Nature. Later these stones became polished tools and more sophisticated instruments were created. Nowadays, the digital era is promoting interaction between audio, visuals, images, musical composition and improvisation in virtual and mixed reality spaces. Have we again *"stones"* in our hands - the computer technology?
As the primitive man was stimulated by the images and sounds from the stones, we might be stimulated, by mixing the virtual and real worlds, to understand the integration of the Brain with sounds, images and music with such yet unpolished new computer and digital technological models and tools. As also the Greek composer Xenakis [7] envisioned:

> *"We shall thus be able to reascend to the fountain-head of the mental operations used in composition and attempt to extricate the general principles that are valid for all sorts of music. We shall not make a psycho-physiological study of perception, but shall simply try to understand clearly the phenomenon of hearing and the thought-processes involved when listening to music. In this way we hope to forge a tool for the better comprehension of the works of the past and for the construction of new music. […] We shall confine ourselves to following a path which may lead us to regions even more harmonious in the not too distant future (p. 155)".*

Ada Lovelace Lady Byron in documenting Babbage's analytical engine anticipated that the mechanized computational operations of this machine could enter domains that used to be the exclusive domain of human creativity:

> *"Again, it [the Analytical Engine] might act upon other things besides number, were objects found whose mutual fundamental relations could be expressed by those of the abstract science of operations... Supposing, for instance, that the fundamental relations of pitched sounds in the science of harmony and of musical composition were susceptible of such expression and adaptations, the engine might compose elaborate and scientific pieces of music of any degree of complexity or extent." (Taylor's Scientific Memoirs 3)[8].*

Almost 170 years later such machines do exist and computer based music composition has reached high levels of sophistication. For instance, based on a prior analysis of harmonic relationships, hierarchical structure, and stylistic patterns of specific composition(s), Cope [9] has written algorithms to

generate plausible new pieces of music in the style of the composer behind the original pieces.
However, despite these advances there is no general theory of creativity that either explains creativity or can directly drive the construction of creative machines. Definitions of creativity mostly follow a Turing test like approach where the quality of a process or product is declared to be creative dependent on the subjective judgment by other humans of its novelty and value. The emerging field of computational creativity defines its goals explicitly along these lines see Colton [10].
Although these approaches could generate interesting applications its definition is not sufficient either as an explanation nor as a basis to build a transformative technology as the classic arguments of Searle against the use of the Turing test in Artificial Intelligence has shown Searle [11]: "*mimicry of surface features is not to be equated with emulation of the underlying generative processes*".
In this article we address the question of how we can advance our understanding of the interplay between computer intelligence and music creativity, by placing human experience in expressive and artistic contexts at the centre of the solution. So, our approach is to experiment with interaction in performance situations based on virtual sources, mostly in form of audiovisual materials, human gestures, real movements, register the behavioral outputs and bio-signals of humans.
Thus, extending this point of view in the direction of multimodal performances and interaction in mixed reality, our research intends to develop a program to: a) combine multimodalities using interactive media; b) produce digital immersion and augmented cognition; c) study human cognition and creativity using databases generated by computer music, computer graphics, sensory devices, bio-signals and motion caption.

Interactive Media as Laboratory

In the use of the new interactive technologies, an interactive environment can function as a laboratory to explore computational models of cognitive processing, and interactive behavior. With the advent of new technologies that have emphasized interaction and novel interfaces, alternative forms and modes of interactive media have been realized, as described by Rowe and Winkler, [13][14].
For example, interactive music systems depend on a human user to control a stream of musical events, as in the early example of David Rockeby's Very Nervous System (1982–1991). This pioneering perspective on sound interactive media was developed to integrate musical performance with the human nervous system. Miranda and Wanderley [15] discuss the development and musical use of digital musical instruments (DMIs); that is, musical instruments comprised of a gestural controller used to control the parameters of a digital synthesis algorithm in real time, through predefined mapping strategies.
On the other hand body's perceptual, cognitive, motor and kinesthetic 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, as discussed by Coessens [16].

Thus we will deploy methodological efforts focusing on interactive media within mixed reality environment in order to study the constructions of meaningful relationship between agents and environmental stimuli in a virtual space. The assumption is that the interaction of an agent or group of agents with an immersive space, using interactive devices, indicates how these processes affect their behavior and the meaning that is constructed by them.

ANTICIPATION, DISCOVERY AND ABDUCTION

Acquiring knowledge from experience is an important evolutionary accomplishment, for it aids the organisms in predicting future outcomes of the always-shifting environment. In the sound domain, Anticipation seems to be a very prominent aspect of musical experience; listeners seek for relations in and of the antecedent sound events creating expectations as the possible consequents. Music expressivity and aesthetic pleasure or affects, important parts of artistic appreciation, are derived from the dynamics of expectations and their possible fulfillments in the unfolding of musical works, described by Huron [17].

On the other hand, concerning to the idea that there is logic in discovery processes, the work of the American philosopher Charles Sanders Peirce is paramount. Peirce's notion of Abduction (Peirce 1931-1958) is addressing the study of discovery in scientific knowledge that started to receive more attention in the 19th century.

Peirce described three types of reasoning: *Abduction, Induction and Deduction*. While induction and deduction are traditionally investigated thoroughly in philosophy, abduction seems to be less scrutinized, despite being one of the most important contributions of Peirce's Pragmatism. Basically, abduction is the kind of inference that generates explanatory hypotheses when anomalous facts are perceived. It is related to the presence of surprising or unexpected events. According to Peirce, the main activity of any mindful or cognitive system is the production of habits. Stable habits, in turn, constitute beliefs from which the reality is apprehended. From this perspective, a mental system could be understood as a dynamic network of stable habits (or beliefs) from which novelties and anomalies are detected as surprising events.

In previous article [4], we postulated that musical experience is not diverse from other kinds of cognitive experiences, thus employing similar reasoning those applied on daily life. Solving a very complex mathematical puzzle or doing the supermarket, or listening to music employs the same mental-logical operations available to acquire knowledge from experience. Our hypothesis is that artist, composers, performers and public generate and exchange expectations using these three kinds of reasoning understanding of the concept of meaning in a new (pragmatic) perspective.

TRAJECTORY OF INSTALLATIONS AND PERFORMANCES

In previous works, we had already developed artistic performances based on the perspective presented above: re(PER)curso (2007) and Multimodal Brain Orchestra (2009). In the first, the approach was to integrate algorithmic

composition with interactive narratives and scientific sonification and visualization. The structural pillars of that work were not a script or textual narrative, but how the concept of recursion could be used as a way of constructing meaning. Specifically, the interaction between two human agents that produced recurring changes in the physical world and an avatar in the virtual world, created a substrate for the emergence of meaning [5].
In the second study, we explored how the internal and external representations of the world could be joined together in a performance to create music, sounds and video, which can be also seen as a form of interactive narrative of a mixed reality [6].
These two works were preceded by the *RoBoser* project (1998) [18] and *ADA: intelligent space* (2002) [19], projects that were realized in real-world systems of multiple forms and functionalities. The RoBoser paradigm has been generalized from the musical domain to that of multimodal composition in the (Figure 1) exhibition as well the other two mentioned works, *Re(per)curso* (Figure 2) and *The Brain Orchestra* (Figure 3).

Figure 1: *The Ada main space (180 M^2) interacting with its visitors through interactive multi-modal compositions. The hexagonal floor tiles are pressure sensitive and display colored patterns dependent on Ada's behavior modes and on visitor interactions. The walls are made of semitransparent mirrors and allow visitors in the voyeur corridor to view what happens inside Ada. Above the mirrors a circular projection screen displays real-time animated graphics that, similar to the music, represent Ada's current behavior and emotional state. Ada was operation from May until October of 2002 and was visited by over 500.000 people.*

Figure 2: *The interactive performance re(PER)curso was presented in Barcelona in 2007 at the Museu d'Art Contemporani de Barcelona and in 2008 at the Art Futura festival at the Mercat de Les Flores. The performance explores the confluence of the physical and the virtual dimensions which underlie existence and experience, and it poses questions about the significance of artificial sentience and our ability to create and coexist with it.*

Figure 3: *The Brain Orchestra performance. The four Brain Orchestra members play virtual musical instruments through Brain Computer Interface - BCI - technology alone. The orchestra is conducted while also an emotional conductor, seated in the front right corner, is engaged who drives the affective content of a multi-modal composition by means of her physiological state.*

Table 1 presents a review of the concepts encapsulated by these works and also key ideas of minDSounDS (2014) that will be presented in its first run at the Generative Art Conference 2014.

Motivations
• *unfold performance in line with improvisation and audiovisuals.* • *create a live interactive composition system in which the physical space, light, sounds and images are integrated in a broad notion of musical instrument.* • *broaden exploration of the countless possibilities to correlate sounds, visual material and text.* • *understand music performance as re-creation and not merely reproduction of a work.*
Concepts
• *mixed reality performance as a performance environment* • *dynamic of creativity is correlated with semiotic operations* • *meaning driven by broken habits and abductive reasioning*
Interactive Performance
• *agents: human perfomers and avatars* • *interaction between trajectories build up from moviments and music improvisation* • *moviments and music improvisation interactive paradigm* • *improvisation and self-organization in the heart of the performance* • integrate performance trajectories to produce changes on Avatar's behavior

Table 1: *It features a review of the concepts presented above and also the key ideas of minDSounDS.*

PERFORMING MINDSOUNDS

minDSsounDs is based on the notion that the delivery of *Presence* is closely tied to an understanding of consciousness [12] and, in particular, of the interplay of implicit and explicit factors in the construction of human behaviour and artistic expression (as described in previous section). It is a performance where a group of musicians and machines dialogue in a network, there is a continuous exchange of information between these agents, and the emerging sounds and visuals are shaped by physical actions, movements, music improvisation and implicit signals captured by BCI.

Interactions between five musicians give rise to an artwork that uses interactive media in a multimodal performance (see figure 6). They come together to create a plot that plays with poetry, sound and visual textures, capture and analysis of movements and the use of BCI to control the movement of an Avatar in the virtual reality, audio and video in real time.

MinDSounDS speaks to the notion of "sound imaginary" and the idea of "mind the sounds". Its poetics describes creation and re-creation of meaning from the exchange of information among agents. It projects the building of a visual form based on sound manipulations within a network of exchanges between performers and computers (see figure 4). The composition uses sound material created from the Manzolli's poem "Apeiron[1]", originally in Portuguese, but presented in five languages during performance. The original poem is presented below in Portuguese and in a free translation to English (see Table 2)

[1] Apeiron is a Greek expression describing a cosmological theory created by Anaximander in the 6th century BC.

APEIRON Jônatas Manzolli		
no mesmo momento a origem de todas as coisas fez-se nas partes uma das outras. árvore dos fragmentos peixes e luas dos grãos de areia e as sementes de todos nos outros. sonho do pensamento pensamento do movimento movimento do gesto gesto do som som da mudança mudança do sentimento sentimento da transformação. transmutam-se elementos e universo preenchem vazios cósmicos particionam direções do tempo plantam sementes todos os outros elementos. árvores voltam às cinzas grandes peixes às luas-grãos-de-areia matéria e conhecimento aos sonhos movimento ao gesto desejo ao prazer. o universo sustenta-se no encadeamento da conciliação.		at the same time the origin of all things made itself of each other's parts. tree of fragments fishes and moons of grains of sand and seeds of all in others. dream of thought thought of movement movement of gesture gesture of sound sound of change change of feeling feeling of transformation. transform themselves elements and universe filling cosmic voids partitioning directions of time planting seeds all the others elements. trees return to ashes big fishes to the moons-grains-of-sand matter and knowledge to dreams movement to gesture desire to pleasure. the universe sustains itself in the stream of conciliation.

Table 2: *Poem Apeiron, originally in Portuguese, used to produce an immersive chain of fragmented words in minDSounDS.*

The aim is to produce an immersive chain of sound information, a soundscape resonating various meanings and turning points. Thus, words are fragmented and (de)constructed with granular synthesis and these sounds are spatialized in real time using motion capture and interactive gestures.

Along with this process of integration between sound and movement, MinDSounDS dialogues with sound material generated by the flutist improvisation and gestural controls with the Wiimote interface. These elements are integrated to build a virtual representation of the interaction itself and the action between the five agents: the structure of movements and body construction of an Avatar is controlled by a BCI interface (see Figure 5).

All these elements are used to create a universe that can only be sustained by a chain of reconciling between actions and agents.

Figure 4: *Interaction with the Avatar. minDSounDS builds a visual form based on sound manipulations within a network of exchanges between performers and computers.*

minDSounDS concept follows this path: "*while an agent and a group of agents are interacting all multimodal signals produced by the agent(s) are shared in a network, captured and analyzed in real time and/or stored for future off-line manipulation, remotely or locally*. The concept is to create a live interactive composition system in which the physical space, light, sounds and images are integrated in a broad notion of musical instrument.

Figure 5: left: flute improvisation; right: the BCI interface *Interaction with the Avatar.*

Figure 6: *minDSounDS team. In left photo: Tiago Tavares, Clayton Mamedes, Gabriel Rimoldi e Vânia Pontes. In the right photo: Jônatas Manzolli and the Team at the electronic studio of NICS.*

Conclusion

We presented in this article the possibility of combing multimodalities and interactive media to unfold live performance in line with improvisation and audiovisuals such as re(PER)curso (2007) and the Multimodal Brain Orchestra (2009). As we understand music performance as re-creation and not merely reproduction of a work, we aim to enlarge the countless possibilities to correlate sounds, visual material and text in minDSounDS (2014). Thus we presented interactive performances aiming to create meaningful relationships between agents and explore their interactions using visualization and sonification. Further, for studying music cognition in its fullness and understand its processes of discovery and creativity, it is necessary to examine how the brain and body work together in the solution of such complex problem.

Many decisive steps in the processes of creativity and discovery rely on implicit factors rather than explicit ones. Our goal is to explore these factors to validate a mixed reality implicit and explicit Presence delivery system linked to expressive experience in artistic domains.

In short, these artworks illustrate that aesthetic experience can be, at least partially, obtained as emerging organization from the interaction between human users and an interactive system. Since our goal is to enhance creativity, this approach seems powerful and can lead to unexpected results (surprise is another form to describe information).

Acknowledgements

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Joseph Hyde

Molecular Music: repurposing a mixed quantum-classical atomic dynamics model as an audiovisual instrument (performance and paper)

Topic: Music

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Main References:

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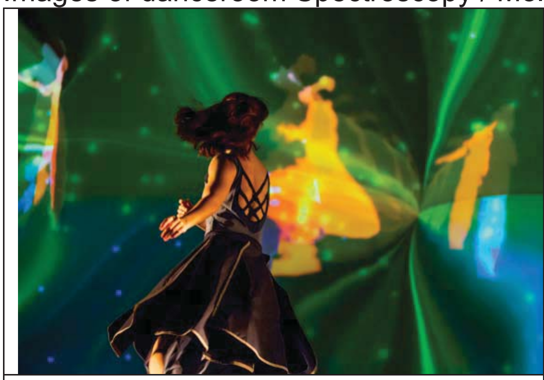
Molecular Music is an offshoot of a long-term collaborative project, the multi-award winning danceroom Spectroscopy (dS). dS has its roots in computational molecular dynamics, and was originally conceived to serve as an interactive platform for molecular simulation. It offers a multisensory immersive experience based on cutting-edge science facilitating an understanding of the principles of our microscopic world through direct experience rather than traditional academic learning. It consists of system of particles, simulated according to strict scientific principles; represented both visually and sonically, which can be interacted with through human movement. The project consists of a public installation, and also a contemporary dance piece, Hidden Fields, which is performed using the system. Hyde's contribution to the project consists of the sonification (interactive systems and sound design) for the installation, and the composition of an interactive score for the dance piece.

Molecular Music is intended to facilitate further exploration of the audiovisual relationships at play in dS and Hidden Fields and to explore more deeply how to sonify vibrations on a micro scale (where sound does not, as such, exist). We have built some highly developed algorithms based on FFT analysis of molecular vibration data outside the range of human hearing to yield subharmonics on which sonic material can be based. We also have in place a sophisticated system whereby sound can control the particle system and the particle system can in turn control the sound. We are exploring how this combination can be used to make a novel kind of feedback loop, and a network of non-trivial audiovisual relationships whereby the influence of sound on image and vice versa is mediated via the medium of an advanced mixed quantum-classical model. Using these tools we can use dS as a highly evolved 'visual music' instrument.

The performance consists of a solo audiovisual performance of around 15 minutes duration. The paper outlines the algorithms at the heart of the dS system and their broader implications for Sci/Art visualisation/sonification and understanding, before moving on to examine how these algorithms have been adapted as an audiovisual instrument. The history of the project, including installations, dance performances and music-based collaborations, will be examined followed by a look to the future – in particular the development of dS as a large-scale permanent exhibit for ZKM in Karlsruhe to open in 2015.

Images of danceroom Spectroscopy / Molecular Music:



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Scientific visualisation, quantum mechanics, SciArt, Dance, Music, Audiovisual

Molecular Music: repurposing a quantum model as an audiovisual instrument

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Abstract

Molecular Music is an offshoot of a long-term collaborative project, the multi-award winning danceroom Spectroscopy (dS)[1]. dS was originally the brainchild of Computational Chemist David Glowacki (Stanford University). It offers a multisensory immersive experience based on cutting-edge quantum mechanics facilitating an understanding of the principles of our microscopic world through direct experience rather than traditional academic learning. It consists of system of particles, simulated according to strict scientific principles; represented both visually and sonically, which can be interacted with through human movement. The project consists of a public installation, and also a contemporary dance piece, Hidden Fields, which is performed using the system. Hyde's contribution to the project consists of the sonification (interactive systems and sound design) for the installation, and the composition of an interactive score for the dance piece.

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The performance consists of a solo audiovisual performance of around 15 minutes duration. The paper outlines the algorithms at the heart of the dS system and their broader implications for Sci/Art quantum visualisation/sonification and understanding, before moving on to examine how these algorithms have been adapted as an audiovisual instrument. The history of the project, including installations, dance performances and music-based collaborations, will be examined followed by a look to the future – in particular the development of dS as a large-scale permanent exhibit for ZKM in Karlsruhe to open in 2015.

1. The danceroom Spectroscopy project – background

danceroom Spectroscopy is an indirect outcome of the scientific research of Dr. David Glowacki. Glowacki works in the field of Computational Chemsitry, using complex algorithms to model the behaviours of matter and energy (a detailed exposition of the algorithmic basis of dS is outlined in section 3 below). In 2011, with programmer Phill Tew, he began to explore the idea of a visualisation system which would afford non-specialists an insight into the principles at work in Glowacki's research, and an instinctive understanding of the inner workings of our world on a nano scale.

In its initial form, c. mid 2010, the project consisted of a simple particle system, but one where the movement of the particles is governed by the algorithms at work in Glowacki's research. These particles inhabit what Glowacki and others in his field refer to as an 'energy landscape'. One might simply think of this as a contoured landscape in which 'higher' areas (hills, mountains, ridges) are 'hotter' (ie, of higher energy) and 'lower' areas (valleys, dips, craters) are 'colder' and have lower energy.

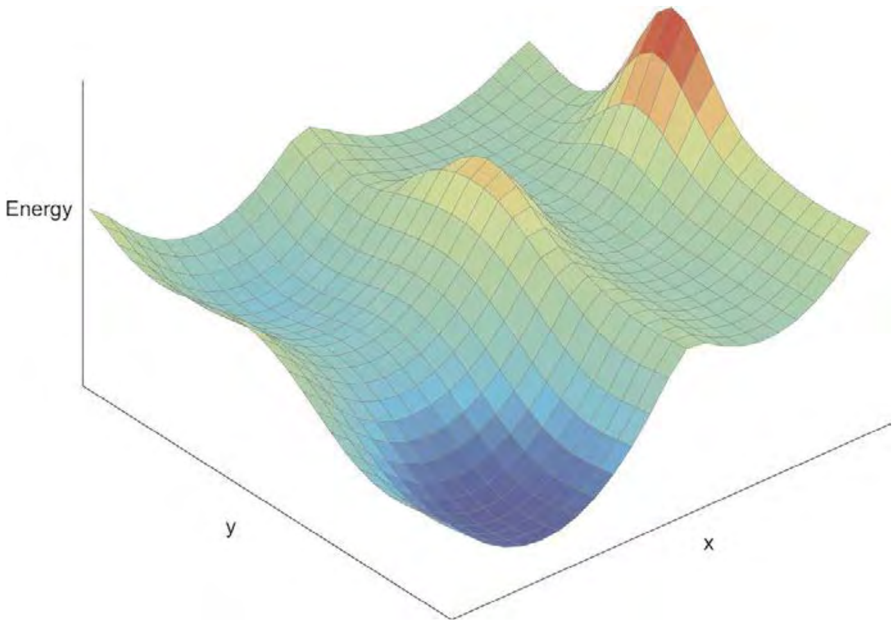

Figure 1. A representation of an energy 'landscape'

A crucial feature of the energy landscape at play in dS is that someone viewing the particle system can actually become part of this energy landscape. This is achieved in a relatively straightforward manner by interpreting their body as a peak, or a trough (both are possible with the system) in the energy landscape. Various interactive technologies have been explored in order to make this possible, but early on in the project the Microsoft Kinect sensor was adopted as a cheap and relatively simple solution.

The Kinect, introduced in November 2010, was released as a games controller for the Xbox 360 games console, but was rapidly ‘hacked’ and adopted for many broader purposes, including a number of arts projects. The controller consists of a standard-definition colour camera (broadly equivalent to a webcam in terms of functionality and quality), an infra-red camera, an infra-red laser projector (strictly speaking, both are near-infrared) and a microphone array. The infra-red projector and camera, working in tandem, constitute a so-called “structured light” system which allows the device to yield a depth value for every pixel of the camera image. This “depth map” is produced by comparing the pattern of dots projected with the pattern picked up by the camera, and extrapolating depth values from distortions detected in this pattern. For most applications, the purpose of this depth-map is simply to separate foreground from background, and specifically to separate human forms from what – in the domestic setting envisioned for this device – might be quite a cluttered and chaotic environment. dS uses this background separation, but also makes full use of the depth map to allow the shape of human bodies, captured in real time, to become contours in the energy landscape.

Early versions of dS were essentially manifested as small-scale public installations for demonstration purposes, using a single Kinect. However, these rapidly garnered considerable interest and in light of this the scope of the installation was expanded. The graphics were improved, more Kinects were used to allow the system to work in larger spaces (an array of up to 10 of the devices can be used with the latest version) and – crucially for the purposes of this paper, a sonic component of the project began to be developed. The latter will be discussed in detail below.

2. Hidden Fields

By 2011, the installation had grown into a highly successful and popular Sci-Art installation sufficiently flexible to be installed in a wide variety of spaces, including a dome environment with full 360-degree capture and projection (see figures 1 and 2). At this point a large team of collaborators had gathered around the project, including Professor Joseph Hyde and Dr Tom Mitchell. A decision was made at this point to further explore the aesthetic possibilities of the system using a small number of ‘expert users’. Trained dancers seemed the obvious choice for such a role. Applicants from the contemporary dance community were invited to apply to take place in a specialist workshop using the system at the Arnolfini in Bristol in June 2011. Following the success of this a decision was made to develop a fully-fledged dance work, known as Hidden Fields (see figure 3). This went through a number of iterations throughout 2012, with development supported by a grant from the Arts Council of England, and a number of performances in the UK and Europe.

Figure 1 – the Igloo 360 dome being installed for the dS festival, The Passenger Shed, Bristol, October 2012

Figure 2 – the dS installation in dome formation

Figure 2 - Hidden Fields performance in Seeing Sound [2], November 2013

Hidden Fields offered a tremendous opportunity to develop the sonic and musical dimensions of the project. During this period, Hyde and Mitchell, broadly operating in the roles of composer and music technologist, evolved the broad palette of sounds and techniques outlined below. The controlled environment of a dance performance and an extensive rehearsal process incorporating dancers (as expert users) allowed for an exploration of extremes. Whilst a public installation needs in some respects to 'play it safe', to allow for a wide range in terms of the numbers of users and the ways in which they might interact with the system, Hidden Fields allowed us to decide what we wanted the system to do, and to evolve ways of achieving this end. In this way, the aesthetics of the project were allowed to evolve, visually and sonically.

As the piece evolved towards its current duration of around an hour, it was felt necessary to firm up a quasi-narrative structure for the piece. This was largely driven by the music, and we felt the need to have certain points in the structure where the sound/music was not fully driven by the particle system (with the chaotic behaviour that paradigm produces) but rather allowed to operate according to a more traditionally musical/compositional logic. Rather than break the connection between the particle system and the sound at these junctures, we evolved a set of techniques whereby the sound could control the particle system as opposed to vice versa. This opened up a set of possibilities only explored in embryonic form in Hidden Fields, and was arguably the origin of what would become Molecular Music. It allowed the possibility of a complex feedback loop where the particle system and sound operate upon each other. We only scratched the surface of what such a system makes possible within the context of Hidden Fields and this led us to actively seek another avenue within which to do so.

3. Scientific Underpinnings

As stated above, the Kinect sensor (or array) yields a depth map whereby for every pixel in an x/y array, a value is given for z (depth). The plot in figure 5 shows a human form incorporating data derived from this depth map - here the intensity of the colours is linked to the magnitude of the local gradient vector on the image. The manner in which it is plotted suggests analogy with the concept of an energy landscape, which has become a fundamental idea guiding how chemists and physicists think about both kinetics and dynamics in a range of chemical systems, from small molecules to complex materials and biochemical systems [3, 4]. An energy landscape is effectively a topological map of a system's potential energy, *V*, at a range of different configurations. Within any localized region of the energy landscape, the gradient of the energy, $dV/d\mathbf{q}$, relates the topology of the energy landscape to the classical forces felt by a particular molecular configuration. dS interprets people's movements as perturbations on a virtual energy landscape.

Figure 5 - Force topology map of the human form. Gray indicates a gradient of zero. The intensity of each color is related to the magnitude of the local force vector on the depth image. Color choice has been selected to effectively illustrate depth

In its present form, dS carries out an MD simulation involving N atoms, each of which may move in a virtual coordinate system defined by Cartesian x, y, and z directions. Hamilton's equations of motion, commonly used to discuss the dynamics of molecular systems in both classical and quantum frameworks, provide a useful vantage point for describing how the system works. They are as follows:

$$\begin{aligned} d\mathbf{p}/dt &= -dH/d\mathbf{q} \\ d\mathbf{q}/dt &= \ \ dH/d\mathbf{p} \end{aligned} \tag{1}$$

where **p** and **q** are the momentum and coordinate vectors of each atom in the ensemble, and H is the so-called Hamiltonian function describing the total system energy - i.e.:

$$H = \sum_{i=1}^{N} \frac{m_i v_i^2}{2} + V \qquad (2)$$

where *i* is an index that runs over a collection of N total atoms, *m* is the mass of an atom, and *v* is its velocity. The first term in Eq (2) describes the total kinetic energy of the system while the second, *V*, describes the total potential energy. Within dS, there are two different contributors to *V*:

$$V = V_{\text{int}} + V_{\text{ext}} \qquad (3)$$

where the total potential energy, *V*, is calculated as the sum of two terms, V_{int} and V_{ext}, which correspond to the potential energy owing to internal and external fields, respectively. Like many MD programs, the most expensive loop in dS is associated with calculating $V_{int,}$ and involves summing over all possible pairwise interactions:

$$V_{int} = \sum_{i=1}^{N} \sum_{j=i+1}^{N} V(r_{ij}) \qquad (4)$$

where r_{ij} is the distance between atoms *i* and *j*. During initial prototyping and benchmarking of the dS system, V_{int} included only non-bonded Lennard-Jones type interactions with parameters derived from electronic structure calculations [5]. However, as discussed further below, we have recently implemented a set of fast C# wrappers which allow dS to call the GPU-accelerated OpenMM program whenever a force evaluation is required. OpenMM allows for a wide range of force interactions, including bonds, angles, torsions, non-bonded Lennard Jones interactions and electrostatic interactions [6].

The V_{ext} term in Eq (3) is calculated as a sum over the difference between a raw depth matrix at time *t*, $V_{ext}(x_i, y_i, t)$, and an average background depth image, $\langle V_{ext}(x_i, y_i, 0)\rangle$ as follows (angled brackets indicate an average):

$$V_{ext} = C_i \sum_{i=1}^{N} [V_{ext}(x_i, y_i, t) - \langle V_{ext}(x_i, y_i, 0)\rangle] \qquad (5)$$

where the term in square brackets represents the potential energy that an atom 'feels' as a consequence of people's motion, and C_i is a variable scaling constant applied to a specific atom. Interactive control over C_i allows the user to determine how strongly any given atom 'feels' forces from the users' fields, and whether a person's field is 'attractive' or 'repulsive'. Eq (6) is responsible for coupling human motion to the atomic dynamics, allowing humans to sculpt the potential energy landscape felt by the atomic ensemble, and thereby chaperone the system dynamics.

In Hamiltonian mechanics, the energy function, *H*, should remain constant for any closed dynamical system, in line with the conservation of energy required by the first law of thermodynamics [7]. However, the Eq (2) Hamiltonian is not subject to this constraint because of the V_{ext} term, which effectively makes the system open rather than closed. Fluctuations in the depth data arise as a consequence of noise in the depth images, or people's motion within the space mapped by the depth sensors. Both of these effects effectively result in fluctuations of the total system energy, introducing significant instabilities into the Velocity Verlet [7] scheme used to propagate the time-dependent system dynamics in Eq (1). To address this, and avoid the crashes associated with such instabilities, we have implemented a modified velocity rescaling Berendsen thermostat, in which the instantaneous system temperature T_t approaches some desired temperature T_0 with a first order rate

$$\frac{dT_t}{dt} = \frac{1}{\tau} \cdot (T_0 - T_t) \qquad (6)$$

that depends on a user-specified rate coefficient (1/*t*) and how far the system is from T_0. Rearranging (6) gives an expression for the temperature change dT_t over some time step *dt*:

$$dT_t = \frac{dt}{\tau} \cdot (T_0 - T_t) \qquad (7)$$

where *t* is a first order time constant, and

$$T_t = \frac{1}{d \cdot N \cdot k_B} \sum_{i=1}^{N} m_i v_i^2 \qquad (8)$$

with *d* the number of dimensions in which each atom can move (three), *N* the number of atoms in the simulation, and k_B the Boltzmann constant. The velocity rescaling constant *l* is determined via definition of *T*(*l*), which is the temperature that results when all the atomic velocities are scaled by *l*, i.e.:

$$T(\lambda) = \frac{1}{df \cdot N \cdot k_B} \left[\sum_{i=1}^{N} m_i (\lambda v_i)^2 \right] = \lambda^2 T_t \qquad (9)$$

We evaluate *l* by specifying that $dT_t = T(l) - T_t$, and substituting Eq (7) and (9) to give:

$$\frac{dt}{\tau} \cdot (T_0 - T_t) = \lambda^2 T_t - T_t \qquad (10)$$

which may be solved to yield

$$\lambda = \sqrt{1 + \frac{dt}{\tau} \left[\frac{T_0}{T_t} - 1 \right]} \qquad (11)$$

Prior to determining the value of T_t required for calculating that atomic velocity scale factor l, there is an added stability measure: we loop over the atomic velocities to ensure that none of the atoms within the simulation have a velocity more than two standard deviations larger than the average atomic velocity. We have found the procedure outlined above gives a good compromise between computational efficiency, interactive fluidity, and system stability. Moreover, it is extremely robust to numerical instabilities that can arise when user motion suddenly ‘injects’ energy into the system Hamiltonian.

4. Technology

The primary dS software consists of a bespoke application coded in C#. Later versions of the software are highly CPU-optimised, and make full use of top-end NVIDIA graphics cards – the primary system currently in use contains a dual-card system with over 4000 cores, all of which are co-opted by the software. Thanks to the work of a team of programmers specialising in code for GPUs, these cores are used not only to produce the graphics for the system, although at up to 6xHD resolution (11,520 x 1080 pixels – see figure 6) the rendering is a non-trivial task.

Figure 6 – 11,520 x 1080 pixel renders captured directly from dS software

The GPU cores are also used to resolve the equations outlined above – a unique aspect of the project which has attracted considerable interest from the scientific community, since it essentially allows a domestic PC (albeit a very high end one) to function as a massively parallelized supercomputer for the solving of many simultaneous quantum dynamics algorithms in real time. For the purposes of dS, it has allowed us to massively increase the particle count.

The audio component of dS runs on a separate machine, and is built using Cycling74’s Max environment [8]. For the purposes of Hidden Fields and subsequently Molecular Music, the Max software has been devolved into a number of Max for Live [9] plugins. The advantage of this approach is that it allows Ableton Live to function as a timeline for durational structures – whilst the micro-level elements of both sound and image will be aleatoric and interactive, the overall behaviour of the system can be controlled with the sophistication and reliability that a modern Digital Audio Workstation (and in this case, one specifically designed for live performance) affords.

Communication between the two machines is achieved using the Open Sound Control (OSC) protocol, developed by Martin Freed and his team at CNMAT, University of California, Berkeley [10]. This protocol offers many advantages for us in this context – primarily by virtue of its flexibility and speed. We have been able to develop a system where what multiple streams of information are sent in both directions – these can be massively parallel (for example, collision data from every single particle in the system) and/or extremely fast – we are able to use data streams at close to audio rates, which makes the system incredibly responsive and opens up many creative avenues.

Although the OSC protocol operates essentially as a network, allowing data to travel in any direction between multiple machines, dS – at least as used in Hidden Fields and Molecular Music – operates in a configuration where the PC running the main dS software (quantum simulation, particle display, depth map acquisition etc.) is essentially ‘slaved’ to or controlled by the audio machine. This is mentioned here because it is one of the factors that makes the system so suitable as a compositional or audiovisual performance tool – this is discussed in more depth below.

5. Sonification – general principles

We will discuss in turn the two primary categories of interaction involved in the system: firstly interaction where data is being sent from the primary dS machine to the audio machine and secondly where data is sent in the opposite direction. In reality both are operating continuously and simultaneously, as will be discussed below.

The simplest type of interactivity, and the first to be developed, is collision detection. Data is produced when particles collide, at which point the system yields the coordinates at which the collision takes place, and the speed at which the particles collide. The capabilities offered by the type of interaction will vary according to the physical properties of the system being simulated (this is something of a universal principle in terms of dS, and is something we discuss further below). Where particles and energy fields are 'attractive', ie where simulated physical forces will draw them together (using the energy landscape metaphor, this would be equivalent to a ‘trough’), particles will tend to be drawn together to form clusters, and the collision data – when sonified – will tend to yield recognisable patterns; not entirely regular but nonetheless with a clear contour. These can function well as stochastic rhythms or melodies.

Where simple particle collision data is combined with a model whereby particles and energy fields repulse each other (modelling ‘peaks’ on an energy landscape), a different set of possibilities is afforded. With no external stimuli the system in this state will become entirely chaotic, but with an external source, the particles will tend to be driven by boundary conditions in the source (edges between areas of different hue or luminance, for example) and to form wave-like structures at these points. Within the sonification, this will tend to yield granular-type textures where the sounds associated with individual particles get lost perceptually, but overall contours of particle waves are perceptible and structurally useful. The fact that this type of sonification only becomes perceptually interesting with some kind of external stimuli is why a video source is still usually used with Molecular Music performances as a ‘substitute’ of sorts for the Kinect-derived depth map used in the original dS installation. The content of the video source is almost irrelevant – it can simply serve to provide some kind of irregularity or granularity in an energy landscape that would otherwise be entirely uniform.

Once a large number of particles are introduced it can be very hard to produce structures and sounds which are meaningful using collision data – as might be imagined, if tens of thousands of particles and the collisions between them are sonified the result will tend to approach noise. At this point there are two other models of interactivity that can be employed. The first of these has become known as 'group data'. This data will generally only be produced, or at least meaningful, under certain conditions. There will need to be a relatively large number of particles, and they will need to be 'attractive' (ie attracted to energy fields). In this set of circumstances, the particles will tend to 'swarm', to form into large groups. (In the installation or dance performance, these groups will tend to correspond to individual users). The system has the capability to treat such groups as 'super-particles', and the system can provide corresponding data to that which it provides for individual particles - spatial coordinates and speed data. This allows the production of relatively simple, or at least perceptually ‘digestible’ musical patterns and contours using very large numbers of particles. However, it is dependent on a fairly specific set of conditions in terms of the physical simulation – without these the groups will not even form.

Where large numbers of particles are used in more chaotic formations, without the grouping mentioned above, a third type of data becomes particularly useful. This data involves a Fast Fourier Transform (FFT) analysis of the vibrational energy of the particle system (the frequencies yielded by the transform function are sub-audio, below 1 Hz, but are effectively transposed up into the audio domain). This is of interest because it will tend to highlight overall properties of the particle system, in particular any kind of coherence in the movement of the particles in the system.

Such coherent movement will result in measurable peaks in the FFT data, which can be made to yield perceptible sonic feedback when transposed up into audible frequency space. In the case of installation or dance performance, these peaks will be produced when a significant number of the users in the space move in the same direction, or in the same manner. In the case of Molecular Music, in the absence of such stimuli, the only way to produce such coherent motion is by using sound itself to stimulate the particles to move in an ordered fashion – this forms the basis of a kind of feedback loop which has become core to the project.

At the same time as these methods are provided whereby the particle system can control the sound, as of latter versions of dS, the sound can also control the particle system – we have explored methods whereby amplitude, frequency and more complex FFT-derived data can be used to control all aspects of the simulation. What is particularly interesting is that the sound is controlling physical rather than graphical properties, so that (for example) a mapping of sound intensity onto temperature will manifest itself as complex and multifarious (and sometimes unpredictable) changes to the visualisation.

In addition to mapping sound-derived data onto physical properties, we have also built in functionality whereby the sound machine and software can control the dS machine directly through OSC. This is largely used to achieve long timescale changes using the timeline functionality of Ableton Live (and Max for Live). It allows us to shape the system into time-based structures – essentially, to 'compose' it. This has proved invaluable in the Hidden Fields dance project and Molecular Music.

Of course, all these types of sonification and visualisation (in this context these terms, particularly the latter, could be seen as something of a simplification) are used in various permutations, often all together. Recent versions of the dS system allow the combination of 'attractive' and 'repulsive' behaviours, where some types of particles exhibit the former pattern of behaviour and some the latter. The permutations between these types of behaviour and the three types of data offer a plethora of possibilities, and make the dS system uniquely flexible in terms of sonification.

6. Molecular Music – Introduction

Molecular Music started life through the agency of a specific opportunity. The dS team were offered the chance to perform with violin virtuoso Nicola Benedetti and her string trio, as part of the first-ever Bristol Proms season at the Bristol Old Vic in August 2013 (figure 7). Given limited rehearsal time for this performance, we used something close to the existing dS setup, but with additional weight given to sound-particle system interactivity. We used the system with a multichannel interface for the first time, and used separate feeds from violin, cello and piano to drive individual elements of the simulation.

This performance was considered sufficiently successful that we were invited back to participate in the 2014 Bristol Proms. Tom Morris, the festival's Director, agreed that it would be interesting to explore a more flexible and collaborative framework in this second iteration, and to have more time to develop a unique working methodology. In this instance we worked with the Charles Hazlewood All-Star Collective, a loose confederation of musicians mostly based in Bristol and the South West. The crucial difference between this performance and the one that preceded it was that whereas the Benedetti trio performed from the Classical music repertoire, Hazlewood and his ensemble worked up an interpretation of Terry Riley's 'Rainbow in Curved Air'. This work has much in common with Riley's work 'In C' in structure, but actually has no score – our performance was based on an interpretation of the 1969 album (recorded by the composer) and the 'Rainbow in Curved Air Calligraphies' – abstract representations that Riley released more as interpretations of the music than as performance instructions.

Figure 7 - The Nicola Benedetti trio at the Bristol Proms with dS visualisations

Figure 8 – Bristol Proms performance with Charles Hazlewood All Star Collective

This time we were able to enter a more collaborative process where improvising musicians were able to respond to the visual stimuli yielded by dS as much as dS was in turn responding to their playing. Although this was some way short of a feedback loop (dS only providing the visual dimension to the performance rather than driving any sonic elements) it provided the closest analogy to some of the principles that would become core to the Molecular Music endeavour. It also allowed us to develop considerably more sophisticated sonification algorithms – in this instance we had separate audio feeds from 8 musicians, as well as several channels of MIDI, and a research and development period at Bath Spa University with some of the musicians allowed us both to evolve these techniques and to give the musicians time to learn how to ‘play’ the system to an extent.

One of the most important departures in the *Rainbow* performance was the decision to jettison the Kinect array. This put the emphasis firmly on sonification – although we did actually use a standard camera feed (a moving camera trained on the musicians) to provide some texture to the simulation in the manner outlined above, this was thoroughly abstracted and had no depth map – the energy landscape employed by the simulation was therefore entirely driven by sound rather than image.

7. Molecular Music – Aesthetic Considerations

Molecular Music essentially reimagines danceroom Spectroscopy as an audiovisual instrument. We see it as sited broadly as within the field of Visual Music, defined by Hyde thus: *Visual Music involves the artistic expression of musical ideas or material through ocular media* [11]. Although this term is generally applied to fixed media artworks, whether they be paintings, cinema or video art, many interactive and/or performative examples can be found, dating as far back as Oskar Fischinger’s *Lumigraph* in 1950 (and of course earlier ‘light organ’ instruments), and far more prevalent in more recent times). These tend to be interactive – that is to say user controlled, or to be based primarily on visualisation (visual elements driven by sound) or sonification (vice versa). Although examples can be found that combine more than one of these modes, Molecular Music is unusual in that it combines all three, and unique (to our knowledge) in that the interaction between these modes is via the medium of a quantum molecular simulation.

This factor is crucial in determining the characteristics of Molecular Music as a visual music instrument. In the design of any interactive system it can be hard to find the sweet spot between ‘mickey mousing’, where mappings and relationships are highly perceptible but too facile to be of lasting interest, and complex interactions where these relationships may be too indirect to be easily perceived. Using the simulation as a medium allows for a certain amount of uncertainty to be introduced which gives a pleasingly organic characteristic to modal interactions. We might use the metaphor of a vactrol, a component popular in modern analogue synthesizer designs. A vactrol contains an LED and a light dependent resistor – a varying voltage (or sound) at the input controlling the brightness of the LED will produce a variable resistance from the resistor, usually converted back to a voltage variation via a voltage divider circuit. The indirect nature of the connection between input and output (actually, in electrical terms, they are completely disconnected) results in a certain amount of variability that is highly prized as imparting a kind of musicality.

This is a function of principle that the system is predictable but also chaotic. This is evident even in the simplest instances. Figure 9 shows two runs of the same simulation, and the most basic that dS can offer. In this instance, a single particle is released and given an initial velocity by a short burst of a 1000 Hz sine wave (producing a short 'spike' in the simulation temperature). It loops back on itself by virtue of its own mass and, as can be seen, the basic form in each case is the same but the exact details of the form differ. Every time this simulation is run the results are recognisable but unique. This is perhaps not surprising from a scientific perspective, but from an artistic viewpoint it has great potential in injecting a 'musical' variation into the interaction between sound and image.

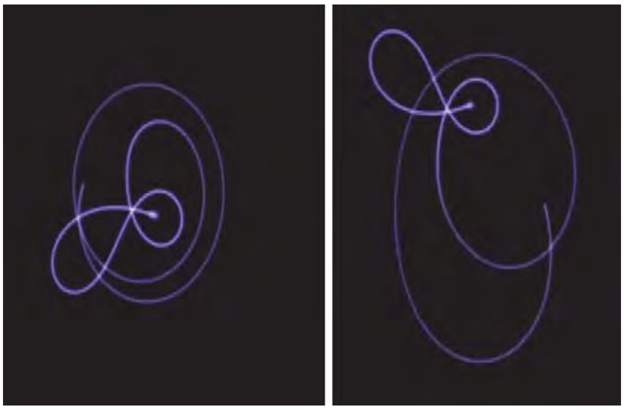

Figure 9: two instances of a one-particle simulation

As the complexity of the system increases, so do the creative possibilities of this chaotic behaviour. Figure 10 shows a very similar situation to that seen in figure 9 above, - again a short sine tone burst is controlling the temperature of the simulation, but in this case with many more particles of several types.

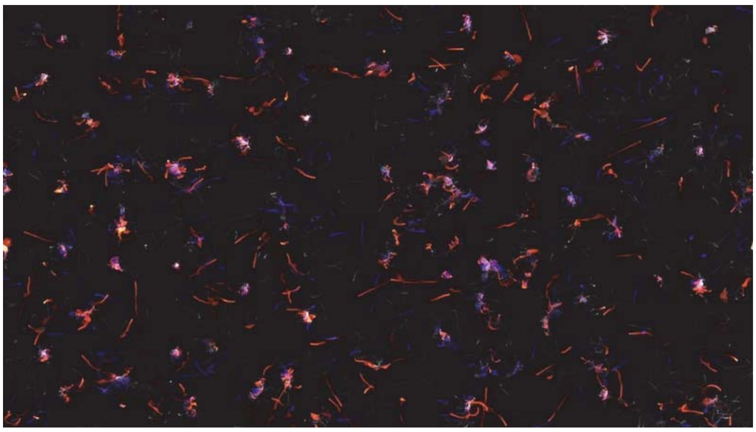

Figure 10: a similar simulation with multiple particles of different types

This is particularly the case where a feedback loop is established. The basic methodology of such a feedback loop is to set up conditions in which the particles control the sound and the sound controls the properties of the simulation (note that this is not directly equivalent to sound controlling image and image controlling sound). This amplifies the chaotic qualities of the system. The results are far less predictable, but are nonetheless repeatable. With exploration aesthetically pleasing results can be found. Some examples are shown here:

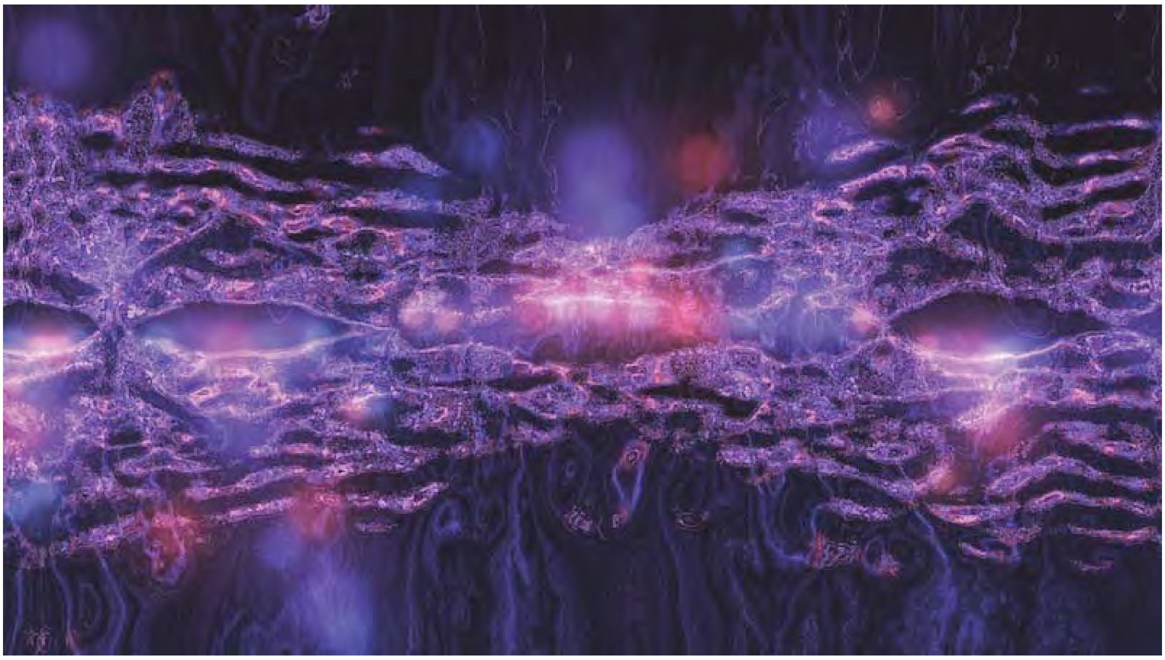

Figure 11 – Complex forms made through feedback via the dS simulation

8. Next Steps

The danceroom Spectroscopy project and its 'satellites' Hidden Fields and Molecular Music continue to enjoy great success and exposure. The scientific basis of the simulation is being continuously developed by Dr Glowacki and his colleagues at Stanford University. The dS system described here, and used for Molecular Music performances to date, only simulates single atoms, whereas versions of the software have since been produced to simulate more complex molecules, even protein strings (see figure 12 below)

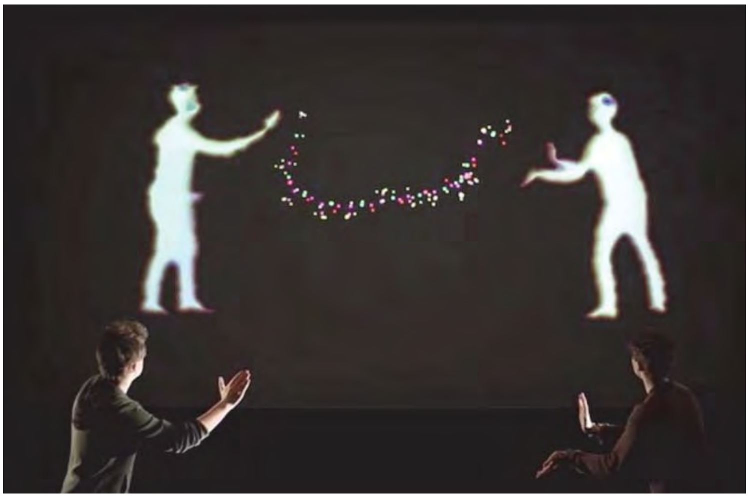

Figure 12 – Interactive protein folding using a dS-based simulation

Work is also being carried out to allow more complex energy 'landscapes' to be explored using the system. A recent experiment (show in figure 13) allows users to literally sculpt such a landscape using a sandbox, and then to see how particles of matter (literally projected onto the sand landscape) would behave in the landscape created. Neither of these recent developments has incorporated a sonic element as yet, and the possibilities for sonification seem very promising.

Figure 13 – sculpting an energy landscape in sand

A great opportunity will be offered by the building of dS as a permanent installation, at ZKM in Karlsruhe, Germany. There are many challenges involved in such an undertaking – reliability and sustainability to name but two. Amongst the more creative challenges will be the sonic aspects of the installation. As an installation, dS has to date usually involved a single ‘state’ (model of sound-simulation interaction). This has been seen as desirable in a situation where many parameters are outside of our control – the most influential perhaps being the number of people present in the space. The state that we have is capable of surprising variety, but nonetheless in an installation that may be in place for years rather than days we feel the need to allow for more long term evolution of the sound (amongst other things). This will give us the creative impetus (and space and time) to take the sonic aspects of the project to the next level.

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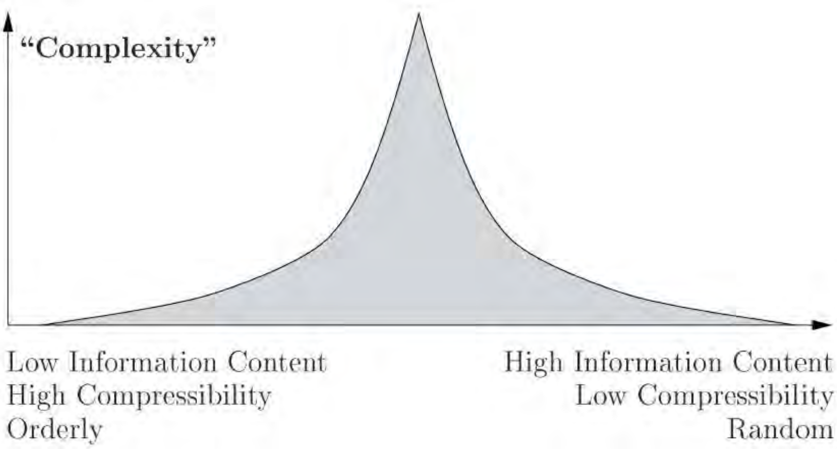
TOWARD GENETIC AESTHETICS: MUTATION OF BIO INFORMATION AND GENERATIVE ART SYSTEM

Abstract:
We propose the meaning and potential of "genetic aesthetics," because bio information can inspire the aesthetic purpose of generative art. By examining the definition of generative art and the term, *generative*, the conditions of generative art can be compressed as rule, autonomy, and system. Among them, system is considered as a key element in generative art, because an artist transfers subsequent control to system. In particular, genetic system is regarded as the highest position on the Gary Flake's graph of complexity (Fig.1) [1]. The graph shows that truly complex things occur at a transition point between orderly things and random things. It is a nexus of bio information and generative aesthetics, because it confirms that unity and diversity are not mutually exclusive concepts. Here, noise of information theory and mutation of biology have an important role to explain the aesthetic value within generative art. Thus, we analyze noise by using the Shannon's binary entropy function, and then apply mutation to that function. The analysis shows that the uncertainty due to mutations can create the biological complexity in keeping with the certainty due to redundancy. Mutation might be a factor to produce probabilities of innovation or deviation under the well-knit database of bio information. Bio information in terms of mutation eventually can be more persuasive to explain the aesthetic value of generative art in that the aim of generative aesthetics is the artificial production of probabilities of innovation or deviation from the norm [2]. A specific process that can lie beyond the artist's intuition can be derived from a specific factor such as mutation. It can inspire computer-based generative art in the relative discussions on the noise of complex system. Accordingly, genetic aesthetics can present the ultimate aesthetic direction at which computer-based generative art aims.



Complexity in terms of information, compressibility, and randomness

Topic: Art & Science

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Generative art system, Complexity, Bio information, Noise, Mutation, Generative aesthetics, Genetic aesthetics

Toward Genetic Aesthetics:

Mutation of Bio Information and Generative Art System

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Premise

We propose the meaning and potential of “genetic aesthetics,” because bio information can inspire the aesthetic purpose of generative art. By examining the definition of generative art and the term *generative*, the conditions of generative art can be compressed as rule, autonomy, and system. Among them, a system is considered as a key element in generative art, because an artist transfers subsequent control to system. In particular, a genetic system is regarded as the highest position on the Gary Flake’s graph of complexity. The graph shows that truly complex things occur at a transition point between orderly things and random things. It is a nexus of bio information and generative aesthetics, because it confirms that unity and diversity are not mutually exclusive concepts. Here, noise of information theory and a mutation of biology have an important role to explain the aesthetic value within generative art. Thus, we analyze noise by using the Shannon’s binary entropy function, and then apply a mutation to that function. The analysis shows that the uncertainty due to mutations can create the biological complexity in keeping with the certainty due to redundancy. A mutation might be a factor to produce probabilities of innovation or deviation under the well-knit database of bio information. Bio information in terms of a mutation eventually can be more persuasive to explain the aesthetic value of generative art in that the aim of generative aesthetics is the artificial production of probabilities of innovation or deviation from the norm. A specific process that can lie beyond the artist's intuition can be derived from a specific factor such as a mutation. It can inspire computer-based generative art in the relative discussions on the noise of complex system. Accordingly, genetic aesthetics can present the ultimate aesthetic direction at which generative art aims.

1. Introduction: Generative Art

The term *generative* was used formally for the first time at the computer art exhibition of Georg Nees, *Generative Computergraphik* in 1965, Stuttgart, Germany. In the same year, Georg Nees and Frieder Nake used the term *generative* to identify their works produced from a computer program. After that, Manfred Mohr began to use the term *generative art* to connote drawings made from a computer program since 1968. On the other hand, Jack Burnham identified the new works as process art of post-Minimalism. In this brief trace of the term, we can get a sense that generative art has been confused with process art, computer art, electronic art, and so on. Such puzzles concerning the identity of generative art are often confusing for both of artists and audiences.

Celestino Soddu has tried to clarify that the generative approach is to operate with a preference of metadesign to design. The concept idea is that complexity is controlled by using an approach that follows the complexity procedures existing in nature and artificial worlds. The idea is related to the natural/artificial dynamic system. Accordingly, he has identified that the generative approach cannot use an array of data, but a set of different generative devices, like a set of different dynamic chaotic systems, that work together and use the unpredictable contamination each other to access to different point of view. [1]

Here, we have noticed that a system in the generative approach would be an essential element. It is remarkable that the artist can give over his/her partial or total subsequent control to the system. Actually a system is necessary for *autopoiesis* as Maturana acknowledged: he realized that what was indeed needed was the characterization of a kind of system which would operate in a manner indistinguishable from the operation of living systems. Philip Galanter also mentioned that the key element in generative art is the system to which the artist cedes subsequent control. [2, 3]

Therefore, this paper is on a detailed analysis of the system as the key element of generative art, and on a discovery of characteristics of the system which generative art can fit in. Next, we explore the meanings and the relationships between the noise in information theory and the mutation in biology, associating them with systems which can be applied to generative art. Finally, we propose the interrelationship between generative art system and bio information, using ‘generative aesthetics.’ In conclusion, we propose the meaning and value of ‘genetic aesthetics.’

2. Generative Art System

The dictionary definition of *system* is an assemblage or combination of things or parts forming a whole. Even if a system is broadly used in various fields, it is strictly used in thermodynamics. A system in thermodynamics means a precisely specified macroscopic region of the universe. All space in the universe outside the system is regarded as the surroundings or environment. A system is separated from its surroundings by a boundary (*Fig. 1*). Transfers of work, heat, or matter and energy between the system and the surroundings may take place across the boundary.

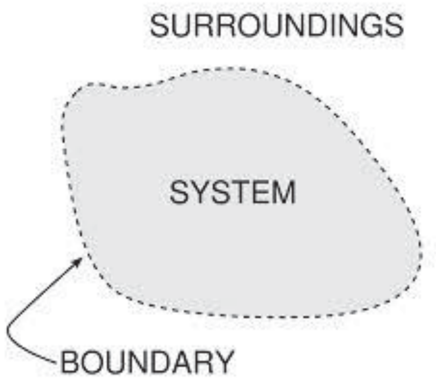

Fig. 1 - System-boundary

In the aspect of media, a system is a set of all real beings that operate in the inherent rule and associate with the surroundings. Simply put, a system exists in the universe, follows rules of the universe, and has an association with the surroundings. If we redefine a generative system, it can be an aggregation of components that form patterns based on mixtures of order and disorder, depending on the basic rule and autonomy. The fields utilizing generative systems are gradually expended by the development of the computer, from music and drawing to design and architecture. [4]

2.1 Category of Generative Art Systems

According to Galanter's view, generative art systems can be largely divided into three categories of ordered, disordered, and complex systems. He argued that the highly ordered systems is discovered in the several examples such as tiling used aesthetically in Islamic mosques, Maurits Cornelis Escher's use of the magical algorithms, and conceptual artists' uses of generative elements. The examples show that rules seriously affect their generative processes. On the other hand, as the highly disordered systems, he considered Wolfgang Amadeus Mozart's random combination of 176 measures, William Burroughs' cut-up-technique and John Cage's random selection of sounds. The examples show that autonomy has a decisive effect on their generative processes. [3]

Galanter has presented the graph of generative art systems in order to establish the relationship between complexity and order in generative art. This graph classifies from 'symmetry and tiling' to 'randomization,' following a degree of complexity and order. There are 'genetic system and A-life' on the highest degree point of complexity. However, there does not seem to be a method for measuring order and disorder practically, because it is never easy to analyze the states of generative art systems by utilizing quantification tools. That problem makes a question about the classification of Galanter. That is, it is doubtful not only whether he had good ground to classify generative art systems, but also whether he learned the reason why genetic systems are most complex.

2.2 Relationship between Generative Art System and Complexity

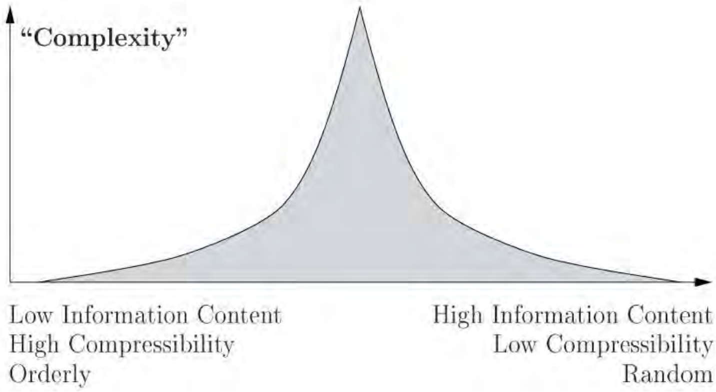

Fig. 2 - Complexity in terms of information, compressibility, and randomness

The complexity graph of Gary William Flake (*Fig. 2*) is more suitable to explain the relationship between generative art systems and complexity, because Flake's graph, the source of Galanter's graph, contains more fundamental contents related to information theory. In the graph, while 'orderly' is the concept related to low information content and high compressibility, 'random' is the concept related to high information content and low compressibility.

Above all, the graph shows that truly complex things occur at a transition point between orderly things and random things. While strictly regular things as well as strictly irregular things are simple, things that are neither regular nor irregular are complex. For example, while on one extreme of the graph is Euclidean objects which correspond to the orderly system for generative art, on the other extreme is pure noise which acts randomly. Meanwhile, mixed things of 'orderly' and 'random' such as Brownian motion seem to be complex. Brownian processes have memory in that every random injection is always made relative to the previous state. In Brownian process, a random injection implies a correlation of the current state with the previous state. It means that a rule as well as autonomy affects Brownian motion. Thus, it is possible to apply the conditions of generative art to the variables of complexity graph. The criteria of order and random can be derived from rule and autonomy. That is, generative art systems can be fundamentally classified, depending on the influence of a rule and autonomy. [5]

2.3 Complex System as the Ultimate Direction of Generative Art

A complex system has been across diverse studies such as physics, chemistry, biology, economics, sociology, and so on. Economists study a complex system in a stock market, biologists in a brain, psychologists in a mind, and ecologists in an ecosystem. A complex system is an inevitable point for many scholars who cognize the limits of existing world views, because those existing views are linear, dichotomous and mechanistic.

Complex systems have a lot of small components that interact with other components. These local interactions lead to self-organization without master-controls or external agents. Also, these self-organized systems emerge themselves, and adapt to the change of external environment. The crucial point is that the process is similar to the expression of bio information. Here, bio information is derived from bioinformatics, which is an interdisciplinary study of both biology and computer science. Since information is stored at a molecular level, it is closely related to genetic information. As the molecular level grows up step by step, emergent and complex attributes appear in living organisms. The process can be involved in evolution, because evolution as the core theme of biology accounts for the unity and diversity of life. Unity made by a rule and diversity formed by autonomy are eventually important resources of a complex system. [6, 7]

A cellular automaton is an example that shows complexity by using computer programs. All grid points called cells follow the same simple transition rule that specifies how each point interacts with its neighborhood. In cellular automata, all cells change their state simultaneously in discrete moments of time. The subsequent state of a cell depends only on the states of its adjacent cells. Accordingly, each cell functions like a little computer, repeating the same rule defining how to react to its neighbors. Cellular automata offer a paradigm for complex systems based on the local interaction of the cells and the iterative processing of subsequent configurations. Here, there is something that is inferred. The reason why generative art is based on computer programs is closely related to maximization of aesthetic value produced by the optimum combination of unity and diversity.

The ultimate direction of generative art system exists in the optimum combination of unity and diversity. It is beyond the level of complex systems such as Brownian motion or cellular automata. It is located at the very peak of complexity graph. Although the optimum combination of unity and diversity may create excellent aesthetic states, its realization cannot be easy. We do not know the identity as well as the method of optimum combination. However, as Soddu presented, it may correspond to natural-like complexity such as genetic systems. We may discover its evolutionary procedures and aesthetic clues by exploring information theory and biology. [1]

3. Mutation as Noise

3.1 Reason why Noise and Mutation are Important in Generative Art

At the very peak of complexity, we have hoped to find things such as the human brain and tried to invent things such as the perfect genetic system. However, it is difficult to realize the highest complexity in the current technology level of mankind. Rather, it is reasonable to assume that the highest complexity is not a target of realization but a target of conception. As Flake said, at a philosophical and scientific point of view, there seems to be something exciting happening between orderly things and random things. In particular, because 'orderly' and 'random' in the complexity graph are involved in information quantity, it is important to explore complexity in the aspect of information theory. Additionally, because information has been considered as the essential element of activity of life since the discovery of

DNA, biology is also important. Above all, noise of information theory and a mutation of biology are closely related to the reason why genetic systems can be located at the very peak of complexity graph.

3.2 Noise in Information Theory

In 1906, the simple formula $S = k \cdot \log W$ was inscribed on the grave of Ludwig Boltzmann who had brought a revolution to thermodynamics and information theory. He proved the second law of thermodynamics that the total entropy of the universe never decreases in course of every spontaneous change. The second law of thermodynamics was controversial by Maxwell's Demon in the view of statistics. After his death, Claude Shannon's information entropy theory not only played a key role to solve the paradox of thermodynamics, but also showed that information can become an object of physical rendition. Shannon was excellent in that he helped us find the answers concerning our simple questions with 'binary digit' or 'bit'. He introduced '1/0' as 'true/false', 'yes/no', and 'on/ off'. He also realized that a question with N possible outcomes can be answered with a string of $\log N$ bits. That is, we only need $\log N$ bits of information in order to discern a desirable answer from N possibilities. This is eventually connected with his theorems. Shannon's theorem has a strong influence, because entropy and redundancy are applied to them. [8]

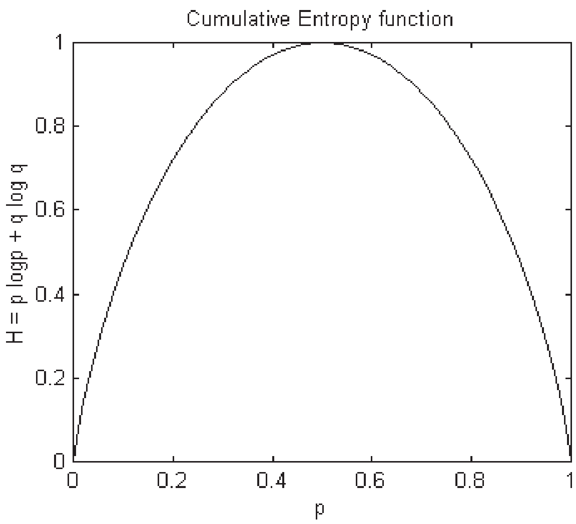

Fig. 3 - Entropy in the case of two possibilities with probabilities p and (1-p)

The more uncertain or irregular a string of bits is, the more a volume of information is. That is, the less redundancy a message has, the more information it can contain. On the other hand, the more predictable a string of bits is, the smaller a volume of information is. It is simply turned out by using the binary entropy function of Shannon. The entropy of the probability 'p' and 'q=1-p' come up with the function '$H = -(p\log p + q\log q)$', which can be expressed like the graph above (*Fig. 3*). As seen in the graph, in the point of 'p=q=0.5', the entropy is at the highest, and the amount of information is at the biggest. It means, when each probability of every symbol is same, the uncertainty and the information are at the largest. While Boltzmann's entropy is a measure of disorder, Shannon's entropy is a measure of information. [9]

Shannon explained Channel capacity theorem by using noise on the basis of his binary entropy function. The increase of noise means the growth of entropy, because noise augments the uncertainty. Meanwhile, the redundancy of desirable codes can become a way to reduce entropy. In this regard, even though the redundancy has to be augmented for errorless information delivery, it may decrease the amount of information. On the other hand, the accumulation of entropy owing to noise may make a volume of information grow effectively under the same error control capacity. Therefore, in the view of generative art, the amount of noise might be crucial to secure diversity and complexity, because generative art seeks unpredictable self-peculiarity under the basic rules.

3.3 Mutation in Bio Information

If we look into Galanter's complexity graph in the same context of Shannon's entropy function, we can infer the way to keep high complexity in genetic systems. Genetic information flows via transcription and translation as well as DNA replication. Information in cells passes from DNA to proteins as well as RNA. That is the Central Dogma of molecular biology. Shannon's information theory seems to be applied to the Central Dogma properly. Genes contain their information as a specific sequence of nucleotides in DNA molecules. Only four different bases are used in DNA: guanine, adenine, thymine and cytosine (G, A, T, and C). They are similar to quaternary numeral system codes. But we can think about them more simply. If each base has an allocation of 2 bits, four nitrogenous bases can be also substituted for 00, 11, 01, and 10. Furthermore, we can apply DNA double helix to the binary entropy function, using Erwin Chargaff's rules that DNA has a 1:1 combination ratio of Purine and Pyrimidine bases (*Fig. 4*). The complementary base pairing can be replaced with the binary numeral system, because the amount of G is equal to C's and the amount of A is equal to T's in the two strands of DNA. [6, 7]

Fig. 4 - DNA base pair binding

Now we can get a meaningful result from the graph of Shannon entropy. If the number of A and T bases and the number of G and C bases are equal in human DNA molecules, the amount of entropy and information would be the biggest on the graph, because the same occurrence probability as p=0.5, q=0.5 indicates the highest value of the graph. However, according to the Chargaff's rules, the four nitrogenous bases are present in these percentages: A=T≒30% and G=C≒20%. Applying this to the graph of Shannon entropy, we can get the high enough entropy value which is corresponded to p=0.6, q=0.4. But comparing with the highest entropy value which is corresponded to p=0.5, q=0.5, we need to consider the reason why human DNA base pairs are not composed by the proportion that can have an extreme high entropy value. The clue can be found out in a mutation.

In the late 19th century, a mutation was used to indicate a rare genetic freak found in Evening primrose by a Holland geneticist Hugo de Vries. It means a change in genetic information of a cell. Generally in biology, mutations are responsible for the huge diversity of genes found among organisms, because mutations are the ultimate source of new genes. Different versions of any given gene within a species of organism are known as alleles. Differences among alleles cover a broad spectrum ranging from those that are relatively innocuous to those that have very dramatic consequences. Change in the relative frequencies of these different alleles is the essence of evolution. New alleles arise from mutations occurring to an existing allele within a single member of a population. Therefore, the biological diversity is the diversity of the primary structure of DNA in essence, and its changes mainly depend on the mutation. The entropy is the best measurement for the biological diversity. Mutations can not only contribute to evolution by generating new factors, but also become a factor that increases the biological diversity. [7, 10]

Chargaff's rules reveal a problem of composition ratio in human DNA base pairs, compared to the maximum entropy probability distribution of Shannon entropy. Redundancy in the genetic code, however, has different influences on entropy. As redundancy is used to deliver information effectively in Shannon's information theory, redundancy is also used to translate genetic information effectively in the Central Dogma of molecular biology. RNA is made from DNA molecules during the transcription. There is 1:1 correspondence between the nucleotides used to make RNA (G, A, U, and C: "U" is uracil) and the nucleotide sequences in DNA (G, A, T, and C). Next, proteins are made from the information content of RNA molecules as they are translated by ribosomes. During the translation, ribosomes use a triplet code in order to translate the information in RNA into the amino acid sequence of proteins. Each group of three nucleotides in RNA is called a codon, and corresponds to a specific amino acid. Thus, there are 64 possible combinations (4×4×4=64) made from 4 different bases (G, A, U, and C) in RNA. However, despite 64 different codons, there are only twenty amino acids. It is the redundancy in the genetic code, because one amino acid can correspond to several codons. For example, glutamic acid is specified by both codons GAA and GAG.

The redundancy in the genetic code can decrease the entropy within a cell, in order to communicate clearly, using a lot of information produced by simple quaternary numeral system codes. On the other hand, as Shannon's information theory shows, it is effective to increase the information capacity owing to noise under the same ability to control errors. In the same context, biology including the evolutionary theory shows that it may be effective to expand the capacity of the uncertain information such as mutations. The uncertainty due to mutations can create the biological complexity in keeping with the certainty due to redundancy.

We could connect the high complexity of genetic systems with the generative approach Soddu has identified. The high complexity and unpredictable self-peculiarity obtained under the basic rules can be related to the selections exploding the artist/designer identity. Furthermore, if we can expand the biological complexity into the aesthetic dimension, we could suggest several clues for interdisciplinary research including art, information theory and biology. [1]

4. Genetic Aesthetics: Generative Aesthetics of Bio Information

4.1 The Projects of Generative Aesthetics

Evolution as the core theme of biology accounts for the unity and diversity of life, and then proves how the genetic information expresses the duality of life's unity and diversity. Among them, mutations hold a key position in the huge diversity of genes. In the exploration of the aesthetic value within generative art, it is necessary to discuss mutations and its corresponding noise, because the information theory has already been discussed enough in the range of aesthetics. The discussion has been called *The Projects of Generative Aesthetics*.

In *The Projects of Generative Aesthetics*, Max Bense noted that "generative aesthetics implies a combination of all operations, rules and theorems which can be used to create aesthetic states." The system of generative aesthetics aims at a numerical and operational description of characteristics of aesthetic structures which can be realized in a lot of material elements. Aesthetic structures contain aesthetic information only in so far as they manifest innovations. The aim of generative aesthetics is the artificial production of probabilities, differing from the norm using theorems and programs. It is connected with the aim of evolution that intends to obtain the possibilities of innovation, securing diversity within unity. [11]

4.2 Generative Aesthetics in Molecular Biology

Bense's view reveals the potential to connect the generative aesthetic processes with the results of biology which considers evolution as the core theme. He extended the meaning of generative aesthetics to aesthetics of production. It made possible the methodical production of aesthetic states. It helps the generative aesthetic processes to be connected with the results of molecular biology's Central Dogma.

We can survive by dint of the results of replications and deliveries of genetic codes produced by specific rules and operations. In particular, DNA is well suited for biological information storage. Both strands of the double-stranded structure store the same biological information. Biological information is replicated as the two strands are separated. The two strands of DNA run in opposite directions to each other and are therefore anti-parallel. Within cells, DNA is organized into long structures called chromosomes. DNA can be twisted like a rope in a process called DNA supercoiling. Folding and coiling by specific operations transform a DNA double helix into a chromosome. Here, each chromosome shows the aesthetic states that have self-peculiarity despite their similar shapes (*Fig. 5*). Each homologous pair has the same shape by sharing the corresponding genes. Meanwhile, their subtle different shapes among chromosomes are caused by different inserted genes. Their different shapes and formations eventually affect their different functions. It is closely connected with the methodical production of aesthetic states. The results reflect both unity and diversity derived from rule-based steps and specific operations.

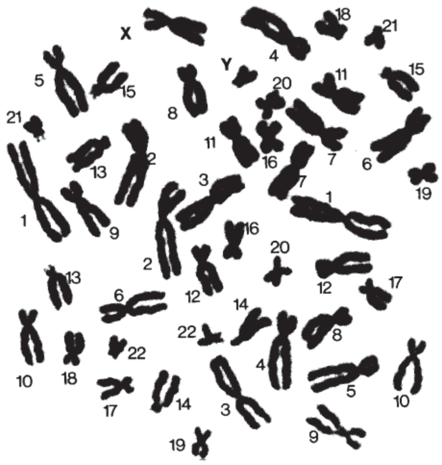

Fig. 5 - Human metaphase chromosomes

Proteins are large biological molecules which perform a vast array of functions within living organisms. A linear chain of amino acid residues is called a polypeptide. It refers to the primary structure. A protein contains at least one long polypeptide. It has directionality like DNA supercoiling. Specific operations help the primary structure to be folded and combined in order to form the secondary and tertiary structure. The last structure is referred to as the quaternary structure such as an active enzyme composed of two or more protein chains. Quaternary structure is the three-dimensional structure of a multi-subunit protein. Proteins create not only the basic aesthetic state of the primary structure but also various aesthetic states of the secondary, tertiary, and quaternary structure by specific operations (*Fig. 6*). They also show aesthetic states that have self-peculiarity. The folding and combining processes include a number of distinct and separate steps. The results imply both unity derived from rule-based steps and diversity caused by individual specific operations.

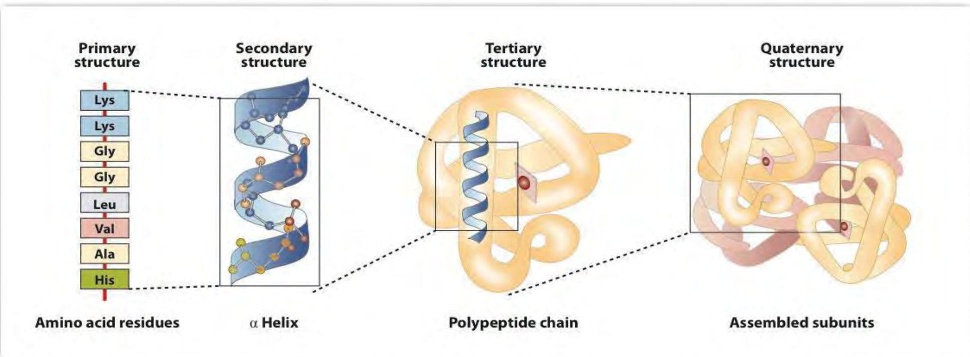

Fig. 6 - Levels of protein structure

The remarkable point here is that the structural figures of chromosomes and proteins represent high complexity formed by local interactions of small components, autonomic self-organization, and emergence. This is analogous to the ultimate aesthetic state that generative art concludes through complex systems. Therefore, bio information can not only be involved in creating material components such as DNA or amino acid as well as physical aggregations such as chromosomes or proteins, but also implies a combination of all operations, rules and theorems which can be used to produce unique distributions and configurations. This view meets Bense's generative aesthetic point of view. That is, bio information's self-peculiarity, represented by obtaining the autonomy and singularity under the basic rules, satisfies generative aesthetic aims. These aesthetic states, exposed by a combination of all operations, rules and theorems, help us understand why a genetic system can be considered as a highly complex state.

We can now review the relativity of generative art system to bio information by utilizing generative aesthetics. As seen in the organized *table1* below, our main themes are divided into two parts, the macroscopic dimension and the microscopic dimension. The dynamic entanglement of two dimensions infuses life into three themes of generative aesthetics, complex systems and bio information. Genetic aesthetics begins from putting genetic systems on it.

Table 1 - Contents of two dimensions in generative aesthetics, complex systems, and bio information

	Macroscopic dimension	**Microscopic dimension**
Generative Aesthetics	rules and theorems	operations of agents
Complex System	basic rules	interaction, self-organization, emergence
Bio Information	central dogma	operations of material components

4.3 Genetic Aesthetics

Bense said that "the aim of generative aesthetics is the artificial production of probabilities of innovation or deviation from the norm." Here, 'probabilities of innovation or deviation' is considered as an important point. We need to ask whether the complexity of a genetic system can be completely described by only interaction, self-organization and emergence or not. As shown in the figure below (*Fig. 7*), 2346 proteins (marked dots) and their interactive networks (connected lines) in a drosophila (a fruit fly) cell make the complexity come into sight. In fact, even if the content of this picture is complex enough to have difficulty in identifying respective dots and lines, this complexity just comes from a set of operations within the huge database. In other words, there is no specific factor to produce probabilities of innovation or deviation in this picture. [11, 7]

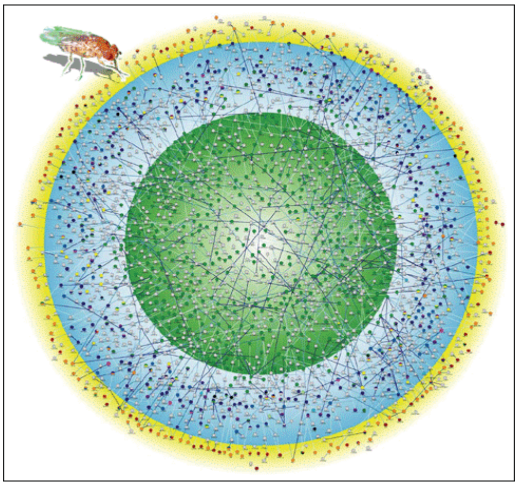

Fig. 7 - A protein interaction map of drosophila

A mutation is the possible factor which can solve that problem. It may be regarded as the element which can lead to super high complexity. We have already confirmed that some degree of noise under the same ability to control errors can bring about the effective increase of the information capacity. We have also thought that from the mixture of Chargaff's rules and Shannon's binary entropy function, the lack beside the highest entropy value could be an empty seat to accommodate other information like a mutation. A mutation eventually might be a factor to produce probabilities of innovation or deviation under the well-knit database of bio information.

Eduardo Kac has utilized such characteristics of mutation in his artworks. *Genesis*, produced in 1999, is a transgenic artwork that explores the intricate relationship between biology, information technology, dialogical interaction, and the Internet. It includes a synthetic gene that was created by translating a sentence from the biblical book of Genesis into Morse code and converting the Morse code into DNA base pairs according to a conversion principle developed specifically for this work. The *Genesis* gene was incorporated into bacteria, which were shown in the gallery. Participants on the web could turn on an ultraviolet light in the gallery, causing biological mutations in the bacteria. After the show, the DNA of the bacteria was translated back into Morse code, and then back into English. The mutation that occurred in the DNA had changed the original sentence from the Bible. In the context of the work, a mutation is a factor to cause innovation or deviation under the database of bio information. [12]

Here, a specific process that can lie beyond the artist's intuition can be derived from a specific factor such as a mutation. Thus, the biological aesthetic states created from the specific process might accord with the aim of generative aesthetics, because they embrace the deviation as well as the norm. The aim of generative aesthetics can be similar to an information system which expansively accepts noise under the same ability to control errors, and to a genetic system which expansively accepts a mutation in order to arrive at the super high complexity. Here is the real reason why genetic systems can be located at the very peak of the complexity graph. Therefore, genetic aesthetics does not only show the form of the highest complexity that computer-based generative art desires to express, but also present the best method for arriving at optimum combination of unity and diversity.

A potential factor such as a mutation now can be added to the microscopic dimension of the previous table, and then provides a clue that can connect generative aesthetics to genetic aesthetics. Aesthetics of Richard Shusterman as well as Bense's generative aesthetics inspired us to establish genetic aesthetics. Shusterman suggested that the complex cluster of disciplines devoted to bodily beauty and the art of living be today's aesthetic alternative for the ends of art because the end of modernity's artistic monopoly could augur some vibrant new beginnings for different forms of art. [13]

As Shusterman considered the human body as an essential in the art of living, we can connect the gene expression to the fundamental aesthetic states of our body and living. In the context of the vibrant aesthetic alternative, the collaboration project *Metallic Genesis* currently ongoing reflects the gist of genetic aesthetics. Even though Kac utilized the characteristic of a mutation in his work *Genesis*, it did not have the morphological concept of aesthetic object related to a mutation. Meanwhile, in *Metallic Genesis*, the sculpture suggestive of human body shows complexity including the characteristic of a mutation. Furthermore, while *Genesis* expressed the characteristic of a mutation through external participant involvement, *Metallic Genesis* reflects it by using internal residual energies. In fact, *Metallic Genesis* is derived from the biomorphic art *Metallic Communication* // created by Eunju Han in 2012 (*Fig. 8*).

Fig. 8 - Metallic Communication //

Fine copper wires and shape memory alloys utilized as its formative material play roles to bring the artwork to life by providing electronic energy. The state entangled by copper wires and shape memory alloys are taken to *Metallic Genesis*. It looks like a chromosome formation made by DNA coiling. In the flow of electronic energy, a conversion principle developed specifically for this work can help the specific human DNA sequences to be converted into Morse codes. The converted Morse codes control directly the flow of energy and affect the physical movement of the sculpture.

Then, when the power supply is cut off, the overall shape can be unpredictably changed by memory effect and elasticity of shape memory alloy only using internal residual energies. It is the genetic aesthetic form which reflects an unpredicted element such as a mutation under the database of bio information.

Therefore, in the genetic aesthetic point of view, we can separate out the specific aesthetic object such as the expression of genetic information, and connect with our living by observing them and leading to aesthetic experiences. As a result, genetic aesthetics can be referred to as the innovative combination of bio information and complex system within generative aesthetics. We need to recognize the potential of genetic aesthetics, because it might offer a convincing explanation for dynamic entanglement of our lives.

5. Conclusion

The recent argument over junk DNA shows clearly what the discovery of new values means. The term *junk DNA* means the portion of a mammal genome sequence which no discernible function has been identified for. This seemed to be presumptively proven in 2000 through the Human Genome Project. The project announced that a significant portion of human genomes accounts for only a very small fraction (1.5%) and the rest (98.5%) is associated with junk DNA. However, the results of the ENCODE project, which was published in Nature in 2012, rediscovered junk DNA as some degree of functional elements. In fact, we should be alert to the possibility of making over-interpretation about the meaning and function of junk DNA, because this part is still an unknown world under the current technologies of genetic engineering. Nevertheless, the rash conclusion such as junk DNA might often occur around us, because we have a narrow sight and knowledge. [14]

In the future, due to the expansion of acceptable range, we might discover the secret of super high complexity created by an optimum mixture of unity and diversity. Even if it has not yet been revealed in fields of science and technology, it might be always the goal and object of art. Thus, it is natural that generative art aims at high complexity created by an optimum combination of a rule and autonomy. It does not simply focus on how it copies a genetic system, but how it creates the aesthetic states by comprehending noise and mutation. This view shares Bense's context. The aesthetic structure has a specific meaning only by showing innovation which does not imply the fixed reality but the probable reality, and thus the guiding motif of generative aesthetics is to yield probabilities deviated from the norm through theorems or programs. Here, yielding probabilities deviated from the norm might be connected to the view of Soddu and Colabella. As they mentioned in the last conference, the most important reason why we approach art using the generative way is in the relationship between the generative approach and the human creativity. When the artist creates a generative dynamic artwork able to generate variation, he is able too to create a representation of his own idea. It entails the acceptance of mutations as well as the processes including interaction, self-organization and emergence. Thus, bio information is worthy of generative art by itself, and then being involved in generative aesthetics, it can evolve into genetic aesthetics. [15]

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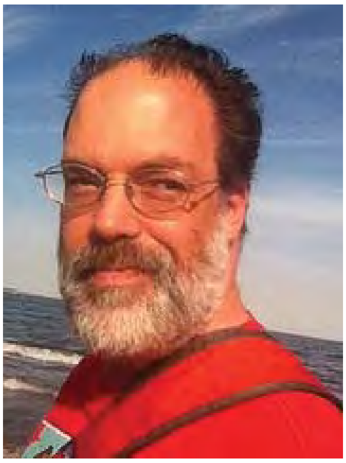
Marc Mancuso

Mind Over Matter: Generative Concepts in Three Dimensional Sculpture *(Paper, Artworks)*



Topic: (Generative Art)

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This paper discusses the effect of generative concepts on the planning, execution, documentation, and interpretation of my recent series of three-dimensional sculptures. My intent was to build systems that had both cyclic and open-ended processes from which there is no combination of fundamental design or surface evidence that traditionally identifies an object as precursor or final product.

Metal, plaster, rubber, clay, and other commonplace sculptural materials are categorized as points on a set of continuums including rigid-flexible, absorbent-waterproof, opaque-transparent, buoyant-dense, and so on. Based on these intrinsic qualities, I build systems that manage constraints and define and implement rule-sets to regulate the order of interactions. Despite the limited use of virtual technologies, the results of these physical activities can be compared to computational and iterative processes including Boolean operations, graphical user interface tools such as *fill* and *skew*, programming structures such as loops, random number generators, and geometric identities.

Additionally, my intent was to allow any transformation to initiate or conclude another process. Observable “links” to preceding or successive iterations may be perceptible, but traditional notions of completeness or progress towards a particular state are discarded. The physical constraints in these systems inform a discussion of successes and failures encountered during the building of processes that respond to these these requirements.

Of particular interest is the way in which plaster, metal, clay, and rubber are used over a series of transformations that demonstrate recursive structures, variations in high- and low-fidelity data compression, and distortion.

(1) flexible form generates unique design from sequence of metal strips
(2) liquid plaster fills all spaces for separable, closely-interlocking pieces
(3) liquid clay copies one of many possible spaces among plaster pieces
(4) drained, separated clay shell ready for baking, shrinking, and reusing

Documenting ongoing systems that have one or more real-time unfolding aspects and one or more physically durable artifacts raises philosophical issues as well as practical ones. The paper examines the implications of documentation through still images and time-dependent mediums.

The paper concludes with a brief discussion of how the classification systems and transformational rules could inform future work.

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Keywords:
sculpture, iteration, algorithm, recursion, materials science, plaster, casting

Mind Over Matter: Generative Concepts In Three-Dimensional Sculpture

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Abstract

This paper discusses the effect of generative concepts on the planning, execution, documentation, and interpretation of my recent series of three-dimensional sculptures. My intent was to build systems that had both cyclic and open-ended processes from which there is no combination of fundamental design or surface evidence that traditionally identifies an object as precursor or final product.

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Overall Objective

This paper describes sculptures and imagery that emerged from generative fabrication processes developed between January and November 2014. The overall objective of this work has been to achieve diversity over the course of iterations by adding or removing subdivisions. Having learned traditional mold-making techniques in which containment fields are blocked off one section at a time in a worthy but time-consuming process, a faster means was sought to make plaster objects fit closely together without cutting. The traditional means of using metal shims to divide a soft clay original into a short wall for plaster to rest against led to the insight that perhaps the role could go entirely to the metal shims or to thin partitions in general. The response was devise ways to assemble a certain set of rigid objects to contain and/or subdivide a material in its fluid phase, then disassemble that set of objects from the system after the liquid reaches its solid phase.

An additional objective was that the parts be modular and repositionable among themselves. With a small number of materials and completely quantifiable parameters, they define a great variety of spaces, allocate material to those spaces, group or subdivide that material, and create objects which are completely repeatable or widely variable. In so doing, the physical materials manipulated here mimic or embody aspects of Boolean logical operators and familiar aspects of digital interface tools. The generative aspect of the processes refer to what aspects of the system can be quantified and varied, and the degree to which that potential is expressed, if at all.

Result: Partition Cycle--Styles One through Six
The generative fabrication processes are identified by six styles, presented in an order that demonstrates progressively complex changes in construction rules. It will be seen that each material may take on the role of form-giver or thing formed, often displaying distinctly different qualities across the sculptures and photographs that emerge during the many constructing, assembling, and disassembling processes. The set of objects or materials that creates subdivisions is called a *mesh*, regardless of the differences of material.

Means
The straightforward choice was to use plaster and liquid clay slurry, both of which have fluid and rigid modes and which release from each other easily. This releasing quality has been used for centuries all over the world, but adding the thin partition concept, embodied here by thin metal sheet, rubber latex sheet, and brushed clay slurry, allows the creation of an unprecedented diversity of objects. The thin partition arrangement allows many close-fitting parts to be made *in situ* from one or perhaps several batches of liquid material. The resulting separated shapes can then be reused as containments for further processes in many combinations.

Notably, these processes can both increase or reduce complexity with equal ease, by installing a greater or lesser number of partitions into a containment space. The six styles differ in part because, with the appropriate separator, each material explored here can function either as "tool" (thing-former) or "content" (thing formed). Moreover, since the waterproof separators are all reversible, it enables an absorbent material to be waterproof for a certain period of time in order to form new materials.

The separation apparatuses involved often take on qualities of generative art as much as the filling materials do.

Introduction to materials

The materials used in this series are commonly available, simple to use and modify, and combine easily with each other. Basic information on materials and processes that are not germane to the manipulations in this series can be found in the voluminous literature available elsewhere. Notably, plaster use for statuary and mold-making, and clay use for absorption casting represent a vastly interesting and complicated subject. But since only one type each of plaster and clay slip is completely sufficient for these systems, I only describe the quantifiable aspects that are allowed to vary that have direct "generative" bearing on the results.

Plaster
This series involves plaster as material that is at first a liquid that flows, then gradually gels, and finally hardens. When it first hardens, plaster is completely saturated with the water used in mixing, and over approximately 2-3 days, the water completely evaporates, leaving a rocklike absorbent material. These systems exploit the fact that a plaster object is absorbent, is rigid, is not too brittle (but can be made to fracture), and allows for easy subtraction of material by standard means. Moreover, its unsurpassed ability to capture and retain detail is exploited by leaving many of the marks it takes on during casting.

The current procedural constraints do not allow sawing of plaster objects into pieces; however, breaking a single plaster object into more than one piece is allowed because the fracture plane is an attractive separation surface that otherwise can't be sculpted. Since plaster's ability to capture detail is so complete, nearly all process marks are left alone, but constraints do allow for the shaving down of slightly rough surfaces that were intended to be flat.

A meaningful variable that affects plaster's shape is the short window of time after it is a completely mixed liquid, but before it completely hardens. Quantifying and allowing this time variable to change affects future processes dramatically. The most common use for this frosting-like, gelling state is that it allows for partitions to be pushed into plaster and immediately held there by the plaster with an absolute minimum of disturbance to the surrounding surface.

The implications for generative processes is that as mixing time changes from standard duration of about 5 minutes to longer than that, the gel window starts sooner and sets up faster, leaving less time for liquid- or gel-specific events. For example, larger or more convoluted areas that need to be filled with freely flowing liquid plaster might be completely covered or might not be covered, which we see in Style No. 6. A great number of partitions that need to be positioned might not all drive in easily or only do so with evidence of disturbance, as we see in Style No. 4, in which a certain number of metal parts that must be arranged--often improvisationally--within the 2 minutes the single plaster layer is still gelling. If that gel should set up sooner than all partitions are in place, will the fewer number of partitions affect the layer favorably?

The standard recipe of plaster is completely sufficient as absorptive material for clay slurry. Additionally, there are instances in the Partition Cycle in which new plaster is cast against old plaster. In traditional processes, a waterproofing agent is applied between old and new plaster to prevent chemical bonding. This sealant is generally considered irreversible, meaning that clay slip will no longer cling to and build up against the waterproofed surface.

Since the goal of these systems is to be more open-ended than that, a different method was needed. After the thin layers of spilled slip that often happen when emptying the mold were seen to peel off cleanly, it was an indication that the same thin release could be used deliberately. Applying a very thin coat of clay slip to old plaster proved the best choice for enabling new plaster to release cleanly. Afterwards, the thin, detail-preserving clay slip film used as separator can be cleaned off completely. Establishing plaster's binary and reversible role either as a surface to be sealed to itself or absorbent to clay slip is a key element of these discoveries.

Clay Slip (Slurry)

The standard usage of specially prepared liquid clay is that it builds up a structurally sound 2-5mm shell when it fills a containment area made of absorbent surfaces like plaster or other clay. The greater the length of time the liquid dwells in the containment area, the thicker the coating on all surfaces becomes. Draining the excess material stops the thickening process, and starts the drying and shrinking process until the casting is stable enough to release itself from the mold. The outside surface of the clay casting takes an exact impression (negative) of the mold surface, while the inside of the clay casting exhibits a somewhat rounded surface where the clay built up in the narrow spaces that inhibited complete draining. When both surfaces are visible as in several of the Styles, the comparison between the two is appealing.

It is worth clarifying here that these systems are designed to have clay slip function at a very wide range of thicknesses. In separator mode, clay slip is applied as thinly as possible, approximately 0.2mm-0.5mm thick, used between old and new plaster. Conveniently brushable, the separator coat can be applied by hand. But perhaps more useful is the fact that clay slip can be poured into very complex inaccessible surfaces and drained immediately. In structural mode, clay slip is built up to a standard thickness of approximately 2-3mm, appropriate for ceramic objects intended to hold their own shape. In "erosion filter" mode, clay slip is left to dwell for up to 30 minutes to really obscure its own interior details with a wall as much as 4mm thick. Thickness growth slows down as the wall gets thicker, even when excess liquid clay still dwells in the mold. Programming that specifies times greater than approximately 20 minutes does not appreciably affect thickness. (The effects of leaving all the liquid clay in the mold without draining are not discussed in this paper.)

Generally the only thickness of clay slip wall that is intended to survive as a baked object is the structural coat. Timing of the dwell can run short or long, which might or might not build a shell at an appropriate thickness for its intended function. In this way, like plaster, which has more than one role depending on manipulation of the materials around it, clay slip can function as a separator, a structure, or a filter.

Another quantifiable and potentially meaningful aspect of using clay slip is fact that it can be colored beforehand. In some cases, as in the combination casting from Styles Nos. 2 and 3, different colors act as visual cues that separate events have taken place in time, using color to identify an event that might otherwise have gone unnoticed because no textual or structural evidence can be seen.

Future developments regarding clay slip usage

An obvious but unexplored generative aspect of using clay slip for baked objects is the fact that its approximately 20% shrinkage after baking is a form of "data filter" that can be used without computation for feedback loops. A baked clay structure can be brought back into the mesh creation stage and its shrinkage accommodated. In addition to shrinkage, baked clay objects may exhibit some shape distortion from unavoidable or deliberately induced warping. If the object is used in further processes, this distortion is analogous to a shape filter in digital systems.

Aluminum sheet

Commercially available aluminum metal flashing is thin, waterproof, easily cut, and bendable. It is reusable depending on what was used to connect pieces together and whether dismantling it after use went smoothly. Conveniently, it can be scored and snapped into pieces with minimum of effort and maximum accuracy. Because cutting with scissors or guillotine invariably bent the metal, cutting curves from flat metal was not explored in this series. (Bending curves was explored, however, in Style No. 4.) In this generative aspect, it provides very close tolerance between plaster objects when plaster is on both sides of the metal. Extending the traditional use of metal sheet to separate mold sections when plaster is used, metal thinness created an equally thin gap between flows of liquid plaster that was leakless when properly reassembled before use with plaster or slip.

A quantifiable and meaningful generative aspect to using metal shims is that connectives vary and each contributes to information captured by the plaster flowed into it: tape and magnets used to join pieces leave surface/process information. If care is taken not to distort the metal, another generative aspect is that a set of metal pieces can be reused in different arrangements, leading to an underlying consistency of form. In Style No. 4, the same set of a dozen or so separator glyphs were sunk into gelling plaster and rearranged every time a new layer had to be cast. Though the patterns were different, there was an unmistakable design resemblance among overall patterns.

Rubber latex

Commercially available rubber latex sheeting at a thickness of .03mm serves perfectly well as a thin separator for plaster that is flexible, waterproof, reusable, and easily measured and cut. Since it is never absorbent, it has no use in these systems as a separator for clay slip. Making connections among separate pieces of latex is easily accomplished with double-stick tape if tensions are not too great and the width of the tape can be exploited or ignored, and with rubber cement when the connections need to withstand greater tensions. Double-stick tape was sufficient to hold up under the tensions involved in Style No. 5. The generative aspect of using latex as a mesh is that while the mesh components might be very accurately measured and assembled, during use the resulting mesh varies considerably based on what forces act upon it before and during use. Moreover, because the rubber mesh can move during the flow of plaster, varying the starting location and number of pours has great impact on the resulting objects.

Foam core
At a thickness of 3-5mm, commercially available foam core is lightweight, easily cut, somewhat rigid even when thin, and somewhat reusable depending on whether it gets bent or wet and whether its deterioration can be exploited. While foam core can be sealed with brushable coatings like shellac or paint, it is slower to execute, and, other options are preferable.

Various plastic packaging tapes and water-resistant edging tapes were used to waterproof the foam core partitions because of two additional attributes those materials contribute. The waterproofed panels became miniature abstract paintings in themselves from the color, translucency, and direction of the tape application. Moreover, the thickness and surface qualities changed subtly, definitively captured by the plaster that was poured against it. A great many distinctive patterns can be executed by means of the tapes, which in turn would have graphic validity in themselves, or transfer their textures to plaster objects. Moreover, since the panels themselves can be joined at any point, the tape/noise patterns are interrupted and collaged anytime two panels are combined in a different way.

Several other generative aspects emerge from tape-waterproofed foam core. From a graphic standpoint, the texture imparted to the plaster surfaces can be a target site for other events, such surface decoration. The tapes may not release plaster in the same way, causing bits of plaster to adhere to the panels on disassembly, leaving physical chunks that can be resealed and incorporated as "noisy" data in the next iteration.

Structurally, foam core as a mesh element is by far thicker than the other materials in use, providing a 3-6 millimeter gap between plaster pieces. This is more than enough room for liquid clay slip to flow and be structurally sound enough to survive unmolding, which, incidentally, is the only way in these systems a clay wall could be created from plaster mold pieces in their original positions. Alternately, the narrow gap within the plaster mass provides easy access for leverage to pry open the mass and crack it somewhere, using that violent act as a secondary form of separation.

Regrettably, though the tape-waterproofed foam core is in theory reusable, the complications of building Style No. 6 were of great value to improvisational nature of casting plaster, but bad news for recovering and saving the mesh. Fortunately, many interesting pictures were taken of that mesh, and it provided generative material all by itself. Future attempts at making such labor-intensive, information-rich meshes reusable are likely to be more successful.

Operational concepts

Throughout the entire Partition Cycle, various operational concepts governed choices of shapes and guided priorities of timing. Several major topics, discussed below, define the narrower set of options these systems operate in than those of more generalized sculptural processes involving these materials.

Draft angle
As will be familiar to those exposed to a wide range of manufacturing and molding practices, for two rigid objects that meet exactly that are required to move apart without breakage, all shared surfaces must be visible along the direction of movement. Much literature exists explaining the pragmatic and ingenious solutions this requirement has inspired. All the separators and rigid objects in this Cycle satisfy the requirement of positive (releasable) draft angle. For example, in Style No. 4, all the "puzzle" pieces slide sideways away from each other because when the missing ones are cast in clay or plaster, it is likely that there is only one direction of unmolding. Systems that allow locked-in pieces, while fascinating, are not addressed in this cycle.

Computational analogs
Many aspects of the systems described in this Cycle rely on materials that can be quantified by shape or volume, and processes that can be quantified by time, location, or rate. The variety of objects created and used throughout the Styles have computational analogs in virtual processes common to 3D modeling and mathematical logic. The following list of concepts will be familiar to anyone comfortable with digital design environments and programming languages: FLIP, SKIP, SLIDE, CONCATENATE, STRING, ROTATE, GROUP/UNGROUP, UNION, SUBDIVIDE, FILL, SKEW, BLUR, SHRINK, INTERSECT, ADD/REDUCE NOISE, SELECT.

Some of these concepts are mentioned in the description of the styles where noteworthy. Conceptualizing these early demonstrations in this way, future work in these Styles can easily progress not simply from an intuitive ordering of events, but also from a kind of pseudo-code or program that drives events, limits options, and results in a "render" or some manifestation of the command-implementation cycle.

Intuitive input
The Styles vary considerably in appearance, but the level of choice involved in changing features of mesh creation was based more on intuition than on rigorous method. As each style is described, it is often noted what future recommendations could be made to the generative aspect of the existing Style. The next Style is described in terms of what it addresses from the previous one.

Conservation
In some styles, an aspect of the partition is conserved, or in other words, limited in how much it varies. Most meshes made of metal sheet that are used in the Styles have some basic dimension equal to the size of the original sheet. The height of the mesh in Style No. 2 is conserved so that other variables can be made important. In Style No. 4, the same metal "glyphs" are repeatedly used in different combinations. Obviously, no such restrictions need occur. Think on how different the configurations of metal mesh would be in Style No. 3 would be if the number of prefabricated triangles could be chosen from 5 to 100.

Similarly, the quantity of material for filling might be conserved. Style No. 4, for example, features plaster layers of consistent thickness because the containment does not change shape, the same amount of plaster is mixed (conserved), and the metal pieces that sink are of negligible volume. But what if the metal shims were replaced with the thicker foam core partitions? The displacement could become quite noticeable from one layer to the next. Similarly, what might have happened in the case of Style No. 1 if the plaster poured for the layers had been conserved. (It wasn't.) As the same amount of plaster is poured between the consistent containment field around a form that becomes smaller, the resulting plaster layer becomes thinner and thinner. In this way, the thickness of that layer is not arbitrary, but conceptually and physically directly indicative of the form it buried. Many aspects of future Cycles will exploit such events that arise from conserved materials.

By recognizing the implications of conserving materials or operations, these physical systems acquire more attributes that define recognizable styles of object. Further variation will emerge from similar systems not just from my intuitive approach, but also when combined with further refinements to how conserved resources are used.

Style Descriptions and Documentary Photographs

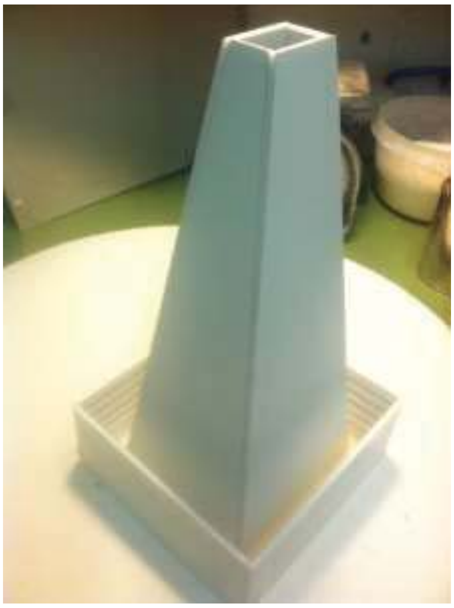
The following sections present an analysis of the Styles in terms of what was accomplished and how its generative aspects were changed to continue this exploratory Partition Cycle. The images were all taken by the author and represent either the interesting graphic presentation of an apparatus, or documentation of some installation or "still life" aspect of the objects generated. Note that it is well within the intent of this Cycle that objects function both as "tools" and as "content," and so the photographs of the process are included as well.

Style No. 1

Foam core original, pyramid vase type.

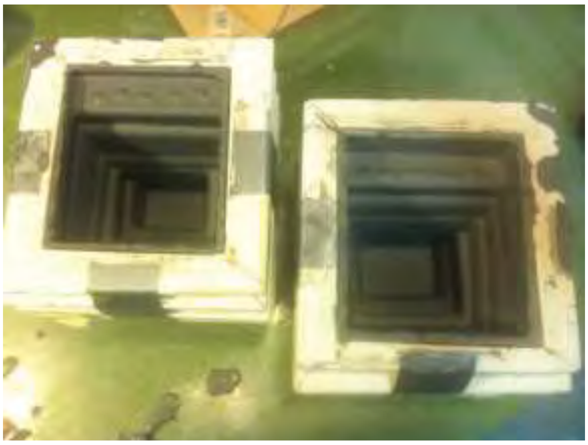
- Object design exists first.
- Plaster mold cast around it in standard box former not intended to be interesting.
- Generative qualities emerge from fact that form is buried in many thin layers that separate. The result is that layers can be used in many combinations for different profile, all but the most extreme "slide" variations are still leakless.
- Appealing concept is that if the twelve layers are divided up into more than one group, and all are used, family resemblance among objects cast is easy to see.
- Refinement needed: **Why build original in the first place?**
- Refinement needed: **Why have such bland exterior shape (mold only does one thing)?**
- Refinement needed: **Mold pieces cannot easily be used in rotation** or non-mesh defined spacings because outside is so bland.

Images for Style #1




(1.1) Foam core original form with repositionable containment box in lowest position, without plaster layers.
(1.2) Containment box moves upwards as plaster slices are poured until form is completely covered in plaster layers


(1.3) Separated layers after hardening.
(1.4) Labeling on plaster layers indicating reordering variations "skip" and "flip."

(1.5) Castings depicting (l-r) "flip," "skip," next to complete set in original order.
(1.6) Interior of castings still in mold with "slide" variation.


(1.7) Unmolding in progress for casting with "flip," "skip," and "slide" variations. Note split in each layer that solves draft angle problems.
(1.8) Unmolded castings when twelve layers of original mold are divided into two groups ("skip") and reoriented ("flip" and "slide").

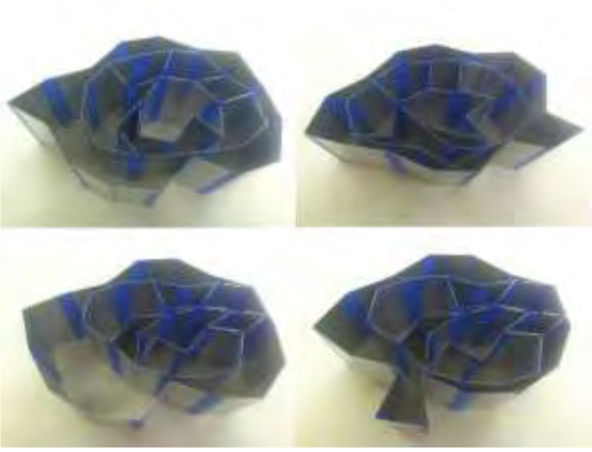
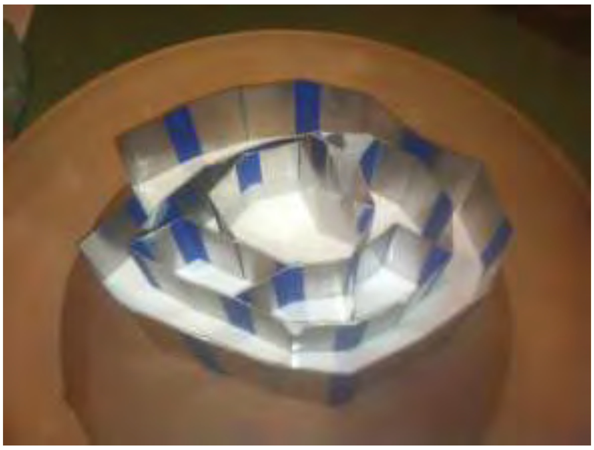
Style No. 2

Prism mold set

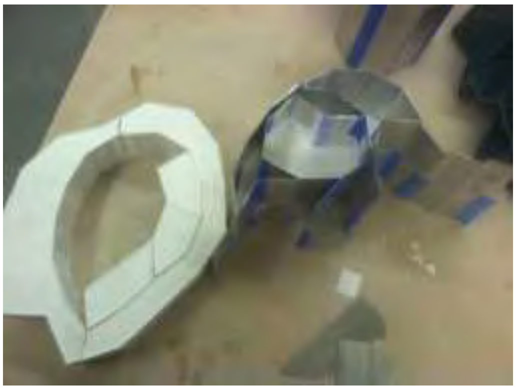
- Addresses blandness of exterior shape by being irregular, directly expressing space-filling potential: perimeter has same character as contents.
- Very simple hinged metal strips as mesh; blue tape is compelling to me, also textural. Tape need not span entire height, and gaps in tape could be used in future for generative variation.
- Flat upper and lower surfaces invite combination with other sets. (See Style 2 atop Style 3 castings.)
- If flat panels of plaster are added to top and bottom, hollow castings can be filled from any direction: any combination of contiguous objects, with any being entry/drainage point for liquid clay.

- Objects have non-mesh-defined arrangements as well, requiring minimum leak-management.
- Mesh arrangements used graphically in composited photographs.
- Refinement needed: **Need greater subdivision count, and outer surface of containment shapes themselves is not accessible at all.**
- Refinement needed: **What if mesh isn't flexible-strand type** and needs specific shapes?

Images for Style No. 2

(2.1) Various possible configurations of perimeter and subdivisions.
(2.2) Plaster poured into mesh.




(2.3) Partially disassembled plaster pieces from metal mesh, mold configuration (foreground) fits together perfectly.
(2.4) Completed mold with all pieces.

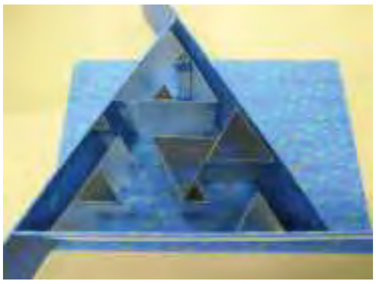
(2.5) Missing pieces (left) and liquid clay forming shell drying in their place.

Style No. 3

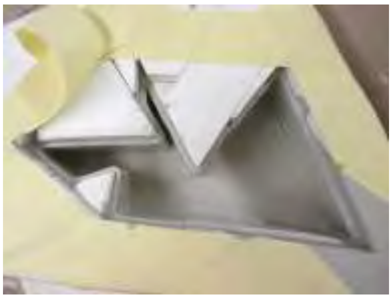
Triangle mold set

- Increases subdivision count, larger overall size, greater variety of convex surfaces.
- Faster installation times by virtue of tape coverage improvement (only top and bottom of metal partitions) with equally effective separation of plaster objects but easier disassembly.
- Perimeter shape identical to some of the interior division shapes; moreover, self-supporting units triangle "extrusions" are very strong.
- Mesh creation has prefabricated components like triangle prisms and flat panels.
- Generative variations emerge from liquid-gel progression and friction of smallest mesh shapes: dramatically lower fill-level surface inside smaller triangles demonstrates that time increased during mesh installation.
- Ceramic development **milestone**: within that same set, clay walls poured in two stages that fuse together (both same color, or different colors).
- Ceramic development **milestone**: used two different sets as stack to combine molds in two layers, with three pour-fusing stages as more mold parts are removed.
- Refinement needed: **Some curves would be nice.**
- Refinement needed: **Maybe tape isn't required at all.**
- Refinement needed: **Rebuilding mesh seems tedious** and metal panels are distorted (which could be a good thing elsewhere).

Images for Style No. 3


(3.1) Triangle prism shapes for predetermined aspect of subdivisions.
(3.2) Perimeter containment box also triangle prism shape with prefabricated triangle metal subdivisions arranged first.
(3.3) Disassembly of plaster pieces (side view) showing non-triangular straight pieces added to increase subdivision count.

(3.4) Disassembled plaster objects showing the downward-dragging effects of smaller-area partitions on what was originally level plaster.
(3.5) Example casting #1: Clay shell drying from example casting. Note thin section upper left.
(3.6) As clay wall hardens, this first casting supports its own weight as some plaster pieces are removed from containment area, creating new open spaces.

(3.7) Next set of open areas created for second casting filled to shorter level. Note thicker wall on newly exposed (most absorbent) plaster surfaces, and thinner wall fused to original wall (less absorbent).
(3.8) Fully unmolded casting showing higher wall of first pour and lower wall of second pour.
(3.9) Detail of casting. Note details on clay surface left from tape originally used to hold metal sheet together.

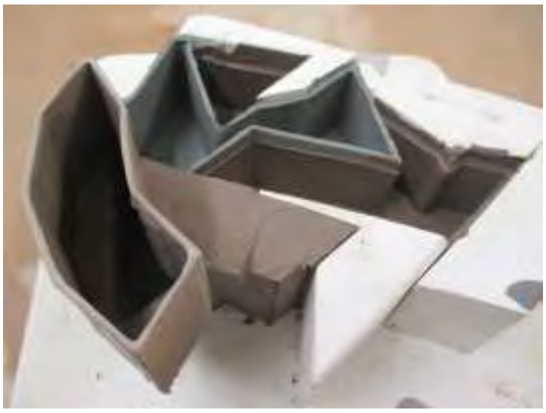
Images for Stacked Combination of Styles 2 and 3
A second casting event in Style 3 mold with Style 2 stacked on top.

(3.10) Missing pieces from Style 2 layered over missing pieces in Style 3.
(3.11) First pour of tan slip (seen as brown shiny liquid in photo).
(3.12) Drained and partially unmolded.



(3.13) Second pour of white slip (seen as grey shiny liquid in photo) in newly exposed containment.
(3.14) Drained and partially unmolded.
(3.15) Third pour of tan slip (seen as brown shiny liquid in photo).




(3.16) Entire casting shown partially unmolded.
(3.17) Completely unmolded object.

(3.18) Completely unmolded object in standing poses.

Style No. 4

Puzzle Étude

- Prefabricated strips of metal as a set of "glyphs" with curves and straights.
- Conserved amount of plaster in standardized overall containment, yielding regular layers/slices that can be stacked.
- Making use of 2-3 minute time constraint that liquid plaster becomes gel that accepts weight of metal strips, but must improvise quickly.
- Shaving meniscus unevenness is minor and brings leak-management to feasible minimum.
- Standardized surfaces on all six sides of plaster chunks allows leakless abutting in all directions.
- With additional flat panel containments above and below, many more open castings could result.
- Generative aspect: same "glyphs" are used as separators, the overall pattern relates well visually to others also made from them.
- Separation of parts is fastest yet and metal pieces almost completely unchanged.
- Ceramic development **milestone**: incredibly complex shapes still release from mold because all draft (withdrawal) angles are monitored and locked-in plaster chunks are rare.
- Graphic development **milestone**: while unmolding casting from plaster chunks, very interesting forms emerge, used as graphic content.
- Conceptual development **milestone**: casting and separable plaster parts thought of as abstract typography, resembling radical/stroke relationships of meaning with modifications.
- Refinements needed: **Reassembly of unmarked pieces very, very tedious.**

Images for Style No. 4

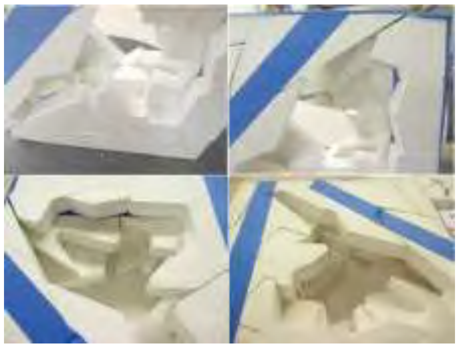


(4.1) Metal strips in straight and curved pieces for pushing into gelling plaster (not shown).
(4.2) Detail of metal subdivision being pushed downward into gelling plaster. Note close fitting strips against edge and against each other.
(4.3) Fully hardened plaster with metal subdivisions.



(4.4) Detail of disassembly. Note clean edges to complex shape.
(4.5) Minimal shaving on top surface of plaster layer ensures leakless stacking with future layers.
(4.6) Disassembly views.





(4.7) Comparison of four layers, each made with the same set of drop-in partitions.
(4.8) Four layers with various central pieces removed, edges bound together, and stacked into block. Reserved pieces shown at top.
(4.9) Comparison of viewing angles.

(4.10) Drained casting still wet



(4.11) Views of unmolding (raised stance).
(4.12) Views of unmolding (right side up stance).
(4.13) Views of unmolding (bottom side up stance).

(4.14) Completely unmolded object (baked color is white).


(4.15) Abstracted views, close detail.
(4.16) Abstracted views, close detail.

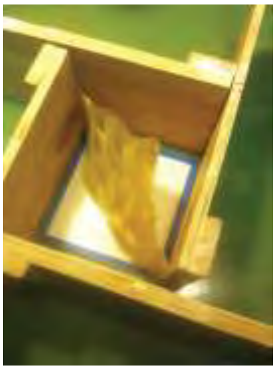
Style No. 5

Latex 9-cell

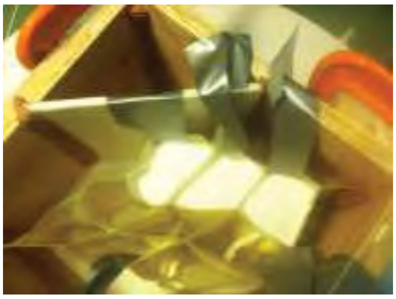
- Actually made before all the rigid systems, but conceptually distinct and evolved separately.
- Notion of partition grid starts with flat panels, but flexibility of mesh when unfilled is made dramatically distorted when filled.
- Procedural **milestone**: multiple-plaster pour enables early plaster layers to act as anchors to flexible material, which is distorted by creating more tension than was in original system.

- Containment is a bit less interesting than the latex mesh it contains but the technical means to make the outer containment out of latex under tension is still in development.
- Plaster shapes are the most variable, comparable to those from Style No. 6.
- Refinement needed: What about **horizontal subdivisions** within cells defined by meshes?
- Refinement needed: What if design of **mesh collapsed and deployed** over several uses?
- Refinement needed: What if partitions **contributed more to surface information**?

Images for Style No. 5

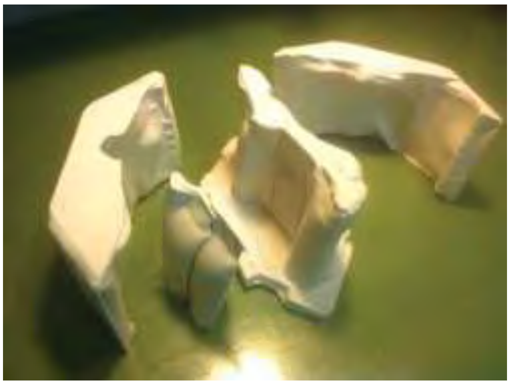
(5.1) Measured pieces of latex for flexible partitions.
(5.2) Mesh supported by containment box.



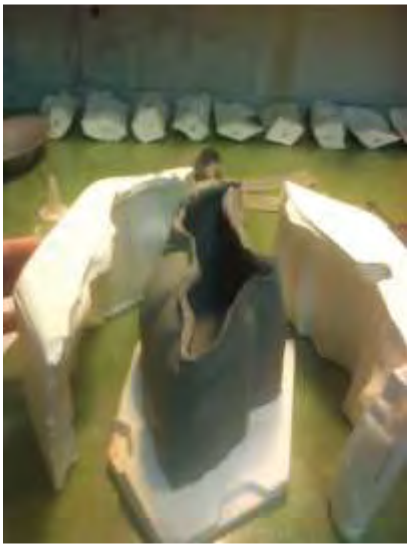
(5.3) Fill of first three minimally constrained cells, showing much distortion.
(5.4) Fill of middle row of cells, constrained by previous hardened plaster on one side, and round clay shapes in adjacent still-empty cells on other side, and tape (grey) pulling outward.
(5.5) Fill of last row of cells, similarly constrained as earlier row.

(5.6) Nine cells fully filled with plaster containment pieces around them, scraped

level (bottom view).

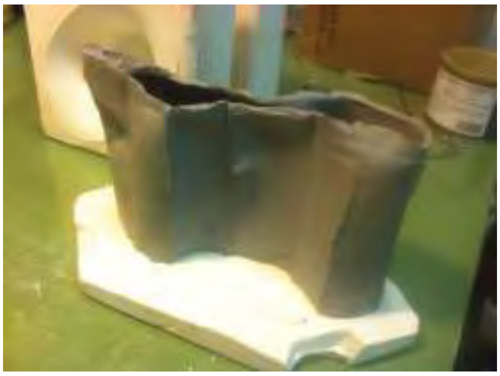


(5.7) Dismantling of mesh revealing organic plaster objects formed by latex distortions.
(5.8) 12-piece plaster mold from flexible latex mesh, partially disassembled.



(5.9) Largest possible form that results when all nine plaster pieces are removed (shown in background).

(5.10) Form that results when plaster pieces 1,8,9 remain in mold, creating union of pieces 2,3,4,5,6,7 (shown from bottom of mold)
(5.11) Form partially unmolded, side view. Plaster piece 1 (in hand), grey casting in middle (grey) union of pieces 2-7, plaster pieces 8,9 on other side.

(5.12) Comparison of two castings created from same mold, full form (foreground) and partial form.
(5.13) Completely unmolded form created from "union" of pieces 2-7, showing wrinkle details from inside of original nine latex cells.

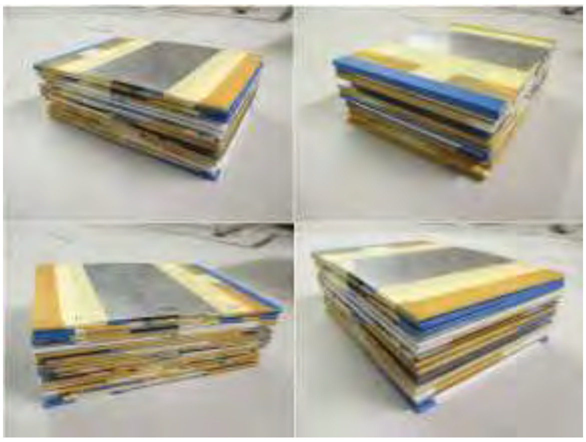
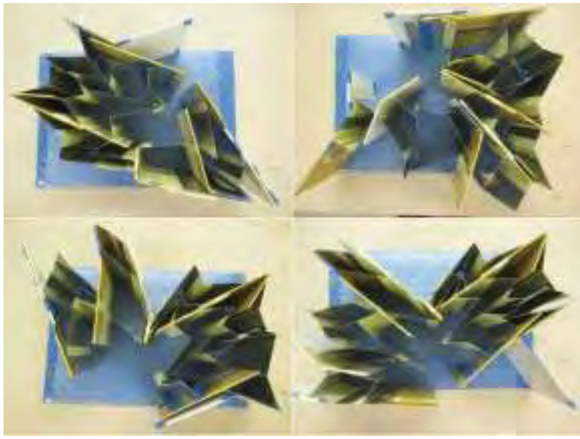
Style No. 6

Massive geologic mesh with complex mesh

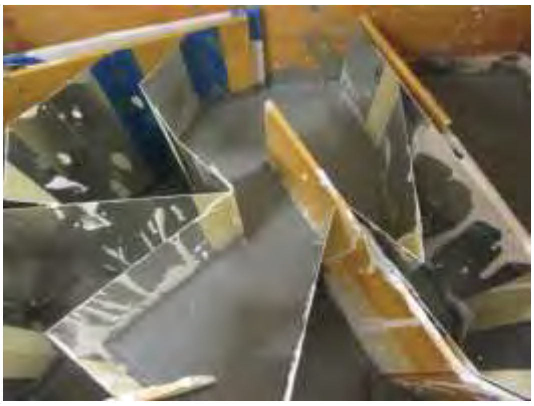
- Successful on several levels, but not pourable.
- Massive unliftable mold needs drainage platform (under development).
- Very noisy process with plaster amounts and gel times creating wandering surfaces at end of pour.
- Mesh built up from layers of foamcore, metal, and tape while completely flat; mesh cell shapes emerge only when parts are moved out of flat stowed position.
- Operational **milestone**: thin clay slip as separator between old and new plaster for subdivide again operation.
- Conceptual **milestone**: mesh parts not completely unfolded/deployed implies that information "within" mesh contains can be "expressed" or "suppressed"; stowed mesh elements create void in plaster object set that will be used by all neighboring arrangements. If identical mesh were constructed and deployed a little farther, "new" information/chunks become available, partition number increases.
- Clay slip used as separator among horizontal areas was completely successful, required no anticipation of shape, and interesting patterns emerged at disassembly when parts tore slip layer into abstract but complementary patterns.
- Generative aspect that shapes which emerged from noisy process have organic, almost geologic quality absent in all previous systems; pieces themselves can be rearranged as sculpture.
- Graphic potential of mesh by itself is greatest among others discussed so far.
- Technical challenge **not yet solved**: using mesh for plaster was far more destructive than anticipated, so mesh layers that used incrementally posed meshes will have to wait.
- Technical challenge **not yet solved**: leak-management for such noisy, broken-edged objects is beyond current ability to patch subtly.

Images for Style No. 6


(6.1) Separator plates of foam core with tape and metal waterproofing.
(6.2) Individual plates are grouped into a stack with more tape.

(6.3) Concept included a mesh that was originally flat and can expand into containment area.
(6.4) Exploring possible deployed arrangements.

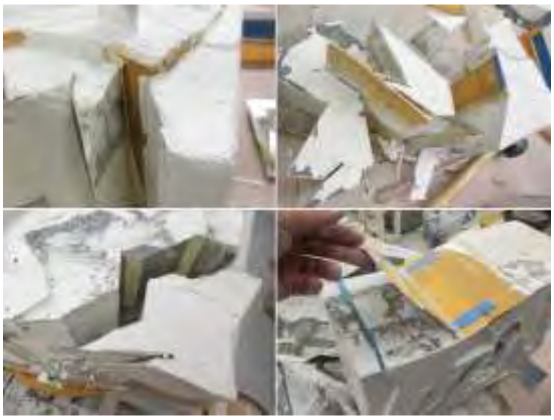
(6.5) Pouring plaster into mesh in multiple batches.
(6.6) Detail of brushed clay slip separator for subdivisions not indicated by vertical mesh walls.

(6.7) Plaster pouring targets different areas of mesh, which fills them earlier. This means subdivisions will be at various levels.
(6.8) Example of plaster gelling state slowing down flow.

(6.9) Example of metal shim (not shown) pushed into gelling plaster and then pulling it back out when plaster has hardened enough not to close back up (seen here as the thin dark lines). These divisions will not be part of later layers.
(6.10) Plaster has filled the mesh and weighs over 30 pounds.

(6.11) The containment box is pulled apart and disassembly begins.
(6.12) Stages of disassembly.

(6.13) Complementary grey (clay slip) and white (plaster) designs from slip separator layer.


(6.14) Representative stacks of objects generated.
(6.15) Arrangement of objects reminiscent of geology and architecture.

Creative concepts, moving forward

The systems under discussion explore generative concepts in a very hands-on sculptural process. As these processes continue to unfold, a number of aspects should receive attention.

Style No. 4 is an extremely interesting set of objects that combine elements of abstract art and typography. Much thought will be given to the idea that the casting might represent a radical, as in Chinese writing systems, and that the mold parts all total represent the additional "strokes" that change the meaning. During the process of unmolding, as fewer and fewer mold pieces remain in their original locations, the object takes on more and more aspects of a changing set of graphics. The concept is compelling that the casting plus some of its mold might be as much the object of attention as is the casting by itself. Much effort will be put into having this concept affect choices as far back as the metal drop-in pieces, to see whether the resulting assemblages can be photographed and rendered as abstract typography.

Style No. 5 is perhaps the most distinct of the meshes because of its extreme fluidity. It will be difficult but interesting to bring some of the modularity of the other systems into those with latex meshes.

The tool-versus-content duality should be used to inform decoration on the surfaces of the plaster and ceramic objects, an application that has been conspicuously avoided in this Cycle. It would be relatively easy to generate 2D artwork from photographs of an arrangement, convert it to some imagery system like screen-printing, and decorate some surface with that imagery. Does the image represent some aspect of that object's past? Its future? Or depict some entirely different Style?

In all styles in which plaster is the former for clay slip, it is tempting to switch the roles. The thicker the casting, the more dramatically abstracted is the casting inner surface compared to the mold inner surface. Usually ignored as irrelevant, this interior form is actually very interesting because it represents a kind of "erosion filter" that in digital systems requires computations. In future Partition series, when liquid clay is left for long enough in the mold, the loss and distortion of information will likely be remarkable.

The flow of information toward or away from "surface noise" should be more pronounced in future systems. Iterations from one Style can magnify some minor detail until it is larger than the object that created it in its "formation history." By including a greater number of iterations into these Styles, these physical systems will even more take on aspects of digitally produced generative art than has been seen here.

Conclusion

These systems represent an achievement of planning over virtuosity of gesture. The generative nature of these processes should indicate to anyone with tenacity and a methodology that highly complex objects can be made. These objects can be interpreted as tools for what they do, and can be interpreted as photographic subject matter for what they look like. This open-ended, diversifying aspect aligns well with the basic intent of generative art in digital and physical form.

From a procedural standpoint, these systems exploit the often conflicting concepts of "flow" and "stasis." By combining these basic universal aspects in different proportions, the variety of objects in this Partition Cycle might develop into larger, meaningful, compelling collections of abstract objects. Perhaps, in so doing, these systems might remind viewers of how a constant dynamic that exists between "flow" and "stasis" can be beautiful while still being of uncertain outcome. These objects have no beginning and no end, but transform a little or a lot at a time. How much of this universe that inspires us is based on exactly those concepts?

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RANDOMNESS, (DIS)ORDER, AND GENERATIVITY *(Paper*

Topics: Art/Science

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Main References:
[1] Marie-Pascale Corcuff, "*Chance and Generativity*", GA 2008, Milano, 2008

http://mpc-info-mpc.blogspot.fr/

Abstract:
One of the most used, but maybe most controversial, terms, when one refers to generative art, is randomness.
In "Chance and Generativity" (GA 2008), chance (randomness) was examined relatively to generative processes, and mainly considered the huge possibilities of combinatorics and the necessity of arbitrarily (and then randomly) choosing among results, which are all, though not strictly *identical*, definitively *similar*.
Here we explore randomness with its links to order and disorder, and its capacity to generate forms or structures.
First, one needs to objectively define those terms (*randomness*, *disorder*), along with others like *entropy*, *complexity*, and confront their reality, which can be measured as probabilities, to our perception of them. For instance, *interacting* randomness may lead to something which seems more ordered, though actually it is not (*cf* Jennifer Galanis and Martin Ehler, "Disorder disguised as Order", GA 2011). This topics can be illustrated in many ways.
Those illustrations of randomness comprise constrained packings (of rods, circles, …, which must not overlap) and the more or less ordered structures they generate, according to the rules one gives oneself in the packing.
Some rules may be interpreted as behaviours. Then we can see how more or less *random* behaviours (erratic walk especially) may paradoxically generate forms that are ordered at some level.
All those experiments illustrate phenomena like emergence, spontaneous patterns, crystallisation, and so on, and let us think about the links between nature, science, and art.

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Keywords:
Randomness, order/disorder, interaction, packing, emergence

RANDOMNESS, DIS(ORDER), AND GENERATIVITY

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Abstract

One of the most used, but maybe most controversial, terms, when one refers to generative art, is randomness.
In "Chance and Generativity" (GA 2008), chance (randomness) was examined relatively to generative processes, and mainly considered along the huge possibilities of combinatorics and the necessity of arbitrarily (and then randomly) choosing among results, which are all, though not strictly *identical*, definitively *similar*.
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First, one needs to objectively define those terms (*randomness*, *disorder*), along with others like *entropy*, *complexity*, and confront their reality, which can be measured as probabilities, to our perception of them. For instance, *interacting* randomness may lead to something which seems more ordered, though actually it is not (*cf* Jennifer Galanis and Martin Ehler, "Disorder disguised as Order", GA 2011). This topics can be illustrated in many ways.
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Introduction

According to wikipedia, “randomness means lack of pattern or predictability in events. Randomness suggests a non-order or non-coherence in a sequence of symbols or steps, such that there is no intelligible pattern or combination.” [1]

Randomness may apply to very different situations, and we will not discuss it abstractly, but in a defined context: some configuration of some shapes, in some 2D space (possibly extensible to a 3D space).

We first need to define that space, and the principal distinction is between a *discrete* and a *continuous* space. If one wants to distribute *random* points in a square, for instance, there is a difference between choosing random pixels in a bitmap (discrete space) and choosing random points in a square that is a subspace of R^2.

In a discrete space, it is a question of combinatorics: there may be a huge number of different configurations, but their number is finite. The probability of some configuration is the proportion of this configuration among all possible configurations, i. e. 1 divided by the number of different configurations, which is a finite number. For instance, the number of 10x10 bitmaps, where pixels may be white or black, is 2^{100}. This is a very large number ($\approx 10^{30}$), but not infinite. Any configuration of pixels in such a bitmap has a probability of $1/2^{100}$.

Defining the probability of an event as the proportion of some event(s) among all events (which you can count) could infer that any probability is a rational number, but it is not so. In a continuous space there is an infinite number of configurations, and you cannot calculate a fraction with ∞ as denominator, but you can still calculate probabilities. For instance, drawing a disk of diameter d inside a square of side d, you can calculate the probability for a point randomly chosen in the square to belong to the disk by dividing their respective areas: $\pi d^2 / 4d^2 = \pi/4$, which is not a rational number. Neglecting his dear naturalism for a while, but in the interest of games of chance, popular at his time, Buffon proved that if you throw a needle of length 2a on a surface where parallel lines are drawn with an interval 2b, the probability that this needle intersects one of the line equals $2a/\pi b$.[2] [3].

A random distribution of points in a square of side d, which is a subspace of R^2, is one where you choose their coordinates anywhere in [0,d]. There is no way to determine the probability of any configuration, but if you divide the square into a grid, the probability of each point to be in any box of the grid is the same. That is, if you have a great number of points, there will be approximately the same number of points in each box. And it must be true for any size of the grid.

Beyond randomness, what we are interested in is to try to define *order* versus *disorder*, and what our perception detects as a *pattern*, something which we find “interesting”, versus configurations which are indifferent. It is also dependant of the context, and we will try to objectively define what an interesting pattern is in each context. It is generally something between total order and total disorder, which are both without interest. It is opposed to randomness which supposes a lack of pattern, but randomness may be an initial condition in a process that leads towards some pattern. Those patterns, which are neither totally ordered nor disordered, but contain an underlying order more or less broken by a certain amount of disorder, are what we qualify as “(dis)order”.

We support our discussion with two models, one that works in a discrete space, and one that works in a continuous space.

I. Randomness and (dis)order in a discrete space: around the Ising cellular atomaton

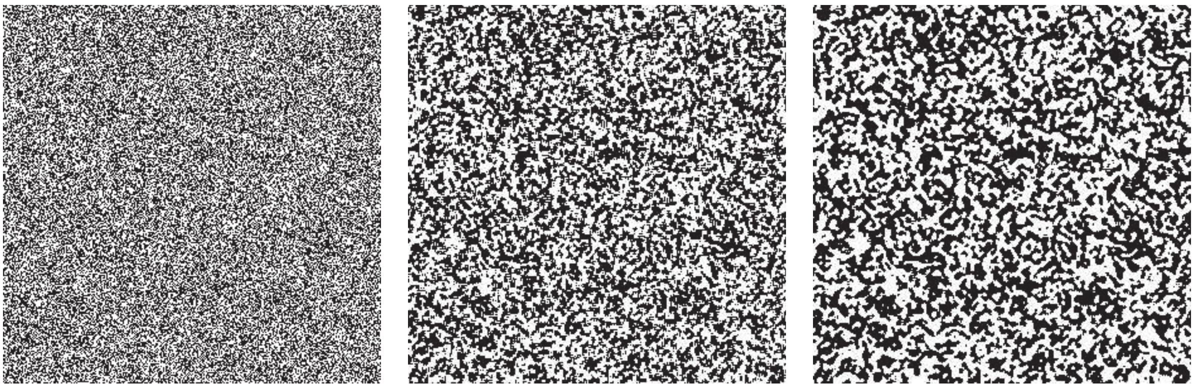
I.1. The Ising cellular automaton

Cellular automata work in a discrete space, generally an orthogonal grid, which we can easily assimilate to a bitmap of pixels. All cellular automata evolve according to the neighbourhood of each cell, either the four neighbours at the edges, or the eight neighbours obtained with adding the ones at the corners. Cells may have any number of states (visualised as colours), but there are already a great lot of results to consider with two-states CA (0 and 1). Metaphorically, one can say that cells are dead or alive. The state of each cell evolves according to the states of its neighbours, but then again, there are a lot of different results when considering only the sum of those states, what one calls “totalistic” CA. The famous “game of life” is one of those totalistic two-states CA.

A CA “works” well when it evolves and does not disappear too fast, i. e. when all cells do not “die” immediatly. This may depend upon the initial conditions. In the game of life many configurations have been studied, some die rapidly, some others after some generations, others seem to evolve indefinitely.

There is a totallistic two-states CA that simulates an actual physical behaviour: the Ising model [4]. The two states do not refer here to life and death, but to the magnetic moments of atomic spins that can be in one of two states (-1 or +1). In this model, each cell adopts the state of the majority of its neighbours (the “majority vote”).

Notwithstanding the scientific side of this model, it interests us here for its involving randomness, order and disorder, in ways we want to discuss. A typical evolution of such a CA is shown in fig. 1. In all these experiments, we consider a “torical topology” (periodic boundary conditions).



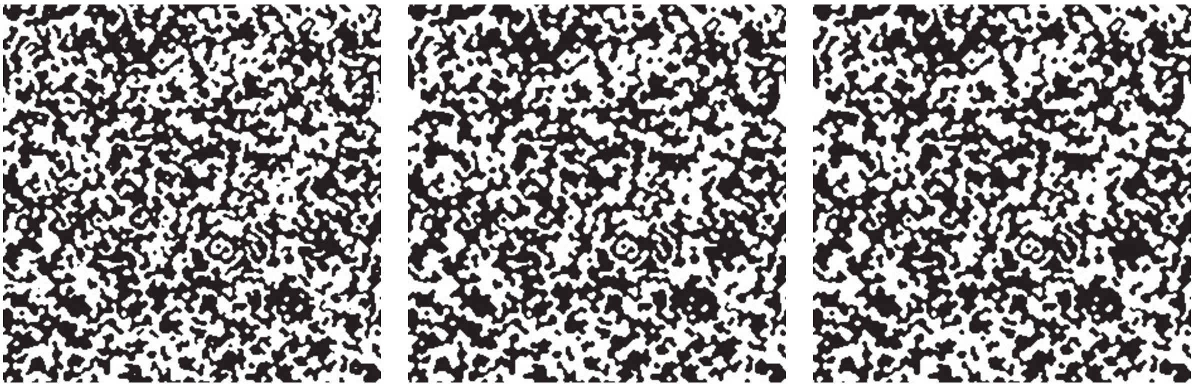


Fig. 1: typical evolution of Ising CA (300x300)

This CA may use different “depths” of neighbourhood, by not only considering the 8 cells lying directly around each cell, but also the 16 ones around them (depth 2), and even the 24 ones beyond (depth 3), and so on. It works as a sort of zoom on the process, and the patterns are similar, but larger.

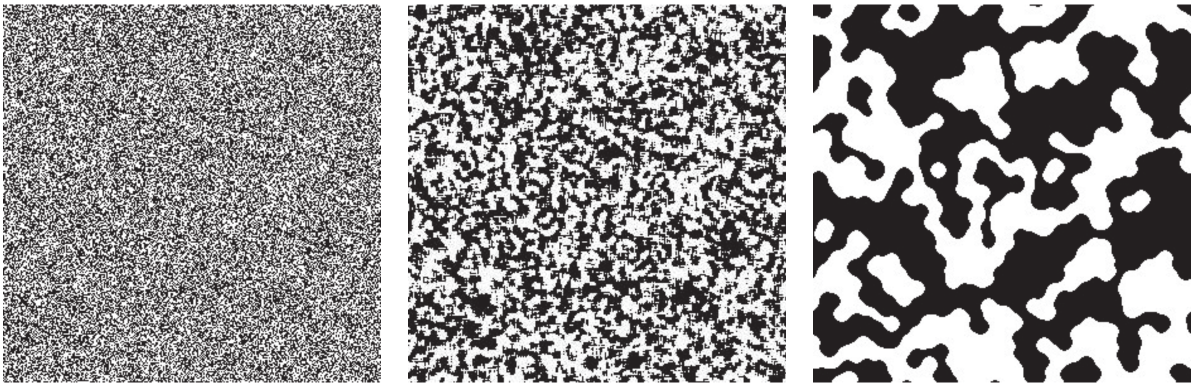


Fig. 2: Ising CA (300x300) with depth 2

What makes us recognise the result as a “pattern”, as “(dis)order”, is, in a first approach, that it seems not totally predetermined (each pattern we obtain is different) but not absolutely nondescript either (like the random initial distribution). We will try to measure what has changed during the process later, but here we can say that those patterns show smooth interlocking of black and white areas, with boundaries that curve themselves in a “natural” way. Without being figurative at all, it can remind us of natural patterns. And, as it were, some animals, horses and cows (especially one cow breed native to our region, the “Bretonne pie-noir”), and other ones, called “piebald” or “pied”, display such patterns...

I.2. Randomness and balance

This CA is supposed to start with a “random” and balanced distribution. The condition of being balanced seems straightforward: if one state predominates at the start, with the majority vote, it is indeed likely that this state will spread and invade all the automaton. But we will see later that it is not such a strong condition.

Let us discuss the “random” condition of the starting distribution. In order to obtain such a random balanced initial state of the automaton, one considers each cell, and “flips a coin”, i. e. chooses randomly between -1 and 1 (or 0 and 1, or black and white). One typical configuration is such as fig. 3.

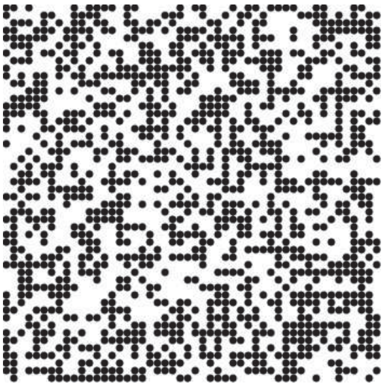


Fig. 3: typical initial state of Ising CA (50x50)

The CA evolves rapidly (in 20 steps) towards a fixed state (Fig. 4).

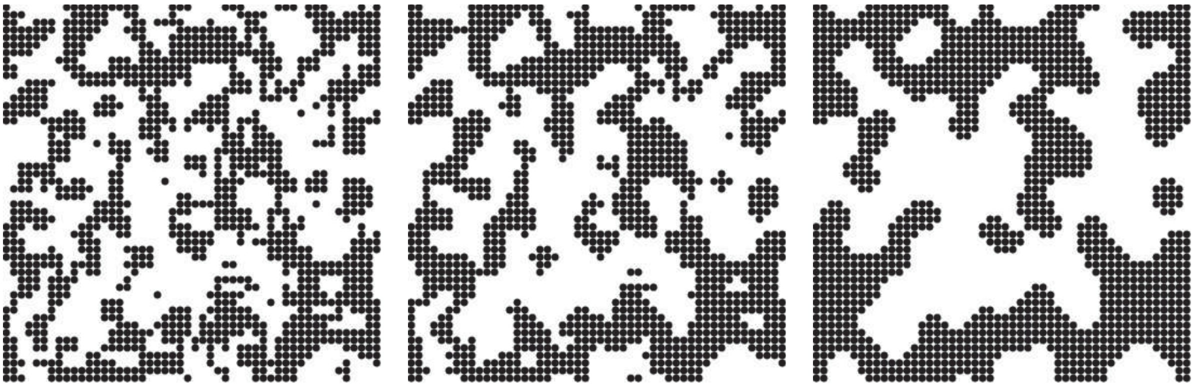


Fig. 4: steps 1, 2 and 20 of Ising CA (50x50)

The automaton has got 50x50=2500 cells. 2500/2=1250, so there should be around 1250 black cells at the start. Actually in this particular example, there are 1242 black cells. It does not perturb the evolution, though. Through the steps, the count of black cells evolves around 1250, and stabilises itself at 1264:

1242 1227 1236 1248 1249 1252 1254 1251 1248 1247 1248 1250 1251 1252 1256 1258 1261 1262 1263 1264 1264 ...

A more subtle way of obtaining a balanced random distribution is to consider the statistical density of black cells. A balanced distribution corresponds to a density of 0.5. We can then try the plasticity of the starting conditions by choosing densities different from 0.5.

With a density of 0.75 and more, the automaton becomes all black. But with a density of 0.7, though a lot of evolutions have the same fate (all black), some keep one, or even two small white area(s) (fig. 5):

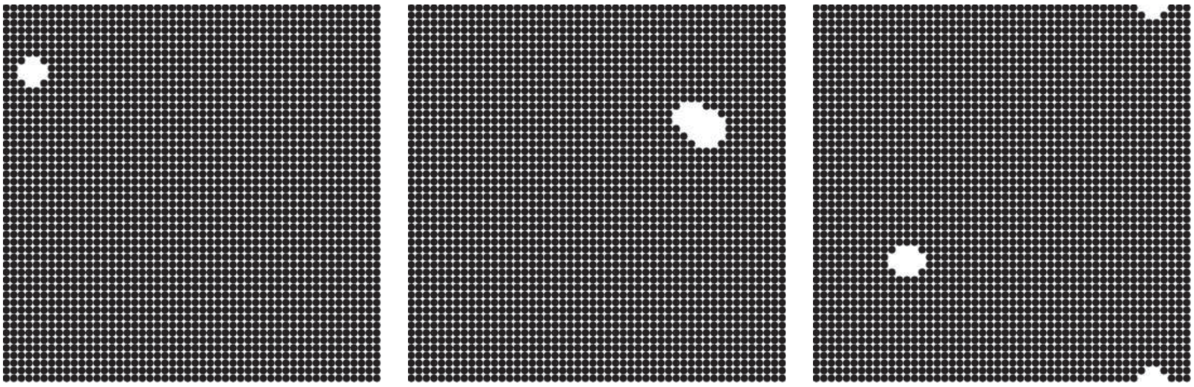


Fig. 5: some final results of Ising CA (50x50) with density 0.7

Below a density of 0.7, white areas remain allways. Typical results are shown fig. 6:

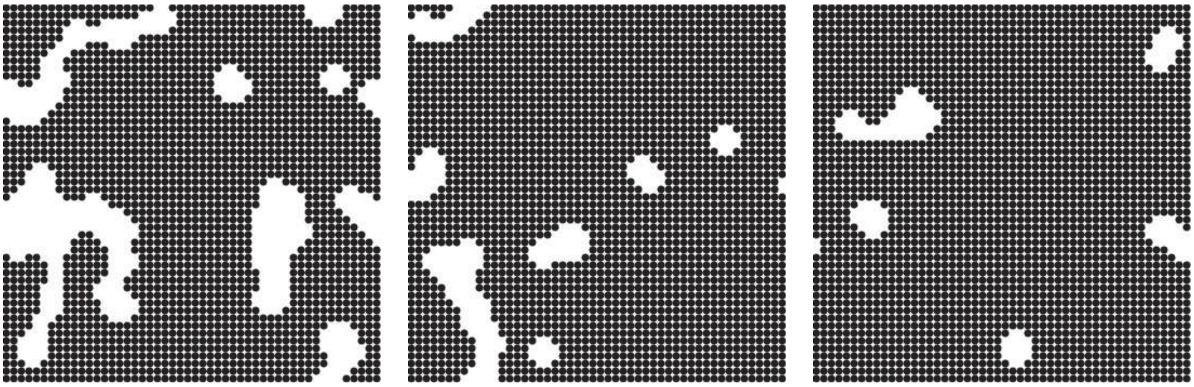


Fig. 6: typical results of Ising CA for densities 0.55, 0.6, 0.65

This CA and its starting conditions allow us to better define randomness and disorder. If we start with ordered though balanced starting conditions, the CA does not work. A strict equality between black and white cells happens in ordered configurations such as striated and checked patterns. A striated pattern evolves as a “blinker”: the black and white stripes exchange themselves at each step. A checked pattern does not evolve, it remains unchanged.

Randomness is then crucial to this CA, more than balance of states of cells.

I.3. Randomness, (dis)order and neighbourhood

In order to better define this randomness, and the disorder it contains, we can highlight a property of cells, directly involved in the evolution of the CA: the number of neighbours. Fig. 7 shows the “black” cells coloured according to their number of “black” neighbours, from 0 to 8 (from red to purple), and the number of cells that have those numbers of neighbours:

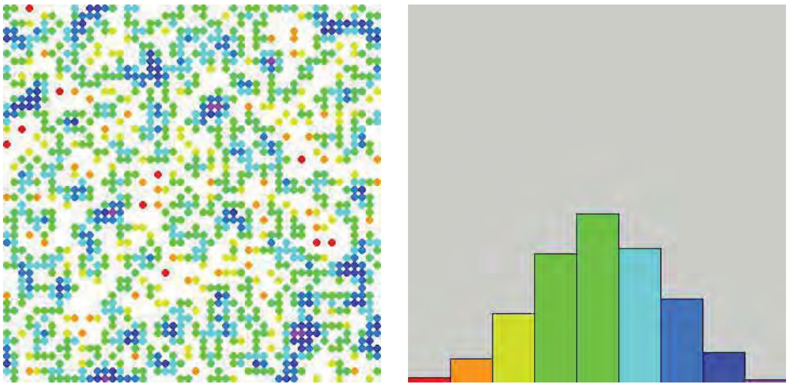


Fig. 7: "black" cells coloured according to their number of "black" neighbours, and amounts of "black" cells by numbers of neighbours

One can see that the repartition of the numbers of neighbours shows a nice so-called "normal" distribution, or gaussian curve. It is a good characterization of a balanced "random" configuration in this context. It is important to remark that we could do the same visualisation for the white cells, which would show the same repartition.

The process of the CA consists in destroying this normal distribution (fig. 8):

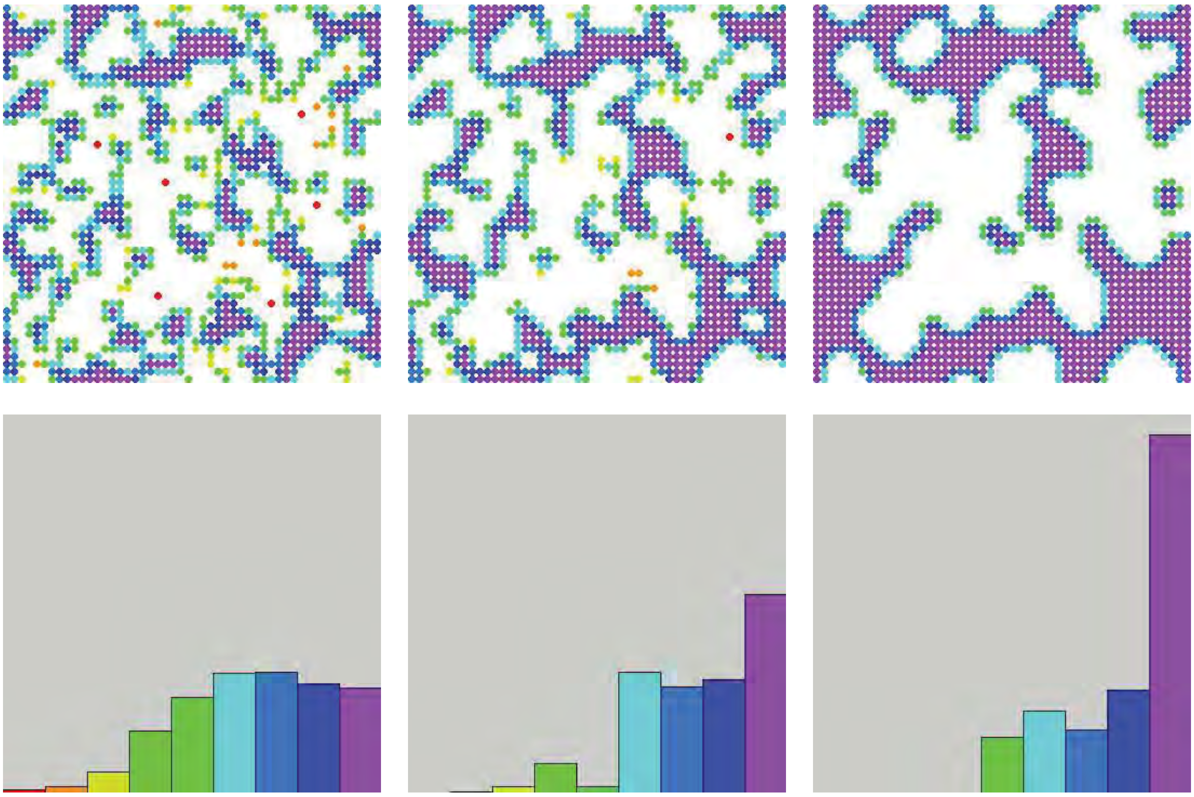


Fig. 8: numbers of neighbours (0 to 8) for steps 1, 2 and 20

By contrast, we can analyse the ordered configurations with the same criteria. The stripes contain black cells that have all only 2 black neighbours; the process of the CA turns those cells white, but the white ones are in the symmetric situation, so they turn black. Hence the “blinker”. For the checked configuration, any cell, white or black, has 4 neighbours in the same state, so the situation is blocked in the nest.

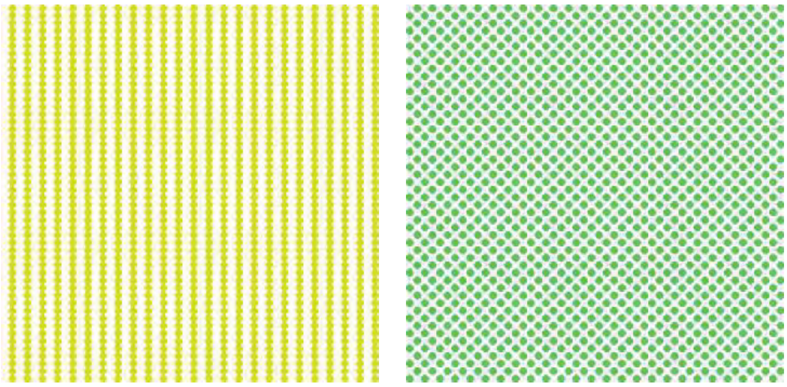


Fig. 9: numbers of neighbours for two ordered initial stages of Ising CA

One other consideration about this model is that we have seen that the balanced condition was not a very strict one when cells were distributed randomly. Now, if we introduce only one perturbation in the checked (and stable) initial stage, the “error” spreads, and invades all the space.

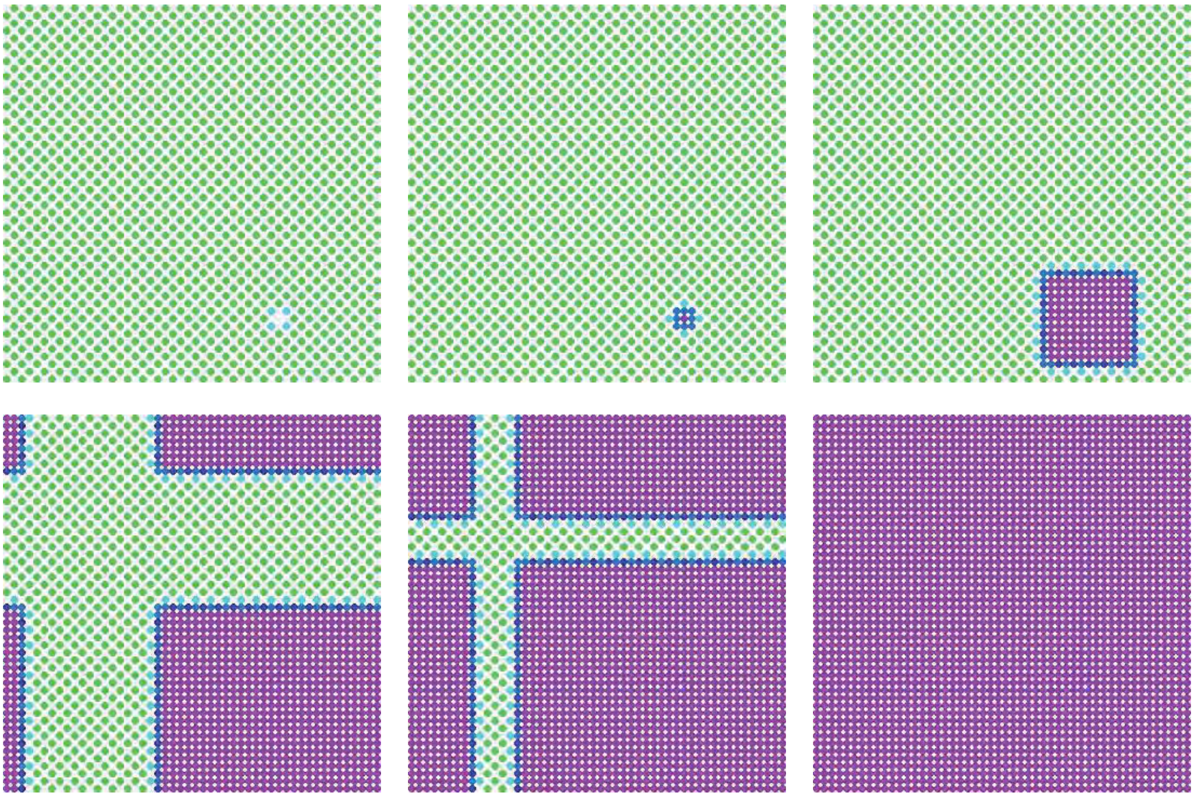


Fig. 10: evolution of Ising CA from initial checked configuration with one error

Leaving alone the Ising CA now, let us examine random densities according to numbers of neighbours.

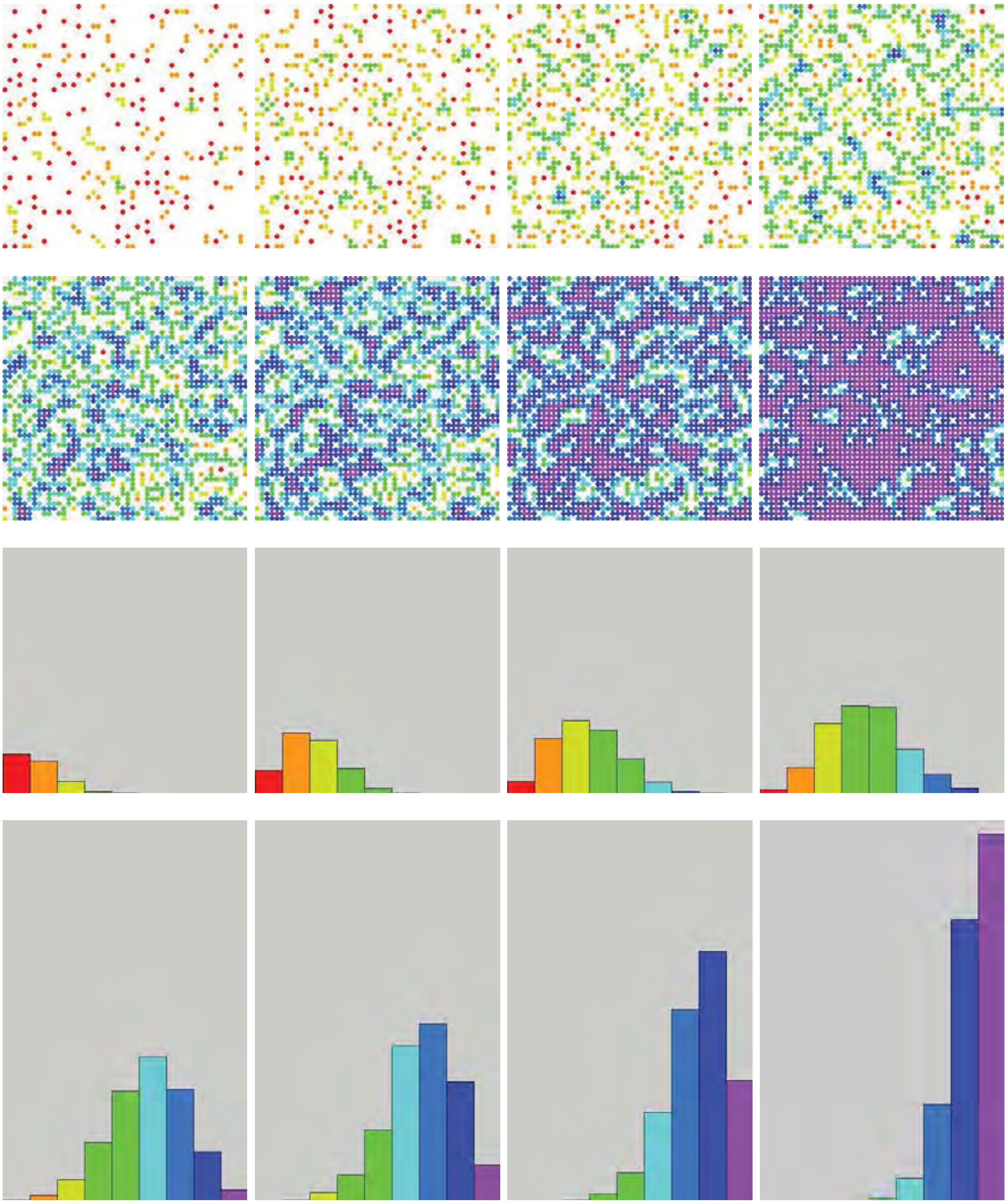


Fig. 11: numbers of neighbours for random densities 0.1, 0.2, 0.3, 0.4

It seems that with a high density (0.8 and 0.9) we have a distributed neighbourhood that resembles that of the results of the Ising CA. Examining the amounts more precisely, there is some difference though. In Ising results we had a predominance of 8-neighbours cells, but 4-, 5-, 6-, and 7-neighbours cells remained. In random density 0.9, 8-neighbours cells predominate, there are no more 4-neighbours ones, and 5-, 6-, and 7-neighbours ones are not of the same amount. We see that it tends progressively to the 1.0 density where all cells have 8 neighbours.

The other important difference is that in the Ising CA results the repartition of white and black cells (and their neighbourhoods) remains balanced. It is this balanced distribution of black and white cells, but also of their neighbourhoods, that characterises Ising patterns.

The discussion could have been continued about cellular automata in general but we will now address another model, which works in a continuous space, though we will see that this question of neighbours will also play a key role.

II. Randomness and (dis)order in a continuous space: disk packing

II.1. First approach

We became aware of this topics through the article “Spontaneous Patterns in Disk Packings” [5] to which we owe a lot in this part. Problems of packing, in general, consist in looking for some configuration of shapes in some space that maximises the density of those shapes, i. e. the proportion of space occupied by those shapes.

Packing disks in a certain area of the plane has been much studied. One must first notice that we can easily define an ideal optimised packing, theorically unlimited (without any boundary), and that it consists in a triangular grid of disks, each one occupying a hexagonal subspace. So the ideal density is easy to calculate: the area of a disk of radius 1 equals π, and the area of the hexagon in which the circle is inscribed is 6 times that of the equilateral triangle of height 1, i. e. 6 times $1/\sqrt{3}$. So the ideal density equals: $\pi\sqrt{3}/6=0.90689968...$

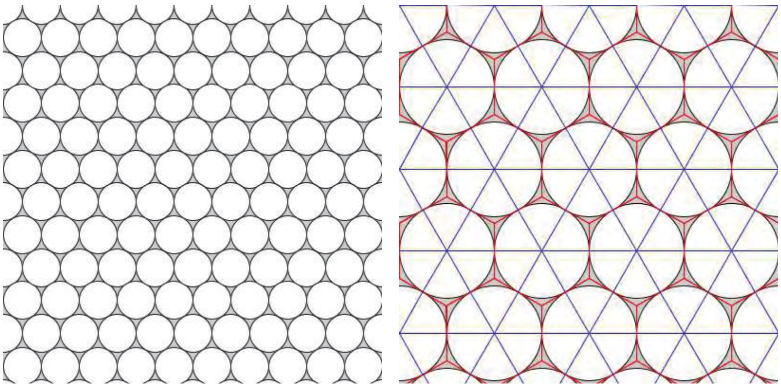


Fig. 12: ideal packing of disks

When boundaries come into play, it is not so simple... If the ideal packing had been orthogonal, there would not have been any problem because its dual is also othogonal, and the square is self-similar, i. e. you can pack squares inside a square. Even if the ideal grid had been hexagonal (each subspace being a triangle), there would have been no problem either, because the equilateral triangle is self-similar as well, and one could have packed “disks” with a maximal density in a triangular area.

But, as it were, the hexagon is not self-similar... So, even with an hexagonal area, never will we be able to pack disks with the maximal density we defined previously.

The hexagon cannot tesselate any convex polygon, though it tesselates the illimited plane; that is a weird but insurmontable characteristics of 2D space...

II.2. Physical model

Along with digital simulations, we wanted to examine the physical behaviour of disks, more exactly balls, or marbles, on a plane. We chose small balls used for toy pistols, for their claimed regularity of diameter, and smoothness of surface.

A first observation is that if you pour such balls into any plane recipient, as soon as there are enough of them, they tend to form ordered areas, separated by more disordered boundaries. These first experiments were not very rigorous, so we built a machine designed to pack balls.

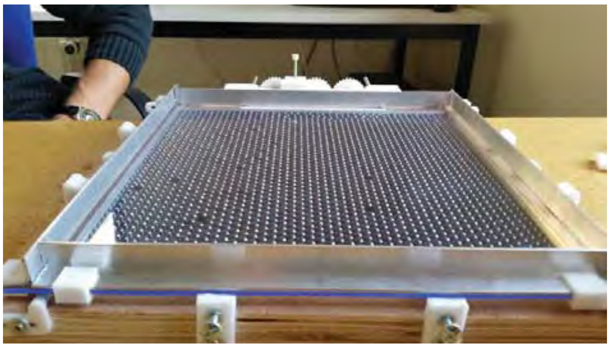


Fig. 13: packing-ball machine

This machine consists in a frame, one side of which is pushed by a system of cogwheels and screws. This moving side packs the balls progressively. We put a plexiglass sheet over the balls in order to help them from moving up. As it were we observed that forces are so strong that, in spite of this precaution, the balls had the tendency to push up on the plexiglass... The desire for an extra dimension of space is very pregnant...

Anyway, we had some results with this device as such. We saw ordered areas forming, and holes (one ball missing), and boundaries that went from curved to straight ones, often perpendicular to the applied force, and phenomena that will appear also in the digital model, such as triangles, and so on.

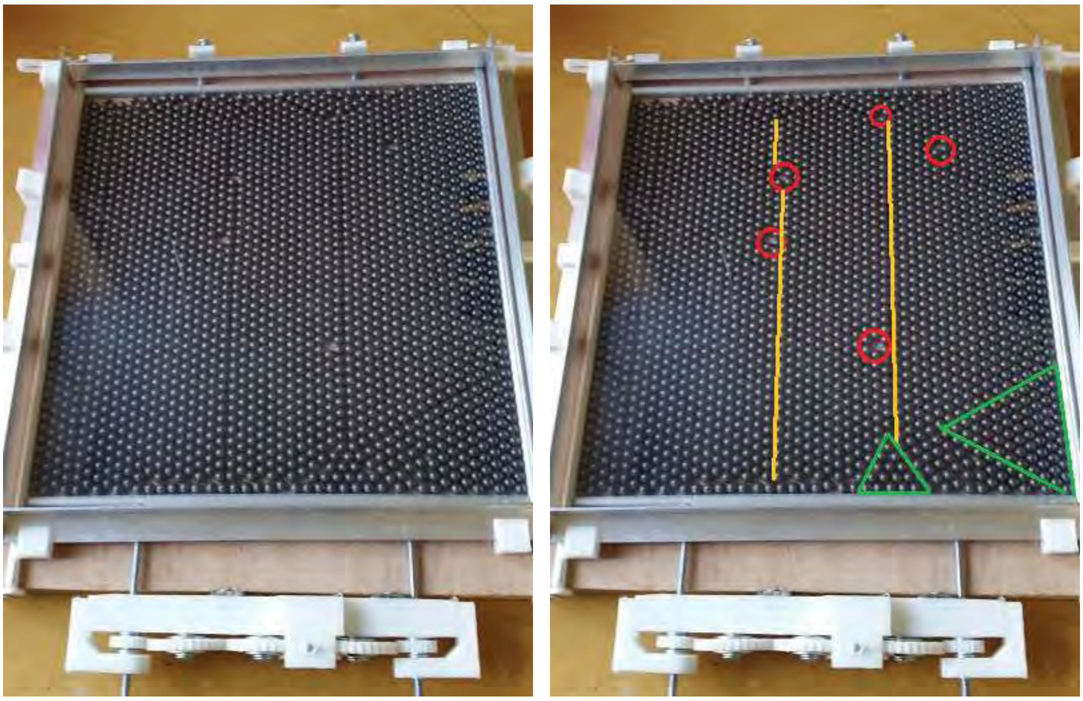


Fig. 14: holes, straight lines and triangles appearing when packing balls

II.3. Digital simulation with mechanical laws

A preliminary remark about a digital simulation, is that we cannot pretend that it works in a *continuous* space. Obviously, no digital model can achieve such an ambition. Real numbers are only approximated by computers, and any digital space is discrete. Hopefully the high resolution of that space manages to simulate a continuous space.

Inspired by [5], the model consists in starting with a random distribution of points, considered as disks with diameter 0. The disks are growing, and as soon as two disks happen to overlap, a force is applied to their centers in order to part them. This system simulates a shrinking of space where a certain number of disks (with a fixed diameter) are first randomly distributed. Contrarily to our physical model, there is no predominant direction of forces.

The growth of the disks happens by discrete steps (0.01 at each step for instance). A crucial element of the process is the rate of this growth. The slower the disks grow, the more compact the final configuration will be.

We considered a square space with borders, or with periodic boundaries. We did some experiments with borders first, and obtained results showing areas seemingly ordered (compact and on a triangular grid), separated by chords issued from the corners (fig. 15):

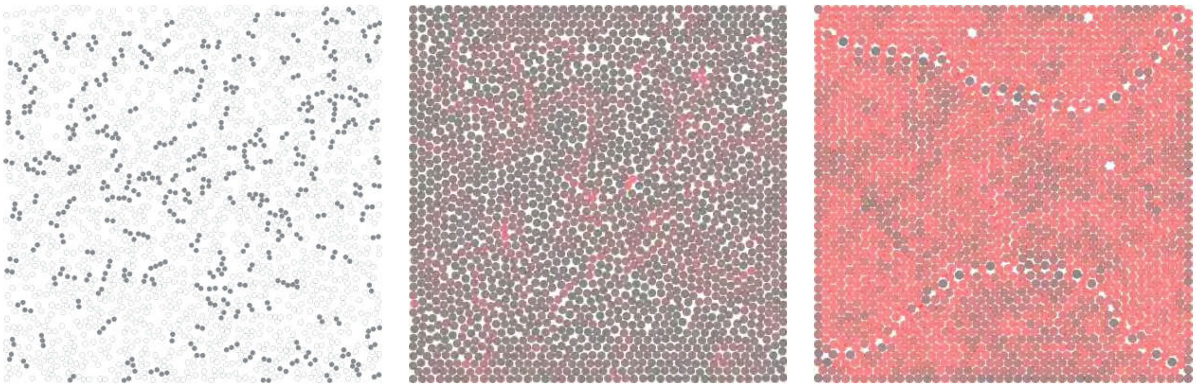


Fig. 15: packing with borders, 2000 disks, steps 220, 400, 1040

We colour the disks according to the forces applied to them (white (no contact at all), and from grey to red). This allows us to see the blocked disks (in red), and those that are more relaxed. The background is also white: the three white “stars” in the final picture of fig. 15 are holes, where one could place a disk. We see that in that final stage, there are three roughly compact areas separated by boundaries which we remark because we see the white background. In these boundaries, disks are mostly subject to smaller forces. But in the compact areas some are not totally blocked either.

We mostly started from random distributions, but we also wanted to see what happened with regular initial distributions. We put the initial 0-diameter disks on a triangular, orthogonal, and hexagonal, grid. A issue is the shape of the frame, either a square or not. We can keep the square with the orthogonal grid, but with the triangular and orthogonal grids, we cannot, since their horizontal and vertical spacings are not the same: they are in the proportion $v/h=\sqrt{3}/2$. With the condition of the periodic boundaries, the initial configuration must repeat itself horizontally and vertically exactly. So the initial frame is a rectangle, not a square.

Not unexpectedly, the triangular and orthogonal grids are stable, since all disks are blocked by their neighbours, but the hexagonal grid collapses, and has the same ulterior fate as a random distribution (fig. 16):

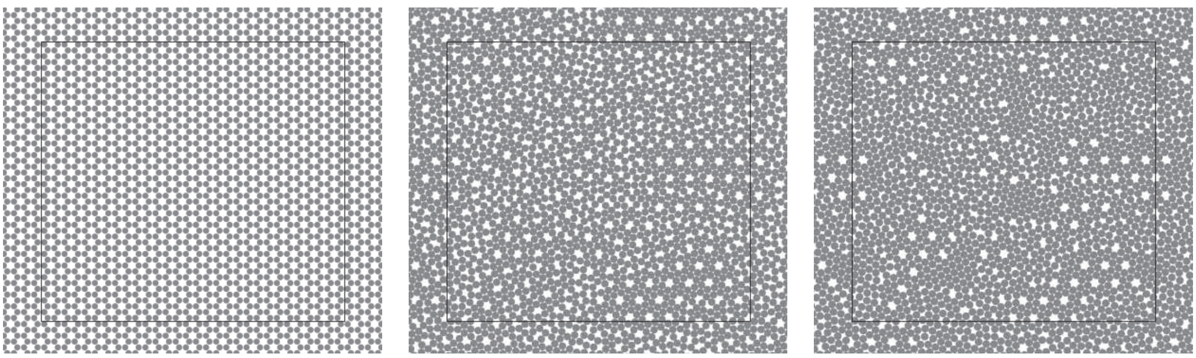


Fig. 16: collapse of hexagonal distribution of disks

What is interesting is what happens with a slightly perturbed triangular or orthogonal grid. One added random disk is enough to perturb the stability of the system.

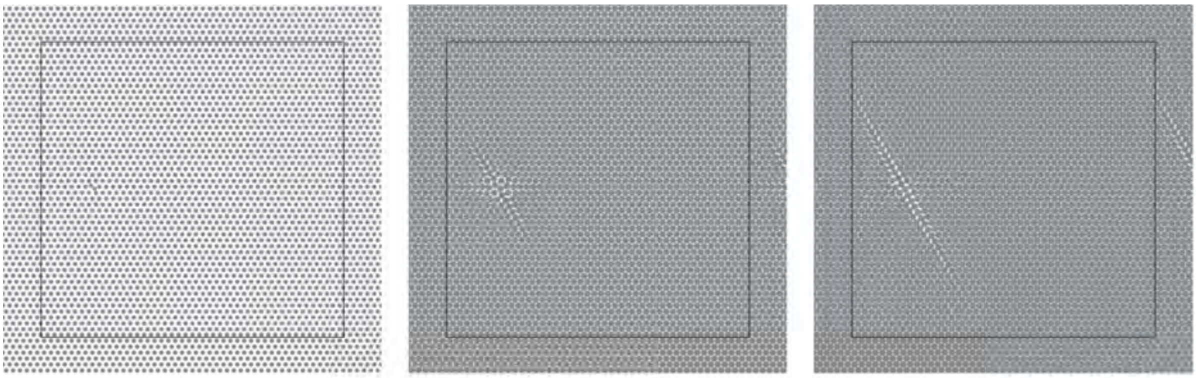


Fig. 17: triangular grid with one added random disk

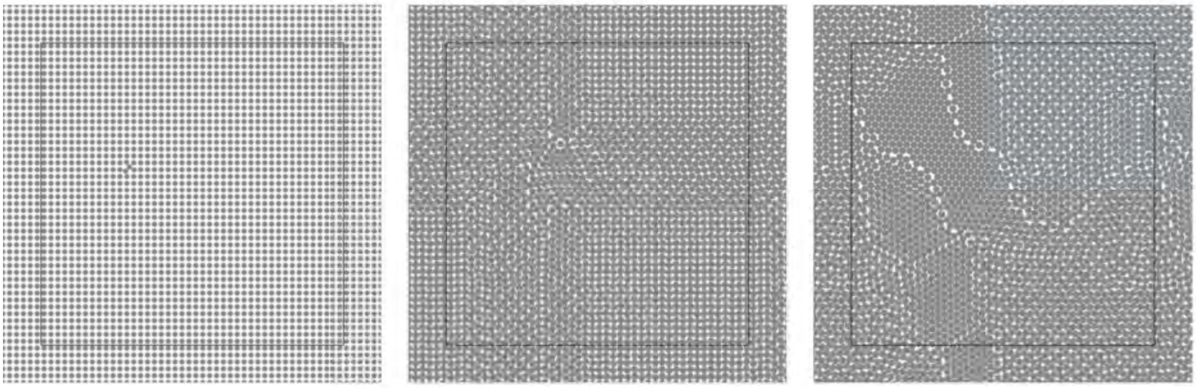


Fig. 18: orthogonal grid with one added random disk

In this last case, the configuration becomes similar to those we get from initial random distributions. We remark that the most stable configuration (triangular grid) is less perturbed, but is perturbed anyway, which is an indication of the difficulty of getting a regular configuration starting from a completly random initial distribution.

Going through all the results we obtained, we retained two categories: "crystals", the most compact ones, very strained though not completely ordered, and "wallpapers", patterns which the periodic display and the colours chosen in order to show different properties of the disks, induce inevitably such an image... In this last category, we got sometimes rough stripes, horizontal, vertical or oriented at 45°.

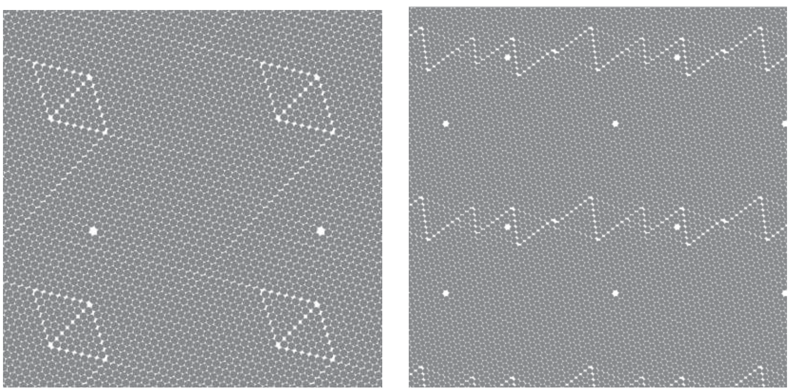


Fig. 19: "crystals" (2x2 display)

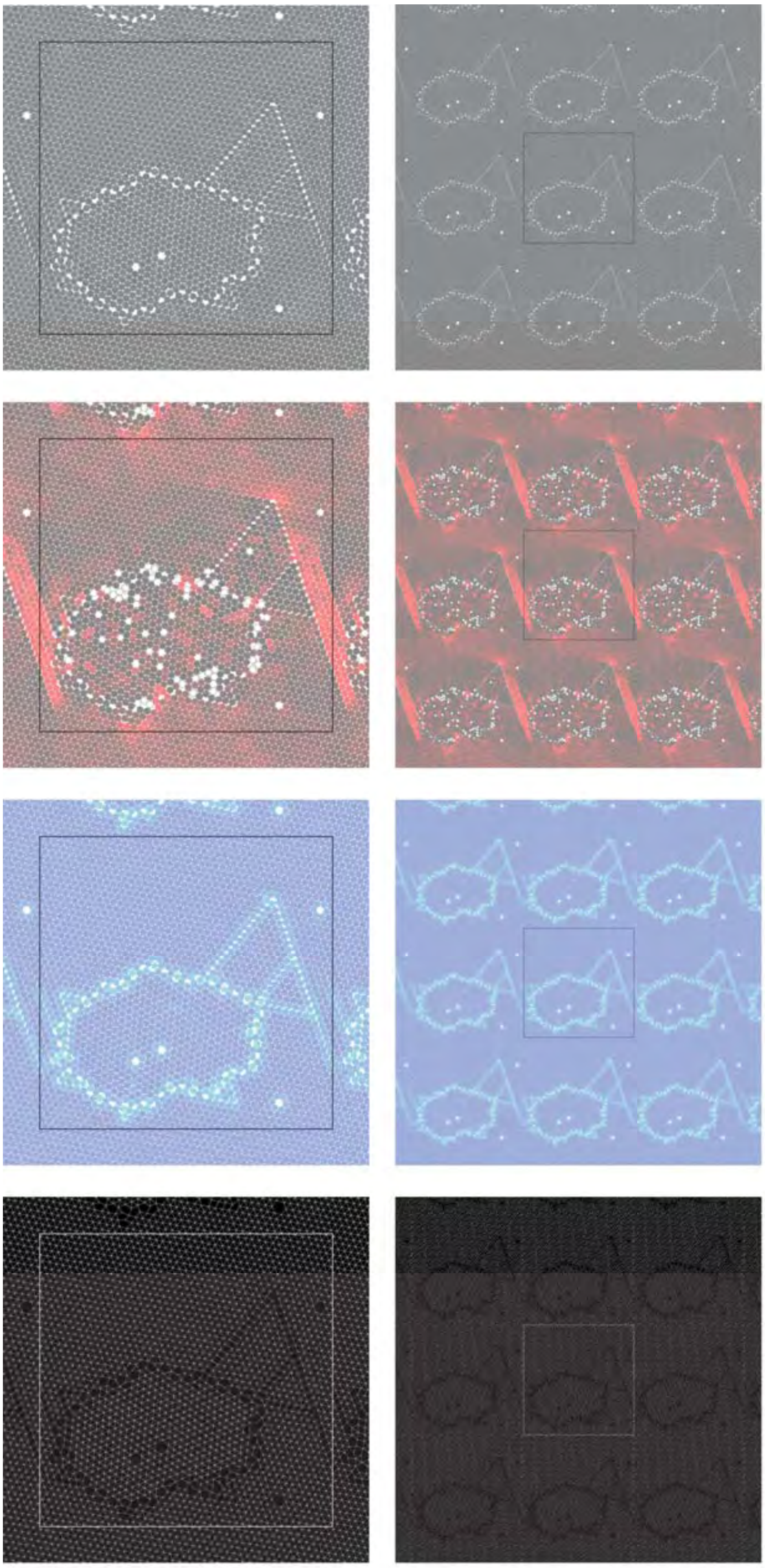


Fig. 20: "fish" wallpaper

Displays show the disks, uniformly coloured in grey, coloured accordingly to forces, to their number of neighbours, and lastly the links between neighbours.

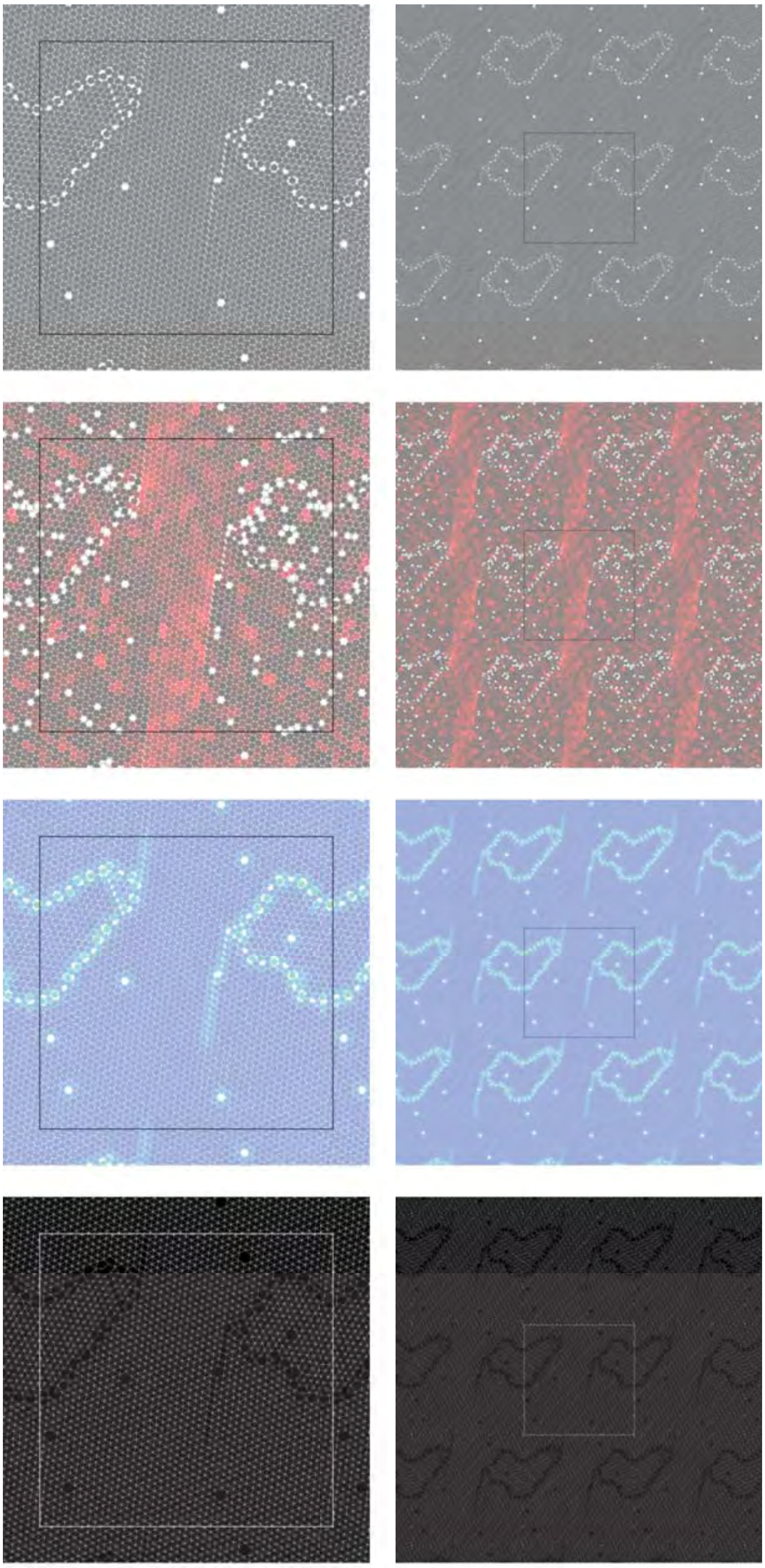


Fig. 21: “chick” wallpaper

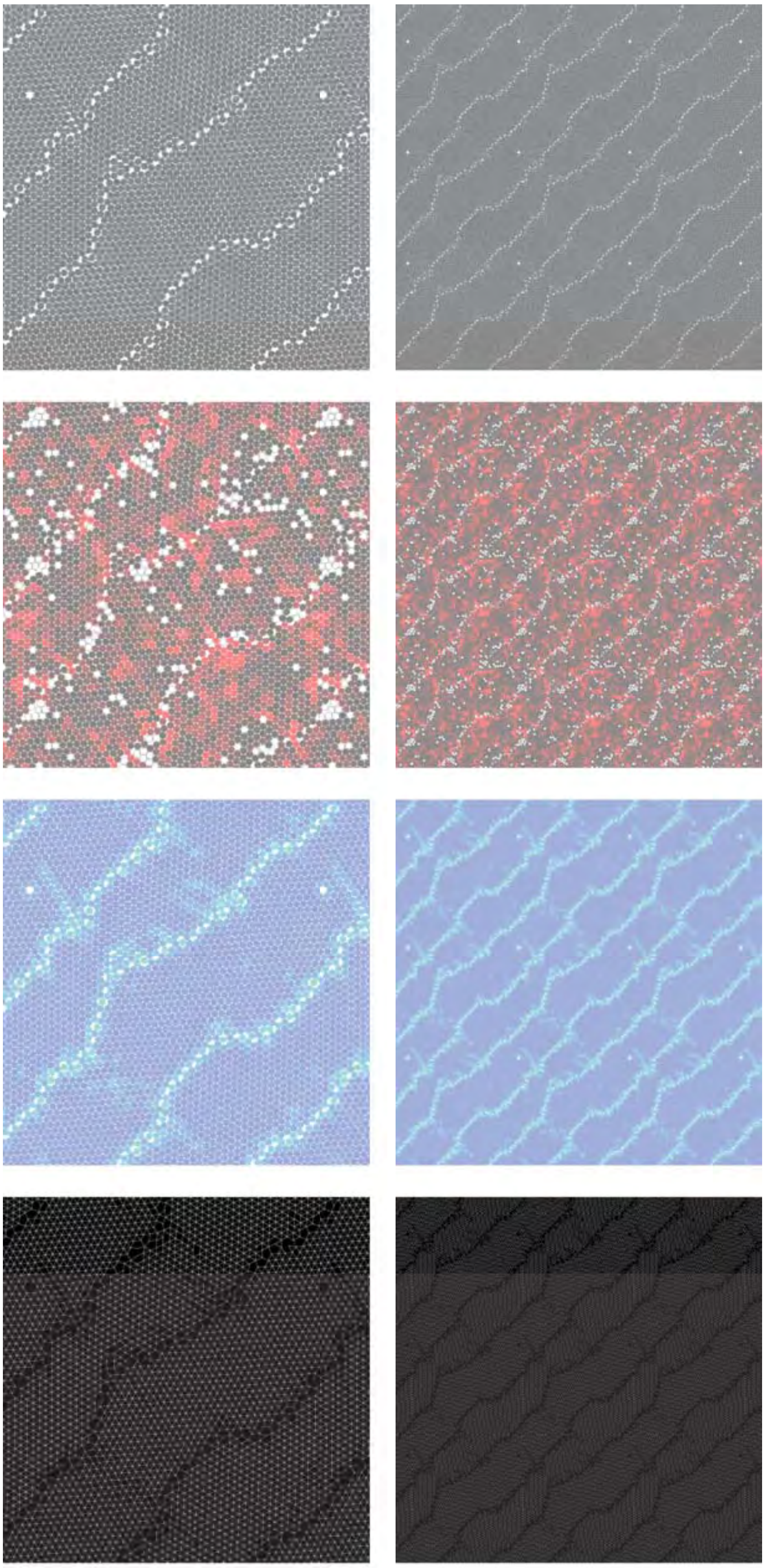


Fig. 22: "stripes" paperwall

Conclusion

Randomness is often a “trick” used to not to have to choose, to reduce the subjectivity, or to display one result among a huge number of possible results [6]. What we learned with the two models we explored is that in some cases, randomness, or disorder, is not only a convenience, but a *condition* of the evolution of the process. Ordered configurations do not evolve, they are stable, and what is even more interesting is that a very slight amount of disorder input in those ordered configurations is enough to perturb this stability.

Apart from their initial distibutions, both models are deterministic. In a way they are ways to display, to enhance, some random distribution of points in the plane, the discrete plane in the first case, the continuous one in the second. We tried to measure this disorder, by characterising not only the distribution of elements (which have the same probability to be in any location of the considered space) but their number of neighbours.

We do not pretend to contribute to a scientific study of randomness, disorder or entropy. At first glance, those models are counterintuitive in relation to a very loose knowledge of what entropy is, which we can express as: “entropy (or disorder) must allways increase”. But this is probably a too ingenuous view of those very difficult topics, and we forgot that it is only true for an isolated system. What we must acknowledge at least is that natural phenomena are well simulated by such processes. The Ising cellular automaton was designed to simulate the behaviour of spins in a ferromagnetic material, but its results suggest that it may simulate what happens in piebaldism, and maybe other phenomena as well. The disk packing model does not only simulate the actual behaviour of balls that you constrain on a shrinking surface, but may simulate what happens in crystallisation, where the random (Brownian) motion of molecules is replaced by a stable ordered configuration of them. What we see in actual crystal, is that contiguous ordered regions of different orientations emerge, as in the disk packing model.

According to wikipedia, “emergence is conceived as a process whereby larger entities, patterns, and regularities arise through interactions among smaller or simpler entities that themselves do not exhibit such properties.” [7] The two models we studied display such a behaviour, and we were able to precisely define and measure this arising of regularities. Beyond this objective measures, those patterns, and, in the case of the second model, the way they arise, are appealing to us (to some of us al least).

This allows to explain how those models ar able to contribute to the issues of generative art.

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Ming Xi Tang

A generative framework for the development of creative cultural industries for western China

Topic: A generative framework for the development of creative cultural industries for western China

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Abstract:

Based on the previous work by the Design Technology Research Centre in the School of Design of the Hong Kong polytechnic University, we have developed a new generative design framework for the development of creative cultural industries for western China as a collaborative initiative among the Hong Kong Polytechnic University, Xian Jiaotong University and Xian Tongli International college. The proposed generative framework is built on an RtttI model for generative and creative design. The terminology of RtttI defines a generative process consisting of Research, translation, transform, transcending and Innovation. It extends the scope of a normal generative system in which a large number of design and its alternatives are generated by programs such as genetic algorithms or other transformation computation. Our RtttI model integrates Research, Generative Design, and Innovation (Making) by linking cognitive and symbolic research of cultural genes, through a generative design process of translation, transform and transcending, with innovation through direct 3D printing as the final means of making. In particular, the generative process involves three inference engines of translation, transform, and transcending, with which creative and stylish design solutions are generated from the cultural genes of tangible products derived from handicrafts or cultural heritages. In this way, there is a sense of expansion of normal generative computation into social, cultural and historic development of design intelligence and design aesthetics. In the meantime, the three generative engines of translation, transform and transcending go beyond mere geometric, spatial or functional calculations. Instead, it relies on flexible integration of a variety of software systems including 3D solid modelling systems to generate new design solutions that can be evaluated with multiple and cultural related criteria, and more importantly, that can be 3D printed directly. Therefore, it is possible with this framework to develop an integrated generative design system that can support the merging creative cultural industries for western China, where the cultural and design heritages are rich and diverse, with great opportunities for design collaborations under a generative approach.

In this paper, we present several examples of using the RtttI model to support generative design based on cultural heritages in Xian. One example is to show how the three generative design inference engines of translation, transform and transcending can work with traditional sculpture and wood face painting techniques that have several thousands of years of history of development by hands, Another example is to show how the same generative model of RtttI and its underline thinking can be applied to music, with Qin opera music pieces as genes for the composition of generative music that can be played by both western and Chinese violins. This paper is accompanied by an exhibition and a live performance in the Generative Art Conference 2014 in Rome.

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Keywords:
Generative music, generative design, creative cultural industries for western China, 3D printing

A generative framework for the development of creative cultural industries for western China

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Abstract

Based on the previous work by the Design Technology Research Centre in the School of Design of the Hong Kong polytechnic University, we have developed a new generative design framework for the development of creative cultural industries for western China as a collaborative initiative among the Hong Kong Polytechnic University, Xian Jiaotong University, Xian Tongli International college, Cultural Bureau of Chen Cang District, and Research Centre on Qin Opera Branches. The proposed generative framework is built on an **RtttI** model for generative and creative product design. The terminology of **RtttI** defines a generative process consisting of **R**esearch**, t**ranslation**, t**ransform**, t**ranscending and **I**nnovation**.** It extends the scope of a normal generative system in which a large number of design and its alternatives are generated by programs such as genetic algorithms or other transformational computation. Our **RtttI** model integrates Research, Generative Design, and Innovation (Making) by linking cognitive and symbolic research of cultural genes, through a generative design process of translation, transform and transcending, with innovation through direct 3D printing as the final means of making. In particular, the generative process involves three inference engines of translation, transform, and transcending, with which creative and stylish design solutions are generated from the cultural genes of tangible products derived from handicrafts or cultural heritages. In this way, there is a sense of expansion of normal generative computation into social, cultural and historic development of design intelligence and design aesthetics. In the meantime, the three generative engines of translation, transform and transcending go beyond mere geometric, spatial or functional calculations. Instead, it relies on flexible integration of a variety of software systems including 3D solid modelling

systems to generate new design solutions that can be evaluated with multiple and cultural related criteria, and more importantly, that can be 3D printed directly. Therefore, it is possible with this framework to develop an integrated generative design system that supports the emerging creative cultural industries for western China, where the cultural and design heritages are rich and diverse, with great opportunities for design collaborations under a generative approach.

In this paper, we present several examples of using the **Rtttl** model to support generative design based on cultural heritages in Xian and Shaanxi province in western China. The purpose is to show how the three generative design inference engines of translation, transform and transcending can work with traditional sculpture and wood face painting techniques that have several thousands of years of history of development and evolution by hands, Another example is to show how the same generative model of **Rtttl** and its underline thinking can be applied to music, with Qin opera music pieces as the genes for the composition of generative music that can be played by both western and Chinese violins. This paper is accompanied by an exhibition and a live performance in the Generative Art Conference 2014 in Rome.

1. A Framework for Generative Design

Generative art and design has great potentials for creative cultures in western China. In the past, we have developed generative systems [1], [8], for product design and interactive music using evolutionary algorithms and computational transformation methods. These approaches opened many opportunities for research and development of generative design systems [3]. However, there is a need for scaling up generative systems to real industrial and product design areas amid the emergence of 3D printing techniques. It is possible now to develop a new framework of design and making integrating generative design and 3D printing, as shown in Figure 1.

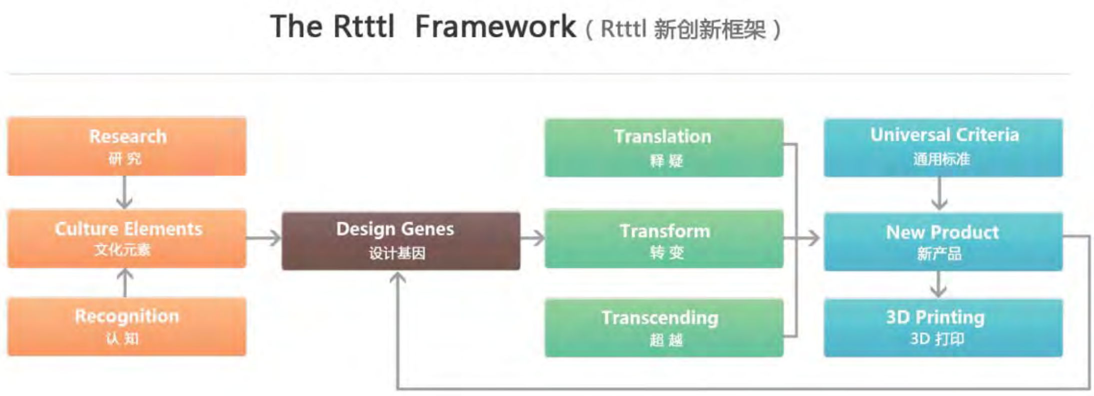

Figure 1: The Rtttl framework of generative design for creative culture industries in western China

The Rtttl framework of generative design has three main parts. These are, Research, generative design inference engines, 3D printing and evaluation. The research focuses on how to recognize the values of cultural elements and convert these cultural elements into the genes of design. The genes of design include form, color, texture, and composition of products or objects that can be processed by the generative design engines as the input.

The generative design engines perform the tasks represented by 3 “t”, that is, translation, transform, and transcending. The task of translation involves converting local and regional meanings of design genes into universal forms of aesthetic and functional substance of a new design concept. The task of transform is concerned with making changes and variations by computational methods in order to increase the populations of an original design gene. There are a wide range of choices for AI based computational techniques to perform such a generative act. But it is also possible to combine human interaction into this process. In most cases, such a generative act can be taken over by human artists or designers. The third task of transcending is the ultimate objective of generative art and design. That is, it must go beyond normal geometric or spatial transformations, in order to create new styles or new forms of innovation. This transcendence involves a sense of collective intelligence, by mixing several design genes in order to generate a collaborative creation or process. In this way, it can be said that new designs have transcended the original ones, such as the handicrafts, which are normally created by individuals.

The new generative design and making process needs to work with universal design evaluation criteria and be implemented by direct 3D printing, in order to demonstrate the advantages of generative art and design for real scale design problems [4], [7].

2. Applications of Rtttl framework with Shaanxi art and crafts

There are many outstanding cultural heritages and talented handicraftsmen/women in Shaanxi, a northwestern province in China. There is a natural link between cultural heritage and any new form of art and design technique. Generative Art and Design involves computational transformations of original design elements into their variations and complex combinations. Such a technique needs a strong connection with traditional art works and handicrafts in order to achieve the qualities that have demonstrated the powers of human brains and hands over a long history [2]. Lacking of cultural and historic significance in any computational art and design approach would only generate designs and art works that create only problems instead of solutions for our planet.

The examples we used to test the **Rtttl** model are the brilliant works done by the masters from Shaanxi, a northwest province of China [6]. They include ***wood works***, ***face painting***, ***clay sculpture, paper cuts, patchworks,*** *and* ***shadow puppets***. They form a great series of original and cultural genes for generative art and design, with which we are developing generative design inference engines. These generative design inference engines can translate, transform and transcend the design thinking behind the tangible objects into higher level of creative works, to be supported by the emerging 3D printing techniques for revolutionizing the process of design and making of the future. Figure 2 is an example of translating and transforming an ancient horse bowl into a table lamp. Figure 3 is an example involving a combination of generative act (translation, transform, and transcending) that requires collaboration and integration; Figure 4 is a 3D printable outcome of our **Rtttl** model in which more cultural characters are introduced into generative design process.

Figure 2: Translate and Transform an ancient horse bowl to a table lamp

Figure 3: Translating, transforming and transcending the original design genes into products that require collaboration within the generative design and making framework

Figure 4: Many variations of designs can be generated and 3D printed with generative design framework combining cultural elements and design genes.

3. Generative Music with Qin Opera

There have been many works on generative music [5] in generative art conferences over the years. Previously we have also used generative techniques to develop interactive dance music [9]. The above discussed framework of **RtttI** can also be applied to music. In our research, we used Qin opera as the example in our exploration.

Qin opera has some 2000 years of origination, development, and evolution. With its current form, it can be regarded as a Chinese opera with a large audience and funs only second to Peking Opera. There are many famous branches of Qin Opera. Li Shufang represents one of the best such branches (known as Xiao branch), as a leading Qin opera soprano in Xian, who has won a national award named the Plum Performance Award for Chinese Operas. In 2014, she established the Research Centre on Qin Opera Branches with the support of Professor Zhong Ming Shan of Xian Jiaotong University. The performance she gives in Rome as part of Generative Art Conference 2014 is the first of its kind on world stage. This is closely related to our research on generative music with Qin opera [6].

Qin opera music is ideal for testing our generative design framework for creative culture industries in western China. The typical characters of Qin Opera good for generative music can be highlighted as follows:

1. There are two main themes (bitter or sad theme and happy theme) which can be used as the control of emotion in generative music;
2. Many pieces of Qin Opera music have been generalized, and can be used in combination with contextual variations;
3. Such pieces have the computational conveniences. That is, they are

repetitively (with slight variations), and recursively combined;

4. The composition methods for Qin opera music can be generalized as rules that are highly associated with the stories of the opera;
5. The singers can make random or regular changes without dramatically getting away from the melodies. That is, it is always possible to leave small rooms for the singers to improvise or for the computers to change;

Figure 5: A performance of generative music with Qin opera music theme in the School of Design of the Hong Kong Polytechnic University, in May. 2014

Because of these characters, plus others features in the vocal and performance areas, there have been many different branches of Qin opera in Shaanxi, Gansu and Shanxi province where Qin opera has been popular for over 1000 years with tens of millions of funs in the vast countries.

In our exploration of generative music with Qin opera, a combination of Chinese Violin and western Violin is used, particularly intended for the live performance at the 2014 generative art conference in Rome. Such a combination is also intended to show how these two music instruments from different cultures can work together to perform and explore generative music derived from the music themes of Qin opera.

At Generative Art 2014, we came as a big group from Shaanxi province in order to introduce Qin Opera and our initial exploration of generative music with Qin opera with both Chinese and western violins.

Figure 6: Yaozhou Ceramic works have great potential for generative design and 3D printing which is our next project of this research team.

4. Conclusions

We have presented a generative framework for the development of creative cultural industries for western China with initial examples in product design developed with this framework. We have also discussed our exploration of the same framework with Qin opera. Our main conclusion is that with the emergence of 3D printing techniques, it is possible now to scale up generative art and design to embrace a new design and making process in which generative art and design is to take a leading role. In the meantime, it is possible to employ generative art approach to revive culture based designs which are traditionally only possible with hand making. Automatic generation of products using techniques such as generative art and design needs a balance and a bench mark with the sophistication and quality level that have been proved over several thousand years' history of Chinese culture. It is an opportunity as well as a challenge to further develop the framework proposed in this paper. Our future and immediate work is to develop more products with 2D inspirations but with 3D outcomes such as the one shown in Figure 6, with fully 3D printable outcomes of generative variations and innovations.

5. Acknowledgements

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Nikolaus Bezruczko

Paper: Stochastic Generative Image Model Contributes to MRI Artistic Judgment Aptitude Validation

Topic: Generative image algorithms and psychometric validation

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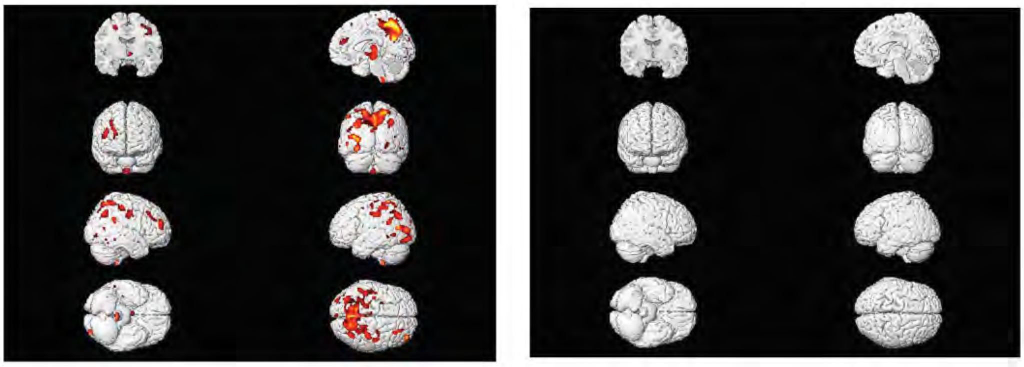
www.generativeart.com

Abstract: This research describes instrumental role of artificially generated images during artistic judgment aptitude construct validation, then corroborates results with structural MRI brain scanning when hypothesis is an aptitude. MRI scanning shows artistic judgment aptitude is mediated by several aesthetic neuron networks with suggestion of asymmetrical lateralization to right hemisphere.
Prominent questions addressed by this research are, first, do MRI brain scans support validity of generative images for artistic judgment aptitude testing? Secondly, how does MRI validation significantly differ from traditional test validation? Do generative algorithms and MRI affect construct validity? Finally, how might future research clarify other contributions of generative art to psychometric validation?
Mathematics and visual arts have a long history. Mathematical proportions were instrumental to art and sculpture of ancient Egypt and Greece, and a reoccurring ratio is Divine Proportion, Golden Mean, and Golden Ratio. By the Renaissance, painters were using mathematical techniques to achieve visual perspective, and then 19th century fragmentation of physical reality by thermodynamics and quantum theory provoked 20th century stochastic reactions in visual art. Tristan Tzara and Jean Arp were early promoters of "chance" in what was then called Dada Art, which was followed by drip paintings by Jackson Pollack and checkered paintings by Ellworth Kelly. John Cage advanced stochastic procedures in the 1970s and 1980s.
Generative image algorithms conveniently manipulate objective properties such as complexity, redundancy, and spatial organization, which has implications for perception of order, coherence, and meaningfulness and are sometimes referred to as syntax or design. Their manipulation fundamentally influences image preference. In addition, generative algorithms can produce images with affective properties that do not require explicit narrative or thematic context. Serenity, agitation, confusion, harmony, and anticipation are affective properties that have been expressed by generative image algorithms. Consequently, generative algorithms are very useful for experimental investigations where control over image properties are important.
Not only can generative algorithms specify exact syntactical and affective properties but they can be replicated without duplicating specific images. By imposing a stochastic procedure on the image algorithm, multiple images can be generated that display intended structure while allowing overall images to vary randomly. Therefore, unique images with identical structural properties can be presented without creating boredom, fatigue, or contamination among viewers. These properties improve artistic judgment construct validation.



sMRI brain scans showing grey matter density correlations with standardized artistic judgment aptitude scores based on preferences for stochastic images

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Keywords: Generative image algorithm, Artistic judgment aptitude, Structural MRI, Rasch measurement model

Stochastic Generative Image Model Contributes to sMRI Artistic Judgment Aptitude Validation

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Premise

This research describes instrumental role of artificially generated images during artistic judgment aptitude construct validation, then corroborates results with structural MRI brain scanning when hypothesis is an aptitude. MRI scanning shows artistic judgment aptitude is mediated by several aesthetic neuron networks with suggestion of asymmetrical lateralization to right hemisphere. Prominent questions addressed by this research are, first, do MRI brain scans support validity of stochastic generative images for artistic judgment aptitude testing? Secondly, how does generative art facilitate and enhance traditional cognitive test validation? Do generative algorithms and MRI affect construct validity? Finally, how might future research clarify other contributions of generative art to psychometric validation?

1. Introduction

Generative image algorithms have been developed for cognitive test models to assess verbal and spatial abilities in education and psychology [1, 2], but applications in aesthetics and visual arts, in general, are rare. Consequently, present research is first application of a generative algorithm to images presented during standardized artistic judgment (AJ) aptitude testing. This report describes contribution of generative art (GA) to AJ aptitude test development evaluated with structural magnetic resonance imaging (sMRI) technology. In this research, an AJ aptitude test model was first validated with conventional correlational procedures then investigated with sMRI brain scans.

Generative algorithms in psychometrics conveniently manipulate image properties such as complexity, redundancy, and spatial organization, which has implications for perception of order, coherence, and meaningfulness. These properties are sometimes referred to as syntax or formal design, and their manipulation fundamentally influences image preference. Generative algorithms can also produce images with affective properties independent of artistic style, image narrative, or thematic context. For example, serenity, agitation, confusion, harmony, and anticipation are affective properties that have been expressed by generative algorithms. Consequently, generative algorithms are very useful for experimental investigations that explore mental and personality development where control over image properties is important.

Not only can generative algorithms specify syntactical and affective properties in images, but specific properties can be replicated exactly without duplicating overall images. By imposing a stochastic procedure on the image algorithm, every generated iteration of an algorithmic specification can display intended formal structure while allowing overall image to vary randomly. Therefore, unique images with identical structural properties can be presented without creating boredom, fatigue, or concern that prior exposure will contaminate subsequent viewer responses.

Generative image algorithms do not affect traditional psychometric validation procedures, which require correlation between hypothetical construct and empirical criterion. In fact, generative algorithms improve construct development because specific image properties can be isolated and correlated with a criterion, which clarifies functional relations between properties and measurement target. Doing so, generative algorithms address a long standing problem in conventional test validation where aptitude constructs are commonly conflated with concurrent abilities and confounded with personality and socio-economic background. In other words, generative images provide more convincing evidence of validity than traditional correlation methods.

Purpose of this report is to describe neurological validation of a cognitive AJ test model that implements a generative algorithm to produce visual test images. Based on speculative aesthetic theory and empirical AJ studies, artificially generated images were first validated with professional artists using conventional correlational methods, then visual preferences and sMRI brain scans were collected from a layperson sample. Structural MRI results were correlated with AJ aptitude scores with intentions of identifying neuron sites that corroborate construct validity. For example, a sMRI scanning hypothesis was AJ aptitude is a measurable construct related to certain prominent neurological sites, as well as dedicated, neuro-aesthetic networks. In other words, high aptitude persons should show neurological structure that not only differs from those lower on the aptitude construct but is consistent with published studies of aesthetic appreciation.

Results in this research show AJ aptitude is mediated by a distributed neuron processing network and modest support for asymmetrical right hemispheric lateralization for at least certain aspects of AJ aptitude. In general, implementation of a generative art algorithm substantially improved AJ aptitude test validity by showing respective brain structures corresponding to independent test factors.

Prominent questions addressed by this research are, first, do sMRI brain scans support validity of generative images for AJ aptitude testing? Secondly, does sMRI validation, in fact, present implications for construct validity that significantly differ from traditional methods? A related question is, do generative algorithms and sMRI affect construct validity? Finally, how might generative art improve construct validation in future?

Sections below provide philosophical orientation to generative art, aptitudes, and mental measurement, which is followed by background for presented empirical research. Then structural sMRI results are presented of an AJ aptitude test sample. Validity implications of these results are interpreted for AJ aptitude testing.

1.1 Philosophical orientation

1.11 Generative art

From a broad metaphysical perspective, generative art is an insight into naturally occurring growth mechanisms found throughout nature. It is a cosmological principle that is not yet understood but is widely recognized. Dorin [3] below alludes to profound implications of generative mechanisms.

> Generative processes have been long evident in art, far predating current era of the digital computer. From Paleolithic ornamental art and hydraulically activated automata of ancient Alexandria (Hero 1st C. CE), Islamic art circa the ninth century, through to medieval and Renaissance clockwork figures . . . . all of these [have] generative processes. [3, p. 240])

Naturally occurring generative mechanisms are independent of particular artistic styles or movements and are, arguably, “universal” [4]. Philosophical foundations for these mechanisms are “Pythagorean concepts of unity and harmony based on numerical principles” [5]. They are fundamental to phylogenetic forces producing natural variation.

Mathematics and visual arts have long, extended relations, which promote contemporary statistical ideas about generative art. Pythagoreans, for example, predate Western philosophy, and their evaluation of proportions was instrumental to art and sculpture of ancient Egypt and Greece. Proportion in art has reappeared historically in Divine Proportion, Golden Mean, and Golden Ratio. By the Renaissance, painters were using mathematical techniques to achieve visual perspective, and a harmony between arts and mathematics continued through the Enlightenment. Nineteenth century cosmological confusion precipitated by thermodynamics and quantum theory provoked stochastic reactions in 20th century art (Arps, 1917, *Collage with Squares Arranged according to the Laws of Chance*). Modern philosophers began to speculate on a scientific metaphysics defined by chance and probabilistic order [6].

Stochastic ideas echoed through 20th century as contemporary artists absorbed underlying cosmological principles of chance and order. For example, Tzara and Arp were early promoters of Dada Art, which popularized chance in visual art. Kandinsky and Malevich would show its influence in their paintings. Mondrian and the school of neoplasticism were based on principles of chance and order. Drip paintings by Jackson Pollack and checkered paintings by Ellsworth Kelly both integrated stochastic methods in 1950s, while John Cage advanced autonomous stochastic procedures in visual arts in 1970s and 1980s.

The generative computational algorithm described in this report reproduces a mechanism of chance, order, and harmony commonly found in both nature and visual arts but with an adaptation that distinguishes between visual preferences of artists and nonartists. Order and complexity have been explicitly manipulated to separate visual preferences into aptitude-based differences predictive of artistic sensitivity.

1.12 Aptitudes

Aptitude conceptions were already contentious issues among philosophers in ancient Athens over 2,500 years ago. Aristotle presented a classical perspective in *Nicomachean Ethics* where aptitudes are natural capacities [7]. Like Plato, Aristotle equated political and philosophical abilities with natural endowments. In Plato's Republic, aptitude determines assignment to education and confers special social status. These rigid, exclusive ideas about aptitude changed during the Enlightenment when Kant [8] rejected fixed human abilities and asserted foundations for a priori mental structures now expressed in terms of "emergence", that is, knowledge that accumulates on basis of incremental experiences. Contemporary aptitude thinking leans toward epistemological conceptions that inherently depend on interactions between mental preconceptions (genetic aptitude) and learning, which establish knowledge. These ideas are foundations for developmental theory, yet archaic conceptions of aptitude as fixed mental traits remain dominant in lay discussions.

By the 20th century, classical rhetorical perspectives were replaced by ontological assertions that aptitudes are nonphysical, nonmaterial "entities" yet can be inferred by observations and are consistent with numerical representation. In context of Galton's broad eugenics movement [9], 20th century aptitudes became a psychometric invention thoroughly grounded in standardized testing movement of that time. Moreover, aptitude testing became instrumental to prediction of future student performance and integrated into public policy and college admission practices. Not surprisingly, college admissions board and scholastic aptitude tests were established in 1930s.

In contemporary discourse, aptitude has acquired objective statistical status and has gained prominence predicting human performance based on aggregated group parameters, while pseudo-scientific nomenclature has increasingly made aptitude conceptions less transparent. Aptitude has progressed from Platonic and Aristotelian rhetorical conceptions to contemporary developmental theory, which is filled with new terms such as latent structures, genetic variance, genetic factors, and genetic "influences" [10], as well as heritability estimates [11]. Aptitude is also generally subsumed under genetics of cognitive ability and behavior genetics. Aptitude in contemporary technical nomenclature is an obscure term to laypersons though typically associated with talent and ability. Not surprisingly, this shift to objective formulation is accompanied by growing politicization. By mid-20th century, aptitude was perceived as a source of socio-political control [12].

This shift from an Aristotelian rhetorical approach to contemporary statistical construct with predictive applications, however, is now recognized to come at substantial cost to human development. Traditional aptitude models have encouraged public policies that systematically exclude cultural minorities and disadvantaged youngsters from high quality educational resources, which, in turn, has institutionalized low school performance [17], as well as fostered an appraisal environment that discourages self-motivation and achievement [18, 19]. Issues surrounding debates between nativism and empiricism such as "emergence vs representation" models of encoding neurons,

relevance of latent structures and influence of social environment on human development are central to contemporary understanding of aptitudes.
As a biological concept, genetic traits govern broad areas of human development. Genetic determination of physical traits such as hair and eye color are commonly accepted, while many behavioral and psychological traits are also associated with genetic origins. For example, twin studies of behavioral traits and disorders such as aggression, schizophrenia, alcoholism, depression, and obesity now show significant portions of statistical variance associated with genetics [13].

Mental aptitudes such as music, language, mathematics ability, language, and visual arts also have genetic components. Substantial research has been conducted into genetics underlying music aptitude [14, 15]. Heritability estimates for creative arts-related aptitudes, which includes visual arts, have been estimated to range between .40 and .71, which suggest around 50 percent or so of observed variability can be safely attributed to heredity [11]. Not surprisingly, other research also points to central role of genetic aptitude in visual arts talent development [16]. Yet predictive accuracy is now understood to be precarious because aptitude expression is keenly dependent on genetic switches linked to both biological and social-cultural conditions.

2. Background

2.1 Generative image algorithms

Generative art in psychometrics has 19th century origins. A visual preference survey was first conducted by Fechner [20] when he manipulated proportions of an original painting to resolve an authenticity dispute. At that time, he pointed to central role of complexity or *variety* on visual arts preference and implied coherence or "unity" fundamental to understanding aesthetic preference. Fechner described procedures for measuring complexity of polygons but did not produce images.

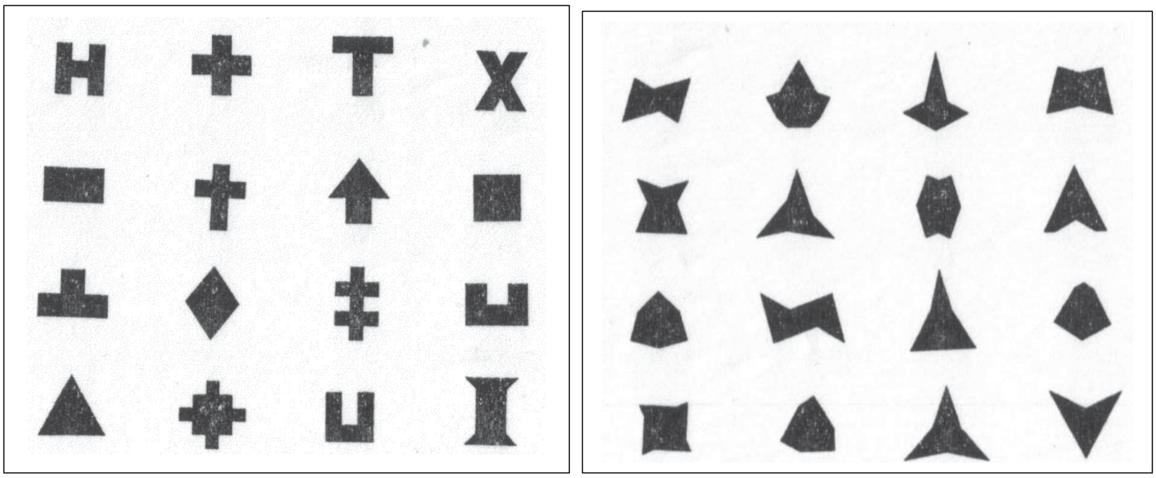


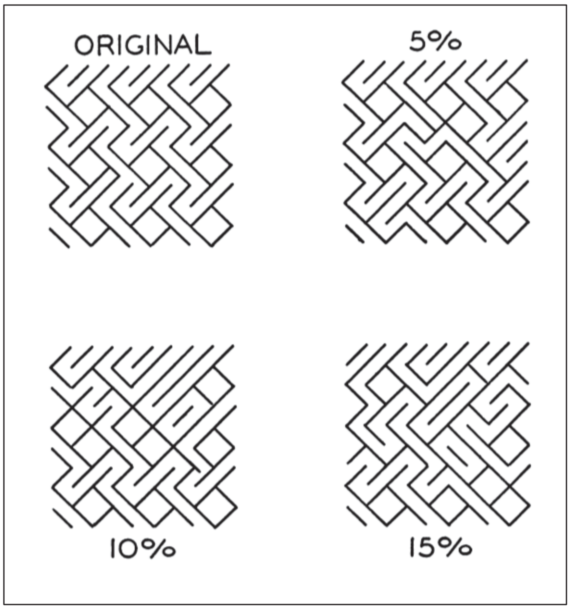
Figure 1. Birkhoff samples contrasting items with highest positive and highest negative factor loadings, from Eysenck [24].

Synthetic images representing explicit manipulation of complexity and order first appear in Birkhoff [21]. He proposed the following mathematical model and produced 90 polygons based on it.

$$M = O/C \tag{1}$$

Where M is an artistic measure that is a function of order and complexity. In other words, artistic value of any pattern is always greatest when order (O) is maximized relative to complexity (C). At any level of complexity, an increase in order always increases overall aesthetic value of a design.

Eysenck followed Birkhoff's lead and collected ratings for polygons from artists and nonartists, which he factor analyzed [22-25]. Figure 1 presents examples of Birkoff's polygons. Eysenck found those on left with highest positive factor loadings, while polygons on right with highest negative loadings. He combined them to obtain a "supra" factor with relatively high psychometric reliability, .89, which suggests visual preferences are quite stable, an extraordinary finding at that time. Eysenck empirically identified two visual preference factors, "T" and "K", and he considered T especially important because artists and nonartists agreed on it. A general preference factor, while K was a bipolar factor separating artists and nonartists. In general, he found



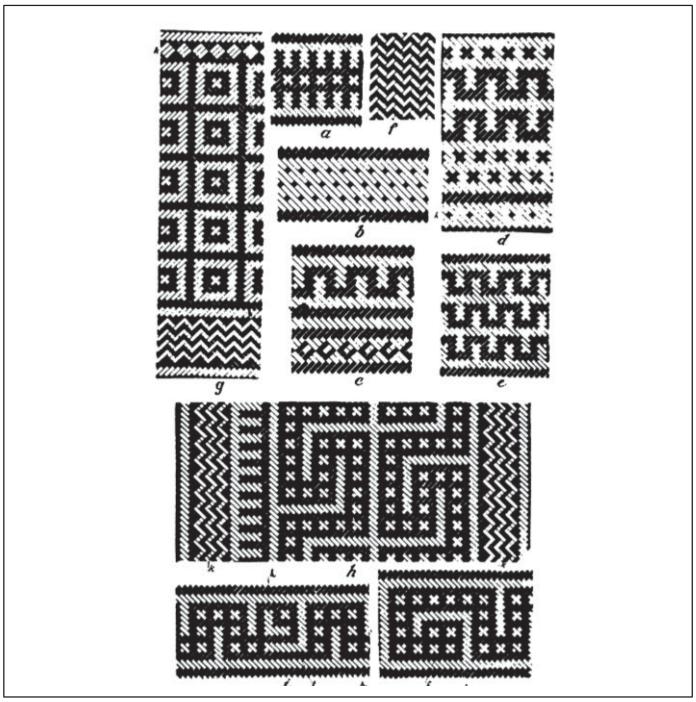


Figure 2. Attneave [30] discovers function of redundancy in visual images. His manipulation of redundancy on left demonstrates explicit visual effects. Image on right shows practical applications of redundancy in native basket weaving.

responses to polygons manifested a curvilinear relation between preference and complexity, which distinguished between nonartists and artists. Artists reach their peak for random complexity significantly sooner than nonartists. This important finding has led to enormous confusion because many replication studies failed to include both artists and nonartists, which lead to inconsistent and unusual results about preference for complexity. Eysenck's T later became basis for Visual Aesthetic Sensitivity Test (VAST) [26], which also became controversial because psychometric reliability was never adequate for valid use.

Eysenck successfully demonstrated visual preferences are consistent and a likely source of individual differences, which he speculated might be associated with personality [27]. However, his success was largely limited to preferences for polygons. Later, Attneave also conducted preference studies but in a format that we now call pixels [28]. Attneave [28-30] applied principles of information theory developed in acoustics to vision perception and discovered statistical parameters associated with preferences for statistical images that systematically differ in complexity and redundancy (order). Figure 2 presents several manipulations of redundancy and compares them with native basket weaving.

Attneave demonstrated effects of redundancy when manipulated as a fixed parameter. In contrast, Noll [32-34] advanced generative art by developing algorithms with fixed parameters which also included a stochastic component executed by computer. He essentially extended potential range of images and effectively introduced unique methods to produce images that simulated authentic visual art. Figure 3 presents computer rendered samples and a copy of Mondrian's *Composition with Lines*, 1917.

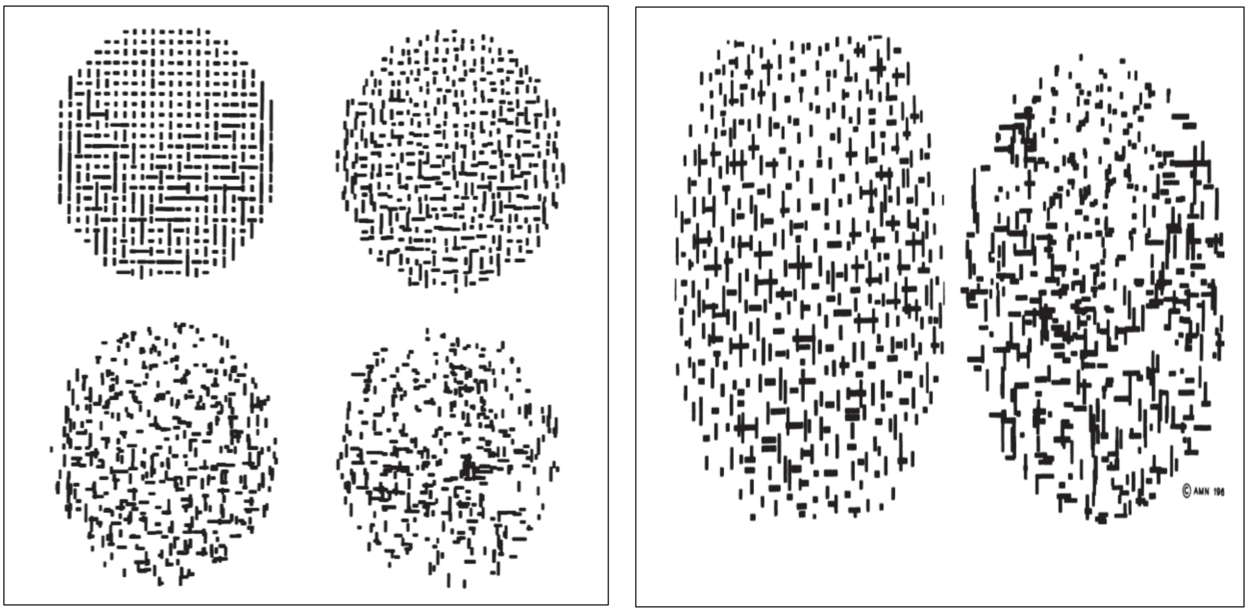


Figure 3. Images on left represent redundancy variations produced by computer [32]. Images on right compare Mondrian's Composition with Lines, 1917 and a computer reproduction.

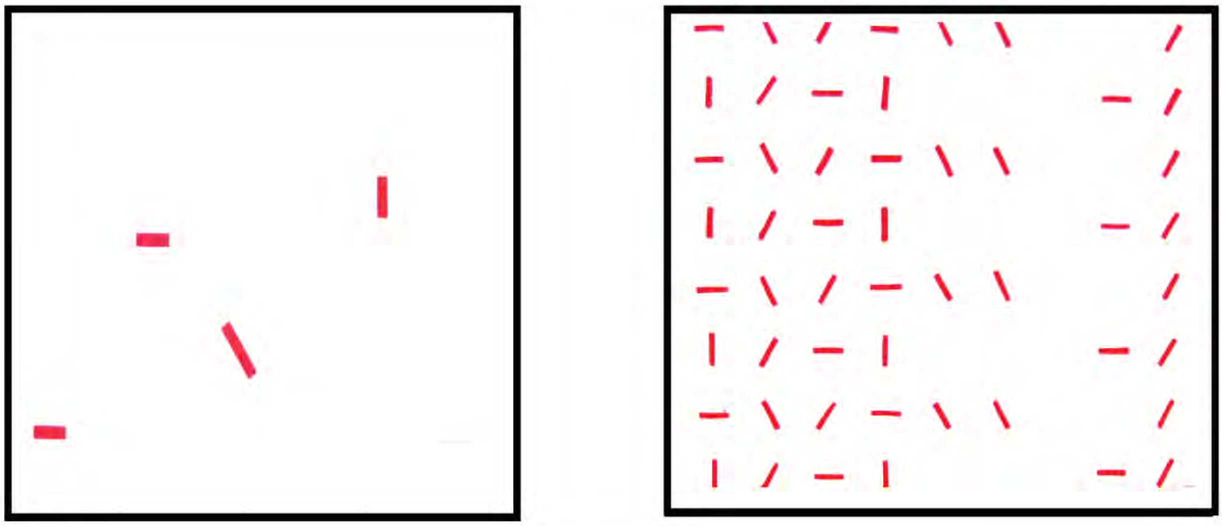


Figure 4. Generative image algorithm applied to aptitude measurement.

2.2 Generative art applied to AJ aptitude testing

Developments above describe key insights into stability of human visual preference, influence of image properties on visual preference, and image manipulation by computer algorithms. However, with exception of Eysenck, these advances did not address individual differences. A dedicated generative algorithm to produce images for identifying AJ aptitude differences first appears at the Johnson O'Connor Research Foundation (JOCRF) in Chicago in late 20th century when an effort was initiated to improve AJ aptitude testing.

Substantial advances described above made this goal reasonable and practical. Building on foundations of generative art and visual preference studies, a stochastic algorithm was developed to manipulate complexity and redundancy in random patterns, and factor analytic investigations confirmed Complexity and Redundancy factors. Extensive validation studies were conducted with adults and school children, as well as professional artists. Those studies found broad support for measuring AJ aptitude with calibrated test images. Figure 4 presents sample images from a generative algorithm based on Eysenck's K or complexity factor that distinguishes between artists and nonartists.

3. Generative art and test validity

Mental test development is dependent on items that solicit responses and empirical validation to establish meaningfulness of score distributions. Both requirements present special challenges to visual arts testing. Authentic, historical artworks are well-known and typically rich in thematic content, figurative details, and artistic style. Not surprisingly, these characteristics may interact with viewer background such as arts training and interest when images are presented for preference judgment. Consequently, AJ aptitude studies based on authentic artworks typically represent a confounding of genetic endowment, social-cultural background, and arts training. Despite protracted commercial and educational efforts through 20th century, failure to address these problems led to virtual abandonment of AJ aptitude testing. An exception is VAST, a standardized aesthetic sensitivity test originally developed by Eysenck based on his T factor. Unfortunately, field testing largely rejected VAST because of low score reliability and inadequate validation [34, 35]. Validation was based on a sample of only eight professional artists, while other research indicates confounding relations with personality, intelligence, and creativity [36].

In addition to complications presented by authentic art works, artist validation samples are also problematic because of vulnerability to selection bias especially in restricted small artist samples. See Osborne, [37] for discussion of artist validation problems.

GA addresses these problems in two ways. First, generative algorithms provide control over image production, which increases objectivity of aptitude testing. Images can be developed with specific properties such as hypothetical genetic components that can be separated from experience-based learning components during statistical analyses. Those image aspects believed to elicit genetic-linked responses can be isolated, while all other image properties are randomized hence eliminated from comparisons. Instead of idiosyncratic, subjective reactions to complex, multidimensional images, generative algorithms parse an image into those components directly relevant to cognitive or psychological performance being tested.

Secondly, generative algorithms provide an additional advantage by modeling AJ preference in a sequential process during overall image appraisal, which provides a theoretical context for collecting preference judgments and evaluating their validity. A related benefit is examination of separate factors during preference, which contributes to understanding perceptual mechanisms guiding preference judgments. Moreover, GA manipulation of separate factors facilitates evaluating their cumulative effect on preference, as well as interaction with other characteristics. Likewise, temporal effects of their presentation order become more apparent.

3.1 sMRI validation in psychometrics

In general, structural sMRI reveals neuron tissue associated with some aspect of person or environmental variation. Consequently, MRI technology offers a method of examining specific cognitive or affective structure and functions purported being assessed by a psychometric instrument, which is construct validity. For example, MRI has been applied to psychometric music and language aptitude models [38, 39]. Other examples are creative writing, which was divided into a generative and evaluative procedures and functional MRI mapping demonstrated separate activation pathways [40]. MRI has been useful for verifying cognitive change [41]. In present research, AJ aptitude scores were compared with brain tissue density and inferred brain function.

In this research, validity of GA images for measuring AJ aptitude was established first by conventional methods, that is, image properties were statistically correlated with preferences of a large sample of professional artists, which established a scoring protocol. When these images were presented to a sample of laypersons, structural MRI brain scans were collected and neurological gray matter density correlated with their AJ aptitude test scores. In other words, generative images helped to define a preference gradient or continuum, which was reconciled with visual preferences of professional artists. Then brain scans were collected of laypersons to verify neurological implications of validated aptitude scores.

A central issue in sMRI aptitude validation concerns hemispheric concentration of gray matter brain tissue. Traditional neurological views are visual arts aptitude should be lateralized to right hemisphere because of dependence on spatial abilities, mental imagery, and creativity [42], which contrasts with left lateralization of cognitive abilities such as math aptitude (addition and subtraction, left anterior portion of arcuate fasciculus [43], reading ability [44], cognitive abilities in general [45, 46], language (leftward lateralization of the inferior frontal gyrus in second language learners) [47], and music aptitude [48].

However, traditional ideas about hemispheric lateralization have been substantially weakened by growing sophistication of sMRI studies [49, 50], which emphasize more complicated neuro processing of creative arts distributed across both hemispheres depending on task. For example, Aziz-Zadeh et al. [51] found left lateralization even for canonical right hemisphere tasks, while drawing lateralization was not correlated with 22 variables in a study by McManus and Chamberlain [52]. Mihov et al. [53] did not find hemispheric differences in a study of creativity, while Bolwerk, et al. [54] did not report lateralization for visual arts. Moreover, direct sMRI evidence for hemispheric specialization during representative *drawing* is limited. Makuuchi, Kaminaga, and Sugishita [55] found drawing in nonartists characterized by bilateral parietal lobe activation, while Chamberlain et al. [49] presented mixed results in a drawing study. Following statement by Chatterjee and Vartanian [56] presents several contemporary issues concerning visual arts and hemispheric lateralization.

> The popular notion that the right hemisphere is the artistic hemisphere is likely wrong. According to this view, damage to the right hemisphere should profoundly affect artistic production and left hemisphere damage should largely spare such abilities. . . If anything, damage to the left hemisphere induced more extensive alterations in artistic production, including in the symbolism depicted, than did damage to the right hemisphere. [56]

Another issue in sMRI aptitude validation concerns whether aptitude brain structure conforms to published neuroaesthetic networks. Brown et al. [57], for example, conducted a comprehensive investigation of published neuro-networks and rejected claims they represent subsystems exclusively dedicated to neuroaesthetic processing. In contrast, Vartanian and Skov [58] concentrated on a narrower subset and identified a neuro-aesthetic network they believe more clearly defines a coherent neuoaesthetic system. The prominent issue here is whether aptitude-related neuron structure uniquely associated with professional artists replicates established neural-aesthetic networks. If aptitude results are mainly incoherent or inconsistent, then an aptitude validity argument is substantially weakened.

3.2 Hypotheses

An assertion in this research is GA methods for producing visual images can manipulate features that systematically elicit preferences associated with AJ aptitude. Moreover, this manipulation can target both physical and emotional properties independently of all other image features.

Given this context, goals of this research were to demonstrate convergence of preference for synthetic images with published arts-related neuro-processing centers. Then a related goal was to clarify whether neuron structure provides any support for asymmetrical lateralization traditionally associated with arts and creativity processing in right hemisphere.

Consequently, this research will test following hypotheses.

> Hypothesis 1: AJ aptitude is a physical entity. Therefore, sMRI brain scanning will identify significant gray matter density associated with AJ aptitude scores, as well as asymmetric lateralization to right hemisphere, the traditional center for aesthetic activities.
>
> Hypothesis 2: sMRI will demonstrate consistency between AJ aptitude structure and published visual arts processing networks, in particular, a neuro network established by Vartanian and Skov [58].

4. Method

4.1 Sample

Volunteers from Johnson O'Connor Research Foundation (JOCRF) in New York were invited to participate in an aptitude study, while sMRI scanning was conducted at Mt. Sinai Medical Center. All who volunteered were screened for medical and psychiatric illnesses including a history of head injury and substance abuse. The final 40 subjects completing sMRI included 21 males and 19 females, aged 18-35 years (mean age = 26.6, SD = 4.9).

4.2 Data

sMRI image parameterization was conducted with standard procedures.

4.3 Cognitive test model

Standardized test items (visual images) were constructed with a published statistical algorithm based on a theory-based visual arts test model and validated with

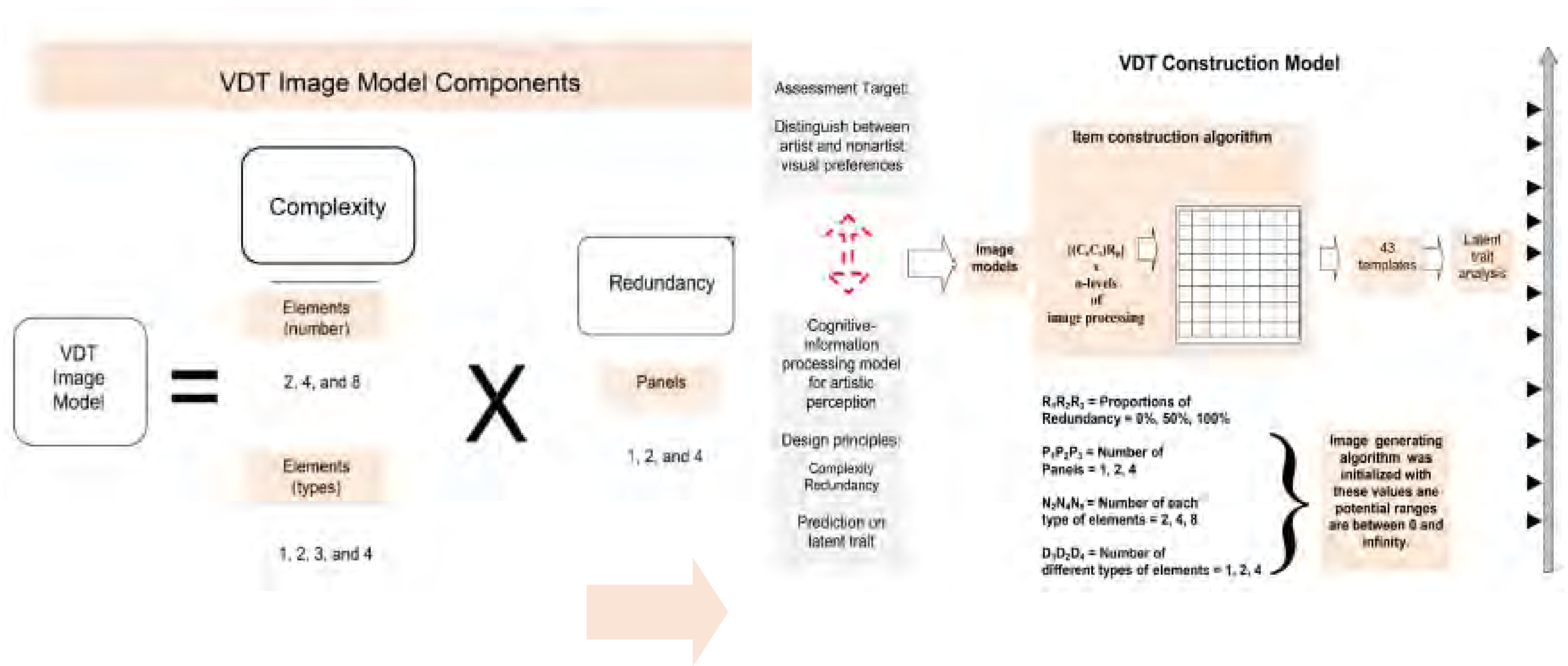


Figure 5. Synthetic image development with a statistical algorithm. Complexity and Redundancy factors were manipulated in random patterns based on a theoretical AJ cognitive-perceptual aptitude model where artists and nonartists significantly differ in visual sensitivity.

professional artists [35]. Item parameters were estimated with a linear probabilistic measurement model [59].

4.4 Psychometric image development

A cognitive model based on Eysenck's K factor, Attneave's stochastic composition process, and classical information theory principles [60, 61] was implemented to manipulate complexity and order (redundancy) in images that distinguish between artists and nonartists (see Figure 5). A factorial design was developed where 3 levels of 3 complexity factors were crossed with 3 levels of a redundancy factor to construct images contrasting higher and lower complexity/redundancy levels. Then 84 image pairs contrasting higher and lower complexity/redundancy combinations were presented to several JOCRF examinee office samples with instructions to select their preference. Their responses were dichotomously scored (0/1) in conformity with Eysenck's research indicating artists prefer less-complex designs. Conventional factor analysis then identified two prominent factors that were called Simplicity (Visual Designs 1) and Uniformity (Visual Designs 2). Original 84 items were reduced to 35 forced-choice items (Simplicity = 22 items and Uniformity = 13 items). Following algorithm represents an image model for simultaneously specifying complexity and redundancy in stochastic images:

$$(C_e C_t)R_p \tag{2}$$

which was implemented across 1-layer of image processing levels, where each level has rank in an overall hierarchy, and: e = n of elements and n takes values 2, 4, and 8 t = types of elements and ranges from 1 to 4 p = n of panels p and n takes values from 1, 2, and 4, which leads to images of 0%, 50%, and 100% redundancy, respectively. Figure 3 presents complexity and redundancy components in a VDT image model.

Figure 6 presents an aptitude processing model that guided this research and distinguishes between artists and non-artists. Several principles underlie this model, namely, recursion, information components, and hierarchical order. VD 1 and VD 2 are processed by syntactic component early in the judgment process. Some authorities have demonstrated instantaneous decisions about artistic quality when images are presented. More complicated images would involve many more components and frequently several iterations through the model before an appraisal is established.

4.5 Analysis

Volumetric gray matter measurement/correlations were computed between scores and white matter density.

4.6 Procedures

Thirty five calibrated image pairs were printed and presented to several hundred examinees in JOCRF testing offices. Standardized protocol was followed and total test scores were entered in computer files.

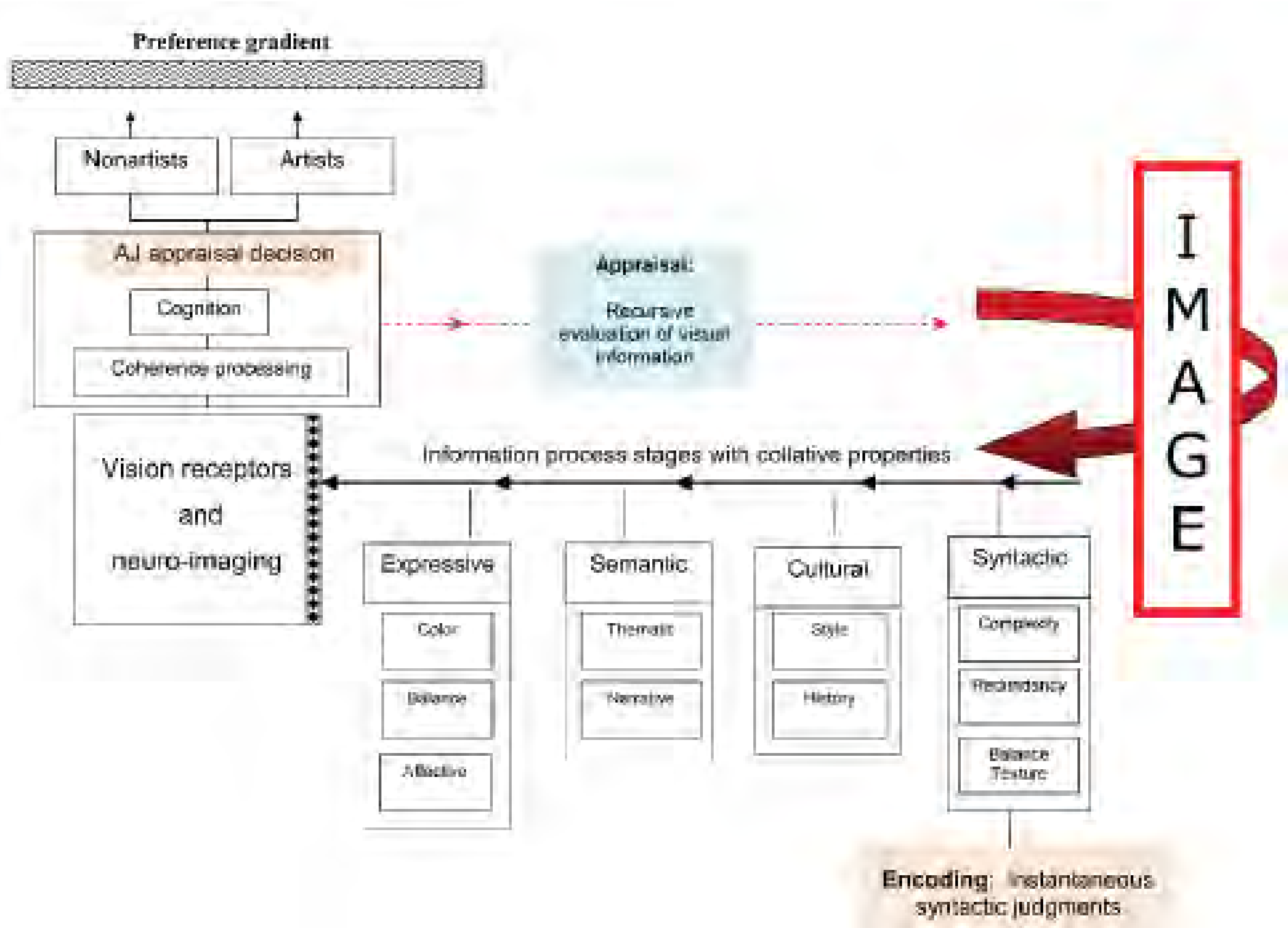
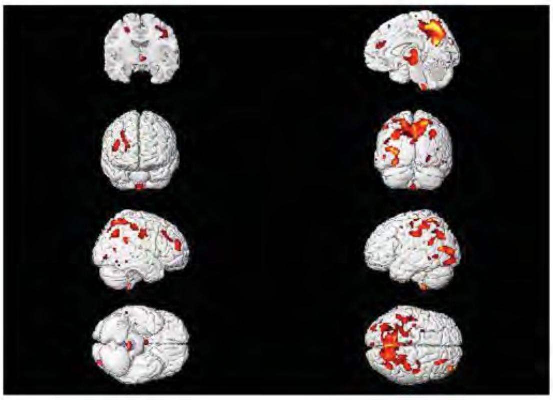


Figure 6. Information processing model of artistic judgment aptitude that distinguishes between artists and nonartists. This model implements multiple information components that are hierarchically organized and visually processed recursively. A viewer may circulate through visual information several cycles before arriving at comprehension and understanding.

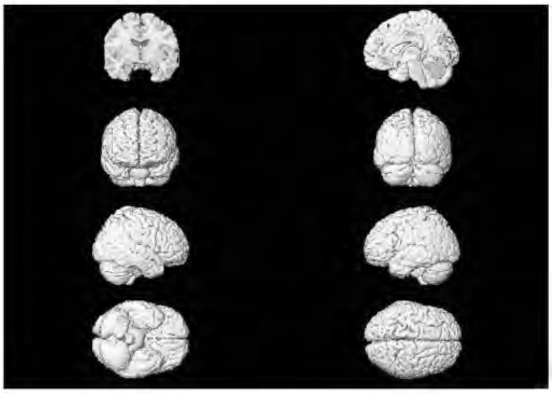
Visual Designs 1

Overall

Positive

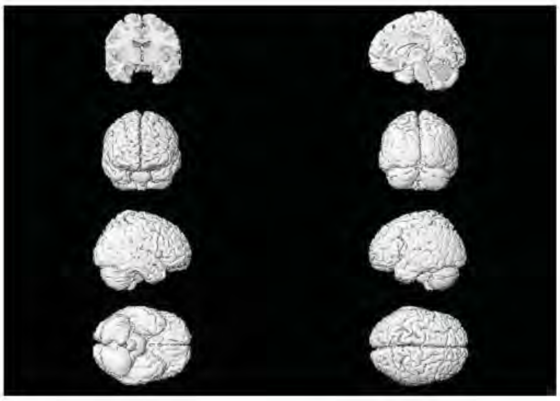


Negative

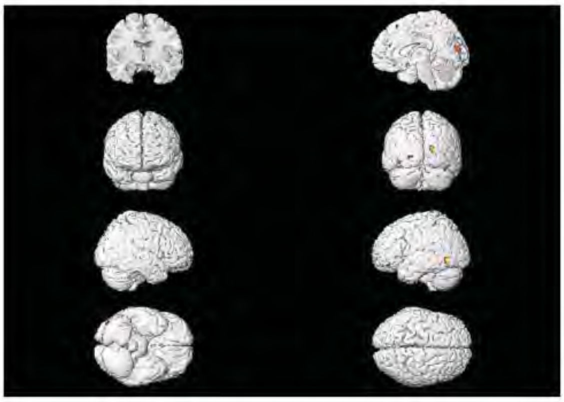


Males

Positive

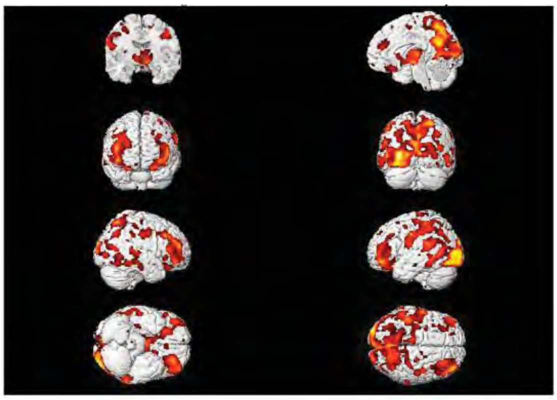


Negative



Females

Positive



Negative

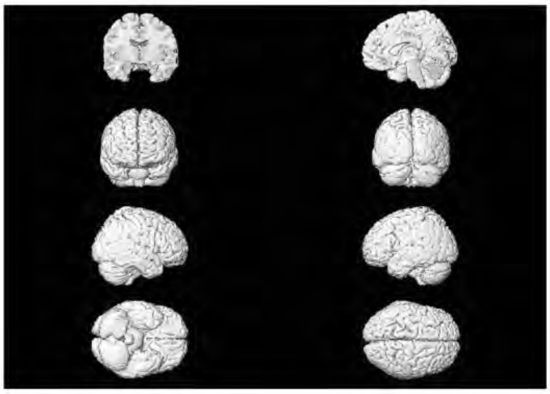


Figure 7. Distribution of increased gray matter density associated with VD 1.

Table 1

Brain regions in which gray matter density significantly correlated with Visual Designs 1 scores in overall sample (p < .01).

			Anatomy(Brodmann)		MNI coordinates			Cluster Size	Z	P_{uncorr}
					x	y	z			
VD 1										
Overall										
positive										
	R	Parietal lobe	Inferior parietal lobule	B 7	34	-58	42	257	3.81	.000
	R	Parietal lobe	Superior parietal lobule	B 7	16	-54	56	5349	3.73	.000
	L	Parietal lobe	Precuneus	B 7	-12	-46	54		3.46	.000
	L	Parietal lobe	Precuneus	B 39	-32	-64	35		3.42	.000
	R	Frontal lobe	Medial frontal gyrus	B 9	22	42	18	330	3.61	.000
	R	Frontal lobe	Middle frontal gyrus	B 8	32	27	37		2.77	.000
	R	Frontal lobe	Superior frontal gyrus	B 10	26	51	7		2.43	.008
	L	Occipital lobe	Middle occipital gyrus	B 19	-32	-83	13	695	3.53	.000
	L	Temporal lobe	Middle temporal gyrus	B 39	-38	-67	16		3.29	.001
	L	Occipital lobe	Inferior occipital gyrus	B 18	-34	-82	-6		3.04	.001
	R	Parietal lobe	Supramarginal gyrus	B 40	48	-41	30	130	3.31	.000
	R	Frontal lobe	Middle frontal gyrus	B 10	44	53	19	184	3.19	.001
	R	Brainstem	Medulla		4	-37	-45	158	3.09	.001
	R	Frontal lobe	Precentral gyrus	B 6	46	-14	34	255	3.06	.001
	R	Frontal lobe	Precentral gyrus	B 6	40	-4	33		2.52	.006
	R	Frontal lobe	Middle frontal gyrus	B 6	36	-4	46		2.44	.007
	R	Occipital lobe	Middle occipital gyrus		30	-76	4	74	2.98	.001
	R	Occipital lobe	Middle occipital gyrus	B 18	26	-82	-3		2.65	.004
	R	Brainstem	Midbrain	RN	2	-20	-7	615	2.96	.002
	R	Sub-lobar	Thalamus		4	-21	1		2.87	.002
	R	Sub-lobar	Thalamus	MDN	4	-19	10		2.69	.004
	L	Occipital lobe	Cuneus	B 19	0	-90	28	48	2.74	.003
	R	Occipital lobe	Middle temporal gyrus	B 19	40	-61	14	33	2.68	.004
	L	Temporal lobe	Middle temporal gyrus	B 37	-51	-58	1	43	2.68	.004
	L	Frontal lobe	Middle frontal gyrus	B 6	-24	2	44	66	2.67	.004
	R	Temporal lobe	Fusiform gyrus	B 37	40	-53	-11	23	2.48	.007
	L	Frontal lobe	Precentral gyrus	B 4	-36	-13	52	41	2.57	.005
	L	Occipital lobe	Lingual gyrus	B 18	-12	-68	2	26	2.60	.005

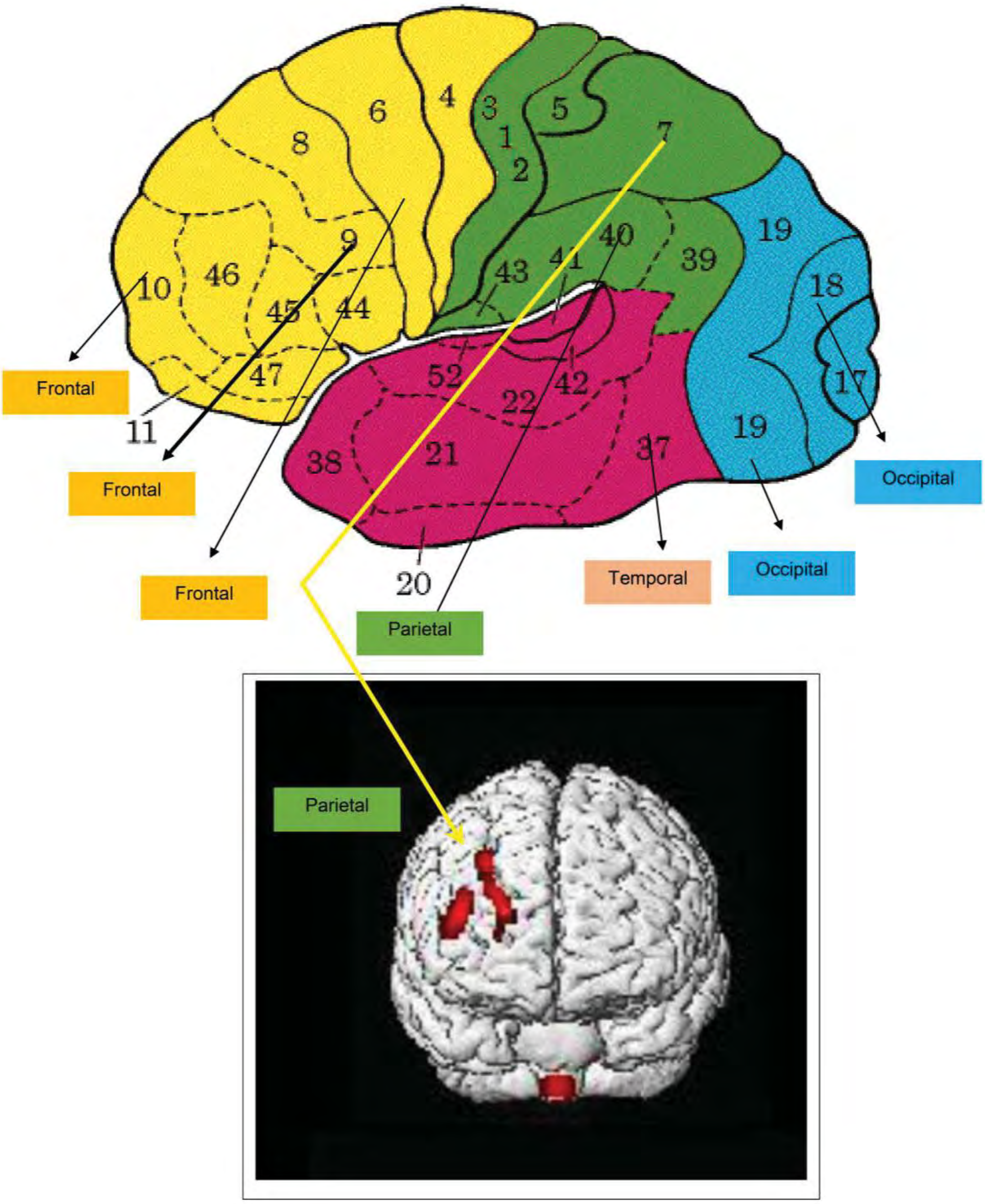


Figure 8. Brain sites show increase of gray matter density structure and asymmetrical lateralization to right hemisphere associated with artistic Judgment aptitude test scores.

4.7 Brain image acquisition and analyses (Structural sMRI acquisition)

A 3T Siemens Allegra sMRI scanner (Siemens Medical Systems, Ehrlangen, Germany) was used at Mt. Sinai Medical Center, NYC. (Scanning details on request.)

4.8 Voxel-based-morphometry and statistical analyses

Voxel-based-morphometry (VBM) was implemented to identify brain areas where gray matter volumes were correlated to AJ scores. Statistical Parametric Mapping software (SPM5; The Wellcome Department of Imaging Neuroscience, University College London) was implemented applying VBM unified segmentation protocol [62, 63].

5. Results

5.1 Overview

Data analyzed for this presentation show AJ aptitude scores were positively correlated with gray matter density in 21 brain regions spanning parietal, occipital, frontal and temporal lobes, as well as regions in the thalamus and brainstem. Figure 7 shows their distribution across brain sites, which indicates increased gray matter density of AJ aptitude is associated with following neurological functions:

- Visual processing (occipital lobe)
- Spatial relationships visual imagery (parietal lobe)
- Emotion (temporal lobe and insula)
- Dopamine (frontal lobe)

In addition, significant gray matter density increases were found in brainstem, both medulla and midbrain.

5.2 Aesthetic networks

Table 1 presents results identifying brain sites with significant correlations between matter density and AJ test scores. Results also show predominant concordance between AJ aptitude scores and specialized networks. For example, AJ aptitude scores were consistent with both passive, art appreciation neuro-networks [57, 58], and an active, representational drawing network [55].

5.3 Asymmetric lateralization

Finally, brain gray matter density showed both bilateral and asymmetrical lateralization with significant accumulation lateralized to right hemisphere. Greatest concentration of gray matter density occurred in superior and inferior parietal lobes of right hemisphere. Lateralization also occurred frontal, occipital, sub-lobar, and brainstem. Figure 8 presents graphic details about parietal lateralization and Table 1 presents coordinates.

6. Discussion

This study examined statistical relations between volumetric gray matter density and AJ aptitude scores based on visual preferences for images generated by a generative image algorithm. Images were presented in pairs that contrasted variations of complexity and redundancy. Prior studies had validated preference scoring with a broad consensus of professional artists. sMRI results showed significant correlations between visual preference, scored in direction of professional artists, and increased gray matter density in 21 brain regions. In general as AJ scores increased from low to high, gray matter density increased in those brain regions. Therefore, persons who tended to express preferences conforming to those of professional artists, tended to show increased gray matter density in corresponding brain sites, namely, frontal, parietal, temporal, and occipital lobes. Consistency between increased AJ density areas and published aesthetic appreciation networks was also evaluated for purposes of test validation, and those results showed general concordance of VD 1 and VD 2 with neuro-aesthetic networks.

As expected, results showed VD 1 (Complexity) and VD 2 (Redundancy) associated with different neuron sites, respectively, and VD 1 was dominant showing substantially more significant brain structure. Of that structure associated with VD 1, approximately 70 percent occurred in parietal and frontal lobes. As predicted, right hemisphere lateralization occurred primarily for VD 1 images.

6.1 GA contributions to test validation

While these results tend to support results from prior conventional validation procedures, GA implementation presented important epistemic benefits during sMRI, which substantially improved validation. Several benefits are described below.

- sMRI demonstrated a cognitive perceptual aptitude test model based on underlying factors is not only largely consistent with published neuroaesthetic studies of visual arts appreciation but also clarified the underlying perceptual mechanism – avoidance of higher complexity random patterns when presented in contrasting pairs.
- GA images provided insight into importance of coherence on arts-related visual preferences.
- sMRI results indicated that GA factors were instrumental to measuring not only visual arts sensitivity but also drawing production – an unexpected performance implication of AJ aptitude measured with VD 1 and VD 2.
- GA established foundations for constructing more complicated visual art and designing more sophisticated preference models.

Psychometric validation is a process of accumulating empirical evidence that supports claims of a test model. Those claims here refer to increased brain structure for high AJ aptitude persons, and consistency with expected neuro-processing. In general, these results show neuroscience analysis of preference for generative images offers insight into brain structure, as well as functions relevant to those claims.

6.2 Implications for cognitive test validation

sMRI brain scans provide physical corroboration for a hypothetical construct, which is more profound than validation with only conventional test score correlations. It offers insight into the cognitive mechanism involved in AJ aptitude expression, and in certain study designs, sMRI of GA preferences could provide values for estimating variance components of genetic and learned abilities. In this research, sMRI results also substantially expanded AJ aptitude interpretation by including drawing performance.

6.3 Future research

An interesting question is association of visual arts learning instead of AJ aptitude with brain structure, which may also show significant neuro structure. Bolwerk [54] in fact described substantial influence of art making on brain structure described below.

> We observed that the visual art production group showed greater spatial improvement in functional connectivity in frontal and parietal cortices . . . than the cognitive art evaluation group. Moreover, the functional connectivity in the visual art production group was related to psychological resilience (i.e., stress resistance) at T1. Our findings are the first to demonstrate the neural effects of visual art production on psychological resilience in adulthood. [54]

Other studies [40, 49] present additional support for neurological structure associated with visual arts-related learning. Consequently, results in this research would benefit from longitudinal study before and after visual arts training to clarify independence of aptitude neurological structure from experience and learning.

These prospective investigations of learning and aptitude, as well as neuroprocessing comparisons between professional artists and nonartists should be examined in the framework of linear measures. Published neuro-aesthetic studies are typically conducted with ordinal measures, which lack precision and objective measuring units for investigating longitudinal change.

6.31 More sophisticated visual images

Generative images examined in this research only manipulated complexity and redundancy at the syntactic level of image processing isolated from other information in an image. The algorithm developed in this research should be elaborated to accommodate more complex arrangements of hierarchical components with narrative, emotional and expressive content. These studies would lead to more sophisticated understanding of AJ aptitude brain structure.

6.4 Limitations

For an aptitude study, this research was limited by its concentration on a single observation of modest sample size. Consequently, variance components were not computed to clarify stability of neuro structures presented here. Another limitation was lack of professional artists in the sample. Some participants may have had some arts background, but without background information, association with neuro structures was not possible to investigate.

7. Conclusion

What are the contributions of GA to psychometric test validity?

- Isolation of relevant components in cognitive test model, which facilitates an understanding of their function during human performance.
- Theoretical cognitive foundations to guide construct development
- Reproducible methodology

How does sMRI improve mental test validation?

- Clarification of components that contribute to human performance
- Corroboration of cognitive test model theory with brain function and structure

Acknowledgements

AJ aptitude was examined in this research with calibrated stochastic visual images developed at Johnson O'Connor Research Foundation (JOCRF) for purpose of vocational guidance and is part of a larger JOCRF neuroscience commitment to aptitude testing advancement [64-67]. Author is grateful to JOCRF for sharing these data. sMRI scanning was conducted at the Mt. Sinai Medical Center, New York City and funded by the non-profit JOCRF. JOCRF did not exercise any institutional approval or supervisory role in preparation of the manuscript or decision to publish. Author thanks Chris Condon and Emily Eaves for invaluable help in data collection. Author appreciates expert contributions from Etienne Manderscheid and David H. Schroeder interpreting sMRI results reported here.

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Space's Interiority by Probabilities Dicing *(Paper)*

Topic: Design

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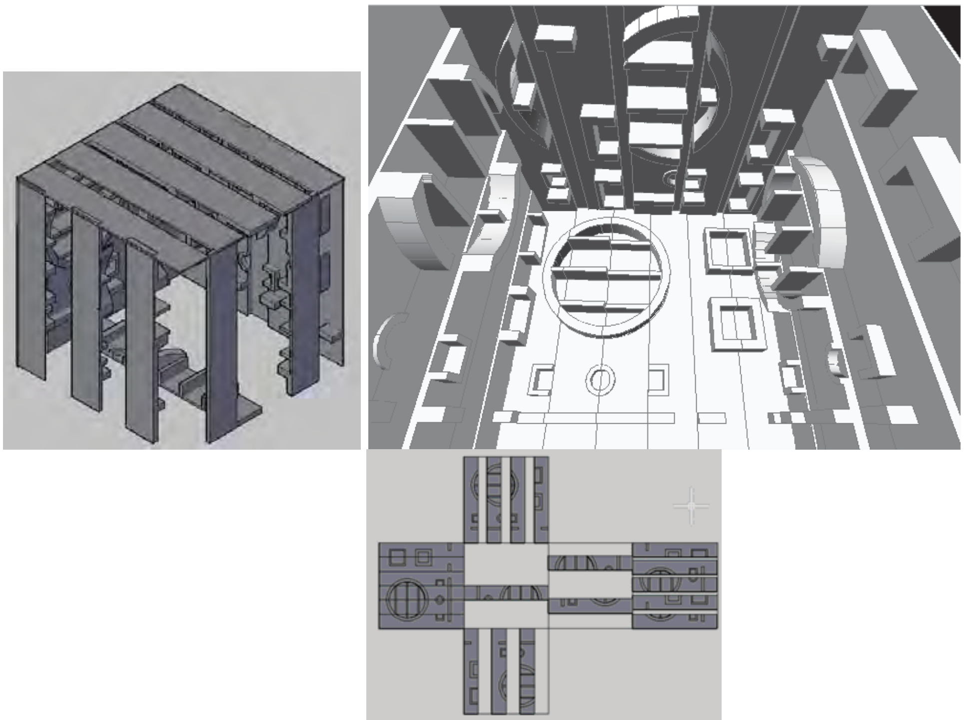
Abstract:
The interior design process is linked to mass and void term, Masses consist of the main elements of interior design, such as walls, ceilings, floors, levels. Interior is the confluence of the components of these elements to generate a coherent interactive interior design. The possibilities of using specific design elements in generating different interior spaces is a creative and tricky method. Interior design projects can be simulated as a possibilities box for generating mass and formations shape inside.
This study related to design retail space that offers small and medium area. Because of the requirements of the current technological era, simplicity is needed to design interior elements, and reflected multiple meanings and functions of the form. Simplicity and complexity are linked with each other and considered to be a measurement tool for aesthetic standards in interior design.
Study adopted to deal with the main interior design principles in the generation of simple primary shape, these primary shapes can be assembled in a manner possibilities in one space. Depending on area, the area is modulated to find the value of the units and scale of space. Shape possibilities for each of the walls and ceilings and floors will be different as result, But identical in terms of primary forms constituents. Virtual design will be studied in this paper for 6m x 6m x 6m. The value of the modular is 1 unit, the process of generating space possibilities to arrange elements of space. As it is similar to the process of throwing the dice, depend on each space module in addition to the principle adoption of repetition and reflection in composition. This study is an analytical and applied study for generating possibilities of space that carry an aesthetic value and convenience for users. Academics will enter through the results models by virtual And record their assessments as a model questionnaire, which designed to adopt the aesthetic values associated with the formation of Shape grammar.



Generating complexity by simplicity

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Keywords:
Interiority, Space, shape relations, shape's linking, probability.

Space's Interiority by Probabilities Dicing

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Abstract

The interior design process linked to mass and void term, Masses consist of the main elements of interior design, such as walls, ceilings, floors, levels. The interior design process is the confluence of the components of these elements to generate a coherent interactive interior design. The possibilities of using specific design elements in generating different interior spaces are a creative and tricky method. Interior design projects can be simulated as a possibility box for generating mass and formations shape inside. This study related to design retail space that offers small and medium area. Because of the requirements of the current technological era, simplicity is needed to design interior elements, and reflected multiple meanings and functions of the form. Achieving simplicity should consider interior design principles as the real generator interior space tools. Depending on the area, the area is modulated to find the value of the units and scale of space. Shape possibilities for each of the walls, ceilings and floors will be different as results, But identical in terms of primary forms constituents. Virtual design will be studied in this paper for 6m x 6m x 6m. The value of the module is 1 unit, the process of generating space possibilities to arrange the elements of space. As it is similar to the process of throwing the dice, depend on each space module in addition to the principle adoption of repetition and reflection in composition. This study is an analytical and applied study for generating possibilities of space that carry an aesthetic value and convenience for users. Academics will enter through the results models by virtual And record their assessments as a model questionnaire, which designed to adopt the aesthetic values associated with the formation of Shape grammar.

1. Introduction

The evolution of the technology of methods and design materials significantly affected the limitation of interior design. Interior design nowadays doesn't depend on the principles of interior design only, but it should use new and strange methods of design to create mass and space to connect with technological development. Retails everywhere, with different types are designed by different designers with different purposes. Some of these designs attracted users by the aesthetic elements, which connected to the users' comfortability value with that design. Strange design leads to the same value of attraction and excitement. Interior design as box are a strange method to design space and masses, actually is a dialectical relation. Who is created the interiority of interior design, space or mass. In this paper, both are used to generate interior design. Some researchers mentioned that the main elements of the interior design process are the structural element (walls, ceilings, and floors) [1][2]. Interior design should connect these elements as a one body to reflect the Affiliation to one place. The relationship among the design of structural elements follow same strategy process, and it could be different, but at least some matching should by using integrated design characteristics[3].

Simplicity and complexity are linked with each other and considered to be a measurement tool for aesthetic standards in interior design. The study adopted to deal with the main interior design principles in the generation of simple primary shape, these primary shapes can be assembled in a manner possibilities in one space. Simplicity doesn't mean poor shape and space without design or designers' purposes. Simplicity could lead to complex design and could affect the psychology and physiology users' needs. The most important value of the design should match these needs. This matching lead to achieve users' second skin, which designer have to reach it by playing on the strategy and methods of interior design role[4]. The study is an attempt to find a suitable method to use the principle of simplicity in the generation of an interior space, to be matched the second skin of the user by simulating the interior space as a cubic. To solve this problem, objective of this study was to find the suitable principles to create interior design by simple way to be aesthetic and exciting design. Reaching this goal will depend on two types of literatures.

2. Literature Review

The interior design process linked between the design strategy and shape expression. The literature review part have two types of studies, each type focuses on specific area. Some of Studies related to interior design principles and creating shape, another studies focuses on psychology and perception term.

2.1 studies related to generating shape:

Different studies discussed the principles of interior design and its affect on the perception and user behaviour. In this part, studies that related to simplicity strategy in creating shapes in interior design will be discussed. Qasim (2005) explained that the objectivity purposes can be reached by basic and simple design principles in order to achieve high quality of the interior design feelings[2]. These basic and simple design principles are:

- Rhythm.
- Balance.
- Proportional relationships.
- Dominion in space by:
  - Differentiation of one formal element.
  - Differentiation in colour or its tones.
  - Unification the perspective direction.
  - Oncoming or estrangement degree from the receiver[2].

Ching and Binggeli (2012) marked that interior designing process follow two main ways. First way, design as one part, every detail will follow the overall design and have a specific position and function in that design. Second way, interior design process could start from detail then links with the element of space to produce overall interior design[1]. Abdulqader and others (2011) explained that any design can analyzes depending on three stages of group(detail, part, overall) (Figure 1)[5].

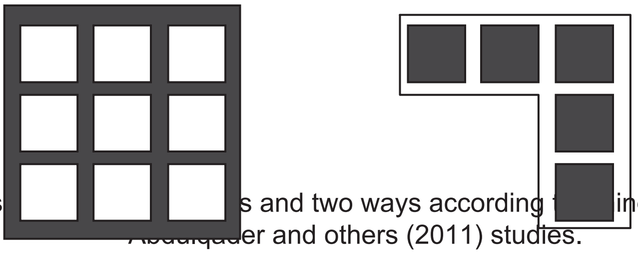


Figure 1. Creating s s and two ways according t ing and Binggeli (2012) and er and others (2011) studies.

Caan (2011) and Feldman (2013) illustrated that interior space have two main groups of element, floor and ceiling as the first group, which may be design as one part or as negative and positive design (Figure 2). Walls and partitions as second group, which nowadays designed by one strategy to reflects that boundary of space and give unlimited area like using mirror in interior space (Figure 3)[3][6].

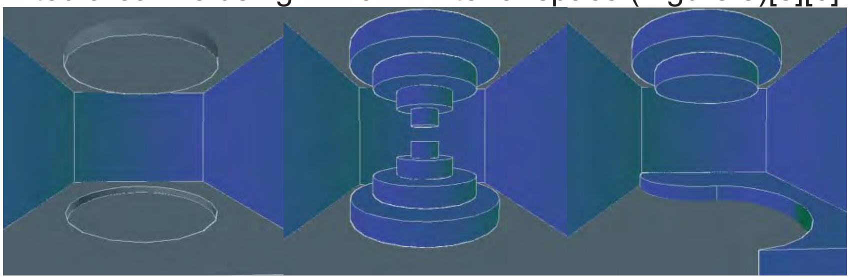


Figure 2. Relationship between element of group 1 (floor, ceiling) according to Caan (2011) and Feldman (2013) explanation. (Reference: researcher)

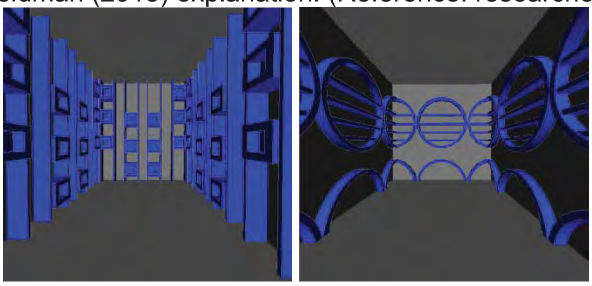


Figure.3 Walls designed as mirror in one group according to Caan (2011) and Feldman (2013) explanation. (Reference: researcher)

Some researchers mentioned that simplicity could be created by using scale and modular principles, to create a unity in design [7]. Designers can create their own scale and modular unit according to the area of design and functional needs. Modular could be used in different levels (area, volume) (figure 4) with different types (with transformation in scale, with transformation in proportion rate, with reflection transformation) [8].

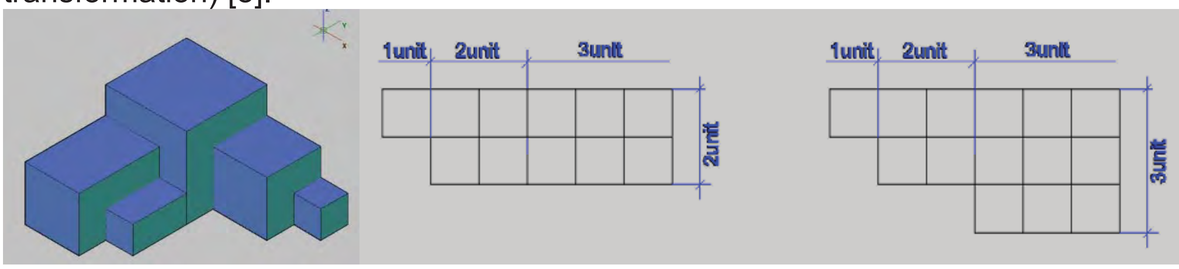


Figure 4. Levels of scale with modular, which can be used in dicing interior design. (Reference: researcher)

2.2 **studies related to perception and psychological needs:**

The studies in this part focusing on the design results and psychological effects on users' behaviour more than the actions. Realizing the creative design value depends on achieving second skin by achieving the physiological and psychological needs. Designers should be depended on the second skin elements in interior design processes, by playing on simplicity concept and its relationships with the user's perception. This strategy linked to generating shape processes which can address the users' minds by effecting on the mental image store [9]. The effective process of perception in interior space is one of designer responsibility, which depends on transferring what in the designer's mind to physical material and shapes. Physical output perceptible sensory by the user, then the perception process starts [10]. Jirjees (2008) explained that the concept of design is the main effective element in the users' perception. Each design or designer have special effects, exciting users in interior design is very important to evaluate the design by touch users' second skin [10]. Cann (2011) mentioned that users could be excited by attract them to evaluate the design, especially when design have the strange idea like using simplicity concept. One colour interior space, using mirrors, similarity between designed elements and negative with positive all these ways could attract users to interior space. Touching users' second skin doesn't mean just in positive feelings, but negative feelings are one of the attracting element [6]. Interior design of retail follows these attraction element for different purposes, it's not just for economical and marketing term, but in the famous cities, interior design have a high level of attracting to make these cities memorized by users in order to be as a measurement tool.

3. Interior Design as a Cube

From the previous studies, variables to design interior space as cube were found. In addition to identifying stages of design the interior space. Dicing interior design generating strategy is a metaphor strategy, which created vary of models for the same space. Playing on the design of structural element and making the interior space able to formation process to fix the suitable design for users. Users will be one of the effective elements in the design process, part of the process. The Interior space have six elements to design it as a cubic volume. As a results of the previous studies findings, simplicity strategy can be used to create interior design for retail space by modelling it with dicing space, which follows the following stages to produce different models for the same space and element of design:

3.1 stage 1:

Selecting the area and volume that the designer wants to reflect his idea by using simplicity term. Actually, in this paper, six faces considered to apply the concept of dicing (4 walls, floor, and ceiling) (figure 5).

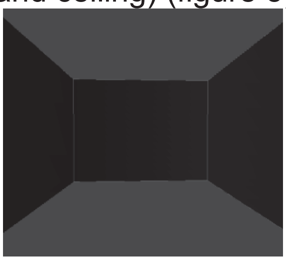


Figure 5. The basic element of space to start the dicing design.

3.2 stage 2:

Finding the value of modular from existing or metaphor element, which designer wants to use it in the design, simply by divided the six faces and find the related units to prepare it to the next stage (figure 6)

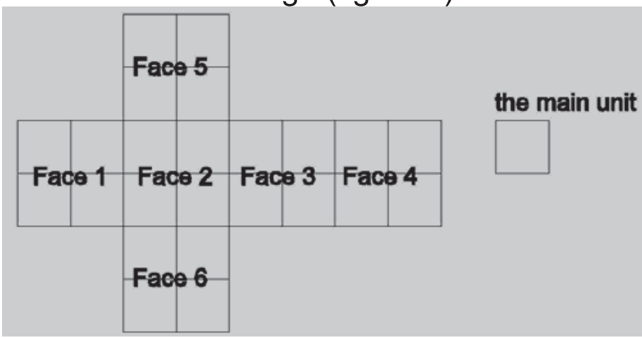


Figure 6. Finding the main unit.

3.2 stage 2:

In this stage designer can reflect his concept to formulate the main unit as a module for all design, this should follow the psychological and physiological needs for users to be acceptable for users' second skin. Designers could select design element to be in two groups (walls, floor with ceiling). There are many suitable designs for retail space to create creative and attraction interior space (figure 7).

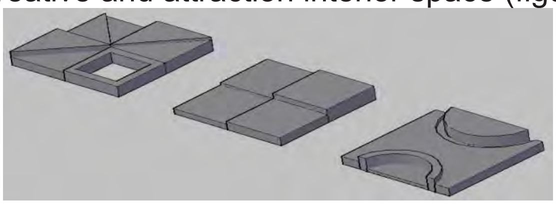


Figure 7. Designs for unit selected from existing retails.

3.3 stage 3:

This stage is to design the faces each one can be designed by same unit but with different principles of design that mentioned in the previous studies. As a result of this stage six faces designed depending on designers and users needs (figure 8).

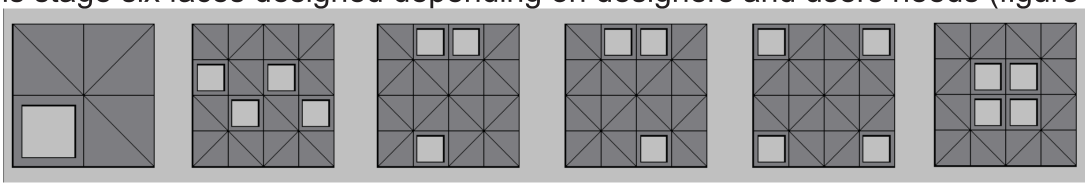
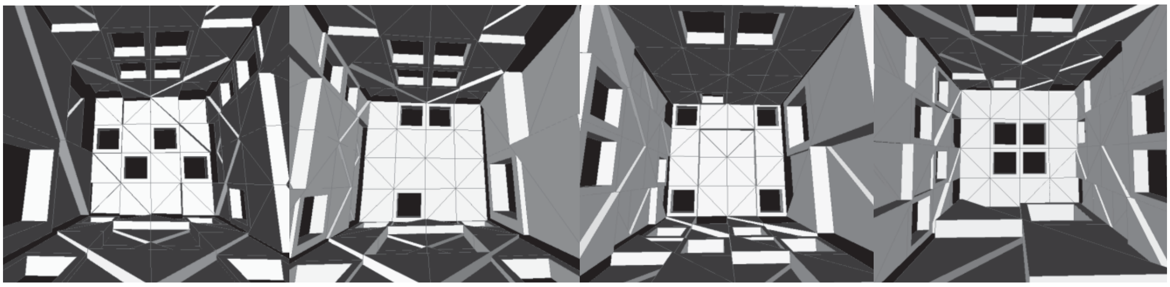


Figure 8. Six faces design depending on the main unit and generated by using reflection, scale, and repetition.

3.4 stage 4:

To reach the overall interior design, designer can select the faces for walls, floor, and ceiling according to the variable's value that mentioned in the literature review. As applied to this study four designs (figure 9) generated to test it by users virtually, to find which models touch users' second skin and attracted users to evaluate the design negatively or positively.



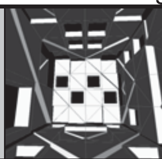
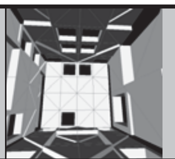
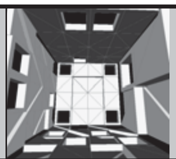
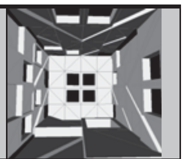
Model1 Model2 Model3 Model4

Figure 9. Four different models designed by the probability of dicing (Reference: researchers)

4. Testing Designed Models

The results of design models for the same space with the same unit of design will faced the real test by the recipients to evaluate the models according to perception and psychology variables, which were mentioned in the literature review part. The test is not to select the best design from the generated models, but to marking the suitable strategy that can be used to create interior design from simple stage. This test made depending on checklist of variable(Table 1) designed as a questioner with interview to evaluate the four models in virtual, after making tour inside the models. Recipient will feel the interiority of design from the first time, all image will be translated from real image to mental image, which is what recipient want to start the evaluation and find the value of aesthetic and exciting.

Table 1. Perception and psychological variables to test generated models.

No.		Give sequnce for models				
Main variable	Exciting	Details				
		Overall				
	Scale	Normal				
		Huge				
		Tight				
	Strangeness	Adaptable				
		Strange				
		Unadaptabl				
	Spiritual	Anti				
		Friendly				
	Function	Suitable				
		Efficient				

The population of study was from different nationality and different ages, it selected randomly from vary places from shopping centre and shopping street in Pulau Penang – Malaysia, which contained many famous malls, famous shopping centers, famous shopping streets.

5.Results and discussion

The results of this paper appeared in two levels, the first level is results from checklist and interview with recipient, which show that exciting variable was 45% for model4 and 20% model3, 15% for model2, and 20% for model1 and that matched with the sub-variable (exciting in details and overall). Normal Scale variable results show 37% for model 1 and 31% for model2, 12% for model 3, 21%for model4. Results for strangeness show 23% for model1, 26% model2, 24%model3, 27% model 4. The results for spiritual feelings were very near for all models, all were between friendly and anti-friendly. 87% from recipient mentioned that the design suitable for different function. The second level of results it related to matching the designed principles with checklist variables, which show that the matching value was 79% for all models. The users attracted to make this test to inter this virtual interior environment and give their opinion in negative or positive way, that mean the strategy of design were successful to exciting the tester to evaluate the interior space, because they feel like part of design process. Even there is some limitation of the study, but dicing design or interior design as cube is a simple design stage to get creative spaces.

6.Conclusion

Interior design as a cube is a theory for simple interior design, which can used to generate creative interior design by simple stages. Interior design in a complex process, which have many effects and factors that should treatment to create efficient space. As the results show, the simple way to achieve the second skin for users is by involving users in the design and used set of principles suitable for dicing interior design. As a checklist results, users gave high value to models that used modular in design by selecting or creating unit of module in addition to use the scale factor in the two directions. The results indicated the changing proportion is not efficient to use it in dicing design. The most important factor is reflection and its type, which have the gained affect on the dicing interior design process to generate interior space as a cube, by selecting which face to which design and finding the probability interior design form this process.

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Orkan Zeynel Güzelci

(Paper): A Shape Grammar Based Expert System to Generate Traditional Turkish House Plan Layouts

Topic: Architecture

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Main References:

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Abstract:

The traditional Turkish Houses have a long history which has gone through many stages of development in Anatolia and Rumeli in the last five centuries. However these houses have certain characteristics in common where the plan layouts are the most important characteristic features [1].

The purpose of this study is to experience the formal and syntactic information underlying the plan layouts of traditional Turkish Houses having a certain design language through an interactive and highly visual expert-system [Figure 1]. In the study, the shape grammar was applied as the method, which is introduced by Stiny and Gips in 1970's [2]. The method enables the analysis of design languages of algorithmic structure and the production of new designs. Hence, the shape grammar can also be defined as a rule set deploying a design language.

By referring to the shape grammar which contains its own rules and design components, an algorithm is developed to produce plan layouts. These plan layouts are used to interpret the algorithm via computer. The input data to the computer is derived from Çağdaş's [3] study named as "A Shape Grammar: The Language of Traditional Turkish Houses".

The present study generates the plan layouts of traditional Turkish Houses in Çağdaş's study. The novelty is the introduction of a 2D analytic plane by means based on an algorithm. The generation process is executed by users due to the interactive structure of the expert system by the help of keyboard. During the generation process performed based on the algorithm, the combination rules of design components and restrictions are taken into consideration and an instruction list is displayed [4].

The study is a trial where the artificial intelligence is dealt with in design training while regarding the use of shape grammar method. The shape grammar interpreter (expert system) in this study helps users to understand the formal compositions and plan layouts of traditional Turkish houses. Whilst, the study is a design tool to record numerous plan layout alternatives.

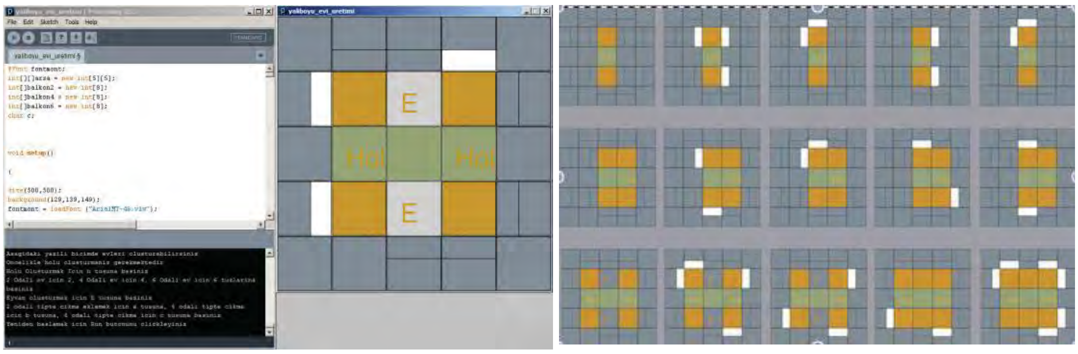

Figure 1. Coding Interface and Generated Plan Layouts

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Keywords:
Shape Grammar, Artificial Intelligence, Design Language, Processing, Traditional Turkish Houses

A Shape Grammar Based Expert System to Generate Traditional Turkish House Plan Layouts

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Abstact

The traditional Turkish Houses have a long history, which has gone through many stages of development in Anatolia and Rumeli in the last five centuries. The purpose of this study is to experience the formal and syntactic information underlying the plan layouts of traditional Turkish Houses having a certain design language through an interactive and highly visual expert system. In the study, the shape grammar was applied as the method. Shape grammar enables the analysis of design languages of algorithmic structure and the production of new designs. By referring to the shape grammar, an algorithm is developed to generate plan layouts. Developed algorithm is interpreted to computer by using "Processing" coding interface. The input data is derived from Cagdas's study named as "A Shape Grammar: The Language of Traditional Turkish Houses". The generation process is executed by users, due to the interactive structure of the expert system by the help of keyboard. The shape grammar interpreter in this study helps users to understand the formal compositions and plan layouts of traditional Turkish houses. System also record numerous plan layout alternatives generated by users.

1. Introduction

1.1 Aim and Methodology

The purpose of this study is to show the formal and syntactic information within the plan layouts of Traditional Turkish Houses. The plan layouts are the most important characteristic features of Traditional Turkish Houses. This certain characteristics can be defined as design language and shown through an interactive and visual expert system. In this study, shape grammar was chosen as a method, which can be used in analyzing design languages and producing new designs.

The syntactic information about Traditional Turkish Houses is obtained from Cagdas's study named as "A Shape Grammar: The Language of Traditional Turkish Houses [1]. The plan layout generation algorithm is interpreted to computer by using Processing interface. Design components, shape rules and restrictions are also defined to computer by coding. The present study generates the plan layouts of traditional Turkish Houses analyzed in Cagdas's study.

1.2 Design Languages and Shape Grammars

People use natural languages to maintain daily relationships. Languages may change or develop but in a long time. Language is an abstract definition to show and explain the reality. On the other hand, artificial languages are special communication tools invented by the people. As an example, music notes are a part of a special language used by musicians. Moreover, Fortran and Pascal are computer based artificial languages [2].

Language consists of arrangements of the words in its own vocabulary. Likewise, design is an organization of design components. New designs are produced with new arrangements of shapes [3].

Many researches emphasize that there is a strong relationship between the structure of language and architectural design. Languages have a grammar that defines the combining rules of words. As mentioned on languages features, a similar approach for combining design shapes is possible.

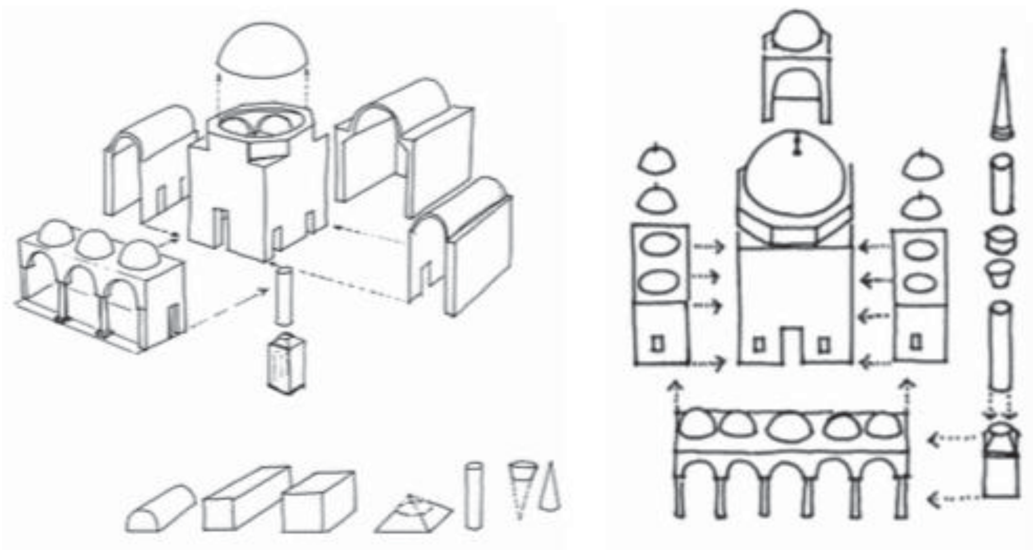

Image 1. Components of Classical Ottoman Mosque [5]

In the 1980's the researchers focused on the architectural designs, which are belonging to an era, an architect or a region. Each of these architectural languages that belong to a certain era or an architect has its own compositional principles. These architectural principles are defined with the set of rules and these made up to the grammar of that language [4].

In architectural design with using a limited number of components, the number of created combinations is numerous. However, it cannot be said all combinations are meaningful. In this point, shape grammar includes the rule set to provide the appropriate relationships between these components.

Shape grammar is a method introduced by Stiny and Gips in 1970s, enabling the analysis of design languages of algorithmic structure and the production of new designs in the same language.

Shape Grammar can be defined as a rule set which is deployed to form a design language. As linguistics does not invent a new language, shape grammar does not invent a new architectural language.

Shape grammar consists of generative rules used to produce shapes. Repeated application of shape rules to an initial shape lead the generation process of new shapes. A sequence of derivation often generates shapes that are unexpected [6].

First studies on shape grammars aim to criticize and analyze design languages with working on shape rules. By analyzing these rules, the original language is realized and new forms produced by using language. Each shape grammar is unique and expected to produce different designs. As, there is not an official language for all societies, there is not a common or finalized form of shape grammar.

Vernacular architecture language is evolved in a long term with additive and repetitive process. The language of vernacular architecture is complex but the whole keep architectural orders and information. This architectural information underlying vernacular architecture language can be defined through an algorithm. It is possible to analyze and decompose the vernacular architecture language. Decomposition is made by exploring the components and the rules of combining rules for these components. The components and the rules formalize the grammar of the language.

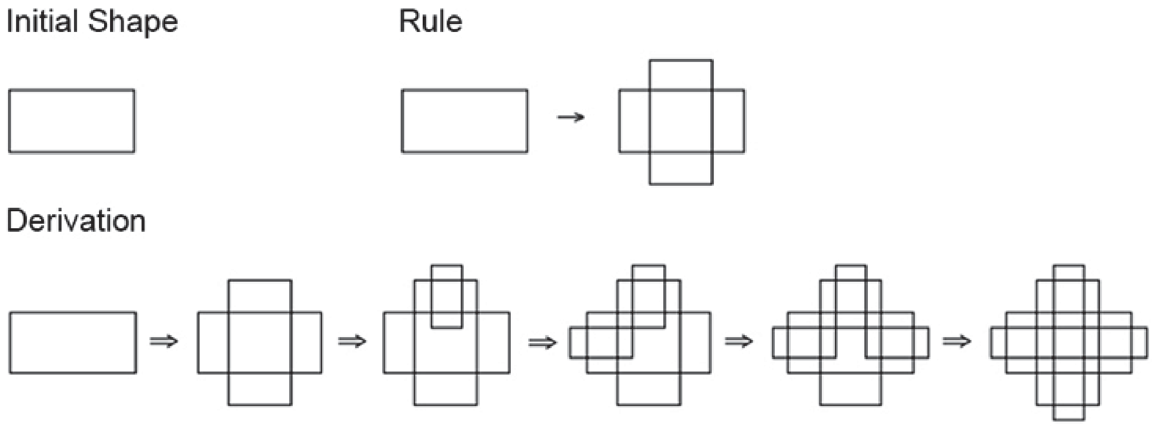

Image 2. Applying the rule on an initial shape [7]

2. Traditional Turkish Houses in the Context of Shape Grammars

2.1 Main Features of Traditional Turkish Houses

The building process of Traditional Turkish Houses started in Anatolia in 15th and 16th centuries. These houses expanded to other regions within the borders of Ottoman Empire. Traditional Turkish Houses have many developments in the architectural context during five centuries [1].

Image 3. Different types of Traditional Turkish Houses [8]

Various types of Traditional Turkish Houses were evolved under different geographic features, climates and traditions. In spite of all this diversity, some features of the Traditional Turkish Houses are remained unchanged in many regions. As Eldem [9] stated, all Traditional Turkish Houses have certain characteristics in common. The plan layouts of the houses are the most important characteristic.

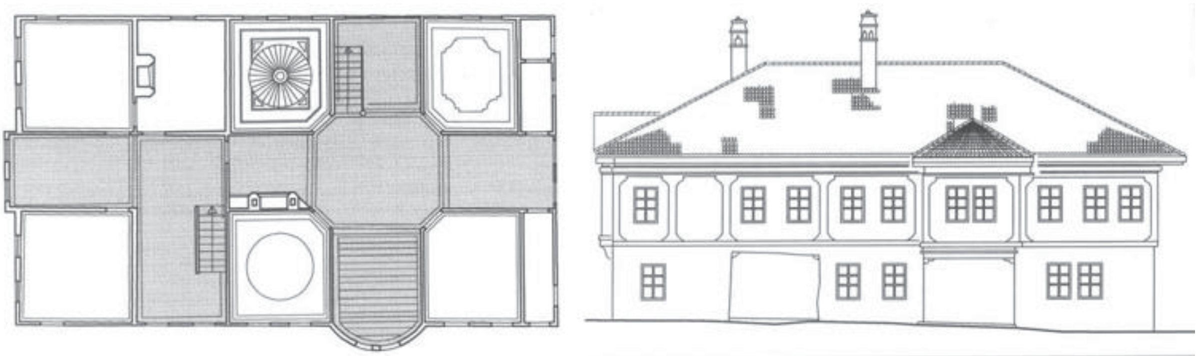

Image 4. Plan layout of main living floor and facade of a Turkish House [10]

The Traditional Turkish Houses usually have one floor. Over time, houses floor quantity has increased. Even the number floor is increased; the main living floor is generally located at the highest level. The plan layouts of main living are presenting the common language that belongs to Traditional Turkish Houses.

The architectural language of Traditional Turkish Houses consists of the organization of rooms, halls, eyvans and bays. The organization of these plan elements is a main issue. For this reason, certain details of house plans are ignored in the scope of this study.

2.2 Elements in the Traditional Turkish Houses Plan Layout

In this section, the elements that composing the Turkish Houses plan layouts are examined. These elements are rooms, halls, eyvans and bays.

Room can be described as the most important plan component. Number and the location of rooms directly affect the plan types. Aligning the rooms in one or more axes creates the hall. The hall is a corridor that connects the rooms. The plan types are named by the relationship of between rooms and hall.

According to the location of halls plan layouts are classified as without a hall, with an outer hall, with an inner hall and with a central hall. Graphical representation of hall types can be seen in Image 5.

Rooms on a single row can divided with a space called eyvan. Eyvan is an additional hall to get sunlight into the hall and to reach the courtyard from hall.

The bays are generally added to enlarge the interior volume of the house. Another purpose to add bays is to get sunlight and gravitate to view. Bays are generally located on the outer border of rooms but in some plan types bays are used as an extension of hall.

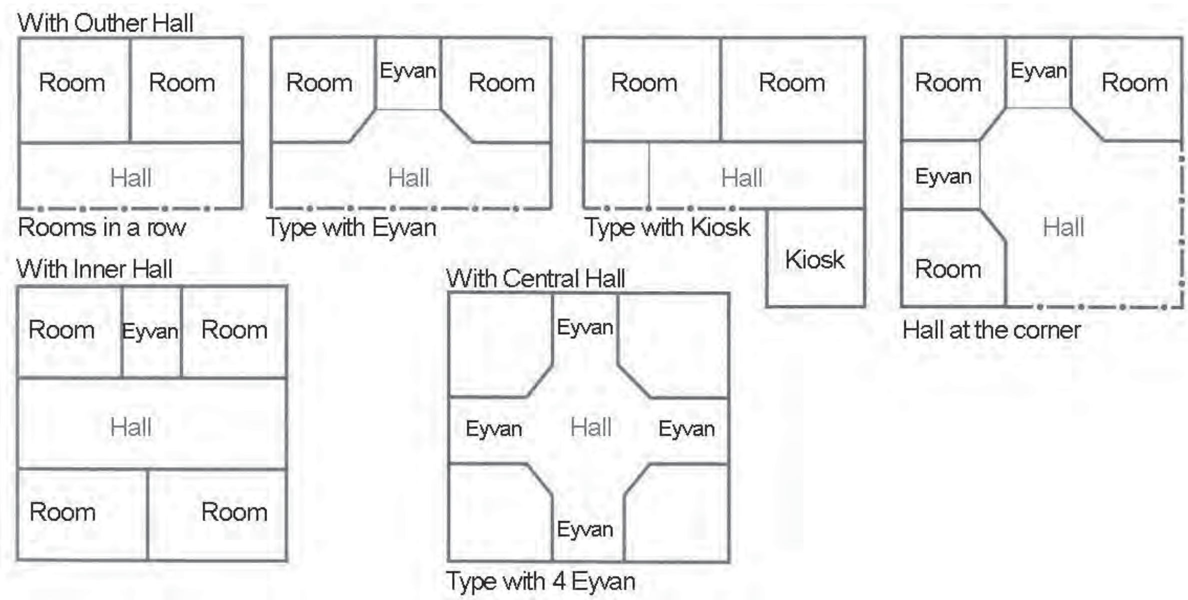

Image 5. Plan types and plan components of Traditional Turkish Houses [8]

2.3 Shape Rules to Generate Traditional Turkish Houses Plan Layouts

A parametric shape grammar to generate the Traditional Turkish House plan layouts is developed by Cagdas [1]. For guiding the generation process of the plan layouts an imaginary grid is used. Straight lines are used to create shapes. Definition of the spatial relations between the plan elements is made through shape rules sets. In the rule set vocabulary elements are represented with polygons. Polygons are placed in a grid to determine the alternative locations of the plan elements.

In Cagdas's work, the main vocabulary elements of Traditional Turkish houses are rooms, halls with their extensions. Two dimensional shape grammars are usable to create plan alternatives. The dimensions of plan elements may vary in different plan layout. To avoid that, blocks size parameters are standardized to make the modifications easily [1]. To create the expert system, the scope is limited only with rule sets belong to the plan types with inner hall. The rules that will be used in program are explained. In the rule set, RI code states the rule set for houses with inner halls. For example, RI31 code means the first shape rule of the third rule set.

In Cagdas study, the rule RI1 replace the initial shape with a hall labeled with letter "H". This rule application creates the core of the plan. This case means that every house should have a hall. RI2 rule set is used to locate rooms around the hall. RI21, RI22 and RI23 rules are used to add rooms. These shape rules are applied to generate plan types with more than one room. During this process the hall length is increased as seen in rules in Image 6. In other words the hall length is equal to the room length in those rules. Rooms are labelled with letter "R". The RI31 and RI32 and RI33 RI34 rules place the eyvan to the corner or between the rooms in a row. RI71, RI72, RI73, RI74, RI75 and RI76 rules add the bay to the outer border of a room [1].

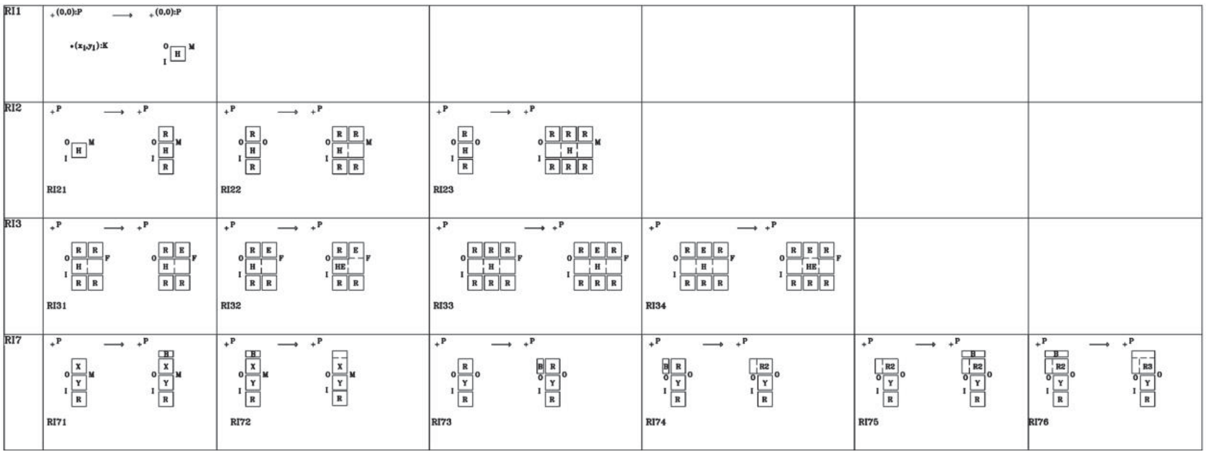

Image 6. Shape rules to generate plan layouts with inner hall [1]

3. Shape Grammar Based Expert System

3.1 Theoretical Background of the Expert System

Shape Grammar Interpreters are expert system that allows users to develop or generate designs. A Shape Grammar interpreter is a computer based system that can make operations. With using these systems development of these design alternatives can easily created in an interactive way [11].

Early shape grammar expert systems were implemented in Prolog by Krishnamurti [12]. Krishnamurti's approach is defending the need of algorithms for performing the shape rules. First visual shape grammar interpreter was done by Tapia [13]. Tapia developed a 2D shape grammar interpreter that is able to work on an entire shape with Euclidian transformations.

Jose Duarte developed a shape grammar for Alvaro Siza's houses at Malagueira. For the generation of houses, shape grammar proceeds recursively by locating rectangles. Duarte used the shape grammar to create an interactive computer system for the design of mass housing. Houses are created and rendered due to user preferences [14]. Such interactive systems enable user participation in design process.

3.2 Developing the Logic of the Expert System

Processing is a very flexible interface to create 2D geometric compositions. First, design components are defined on a 2D analytic plane by using coordinates. Shapes, sizes and the label are also specified. The components that will create the plan layouts are become unique with these specifications. The combination rules of components and restrictions are also defined. Processing interface is used to interpret all information about components.

Generation process of plan layouts is specified with a verbal algorithm and flowchart. Instructions about generation process are displayed to help the user while the code is running. Interface has coding screen, display screen and an interactive screen. Users have the chance to lead the process by the help of keyboard on interactive screen. Keyboard places the components into plan layouts due to the rules and restrictions.

The drawn plan components have different colors and labels. Overlapping between components and transforming components is restricted. The reason of these restrictions is having finite plan schemas by grammar.

To use the generative feature of shape grammar an algorithm schema is developed to perform the generation process. Algorithm schema help users to avoid from making errors and create design step by step.

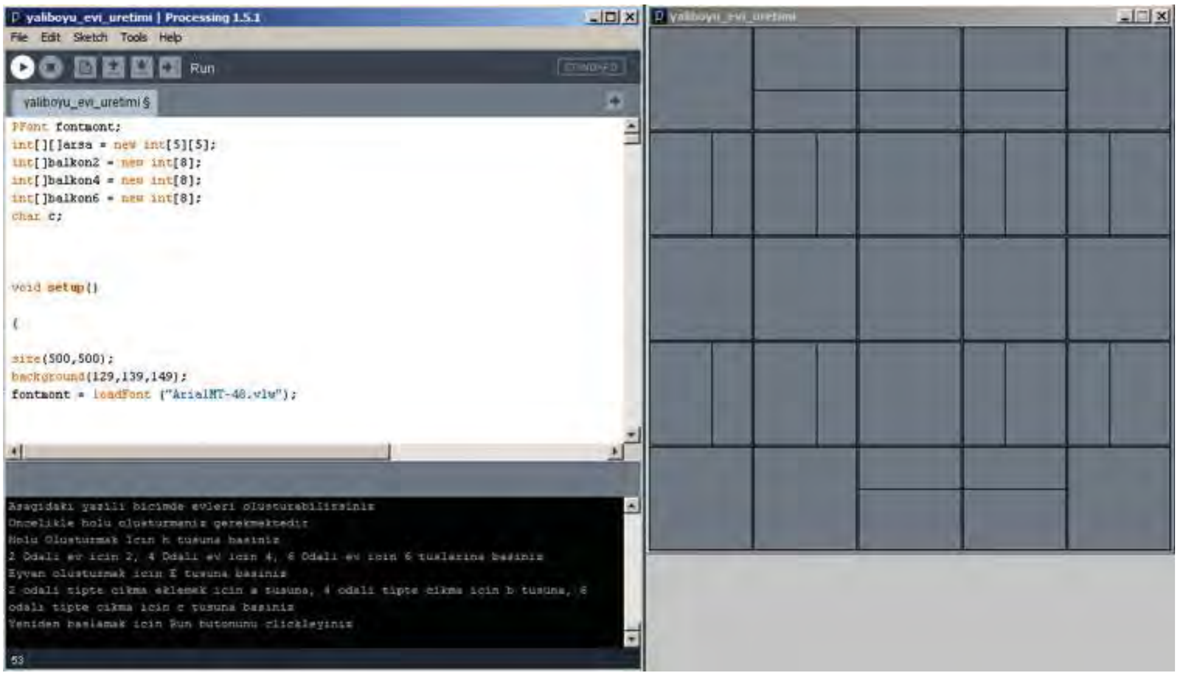

Image 7. Interactive interface of Processing

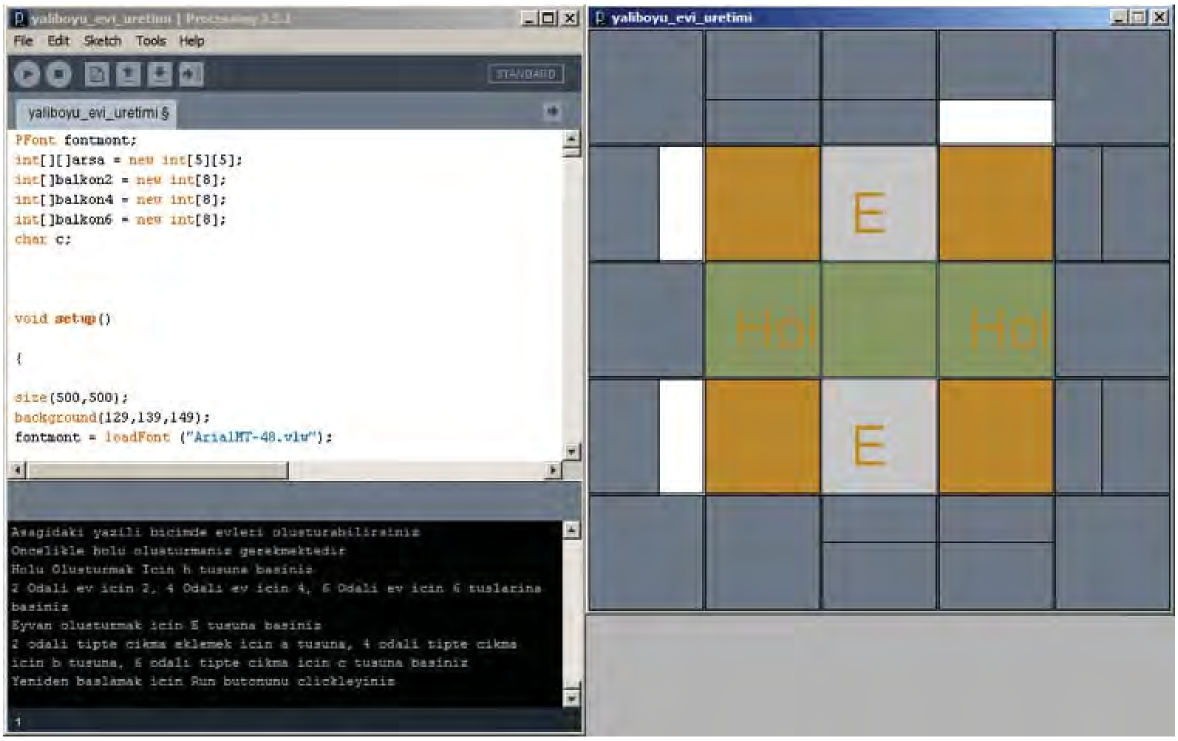

Image 8. Coding screen, display screen and interactive screen

3.3 Algorithm Schema of the Expert System

After mentioning how the Processing code operates, it is essential to give the working process of algorithm schema. The algorithm schema is generating plan layouts based on Cagdas's shape grammar study. Users are managing the generation process of layouts by communicating with code interactively by using keyboard. As shown in Image 9, process begins by drawing the layout, hall, room, eyvan ends with the addition of bays.

Algorithm schema is leading the user to define the size of layout in coding screen. After defining the size of layout the code is run. First, user is expected to create hall, which is the main element of Traditional Turkish House's plan layouts. In the next step, the rooms are located around the hall. The number of the rooms can be 2,4 or 6 based on grammars. Operation of adding rooms is reversible. It means layout with a 4 rooms can transformed into type with 2 rooms by deleting 2 rooms. Another plan element eyvan can be added to plan layouts. Eyvans can only added to plan layouts with 4 or 6 rooms. In other circumstances, the code does not respond to inputs. Before lasting the generation process, user can create bays. The bays are added randomly to plan layout on every pushing to the button. Adding bays is not a necessity.

After completing the code, the expert system based on an algorithm is run and the bugs are fixed. New steps and new components are added based on grammar developed by Cagdas [1].

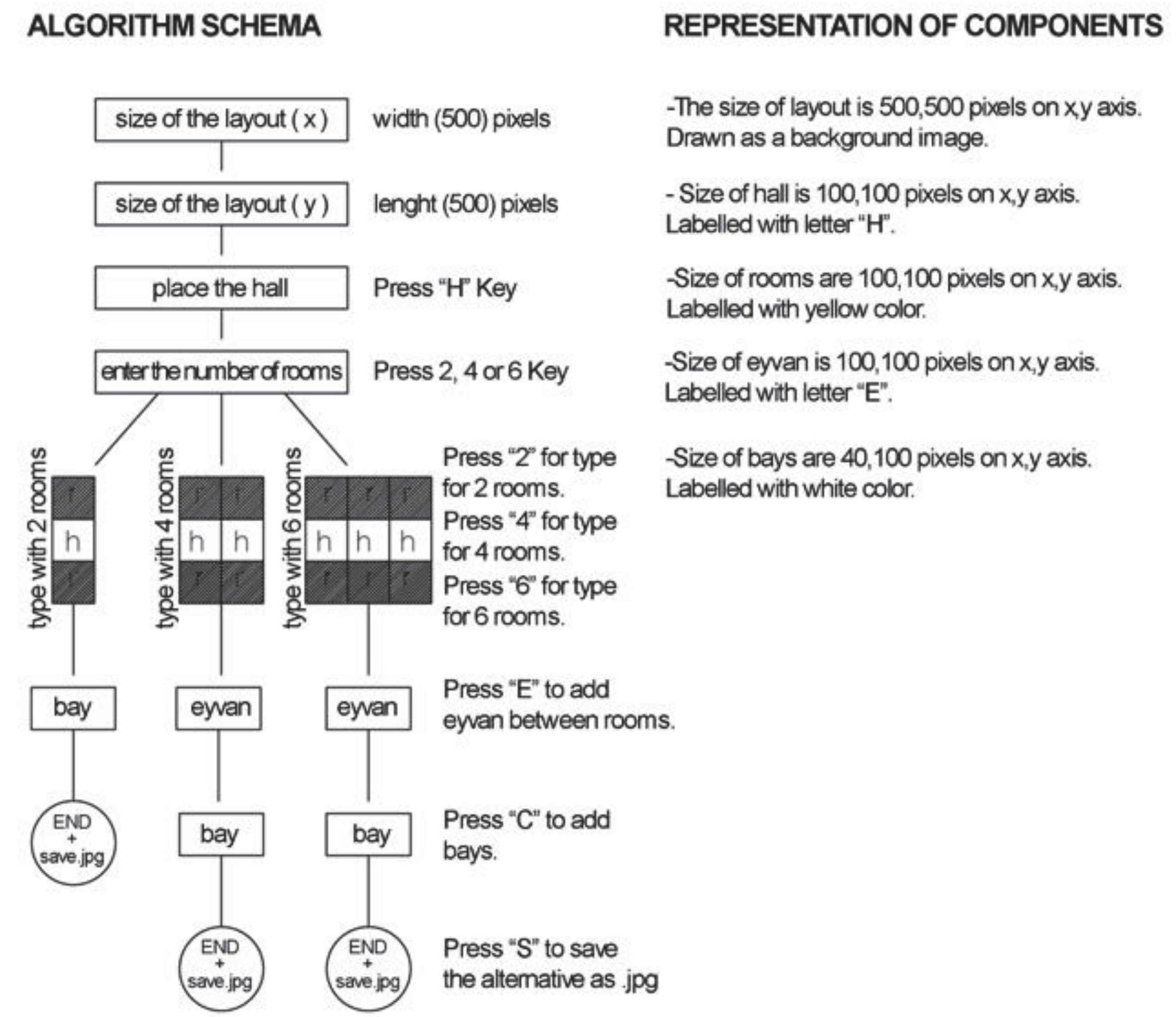

Image 9. Algorithm scheme and representation of design components

3.4 Rules and Restrictions on Creation Process

The system is running on an order, which is defined on algorithm scheme. The generation process is explained step by step below.

The layout (field) is the area where the design alternatives created on. Before running the Processing code the size of the layout has to be defined by the user in coding interface. Processing interface draw the layout once as a background. Changing the size of layout is not possible during the code is running. The user enters the width and length as parameters.

Every created plan layout based on a grammar has to include a hall. The distinction between inner or outer hall is not defined to the system. Expert system is able to produce only plan layouts with an inner hall. After running the code, the system automatically draws the background to place the plan components. Afterwards, system communicates with user from the instruction display screen.

Placing hall is the first step to generate a plan layout. “Push the letter H from keyboard to place the hall.” statement is written on instruction screen. By pushing to “H” button from keyboard, system places a hall at the middle of the layout. The hall size is 100,100 pixels on both axes.

The houses with inner hall may have 2, 4 or 6 rooms. System consults to user to choose one of these alternatives. User press the button “2” from keyboard to create 2 rooms, press “4” to create 4 rooms or press “6” to create 6 rooms. The rooms are located on the both side of hall on y-axes. Having 4 or 6 room create 2 rows this also enlarges the hall, which is a passage between rooms. Example can be seen in Image 10.

Houses with 4 or 6 rooms may have 1 or 2 eyvans. Users press “E” button to place one or two eyvan between rows of rooms. Adding eyvan is transforming rooms into eyvans. With this operation plan layouts with 3 and 5 rooms are created.

Bays can be located on outer edges, which is not neighbor with the hall. To locate bays user press button “A” for types with 2 rooms, press “B” for types with 4 rooms and “C” for types with 6 rooms. This operations start to create random bays on the edges which is not neighbor with halls. The restrictions within the process are listed in Image 10.

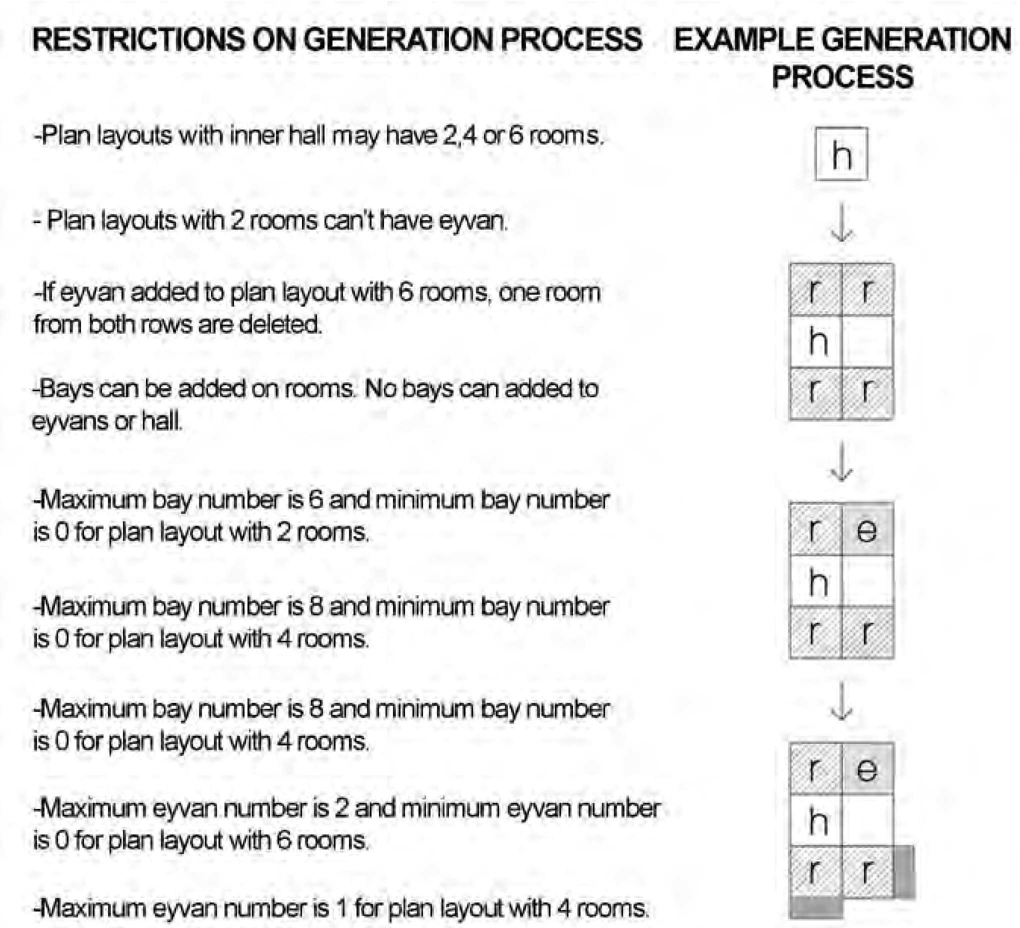

Image 10. Restrictions on generation process and example plan layout generation

3. Conclusion

This study presents an expert system that generates plan layouts in a closed shape grammar. In the scope of this study, an expert system is developed to generate fast and different design alternatives with using rendering, generating and saving abilities of computer. The expert systems code structure is changeable for any modification for further shape grammar studies.

Written code allows users to participate generation process interactively. Users also make inputs to the process. Expert system is explaining rules to combine design components. System also controls the process with specified restrictions. With the help of interactive display screen users generate plan layouts by following the process step by step.

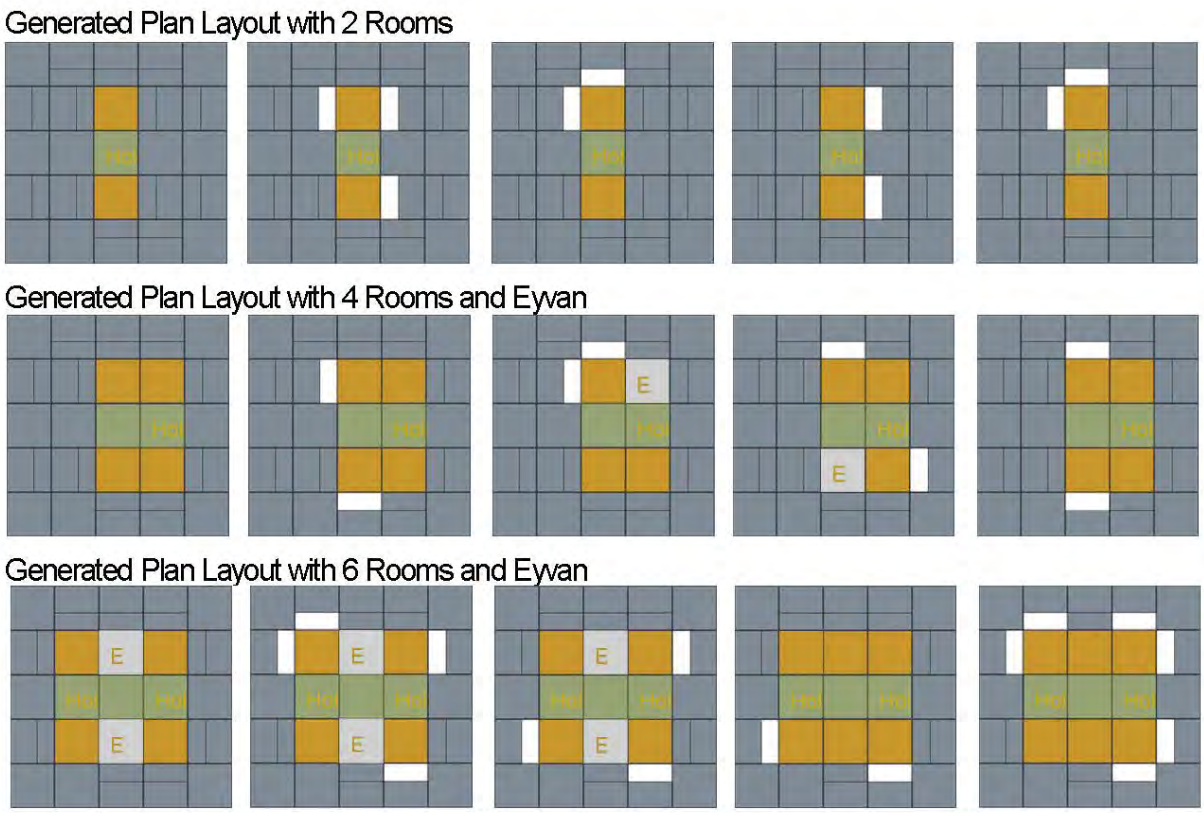

Image 11. Generated plan layout alternatives

Consequently, users learn the plan layout types, design components and the rules to combine these components. All these steps constitute the generation process, which are not separate processes. New plan layouts are generated based on a same shape grammar. Applying different rules for generation process end up with different plan layouts. The system is able to record these numerous plan layout alternatives.

The study is a trial where the artificial intelligence is dealt with in design training while regarding the use of shape grammar method. The shape grammar based expert system in this study helps users to understand the formal compositions and plan layouts of traditional Turkish houses.

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Saki Tagawa

On Effects of Cooperation with the Machine in Human-Computer Co-Drawing *(Paper)*

Topic: (Art, Drawing)

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Abstract:
Co-creation by human and machine is one of the methods to produce an artwork by a generative way when both take even leaderships. In this paper, we present a system model for studying the effects of cooperation with the machine during a human and a machine are drawing a subject picture together on the same canvas. Figure 1 is a conceptual illustration of the environment. We argue a method to find factors that enhance human performance in the drawing, which progresses study of human-computer co-creation.

We propose two questions;
(1) How does *the drawing style* of the computer affect the users performance?
(2) How does the distance between computer- and human-drawn strokes affect the users performance?
We assume that “the drawing style” is represented by a triplet of base drawing speed, a series of speed ratios of base speed, and waiting time between latest drawn stroke and next stroke. These questions are partly drawn from our preliminary experiment with ten subjects. Figure 2 shows an example of the results in the experiment.

We are pursuing the answers through more experiments in which the computer draws with two parameters, imitation rate of drawing style and spatial interference rate. The effects of the rates are investigated by assigning a variety of probability distributions of occurrence for each rate.

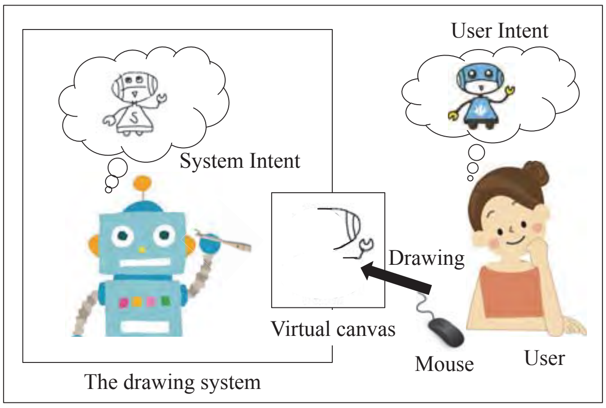

Figure1: Conceptual illustration of an environment of co-drawing.

(a) *(b)*

Figure2: The results of preliminary experiment in co-drawing between human and machine. (a) The shown target picture, (b) the result.

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Keywords:
Human computer interaction, Co-creation, Human computer co-works

On Effects of Cooperation with the Machine in Human-Computer Co-Drawing

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Premise

This paper proposes a system model for studying the effects of computers cooperating with humans in drawing a subject together on the same canvas. We present our hypotheses, partly drawn from a preliminary experiment with ten subjects. It is a part of our plan in wider experiments on the subjects. We propose two questions; (1) "How does the drawing style of the computer affect the users performance?" and (2) "How does the distance between strokes drawn by computer and human affect the users performance?" We are pursuing the answers through more experiments in which the computer draws with two parameters, imitation rate of drawing style and spatial interference rate. The effects of the rates are investigated by assigning a variety of probability distributions of occurrence for each rate.

1. Introduction

The doodle is a play drawing with paper and pen. Wide people, from small children to the elderly enjoy it. In addition, it is also generic and highly scalable play. It expands to graffiti on the walls, the drawing on the screen using the projector, and so on. Traditionally, creative activities such as doodle, has been considered as the act only human do, so only human can collaborate on creative activity. However, computers those perform autonomously and creatively have begun to be accepted by people, recently. Artificial intelligence artist AARON [1] is a typical example. Along with these creative computer, the possibility of human-computer collaboration on doodle has begun appear.

In fact, there already have been computers that aim to collaborate with human. There are two examples of the studies; SHIZUKA [2] is a computer system which draws picture interactively by associating next drawings from human drawings, and another system aims to mix own creativity and human's [3]. In the aspects of human-computer interaction, *human-computer doodle* is one of the "collaborative interactions of which primary aim are spending a fun time together [4]".

Yamamoto et al. argued that one of factors that bring fun to humans on such as collaborative interactions is "itself that thinks partner is human" [5]. Therefore, it has been said that it is difficult to make human fun by such human-computer interaction. However, Yamamoto et al. also pointed out that; might humans can enjoy human-computer interaction itself, if computer's behavior achieve the level in which human can empathy with it or can superimpose psychological state on it.

When humans doodle together, they tend to care what the partner is drawing and how it is possibly going on. In this study, we consider that the computer which human empathies with or superimposes psychological state onto gives the partner feelings of "the computer cares me" and "I'm caring the computer". Further more, we assume such computer promotes human-computer interaction spending a fun time together.

In human-computer doodle, the computer reaction that gives the partner the feelings of "the computer cares me" and "I also care the computer" have not been much studied. In addition, the creative computers are not suitable for verification of computer interaction, because these computers are not yet adequate to "doodle together with".

In this study, we develop the Co-Drawing System (CDS) which doodles a presented image based on a teaching data together with human, and propose two assumptions to give human feelings that "the computer cares me" and the Co-Drawing System TOMMY (CDST) which is the system to investigate these assumptions. These assumptions were induced based on our preliminary observation using CDS.

As a result of the human-computer drawing observation using the CDS, we assumed two hypotheses; 1. Human is easily aware of the drawing style, and feels easily "the computer cares me" if the computer imitate the person's drawing style, 2. Human is easily aware of the spatial interference of strokes, and feels easily "the computer cares me" through the spatial interaction with the computer.

To investigate these two hypotheses more deeply, we propose the CDST that can set imitation rate of drawing style and spatial interference rate and change behavior of the system.

2. CDS Overview

2.1 System doodling together with human

Figure 1 shows the schematic diagram of the CDS. CDS is software running on a PC, and it doodles an imitated figure of the image presented by an experimenter together with a person on a single canvas shared between them. The CDS does not only doodle on its own, but also do together with a person. If the person doodles a stroke on the canvas using a pointing device such as a mouse, the CDS detects it, and acquires information of drawn strokes. In addition, the person sees how strokes are drawn during the CDS is doodling the strokes on the canvas in real time.

The CDS doodles in accordance with the teaching data obtained by converting the presented image to interpretable form. Figure 2 shows the flow of processes to doodle in accordance with the teaching data, with acquiring strokes drawn by the person. Until the teaching data exhausted, the CDS repeatedly selects a stroke from the data and acquires information of a stroke drawn by the person if it detects the person drawing strokes on the canvas.

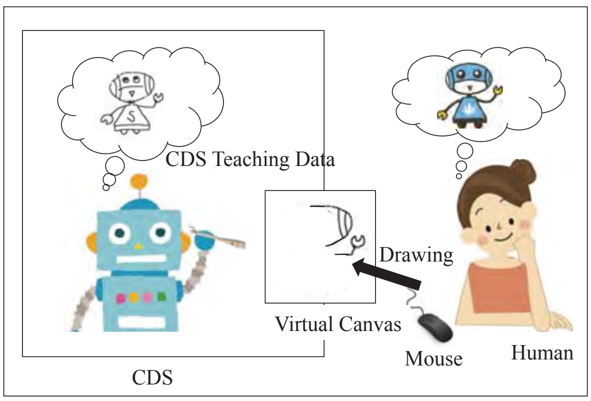

Figure 1. Schematic diagram of the Co-Drawing System.

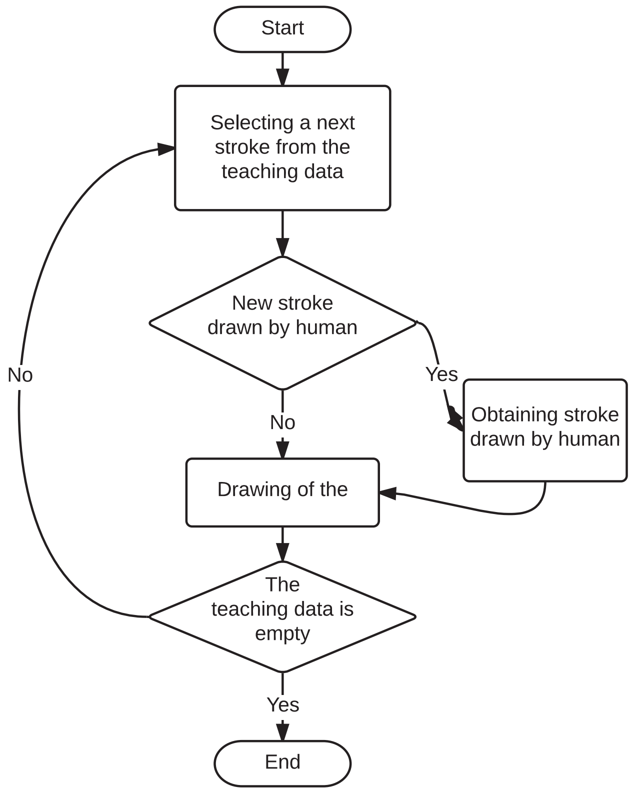

Figure 2. The flow of processing to doodle drawings with acquiring strokes drawn by the person.

2.2 Creation of teaching data

Teaching data is obtained by converting a presented image to a recognizable form of the CDS, and a hand of man converts the presented image. First, a person doodles the presented image on the canvas using a mouse. Next, the CDS gets boundary of each stroke, absolute coordinates of the stroke, and drawing speed of the stroke from the drawn data. Finally, the presented image is converted to the teaching data. At that time, beginning and end of each stroke are obtained by detecting the moment the mouse is pressed or released, and each strokes is obtained as a set of points. The points are taken at predetermined time intervals, so if a distance between points is long the drawing speed of the stroke is quickly, and if the distance is short the speed is slow.

When the CDS doodles on own, it can faithfully reproduce strokes forms of the teaching data and the drawing speeds of the strokes.
However, draw order is not recorded.

3. Outlook of the factors that affect human

3.1 Observation of human-computer doodle by CDS

In this experiment, the CDS operates according to the following three policies, in order to hold the act of doodle together.

• Do not draw a stroke on the stroke drawn by human.

• Select a stroke from the teaching data, with priority the furthest from the stroke drawn by human.

- The stroke of teaching data, which is not yet drawn, is considered that it is already drawn, if the stroke is close to a stroke drawn by human.

These policies realize human-computer doodle sharing, separating the area to draw strokes.

Below we describe the conditions of the experiment.

- At first, the subjects are informed the partner of doodle is a person.
- Drawing speed of the CDS is based on the teaching data (it is same as the teaching data creator).
- It seems that the CDS draws strokes at random order from a person who doodle together with the CDS, because it chooses a stroke from teaching data in favor of distant stroke from the strokes drawn by the person.

In this experiment, we asked some questions to subjects; whether felt that "doodle together with", whether felt that drawing speed of a computer is adequate, whether felt that the computer doodled drawings at adequate order, and so on.

3.2 Observation results

Subjects were ten university students, and of which eight people answered that "I felt drawing together with the computer", but other two people did not feel so. The computer / the person supported the other, or they succeed to share the canvas to complete drawing the presented image, these are the reasons why the eight people felt drawing together with the computer.

On the other hand, as the reasons why they did not feel so, the two people mentioned that the computer drawing speed was too unlike their own. About feeling of computer drawing speed and feeling of computer drawing order, we prepared some choices.

For the drawing speed, there were slow, somewhat slow, normal, somewhat fast, and fast choices. For drawing order, there were unnatural, somewhat unnatural, neither unnatural nor natural, somewhat natural, and natural choices. While a half of subjects answered the drawing speed is normal, seven subjects answered the drawing order is unnatural or somewhat unnatural. Despite the computer's drawing order is unnatural, nobody mentioned about it at free impressions. To the contrary, some subjects mentioned about the drawing speed.

3.3 Hypothetical factors affecting human

First, we considered that there are conscious factor and unaware factor, in human-computer doodle. From a result 3.2, we regard the drawing speed and each other's drawing area as conscious factors. To contrary, the drawing order is seemed to be unaware factor.

The drawing speed is not fixed while a stroke is drawn, and it is closely related to how to draw the stroke. Thus, we considered that humans imitate other party each other, and assumed that the person feels easily "the computer cares me", if the computer imitates person strokes.

Therefore, we devised the system which the experimenter can change how much imitate and how much interference to strokes drawn by human. This system extends the CDS, and it is called Co-Drawing System TOMMY (CDST).

4. Imitation of how to draw strokes

In this study, we define the drawing style, which represents how to draw strokes using the drawing speed, and CDST imitates the style using "imitation rate" which CDST has. Using the system CDST, we investigate the change in human impression due to increase or decrease of imitation rate. Then, we will verify the relationship between imitation of the drawing style and whether the person feels that "the computer cares me".

4.1 Style of how to draw the stroke

Each stroke has own style of how to draw strokes, and each style is represented using the three factors.

The first factor is the average drawing speed to draw the stroke. The average drawing speed V_{ave} is the number of the stroke length divided by the number N of points contained in the stroke, and it is expressed by following equation.

$$V_{ave} = \frac{\sum_{k=1}^{N-1} D_{k,k+1}}{N} \quad (1)$$

where $D_{t,t+1}$ is distance between point P_t and next point P_{t+1}.

Second factor is the drawing speed ratios arranged in order from the first section to the last section. It is prepared to express a habit of how to draw such as initially slow gradually faster. Figure 3 shows an example of the habit of how to draw in the graph. When the drawing speed ratio in the vertical axis is 1, drawing speed of the section equals the average drawing speed of the stroke. Therefore, figure 3 shows the change of drawing speed; the start drawing speed is slow, but it is gradually faster, and it again gets slow at the end of drawing. The drawing speed ratio R_t of section S_t is expressed following equation.

$$R_t = \frac{D_{t,t+1}}{V_{ave}} \quad (2)$$

where, section S_t is between the point P_t and next point P_{t+1} on the stroke, and the drawing speed of section S_t is distance $D_{t,t+1}$. Such drawing speed ratios R_i arranged in order from the first section S_1 to the last section S_{N-1} is treated as a habit of how to draw which the stroke has.

Third factor is the waiting time from time finished previous drawing to time beginning current drawing. The previous two factors can be calculated only from the current stroke, but the third factor needs to measure the time continued from the stroke drawn previous.

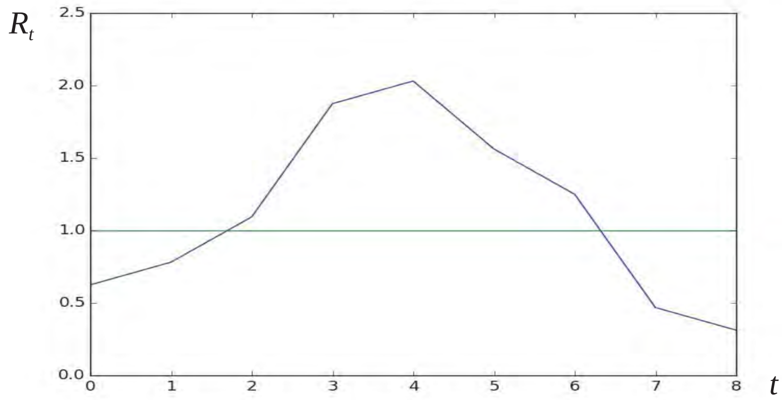

Figure 3. An example of habit of how to draw

4.2 Acquisition and imitation of drawing style by person

If CDST detects a stroke drawn by person, it acquires the stroke, and calculates the drawing style using representation of 4.2. When CDST draws a stroke L_c chosen from teaching data, it imitate human drawing style using own imitation rate. That means it calculates drawing speed V_t used to draw the point P_t on the stroke L_c by own drawing style and acquired human drawing style. When the imitation rate is high, the calculated drawing style close to human drawing style, but it is close to the CDST drawing style if the rate is low. Imitation rate takes the real number of 0 or more 1 or less.

Now, we assume CDST draws a stroke L_c with imitation of human drawing style acquired from stroke L_h. When imitation rate is M, the drawing speed V_t of section S_t on stroke L_c is expressed following equation.

$$V_t = (1 - M)R_{ct}V_{\overline{c}} + MR_{ht}V_{\overline{h}} \tag{3}$$

where R_{ct}, R_{ht}, respectively, refers to the habit of the CDST's drawing and humans at point P_t and point P_{ht}, and V_c, V_h, respectively, refers to average drawing speed of the CDST's stroke and humans. The point P_t is on stroke L_c, and the point P_{ht} is on stroke L_h and corresponding to the point P_t. Figure 4 shows the correspondence of point P_t on stroke L_c and point P_{ht} on stroke L_h.

Finally, the waiting time d until choosing next stroke from teaching data and starting drawing is expressed following equation.

$$d = (1 - M)d_c + Md_h \tag{4}$$

Here, d_c, d_h, respectively, are the CDST's waiting time and the human waiting time.

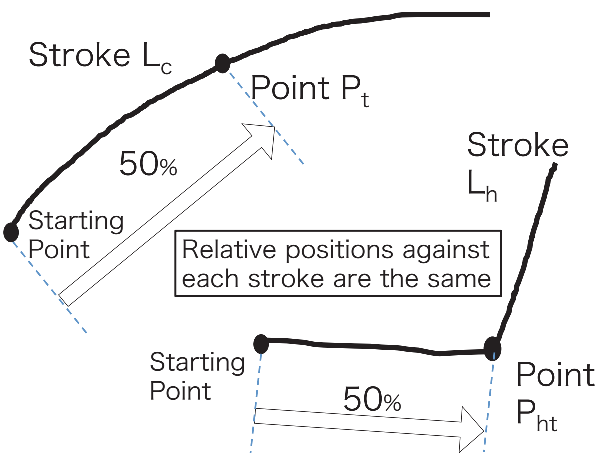

Figure 4. The correspondence of point P_t on stroke L_c and point P_{ht} on stroke L_h.

5. Spatial interference

The CDST adjusts by interference rate the distance between human previous stroke and the stroke chosen from teaching data, in order to observe the impact of spatial interference among strokes.

First, get strokes which are included in the teaching data and have not yet drawn, to sort that in the order of proximity to the stroke drawn by human. The distance between a stroke drawn by human and a stroke gotten from teaching data is regarded as the distance of which the combination of most closer points. Then regard 100 * (1 - interference rate) as the percentile value, and choose appropriate stroke from sorted strokes.

In other words, when there is the interference rate I $(0 < I \leq 1)$, the chosen stroke L_n is located n_{th} of sorted strokes counting from 0, then, the n is given by the following equation.

$$n = \lfloor (1 - I)N \rfloor \tag{5}$$

where N is the number of strokes which included the teaching data and not yet drawn. Therefore, when the interference rate is high, the CDST draws in favor of close stroke from strokes drawn by human, and when it is low, draws in favor of distant stroke from strokes drawn by human.

However, because selectable strokes gradually become less, the CDST can draw distant stroke from strokes drawn by human despite the interference rate is high, and it also can draw close stroke despite the rate is low.

6. Occurrence probability and combination of imitation rate and interference rate

When a human does something, it is difficult to repeat the same thing exactly like computer. In order to provide some fluctuations in the behavior of computer, the spatial interference rate and the imitation rate are updated with a random number according to a triangular distribution on the each time to draw a stroke.

Triangular distribution of the probability density function *f(x)* is given by following equation.

$$f(x) = \begin{cases} \frac{2(x-a)}{(b-a)(c-a)} & (x < c) \\ \frac{2(b-x)}{(b-a)(b-c)} & (x \geq c) \end{cases} \tag{6}$$

Here, a, b, c denote respectively, the lower limit of the distribution, the upper limit, and the mode value. Table 1 shows values of experimentally used three distributions.

Imitation rate in the 0 to 1 inclusive of the real number, and spatial interference rate is greater than 0 to 1 or less of the real number. Figure 5 shows the probability density function of the triangular distribution using values in table 1.

The horizontal axis expresses the value of imitation rate and interference rate. In Figure 5, as distribution of imitation rate goes from (1) to (3), the CDST often imitates drawing style of the person a lot. In interference rate, as distribution goes from (1) to (3), the CDST often disturbs human strokes.

The behavior of the CDST varies by the combination of the shape of the imitation rate distribution and the shape of the interference rate distribution. Because the imitation rate and the interference rate have respectively three shapes of distribution, the CDST have nine behaviors.

	a	b	c
(1)	0.0	0.5	0.2
(2)	1.25	0.75	0.5
(3)	0.5	1.0	0.8

Table 1. Values of distributions.

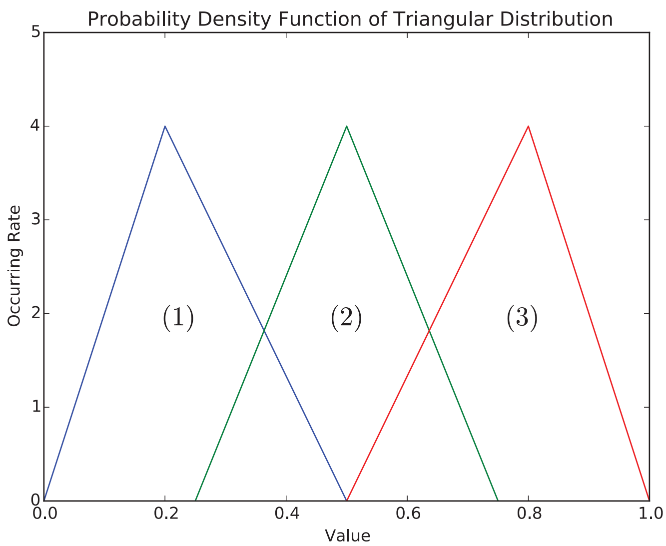

Figure 5. Probability density function of triangular distribution.

7. Conclusions

In this study, we assumed the two hypotheses; 1. When the computer imitates the style of drawing by the person, the person feels that "the computer cares me", 2. If there are appropriate spatial interferences, the person feels easily that "the computer cares me".

These hypotheses are based on the prediction that there are possibility of which human feels a fun through human-computer interaction itself, if a computer reaches the level in which human empathies with and superposes psychological state onto. In addition, to investigate the two hypotheses, we proposed the Co-Drawing System (CDS), which can doodle together with human, and Co-Drawing System TOMMY (CDST) which can adjust degree of imitation of drawing style and degree of spatial interference.

Then, we show that the CDST behaviors are changed by combination of imitation rate and interference rate, in the other words, varying the distribution of imitation rate and spatial interference rate.

In the future work, we will conduct the verification of the hypothesis throughout the experiment.

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Silvija Ozola

Paper:

THE SCALE AND RELATIONS OF SPATIAL FORMS IN THE MODERN LATVIAN REGIONAL ARCHITECTURE

Topic: Architecture

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Abstract:
In territory of Latvia the origins of the regional architecture formation are related to wooden houses built by the Baltic tribes and the architectonic space arrangements on castle hills, as well as spatial solutions in the rural environment – in farmsteads where in the natural environment context, following peculiarities of the topography, near water basins the building-forms of residential and household buildings were arranged and the proportions of their separate constructive parts were looked for. Due to the environmental interaction created by nature and people, every region of Latvia – Kurzeme, Zemgale, Vidzeme and Latgale – over the centuries has acquired its own language of architecture forms typical for the particular region: their qualitative features are the scale and relations of spatial forms.
Searches of the space and shape mutual impact and arrangement are also topical nowadays. Architects, following old traditions and preserving the human scale in environment, have created modern buildings in Latvia regions – complexes of residential and public buildings – and culture environment for daily activities. The interpretation of the building-forms formation and their separate parts, usage of natural building materials, also the searches of proportional relations of separate parts and details of buildings improve the language of architecture forms, awarding it new features.
The goal of the research is to find out the significance of the qualitative features of architecture – relations of the scale and spatial forms – for the emotional artistic expression achievement in the modern regional architecture of Latvia.

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A roof of a house in the village "Amatciems" in Latvia

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Keywords: environment, natural building materials, regional architecture, residential and public buildings, scale, shape, traditions

Scale and Relations of Spatial forms in Modern Latvian Regional architecture

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Abstract

In territory of Latvia the origins of the regional architecture formation are related to wooden houses built by the Baltic tribes and the architectonic space arrangements on castle hills, as well as spatial solutions in the rural environment – in farmsteads where in the natural environment context, following peculiarities of the topography, near water basins the building-forms of residential and household buildings were arranged and the proportions of their separate constructive parts were looked for. Due to the environmental interaction created by nature and people, every region of Latvia – Courland, Semigallia, Vidzeme and Latgallia – over the centuries has acquired its own language of architecture forms typical for the particular region: their qualitative features are the scale and relations of spatial forms.

Searches of the space and shape mutual impact and arrangement are also topical nowadays. Architects, following old traditions and preserving the human scale in environment, have created modern buildings in Latvia regions – complexes of residential and public buildings – and culture environment for daily activities. The interpretation of the building-forms formation and their separate parts, usage of natural building materials, also the searches of proportional relations of separate parts and details of buildings improve the language of architecture forms, awarding it new features.

The goal of the research is to find out the significance of the qualitative features of architecture – relations of the scale and spatial forms – for the emotional artistic expression achievement in the modern regional architecture of Latvia.

Keywords: environment, natural building materials, regional architecture, residential and public buildings, scale, shape, traditions

Introduction

Regional architecture in Latvia countryside and cities has been developing during lots of centuries thanks to the geographical placement of Latvia which has provoked the visits of neighbouring nations and impact of different cultures. Originally, typically rural wooden houses created the city building, which gradually were adapted to the requirements of city building. The oldest wooden buildings in

Latvia have been created by unknown authors: the building structure was made in order to achieve an aesthetically wholesome architectonic solution avoiding mechanical collection of separate elements in the construction volume. In the second half of the 18th century buildings were given a monumental shape, and each ethnographical region of Latvia (Picture 1) – Courland, Semigallia, Vidzeme and Latgallia – obtained its own characteristic language of architectonic forms, whose qualitative features are the scale and relations of spatial forms.

Picture 1. Map of Latvia with four ethnographic regions [I-1]

1. Ancient Wooden Building in Latvia

If we look into the distant past, we can see lots of common features in the urban and rural building layout and constructive formation, whose origin was connected with the subsistence farming. Popular architecture appeared in the presence of foreign relations and newly-introduced stone architecture.

The oldest buildings in Latvia territory were built of natural building material – wood, whose constructive possibilities and sizes – cover span, length of horizontal beams or straddle height, also the features – sensitivity to humidity, precipitations, long-horned beetles and fire, were taken into account when building wooden houses in different ages and countries in the corresponding climatic zones. The main types of wooden construction buildings were timber frame, log building and strut or lattice construction. The environmental influence was strong and local traditions obtained their reflections also in the buildings' architecture. This process was promoted by social structure, climate conditions, resources of local building materials and the use of logic, as well as the desire for simplicity in construction and décor. The architecture of wooden buildings was expressed in the construction silhouette, roof constitution, also in the forms and décor of openings and small details. Understanding of wood properties had great significance which was expressed in a conscientious care of the created material and potentially longer live expectancy of the art value.

Evolution of wooden construction forms was a complicated and mutually reversible process, which was implemented in the contact of popular architecture and style architecture: first it was expressed in the city construction, but later it echoed in rural centres – manors, also influencing the architecture of farmsteads. The architecture of styles in the urban wooden construction encountered severe resistance of traditions.

The roof took an important place in construction: the roof pitch approved for rural buildings could also be met in urban wooden construction, confirming the influence of national building traditions on wooden architecture in towns.

Décor in construction was used very sparingly. Small detailed forms of functional significance can be counted as a decoration: porch railings, carvings at the end of barge boards, regularly placed reinforcement elements of the roof ridge. In barns the porch columns and lintel elements were emphasized with décor.

In the architectonic artistic form of buildings a special attention was paid to window and door openings and their infill. Smooth door leaves of vertically placed boards were made for buildings, but with crafts development the constructions of leaves were improved. Doors of buildings were emphasized starting from the 17th century – they obtained a decorative significance.

The window has always been an active element in the façade of the building – the construction document of the age which included the information on the stylistic and constructive evolution of the construction components. Window leaves were divided into several panes and their sizes were determined by the glass manufacturing facilities. Glazing of small panes was used for the window leaves of urban wooden residential buildings which were fastened in wooden laths. Glass size determined the constructive and architectonic construction of windows.

2. Planning of Latvian Farmsteads and Urban Environment in Latvia Historically Ethnographic Regions

In **Courland** the prevailing type of farmers' settlements was single-homesteads, but there were also lots of dispersed villages. The system of two yards was popular: the residential building was in the centre, but between it and the stockyard – the work or "dirty" yard. The "clean" yard was made between the residential building and barn. People of the residential building could easily get into both yards through the communicating hall in the central part of the building. There were also other types of the yard planning, in which the layout of the buildings depended on the size, terrain and other factors of the farm. All buildings were placed round the yard, bet several rooms of different character – residential and outbuildings – were joined under one common room in one building [1, *40–41*].

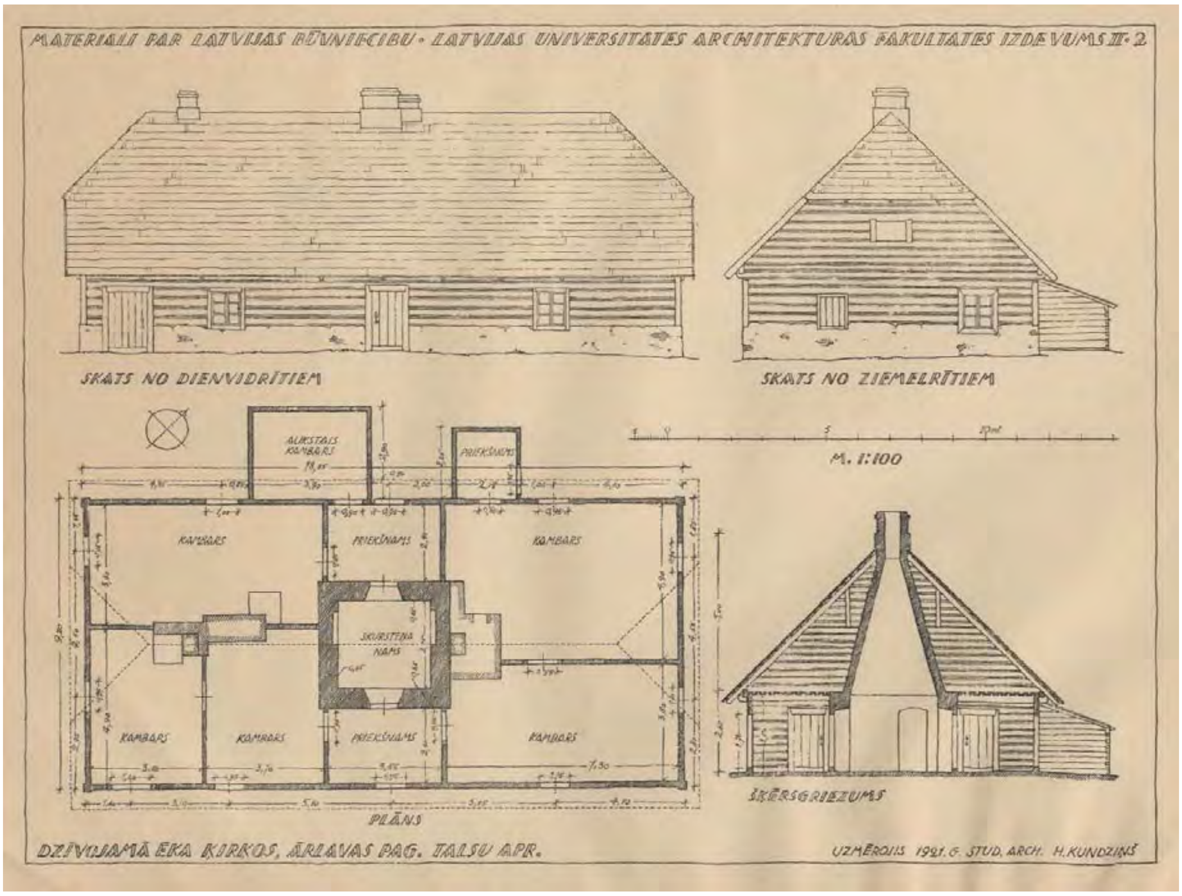
Semigallia due to the fertile lands and more favourable historical conditions became economically the most developed region of Latvia where single-homestead settlements dominated, but along the border of Lithuania and on the coast of the Rīga Gulf – villages. In Semigallia a residential building was situated in the centre of the yard which was surrounded by a garden. On one side of the residential building barns and granaries were placed. The buildings together formed a closed yard. Further on the other side of the residential building a threshing barn was built, but even further behind the barns a bath house was situated [1, *196–197*].

In **Latgallia** the farmers' material culture was based on the regional ancient inhabitants' – Latgallians – culture. Due to the cultural interaction of strong Latvian and Slavic people- Russians, Poles, and Byelorussians – in all areas of life and regions lots of local peculiarities appeared. In Latgallia the prevailing types of farmers' settlements were terraced villages and dispersed villages. Each type had several versions: a street made the planning of the terraced village; a cruciform or T-shape layout was also possible. Within the borders of the villages farmsteads had several options of layouts: buildings were built around a rectangular yard which was formed by two parallel buildings built facing with their side walls the street, or all buildings, facing the street with their side, were placed according to the principle of two yards – the residential building in the centre, on one side from it – the barn, on the other side – the granary. Sometimes the residential building and barn were placed so close together that the roof pitches touched each other. A closed stockyard was situated between the buildings, but the barn and other buildings were placed further [1, *162–163*].

Vidzeme farmers' material culture was based on the ancient inhabitants' – Latgallians and Livs – material culture which during the historical development was influenced by the Selonians, Estonians and Slavs living in the neighbourhood. Due to the interaction of different national cultures and historical and social-economic conditions several local regions with their own material cultural peculiarities were formed in Vidzeme. In Vidzeme during the 18th and 19th centuries there were two types of farmers' settlements: single-homesteads and dispersed villages, which sometimes were rather closely built up. In single-homesteads and villages buildings were placed around an irregular yard, where on one side the residential building was placed, but on the others- outbuildings. The barn was sometimes built in the garden, but the granary was placed further from the other buildings, as if forming a special threshing barn's yard [1, *90–91*].

3. The Earliest Buildings in Latvia Countryside and Towns

In **Courland** farmstead and town buildings were mainly built in log construction with trimmed beams which had already been used in building since the 13th century. Wall resistance of log buildings depended on the wood bonding techniques; therefore in the corners of the buildings dovetail joints were made which had already been used in building since the 16th century. The quick boom of wood construction encouraged carpenters to improve their woodworking techniques, look for a variety in the constructive formation and appearance of walls. The economic considerations became important – walls of strutted log edges were made, in which it was possible to use shorter timber. Such a wall construction solution was pretty close to the strutted or lattice construction principles. The variety of wooden buildings increased – residential homes, warehouses and outbuildings were built. The construction form and décor were solid.



Picture 2. Residential building of a three-part planning with a smokestack in Talsi Parish, Courland [2]

The proportions between the walls of the building and the height of the roof were important in Latvian national building. Traditionally the roof takes an outstanding place in building construction and about two thirds of the total building height was allocated to its construction. Buildings were covered with either a tent roof or a double pitch roof, or a double pitch roof with hip ends. Straw, reed and also shakes were used for roofing. The roof pitch had to be a little smaller than 45 degrees, so the rafters in the gable would make a little wide angle. The roof pitch approved as appropriate in the national building was also found in the urban wooden building [4]. In Courland as the local peculiarities in national building should be mentioned: a residential building of two-part or three-part planning with a communicating central part of the building, in which a furnace with a funnel type smokestack and two unheated vestibules (Picture 2), a massive barn with an open porch and porch poles adorned with decorative woodcarvings (Picture 3) were situated, as well as a horseshoe-type or angled stockyard, where under one roof different rooms connected with cattle breeding were joined together [1, *41*].

Picture 3. Log barn with an open porch adorned with decorative poles in Courland. Foto: Vitolds Mašnovskis. 31.03.2010. [I-2]

In **Semigallia** farmers built solid log buildings from trimmed beams which in the corners were joined in cross corners (Picture 4), also strut structures were used. Buildings were covered with a tent roof or double pitch roof with hip ends, and straw was used for the roofing, but in the second half of the 19th century – also shingles and tiles. In the villages by the Riga Gulf coast reeds were used for the roofing material [1, *197*].

In Courland and Semigallia a two-part and three-part planning was common in residential buildings since the 17th century, which in the second half of the 18th century was improved: in the central part of the building a smokestack with a furnace was made, but one could enter the rooms only through the vestibule [3]. In towns next to the smokestack, placed in the central part of the building, two vestibules were attached: one facing the street, but the other facing the yard, through which it was possible to get into the outbuildings and garden. The entrance into the building was emphasized by the form of the door opening and portal.

In the western part of Latvia the two-part and three-part planning residential houses with a communicating central part were adapted to town conditions and construction of wooden buildings was promoted. Three-part planning residential houses were considered as the most appropriate for town building and they were placed on both sides of the street, so that the longer façade directed towards the carriageway would form the building line. In the townscape the silver grey wood tone and moss green tone prevailed. In some places the existing tiling roofs stood out especially brightly. People from towns and countryside, when staying in a particular spatial environment, which provoked emotions, obtained a certain understanding of environmental characteristics and functional content of spatial forms, the sense of scale – the ability to compare the proportions of the environment and body dimensions – was developed.

Picture 4. A wealthy farmer's residential house in Semigallia [I-3]

Picture 5. A residential house with a massive double-pitch, thatched roof with hip ends [I-4]

In **Vidzeme** farmers mostly built log buildings from round or slightly trimmed beams, which in corners were joined in cross corners. Buildings were covered with tent roofs or double pitch roofs with hip ends, but in East Vidzeme – also double pitch roofs. Straw or shakes were used for roofing, but in the second half of the 19th century shingles were used more often. Wealthier farmers' buildings had tiles on roofs. In the 18th-19th centuries buildings of Vidzeme farmsteads had lighter building forms than in Courland. Decorative elements were used less, whereas they were homogeneous. In Vidzeme as the local peculiarities in national building should be mentioned: a residential building of a two-part or three-part planning, threshing barn with a low and wide roof, tradition to build in one farm several small single-room barns, a bath house with additionally built living-rooms, as well as a threshing barn for living whose walls under the deep eaves made up only one fourth of the overall building height (Picture 5) [1, *91*].

Picture 5. Threshing barn with a high roof in Vidzeme. [PK]

In **Latgallia** in the 19th century farmers built small log buildings from round beams, which were joined in corners with cross corners. Buildings were covered with double pitch roofs of straw or shake roofing. Utility rooms of different character were often joined under one roof, but sometimes also living-rooms and utility rooms. In

Latgallia the most obvious local peculiarities in national building should be mentioned: an Eastern European style chimney-less log with a “Russian stove”, a two-part or three-part residential house with an unheated vestibule, porch poles decorated with wood carvings, roof barge boards (Picture 6), window ledges (Picture 7) and gables of the buildings. A high fence with a decorative gate separated the yard from the street [1, *163–164*].

Picture 6. Décor – barge board horses on the gable of a residential house [I-5]

Picture 7. Window decoration of a residential building in Latgallia. 09.06.2013. [I-6]

4. Artistic Expression in Modern Regional Architecture in Latvia

In the dynamically variable and information exuberant world where, forming super big spatial structures the scale and proportions are totally subjected to the economic requirements, each of us assesses the events and phenomena according to our knowledge and understanding of space and time. The scale determines a person’s attitude towards regional expressions in art and architecture. A definite, diverse environment, where expressing an active attitude towards the surroundings, a human being would be able to develop the sense of scale and proportions, which has been developed in the interaction of experience and information during the lifetime, is very important for personal development.

In Latvia during lots of centuries rural and urban environment and landscape rich in architectonic and natural forms have been formed, which cannot be imagined apart from the cultural values and traditions. Wooden and log buildings have become a part of rural landscape, which encourage us to cultivate and develop the ancient building traditions. The ability to perceive with an interest and shape the surrounding area in a creative way gives stimuli to restore the ancient buildings, changing their original function, as well as to create modern and contemporary wooden buildings. Studying the historical heritage, which shapes our living space, Latvian architects find new, creative solutions for the development of the informative emotional potential, for the attainment of artistic expression and identity preservation. The regional architecture is enriched by compositions of new construction planning created on a human scale, as well as in the spatial context of landscape and architectonic space.

Picture 8. Village "Amatciems". Architects: Sarmīte Bumbiere and Pēteris Blūms. [I-7]

In Vidzeme village *"Amatciems".* was built, changing the landscape (Pictures 8, 9 and 10), whose owner is *Aivars Zvirbulis*. The idea, construction and traditions of Latvian single-homestead were included in the planning of "*Amatciems*". Few-storey residential buildings placed among the water bodies and clusters of trees integrate nicely into the landscape. Preserving the human scale in the spatial composition of separate buildings and houses, it is possible not only to amalgamate organically and cover all spatial expression components, but also guarantee an appropriate perception of the spatial composition. Territory of village "*Amatciems*" is divided into 0,4 to 1,5 ha large piece of land.

Picture 9. Winter panorama of village “Amatciems”.[I-8]

Picture 10. Autumn panorama of village “Amatciems”. [I-9]

In Latvia due to the impact of different cultures the architectonic image and constructive solution of individual contemporary residential buildings is developing. The planning of family buildings is being improved, therefore the historically traditional two-part and three-part planning is not topical any longer. An environmentally – friendly and ecological building and harmonic integration into the landscape have become essential. Natural materials are used in building, the technology of log house building, technologies of thatched roofs and other national building traditions have been developed. One-storey buildings of village "*Amatciems*" have a single silhouette, which can be supplemented with a ground floor and attic (Pictures 11 and 12).

Picture 11. Village "Amatciems".. Family house with living-rooms in the attic [I-10]

Picture 12. Village "Amatciems". A country house [I-11]

Picture 13. Village "Amatciems". A family house [I-12]

Picture 14. Village "Amatciems". On a terrain slope a residential building a with a reed roof in winter [I-13]

Picture 15. Village “Amatciems”. Stylized shingle roof of a country house [I-14]

Nowadays in order to create an image of detached houses built in Latvia towns, countryside or outskirts, solutions are being searched for the compatibility of the modern building with historical one. The changes in wooden and log house constructions are mostly connected with solution searches for a rational planning of the houses, constructive architectonic building, houses’ sustainability and efficient energy, using local timber resources and providing a comfortable erection of prefabricated wooden houses. Developing the construction of log houses, the traditional building techniques are used, at the same time enriching the regional architecture with expressive building forms, where a special attention is paid to the proportions of exterior walls and roof height (Picture 13), as well as the roof shape and roofing material (Pictures 14 and 15). Ornament is used modestly.

Home construction can choose one of the three building types – timber frame, log or stone building, supplementing it with a boulder, decorative wooden cladding, colored glass or stucco exterior wall finishes. Acceptable roof coverings are reeds, split wood chips, clay or concrete tiles, as well as turf coverage. Each farm building volumes are adapted to site terrain, up to 8 meters above the spatial scale to be built or cultivated surface of medium height.

Picture 16. Guest house “Kraukļīši” in Vidzeme. [I-15]

In the modern rural landscape of Latvia ecological, structural and functional changes take place, and under this influence also building of functionally new unconventional wooden buildings and log houses – rest homes and guest houses, social buildings and monumental complexes. A new type of wooden buildings, preserving the human scale, creates changes in the perception of open space, construction volume relations and language of architectonic forms. In Vidzeme the construction forms of the guest house “*Kraukļīši*” (Picture 16) recalls a residential house in the countryside. In the high-roof attic rooms are made for guests' accommodation.

Conclusions

1. In the modern Latvia the conventional building techniques are used for creation of wooden buildings and log houses of unconventional construction volume. The roof is emphasised in the human scale built houses, but the height of the ground floor exterior wall reaches approximately one third of the construction overall height.
2. Newly erected buildings are covered with stylized ancient roofs which are made of natural roofing material – straw, reed and shingles.
3. In rural environment buildings are mostly placed in groups, preserving the traditions of a single-farmstead planning.

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Slawomir Wojtkiewicz

Generative Systems in architecture design

Abstract:

Generative synthesis systems are systems of mechanisms that are combine together, and are capable of creating alternative compositions that address design problems, express design view, and additionally, offer a huge scope of satisfactory solutions.

The system is developed form one side to support architects in designing sustainable buildings, from another side allows uncover new forms of shapes and meanings, including architecture, engineering, design, art.

The generative synthesis system provides a mechanism for generating design alternatives. If efficiency criteria such as daylight, solar heat, real state preferences established and solutions are modeled and analyzed, then architects or design team can compare design alternatives and better pilot the design space.

The system lends itself well to calculation and simulation realization. As a matter of fact, the use of more affected analysis tools would provide for more potent solutions.

The symbiotic relationship between the generation and testing mechanisms would lead to a larger set of attainable solutions and can assist both the design team in establishing intelligent, sustainable and superior designs.

In this paper, I will describe generative performance based design methodology and its expected benefits. I will begin first providing a brief argument on generative systems and their use in design. It will be followed by talking over analysis systems used in architectural design. I hope to explain the methodology phases and show how the methodology influences design process. In the following paper, I focus first of all on the theoretical aspect of design derives from generative design methodology.

Topic: Architecture

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[1] Name FamilyName, "*Title*", Publisher, Where, Year
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Generative Systems in architecture design

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Premise

Generative synthesis systems are systems of mechanisms that are combine together, and are capable of creating alternative compositions that address design problems, express design view, and additionally, offer a huge scope of satisfactory solutions. The system is developed form one side to support architects in designing sustainable buildings, from another side allows uncover new forms of shapes and meanings including architecture, engineering, design, art. The generative synthesis system provides a mechanism for generating design alternatives. If efficiency criteria such as daylight, solar heat, real state preferences established and solutions are modeled and analyzed, then architects or design team can compare design alternatives and better pilot the design space. The system lends itself well to calculation and simulation realization. As a matter of fact, the use of more affected analysis tools would provide for more potent solutions. The symbiotic relationship between the generation and testing mechanisms would lead to a larger set of attainable solutions and can assist both the design team in establishing intelligent, sustainable and superior designs. In this paper, I will describe generative performance based design methodology and its expected benefits. I will begin first providing a brief argument on generative systems and their use in design. It will be followed by talking over analysis systems used in architectural design. I hope to explain the methodology phases and show how the methodology influences design process. In the following paper, I focus first of all on the theoretical aspect of design derives from generative design methodology. The practical approach generative design methodology should appear through experiments that I will have carried out on actual experiments project. I hope to present results of experiments soon in succeeding the paper.

1. Introduction

The design of buildings is a usual purpose by the need to meet a set of minimum efficiency criteria such as beauty, functionality, budget, energy requirements. In order to achieve better performing and sustainable architecture, architect needs to work together in a focused effort. Generative synthesis systems offer us a number of options to compare and select from entirely. Once we encapsulate our design intent in procedural terms, we can automate the design process, and generate many alternatives to choose from.

2.The Generative System

The contrivance of using generative systems in design has roots in the past. Design patterns and design rules have been implemented throughout the history of architecture and art. Characteristics of the such systems can be found in many historical examples including painting, architecture, design art. The study of Greek and Roman architecture, for example, demonstrates the consistency in design that was figured out through logical design rules. Palladio, a famous renaissance century architect throughout his architectural work, developed a process of designing that was based on such logical design rules. In the 1970s, Stiny and Mitchell were able to extract from Palladio's writings and work a set of such shape rules and grammars **[1]** (Stiny and Mitchell 1978). These grammars were capable of creating many variations of Palladio's designs.

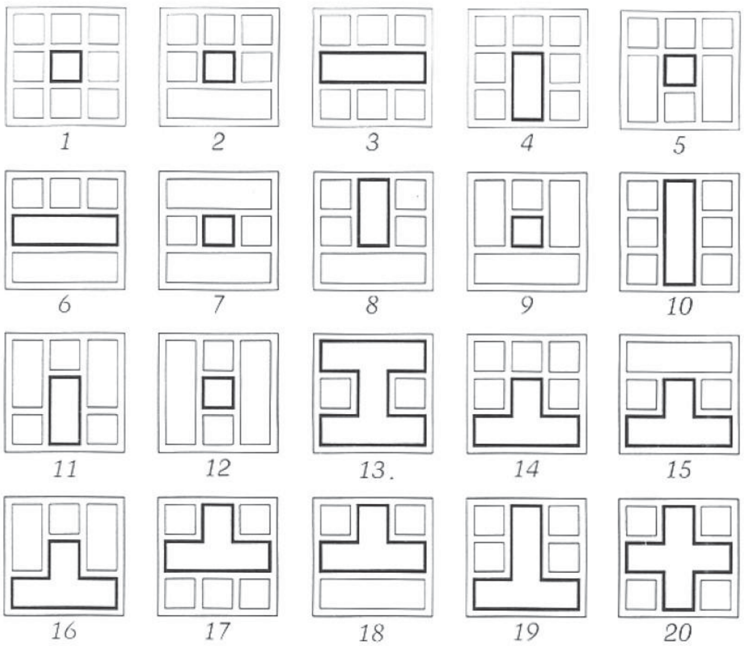

Fig.1. Stiny and Mitchell translated Palladio's writings producing his design into a series of Shape rules (Shape grammars). Palladio grammars where structured in stages (as per Palladio's writings). The grammars was capable of producing many variations, all of which resemble Palladio design.[1]

Durand a French architect in the eighteenth century provided his students with a kit of shape rules and instructions on how to build architecture (Britt 2000)[2].

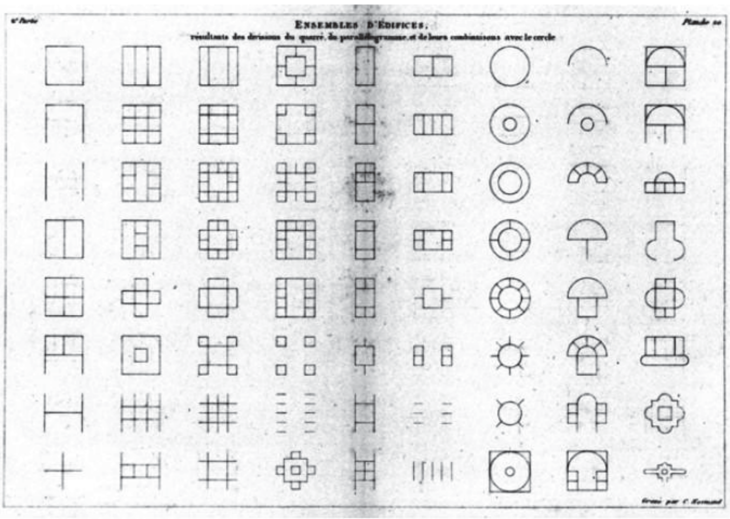

Fig.2. Durand's geometric shapes and rules of how to build Neoclassical architecture [2].

In the early twentieth century, Sullivan - American architect demonstrated the development process of ornament plates. Sullivan's plates ornament showing the construction process through a set of instructions and rules that were then given to the craftsman within Sullivan's design style (Twombly 2000) [3].

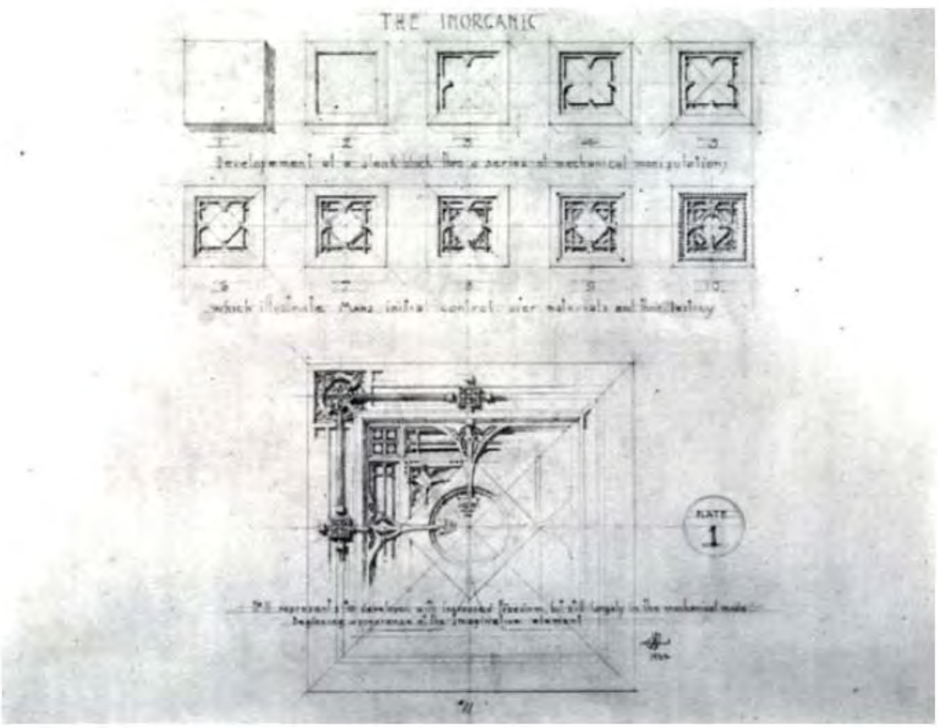

Fig.3. Sullivan's ornament plates instruction.[4]

In the Modernist theories of design became means to improve the mode of communication, representation, thinking and building. Established design rules that

promoted the simplification of form and the elimination of ornament were implemented. The “Constructivism” as design methodology in architecture that indicated a mode of thinking and a certain ordering of the process of thought also implemented its design rules. As a group, the Constructivist's architects refuted charges of trying to eliminate the aesthetic emotion. They argued that they purely seek to recognize that the character of building had changed under the influence of different conditions of life, new economic priorities and new technology (Cookie 1983) [4].
In Netherland, the “De Stijl” was established as an approach influenced by ideal geometric forms such as the perfect straight line and the Neoplatonic philosophy of mathematician Schoenmaekers. Its underlying philosophy also argued for embedding a certain logic and design rules within architecture.
The relevant issue highlighted assumes the necessity to develop a design process that is more systematic and even scientific combining the pursuit of modernity with the pursuit of knowledge. Therefore, architecture is considered as the result of an unveiling or a rediscovery process or even as problem-solving process similar to that of solving a mathematical problem.
It could be argued that design based on rules is influenced by mathematics and logic. In the right sense, neither Russian constructivists nor Dutch De Stijl’s theories would have been realized without mathematical developments at the beginning of the twentieth century. Therefore was ought to indicate the relevant role mathematical ideas not only those related to geometry, but even logic as an essential factor influencing architecture.
Since the early 1960s, Christopher Alexander has been arguing for the development of design rules in architecture and urban planning. He designed a set of rules and process to offer solutions for various urban design contexts. Alexander’s Pattern Language showcases several algorithms to solve urban design issues. These include topics such as street corners, street pedestrian view, public spaces, access points, among others (Alexander 1977) [5].

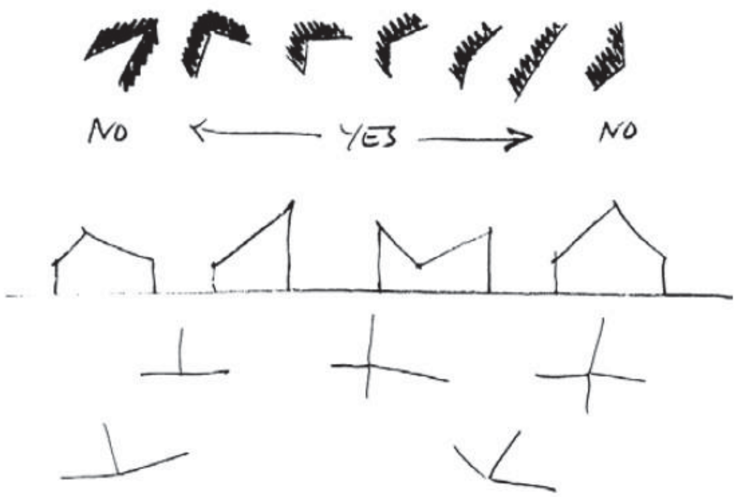

Fig.4. Chsitopher Alexander designed a set of rules, and processes to offer solutions for various urban design contexts [5].

In addition, many experimental architects like Peter Eisenman base their work on the assumption that architecture is based on such settled design logic. Eisenman described (House X) as a series of “Transformational diagrams” in order to define the process of design. His design rules were expressed in how the design evolves (Eisenman 1983) [6].

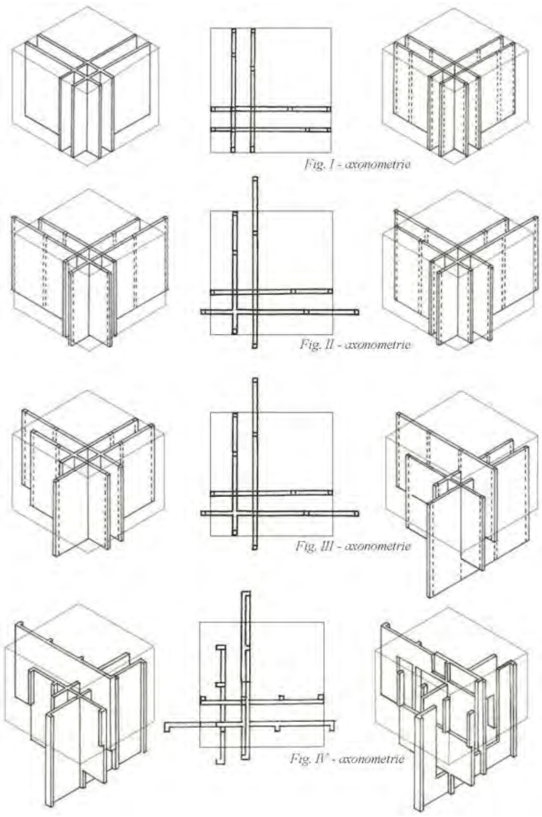

Fig.5. Eisenman described (House X) in a series of “Transformational diagrams” to define the process of design [6].

In the early 1970s, Benoit Mandelbrot evolved a new type of mathematics called fractals capable of describing and analyzing the structure irregularity of the natural world. Fractals are forms with detailed structure on every scale of magnification (Mandelbrot 2004) [7]. Fractal geometries and theories also had an enormous influence on architecture within the twentieth century and specifically on the development of the concept of generative systems in design.

Several of the examples discussed above represent design approaches that intentionally or not attempt to develop a generative system although without apparent formalism. Currently, there are a number of existing formalized generative systems divers from mathematics and computer science. That have been applied within an architectural design context such as Cellular Automata; L-Systems and Shape Grammars.

Generative systems are formalized mechanisms that are capable of producing alternative solutions. Generative systems provide the ability to create complexity, many orders of magnitude greater than their specification, whereby interacting components of a given complexity generate aggregates of far more significant behavioral or structural complexity. Generative Design System exploits the principle of generating complex forms and patterns from a simple specification in order the

supervision of an architect (McCormack et.al.2004) [8].
It should be noted however that the development of a generative design system is only possible after identifying the design objectives and intent in order to entails defining rules, relationships and algorithms.

3.Why Generative synthesis systems?

When we explore design processes to provide for a design solution, we typically explore various concepts, methodologies, geometries, materials and compositions. Selection and comparison are only possible when we have a number of alternatives.
Herbert Simon (Science of the Artificial) [9] described create a loop of Generate and test. If we were to consider design as such, we may represent our design process in the diagram shown below:

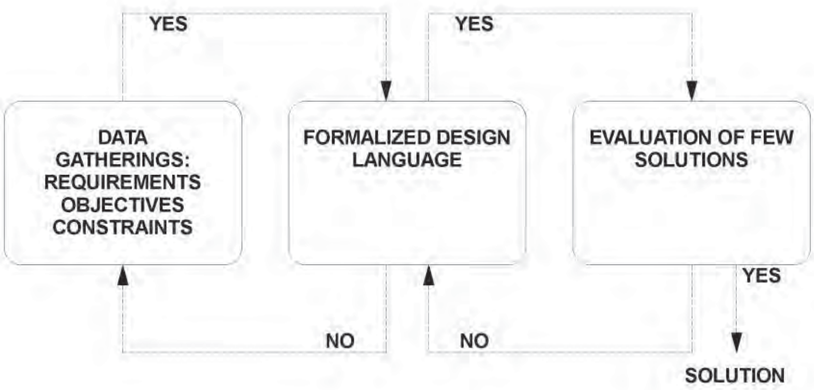

Fig.6. design a loop of Generate and test.

The combination of a generative synthesis system with a design process is only possible after formalizing a precise definition of design objectives, a set of generative design procedures, and the language expressing it. The diagram below suggests a provisional process of such integration.

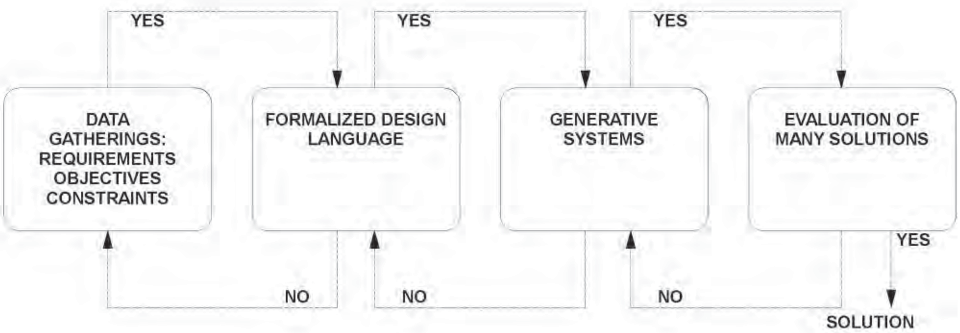

Fig.7. provisional process of the integration ofa generative synthesis system with a design process.

3.2 The analysis System

Vitruvius frequently called “the father of contemporary architecture” formed fundamental principals regarding architecture. These principles were *firmitas, utilitas* and *venustas* – strength, utility and beauty (Morgan 1914) [10]. It could be argued that Vitruvius in the first century BC constituted a system of analysis to facilitate assessing quantitative and qualitative aspects of architecture design. Strength and Utility could be measured and are value driven. They indicate an objective assessment of the architectural approach and therefore represent quantitative features of the model. Beauty attributes however are not of a constant value and rather mean a subjective notion. Beauty submits to qualitative features of the model. The quantitative features could include the building construction initial cost, the building running cost or even the building’s return on investment in the case of commercial buildings. The environmental and energy features could include aspects like daylighting, thermal, indoor air quality, acoustics, or even structure.
The quantitative features in the building design are much harder to gauge or identify such aspects affected by social requirements or aesthetics and style preferences.

3.3 Proposed Methodology.

The key properties of generative performance based design system can be compressed according to the following stages:
Design concept, Hierarchies and levels, and a Generate and Test loop which combines both generative and analysis systems. However, the previous phases cannot be treated separately because of the inherent relationships that exist between them and how they affect each other.

3.4 Design concept.

Developing a design concept is the initial step on any approach to design. The building design concept is influenced by aspects that include building program, cost, and social and historical conditions. Building program information such as functional program, main building assumptions, public and private space or commercial space are necessary for developing the design concept.
Economical conditionings and aspects also present significant factors that determine design strategies and goals. Social, as well as historical conditionings, also help set the stage and draw both on the contemporary reality and on experiences of the past.

3.5 Hierarchies and Levels.

A hierarchy defines a system as being composed of several subsystems, each of which can also have their own authorities. A hierarchy can also be seen as a collection of parts with ordered asymmetric relationships inside a whole. That is to say, upper levels are above lower levels, and the relationship upwards is asymmetric with the relationships downwards (Simon 1996) [10]. A developed design concept can be broken into hierarchies and levels to handle design complexities and simplify the design process. Each level within the system includes a generate and test loop.

3.6 Generate and Test Loop.

Within a design process designers while seeking a design solution typically initially propose certain geometries and compositions and then reflect on the results and analyze and evaluate the solution, and then investigate certain modifications to the proposal that might present more potential and then repeat the process. This is what is referred to here as a Generate and Test Loop (Rowe 1998) [11]. The generative-and-test loop is in essence a trial-and-error process. However, the results of tests are specifically used to guide successive attempts to generate solutions. Moreover, the procedure takes place in the environment of definite, explicitly enclosed problems.

3.7 Generative System.

The Generative System I m proposing includes the following elements: parameters (constants and variables), constrains, rule set, and algorithm.
Typically, after the system constants are set, the rule application is initiated, and is restricted by the system constrains. The system variables will control the design variation. These elements work collectively within the algorithm to multiply a design solution each time the algorithm runs.

3.8 Parameters.

The parameter is a measure or value on which something else could depend on. The architect and design team define what sort of parameters can be expressed as constants within the design and what parameters are able to pass on as variables. Constants could be defined as a word expressing a property, quantity, or relation that remains unchanged under specified conditions. However, variables could be defined as something that can be changed and varied. There are different types of variables, manipulated variables and responding variables.

3.9 Constraints.

A constraint could be defined as a restriction on the degree of freedom in the process of providing a solution. Each constraint has the potential to restrict our ability to deliver a solution as we visualize it. Therefore, each constraint must be carefully considered as part of planning process. In proposed methodology, constraints could be divide of two types, geometric, and functional or performance constraints. The geometric will control geometric characteristics such as building height, internal spaces, area, etc. The functional or performance attributes such as the minimum illumination required for an interior space or the maximum solar intensity allowed on an external surface, etc.

3.10 Rule Sets.

A set of form rules must be first extracted from the design concept. The rules specify how each of the shapes in the grammar is replaced with another form. The system begins with the axiom and replaces each of its shapes according to the form rules to produce a new combination of forms. This process of shape replacement continues until an individual way rule is triggered terminating the process.
These shape or design rules are the basis of the generative design system. The generated design alternatives fall within the design space generated by the rule set.

3.11 Algorithms

Algorithms describe a process or sequence to be followed in calculations. This course should consist of unambiguous instructions for solving a problem and for obtaining the required output for any valid input in a finite amount of time. Algorithms are descriptions and blueprints for building design. These descriptions however require clearly defined objectives and design languages.

3.12 Analysis system.

Analysis could be defined as a measure of how well a proposed design solution fits the objectives it is planned to assemble. An analysis system resembles a lab that test alternative solutions. Solutions created within the generative system are handed down to the analysis system in order assess their behavioral and performance characteristics. Here my focus is on quantitative aspects of the design. An analysis system in this sense infers certain attributes from a design solution that are relevant to a particular discipline. In doing so, the analysis system operates on the design solution date through laws of physics and geometry to produce the desired rating. It also depends on specialized disciplinary knowledge such as heuristics, formulae, or simulations to inform how this date is transformed into performance characteristics.

3.1Current examples of generative design processes

Describing design processes in algorithmic terms, relationships, and parameters can be found in many fields such as origami, art, and architecture.

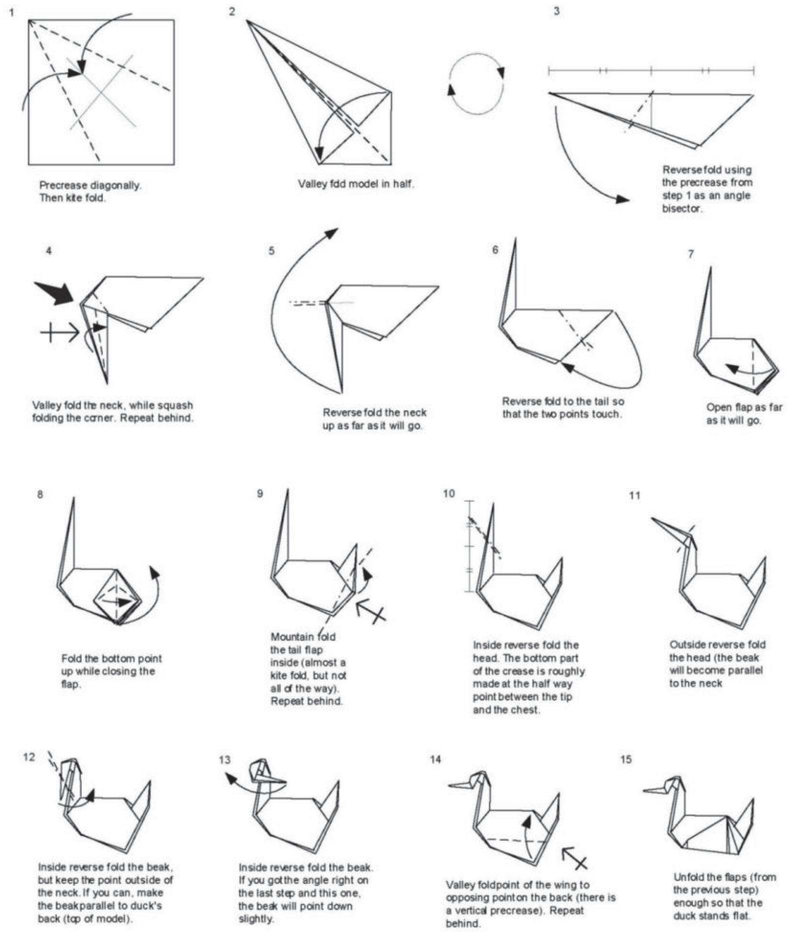

Fig.8. Algorithm for folding an origami paper duck.

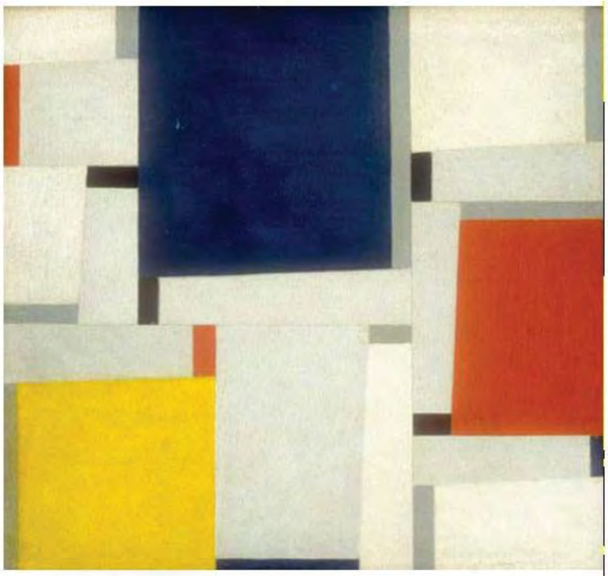

Fig.9. Fritz Glarner's paintings were structured around design rules. Some designs following a Pin-wheel pattern, while others followed "split in half" model.

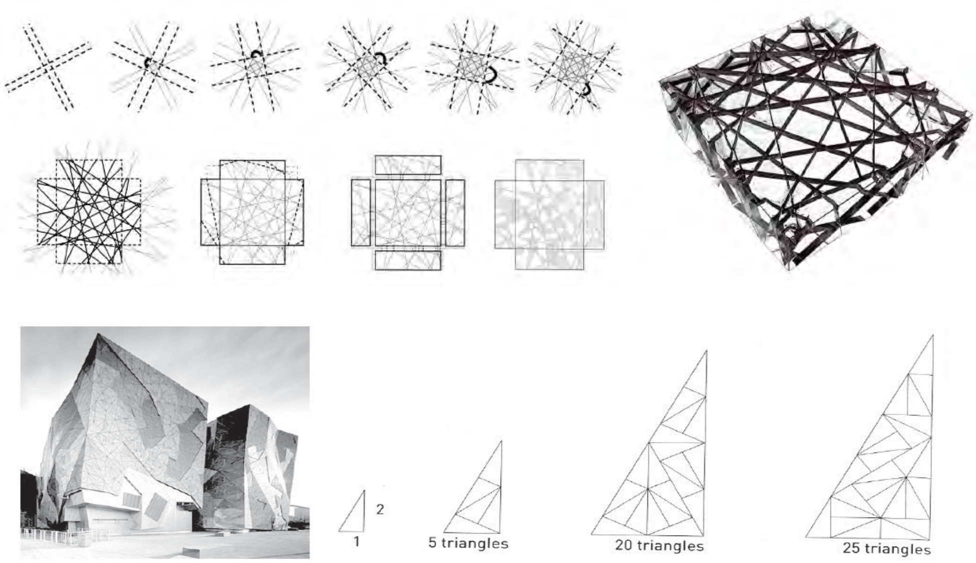

Fig.10.Serpentine Pavilion and Federation Square a sample of alghorithms in shape creation process. Cecil Balmond and Toyo Itto devised an algorithm to create Serpentine Pavilion. Lab-Architecture used a fractal algorithm to design the skin of Federation Square.

We have witnessed a large number of design explorations in the field of architecture that utilized generative design systems. However, there seems to be no structured approaches for studying them; a clear methodology to critically assessing their potentials and limitations; and most importantly a conceptual understanding of how to build them, when to utilize them, and the value for integrating them with our classical design processes.

4. Conclusions.

In this paper, I demonstrated a Generative Design methodology that could be applied in practice. In the next stage seems to relevant to demonstrate the application of proposed method within design experiments. The method starts by identifying a design concept. This design concept is then broken down into different levels and hierarchies. Each of these levels includes a generate and test loop in which a generative system produces a solution that an analysis system can prove. The generative system includes parameters, constraints, rule sets, and algorithms. The analysis system tests for both qualitative and quantitative aspects. The system is relatively flexible and can allow the architect to maintain individual design intentions.
The methodology was able to generate solutions that have high-performance levels. This contributes to the building's sustainability that is an important current issue in the architecture discipline. My objective in the development of this method was to provide a powerful model system that can be included in early conceptual design phases. This proposed method can present both the architect and the client with better understanding of the design space and the effect of different design decisions.
The design system generated by the methodology provides for emergent properties that are only identified through the integrated interactions of the design elements as a whole. In addition, the system lends itself well to computation and simulation implementation. The processing power of the computer can provide for breeding capabilities. Also, the use of more sophisticated analysis tools would provide for more robust solutions.

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Tatsuo Unemi and Daniel Bisig

Visual deformation by swarm – a technique for virtual liquidization of objects. *(Paper)*

Topic: (Interactive Art, Swarm)

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[4] D. Bisig & T. Unemi, “Cycles – blending natural and artificial properties in a generative artwork,” GA 2010, Milan, 2010.

Abstract:

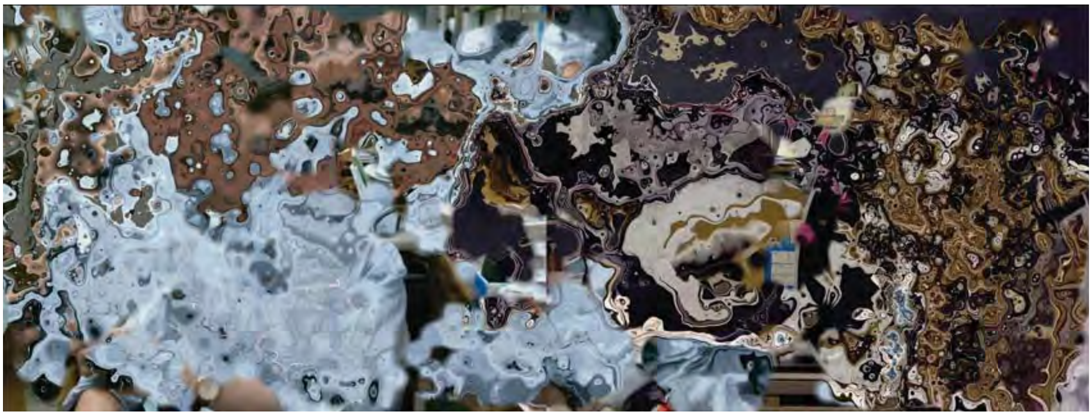
Swarm simulation is a useful technique to produce complex dynamic patterns as response to any type of realtime changes of environment as shown in our previous works [1-4]. This paper presents a method to use it to generate interesting patterns of deformation in order to provide a virtual experience to visitors as if their bodies are liquidized.

It is possible to realize any type of deformation of a 2D image if appropriate distribution of 2D vectors over the image area is given. Assigning a position in the original image for each agent, such distribution that is changing dynamically is easily organized by combination with an interpolation method of continuous vector field. By starting from uniform distribution of agents each of which memorizes its starting position, the movement of swarm produces a dynamic pattern of deformation gradually changing from original to chaotic.

For our new interactive installation named *Visual Liquidizer or Virtual Merge*, we employed BOIDS algorithm in 2D space as the basic mechanism to design the swarm activity. It forms a type of flocking behaviour similar to birds and fish by local interaction among individual agents. To restrict the area of deformation into the part of target object, namely visitor's body, we organize another type of swarm controlled by ANT algorithm, that densely inhabits the target area and sparsely inhabits the background area. Each ANT agent is attracted by virtual chemicals supplied at the area where the target is detected by background subtraction or depth information from the Kinect sensor. The chemicals gradually evaporates and diffuses to form distribution of density gradients as to summon the agents properly. Each BOIDS agent is paired with an ANT agent in one-to-one relation, and only the BOIDS agents whose partners are in the target area contribute to form the swarm. The continuous distribution of 2D vectors in the rendered area is computed based on the distribution of BOIDS agents each of which provides the position of paired ANT agent as a sample point.

To provide more impressive experience for visitors, we added two mechanisms; to temporarily reunite some recognizable parts of original image, and to return the scattered image perfectly back to the original one at the final stage.

All of computation for image processing, swarm simulation, and rendering work fast enough in a recent hi-end personal computer by utilizing parallel processing in both CPU and GPU even if the number of agents is more than 10,000. We hope this technique will provide a hint to create an alternative representation for new media arts.



An example deformed image by swarm.

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Keywords:
Interactive art, Visual feedback, Swarm, Visualization

Visual Deformation by Swarm – a Technique for Virtual Liquidizer of Objects

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Premise

This paper presents a method to apply a type of swarm simulation to generate interesting patterns of deformation that provides an experience to visitors as if their bodies were liquidized. Utilizing a combination of two different types of swarm formation algorithms, BOIDS and ANT; it is possible to focus the deformation only on the part of visitors' bodies captured by live cameras. This mechanism organizes a distribution of 2D vectors on the display area. The final image on the display is rendered using an interpolation algorithm that generates spatially smooth image in any resolution by taking an advantage of GPU power. Parallel processing by multi-core CPU is also helpful to guarantee the smooth movement and quick response for interactive installation.

1. Introduction

Swarm simulation is a useful technique to produce complex dynamic patterns as response to any type of real-time changes of environment as shown in our previous works [1-4] and many others such as [5]. The mechanism was developed as models of collective behavior of animals mainly in the researches of Artificial Life to deepen our understandings on biological complex system. The targets include herbivore, birds, fish, grasshoppers, mosquitos, ants, termites, and so on. Usually, the movement of the simulated swarm is used as a type of brush strokes to draw aesthetic patterns by computer, but we propose here a method to use it to generate a type of deformation in order to provide a virtual experience to visitors as if their bodies were liquidized.

It is possible to realize any type of deformation of a 2D image if appropriate distribution of 2D vectors over the whole area of the canvas is given. Assigning a position in the original image for each agent, such distribution that is changing dynamically is easily organized by combination with an interpolation method of continuous vector field. By starting from uniform distribution of agents each of which memorizes its starting position, the movement of swarm produces a dynamic pattern of deformation gradually changing from original to chaotic.

For our new interactive installation named *Visual Liquidizer or Virtual Merge* [6], we employed BOIDS algorithm in 2D space as the basic mechanism to design the swarm activity. It forms a type of flocking behavior similar to birds and fish by local interactions among individual agents. To restrict the area of deformation into the part of target object, namely visitor's body, we organize another type of swarm controlled by ANT algorithm that densely inhabits the target area and sparsely inhabits the background area. Each ANT agent is attracted by virtual chemicals supplied at the area, where the target is detected by background subtraction or depth information from the Kinect sensor. The chemicals gradually evaporate and diffuse to form distribution of density gradients as to summon the agents properly. Each BOIDS agent is paired with an ANT agent in one-to-one relation, and only the BOIDS agents whose partners are in the target area contribute to form the swarm. The continuous distribution of 2D vectors in the rendered area is computed based on the distribution of BOIDS agents each of which provides the position of paired ANT agent as a sample point.

To provide experience that is more impressive for visitors, we added two mechanisms; to temporarily reunite some recognizable parts of original image, and to return the scattered image perfectly back to the original one at the final stage.

The following sections describe details of behavior models of swarm, an interpolation method to organize a continuous vector field, techniques of parallel processing to accelerate the response speed, additional mechanisms of reunion and homing, and then some concluding remarks.

2. Swarm

We employ a combination of two different models of swarm behavior here, ANT and BOIDS.

ANT algorithm is a model of collective behavior of ants and termites. They live in the well-constructed nest as a group of large number of individuals. Each individual has its own role in the organization. The most individuals are the workers for nest maintenance, larva care, and foraging. The model focuses on the teamwork by workers who seek and gather foods from outside of the nest to feed all of members of the group. It is still an unsolved mystery in the field of ethology, but one of the well-known hypothetical mechanisms behind the teamwork is a communication through the pheromone, a special biochemical each individual produces and senses. In a typical ants living in the nest under ground, foraging workers start roaming from the nest every morning in almost random walks. Once a worker discovers a food, such as a dead body of another insect, she carries it back to the nest if possible. In case the object is too large to bring alone, she releases pheromone on the ground. The chemical gradually defuses and spread around the place. It organizes a distribution of density gradients gradually descending from the food position to the surrounding area. Once another food seeker detects the pheromone on the ground, she stops random roaming and starts walking directed toward higher density of the chemical. As the result of a number of workers gather together around the food, they carry it to the nest by cooperation. If the food is decomposable by individual workers to carry its small part by each, they organize a long stable line of transportation between the food site and the nest. Because the chemical on the ground gradually becomes thinner by evaporation, the line breaks after they finish carrying all of foods. This mechanism is called pheromone trail that inspired a useful method to find an optimal route in a decentralized system in the industrial applications such as packet routing in the communication lines and traffic planning in the transportation system. These application-oriented researches and developments are on going under the name of Ant Colony Optimization [7]. The team organization mechanism by pheromone is a type of communication mediated by signals recorded in the environment, but not a direct mutual conversation between individuals.

We employ ANT algorithm to follow the target area in the 2D space. The attractant chemicals are not provided by individual agent, but the image processing algorithm places a fixed amount of signal in the cell of memory lattice corresponding to the 2D position. The signal spreads to neighboring cells by taking a weighted summation of the amounts, and decreases by multiplying a coefficient less than one to simulate the evaporation. When nothing is detected as a target, that is, there is no signal in the memory lattice; the each individual agent is roaming in a random walk relatively fast. Once an agent finds a gradient of signals at the corresponding position of memory, it starts moving slowly toward the direction of higher value of signals by observing the values in the neighboring cells. By adding an auxiliary repulsion force between agents, this mechanism achieves an efficient arrangement of agents where they gather and stay in the target area in higher density than the other area as shown in Figure 1.

Figure 1. A simple positioning of ANT agents. They gather in the target area with higher density.

BOIDS algorithm is a model of collective behavior of fish, birds and herbivores. They move together with a number of individuals with neither guidance from outside nor central control by a leader, but just a simple mechanism by each member. Such type of decentralized group behavior is useful to reduce a risk of a predator's attack. By splitting a group into subgroups when a single big predator is approaching, some subgroups will survive and it avoids extinction of whole of the original group. It is also helpful for long distance migration of birds and herbivores by finding an appropriate path by some members and following them by others. The development of the model of such behavior is useful not only to understand more about animal behavior in the context of ethology but also to develop software that simulates a group of such animals for movie animation. We can find the pioneering work of computer animation of mixture of fish and birds by C. W. Reynolds in late of 1980's [8].

In this model, each agent follows three types of rules in principal by observing the other neighbouring agents surrounding it. Those are cohesion to gather, repulsion to avoid collision, and alignment to move together. With some additional parameters such as physical coefficients of mass and friction, limitation of observable area from each agent, delay of reaction, limitation of acceleration and speed of both translational and rotating movements, and so on; it is possible to develop a variety of behavior styles from mosquitos to geese.

We use this algorithm to produce a complex pattern in 2D plane. An alternative method might be a simulation of fluid and powder by particles or finite (or boundary) element methods. Those techniques seem more natural for simulation of flowing liquid than BOIDS, but here the objects to be liquidized are not simple physical entities but living things, that is, visitors' bodies. BIODS is more effective to produce unpredictable complexity which provides an illusion to the visitors as if there were something alive behind the observation.

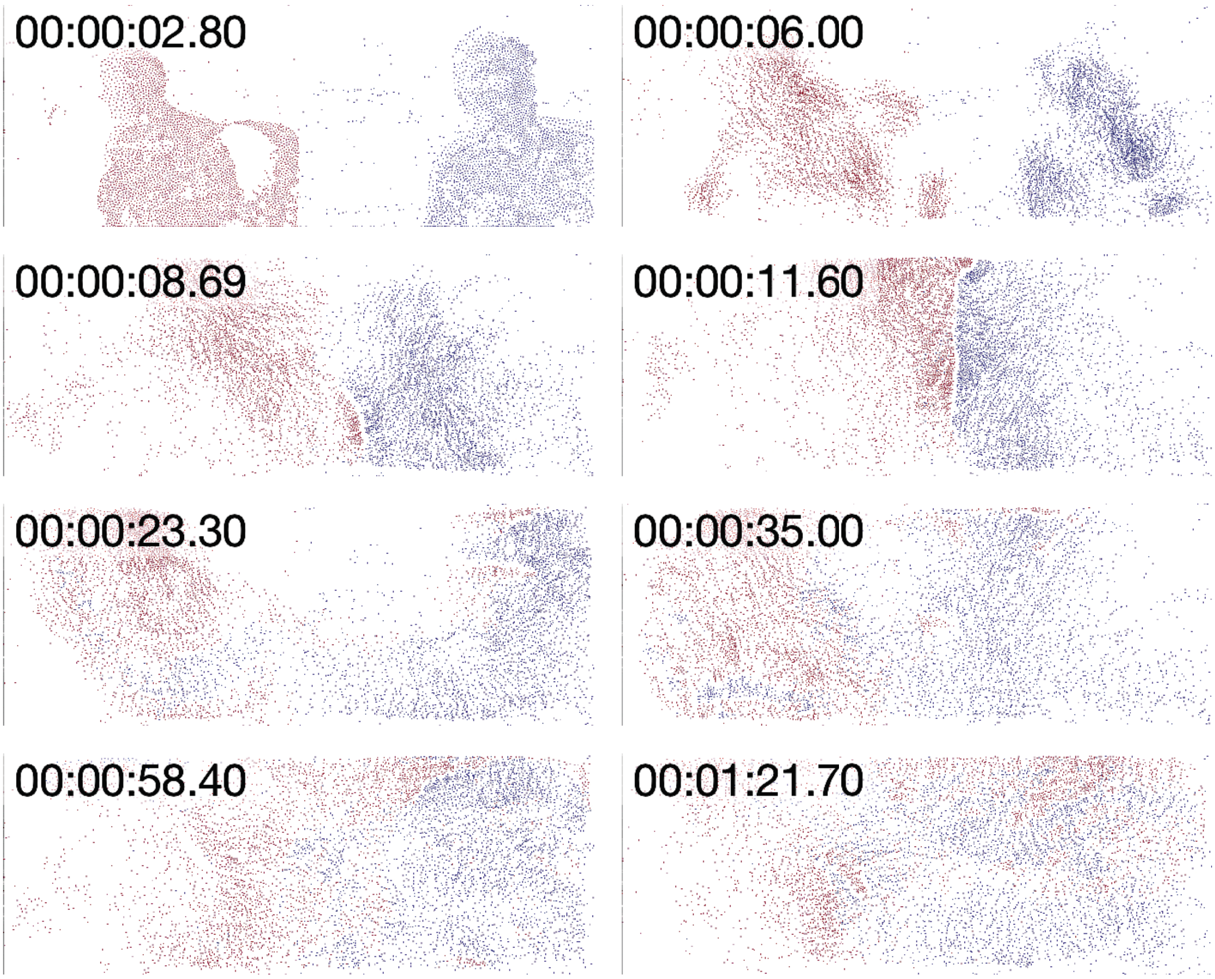

Figure 2. A sample movement of BOIDS agents in Visual Liquidizer or Virtual Merge. Blue dots are agents whose partners are at the left target and red dots are agents whose partners are at the right target. The frame sequence begins from the top left, and proceeds toward the bottom for each line scanned from left to right.

Each agent is coupled with one of the other type of agent in one to one relation, that is, the population is organized by a number of pairs of one ANT agent and one BOIDS agent for each. BOIDS agent is just carrying the 2D coordinate of coupled ANT agent's position to another position. By allowing the BOIDS agents to participate the collective behavior only if the partner settles in the target area, it is possible to produce a deformed pattern only of the target object. By assigning the same position of the partner ANT agent as the initial state, the movement of BOIDS swarm produces a dynamic deformation process that gradually changes the image from the original to chaotic. An example movement of BIODS agents is shown in Figure 2.

3. Interpolation

As described above, the arrangement of BOIDS agents provides a distribution of 2D vector expressing the position of ANT agent. We employ an interpolation method to construct a continuous distribution of 2D vectors to fill the area BOIDS agents are flocking. This distribution represents a function that maps a vector value to another vector value where both are indicating positions of 2D space. Each pixel in the final image is rendered with the color extracted from the indicated position of camera image according to this function. An alternative method is to interpolate not positions but colors. However, color interpolation produces grayish blurry image when the agents are fully mixed, though position interpolation results very complex textures.

In the interpolation method, the estimated value v_i at position p_i is calculated from a set of samples S by the following equation.

$$v_i = \begin{cases} v_i & \text{if } i \in S \\ \dfrac{\sum_{j \in S} w_{ij} v_j}{\sum_{j \in S} w_{ij}}, \quad w_{ij} = |p_i - p_j|^{-\alpha} & \text{otherwise} \end{cases} \tag{1}$$

where $| p_i - p_j |$ is the Euclidean distance between p_i and p_j, and α is a positive coefficient. The terrain of interpolated surface becomes smooth if this coefficient is larger than 2. In out application, v_i is the position of ANT agent, and p_i is the position of BOIDS agent. We use α = 1 based on our preliminary experiments for a variety of values. This setting makes pointed peeks at sampled points, but the rendered image looks more natural than the case of larger value of α even when the sample points are sparsely positioned.

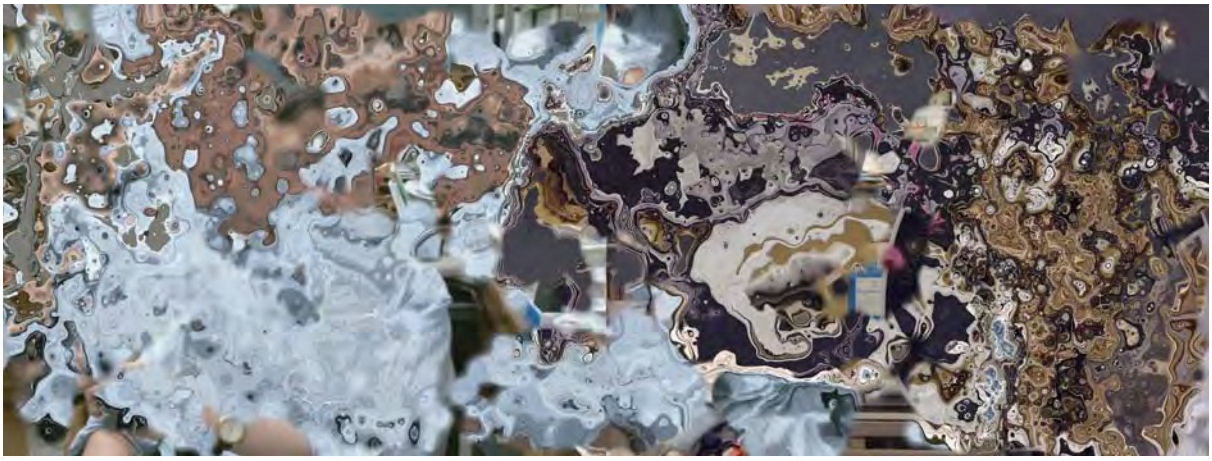

Figure 3. A sample image rendered with the interpolation algorithm from a set of distributed sample points.

To render the deformed image, it is necessary to compute the above equation for each pixel of the image unless the pixel position is far away from any sample points.

Theoretically, it requires the computational cost proportional to the number of pixels multiplied by the number of sample points. Because the target application of this algorithm is a type of real-time visual interactive installation, it is an important point whether the rendering process of one frame image finishes within 1/30 second in order to guarantee a smooth motion and quick response. The other parts of computation necessary to drive this installation are also relatively heavy as described later, but this part is the heaviest because the display of required resolution includes approximately half a mega pixels. The detail of parallel processing to reduce the computation time is described in the later section. Figure 3 shows a sample image of display generated with this algorithm.

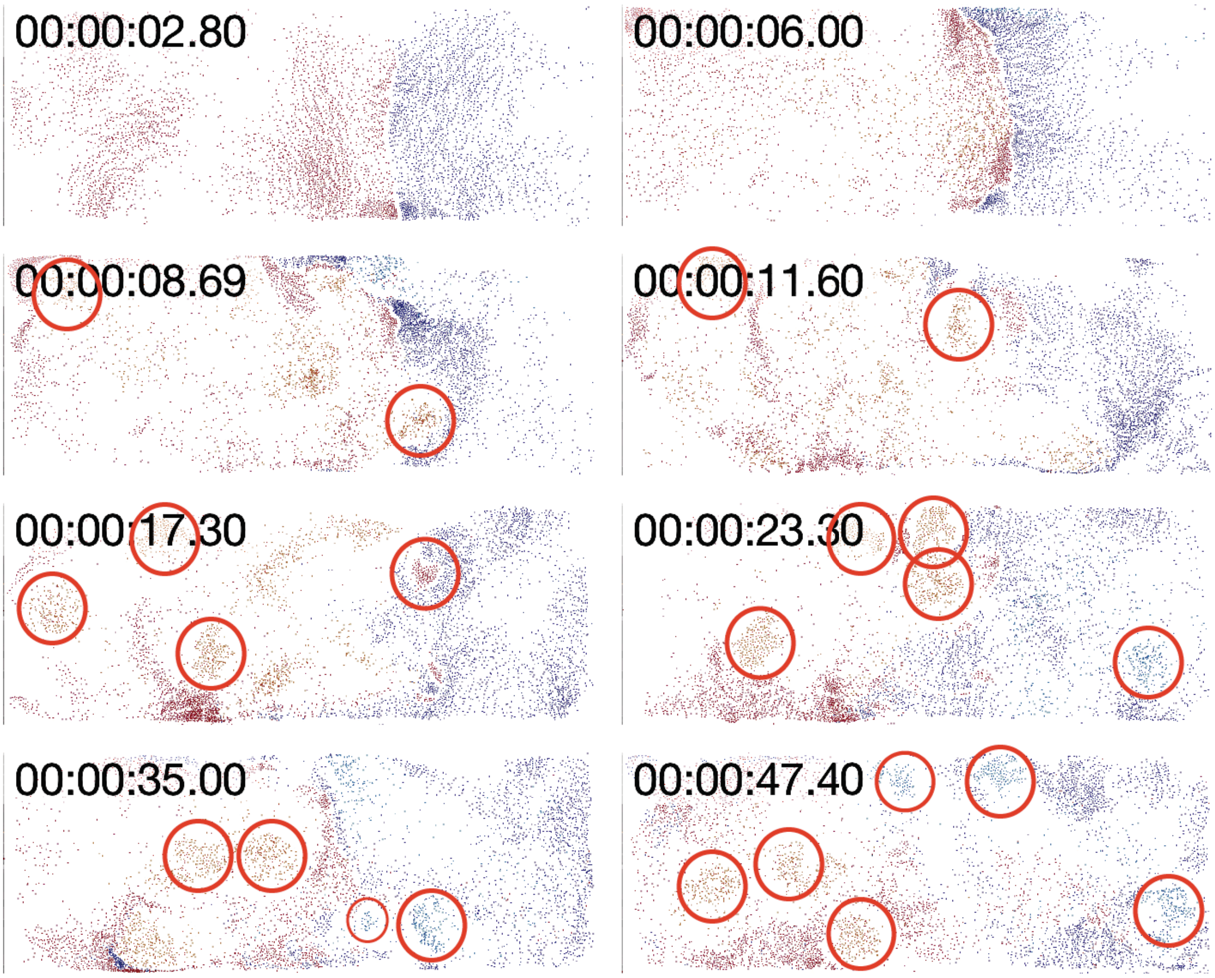

Figure 4. A sample movement of BOIDS agents with "reunion." The red circles indicate the positions where reunions are organized.

4. Reunion

As you can easily imagine, after a several minutes of mixing motion of BOIDS agents, the deformed image becomes too complicated to recognize what the original image is. Sometimes it occasionally produces beautiful dynamic visuals typically when the original camera image contains a number of different clear colors. Of course, there is no guarantee that the visitors are wearing such colorful clothes. It is more effective if the scattered elements reunite so that the visitors can recognize a part of their body is flowing. To realize this type of spontaneous reorganization, we designed and implemented reunion mechanism as described below.

The reunion is a group of BOIDS agents whose partners are located in the neighbouring place in the target area. The reorganization starts by random selection of one agent who becomes a leader of the group. For each of simulation step, each member of the group tries to find a newcomer whose partner is at the near position from its partner. This finding process is conducted targeting the BOIDS agents within the view range, together with the calculation of mutual influence in the basic collective behavior described above. When a member finds an appropriate candidate of newcomer, it sends invitation if the candidate neither belongs to nor be invited to any group of reunion. The invited agent moves toward the relatively proper position from the inviter paying less attention to the force of BOIDS behavior so that the reunion makes recognizable part of original image. The leader distributes the angle of reorganized image for each member in order for members to determine the proper relative position from the neighbouring members. A member leaves from the group when the partner lost the position in the target area. If it happens on the leader, one of the neighbouring members inherits its role. The reunion breaks when the predefined length of duration elapsed from the starting time of reuniting process. Figure 4 shows an example of movements including reunions.

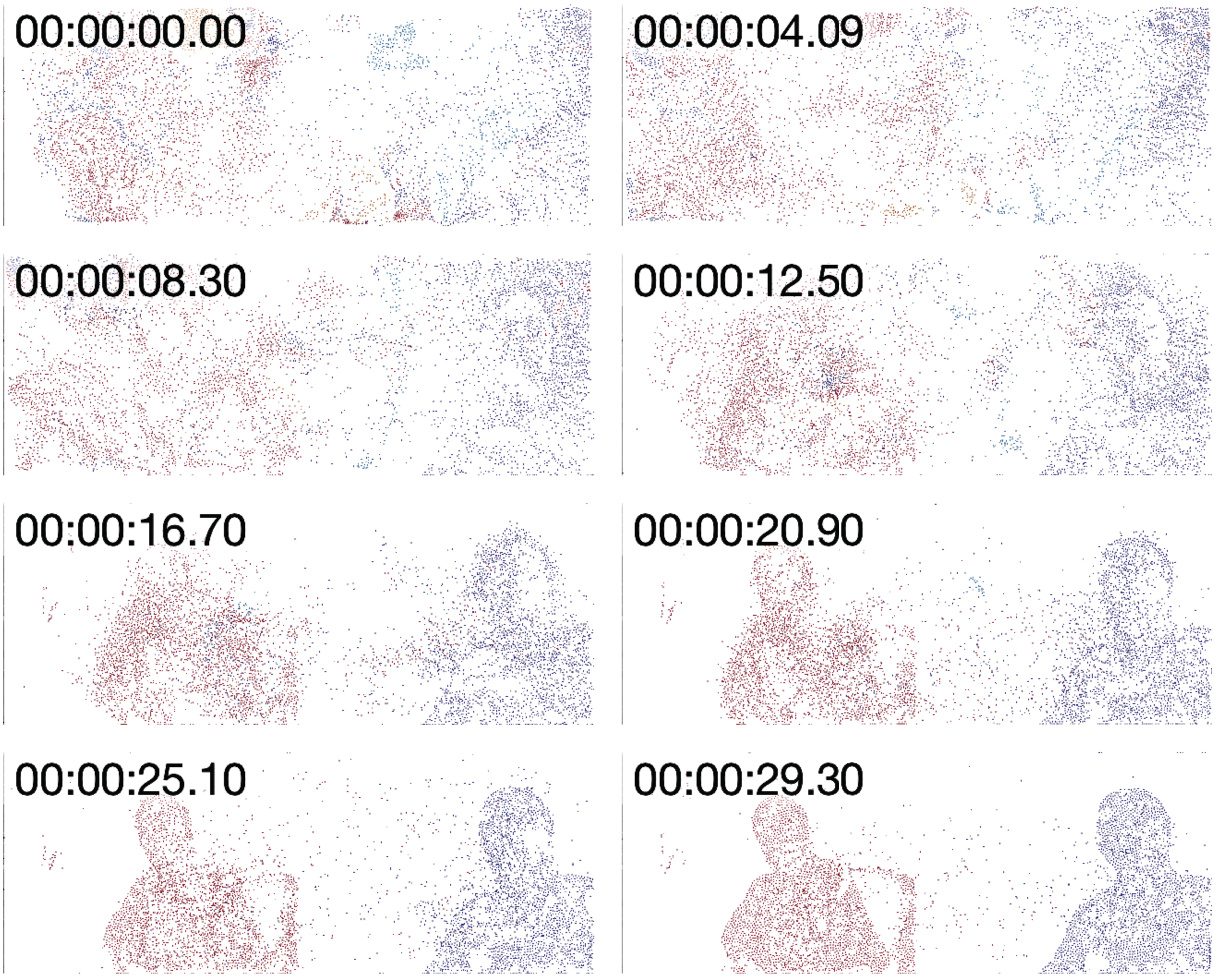

Figure 5. A sample movement of BOIDS agents on homing process.

5. Homing

We introduced a process of turning the scattered BOIDS agents back to the position of their partners for each in the final stage of appreciation by visitors. As similarly as the case of reunion described in the above section, each agent pays its attention to the partner's position as its own goal. Differently from the case of reunion, the weights of balance between flocking and homing behaviors are gradually changed as increasing the ratio of homing. Using the predefined fixed time coefficient, typically 10 seconds, the weight value of flocking behavior exponentially decreases. The agent coheres with its partner and does never move apart once it reaches the position near enough to the goal. The displayed image shifted gradually toward the camera image by dissolving transition effect after the average distance to the goal position over all of BOIDS agents became small enough. By this mechanism, the visitors' figure on the display is reformed back to the mirror image, and it makes them recognize that the show ended. Figure 5 shows an example movement of homing process.

6. Parallel processing

The system needs to compute four types of tasks in order to work as a completed interactive installation, that is, image processing, swarm simulation, image rendering, and sound synthesis. The detail of image processing and sound synthesis is described in another article [6], and the following part of this section describes the other two tasks.

The task that simulates swarm behavior is not light because it needs to care a number of agents and their mutual influences. In the installation, we use thousands of agents to obtain a complex smooth pattern that looks like not particles but liquid. To reduce the computational time, we divided the space into a lattice of 24 by 9 cells to manage the agents in order to shorten the calculation to discover the other agents in the view range for each one. The aspect ratio of grids was induced from the size of 2D space area that consists of 1,280 by 480 pixels in which two VGA camera images are horizontally arranged. This part was implemented mainly utilizing a multi-threading on multi-core CPU.

The heaviest task is the rendering process using the interpolation algorithm as described above. It theoretically requires the computational cost proportional to the multiplication of the number of pixels and the number of agents. The color value for each pixel over the rendering area is determined, referring to the coordinates map calculated with the above equation 1. It is easy to compute in parallel by storing the data in a frame buffer of GPU. To organize the map of 2D coordinates in a frame buffer from the data of swarm as the distribution of sample points, we need to accumulate the weighted 2D values for all of sample points for all of pixels. Because for each pixel the weight value of sample points at the position far away from the pixel is very small, those influences are ignorable. Instead of the iteration over all pixels, we designed the algorithm that iterates over all of sample points to accumulate the distribution of weighted 2D values onto the frame buffer within a restricted area where it affects in some degree of significance. Weighted summation is easily realized with a blending function that adds a source value to the destination value multiplied by the opacity.

Due to the improvement of GPU's power in recent years, our installation runs fast enough for smooth animation and interaction on the personal computer, such as Apple's MacBook Pro with 2.3 GHz Intel Core i7 and NVIDIA GeForce GT 750M. We are using the fixed resolution of camera image in 640 by 480 pixels for each, but the display resolution is flexible. It is possible to render the very smooth image on the 4K display in full screen size using the latest MacPro.

7. Conclusion

We introduced our approach of swarm simulation that produces a unique style of representation for a visual interactive installation. Combination of two different types of algorithms is very effective to integrate the required processing including computer vision as input and image rendering as output. All of computation work fast enough in a recent hi-end personal computer by utilizing parallel processing in both CPU and GPU even if the number of agents is more than 10,000.

We hope this technique will provide a hint to create an alternative representation for new media arts.

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Zita Sampaio

BUILDINGS MAINTENANCE SUPPORTED ON VIRTUAL ENVIRONMENTS *(Paper)*

Topic: Virtual Environment

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Abstract:
The text presents the description of a research work that has as its main objective the development of a technological tool to support the maintenance activity of buildings, with resort to new information and visualization technologies. There were analyzed three main components of the building: roofs, facades and interior walls. A building's roof covering of ceramic tiles constitutes a component of its surrounding and possesses an important function in the performance of an edifice, namely in its protection against the permeation of moisture and rain water; Facade coatings play a significant role in the durability of buildings, since they constitute the exterior layer that ensures the protection of the wall against the aggressive actions of physical, chemical or biological nature; The paint coating applied to interior walls conveys their aesthetic character, performs an important function of protection, and is exposed to agents of deterioration related to the building use. A survey of the main anomalies that occur in these components, the respective causes and the adequate interventions, in order to plan maintenance strategies was conducted. The information collected serves as a basis in the implementation of applications using interactive visualization technologies, to support the planning of building maintenance. During this work the basic knowledge related to the materials, the techniques of rehabilitation and conservation and the planning of maintenance is outlined and discussed in addition, methods of interconnecting this knowledge with the virtual applications were explored. The implemented prototypes were trialed in real cases. This research work brings an innovative contribution to the field of maintenance supported by emergent technology.

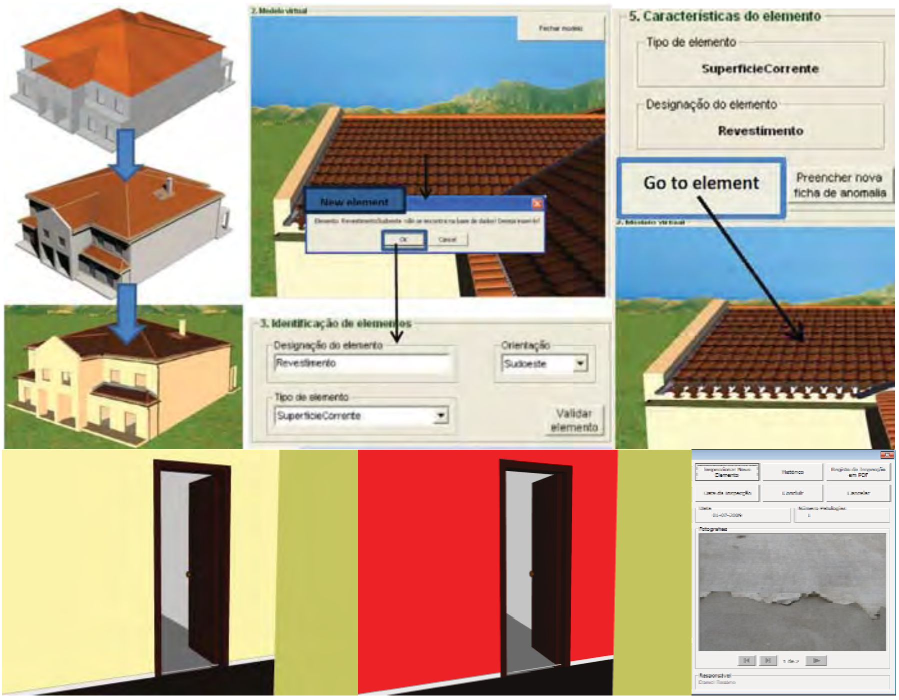

Figure: Images of the interface of VR applications

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Keywords:
Buildings, Maintenance, Interaction, Virtual Reality, Virtual Environment

Buildings maintenance supported on virtual environments

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Abstract

The text presents the description of a research work that has as its main objective the development of a technological tool to support the maintenance activity of buildings, with resort to new information and visualization technologies. There were analysed three main components of the building: roofs, facades and interior walls. A building's roof covering of ceramic tiles constitutes a component of its surrounding and possesses an important function in the performance of an edifice, namely in its protection against the permeation of moisture and rain water; Facade coatings play a significant role in the durability of buildings, since they constitute the exterior layer that ensures the protection of the wall against the aggressive actions of physical, chemical or biological nature; The paint coating applied to interior walls conveys their aesthetic character, performs an important function of protection, and is exposed to agents of deterioration related to the building use. A survey of the main anomalies that occur in these components, the respective causes and the adequate interventions, in order to plan maintenance strategies was conducted. The information collected serves as a basis in the implementation of applications using interactive visualization technologies, to support the planning of building maintenance. During this work the basic knowledge related to the materials, the techniques of rehabilitation and conservation and the planning of maintenance is outlined and discussed in addition, methods of interconnecting this knowledge with the virtual applications were explored. The implemented prototypes were trialled in real cases. This research work brings an innovative contribution to the field of maintenance supported by emergent technology.

1. Introduction

The main aim of a research project PTDC/ECM/ 67748/2006 [1], was to develop virtual models as tools to support decision-making in the planning of construction management and maintenance. Virtual Reality (VR) technology can support the management of data throughout the lifecycle of a building, allowing interaction and data visualization. Factors such as the constant exposure of the coating materials, like ceramic tiles in roofs and facades, stones and painted surfaces in facades and interior walls, to the weather, pollutants and the normal actions of housing use, linked to its natural ageing and, in some cases to the unsuitable application of construction materials or systems of painting give rise to its deterioration and to the appearance of irregularities, which can negatively affect its performance as both an aesthetic and a protective element. According to Lopes [2], in normal conditions of habitation use and when correctly applied, a paint coating can remain unaltered for about five years. To perform maintenance activities a survey of failures in the building must be conducted in order to arrive at the best solution for repair and maintenance.

The Virtual Reality (VR) technology is actually used in areas like education as a teaching support tool or in planning processes concerning industry as a collaborative tool. In architectural design studio, Abdelhameed [3] applies micro-simulation function, inside a virtual reality environment, using the VR Studio program, in order to provide the students with an effective tool to select and visualize a structural system and its construction process. Sampaio and Martins [4] present didactic VR models applied to the construction of bridge field, and developed a set of learning activities for students, in the Engineering Graphics subjects, in order to acquire, develop and improve their levels of spatial skill and, for that purpose; they have structured training with VR, Augmented Reality (AR) and PDF3D technologies. Fillatreau et al. [5] develop a framework for immersive industry checklist-based project reviews, combining immersive navigation in the checklist, virtual experiments and multimedia update of the checklist, relied on the integration of various VR tools and concepts, in a modular way, and Menck et al. [6] uses VR as a tool for collaboration to exchange information and data has increased significantly over time in production-related areas.

2. Interactive Applications

The developed VR models can be considered as useful computer tool with advanced visualization capacities in the maintenance field. The kind of building material that composes the roofs, façades and the interior wall has a continuous lifestyle, so requires the study of preventive maintenance (the planning of periodical local inspections) and of corrective maintenance with repair activity analysis. The models of maintenance facilitate the visual and interactive access to results, supporting the definition of inspection reports, whether in new constructions or those needing rehabilitation. These applications can be easily transported to any building place in order to obtain adequate anomaly surveillance and a consequent methodology of rehabilitation, supported on the data base. The interaction and the data visualization allowed by the models turn these applications simple and direct to work with.

The implemented prototypes, concerning three building components, roofs [7], facades [8] and interior walls [9], incorporate interactive techniques and input devices to perform visual exploration tasks. The following computational systems were used in there development and the scheme of links between software is presented in Figure 1:

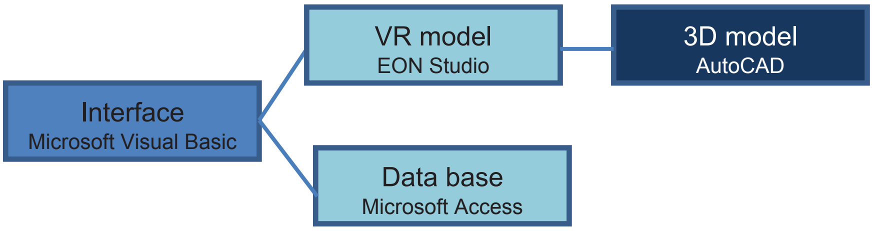

Figure 1: Scheme of links between software.

2.1 The VR model of roofs

The roof covering is the most effective element of a building's surrounding in its edification performance, and, as such, must be efficient in the face of mechanical, thermal, solar radiation and water action [10]. Although several covering materials can be applied in the execution of pitched roofs, the most frequently applied covering in Portugal is the ceramic tile [11]. As the covering performs a predominant role in the protection of buildings, namely against moisture permeation, it requires a greater attention in regards to the analysis of its deterioration process. The developed VR application supports the inspection activity [7].

An in-depth study on the anomalies that might occur, and the most likely causes associated with the different elements of the roof, are contained within the database. To maintain the ease in structuring the database, the causes and the intervention are both linked to the anomaly. Table 1 illustrates two examples of anomalies associated to the type of element (current surface and singular covering points), respective provable causes and recommended interventions.

Table 1. Anomalies, respective causes and recommended interventions.

Element type	Anomalie	Causes	Intervention
Current surface	Cracking of coating elements 	1. Laying the supporting structure 2. Lack of walkways on roofs 3. Placing heavy equipment on the roof 4. Excessive amount of fixations of tiles to support 5. Effect of temperature and moisture	Replacement of damaged elements.
Singular covering points	Insufficient size of the trim 	1. Deficient execution	Element removal and placement of new trim with higher heights.

The implemented interface allows the user to perform, intuitively, an inspection to an inclined roof (Figure 2). The first step in using the application is, naturally, to identify the building to be analysed and the respective roofing characteristics. The filling out of a new anomaly chart or the viewing of existing charts' data is made available through the interface anomaly chart accessed by the main interface. In the anomaly chart the scroll-down menu referring to the anomaly field shows the anomalies that have been registered in the database in association with each of the types of elements. The causes and intervention modes were equally associated to the anomalies, and, therefore, by selecting the respective control buttons, the probable causes and recommended "Intervention" fields are filled-out with the database records connected to the selected anomaly.

The severity of the anomaly can be characterized according to three parameters (low, medium and high), reflecting the previously realized study. The inspection chart interface also comprises a photo insertion zone, thus it is possible to add photographs taken in the inspection location or other images related to the element being analyzed, forming a considerably relevant complementary information for the subsequent study of repair/maintenance relative to the observed severity.

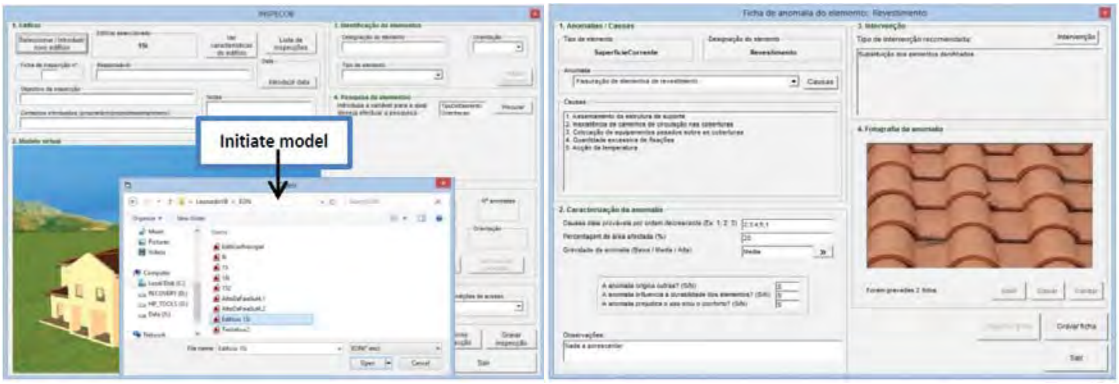

Figure 2: The VR model of roofs interface.

2.2 The VR model of façades

The façades VR model allows interaction with the 3D geometric model of a building, visualizing components for each construction [8]. It is linked to a database (Table 2) of the corresponding technical information concerned with the maintenance of the materials used as exterior closures [12].

Table 2. Anomalies in facades, repair solutions and methodologies.

Anomaly	Specification of the anomaly	Repair solution	Repair methodology
Detachment 	Fall in areas with deterioration of support	Replacement of the coat (with use of a repair stand as necessary)	1º Removal of the tiles by cutting grinder with the aid of a hammer and chisel; 2º Timely repair of the support in areas where the detachment includes material constituent with it; 3º Digitizing layer of settlement; 4º Re-settlement layer and the tiles.

The VR model interface is composed of a display window allowing users to interact with the virtual model, and a set of buttons for inputting data and displaying results (Figure 3). For each new building to be monitored the characteristics of the environment (exposure to rain and sea) and the identification of each element of the façades must be defined (façade orientation, double or single exterior wall, and area and type of coating). Once each monitored element has been characterized, several inspection reports can be defined and recorded and thereafter consulted when needed. An inspection sheet (Figure 3) is accessed by the main interface. Using the drop-down menus of the interface, the user can associate the characteristics of the observed anomaly to a façade element; the type of anomaly, the specification, details and the probable cause of the anomaly, an adequate repair solution and pictures taken in the building. After completing all fields relating to an anomaly, the user can present the report as a pdf file. With this application the user may fully interact with the program referring to the virtual model at any stage of the maintenance process and analyze the best solution for repair work.

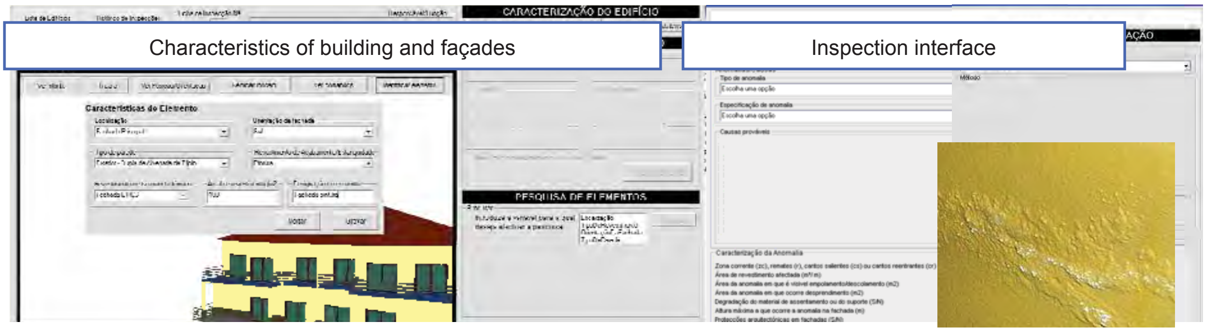

Figure 3: The main and inspection interfaces of the VR application.

2.3 The VR model of painted walls

The material most frequently used in the coating of ordinary interior walls of buildings is paint. Irregularities manifest themselves in various ways and in different degrees of severity. According to Coias [13], in normal conditions of exposure and when correctly applied a paint coating can remain unaltered for about five years. The developed VR application supports on-site inspections and the on-going analysis of the evolution of the degree of deterioration of the coating [9]. The VR model identifies each interior wall surface, in each of the rooms of the house, as independent elements. The application is supported by a database (Table 3), composed by the most common irregularities, their probable causes and suitable repair processes, which facilitate the inspection process.

Table 3. Anomalies and associated repair methodology.

Classification	Anomalies	Repair methodology
Alteration in colour	Yellowing	- Cleaning the surface and repainting with a finish both compatible with the existing coat and resistant to the prevailing conditions of exposure in its environment
	Bronzing	
	Fading	
	Spotting	
	Loss of gloss	
	Loss of hiding power	
Deposits	Dirt pick-up and retention	- Cleaning the surface.
	Viscosity	

The main interface of the application gives access to the inspection module. On an on-site inspection visit, the element to be analysed it selected interactively on the virtual model and using the inspection interface, the specialist can select the irregularity included in the list of the database, which corresponds to the observed defect, and can select also the probable cause and the prescribed repair methodology.

Conclusions

The presented VR applications support the inspection activity of roofs, facades and painted interior walls and promote the use of IT tools with advanced graphic and interactive capabilities in order to facilitate and expedite the maintenance process. The VR capacity of chromatic alteration was applied in two of the models allowing users to see, in the virtual environment, the state of gravity of anomalies or conservation of the coating materials. The information about pathologies, causes and repair methods, collected from a specialised bibliography, has been organised in such a way as to establish each model database to be used as a base for the drawing up of a tool to support building maintenance. The main aim of the applications is to facilitate maintenance enabling the rapid and easy identification of irregularities, as well as the possible prediction of their occurrence through the available inspection record. This analysis has been shown as playing an important role in conservation and in the reduction of costs related to the wear and tear of buildings and contributes to the better management of buildings where maintenance is concerned.

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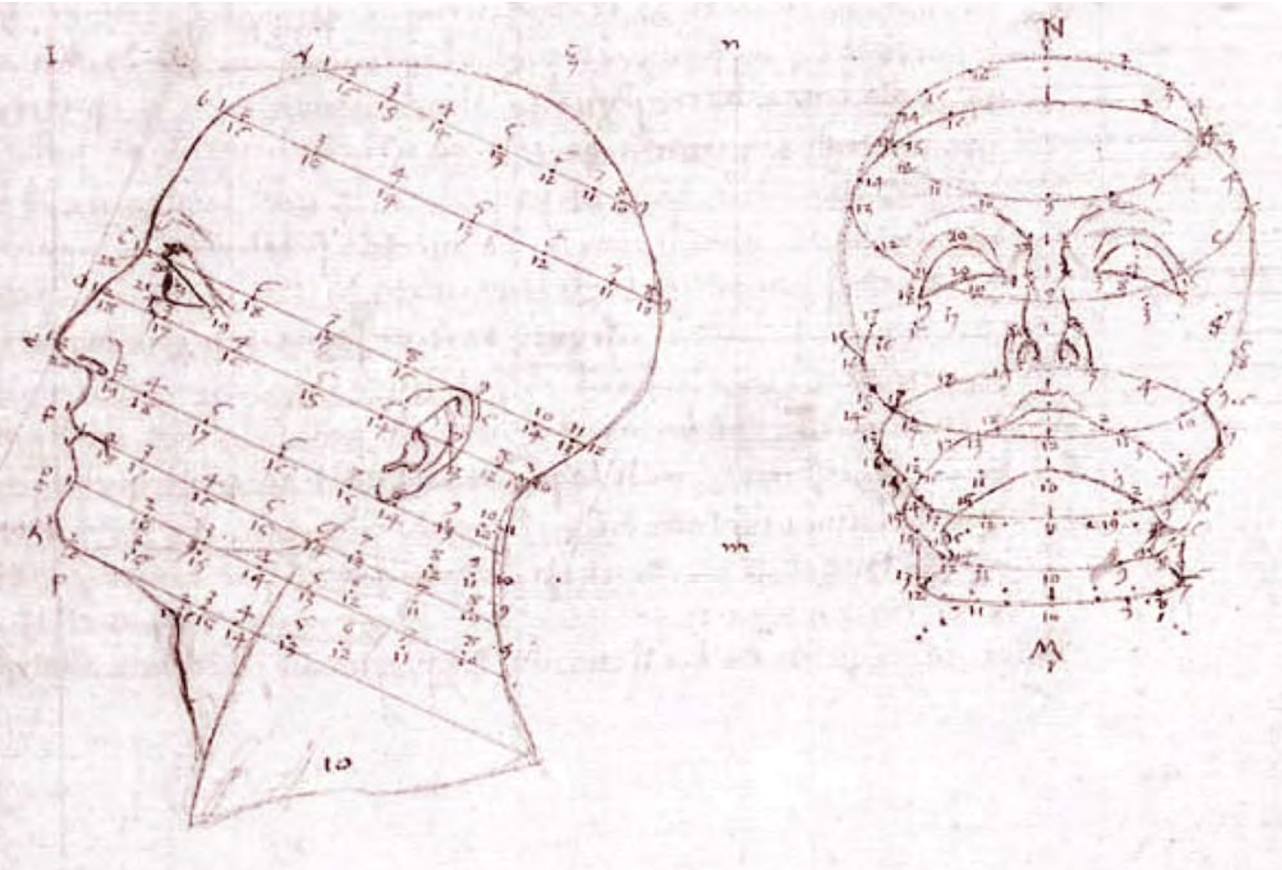

ARTWORKS
INSTALLATIONS
POSTERS

Alejandro Lopez Rincon

Unity *(Artworks, Live Performance)*

Topic: Artwork, Paintings, Performance to show feelings.

Authors:
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CNRS

Main References:

[1] Lopez Alejandro, "*Le hasard a l'oeuvre (the random in the artwork)*", Generative Art 2013.

Abstract:
Is there a way we can show feelings? This is the idea we worked in several artworks and presentations including [1]. The idea is simple: show emotions using the tools made available by art techniques and technology.
In order to show feelings, we decide to measure the electrophysiological signal of the heart, and by the fast Fourier transform, get the coefficients from the different frequencies and introduced them into the spiral model. Following this procedure we are able to generate a sequence of images in real time that depend on the activity of the heart.
We choose the heart because the symbolism it has in culture and society in connection with emotions. Although this symbolism is due to the changes in heart rate produced by the emotional state in a person. For example in the following artwork, we created a series of images by the phrase "I love you" said by a person in love to the responsible of his affection. Then, one of these images was used as a model to create a painting using acrylic.

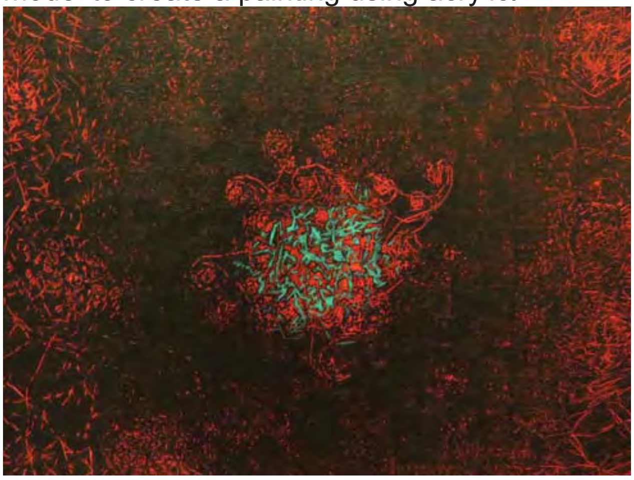

Figure 1.The phrase "I love you" as a painting created using our system.

The circuit used to generate the images is an electrocardiogram. This device measures in a closed circuit the electrical activity of the heart. The mentioned circuit consists of two measuring electrodes (one in the right arm, one in the left arm) and a reference electrode. This is the standard electrocardiogram.
In the circuit we introduce a second person, although the measured signal has no value for medical analysis, it shows the unity of the two people. Therefore, changes the resulting images and can be done with several people. The procedure is; the reference electrode is given to the new person, and then the individual touches the hand of the person with the measuring electrodes. This puts into an electrical closed circuit both people and the signal reflects the result. The idea of this performance is to show unity and giving it a visual result.

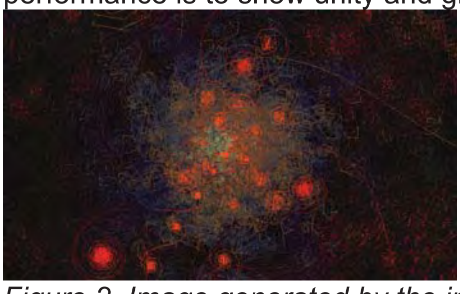

Figure 2. Image generated by the interaction of 5 people in a closed circuit.

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Keywords:
Interaction, feelings, electrocardiogram, spiral model, fractals

Angela Ferraiolo | Artwork: **Three Bankers: Volker, Greenspan, Friedman**

Topic: Computational Art and Algorithms

Artist:
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Abstract:
Three video portraits that use noise and indeterminacy to create broken, unstable, and fragmented representations of official images.

By providing an endless sequence of rational and apparently stable images of authority, technology is always inventing what is called fact, what we know of our existence, a concentration of images that accumulates credibility through repetition, predictibility, and uniformity over time.

Here, as small amounts of noise are introduced into the rending procedures of an ordinary video algorithm, those same technologies are used to form another outline, one that admits the unaccountable, the accidental, and the deviant as a equally real qualities of the system.

The intention is that by subverting the official representation of certain public figures, computational disruption can also shift the viewer's relationship to the orthodox version of key events as well.

Noise instills doubt, creates suspicion and, by blurring what is believed to be accurate with what is unpredictably malformed, shows that what is seen as real, despite a continual and sophisticated assertion of order, can easily be redefined.

Three Bankers: Volker, Greenspan, Bernanke
(Angela Ferraiolo, USA, 2014 image sequence,18 mins)

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Keywords:
computational art, noise, generative video

Anna and Michael Chupa

TITLE: Wearable

Topic: Art

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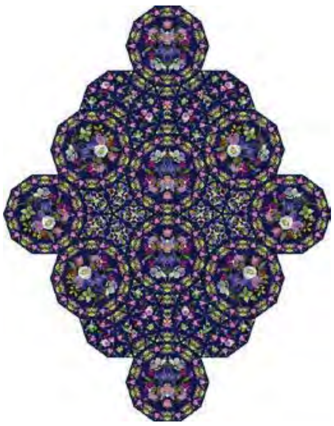

Abstract:

At Generative Art 2012, we introduced *Tilings* made from still life compositions bounded by girih shapes; a decagon, a pentagon, a rhombus, a concave hexagon (bowtie) and an elongated hexagon. Each girih tile is divided further by strapping lines, which are reserved as negative space. As the tiles are joined, the strapping lines reveal larger fivefold symmetries. At GA13, we introduced *Tilings 2*, a two-level design in which the girih forms appear at two scales with a variation on the subdivision rule used on the Darb-e Imam shrine built in 1453 Isfahan.

For GA14 we continue to utilize self-similarity, that is, the smaller scaled girih tiles inflate to create larger tiles through subdivision and substitution. What makes this process more complex is that the tiles themselves are not flat color. In most girih tilings, individual tiles are solid colored. For flips and rotations, orientation of the tile doesn't present a problem. In our girih tiling, each tile is filled with floral compositions that are asymmetrical. There is a clear orientation. As the larger second level tiles rotate to create a new pattern, the boundary tiles between them (where they abut) are bisected and flipped along the axis of rotation. This is where new interior configurations of the tiles are created and this is the process that becomes generative.

For the example shown on the left bottom, we show the small rombus in detail. Above that we show the larger rhombus (scaled down to fit this page) subdivided into ten decagons, ten rhombi, eight hexagons and eight bowties. In our wearable we have arranged the rhombi in a half-drop pattern with slight gaps between each rhombus. The half-drop pattern fills the ground plane. The botanical source material that is readable floats on the surface of the girih construction unconstrained by rules of tiling that permit no gaps and no overlaps.

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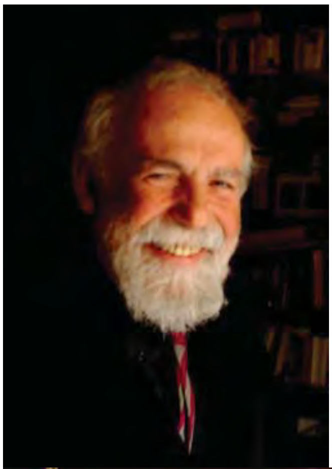
Keywords:
Girih, tiling

Celestino Soddu
Enrica Colabella

Generative Lighting Birds (artworks and live-performance)



Topic: Generative Art and Poetry

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www.generativedesign.com
www.gasathj.com
www.generativeart.com
www.generativism.com

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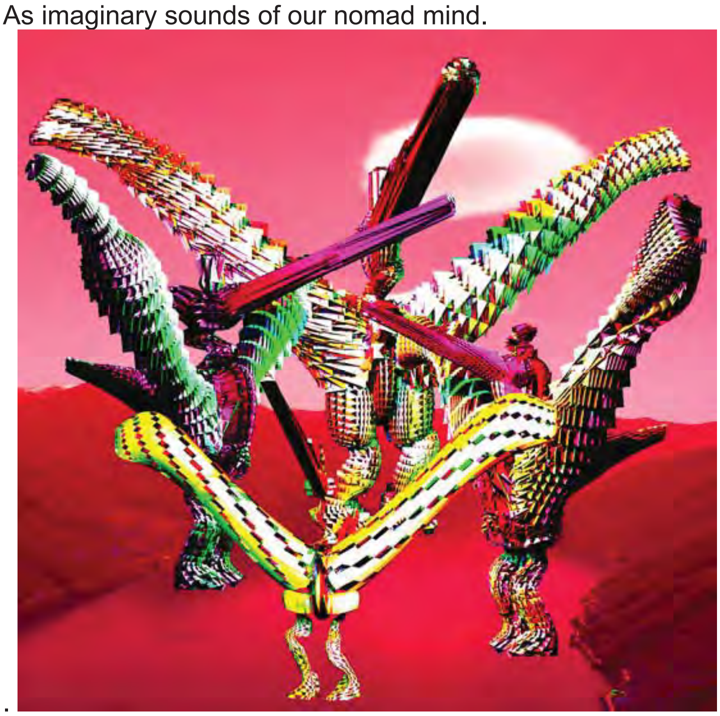
Lightning birds
Birds generate lighting shadows on our windows .
Flying by flying birds touch our windows
Only with their shadows, as visionary objects:
In touching they generate a limpid white lightness
As on our boarded ship sometimes happens,
When the winter calms after a night lightning stormy,
At dawn: a remind of the fear, under our shoulders.
Fear, too much fear in our silence full of ground noise,
Fear, you are so able in missing mirrors,
But not the shadows of lightning birds.
Their lightning disappears all fears,
By reminding the eternal voice of kindness.
On the windows, deflected with their lightning,
A child voice asks "Birds, where Is your song?"
No answer. Lighting birds belong to artificial ware.
They can only generate lightness on our windows
For gaining an open hope toward new art visions ,
As imaginary sounds of our nomad mind.



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Generating birds are performed with my Argenia software. The paradigm follows natural selected shapes of birds. The variations belong to some transformations and upgrades of architectural codes that I used in other generative works.

I designed a topological structure connecting legs, thighs, body to two explained wings, to a neck, a beak, to the eyes and a crest, without forgetting the tail. This paradigm is defined through primary relationships of connections and geometries of spatial transformations able to focus the role of the single events.

Wings, beak, crest and tail are produced transforming codes used for my architectural domes, legs and neck with codes drawn by the architectural construction of pillars and transformed to hoc. The body, the thighs, the head and the eyes are the transformation of generative codes for concluded spaces.

The results and the possible variations, allude to an idea of bird, perhaps to a virtual species of birds living in the Italian historical fantastic gardens, as i.e. in Boboli or Bomarzo.

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Keywords: Generative Art, poetry, geometry, creative process, algorithms, transformation, logical interpretation

Philippe Kocher
Daniel Bisig

Installation: **Sheet Music**

Abstract:

Sheet Music is a sound installation whose physical setup consists of several piezoelectric film speakers distributed in space. The sonic content of the installation is generated by employing time-delayed recurrent networks as sound synthesis systems. The installation setup embodies some of the algorithmic principles that underlay the generative sound synthesis process. Each speaker corresponds to a specific point in the network and renders the network's activity at this point audible. In addition, the physical distances among the speakers are proportional to the time delay applied to the signals between those points. Hence, some of the otherwise hidden properties of the generative algorithm are made visible. Furthermore, each display of the installation is unique and site specific, as the distances between the speakers depend on the particular spatial properties of the venue. The installation represents an attempt to establish a clear correspondence between a generative system and its physical manifestation.

Topic: Music

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An early prototype of a piezoelectric speaker film (left) and one of the actual objects of the installation (right).

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Keywords: Sound installation, sound synthesis, recurrent time-delayed networks, piezoelectric speaker films

The Sound Installation "Sheet Music"

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Abstract

Sheet Music is a sound installation whose physical setup consists of several piezo-electric film speakers distributed in space. The sonic content of the installation is generated by employing time-delayed recurrent networks as sound synthesis systems. The installation setup embodies some of the algorithmic principles that underlay the generative sound synthesis process. Each speaker corresponds to a specific point in the network and renders the network's activity at this point audible. In addition, the physical distances among the speakers are proportional to the time delay applied to the signals between those points. Hence, some of the otherwise hidden properties of the generative algorithm are made visible. Furthermore, each display of the installation is unique and site specific, as the distances between the speakers depend on the particular spatial properties of the venue. The installation represents an attempt to establish a clear correspondence between a generative system and its physical manifestation.

1. Introduction

The use of feedback and delay is commonplace in electroacoustic music. There is a large number of applications that use these techniques for audio signal processing and sound synthesis. Likewise, these mechanisms of feedback and delay also play an important role in artificial neural networks that process temporal data. Despite the shared interest, there exists very little research concerning the adoption of recurrent neural networks as mechanisms for signal processing and sound synthesis [1, 2]. We believe that the arrangement of feedback and delay units in network-like structures has a promising potential to be an attractive artistic tool for computer music. An ongoing research project at the *Institute for Computer Music and Sound Technology* of the *Zurich University of the Arts* investigates these audio feedback networks [3].

Audio feedback networks exhibit a complex and non-linear behaviour. From an artistic point of view, this is a most desirable property: it is the basis of all the unpredictability, variety and richness of the acoustic textures thus generated. On the other hand, due to their complexity the internal operations of such networks are fairly obscure. Hence, there is a concern that these networks become incomprehensible black boxes used as readymade systems but never fully understood [4]. We propose that this issue could be addressed by rendering some of the network's internal properties directly perceivable and tangible. Therefore, we try to establish an *ontology alignment* via a number of correspondences between the sound synthesis network and the physical objects of the sound installation. These correspondences include on the one hand the representation of each network node as an individual sounding object and on the other hand the matching of the distances between the objects and the duration of the time-delays of the connections between the nodes.

Sheet Music is an attempt to prototypically demonstrate the application of an audio feedback network in a sound installation context. It is also an attempt to explore the effectiveness of ontological correspondences. The structure of the sound synthesis algorithms as well as the specific, custom-made hardware are described in the following sections.

2. Hardware

2.1 Piezoelectric Film Speakers

The sound installation is formed by eight sound-emitting objects distributed in a room. Each object consists of a piezoelectric film speaker mounted on the foot part of a music stand (Fig. 1). The operation of the piezoelectric film speakers is based on the piezoelectric effect, which refers to the accumulation of electrical charge in response to an applied mechanical force. Materials that show this piezoelectric effect also exhibit the reverse piezoelectric effect, i.e. a mechanical deformation resulting from an applied electrical field. The latter allows piezoelectric films to be used as sound transducers. Piezoelectric film speakers are characterized by a highly nonlinear frequency response and a variable sound emission directionality, both of which depend on the shape and curvature of the film (Fig. 2). These peculiar acoustic traits render the speakers interesting as musical artefacts that strongly colour the sonic emission in relation to their shape.

Figure 1. Piezoelectric speaker films mounted on the foot part of a music stand form the sounding objects of the installation.

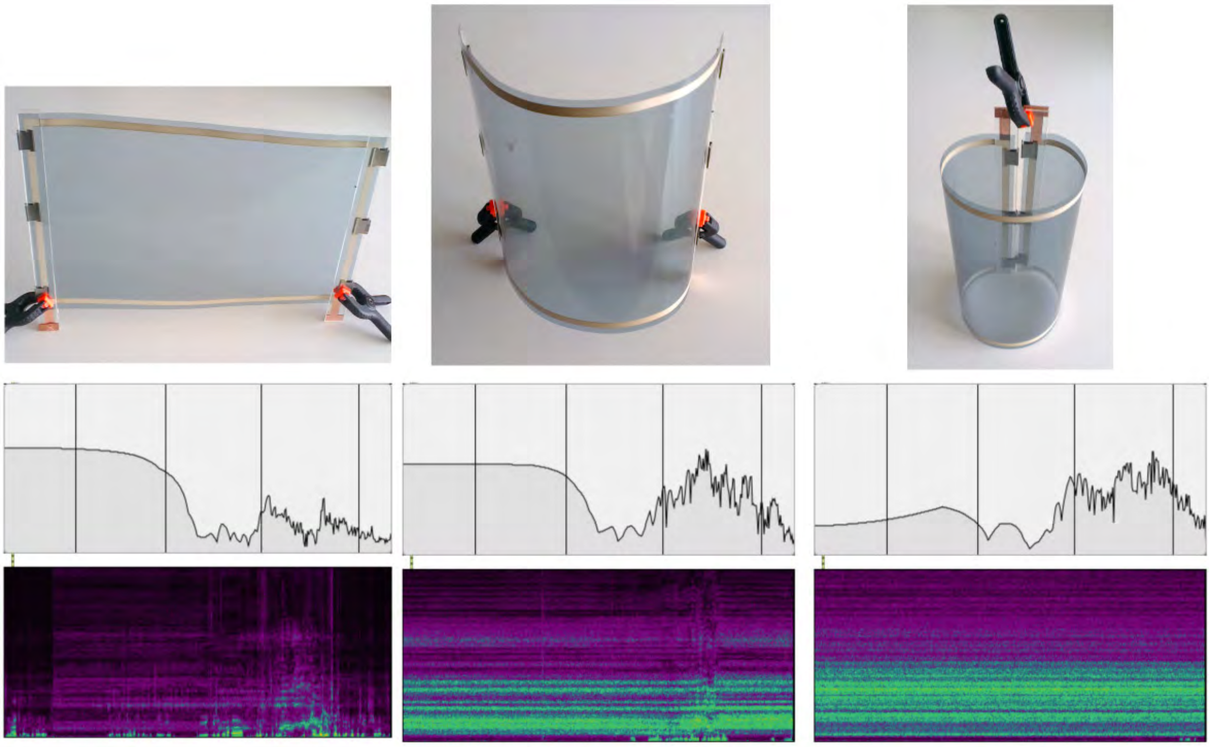

Figure 2. Curvature dependency of the frequency response of piezoelectric speaker films. The figure depicts the speaker films (top row) together with the corresponding amplitude spectra (middle row) and spectrograms (bottom row) of the speakers' audio emissions. The input audio signal is white noise.

Apart from its function as sound emitting device, the piezoelectric film speakers are also an important visual component of the sound installation. Being thin, transparent and weightless, the piezoelectric films possess several material properties unlike those we normally associate with loudspeakers. Therefore, they do not iterate the concept of loudspeakers and sound generation being two detached processes. Rather, the film speakers are readily accepted as sounding objects in their own right, which consequently reduces the gap between sound reproduction and the underlying generative algorithm.

2.2 Audio Amplifier Electronics

Conventional audio amplifiers are not suitable for our needs, as the piezoelectric films require a high voltage to function as a speaker. Therefore, we decided to use custom-made audio amplifiers. These special amplifiers have been developed and manufactured at the *Institute for Computer Music and Sound Technology* (Fig. 3). The amplifiers contain a toroidal transformer that is stepping up the drive voltage to the high level required. The electric power supply is provided either by a DC wall-plug adapter or a lithium-polymer battery, which can be charged from USB. To make the technology accessible to the community, the circuit board design is released under an open hardware license. The amplifiers' electronics are fitted in a plexiglass box, which turns the amplifiers into aesthetically appealing objects. Consequently, they can well be used as visual elements of the installation.

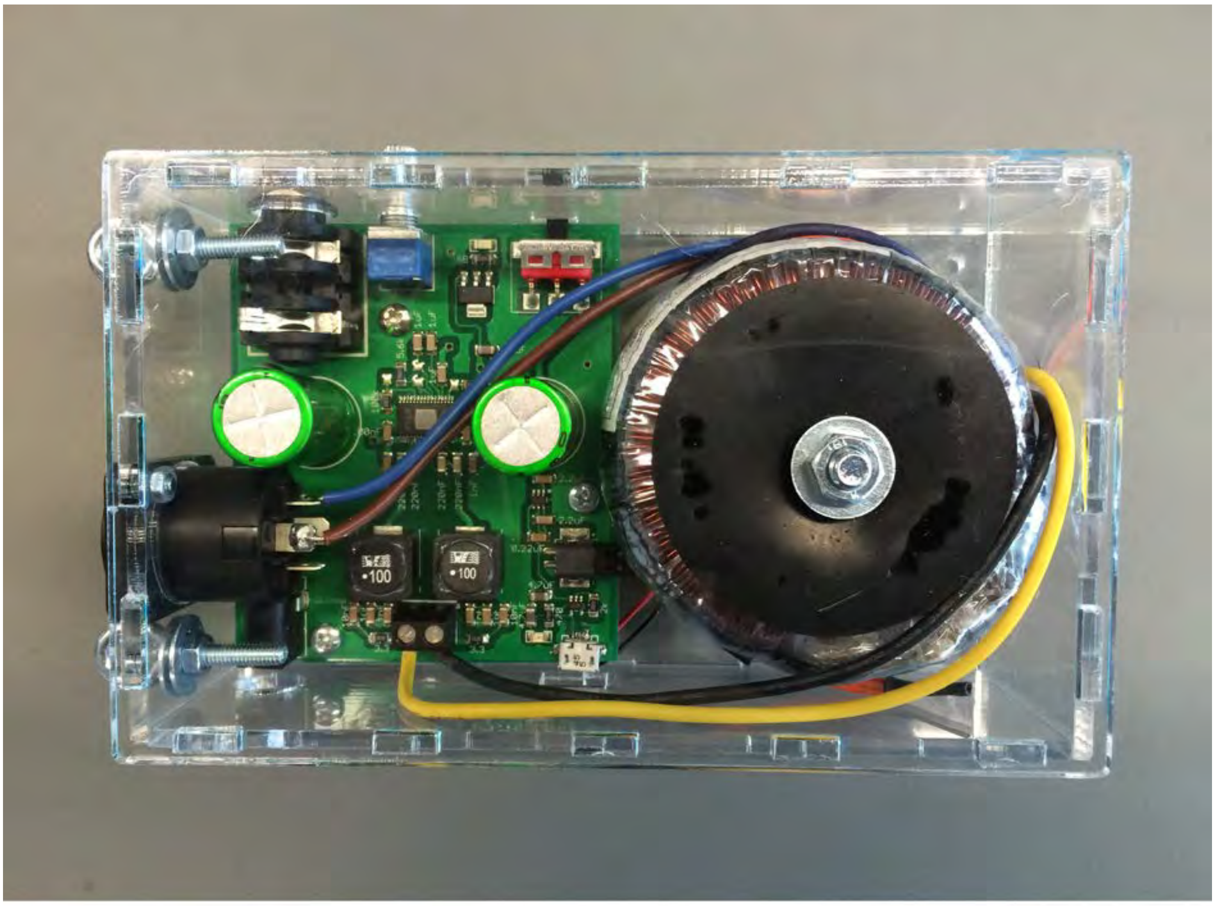

Figure 3. Audio amplifier electronics. Custom designed amplifier board to drive the piezoelectric speaker films.

3. Sound Synthesis

The sound synthesis method that drives the audio output in this setup consists of units organized in a network (Fig. 4). These units – nodes and connections – have certain functionalities. The nodes' function is mainly that of a control mechanism. Since the network contains many feedback loops, audio signals tend to accumulate which is very likely to lead to runaway conditions. This is avoided by switching to another connection whenever the volume rises over a certain threshold. In addition, a peak limiter comes into action when the signal remains above the threshold despite the rerouting. Finally, the summed input of every node is connected to a speaker (Fig. 5). The connections contain a delay line and a low-pass filter. Both the delay-times and the filters' cutoff frequencies have an important impact on the sonic characteristics of the output. In order to compensate for the loss of energy caused by the low-pass filter the signal is multiplied by a gain factor (Fig. 6).

Due to the feedback loops, this sound synthesis system is self-sustained: Once excited with a short audio signal it continuously keeps on sounding. As a result of the different delay times and the ever so often change of the signal path, a variety of different rhythmical gestures and textures emerge. This, however, also depends on the size of the network: It requires a certain quantity of nodes in order to provide a suffi-

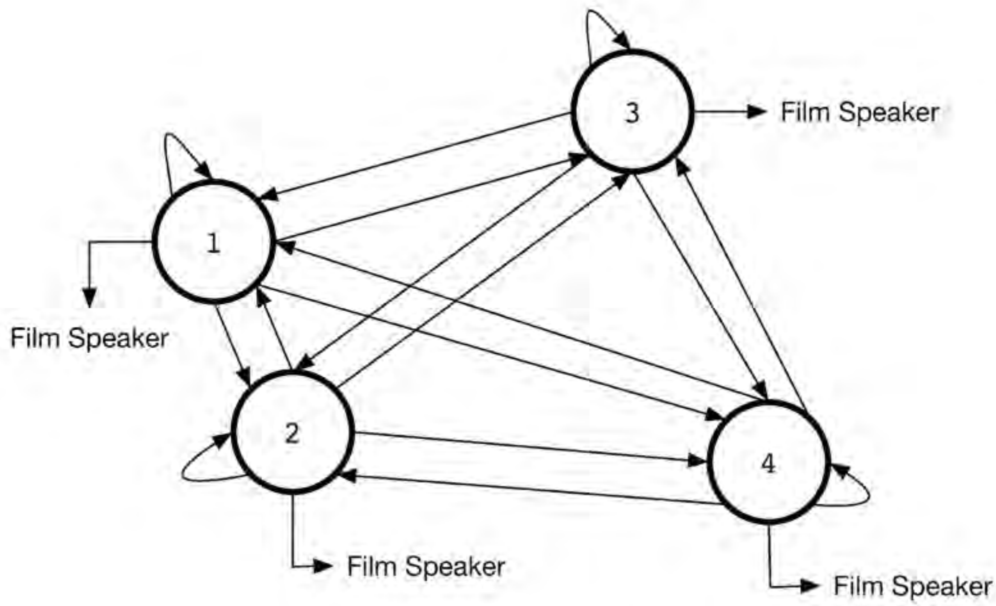

Figure 4. The network topology used for the sound synthesis. Each node is connected to every other node and to itself. (This diagram is simplified; the actual number of nodes in Sheet Music is eight.)

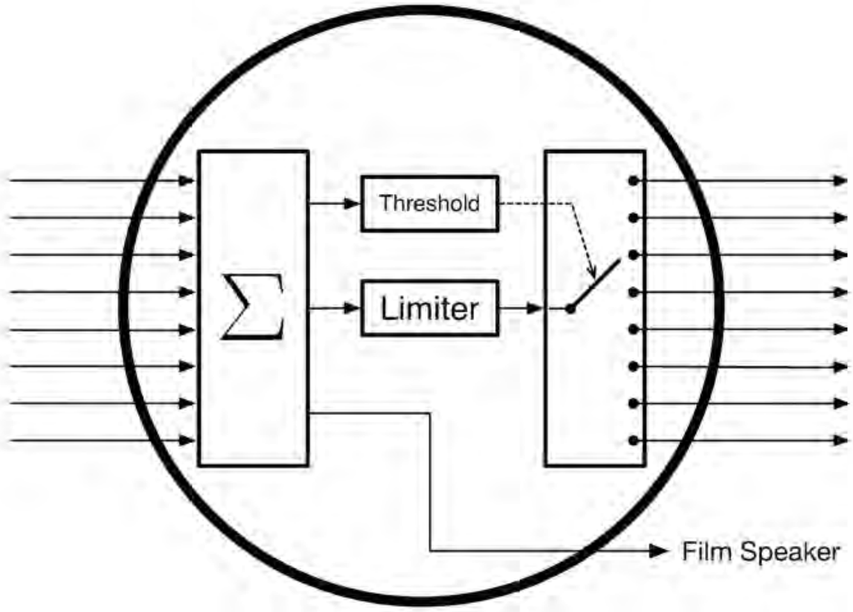

Figure 5. Signal flow inside a node. All input signals are summed and routed to one single output connection at a time, switching to the next connection whenever the level is above a given threshold.

ciently high number of different signal paths. This sound synthesis approach is neither intended to mimic natural sounds (e.g. musical instruments) nor to model any existing physical property. Rather, its artistically most compelling feature is the fact that this synthesis method permits to shape the timbral as well as temporal properties of the sound within the same formalism.

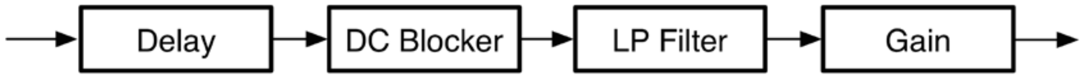

Figure 6. Signal flow inside a connection. The signal is delayed, the DC component of the signal is removed, the signal is low-pass filtered and a gain factor is applied.

4. Discussion

The sound installation *Sheet Music* is an attempt to realize a work that relates the sound generation to the spatial positions of the physical objects. The effect of this relation is twofold: it furthers the tangibility of the underlying generative sound synthesis algorithms and it increases the site specificness of the installation. The spatial layout of the objects makes the network explorable, i.e. the listener can move among the object and hear the sound of the network "from within". The correspondence of the delay times and the distances between the objects is particularly well perceivable when the sounds are short and of a percussive quality. This is achieved by the switching between the connections, which occasionally cuts the sound into short bits. The signal propagation inside the network is reflected in spatial effects, i.e. sounds moving about. As far as the site specificness is concerned, the correlation of the installation's layout and the sound synthesis is also meaningful. The actual sound of the installation depends on a given spatial layout. Due to the fact that this layout is always to a certain extent determined, or at least influenced, by the size and shape of the exhibition space, every rendition of this installation is unique.

In view of this relation between sound synthesis and spatial position of the objects, it must be asked how the sound synthesis algorithm has to be designed in order to obtain the results postulated above. In our case, there are two major aesthetic criteria: First, the algorithm must produce a sufficiently large number of different musical gestures and, second, it must maintain a certain rate of change yielding an output that is neither too static nor too repetitive. No matter what the spatial layout of the objects might be, the algorithm must work flawlessly with the parameters derived from that layout. Therefore, in order to meet the aesthetic criteria in any case the algorithm must be quite robust. At the same time, these parameters should have a sufficiently height impact, in order that the algorithm actually yields a perceivably different result in a different setup. The fact that this installation can take on many different forms is most important. The work is unfinished and only completed when realized in a certain environment. In this vein, the sound installation *Sheet Music* is what Umberto Eco calls a *work in movement* [5].

The relation between the generative algorithm and some of the physical properties of the installation's objects encourages the listener to engage with the work both on a perceptual and a conceptual level. Such an ontology alignment between the material and the immaterial aspects is particularly well realizable in an audio-visual, i.e. multimodal, environment. Yet, establishing a relation between the algorithm and the physical properties of an artwork serves not only the purpose of understanding the particular algorithm of this artwork. It provides also an example of how generative art can play a role in the discourse about today's information society where objects have become more and more de-physicalized and where there is an existential need to find ways to understand the principles of networked structures [6].

The ontological alignment would be even more compelling in an interactive situation, as this would take the tangibility one step further. We therefore intend to address interactivity in future works, for instance, by making the objects movable. This would allow the listener to alter the delay-times or even the topology of the feedback network and listen to the sonic changes in real-time.

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Celestino Soddu
Enrica Colabella

Generative Design Teaching

Posters of Generative Design class

Topic: Generative Design Teaching

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www.generativism.com

Main References:
[1] Celestino Soddu "*Città Aleatorie*" *(Aleatory Cities),* Masson Publisher, Milan, 1989
[2] E. Colabella, C.Soddu, "*Il Progetto Ambientale di Morfogenesi; codici genetici dell'artificiale*" *(Environmental Design of Morphogenesis; the artificial DNA),* Leonardo, Milan, 1992

One of the most difficult aspects in teaching Generative Design has always been to bring the student from a creative analytical approach based on static forms, and on the copy of them, to the ability to define the structure of their design processes with their own Interpretative Logics. These are rules with which to turn into dynamic progression the generative project, creating a bridge among the past, their references and the future.
This is difficult even more today, when technological culture brings us to consider the technology as carrying of our creativeness instead to consider that as fundamental tool to be used for building our design vision.
Moving from an analytical and deductive logic to the Logical Interpretation of own references implies the students to identify their own vision, their own design objective. And this is not a simple thing in a global world where different identities cannot easy survive crossing through homologation.

Our students of Generative Design Class in the Master School of Design of Politecnico di Milano has begun their didactic experience in October 2014, less than two months ago and the materials that we introduce are their first effort to acquire a generative approach to Design.
They originate from studies in various sectors, from the Product Design to Architecture, from Graphics to Fashion.
These drawings in progress show how to reread, in dynamic way, their own reference imaginary, putting aside from an analysis of the forms but activating interpretative logical paths that have as finality the possibility to create generative algorithms, to create own design tools able to manage the progression of their own project.
A suggestion for setting up their posters was Matisse cut down.
These logical processes are also able to fit our main didactic aim: to help each student to create, in progress, his own recognizable style.
Our difficult in performing tools able to build a vision is each year increasing. The reason can be multiple, but the core is clearly connected with the emphasized use of technologies in learning; that starts and ends in processes simplifications. So our effort in teaching is growing but good results with a good will are still gained.

Master Students: Ahmadova Ulviya, Alvelo Maria Juana, Bai Haiyu, Ban Chao, Bite Elina, Candido Alessio, Carli Iacopo, Cholewinski Peter Gregor, De Wambrechies Marc, Dolci Alice, Edman Ida Johanna Elinor, Esparza Jimenez-Moran Guillermo Manuel, Filatov Sergei, Frank Viktoria, Froiio Alessandro, Götze Chris, Graterol Bautista Josabeth, Günther Levin, Xuhaiqing, Hasselberg Elin Nathalie Marie, Hu Jiong Ming, Icke Secil, Jones Rebecca, Kourtidis-Vlachogiannis Christos, Lu Jing, Maestri Carlo, Miao Yufeng, Philipp Anne Storgaard, Pintonello Elisa, Rego Henriques Tiago, Rochulus Jessica, Roos Luuk, Sirait Maria Yosepha, Tao Qian Vanessa, Tesson Louise Corinne Marie, Wang Xiao Yi, Werthmann Winfried, Qin Mian, Zheng Yuting, Guo Wei, Zhang Yunfan, He Qian, Peng Rui, Yibin Xu.

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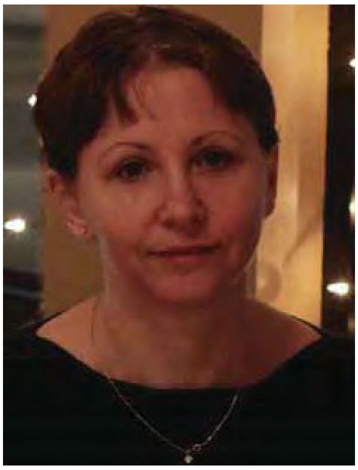
Keywords:
Generative Design Teaching, Interpretative Logics, Transformation Rules.

Daniela Sirbu

Artwork/ Installation: **Living Fence**



Topic: Interactive Art

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References:
[1] Reas, Casey and Chandler McWilliams. 2010. *Form + Code in Design, Art, and Architecture*. New York, NY: Princeton Architectural Press.
[2] Arnheim, Rudolf. 1974. *Art and Visual Perception*. Los Angeles, CA: University of California Press.
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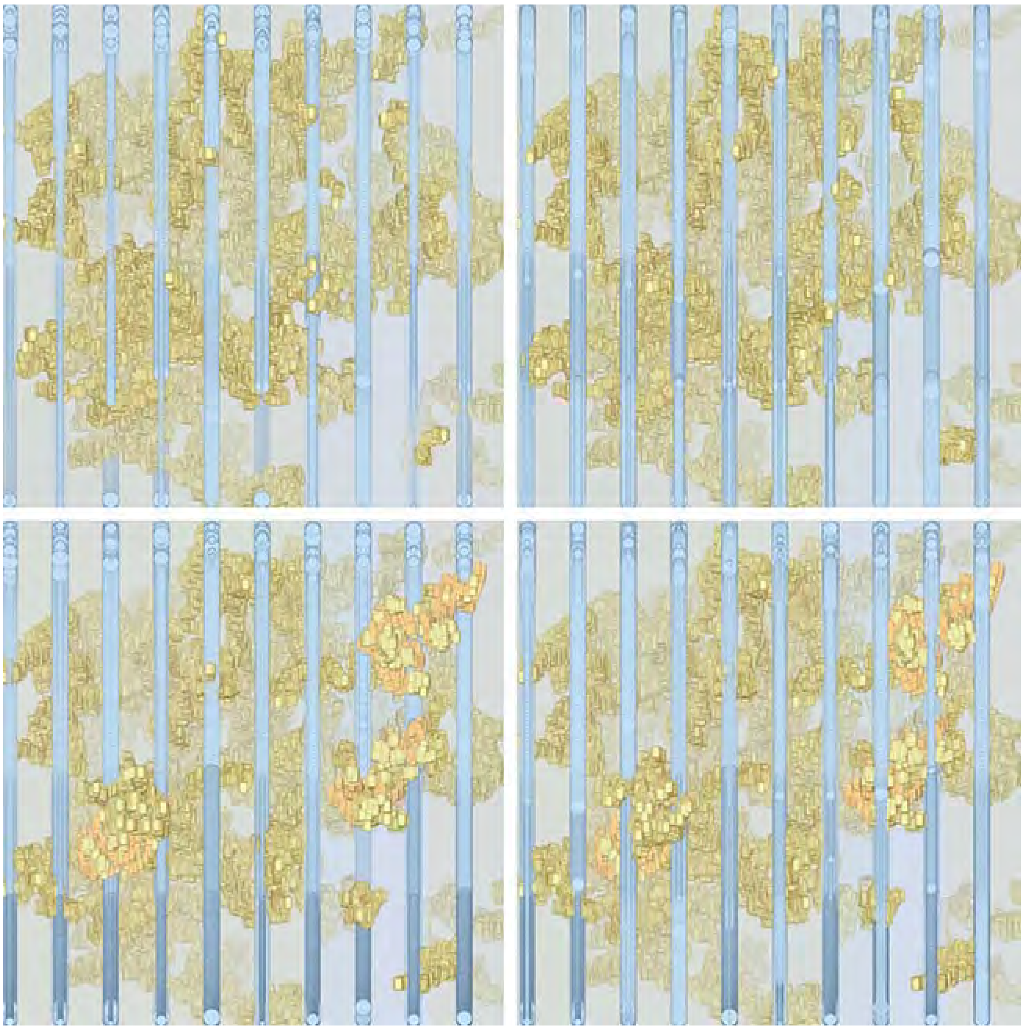
Abstract:
Living Fence is an interactive art piece that creates the appearance of an active living fence crossed by plants in continuous development. While new plant forms grow, the older ones fade gradually until they disappear. The gradual fading of the older plant structures enter in a visual dialogue with the new growing forms so that a suggestion of depth, volume, and space is created. These generative plants seem to be part of a garden space, a digital garden that grows beyond the limits of a decorative fence that also changes itself in time.

The fence and plants are built autonomously or interactively by the system from seed geometrical unit forms that interact with an invisible substrate of active areas embedded within the frame of reference. Based on pure abstract building units, the system creates the illusion of and evolving garden.

The interactive art piece *Living Fence* is created with Processing 2.0 programming language.



Live Fence. Still frames from the time based interactive art piece.

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Keywords: generative art, artificial creativity, Processing.

Donald Tarallo

Type of proposal (Poster):

Generative Typography Poster Design

Topic: Teaching, Graphic Design, Typography

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Frankie Linden
Jennifer Masterson
Cara Swiechowicz
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References:
[1] Processing code was provided by Generative Gestaltung; http://www.generative-gestaltung.de

Abstract:
Letterforms are expressive visual elements in their own right. This assignment exposed students to the inherent visual potential of letterforms through the use of the programming language Processing. Using Processing, the students generated numerous variations of images from photographs of three-dimensional letterforms that they hand crafted. After careful evaluation of the potential meanings of the generative images they created, the students applied one of the images to the design of a poster. The visual qualities of the image determined what poster would be about.

The value of an assignment of this nature is that it introduces a level of chance and unpredictability to the design process. The final outcome, which is a practical design piece, was the result of a visual exploration that did not begin with a premeditated end point. This is contrary to the conventional teaching of design, which typically begins with a prescribed need and outcome (top-down approach). The approach presented here is a 'bottom-up' approach where the outcome is determined by analysis of the potential visual meanings of images made in a free visual exploration. In such an educational context the students learn to open themselves to see meaning in everything.

Left: Poster on a lecture for the great fires of history, by Jennifer Masterson.

Right: Poster of student's creative process (from creating the handmade letter, photographing it, to image generation in Processing).

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Keywords:
Typography, graphic design, generative, processing, analog, digital, design education

Tatsuo Unemi and Daniel Bisig

Visual Liquidizer or Virtual Merge #1 *(Installation)*

Topic: (Interactive Art, Swarm)

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Main References:
[1] Rudy Rucker, "*Wetware*", Avon Books, New York, US, 1988

Abstract:
This is a visual interactive installation utilizing two cameras and one projector connected to one personal computer. The visual output is projected on the rear projection screen visible from both front and rear sides. In a science fiction entitled *Wetware* [1], an imaginary drug named *Merge* takes an important role. It relaxes connections among protein molecules, then the taker's body becomes liquidized, but it recovers back some minutes later. In this novel, a couple of lovers took it together to mix their bodies and felt tripping. *Wetware* is a coined word in the research of Artificial Life that is also pursuing computational models of complex collective behaviours of organisms. There are two well known algorithms named BOIDS for birds and fish and ANTS for ants and termites. This artwork will realize a virtual *Merge* using detection of visitors' images by ANTS and generation of scattering images by BOIDS. When two visitors take seats at the opposite sides of the screen each other, the images of their bodies start scattering and mixing some seconds later. Viewing from the each side, the figure of him/herself is displayed as in a mirror and the partner's figure is visible in normal. Dynamic images rendered by a visualization technique continues two or three minutes, then it gradually comes back to the normal figures. The system starts waiting for new visitors again after the visitors left.
The authors are hoping people merge each other more, not only in a private relation like lovers, to change the world where disruption and violence are rampant.

An example setups of the installation.

Contact:
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Keywords:
Interactive art, Visual feedback, Swarm, Visualization

Visual Liquidizer or Virtual Merge #1

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Premise

This article describes a detail of the authors' artwork entitled *Visual Liquidizer or Virtual Merge*, an interactive audio-visual installation inspired by an imaginary drug in a science fiction entitled *Wetware* by Rudy Rucker. This drug temporarily liquidizes the taker's body, which causes a type of tripping experience by mixing bodies of a couple of lovers. To provide the virtual experience of such kind to visitors, we designed a system that displays dynamic deformed figure of visitors using two types of swarm simulations for the image processing on the camera image and rendering on the display screen. Sounds are also generated to provide more impressive experience for visitors.

1. Introduction

The authors' latest artwork entitled *Visual Liquidizer or Virtual Merge* is an interactive audio-visual installation utilizing two cameras and one projector connected to one personal computer. The visual output is projected on the rear projection screen visible from both front and rear sides. Viewing from the each side, the visitor's figure is displayed as in a mirror from his/her side and the partner's figure is visible in normal as shown in Figure 1.

The idea of the concept is inspired from an imaginary drug named *Merge* in a science fiction entitled *Wetware* written by Rudy Rucker [1]. This drug temporarily liquidizes the taker's body, which causes a type of tripping experience by mixing bodies of a couple of lovers.

The technical idea is from two types of the author's previous works. The one is of SBArt [2] that generates unique 2D images and movies by means of genetic programming. It has a functionality of not only generation of the new image but also deformation of an existing image. The other work is on swarm. There are two well-known algorithms to simulate the complex collective behaviors of animals in the nature, that is, BOIDS for birds and fish and ANT for ants and termites. We have used BOIDS for our interactive installations since 2004, that is, Flocking Orchestra [3], MediaFlies [4], Flocking Messengers [5] and Identity SA [6], and ANT for Cycles [7] in 2010. This new artwork utilizes a combination of these two types of swarm. It realizes a virtual *Merge* using detection of visitors' images by ANT and generation of deformed images by BOIDS.

When two visitors take seats at the opposite sides of the screen each other, the images of their bodies start scattering and mixing some seconds later. The dynamic moving image rendered by a visualization technique continues two or three minutes, and then it gradually comes back to the normal figures as the final stage. The system starts waiting for new visitors again after the visitors left.

The following part of this article describes details of the concept and the technical features.

Figure 1. An example setup of the installation. This picture was taken by the author at the Open Campus of Soka University in 24th of August, 2014.

2. Concept

As described in the previous section, an imaginary drug *Merge* is assumed to be able to relax the connections among protein molecules of human body. The taker's body becomes liquidized as the efficacy, but it recovers back some minutes later. In this novel, a couple of lovers took it together to mix their bodies and felt tripping. Each individual person is an entity physically separated from the others, but we sometimes feel spiritual connection with lovers, friends, family members, and so on. Any type of close communication between persons amplifies such feeling. The closer physical contacts such as hand shaking, hugging, kissing and so on cause the deeper communications from this point of view. It is possible to imagine that it would be more effective if we could physically mix our melted bodies with of the others. Human relation is one of the most important aspects to measure happiness of people. It is somewhat difficult but might be ideal to have as many peaceful relations as possible, rather than conflict or separation. This installation provides not real but virtual situation as if the bodies of two persons become melting and mixing so that the visitors would feel spiritually closer connected with others.

The novel's title *Wetware* is originally come from a coined word in the research of Artificial Life [8] that is pursuing models of complex biological phenomena using any type of scientific constructive methods. The majority of the research projects are based on software that examines computational models for simulation and system implementation, but hardware approaches by mechatronic construction are also not few because it is sometimes much more efficient than software typically when the model requires solving so-called multi-body problems. Wetware is neither software nor hardware, but a research medium using organic or non-organic chemical materials to examine the reaction processes that shows any type of complex phenomena such as reproductive process of molecular structures.

The research results of this field is useful not only to understand what life is from a scientific point of view but also to develop a method to build an artificial system that behaves too complex to predict by human observers. It sometimes brings us a wide variety of generative methodologies suitable for design, art, and entertainment. Typically, it provides a design method by which the product looks as if some unknown living things cause the phenomena behind.

Swarm model is one of those mechanisms. It is a model of collective behaviors of organisms such as fish, birds and ants. It is natural that the simulation of melting and mixing process should be simulated using a model of physical dynamics, but we use swarm simulation to provide the visitor occasion to feel that the materials would be living, namely the visitors' bodies.

The authors are hoping people merge each other more, not only in a private relation like lovers, but also with people from difference cultures, to change the world where disruption and violence are rampant.

3. Technical Features

The hardware setups consist of one personal computer of recent product with relatively powerful graphics board with cameras and projectors. The projector should be of an ultra short focus placed on the table or a normal one mounted on the ceiling. This specification is necessary in order to avoid a conflict between the projection beam and the camera's sight. It is possible to use any type of hi-resolution display or screen to show the visuals, but a rear projection screen is the most effective because it realizes the combination of mirror image of the viewer and normal image of the partner from both sides. The authors think this style is better than the case two visitors view the screen together from the same side. Usually, people are familiar with a mirrored image of him/herself, but a normal image for the others.

The details of swarm simulation and rendering algorithm are described in another paper by the authors [9]. The following part of this section presents two alternative methods to capture the visitors images and then method of sound synthesis.

To organize the visual that consists of deformed visitors' body overlapping with the stable background, the system needs to extract the part of targets from captured image in real time. One commonly used method is by background subtraction. It is easy if the background image is stable and the contrast with the target is high, but difficult if there are moving objects other than target in the scene. For a long time exhibition for one day for example, it sometimes raises a problem of stability on lighting. The sunlight is often the biggest interference since it changes in time and weather condition. Even if the sunlight from the outside could be totally shut out, there remains possibility that reflection of room lights on the visitors body alters the light condition. Another method for more stable installation is to use Kinect depth sensor [10]. It detects the distribution of distances between the camera and the objects in the captured image area. We don't need worry about the changes of lighting condition because the side effect is very small except the case the light includes much of infrared light, but the drawback is the restricted range of observable distance. Because the sensor was originally designed for visual interaction of TV game assumed being played in home, the range is from 0.8 to 4.0 m. It is suitable for a typical setup for single person for each side as shown in Figure 1 in the above section, but difficult to adapt to a further range for a large size of audience. We developed the software adaptable for both web camera and Kinect sensor so that the installation is adaptable for a wide range of situations in the exhibition site. The open source library of Open Kinect project [11] was useful for our development.

The sound effect is very important to amplify the impression. Because the visuals look like dynamically flowing liquid, we gathered sampled sounds of different types of water flows and mixing them that reacts against scene changes. Sound of stream is for the beginning and ending, Bright sounds of bubbles and heavy sounds under the water are mixed for the melting and mixing stage. As described in [9], parts of original images are temporally reunited so that the visitor can recognizes their body is flowing even after some minutes elapsed. The system attaches a sound of drain at the horizontal position of reunion by stereo speaker system. In addition, voices and environmental sounds are recorded in real time to render the sound for reunion with modulation of the pitches and echoes. The sound from the outside is recorded when its loudness exceeded the predefined volume. The recorded sounds are used repeatedly until the predefined time passed. After some minutes of mixing, the melting image turns back to the original just as the drug's efficacy has expired.

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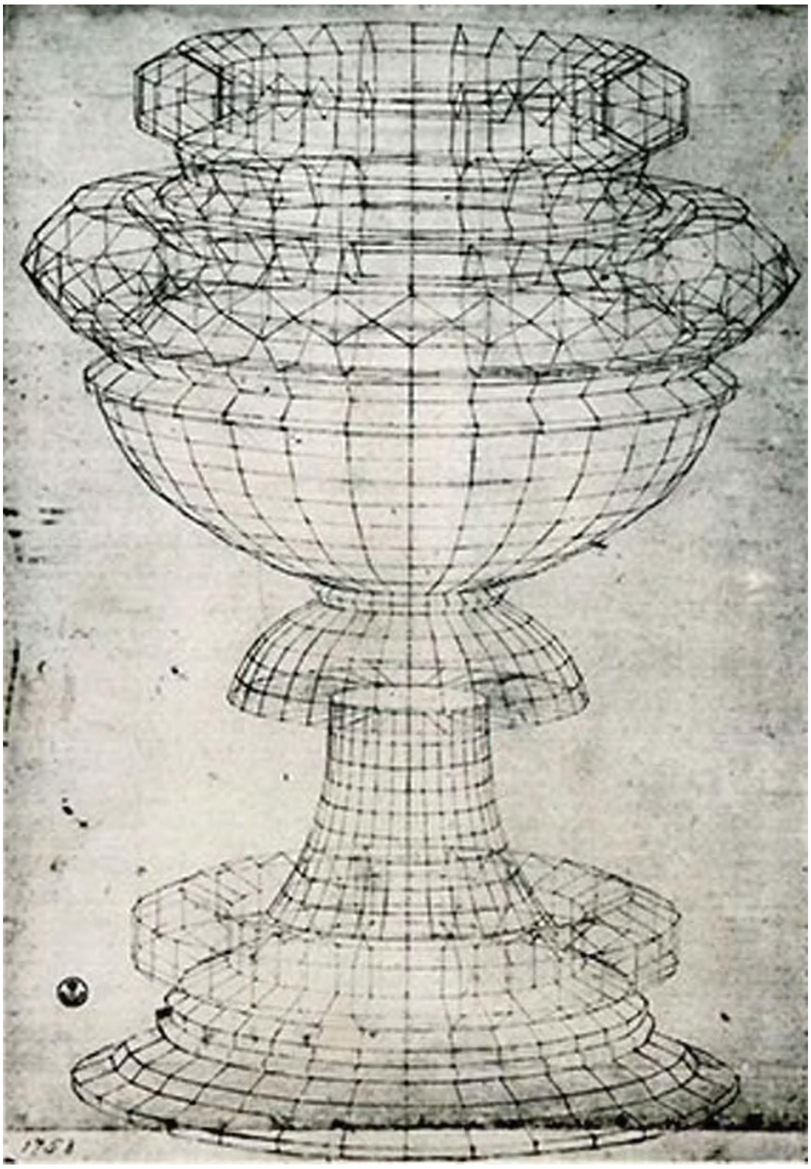
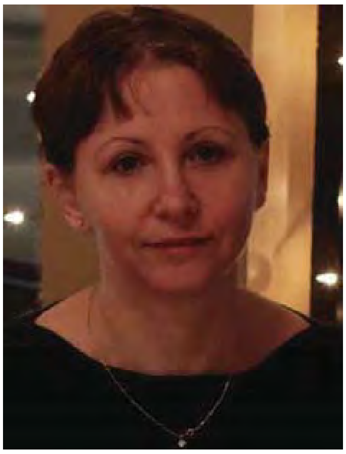


LIVE-PERFORMANCES

Daniela Sirbu

Performance: **Mixed Worlds**



Abstract:
Mixed Worlds is a life animation building a world in which human and animal life, growing plants, cityscapes and interior spaces emerge from one another, mix, and disappear leaving behind a remnant presence like in a dream world.
The Mixed Worlds' life animation is created through a combination of drawing as life performance evolving in tight interaction with an active background that responds to the artist's gestures. The system records temporarily the drawings developed life throughout the performance, but as soon as a line is drawn it starts to dissolve into the active evolving textures developed by the kinematic drawing system. This creates a very particular medium for artistic expression which is designed to visually support the theme of the Mixed Worlds life performance. The kinematic drawing system is based on an algorithm implemented in the Processing 2.0 programming language by the artist.

Mixed Worlds. Still frames captured from kinetic drawing performance.

Topic: Interactive Art

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http://www.uleth.ca/finearts/new-media

References:
[1] Reas, Casey and Chandler McWilliams. 2010. *Form + Code in Design, Art, and Architecture*. New York, NY: Princeton Architectural Press.
[2] Arnheim, Rudolf. 1974. *Art and Visual Perception*. Los Angeles, CA: University of California Press.
[3] Shiffman, Daniel. 2012. *The Nature of Code: Simulating Natural Systems with Processing*. The Nature of Code 1st ed.

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Keywords: generative art, kinetic drawing, artificial creativity, Processing.

Enrico "Catodo" Zimuel

Defrag (Live Performance)

Topic: Generative Art, Music, Performance

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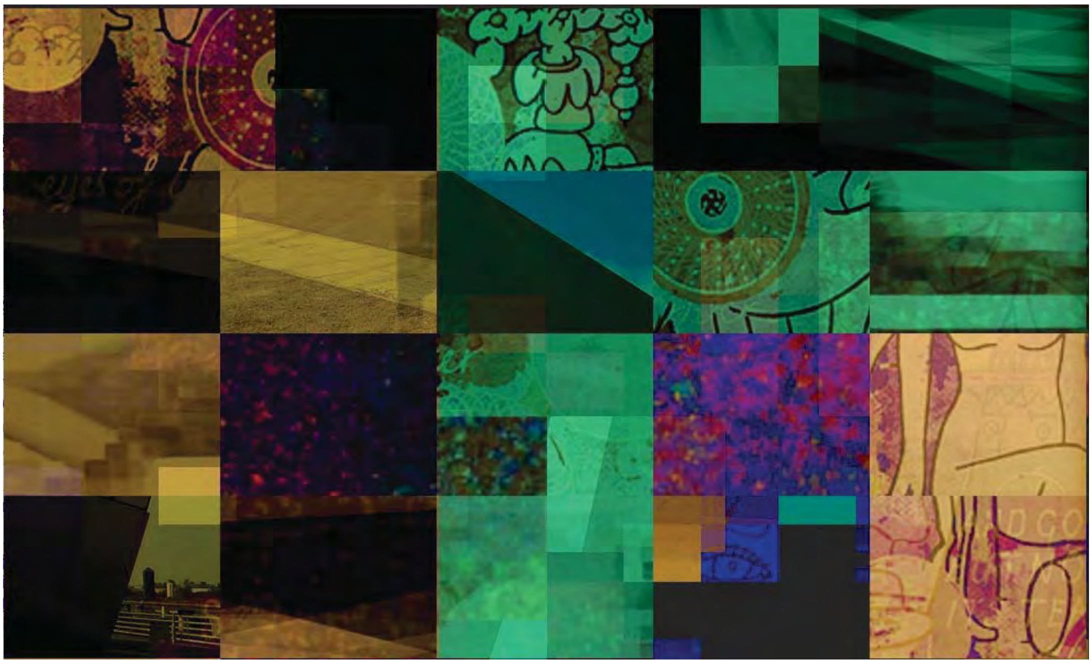
Abstract:
Defrag is the name of a command line tool, used in modern operating system, to optimize disk space and speed access of hard disks. ***Defrag*** is the short name of ***defragmentation***, the process that reduces the amount of fragmentation [1].
In fields of postmodern artwork, **fragmentation** signifies the breaking rather than building up of information, to form a structure that would convey a hidden message rather than the obvious message to its audience. A whole and entire phenomenon on its own, the **postmodernist** movement began in the field of architecture but spread to art, literature, cinema, culture and philosophy in no time. According to writer James Morley, postmodernism seeks to maintain elements of modern utility while returning to classical forms of the past. He describes it as an "ironic brick-a-brack or collage approach to construction that combines several tradition styles into one structure." [2]
In fields of postmodern artwork, fragmentation signifies the breaking rather than building up of information, to form a structure that would convey a hidden message rather than the obvious message to its audience.
In this live performance, I propose a defragmentation show based on a generative software that reduces a set of images and sounds in a puzzle. The images and the sounds are splitted into blocks and rendered on screen and on sound. The images and the sounds of this installation are based on postmodernist art examples. The result is a visual and audio installation that act to explore hidden messages from the original sources. The software has been realized in **Processing** [3] and the performer can interact with the software using a simple MIDI controller interface. The software is released under the Creative Commons License (CC BY-NC) and can be used with any images (.jpg) and sounds (.wav), in any kind of art performance.

Main References:
[1] Di Leva Massimiliano, "*Defrag. Nuove frontiere del postmoderno. Note su Matthew Barney*", Stamen, Roma, 2010, ISBN 9788890413629

[2] The Electric Labrynth, "*Postmodern Culture*", 2000, http://www2.iath.virginia.edu/elab/hfl0242.html

[3] Processing programming language, http://processing.org



Example: Screenshot of the video performance

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Keywords:
Generative art, fragmentation, postmodernism, performance, creative coding

Fernanda Nardy Bellicieri

"THE STORY OF ALL ROSES" *(Live Performance)*

Abstract:

The purpose is to present the live performance "The story of all roses" (or "A história das rosas - in Portuguese) based in a namesake poem which central theme is human frailty and vulnerability when it comes to the dealing with time.

The performance or «the poem lecture as a scene» was anchored in corporal expression, movement and dance, and surrounded by audiovisual ambience (video projection) intending to maximize the poem metaphorical potential.

The poem-performance is a collective work: the poem is part of Fernanda Bellicieri's book "F... tales" (or "Contos de f... - in Portuguese) who is also the performer, and the scene was directed by Hânia Pilan. Videos, photos and drawings were Lúcia Nardy's. The group has been working since 2008 in scene composition based in text, images and audio.

Besides philosophical discussion brought by the poem itself, the intent of this live presentation considering its creative process and the dealing with the poem translation to scene, is to assume the performance as a legitimated vehicle of artistic expression particularly powerful when it comes to dilute the limits between different languages and to synthesize them.

Image 1: performance "The story of all roses"

Image 2: performance "The story of all roses"

Topic: Poetry

Authors:

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Main References:

[1] BELLICIERI, Fernanda - "Contos de F...", ed.1, Brasil, 2011.

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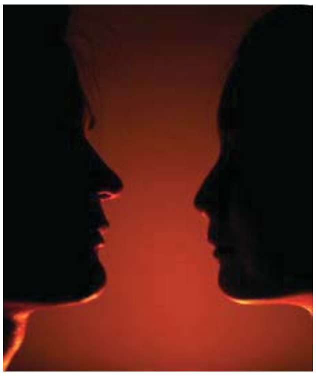
Keywords:
Poetry, Performance, Language, Audiovisual, Translation

Davy Grégoire
Chung Yun

FAR RESONANCES *Live Performance*



«For a long trip, there is always a time when the monotony of a vast landscape takes us on a lyrical state, as short as it is. Our momentary perception of the world and impaired self-consciousness can merge, the time of a mild misunderstanding .. »

Coming from different sound universes, one is inspired by electronic music and digital experiments (Davy.G), while the other is engaged in a meditative listening of healing sounds (Yun.C), *Far resonances* is a meeting point, where digital intensities and meditative tones intermingle and stand out in a imaginary dialogue between indoor and outdoor.

The sounds are generated in two ways, concrete and digital. Physical objects like healing forks, bells and singing bowl with possible smart noise by adding some granular material like beans, leafs... And a digital interface (Bipmat) using the video capture of a flame to modulate synthetized sounds and fields recording samples.

Because this performance was also trained in studio with friends playing guitar(Fenet C.) and drums (Lacroutz F.), it can integrate instrumental improvisations that follow the spirit of the soundscape...

Topic: Music

Authors:
Davy Grégoire
France
Chung Yun
Taïwan

Related artists:
Fenet Cédric
France
Lacroutz Fabien
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Keywords:
Electronica,glitch,healing sounds,generative music,

Hugo Paquete	**TITLE: Unpredictable systems and collapse (*Live Performance)***

Abstract:
This software art its part of a intermedia performance that explore the interaction of sound, image and performative experiences over the concept of Glitch and the general accident of failing involving digital code, performance, indeterminism between digital and human interaction. The factor of transformation over noise and image and sound layer in a glitch aesthetic. Indeterministic conceptual approach against predictability was taken into consideration to generate this software. Accumulation of sonic and visual effects crash over the system generating an entropy disorder to achieve the failure over a general accident when error and noise emerge as a singular form. Over the operative system represented as a counter paradigm of order and functionality. Over imposing a abstract language of colours and shapes base in the virtual environment of the operative system. Saturating the space with sound in till the collapse of the machine. Exploring the post-digital condition of approach the machine and code as a mechanism / language with limits to explore in the error level. As a new aesthetic formulation in a world of supra performativety and order. A system generated to fail in a poetic allegory over the infinity of formulas. Based on the concepts of regularity, irregularity and functionality, this chance proposal was built taking into account factors such as the relationship construction of a machine, tool and non-linearity, abstraction, because there follows a linearity assumption of control. This concept also limits this programmatic intentions expressed in the performance. Because it opens its length up to the point where the system becomes saturated and fails, this being the point of allegoric or poetic search for infinity. Infinity is not a number, not an object, not a formula.

(USC) (Unpredictable systems and collapse)_Hugo Paquete_2013_Museu de Aveiro

Topic: Post-digital, Software art, Sound art, Noise, Glitch, Chaos

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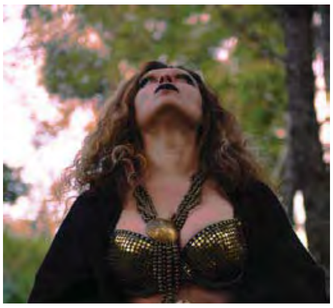
Keywords:
Post digital, Sound, Software art, Glitch, Noise, Chaos, Performance

Isabella Tirelli

My Song of Songs – multimedia art – video e live performance
By Isabella Tirelli



Topic: multimedia art - Video and live performance

Authors:
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Main References:

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Title: **HaShir HaShirim Shelì (My Song of Songs)**
Year of production :2013
Music : Wolfang Amadeus Mozart, Richard Wagner, Gustav Mahler
Students work: yes, like a models and performers
Kind of exhibition: Multimedia installation and performance
Duration: 40 minuts (or scaled-down version of only 4 songs for 20 minutes of duration**)**
Synopsis:
HaShir HaShirim Shelì (My song of Songs) is developed with free associations but faithful to the text and to the alchemical-kabbalistic symbols of the poem, of which the Song of Songs is rich. The interpretation of Song do not forgets all the allegories often linked to the primordial myth of the GreatMother.
This was a great job, realized in 4 years of work as it is a video composed of 1200 images of original digital paintings.
Then the images are been animated one by one and, finally, the animations are been composed in a DVD lasting 40 minutes: 5 minuts each song for 8 songs.
The Song of Songs is in the third section of the Hebrew Bible, that of "Writings" and it is the first of the so-called "Five rolls." In the Christian Bibles, the Song follows the Ecclesiastes. Trailer lasting 2'3'" at link:
http://www.isabellatirelli.it/Isabella_Tirelli_Cantico_PROMO_ENG.mp4
Project of live performance:
When I will know where it's possible to project the video I can create a special live performance in this space with the same men and women (models) that are in the video, in a ritual action during and to close the projection**.**
Equipment *:* a dvd player or a pc with VLC program or similar, 2 or more active speakers, a video projector of 3000 ansi lumen or more, a projection screen or a white wall
the projection is most enjoyable if the projection will be great (mt.3x4 or more)

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Keywords:
Inanna

minDSounDS: live performance of a generative networked music

Jônatas Manzolli, Vânia Pontes, Clayton Mamedes, Tiago Tavares

Topic: (Music)

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Main References:
[1] Verschure & Manzolli,"*Computational Modeling of Mind and Music*", In Language, Music, and The Brain, ESF Reports, MIT Press, 2013.
[2] Le Groux et al., "*Disembodied and Collaborative Musical Interaction in the Multimodal Brain Orchestra",* Proceedings of NIME, pp. 309–314, 2010.
[3] Mamedes et al., "*Composing for DMIs - Entoa, music for Intonaspacio",* Proceedings of NIME, pp. 509-512, 2013.

Abstract:
It is a proposal to present a **live performance** of a generative networked music that uses multimodal signals and brain computer interface (BCI) to produce music and audiovisuals in real time. minDSsounDs is based on the notion that the delivery of *Presence* is closely tied to an understanding of consciousness and, in particular, of the interplay of implicit and explicit factors in the construction of human behaviour and artistic expression. It is a performance where a group of musicians and machines dialogue in a network, there is a continuous exchange of information between these agents, and the emerging sounds and visuals are shaped by physical actions, movements, music improvisation and implicit signals captured by BCI. Thus we present an interactive performance to create meaningful relationships between agents and explore their interactions using visualization and sonification. This perspective is discussed in [1] where we argue that a theory of mind, including one of creativity and aesthetics, will be critically dependent on its realization as a real-world artifact because only in this way can such a theory of an open and interactive system as the mind be fully validated. In two previous works, we had already developed live performances based on this perspective: re(PER)curso (2007) and Multimodal Brain Orchestra (2009). On these we explored how the internal and external representations of the world can be joined together to create a mixed reality interactive narrative [2]. Computational models, technological tools and compositional strategies used on minDSsounDs are also discussed in previous articles [1][2][3].

Figure 1: Performance of MindSounds

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Keywords:
Music, Interactive, Network, Multimodal, BCI

Ming Xi Tang

Generative music with Qin Opera accompanied by Chinese and western violins

Topic: (A live performance of violins with Qin opera singing)

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Xian Jiaotong University
Zhong Min Shang
Xian Jiaotong University
Lv Xiao Ning
Xian Jiaotong University
Yan Xiao Feng
Shaanxi Orchestra
Cheng Baifu
Xian Qin Opera Troupe
Li Shufang
Xian Qin Opera Troupe

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Abstract:
In this live performance, we perform, using both Chinese and western violins at the same time, the music composed with the 2000 years old Qin opera music using generative techniques, with the leading Qin Opera singer who is nation's best Qin opera performer. This experimental performance is aimed at promoting generative techniques and Qin opera music for international audiences. It is the result of the collaboration between the Hong Kong Polytechnic University and Xian Jiaotong University (Xain) under the joint centre of research on creative culture industries for western China. The 20 minutes performance will produce an impact on the audience by both the original Qin opera music and its variations derived by generative techniques. It will also show how well both Chinese and western violins can be adopt the themes of generative music in a collaborative manner to highlight the different features of both instruments. The group consists of 4 academics and 3 professional musicians.

The opening ceremony of Shaanxi Culture and Design Innovation Exhibition incorporating Ars Mathematica exhibition on Materials for Invention in the Innovation tower designed by Zaha Hadid and openned in March, 2013, housing School of Design of the Hong Kong Polytechnic University.

Live performance of Qin Opera with Chinese and western violins in Hong Kong 2014 by the same group.

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Keywords:
Generative music, creative industries in western China, Qin opera, Xian

GA2014
Roma, 16, 17, 18, 19 December 2014
Conference : Tempio Adriano, via de Burro' 147
Exhibition : Galleria Biblioteca Angelica, Piazza S.Agostino
Live-Performances: Cervantes Gallery, Piazza Navona
GA conference is organized by
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Generative Art Lab, Domus Argenia

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