XXII GENERATIVE ART 2019

proceedings of XXII GA conference

edited by
Celestino Soddu
Enrica Colabella



The book contains the papers, installations, posters, artworks and live performances presented at XXII Generative Art conference in Rome, Italy.

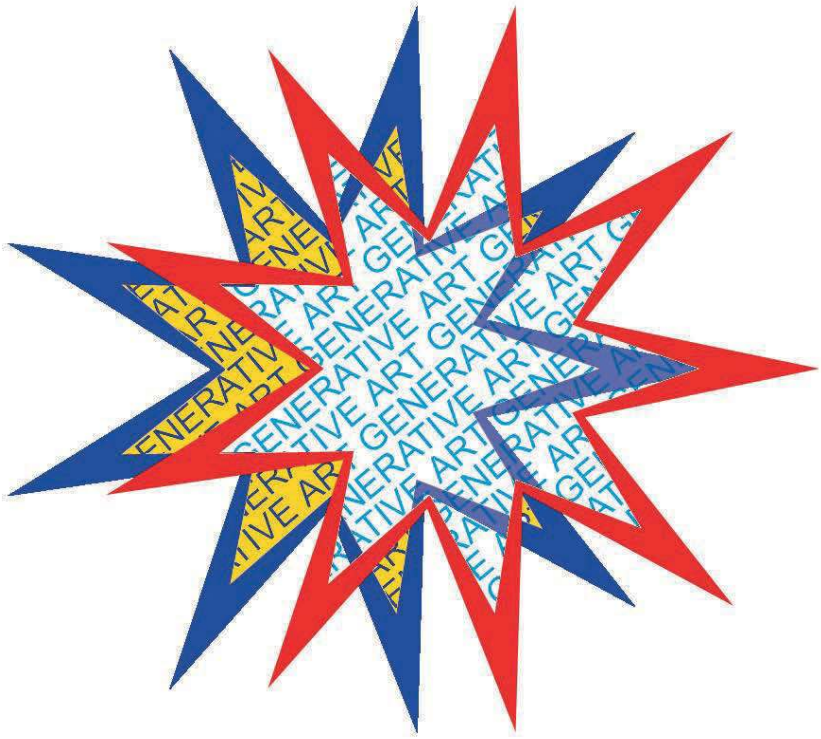
In the cover and in the section titles, drawings by Leonardo da Vinci, representing natural events, as a homage to the 500th anniversary of his death

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GENERATIVE ART 2019

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Proceedings

Edited by Celestino Soddu and Enrica Colabella

Generative Art and Design Lab, Argenia Association, Roma, Italy

INDEX

page 13
OPENING

PAPERS

Page 17
Celestino Soddu
Italy
Argenia Association
Subjectivity in Machine

Page 46
Alex Lobos
USA
Rochester Institute of Technology, Dept. of Industrial Design
Applying Generative Systems to Product Design

Page 57
Angela Ferraiolo
USA
Sarah Lawrence College, Bronxville, New York
The Regeneration of the Earth After Its Destruction by the Capitalist Powers

Page 61
Arne Eigenfeldt, Kathryn Ricketts
Canada
School for the Contemporary Arts Simon Fraser University, Vancouver; Faculty of Education, University of Regina, Regina
Unauthorised: Collaborating with a Performer Collaborating with Creative Systems

Page 72
Christopher Fry
UK
University of Westminster, Westminster School of Art, College of Design, Creative and Digital Industries
Visuality and the haptic qualities of the line in generative artworks

Page 83
CL Fisher
Canada
Centennial College, Toronto, Fine Arts Studio Program
Finland, Turku AMK, Arts Academy
Generative Art and Community Curation: A Proof of Concept

Page 94
Daniel Bisig
Switzerland
Zurich University of the Arts, Institute for Computer Music and Sound Technology
Tuning Shapes and Bending Timbres – Experimenting with Smart Materials for Musical Purposes

Page 109
Dejan Grba, Philippe Kocher
Singapore, Switzerland
Nanyang Technological University, School of Art, Design and Media, Interactive Media; Zurich University of the Arts
STUDY 7/0: Error-Generated Spatiotemporal Animation

Page 118
Dimitris Gourdoukis, Christina Moschopoulou
Greece
Aristotle University of Thessaloniki, School of Architecture
High Resolution Architecture: Ornament as a Generative Force

Page 130
Enrica Colabella
Italy
Argenia Association
Numbering. Where trees move

Page 138
Gaëtan Robillard
France
University Paris 8, AIAC laboratory, INREV team
Max Bense as a Visionary, a Dialectic of Programmed Images

Page 150
Guillermo Bernal
USA
Massachusetts Institute of Technology, Media Lab
Paper Dreams: Real-Time Human and Machine Collaboration for Visual Story Development

Page 168
Hrysovalanti Fereniki Maheras
Canada
York University, Department of Computational Art
An electronic orchestra as an ode to happiness

Page 177
Jeff Morris
USA
Texas A&M University, Department of Performance Studies
Gaming Concepts for Analysing Techniques and Aesthetics in Bytebeat Performance: The Technology Tree, the Tier List, and the Overpowered

Page 190
Libero Acerbi
Italy
Transformations in Art

Page 195
Manuel A. Báez
Canada
Carleton University, Azrieli School of Architecture and Urbanism
Diluvio: Teatro delle Ombre

Page 204
Marie-Pascale Corcuff
France
Ecole Nationale Supérieure d'Architecture de Bretagne (ENSAB), Groupe de Recherche sur l'Invention et l'Evolution des Formes (GRIEF)
Self-Organization and Generativity

Page 218
Meltem Büşra Önal, Erhan Karakoç
Turkey
IstanbulKulturUniversity, Istanbul Technical University
Innovative Approaches To Organic Architecture: Nature-Inspired Architectural Design

Page 232
Monika Karwaszewska
Poland
The Stanislaw Moniuszko Academy of Music in Gdansk, Faculty of Choral Conducting, Church Music, Arts Education, Eurhytmics and Jazz
Intermedial Score – Structural Filiations in the Context of Music-Literature Relations as well as Musical and Visual relations

Page 245
Nicolas Reeves, David St-Onge, Guillaume Crédoz, Vincent Cusson, Pierre-Yves Brèches
Canada, Lebanon
University of Quebec in Montreal, School of Design; École de Technologie Supérieure, Dept.of Mechanical Engineering; Architect, Bits To Atoms; McGill University, Schulich School of Music; Independent Researcher, Mathematics
Point d'Origine from Mende to Chambord: The paths of an evolutive design process
"

Page 263
Nikolaus Bezruczko
USA
Department of Clinical Psychology, Chicago School of Professional Psychology
Psychometric equating methods ease fitness function dilemma in generative art

Page 283
Paul G. Mezey
Japan, Canada, Hungary
Kyoto University, Advanced Future Studies, Yukawa Inst; Memorial University; Eotvos Univ. Budapest
Analogies In Arts and Science: Shape Studies and Artful Molecules

Page 291
Peter Beyls
Belgium
College Ghent, The School of Arts
Computing with Living Components

Page 302
Philip Galanter
USA
A&M University, Department of Visualization
Confusions and Corrections: Complexism and Generative Art Theory

Page 315
Philippe Kocher, Daniel Bisig, David Inauen
Switzerland
Zurich University of the Arts, Institute for Computer Music and Sound Technology
Playing the Piano: Understanding Algorithmic Music Through Interaction

Page 332
Ricardo Andres Diaz Rincon, Javier M. Reyes, Paola-J Rodriguez-C
Colombia
Universidad del Valle, Camaleón Research Group
An approach to Generative Art from Brain Computer Interfaces

Page 344
Rita Moubarak, Jean Pierre El Asmar
Lebanon, Notre Dame University, Department of Design, Department of Architecture
Brand Identity Design and Re-Design Between Resilience and Resistance: Identity, sustainable identity design and the role of generative grammar

Page 357
Ruşen Eroğlu
Turkey
Istanbul Technical University, Department of Informatics, Architectural Design Computing Graduate Program
An Alternative Solution for Architectural Spaces

Page 367
Sever Tipei
USA
University of Illinois, Computer Music Project and National Center for Supercomputing Applications
Manifold Compositions and the Evolving Entity

Page 376
Silvija Ozola
Latvia
Riga Technical University
Generative Transformation of Latvian Urban Space: "Blue" and "Green" Structures In The Planning and The Landscape of Cities' Historical Centres

Page 396
Slawomir Wojtkiewicz
Poland
Technical University of Bialystok, Faculty of Architecture
The art inside an architecture. Generative design system as a tool, and local architecture, as an inspiration in the shaping of the contemporary meaning of architecture in a village landscape context

Page 409
Susannah Hays
USA
University of California Berkeley; with: the Intropy=Entropy Institute, San Francisco CA; Stephen W. Porges, Atlantic Beach, FLA; Susannah Hays, Santa Fe
A Generative Art of Our Own Evolutionary Making

Page 419
Suzanne Gold, Kelly Lloyd, Michal Lynn Shumate
USA, UK, Italy Hair Club, Baltimora, London, Bomarzo
Lather Rinse Repeat: The Iterative Practice and Pedagogy of Hair Club

Page 432
Umberto Roncoroni
Perú
Universidad de Lima, Faculty of Communication
Using the Inka's Calculator for Generative Art

Page 444
Yeşim Okur, Erhan Karakoç
Turkey
Istanbul Kültür University Department of Architecture
Interactive Architecture: The Case Studies on Designing Media Façades

Page 462
Yiannis Papadopoulos, Luis Torrao, Stefanos Zannis and Agelina Vakali
UK, Greece
University of Hull - U.K. & Zannis Studio - Athens, Greece
An Alternative Virtual Odyssey

POSTERS, ARTWORKS and INSTALLATIONS

Page 475
Alessandro Violi
Italy
Design for textile prints

Page 481
Angela Ferraiolo
USA
Sarah Lawrence College, Bronxville, New York
The Regeneration of the Earth After Its Destruction by the Capitalist Powers

Page 482
Catherine Griffiths
USA
University of Southern California, School of Cinematic Arts
Automata I & II: Generative art as a language of the socio-political

Page 484
Chad M. Eby
USA
University of Kentucky, School of Art & Visual Studies
Drift Mirror

Page 486
Gavin O'Brien
New Zealand
Otago Polytechnic, Te Kura Matatini ki
Art and Design: The Unique and the UniformvTopic

Page 488
Raitis Ozols
Latvia
University of Latvia, Department of Mathematics
Art and equations

Page 489
Rowan Simmons, Mark Apperley, Chin-En kEiTH Soo
New Zealand
Faculty of Computing and Mathematical Science, University of Waikato
FilmGrain

Page 495
Tatsuo Unemi
Japan
Soka University, Department of Information Systems Science
Love of Evolutionary Shrimp

LIVE PERFORMANCES

Page 503
Alba G. Corral
Spain
Visual Artist and creative coder, Barcelona
Namba AV

Page 505
Arne Eigenfeldt, Kathryn Ricketts
Canada
School for the Contemporary Arts Simon Fraser University, Vancouver; Faculty of Education, University of Regina, Regina
Unauthorised

Page 507
Beata Oryl, Robert Turło
Poland
The Stanislaw Moniuszko Academy of Music in Gdansk; Academy of Fine Arts in Gdansk, Faculty of Graphics Department
Faculty of Choral Conducting, Church Music, Arts Education, Eurhytmics and Jazz
Soliloquium

Page 510
Enrica Colabella, Celestino Soddu, Nicola Baroni, Marcella Grande
Italy
Numbering. Where Trees move

Page 512
Jeff Morris
USA
Texas A&M University, Department of Performance Studies
The Persistence of Elusion: Hard and Soft Dances — Machine Learning Glitch Version
Divining Rod

Page 515
Kathryn Ricketts
Canada
University of Regina, Saskatchewan
The making of Land(ing), a provocation towards place and space

Page 517
Yuanyuan (Kay) HE
USA
University of Arizona, Fred Fox School of Music
Love YOU … niverse

Page 519
Nicola Baroni
Italy
Conservatorio di Bologna
Kobane for Ipercello

Page 520
Piotr Rojek
Poland
The Karol Lipinski Academy of Music in Wroclaw, Faculty of Instrumental
Free Improvisation on a Pergolesi's Themes

Page 521
Slawomir Wojtkiewicz
Poland
Technical University of Bialystok, Faculty of Architecture
I***nside***

OPENING XXII GENERATIVE ART CONFERENCE

Twenty-two years ago, the Generative Art conference held its first event at the Politecnico di Milano, organized by the Generative Design Lab. The digital era took its first steps.
Today everything changed. The rapid development of technology has led the majority of people to use digital media on a dai ly basis. But it also led to a dev elopment based essentially on technology and not on widespread digital culture.

The Generative Art conference has existed for twenty-two years but a few years ago there was still someone who tried to make us understand what Generative Art is, claiming to do so with an approach dated, still based on c ataloguing into "objective" categories and without considering the thousands of works that had been presented at the GA conference in the previous decade.
These type of attempts to catalogue Generative Art, which however have continued until today, committed a s erious error of approach, which appears immediately clear as these definitions speak of Generative Techniques, inserting Generative Art in the category of techniques i.e. computer art, evolutionary art, robotic art, and interactive art, Most of these definitions of Generative Art was made without considering that, on the contrary, Generative Art is not a t echnique but a pe culiar scientific approach to creativity. It is a revolution compared with the "objective" approach of problem solving and optimization where technique is predominant on the poetic of the artist.

This attempt to define Generative Art as a t echnique has an explicit purpose: it tends to maintain the supremacy of the anonymous on the subjective vision, but above all the supremacy of technology on the subjective interpretative logics, even in art.

What emerges progressively from the works presented in these 22 years is that Generative Art is a pe culiar approach to creativity able to rediscovers the author. Each author uses different “techniques”, most of them directly created by the same author, but the peculiarity is the subjective approach in defining the own vision and the related generative path. Finally, after almost a c entury of collective dominance and disappearance of subjectivity, the recognizability and appreciation of the artist's vision finds a central role in the papers and generative artworks presented to GA conferences. The generative structure stems from the ability to insert subjective interpretation into machines, or rather to use machines to enhance the uniqueness of each artist's vision.

Everything is changing, and di gital culture opens up new possibilities. Today, the need t o conquer new spaces of complexity has led to the rediscovery of the uniqueness of individual logical approaches. This is called singularity in the last AI systems. It opens new horizons to the ability of Artificial Intelligence to be i n line with a pos sible relationship between man and m achine. AI is moving from a merely instrument of pre-packaged services toward advanced tool with the ability to answer to possible unpredictable requests.

Not only. At least in the advanced approach, the axiomatic concept of optimisation, understood as an o bjective standard to be ac hieved in the AI response to requests, has been overtaken. The concept of adaptivity understood as the search for the possible within a subjectively identified and "unique" logical vision, with respect to possible parallel visions, become the future.

Generative Art finds in this new wave its peculiarity. The future of Generative Art is to free

itself from having to be catalogued in categories belonging to the techniques used to achieve it. Instead, it becomes the bearer of what, today, is not only a rediscovery but also an innovation of digital civilization: the identity of the author, of the artist, of the multiplicity of interpretative logics capable of creating not only culture but a pertinent response to the request for complexity.

So let's not talk more about what Generative Art is, there are more than a thousand texts and experiments presented in these 22 years at Generative Art that tell us about it, but let's ask ourselves what the future of Generative Art is. And let's start from the work done in these 22 years by the participants of the GA meetings.

The GA conference has opened the doors to many scientific works and experiments, to different theoretical approaches that have, every year, generated even hard debates. What appears after more than two decades is precisely the re-emergence of subjective visions, of the multiplicity of ideas based on the logical interpretation of the world around us. This appears even if these subjective visions are, very often, hidden because of the current overestimation of technology as a "collective work", each subjective logic emerges and conquers its space as it is the only chance to successfully face the complexity of the context that surrounds us.

The future of Generative Art therefore does not depend on identification in possible techniques, in the use of advanced technologies, but is concentrated in:
1. To support the new course of AI by managing the complexity of these systems through the "singularity" directly connected to logics based on interpretative visions, to the author-artist who defined them. The aim is to create a new man-machine relationship that is not axiomatic but interlocutory and "cultural".
2. Rediscovering the role of the author-artist because the Generative Art results are multiple, different and sometimes unexpected but always linked to a logical interpretative vision of an artist, an author, a software designer. The production of variations by machines tells, with complexity and progressive relevance, the idea of an artist.

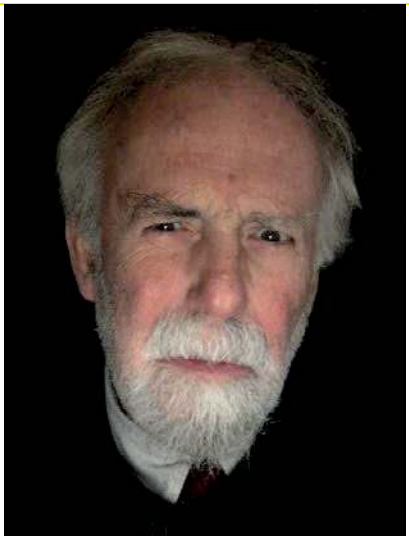
The machines can therefore work partially autonomously but, within the machines, we will finally find the author, his recognizability and identity, and his ability to give us answers not only objective and optimized but complex, different, unexpected, certainly more relevant and more useful to choose how to broaden our vision of the world.

Celestino Soddu and Enrica Colabella

Chairs of Generative Art annual conferences since 1998



PAPERS



Subjectivity in Machine.
The Future of Generative Art

Rediscovering the Author in Generative Artificial Intelligence and saving the Logical Interpretative Memory of Digital Culture for Future Generations

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Abstract

Generative Art has opened the possibility of inserting subjectivity in machines using artificial intelligence.

The debate on how creativity can be managed by machines has always been very open, even if the current approach is still to find objective categories capable of including creativity in software. Categories such as the evolutionary, combinatorial, transformative structure, the search for the new, and so on, have been containers that people tried to use for this purpose. But they are still containers that, as categories, always refer to objective models of a phenomenon that is strictly subjective, following the Renaissance tradition that was the best connection between Art and Science. Every creative approach of man is instead subjective, linked to a personal vision and interpretation of our context of reference, without forgetting our cultural background.

Creativity develops, as it has been theorized many times, along a path that is based on the alternation of an abstract idea, a logical paradigm, and an operational formalization. The path is cyclical in that the first formalization obtained can be interpreted again as a new abstract paradigm that can lead to a new formalization, even extremely different from the previous one. This path in progress increases the complexity having a very precise purpose: to perform an idea that has the characters of artist subjective vision using not an analytical approach but an interpretative approach focused on what, even if partially, corresponds to the artist vision.

This paper explains how the alternation between an abstract idea, as a topological paradigm based on the subjective interpretation of nature and the past, and the progressive formalization based on transformation algorithms are the basis of the possibility to build, and make operational, a digital creativity as a mirror of the specific creative vision of the artist.

We can introduce into a generative program of Artificial Intelligence the progressive but never deductive path, which crosses different interpretative moments. These differences are often due to contingency, but they are never far from the subjective vision of the artist.

We can do it by constructing and enlarging the interpretative labyrinth expressed by the subjectivity of the artist without reducing it to objective categories but working to ensure that this simplification does not occur.

The operative possibility that I am running is to write an AI software as if it were a book in which I have the possibility to tell myself as author, the related contradictions and the parallel possibilities, so that the logical labyrinth that is produced is a possible alter ego of my creativity.

The generative software, being executable even repeatedly at different times, can reproduce the unpredictability of possible outcomes but also, at the same time, the strengthening of the characters and the recognizability of these outcomes as a complex representation of my subjective vision.

The variations in fact, are possible representations of an abstract and visionary idea whose uniqueness is due to the contingency. They are the only possibility, as incremental acting, to represent the idea itself in its complexity.

ARGENIA is an example of the way in which Generative Art rediscovers itself and the possibility of actively participating in the new digital revolution linked to AI.

A world of possibilities, mostly innovative, is in front of generative artists as an essential component of a digital future more and more on a human scale and where the discovery of the author is no denied and unwanted, as happened in the past century.

It is not a case that until now the authors of software, even those of AI, are not considered as authors but only as technicians working in an analytical system.

The future, therefore, even in the digital age, is also the rediscovery of authors and their cultural vision. And Generative Art can play its full part.

Argenia, my generative software, is going in this direction.

In this paper I will try to explain, step by step, the interpretative logics that I used, in the last 35 years, to upgrade my work and to transform my ARGENIA into a Generative AI software able to represent my alter ego and to transform each unpredictable request into generated artworks, architectures and objects able to represent my vision. Like a new type of book, an operative book, for moving a subjective vision to be part of a readable memory.

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Key words: creativity, generative AI, subjective logic,

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Subjectivity in Machine.
The Future of Generative Art.

Rediscovering the Author in Generative Artificial Intelligence and saving the Logical Interpretative Memory of Digital Culture for Future Generations

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Premise

The history of computer use starts from a first approach in which problem solving was the initial aim. With the use of personal computers, at the end of the 70s, however, a w hole series of experiments were also developed based on the possibility of supporting one's subjective point of view in dealing with issues related to creativity and "telling" one's own logical and interpretive vision of what surrounds us.

To make an experimental software based on one's own vision was, in those first moments of experimentation of Digital Art, like writing a book, but with an evident additional element: one's own vision was executable, therefore communicable also through direct experimentation.

Everything changed abruptly anyway. Later, with technological fast development and the widespread production of closed commercial programs, i.e. without the availability of source codes, this subjective and visionary approach weakened. Instead, the approach that we might call overestimating the technological aspects has been consolidated.

The software of creative experimentation based on the subjective identity of the artist has given way, in most cases, to commercial software that has progressively covered many of the possibilities traced by the first experimenters, making them, at least apparently, objective and detaching them from the creative identity of those who had designed them.

This has developed, indeed consolidated through actual practical realization, the philosophical concept triggered by Roland Barthes, "the death of the author" where the recognizability and identity of the subject was overshadowed if not deliberately hidden to the advantage of a presumed collective identity linked to technological progress. This approach consolidated the primacy of technology over subjective logical thought. Art and architecture, for example, have also been strongly conditioned by the latest available technology rather than pursuing the vision and identity of the author, as was already happening with the advanced tools of technical drawing.

Even when a pos sible identity was created, as in the case of "robots that create art", there was no reference to the identity of the programmer, the true author, but an attempt was made to pass on the concept of the autonomous creation of the machine..

In fact, two philosophies clashed.

The first had as its primary concept the definition of objective categories in which to catalogue events, the objective identification of problems and optimization, carried out even at the cost of simplifications, which was based on the choice to develop projects only as a group.

The second identified in the diversity and uniqueness of the subject the possibility of increasing the complexity of the design work and its recognizability as belonging to the author.

The philosophy based on optimization has monopolized the culture of the end of the last century, both in the scientific and creative sectors.

Recently, however, something is changing and even Artificial Intelligence has rediscovered the poetics and the need to overcome the concept of optimization and reduction of events only to objective categories.

It involved the need of accepting the importance of small differences and the need to manage them with reference to different possible parallel interpretations.

This happens mainly because it was found that the limit of the objective approach to "problem solving" was the impossibility to fully face the complexity of the systems..

Even if always remaining in the field of problem solving and optimization, this approach has found the need of the "singularity", that is to develop, in every AI system, a unique subjective peculiarity based on the "learning machines" to face the problems in the specific environmental structure in which the system has fallen.

The next step is in progress.

Rediscovering what thirty/forty years ago were experiments carried out individually, a new type of artificial intelligence is configured, which we could call generative artificial intelligence. It does not propose to optimize the solutions sought but to develop them according to subjective logic in order to restore the pleasure of variations and the discovery of unique and peculiar visions, such as the interpretations of the past, of nature and of what surrounds us.

This new artificial creative intelligence could be further developed by artists when rediscovering and improving their own identity as authors, when telling the interpretative logic adopted to create works of art, architecture, objects, music and poems that are finally recognizable as the work of an author and his subjective vision.

All this comes from Generative Art, that cannot be identified as technique, when it is not limited to experimenting with the latest technology and entering the anonymous world of technological recognition, but is based on the desire to communicate one's own subjective interpretative logic, one's own dynamic vision of the world.

It must therefore be clarified, even historically, a profound difference that already existed between the precursors of digital art.

On the one hand, we found those who experimented with the last technologies available at that time, such as the oscilloscope, where they found, I would say successfully, the possibility of generating complex and pleasant forms based on the synaesthesia between forms and physical events.

The interpretation was fundamentally based on technology since the control of these representations was not for the purpose of communicating a creative idea but for the purpose of finding aesthetically fascinating representations of possible physical events.

On the contrary, other precursors started from their creative vision and, even if they obviously used the appropriate technologies, they did not follow in the wake of the latest technological tools but pursued, with the help of advanced tools,

the development of their own ideas and visions.

There was no categorical difference between the two approaches, also because often the same "precursors" of digital art oscillated between these two possible ways of experimentation.

The recognisability of the artist enhanced by variations.

Between these two approaches, the recognizability of the artist has always made the difference.

While for some experiments the emerging element was the recognizability of the technology used, and the results were not directly recognizable as belonging to a specific author, for others the use of technological tools provided the opportunity to manage the complexity of the results with the opportunity to expand and even consolidate the recognizability of the vision of the artist.

The possibility of acting creatively with digital instruments was based on the operative capacity of the machines to be able to repeat the same logical processes indefinitely, starting from even limited variations. This possibility defined the way of having multiple variations linked to one's own logic and therefore of having control of one's own ideas, of one's own creative action, evaluating, at the same time, the multiplicity of possible outcomes and the recurrent characters common to all variations.

In practice, it was possible to propose and manage the structure of the variations similar to those of natural events belonging to the same species.

The random and the unpredictable contest

The use of random parameters was the easiest way to proceed. Random was configured as a tool capable of unpredictable possible outcomes but also with the risk of eliminating the recognizable characters of the author.

My opinion is that the random factor can be used in the same way that the nature uses the unpredictable environmental context. An olive tree, the more it is beaten and strongly conditioned by the wind, the more it assumes the character of an olive tree.

If instead the random factor interferes directly on the form of the event without being conditioned by its organizational structure, we have the so-called emerging form. In this way the recognizable character of the author's idea moves away. This approach is something similar to the compulsive shopping of forms.

Time, uniqueness and unrepeatable

In my generative software Argenia, but also in my generative parallel software Musicablu, I have identified over time the variables that manage the differences and uniqueness of the events generated within the recognizable identity of the species.

The flowing time parameter is used to orient choices between alternatives and not to act directly on formal outcomes.

At the start, the generative program reads the year, month, day and hour, minutes and seconds. These data, which are updated in real time, provide the codes through which is indexed, for each spatial event, the list of possible alternatives, identified by the structure and characters of the connections indicated by the topological paradigm.

The choice, of course, affects the structure in progress of the generation of the event and is reported, often expanded, in the next development. But this does not change the direct relationship between the author and his own vision.

The use of time means that the scenarios generated in rapid succession are always unique and unrepeatable (time goes on inexorably second by second) but are more similar to each other than those

generated with more extended time frames. This is due to the fact of involving only the seconds or at most the minutes and not the days, months, seasons and years.

Very often, even for the current speed of the machines, I thin out the generations in time to have a r ange of scenarios that cover more possibilities.

The use of time, in my opinion, favors a control of the individual diversity of the generated scenarios, similar to that of an environmental context that varies but that does not affect the recognition of the species that remains the goal of the generative project.

The topological paradigm is the same, even if it is formalized in different ways, and the results, in multiple variations, maintain the basic characters that identify the recognizability of the idea and, obviously, of the author.

In other words, this approach to Digital Art has provided the possibility of creating not only individual events, but especially events able to focus the subjective logic that could generate this multiplicity of variations, linked tp the recognizability and uniqueness of author's creative "style". The forms can change but the idea remains the same.

This is where Generative Art was born, a direct expression of human Creativity in the Digital Civilization.

Generative Art cannot therefore be o nly considered a di gital technique, a representation based on the synesthesia of physical events or considered as art generated by machines without human control.

Creativity and Digital Art. Interpreting Nature and the Past.

Creativity, in fact, comes from the logic adopted and not only from the forms used. As Poincarè stated, creativity is born from the subjective interpretation of the relations between events and of the topological configuration of the possible relations.

The evaluation of the validity of the hypothesized relations is certainly subjective, basing itself, as Poincaré affirms, on "beauty" and not on presumed optimizations. Objective evaluation cannot take place because each creative approach tends towards a different purpose, identifiable in a subjective vision.

The idea of a s tructure of possible connections that follow a subjective vision and characterize it springs as an abstract idea.

The abstract idea could be configured as a Topological Paradigm in which events do not yet have a defined form but of which a network of relations and reciprocal characterizations is assumed. The creative idea configures an idea of organicity that corresponds to one's own vision and cultural references.

The idea can be a bducted from the past or from nature. Every subjective vision is based on the interpretation of the existing matter that, in this way, becomes a way to develop a possible future.

The basis of a cultural identity is related to the interpretation of Nature, in its various and surprising harmonic structures, the interpretation of the past, the unique characteristics of some cities, as well as masterpieces of architecture, music, poetry, art, but also the scientific discoveries, with the various and parallel theories that focus from different points of view the harmony of the universe, noi missing the mathematical and geometric insights.

In particular, the drawings of synthesis between various dimensions, such as perspective theories, are indicators of a harmonic structure whose beauty excites us and that we can use as a reference for the construction of a structure of connections that makes our idea explicit.

Reading Nature and the Past by interpreting the organic aspects that respond to our subjective sensitivity, to the characters that we would like to

consider as pertinent to our peculiar vision of the possible, means building the future by creating new systems of relationships. The act of shaping topological systems capable of increasing and accelerating a system towards a given objective, defining the structure of relationships present in the events in which we are, this is identifying a subjective Idea.

This is creativity.

Identity and subjectivity

Each of us, individually, develops a concept of identity in different ways for events that are common to all.

The very concept of an ideal city is undoubtedly a concept shared at least by those who live in a certain city with a strong power of fascination, such as Venice, Rome or New York. But the same concept of the ideal city is expressed in different ways in each person and the collective result is to work to increase the characteristics of this identity in progress through works, architectures, texts, artworks, music that, in their diversity and multilaterality, contain a possible character able to increase the complexity of the shared idea.

Different interpretations of a common fascination create the possibility of increasing this identity in progress. Each different interpretation of the same ideal city are variations capable of amplifying its identity. Together with the ability of this complex system, as each city is, to communicate and respond to the diversity of subjective requests of its inhabitants, often unpredictable requests.

No one can think of increasing the identity of a city by repeating existing forms, even if this may seem possible. The urban identity, as well as that of each individual, exists only if understood as a way of growing. Otherwise, there is a risk of museification and the death of the identity itself.

The forms are therefore not the basic elements of an identity but only possible outcomes of a process of dynamic interpretation of the existing.

This happens not only for the cities.

Even at the scale of events such as artworks, and specifically in relation to the digital approach to creativity, the interpretation of Nature and the Past opens us to the world of progressive transformations, of algorithms as identification of a possible evolutionary process, of a way of operating in the progressive search for logics that correspond to our identity as artists. Nothing is static but everything is transforming following logics of which we can subjectively evaluate harmony and beauty.

Forms as dynamic entities interpreted as algorithms.

Each form is and must be considered and interpreted as fluid, within a generative logic.

Considering forms from this point of view, that is from the point of view of "vital dynamics", our interpretation of formal events cannot stop at the insertion of a form in a predefined category but must access the possible progressive logic that could generate it.

To trace our interpretation of a specific form as generative dynamics means to opt for a fundamental creative choice, to choose a generative dynamic among the infinite possibilities that could correspond to the identified form.

We can make this interpretation explicit through a dynamic logic, an algorithm that defines its progressive structure and that opens the door to the experimentation of further potentialities inherent in this interpretative passage from static to dynamic.

It's impossible to fix one of this dynamic logic in generating a form as the optimized procedure. The interest is that they are

infinite and, only all together can cover the complexity of possible and, some of them, together, a subjective identity of a vision.

These possibilities have been the basis of the experimentation of the precursors of Generative Art that are not limited to Digital Art but that exalt some possible aspects related to the conceptual and creative passage from forms to algorithms.

Each set of progressive processes of transformation, from unique results to the "species" of results, create identifiable sequences of variations able to identify in a more pertinent way each idea.

Note:

Even the simplest forms can be considered as a poi nt of passage for a spatial geometric progression. A cube could be interpreted dynamically in many different ways, for example as:

1. Moment of passage from a square-based prism with infinitesimal height to a parallelepiped with height tending to infinity. Passage points can be discretized with the height equal to the base, with the height in relation to the gold section with the base, or following the Fibonacci series, and so on.

2. Moment of passage of a square that, rotating around an axis, defines the following edges. The cube occurs when the rotations are 90 degrees but these rotations can be di scretized in different ways until you achieve, when they are infinitesimal, a cylinder.

3. Moment of passage from a square-based pyramid, when the upper square is reduced to a point, to an inverted truncated pyramid when the upper square is greater than the base square and can tend to infinity.

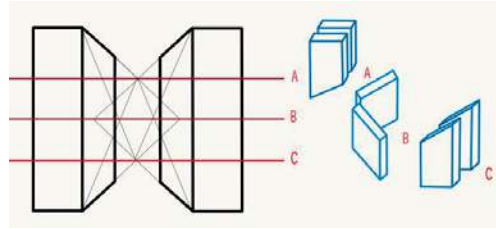
4. Moment of passage of a transformation of a r hombic-based parallelepiped where one of the corners of the base goes from 0 to infinity.

5. And so on, but you can go further

6. Using the subjective interpretation of the past, for example Baroque, we could define the cube as the moment of passage between the shortening of the diagonals and their lengthening, keeping the distance from the center of the cube to the center of each face fixed, and transforming the faces into a double-curved surface, convex or concave.

7. Going ahead, it is also possible to use, to define algorithms for the dynamic transformation of forms, the possible parallel structures of perspective representation. We can move from the historical ones, medieval subjective perspective, Piero della Francesca's perspective, anamorphic perspectives, Florenskji's inverted perspective, to the anamorphic, spherical and inverted perspectives developed by me with my first software of perspective by using the perspective restitution (I developed a software for managing these possibilities: Tracce, 1979) .

If, for example, we consider a perspective drawing, even if rather simple, like the one I proposed in many cases to my students, (see figure), it is possible to activate a whole series of interpretations that can then be t ranslated into algorithms using both the procedures of a perspective system.



We can define different interpretation of the image by varying some parameters connected only to the subjective reading of the image and not to its structure, such as the position and distance of the point of view from the surface of the drawing. It reflects, mathematically, one of the parameters of the subjective interpretation, as well as the logical

procedures of passage from one perspective system to another.

In the example we explain 3 cases.

If we modify the position assumed by the observer to make a perspective restitution, that is to say to geometrically define the represented event, we can identify some positions that significantly alter the stereometry of the event we trace, to avoid ambiguity through an axonometry.

Case A, interpretative variation by modifying the observer's reading position:

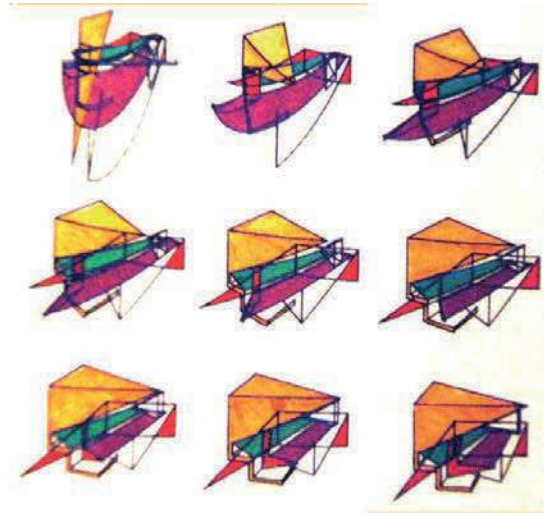
A1. In position A, the trace on t he sheet of the point of observation coincides with the point of presumed perspective focus of the two ridge lines, understood as a plane, a terrace. In this case, the lines that trace the attack on the ground "generate" a plane inclined downwards. The buildings will be parallelepipeds, parallel to each other, rising on a downhill road.

A2. In position B, which may be another point of progressive variation of the stereometry interpreted in the image, not in contrast with the previous but which focuses on the progression of transformation of the event, we can interpret the design as two parallelepipeds that have different vanishing points but it is the same horizon line. In this case, maintaining the stereometric structure of the parallelepiped, the two volumes will no longer be parallel to each other, they will lose the inclination of their bases but will diverge towards the observer forming a plane and triangular space between them.

A3. In position C, we can interpret a variant of position 1. While the attack on the ground will be on a flat road, with the two volumes parallel to each other, the terrace will disappear transforming itself into an inclined roof, with the inclination towards the observer.

Case B, interpretative variation passing from one to another perspective structure.

B1. If we interpret the image through the restitution from a "traditional" perspective, we have the possibilities identified in the previous cases.



Transforming Futuristic Balla picture moving from Euclidean and non Euclidean perspective

B2. If we interpret the image as restitution from a non-Euclidean anamorphic spherical perspective the geometry of the volumes assume an arrangement that we could define "Baroque", because it corresponds to a type of geometric transformation used, for example, by Borromini in S.Andrea delle Fratte.

The lines that represent the sides of the parallelepipeds in perspective, passing from the Euclidean to the non-Euclidean arrangement, move towards the inside of the volume itself.

We have thus found the possibility of constructing a baroque algorithm using the logic of geometric passage from a Euclidean reference to a non-Euclidean one. But this is only one of the many possibilities.

And so on: no limits to possible subjective interpretation of forms as dynamic transforming rules for designing generative algorithms.

ARGENIA

Since the 70s I have developed various generative software dedicated to experimenting how to implement my vision, my interpretations of the past.

With the first personal computers, I have developed, at the end of the '70s, my passion for perspective structures as tools for the passage of spatial events from a dimension to another.

I experimented my logical interpretation of the Middle Ages as a moment of rethinking of multidimensional representation, of the Renaissance as a moment of synthesis between Art and Science and of the Baroque as a moment of experimentation of generative dynamical geometry.

In parallel, I have developed subjective interpretations of scientific research, from chaos to attractors, which opened doors that were unthinkable before for those who did not tried to operate through computer tools.

In addition to the first specific works dedicated to particular themes, my generative work has been concentrated in the development of the software ARGENIA, dedicated to the generation of 3D models of Architecture, Design and Art and, more recently, starting from 15 years ago, also in the software MUSICABLU dedicated to the generation of musical scores and possible variations.

Logical memory

Unfortunately, in recent years the progressive development of technologies has also led to a real practical difficulty: how to preserve and pass on to future generations the work, but especially the logic used by those who have experienced the first steps of digital approach.

Much of the material produced in the world in the last 40 years, scientific articles, software and digital experiments, has been lost or can no longer be read because of the incessant upgrade of the technologies used to achieve it that have made obsolete, and therefore unobtainable, the tools used.

A constant of my work, and in particular of the generative software Argenia, has been to preserve the memory of the generative logics adopted. It was like writing a book that tells in progress my peculiar vision of the world. Every occasion of generative project led me to design new transformation algorithms focused on the realization of events closer to my spatial vision of the moment.

But own identity today is never the same as yesterday.

These algorithms are always a little, or even a lot, different from the previous ones and do not replace the previous ones but support them, increasing the logical memory of my spatial vision in the various facets due to the creative moment and to the progressive sensitivity belonging to the contingencies and passions for different moments of our cultural history.

The structure of this generative software, even if it has progressively used different hardware platforms, from Apple II to the current PCs, has remained essentially the same, especially because it does not use, by choice, the commercial software libraries that are always rapidly obsolescent.

The progressive transformation of the structure of Argenia started from a program strongly built on a path limited to a few variables to arrive at a system based on a very large logical labyrinth and with many possible alternatives that can be activated both in parallel and in sequence.

These alternatives, which are not alternatives to each other but multiple logical representations of the world of the possible, tell my vision, without simplifications, without attempts at optimization, without denying possible negative moments and dead ends with the

conviction that these moments are only a necessary path of transition to complexity.

Argenia is a personal software of AI that is configured as a digital alter ego of mine able to tell operatively my creative vision and, I hope, to communicate it also as a possibility to future generations.

Argenia, as Generative software must be, is not based on a problem solving approach, since every project opportunity presents a range of possible solutions, each one acceptable because it is chosen on the basis of what represents my vision in progress and not on the basis of objective optimizations.

Argenia is like a critical text, a story that documents an evolving point of view where every possibility, concretized in an algorithm of transformation, had its own emerging moment when it was created for a specific project, but still remained in the labyrinth of possibilities to be activated when specific characters are required by subsequent projects or by peculiar spatial arrangements. These spaces can also be generated in projects strongly different from the one for which the algorythms were written.

Each different generative algorythm is therefore a possibility among many others to work logically to transform the system based on the contingency defined by an abstract idea, by an initial topological paradigm that is identified as the backbone of a new generative project.

The progression of Argenia and the logic of transformation activated as an interpretation of the past.

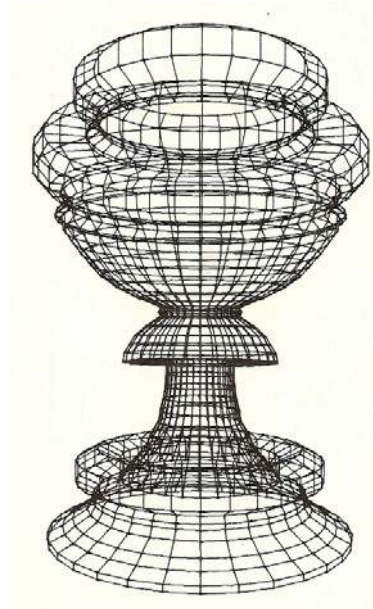
My generative work is born through the interpretation of my great masters, telling their work through the creation of codes of transformation that can identify the potential, at least those that collide with aspects of my spatial, architectural and urban vision.

ARGENIA, step by step

Argenia's first preparatory works were born in the early 1980s from the logical interpretation of Piero della Francesca, whose chalice (which, in the 1980s, was still identified as Paolo Uccello's chalice but was later attributed to Piero) was the basis for the construction of the algorithmic system of perspective views.

This logical perspective system was not born from an attempt to emulate vision, but from the mathematical interpretation of the first geometric sequences identified by Piero della Francesca.

The logical interpretation in algorithms of an encoded system of geometrical procedures had an extra potential. The algorithms could be used by forcing the limits of natural vision and bringing the mathematical and geometric transformations towards the construction of scenarios outside the representations of what can normally be seen by the human eye.



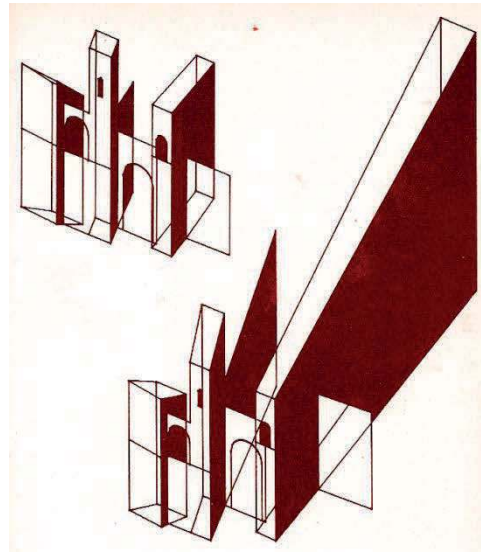
Algorithmic reconstruction of the perspective system used for the chalice of Paolo Uccello – Piero della Francesca.

Based on these perspective logics, the interpretative readings of Giotto and Simone Martini with their representations of medieval cities, had a great potential, that of not being, intentionally, structures prospectively "correct".

Working on multiple virtual points of view and making transformations between the image of the painting and a possible measurable axonometric representation, I realized that these works could be interpreted as dynamically built on progressive deformations that follow and amplify a s pace-time path within the city they represent.

In Simone Martini's representation of the miracle of the "child hit by the wolf" (1328) for example, the virtual path took place from the outside of the city towards the inside and involved, dynamically, the perspective arrangement of each individual building, reformulating the same spatial arrangement.





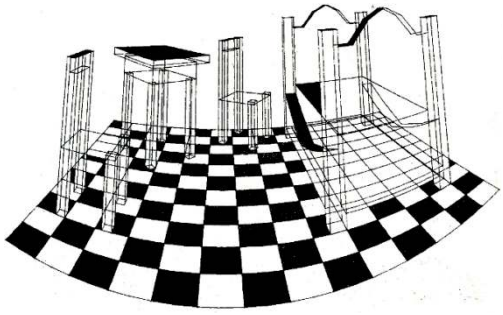
Dynamic reconstruction of the Medieval Town painted by Simone Martini. 1985

It was the first time that perspective logic, based on algorithms written by interpreting the "chalice", focused on the "subjectivity" of the algorithms themselves, becoming capable of dynamically interpreting and telling the progressive transformations of the point of view within a single image understood as a three-dimensional space-temporal representation of a c omplex dynamic event.

The same interpretative basis had a further possibility of being structured as a transformation code. The occasion was to interpret one of Vincent Van Gogh's paintings: the interior of his house, painted several times by the artist. The perspective structure appears, at first glance, correct. But then, when the perspective system is checked, a profound divergence appears, which is then the possible hidden charm of this work.



Van Gogh, the bed room



Curved perspective looking to upside

The perspective of the interior of his bedroom appears as curved perspective seen from above, and t he entire upper part of the room is excluded from the painting following this assumption of vision from above, but the perspective structure is that of a v iew from below as can be seen from the inclination of the vertical lines.

I interpreted this dystonia as the desire to represent space while, looking upwards, only the one he saw downwards with the tail of his eye was represented.

In practice, the view used by Van Gogh appeared on one side, like that of a person lying down looking upwards but, at the same time, the highest part of the room and the ceiling were not drawn, limiting the painting to the "invisible" part except with the tail of the eye. The image appears as a perspective representation in which the exception tells the logic of Van Gogh's communication.

This interpretation of mine was expressed in an algorithm of transformation where the perspective structure acts not only as a narrative of space but as an accentuation of the character sought in the same structure of the spatial order. (These two examples, and others, are in the book C.Soddu, L'immagine non euclidea, Gangemi Ed. Roma 1986, whose second digital edition can be downloaded free of charge from the website https://artscience-ebookshop.com, as are all my books cited).



Piero della Francesca, "La Flagellazione"

This painting by Van Gogh proposes a perspective structure capable of structuring relations, the connection between the seen and the unseen. We can find the same structure of relations in the "Flagellazione" of Piero della Francesca who instead used an upward expansion, "beyond the limits", of the perspective vision, while maintaining the correctness of the perspective geometric construction.

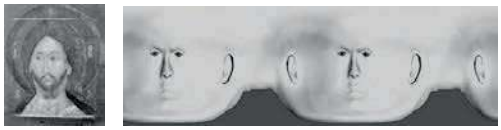
The point of view, in fact, is very low but the three people and the urban background on the right are still correctly represented even if, in a " natural vision" could not have been seen.

The topological tear of the relations between the parts, also in this case, is the basis of the fascination of the painting and

this spatial-temporal distortion can be interpreted with a generative algorithm that responds to this process of disorientation and focusing capable of communicating a dynamic vision in a static image.

In all these cases, from Simone Martini to Piero della Francesca to Van Gogh, these are geometric logics capable of representing at least four dimensions within a t wo-dimensional image. The passage from one di mension to another and the stratification of multiple dimensions in a f irst two-dimensional or three-dimensional event was one of the main ways I used to build generative algorithms for designing my own personal generative logic in progress, based on the subjective interpretation of the past.

These first works of mine between perspective representation and transformation algorithms continued in the following years, also tracing the logical structures of Pavel Florenskij's inverse perspective that allowed me to write and use, in a generative way, the algorithms of a whole series of possible perspective rules.



Icon with Pavel Florenskij's inverse perspective and the anamorphic 360 degree perspective from inside the face. The view from inside identifies the character of the icons perspective creating a new possible transforming structure for generating events.

Perspective is not in fact an ax iomatic method of representation but a po ssibility of focusing on the plurality of possible relationships.

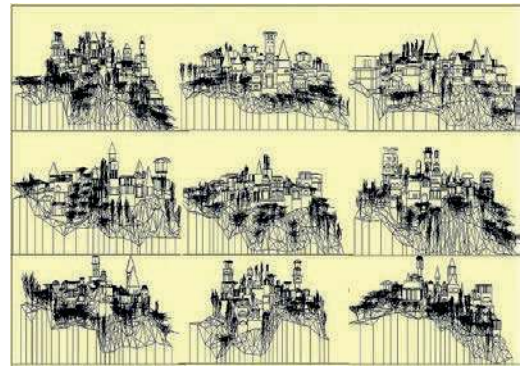
We can refer, depending on the moments of interpretation, both to the perspective of Piero della Francesca (an eye and a target), to the spherical and c ylindrical anamorphic one (an eye and infinite objectives) and to that of Florenskij (infinite eyes and a single objective). (C.Soddu, "Perspective, a Visionary Process: The Main Generative Road for Crossing Dimensions" in Nexus Network Journal: Volume 12, Issue 1, Page 33-46, DOI 10.1007/s00004-010-0016-6, Springer Publisher, New York, 2010)

The construction of Argenia began after the first experiments in perspective geometry with the creation of the first experimental software of generative architecture that had a s its first reference the work on Simone Martini and Giotto.

The idea was to generate 3D models of medieval cities, all different but having in common the characteristics of an I talian medieval city.

To be m ore explicit, the characters of medieval cities are not the results of objective analysis of the real medieval citis in Italy.

They could be i dentified through my interpretations of the works of Giotto and Simone Martini, getting, in this way, a more complex and useful support in identifying its peculiarity.



First generative 3D models of Italian Medieval cities, done referring to Giotto and Simone Martini. 1987

In my 1989 book (C. Soddu, Città Aleatorie, Masson Ed. Milano 1989) I made explicit this experience of generative experiments carried out on medieval cities and on some of their topological variations.



Following this generative work I decided to abandon the evocative power of forms to concentrate on the connections between events and the dynamics of transformation.

For example, it was no longer possible to identify the forms generated with the corresponding medieval forms in the works of reference.

The proliferation of the logic of transformation cancels the relationship between the forms of reference and the forms generated, but maintains, indeed amplifies, the importance of mutual connections, of the topological structure, as the carrier of the medieval identity of the scenarios generated.



In the subsequent book, written together with Enrica Colabella (C. Soddu, E. Colabella, "Il Progetto Ambientale di Morfogenesi. Genetic codes of the Artificial ware", Leonardo project 1992) we presented our educational experience directly related to generative experiments.

In fact, we have seen how the experiences of generative design, the progressive logic of transformations and the use of the catalyst as an interpretative reference to the Past for the construction of the topological paradigm were directly traceable in teaching and des ign laboratories. Especially in the didactic structure connected to the teaching of creativity.

In this book I also presented how I had extended the experimentation on medieval cities to other cities, the contemporary one, the coastal one, etc., and the first experiments to generate design objects, like chairs, for the industrial production of unique and unrepeatable objects, like natural events..

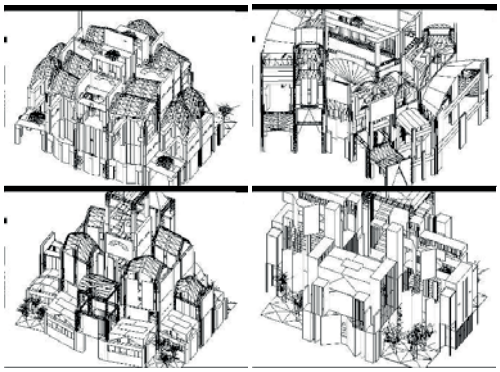


Generated chairs for unique and unrepeatable object to be produced by industrial devices working directly with the outputs of generative software

Focusing the architecture, I defined, for the first time, a topological architectural paradigm based on the number 27, as indicated, without explanation, by Francesco Borromini as the basic number of architecture.

The paradigm 27 for architecture was one of the fundamental steps to move from urban scenarios that alluded only to the urban image to urban scenarios formed by realistic architectural events, i.e. built according to the topological, structural and functional rules of architectural events.

This has led to an increase in the level of reliability and complexity of the 3D models generated and parallel to the possibility of managing the generation following the characters of my architectural vision.

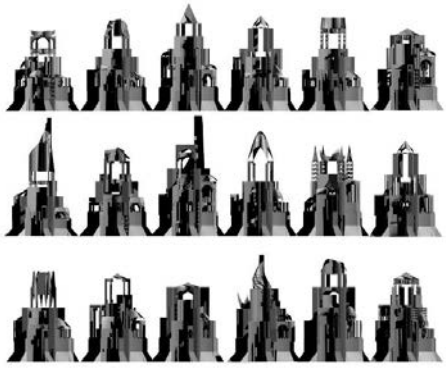


Generated architecture 3D models with paradigm 27.

Paradigm 27 defines a system of connections between 27 events that form a unique "architectural" event.

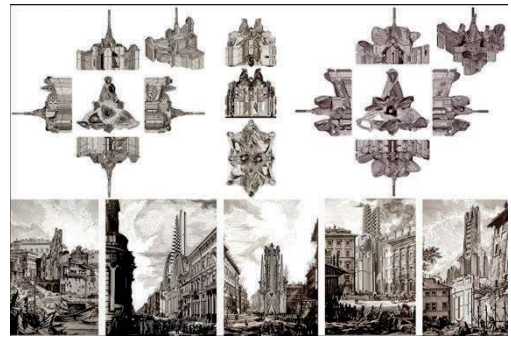
A floor, four corner stones, four basic beams, four columns, four walls, four capitals, four beams, a roof and, of course, an interior space. In all, 27 events that have a basic structure of mutual connections between them, connections that can, of course, assume different values and characters depending on the project and the "point of view". Identifying how to structure connections meant identifying the operational structure of my architectural creativity.

It is not, in fact, a matter of optimising relationships, but of an open organic design that makes it possible to subjectively express one's own vision of each individual topological relationship while maintaining the structuring peculiarity of the architectural event.



Generated Medieval Castles with paradigm 27

Later I built a variant of paradigm 27, paradigm 21, which defined the logical interpretation of the topological structure of the works of Francesco Borromini that I care most about, as Sant'Ivo alla Sapienza. This unique work is in fact based on the extremely complex and exciting use of the geometric matrix of the equilateral triangle and the spiral.

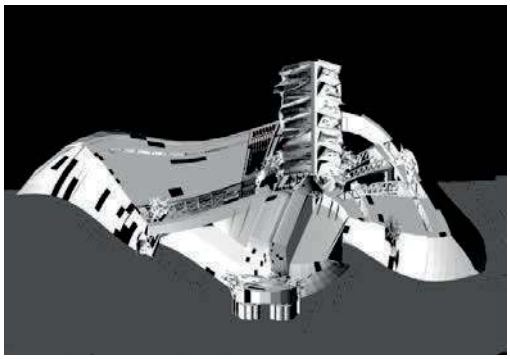


Use of paradigm 21 for generating baroque architectures based on triangular grid.

The use of paradigm 27 in didactics was fundamental, although it was difficult for some students not inclined to have an abstract vision before the formal one to use it.

We have experienced this not only in all the courses at the Politecnico di Milano University but also at the Faculty of Engineering of Cagliari where, beyond the paradigm 27, we have proposed to the students a paradigmatic interpretation of Palladio such as to disregard forms but such as to subjectively retrace the harmony and the logical and organic structure of Palladio's topological matrices.

With paradigm 27, in fact, a cube is not generated following the cubic form, as it might seem by simplifying the control system, but it could generate architectural events completely different from each other while maintaining the topology defined and built with 27 matrices.



Generated Shopping centre near Rome, 2001. The use of pardigma 27 does not exclude the possibility of generating systems with complex geometries.

The use of an abs tract topological paradigm has allowed me to experiment with possible evolutions in the generation of architectural scenarios related to the same organic structure.

Being a t hree-dimensional system of events linked by reciprocal connections and to the characters that these connections could define, increase or vary, I experimented with the use of three-dimensional Cellular Automata in such topological systems.

Cellular Automata insert in these three-dimensional relation systems an evolutionary dynamic, then a f ourth dimension based on the evolution of the interconnection links between events. The logics of these possible evolutions can be written with original algorithms capable of telling an idea.

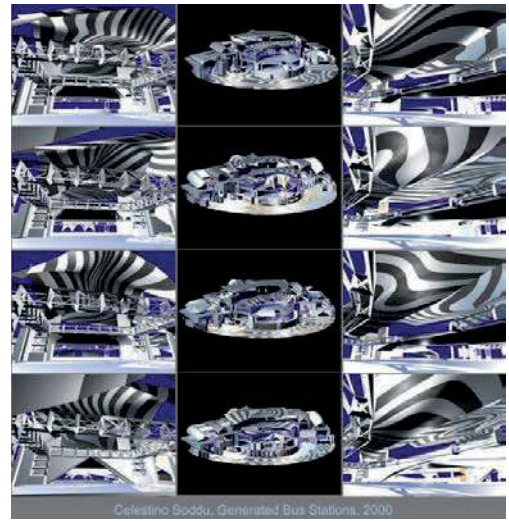
Evolution is always different and surprising precisely because of the possible interrelations and r eciprocal contamination of these logics, once they are activated in an ex isting system also formed by a few basic events located in three-dimensional space.

The results, although they appear unpredictable, maintain the harmony due to the logic of the defined laws of transformation, and therefore generate progressive topological structures with the same characters.

What is fundamental in these generative experiments is, in fact, the absolute extraneousness of the formal references.

Geometries are interpreted as dynamics of progressive transformations and the very structure of the topological architectural paradigm does not affect the formal structure.

The events generated with these progressive paradigms maintain, in fact, the recognizability of the idea even in different patterns of relationships and with the use of different forms. This is due to the fact that the logic of transformation remains the same and defines the general character of the spatial vision adopted.



Generated Bus Station in 4 variations.



Generated Architecture in Lecco, Como lake, 2009

Beyond architecture

In all the experimentations until 2001 I used my software that had been built with the aim of architecture and cities. The X and Y coordinates were dedicated to horizontal events while the Z coordinates managed the structure of the heights, from the ground attack to the roofs.

XY and Z were therefore two types of dimensions constructively, functionally and aesthetically different, because they were based and differently controlled by gravitation. This is true even if, as exceptional events, oblique events could also be generated.

However, the variation in vertical alignment did not deny the topological relations between the parts that remained, in any case, marked by the relations between vertical and horizontal members.

Obviously the horizontal events, which could appear as orthogonal in the paradigmatic representation of the system, had instead a variable geometric arrangement, hexagonal, curved, parabolic, hyperbolic, ellipsoidal, sinusoidal, "baroque" open or closed, depending on the codes of transformation adopted and, of course, depending on all possible contamination between these codes.

The vertical ones, on the other hand, even if they were generated as oblique, maintained the characteristic of structural continuity, of the presence of an attack on the ground and of a structure of "how it ends".

When there was a lack of vertical continuity, this was replaced by the neighbouring events that supported this lack, as it happens in the bridges, in the arches, in the overhangs.

The first generations of objects such as chairs and lamps also continued to have this architectural matrix where the Z coordinates had different characteristics from those of X and Y.

In 2001 I faced these limits and I transformed my generative program making possible, for each event identified in the paradigm, a different "direction of growth" and corresponding to the category of connections that would control the generation of the event.

This has opened infinite possibilities, first of all the generation of "hypercubes" or other multidimensional representations.



Generated Hypercube castle

All subsequent projects had the potential to free themselves, if necessary, from the pure architectural matrix to creatively control the generation of "design" objects, and not only that.

The generation of fantastic animals, the generation of portraits of interpretation by Francis Bacon and the generation of car bodies were only possible after this innovation.

The transformation matrices, the generative algorithms, however, remained the same and continued to grow in number populating a labyrinth of the possible ever larger.









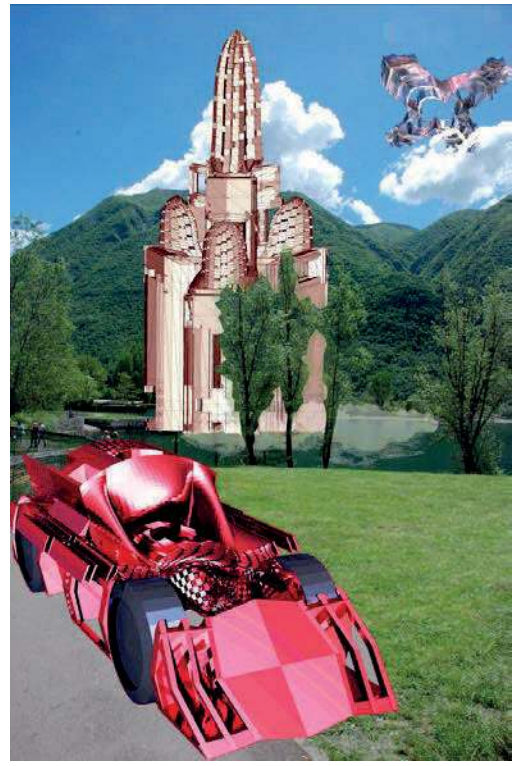
Generated portraits interpreting Francis Bacon



Homage to Francis Bacon of a fantastic animal to accompany him in his dance on the stairs.

Subsequent experiments, and the progressive increase in the logic of transformation, were based on the search for the generative characteristics of Ideal Cities, meaning as ideal cities those whose identity contains a concept of the future, of not yet reached but which is visibly perceptible and felt by those who live in these cities.

Identity is understood as the character of the transformations towards the future, as a vision of the possible. Rome, Singapore, Hong Kong, Chicago, Washington D.C., New York, Venice, Delhi, Ravenna, Shanghai, Milan, Lima were some of the "ideal cities" that I interpreted with generative algorithms.



A generated car, a U.F.O. and a baroque architecture for Porlezza, near the country where Borromini was born.

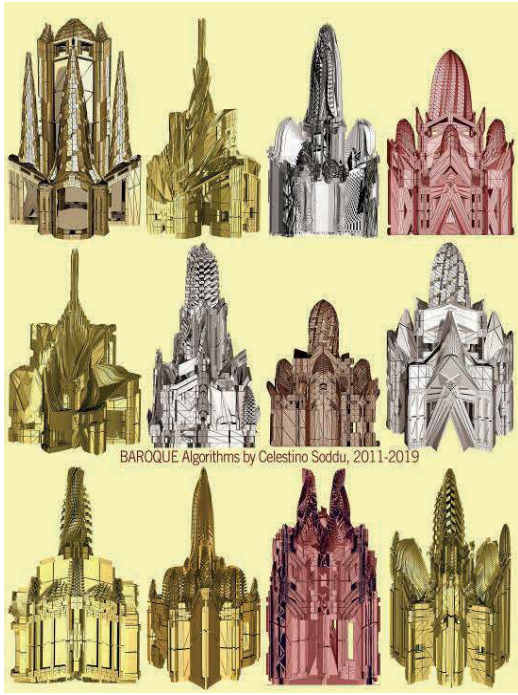


Generated car bodies. 2016

I proposed them, through exhibitions in these cities, futuristic scenarios that tried

to represent these identities in progress. All this work has remained as a trace in the labyrinth of algorithms stored in Argenia.

Everything enters into memory, as in life experiences, not only as a memory of events but as a memory of how to act, transforming the world into a world closer to our vision, and often trying to express the potential of the various contexts, the various urban realities, the various identities.



Baroque architectures for Rome, interpreting geometric transforming rules by Borromini.

I never started from an analysis of the cities but from how they had been seen by artists and architects. For example, I interpreted Rome by entering the world of Baroque geometric transformations imagined by Francesco Borromini, while Venice was interpreted generatively through the works of Canaletto.

Milan, on the other hand, I interpreted it through what has never been expressed in this city: the Futurist feeling.

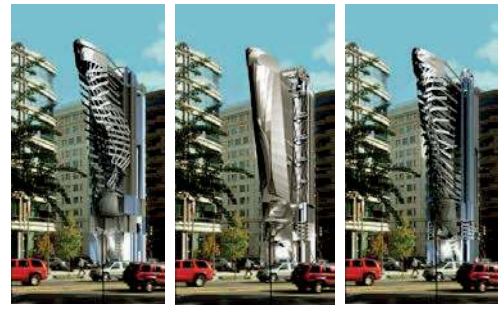
Milan experienced Futurism intensely but Futurism was never allowed to actively enter the architectural image of this city.



3 generative variation for the Futuristic Museum in Milan, 2004

By generating "futurist" scenarios for Milan, I tried to interpret a feeling, a debt that Milan has in the construction in progress of its ideal identity. (C. Soddu, "Milan, Visionary Variations. Futuristic meta-codes for Milan identity", (Italian and English), Gangemi Ed. Roma 2005., which was also the catalogue of my solo exhibitions in Hong Kong and Milan. The second edition, digital, can be downloaded for free from artscience-ebokshop.com)

Each personal exhibition, in Europe, in the East and in America, was an opportunity to increase Argenia's "active" memory.



3 variation for the World Bank cultural centre in Washington D.C., 2002

In my exhibition at the World Bank's cultural center in Washington D.C. I tried to interpret the cultural matrix that led to the construction of this city, an abstract matrix that is not so easily identifiable in the urban form and I experienced the results as recognizable variations of an idea with the generative project of the World Bank's cultural center.

In Los Angeles, in my solo exhibition at the Pacific Design Centre, my future

scenarios were multiple, just as this city is multiple despite having an ex tremely strong identity. I asked visitors to tell me about the generated scenario where, according to them, Los Angeles is more Los Angeles than before.



4 variation of generated broadcasting towers in L.A.

From the answers I identified which interpretations, and which transformation algorithms, were more in tune with their ideal City. This, as well as the parallel responses I had in other cities around the world, gave me incredible indications about the algorithms that were able to tell different identities.

The results were surprising: different identities could be t old with small variations, even related to infinitesimal numerical variations, within the transformation algorithms used.

It was like drawing a logical-mathematical map of variations in urban identity and recognizability.

Potentiality between different identities can be explored through the progressive dynamics of small variations.



Delhi, interpreting Indian identity with small variation of already used algorithms.

Venice, in 2015, was an opportunity to generate Venetian scenarios by interpreting this city in the works of Canaletto.

The results were "Venetian" scenarios that had no formal element of the architecture, cathedrals and bridges of Venice, but only its character that had been grasped by interpreting Canaletto.

However, these were unmistakably Venetian urban scenarios. And also the characters who populated these urban scenarios, just as the paintings of Canaletto were populated, were "Venetians".

In fact, I inserted in these urban spaces a fashion show with models using clothes generated for the occasion with the same algorithms creted to "generate Venice".



Generated Venice referring to Canaletto. Paintings, 2015

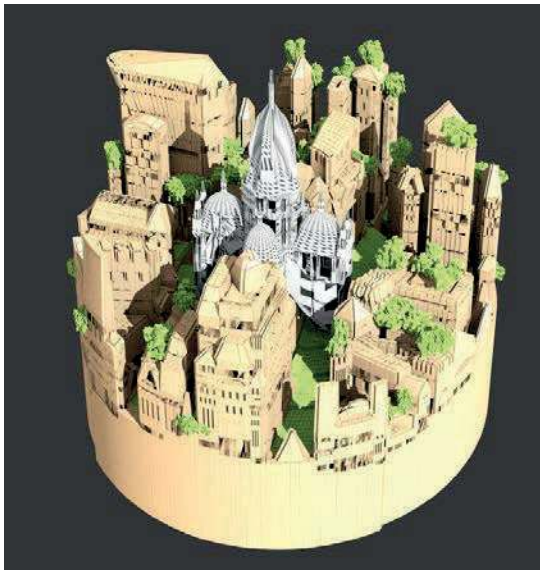
The results were recognized as Venice also by the Venetians, even if immediately

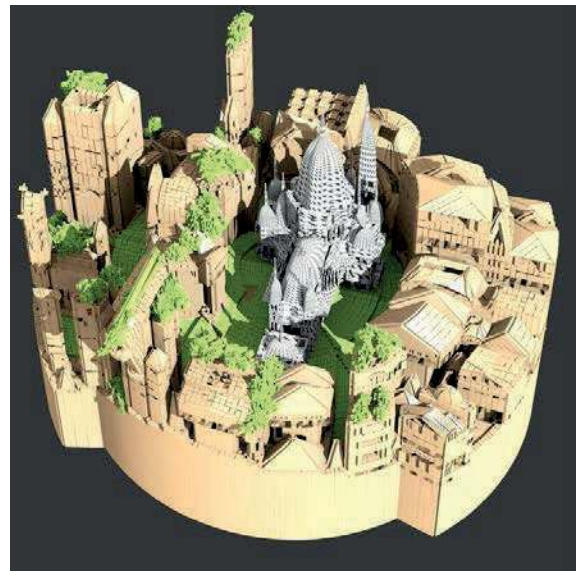
after the first impact the Venetians began to tell me that, yes, the bridges were not those of Venice, Venice did not have the same fireplaces on the palaces, and so on, highlighting what interested me, the existence of a Venetian identity told by my algorithms whose Venetian character was recognizable but was not based on the repetition of forms.

Forms were, as in any generative event, only one of the possible variations to tell the same idea.



Generated town in Tuscany landscape





Generated Tuscanian medieval cities, 2016

Following the exhibition in Florence for the Generative Art conference in 2016, I tried to make a increasing complexity evolution of my first generative work, the Medieval cities. But with a p articular attention to Tuscanian cities that have, like Florence, a core, sometimes different and a city structure fully Medieval. I called this mix of identities “duets”. The generated cities have a strong identity representing the Tuscanian peculiarity.





Generated Mosaic Architecture for Ravenna, 2017. Two variations.

Ravenna, and its mosaics, have been the basis for codes of transformation that have tried to expand, sometimes overturn the relationship between spaces, volumes and details, relocating them in a structure of mutual connections built to enhance the future identity of this city.

The mosaic architectures I generated (exhibition at the Art Museum of Ravenna on the occasion of the Generative Art 2017 conference), while tracing a strong image of this city, struck the common imagination of its inhabitants because they proposed a world that was not utopian but visionary, therefore a futuristic world capable of representing the truly possible imagination of their cultural identity.

Verona, in 2018, through the generative interpretations that I developed for the exhibition of the GA conference at the Museum of Natural History, gave me the opportunity to make a further logical interpretation of the Renaissance matrices of this city, and not only of this city, expanding the cultural reference to the Renaissance that has been fundamental in all my previous work.

I made it together with the possibility of retracing the imaginary figures of some of its monuments, generating the fantastic animals that populated the architectural and urban scenarios generated for Verona.

In the exhibition at the British Cultural Centre in Lima I presented my interpretation of the Inca matrix grafted onto the subsequent development of this city and of Cuzco, the ancient Inca capital.

The interpretation and subsequent recognizability of this historical matrix was born from the consideration of both the architecture that traced the identity of Lima, such as the geometric stereometry of the buildings defined by the facades with special projecting balconies and the structure of the holes, but also and above all from the style of its ancient inhabitants and of what, even today, characterizes the original population.



Verona, generated architectures in BRA Square, 2018



Lima, generated architectures identifying Peruvian identity, 2018



Lima, generated architecture by interpreting the tradition. 2018

Not forms, but structures of connection between the whole and the part, between events in succession, both in traditional clothes, in work tools and in architecture.



Notre Dame de Paris. Generated proposal for the reconstruction of the spire. 2019.

The reading and interpretation of the past has been actively experimented with the works of the artists who have most urged me to find generative structures that involve the characters that I most appreciated.

From Giotto and Simone Martini to Piero della Francesca and Leonardo da Vinci. In the last century, from Van Gogh to Picasso to the Futurists and Francis Bacon.

A recent tribute to Francis Bacon was to generate pets suitable for his self-portraits. These pets are certainly different from self-portraits but, starting from the characters of the muzzle to the general characters, they are born from my interpretation of his paintings, which I had already dynamically interpreted with the previous series of post-portraits by Francis Bacon.

To this I have added, as primary, the reference to a series of new algorithms, realized for example on the occasion of the mosaic architectures for Ravenna that, in the animals for Francis Bacon have been used, with appropriate variations of the parameters, for the mantle of these animals.

This makes clear that each algorithm has its own dynamics, was born for an occasion but finds, in the evolution of ideas and opportunities, its own life and further possibilities to emerge, adapting and interpreting creatively the design context. In this progressive shift they tell the progression of the interpretative and generative logics that build the identity of an artist.



Generative Interpretation of Picasso woman portraits. 1996

MUSICABLU, The generative software parallel to Argenia with output of music scores.

Musicablu uses the same approach as Argenia: the algorithms are built logically interpreting the masters of music that are most in tune with my vision. From Bach to Mozart, from Coltrane to the Modern Jazz Quartet, from the harmonic structure proposed by the Beatles to the codes of mathematical sequences (sequences of prime numbers, Fibonacci, sequences of squares, hailstones, Alcuin, etc.).

In Musicablu I built a topological paradigm of relations and connections between 15 instruments that controls the evolutionary dynamics of the piece and its basic harmonic structure.

Each instrument uses a specific modus operandi in the construction of the melody (construction of the passages from one chord to another, riffs generated with the construction of the retrograde, inverse, etc.. as the fugues of Bach, interpretations of the structure of the sequences of various pieces that do not constitute a reconstructed repetition of the same but are used only when the reference event is no longer recognizable and only its logical structure shines through.

The harmonic structure is also generated based on basic topological structures, carrying on, among other things, the experiments of the Beatles in the 3D progression between tonalities, progressions based on some chords of passage that allow, not only on the plane of horizontal sequences but also vertical and oblique, the tonal movement. (see paper for GA 2013 and article on Gasathj).

In conclusion, Musicablu is not a generative software for music but a generative software able to generate my music. The algorithms fit my abstract idea of a piece of music, following my subjective experience as jazzman in 60s, and cannot be used for any type of results.

Conclusion

In a modern reality that consumes and destroys everything, from the planet to recent history and culture, and leaves nothing to the next generation, a possible door opens.

Argenia's attempt and all the generative software created by those who are actively following the path of Generative Art, can start a parallel path to Artificial Intelligence by inserting subjectivity in machine.

Generative Artificial Intelligence, the personal intelligent systems are the version of AI that can only be born from artists and their subjective view of the world.

Like the books of the past generation, these subjective machines can be the tools through which future generations can read the recent cultural history and, perhaps, enrich the ability to interpret cultural diversity, to find possible paths to develop their own personal logic, to build their own identity in progress as creative people, as people able to identify themselves as bearers of their own cultural vision.

However, the need is to preserve this logical memory, creating generative software able to survive to the quick change of external technologies and libraries with rapid obsolescence.

In this way, we can find, or rather build our own approach on how to transfer from the past to the future, an idea of civilization that comes from multiple subjective interpretations of the past.

Like cathedrals first and printed books later, they can be an important instrument of memory of our transformation into digital civilization.

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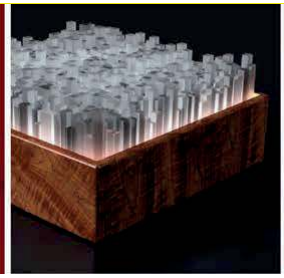
Applying Generative Systems to Product Design.
(Paper)

Topic: Design

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Abstract
Generative Design provides multiple benefits to the development of new products. First is the creation of intricate patterns that resemble natural systems, moving away from geometric shapes typical of mechanical design. Second is the automation of processes where computers perform complex and repetitive tasks that would be too hard or tedious for humans to do. The opportunities that automation provides is frequently considered the main benefit of generative design in the creation of new products, buildings and systems. In both of these approaches, the output that computers generate is driven primarily by a designer's vision that already has a general idea of how the result might look like. A new approach for generative design by software company Autodesk allows designers to define goals and criteria for functional CAD designs, and then having a program generate iterations of potential solutions. This process presents a radical shift where the computer is not just facilitating the ideas of the designer but rather designing itself. While designers still are in charge of the process, deciding which solutions are suitable for further refinement and implementation, the relationship between human and machine becomes collaborative.

This paper explores the concepts described above and it shares the Author's design explorations where both approaches for generative design are used in product design. Examples include products using Voronoi patterns (Fig.1) and procedural networks (Fig.2), where the physical appearance of the product is strikingly intricate and appealing, while the physical attributes of the product are not necessarily improved. Other examples illustrate the application of generative design structures created freely by the computer, following only set goals for supporting weight loads at given points (Fig.3-4). This process results in unique structures that are lightweight and strong but might also have a polarizing appearance for specific product applications. These examples will enable discussion on how designers will continue to integrate automation and generative systems into their process as technology keeps developing.



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Key words: generative design, product design, automation, CAD.

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Applying Generative Systems to Product Design

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Abstract

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1. Introduction

Generative systems have been long used by various civilizations throughout history. Examples of geometric studies related to astronomy and the arts are found in ancient Greece. Islamic art is perhaps the best examples of how humans use geometry to understand the relationships between humans, nature and the divine [1]. The use of computers in the 1960's to generate complex geometries was the origin for generative art [2]. A couple of decades later its use expanded to in

Architecture, Engineering and Construction (AEC) industry, leading to what is known today as generative design [3]. As digital computing has become prevalent in our society, automation is now a key component for generating complex solutions such as the ones in which generative design is based. Automation reduces the burden of performing repetitive tasks, allowing people to focus their energy and intellect into more meaningful activities that improve quality of life. The benefit of automation goes beyond just performing repetitive tasks, opening the door to achieving complex tasks that would be impossible for humans to perform by themselves.

Generative Design is a type of artificial intelligence that develops unique shape grammars based on t hree types of information: a set of rules for rules, a way for shapes to develop, and goals to be meet by the resulting shapes [4]. Goals can include factors such as mass, strength, or manufacturing processes. Generative design provides several benefits, including the development of shapes with unique geometries that are aligned to their context and improvement of mechanical performance [5].

Industrial design is embracing the principles of generative design, first focusing on the unique aesthetic style that comes from nature-inspired organic shapes. Designers have also been able to integrate automation into their process, which provides a s treamlined workflow and intricate geometries with the potential of being efficient and resilient, providing advantages in mechanical performance and use of materials [6]. The integration of generative design can happen either as a tool that executes the vision that designers have for a given product, or as the creation of novel forms that meet goals set by design problems.

This paper provides insights of the workflows describes earlier, and uses design explorations developed by the Author, to illustrate the use of different types of generative design strategies in industrial design. These workflows are just a few of many ways of integrating generative design into creative processes for product development. As designers become more familiar with these workflows, generative design will consolidate itself as a key component of design process, that helps in developing solutions that are efficient, visually engaging, and better aligned with natural systems.

2. Generative systems from tools to collaborators

Designers benefit greatly from generative design and its ability to handle large and complex amounts of calculations. While designers need to understand the basic relations that systems need to have in order to create a par ticular pattern, they do not need to have full knowledge of how to perform these calculations in their entirety. By providing basic sets of rules and objectives, computers are able to turn them into algorithms that create 3D shape grammars [7]. There exists a wide variety of software programs that perform these tasks, and two of the most popular today for AEC and industrial design are Grasshopper and Dynamo. These programs work on brackets of information that generative complex calculations. Designers need to have the knowledge necessary to input commands to the program, and also to program them in with the right commands so that the results are successful. Once this is accomplished, the hard work occurs “under the hood” and the computer takes care of performing the tasks that have been assigned to it. The key element in all of these benefits is that

generative design is a powerful tool, that complements and enhances the capabilities that designers have to create complex systems.

Generally speaking, generative design can be used in product development in two ways: one is as a tool that performs calculations in order to obtain a preconceived solution that the designer needs. In this case automation focuses as a tool that optimizes the creative process. The second way in which generative design can be used is by providing it with goals and parameters that a given solution needs to have, and letting computers generate solutions autonomously, without any preconceived notion of how a solution might look like.

This process elevates the role of the computer from just a tool that performs tasks to an active participant in the creative process. The computer is now more than a tool for the designer; it is a collaborator that provides solutions that would had been unimaginable otherwise. Generative design becomes a source of creativity that is evocative and adaptive [8]. Its evocative character is based in its ability to evoke new thinking and to display new ways of solving problems. Its adaptive character is shown in its ability to generate solutions in a wide variety of applications.

3. Generative methods in product design

The are several types of generative systems, all of which provide varied workflows and resulting shapes. Generative art is an excellent starting point to analyze and understand how generative systems and grammars work, and the shapes that they produce. There are five main categories of generative systems: Shape Grammars, L-Systems, Cellular Automata, Swarm Intelligence, and Generic Algorithms [9,10]. Each one of these categories contain variations within as designers and artists experiment with algorithms and geometries in novel ways. In this paper, three types of generative systems will be analyzed and described: Voronoi patterns, procedural networks, and generative structures' software. These three systems have been selected for the interesting way in which shapes are created as well as because of how they complement the traditional process that industrial designers use to develop new products. The goal of this analysis is to encourage designers to integrate generative systems into their current workflow, or to expand their current use with new approaches. For each of these methods described within, examples of products designed by the Author will be used to illustrate how design process and CAD software can be used.

3.1. Voronoi patterns

Voronoi patters are some of the most common generative systems used in product design. They are subdivisions applied to a plane or surface that sit at the same distance from a specific point [11]. Voronoi patters are quite popular in industrial design as they can be created with just a few, straight-forward parameters: area to be covered by the pattern, distance between cells, and point of origin, called seed. There are several online applications that automatically generate Voronoi patterns and several CAD programs also include this tool either as a native feature or as an add-on extension. Voronoi patterns are visually engaging, with the cells distributed in a fluid order. They are commonly compared to the interior mesh of bones, and in general they highlight organic, intricate nature that generative design is

associated with. A key characteristic of Voronoi patterns is that they are based on pre-existing designs. There is no need to learn complex algorithms in order to generate shapes. This setup provides designers with ample control of the design process, which takes a solid body and cores it out with the Voronoi pattern, similar to how a filter is applied to a 2D image (See Figure 1).



Figure 1. *Comparison of a solid body and its Voronoi-based version.*

Along with their visual appeal, Voronoi patterns can generate forms that are stronger and lighter than their solid versions. By turning solid surfaces into meshes, the geometry of the bodies is filled with more edges, which provides more strength and stability. The mesh at the same time removes surface area, which depending on the manufacturing process, can reduce the amount of material needed substantially. When 3D printing the bodies shown in Figure 1, the Voronoi version would use 40% less material than the solid version. A potential trade-off is that many shapes that would be fabricated with traditional manufacturing processes would not be able to be created if they have a Voronoi version, due to the more complex geometry. For many Voronoi-based shapes, particularly if they are non-linear, the only fabrication method possible will be additive manufacturing, which could increase fabrication time and cost.

An example of a Voronoi pattern in product design is an electric bass guitar (See Figure 2). The bass guitar was originally designed as a solid shape. After the shape was completed, the main body of the instrument was divided into sections. The outer sections were turned into a Voronoi mesh using an online shape creator called Voronator.com. The sections closer to the electronic components remained solid, in order to not affect the functionality of the base as well as to provide enough solid material for the bass to sound well and avoid any feedback. A similar exercise of keeping solid sections was applied to areas that connected with the neck of the bass guitar. The result is an instrument with a strong visual aesthetic and that is significantly lighter than its solid version.



Figure 2. *Electric bass guitar with Voronoi body.*

The same workflow was used to create the stool in Figure 3, which combines solid sections with Voronoi-meshes. This allowed for more control of the shape of the piece, making sure that there was a good flow and proportions all around the object. The inferior sections of the stool were meshed out with a Voronoi pattern in order to create a more interesting design. The top section of the stool remained solid, in order to make the piece more comfortable to sit on, avoiding unnecessary pressure points that could touch against the body. In this case, using the Voronoi mesh in the inferior parts of the stool adds mystery to the overall

design, creating curiosity in the user, without compromising the performance and the perception of strength and stability than a seating object must deliver.

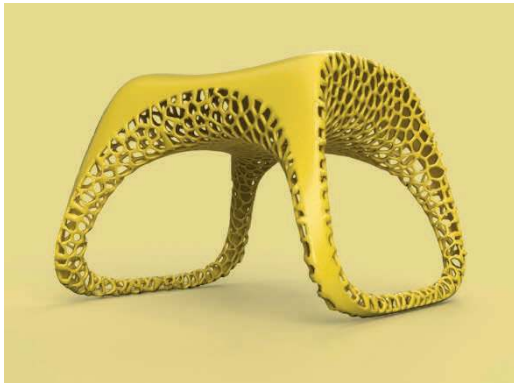


Figure 3. *Stool that combines solid and Voronoi-based sections.*

3.2. Procedural networks

Procedural networks are widely popular in Generative Art. They are based on code segments or algorithms that define physical characteristics of a CAD model [12]. The benefit that they provide is that instead of fully defining forms, textures or animations, which would require massive amounts of data, they define the coding of how these physical attributes will be generated. Procedural networks are very popular in Media and Entertainment for their ability to define the way in which body particles will move in space and be affected by external forces such as gravity, wind or other objects.

The use of procedural networks in industrial design, however, is fairly limited. A reason might be that industrial designers tend to design static bodies that only move when being used by/for the user. In order to explore the benefits of procedural networks in product design, a series of models were developed in MASH, a procedural plugin part of Autodesk Maya. MASH quickly provides exciting and powerful results for complex geometries, ranging from random patterns to more controlled progressions. Patterns created in MASH can be exported in FBX format and imported in most CAD programs. The use of this workflow is innovative by itself as CAD programs like Fusion 360, Solidworks, Inventor, Rhinoceros, etc., which are common for product design applications, do n ot provide simple ways of creating complex shape patterns such as procedural networks. A limitation of the process to keep in mind is that Maya generates polygon-based geometry. This type of geometry is not parametric and depending on how complex it is, might result in a very dense model to import into CAD programs because of all of its vertices and edges.

Figure 4 shows an application of procedural networks that were developed in MASH and then imported into Fusion 360. A grid of rectangles influenced by a noise signal, which creates a random effect with a s trong visual appeal. This effect is applied to a bloc k of translucent material, such as glass or acrylic. When applying light to the translucent material, this creates a v ery interesting lamp, that takes advantage of how the light refracts at different levels along the edges of the structure.



Figure 4. *Table lamp with shade using a grid of boxes with a random pattern.*

The use of procedural networks is applied in a uni que way that benefits industrial

design. Procedural software such as Maya MASH, was developed for animations. This implies time-based movement that makes the patterns move and transition between positions. For their use in products, designers take a "snapshot" of one of the frames in the sequence and use that to define a static shape for an object. This is one of many applications, of course. There can be very exciting cases in which products have articulated parts and they can take further advantage of the procedural sequences, envisioning a wide range of movement. There are even insightful experimentations on using motion time-based procedural modelling to create complex bodies from their steps as they move through space and time [13].

3.3. Generative structures

Generative Design has captured the imagination of product designers for decades. Up until recently, most designers who integrated nature-based patterns into their workflow did it in a way that was fairly manual. This means that they would generate individual shapes multiply them in patterns with incremental variations of shape, position or scale, in order to achieve an organic transitional flow. Programming software allows for users to develop sets of rules and behaviors that turn into interesting shape grammars. The high knowledge needed for successful programming has limited its adoption across design fields but programs such Grasshopper and Dynamo have found effective ways for making programming more accessible. What makes programs like these better, is that the programming is visual, based on brackets, connectors and widgets, making the generative system easier to understand [14]. Additionally, these programs are easily connected to other CAD applications used for design and manufacturing, making the process of design, simulation and fabrication, a lot more integrated and streamlined.

In 2018, Autodesk released their Generative Design application, which is part of Fusion 360. This tool works radically different to programs like Grasshopper or Dynamo, and it brings the process even closer to what true generative design is. Based on artificial intelligence, this program takes the set rules and goals from the user and creates large amounts of shape grammars from scratch [15]. This process is different from generative patterns such as Voronoi, as it doesn't need a pre-existing shape to base its form, and it's also different from procedural modelling, as it takes data from the user not as directions for creating shapes, but rather as a wish list of goals to be met. With the Generative Design app, the user provides data for areas or shapes that need to be preserved as well as well as obstacles that should be avoided when creating a new form. More importantly, goals are set so that the design is able to support specific loads or physical forces. Once the inputs are complete, the computer takes this information and automatically generates multiple designs, all of which solve the design problems in a unique way. The longer than the program runs, the more iterations that will be produced by the computer. The user then goes and checks on the results, which vary in form, material used, strength, and manufacturing processes, although all of them meet the basic criteria set by the user. Designers are able to pick from these solutions the ones that they feel are better for the application, and they can integrate them into their design, or use them as a base for a new iteration of generative design simulations. This process is novel in product design for several reasons:

- The creation of forms is **automated**, which is one of the

key goals of generative design. This process allows for large amount of data to be p rocessed by computers, removing the burden from the user. In many cases, processes like this are limited when run by humans, because of limited time, knowledge, or interest in performing large amounts of calculations, repetitive tasks.

- The amount of solutions that are generated by the software are virtually **unlimited**. This provides a rich foundation to designers to pick the perfect solution, instead of being able to generate only a few iterations, not knowing if they have found the right one.

- The process provides an **increased level of creativity** to the designer. The computer is able to create solutions that many times would had been inconceivable to designers, simply because human brains don't process information the same way that computers do [16]. Additionally, designers can be inspired by the results that they obtain by the software, pushing their creative process to even higher and broader levels.

- With generative design software, the computer is no longer just a passive tool that follows orders of the designer, but it becomes a **dynamic problem solver** that provides unique design solutions. This is perhaps the more substantial contribution of Generative Design to the design field. The computer becomes not only a tool for the designer but an actual collaborator.



Figure 5. *Ceiling lamp combining generative design and procedural networks.*

Figure 5 shows a ceiling lamp created in Fusion 360. What makes this lamp unique is that the actual modelling part of it is minimal, and in fact it didn't have a significant impact in the final shape. Most of the design was created by using generative tools within and outside of Fusion 360. The base of the lamp was created using the generative design tool. In this case, five points were assigned in space: one up high to define where the lamp would be hanged from, and f our point that would connect the lamp to the shield. At each of this point, forces were defined in terms of weight load and moving forces to make sure that the structure would be strong enough to hold the weight of the lamp as well as external forces such as someone hitting the lamp accidentally from the side or below. A few areas were also defined as "obstacles" to make sure that the resulting shape remain within a certain envelop and didn't expand too much. The results of the simulation provided several exciting possibilities for the shape of the lamp. One of the solutions stood out because of having a very unique aesthetic that seemed to have a good balance and go od potential for looking like a "lamp base". The shade of the lamp was created in Maya MASH. A simple cube was created in the workspace, and a s eries of procedural

nodes were applied to turn the cube into a three-dimensional grid with a progressive deformation. These effects resulted in a progressive pattern that is both geometric and organic, and that creates an interesting contrast with the lamp's base. Once the shade was completed, it was imported into Fusion 360 and combined with the base and lighting fixtures as a traditional CAD assembly.

4. Conclusions

Generative design enables an exciting direction where different workflows and ways of achieving nature-inspired systems can be combined in new and unexpected ways. In the case of the lamp shown in Figure 5, the design combines two ways of creating generative systems. The shade uses procedural networks to create a dynamic pattern with an interesting flow an elegance. This approach shows a process where the designer had a general idea of the effect that the shade would have and used digital tools to achieve this effect with ease. The base of the lamp shows a completely different way of generating shapes, which was based just on goals for supporting weights and forces at specific points. As generative design continues to evolve, it integrates criteria for shape development and optimization with goals for engineering performance [17]. The result are shapes that resemble natural structures as much in the way that they look as they perform in living environments.

Generative design is becoming a key tool for industrial design, providing a wide number of benefits. The most important one is the increased capacity that automation brings to the design process, whether it is as a way of avoiding repetitive tasks that become monotonous and time consuming, or limitations to perform complex calculations. Automation is becoming a key element of industry and designers need to become familiar with it, and to make sure that it's used in a meaningful way that enhances human productivity, rather than just replacing it. As generative design matures and becomes a common component of design process, it will be easier to find the right balance of aesthetics and performance, so that products out in the market are embraced by consumers while also providing the efficiency that natural systems have.

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The Regeneration of the Earth After Its Destruction by the Capitalist Powers

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Abstract

The Regeneration of the Earth is an artwork that simulates the re-mergence of life on our planet after the sixth extinction. The system begins as an acidic sludge, a hostile environment seeded with a small number of digital entities that exist as a random collection of energy profiles and genomic instructions. Members of this 'generation 0' are not guaranteed survival. However, though horizontal gene transfer (conjugation, transformation, and transduction), entities are able to evolve. Over time, this initial population may gain the ability to sense, move, mutate, replicate, compete, or co-operate. In *Regeneration*, the fitness test is environmental sensitivity. Entities can evolve their instruction codes to gain greater adaptability to co-habitants and to the world around them by developing cross-type or multifaceted genomes. Ultimately, the more sensitive an entity is to its environment and its co-habitants, the greater its chances for survival.

Keywords: synthetic ecology, origins of life, gene transfer

1. Introduction

In this artwork, I apply recent 'origins of life' theories to a simulation that attempts to describe the re-emergence of life after the sixth extinction.

The model initializes as a hostile, toxic environment seeded with eighty to one hundred agents – briefs sets of instructions that may or may not survive their extreme surroundings. Entities use world materials to create energy and carry out lifecycle events. These entities execute their instruction sequences according to the order prescribed by their genome 'operator' and at the rate prescribed by their energy profile. Entities that reach high enough energy levels are allowed to join networks or communities based on their entity type. Even entities that are group members are not guaranteed survival, but group members are able to benefit from the resources of group membership. Entities may evolve both with and apart from groups and can gain the ability to replicate or transfer

genetic material across a gr oup or network. Using the measure of an entity's sensitivity to its environment and i ts co-habitants as its fitness test, a reaper function periodically sweeps the population and eliminates the lowest scoring or least sensitive twenty percent of entities ijn the environment. A generation function then reseeds the population at random.

Regeneration is an ar twork intended to operate as a metaphorical system. It does not intend to model chemical processes statistically.

2. Project Overview

In *Regeneration,* the agent environment consists of composites or world materials (acid, heat, light, metal, plastic, radiation), agents or entities (acidophiles, halos, gammons, metallics, thermophiles), facilitators (donors, cooperators), communities (colonies, films, vents, vortices), and clocks (reaper, generation).

On startup, the system is initialized with somewhere between ninety and on e hundred entities. Entities are immediately able to consume certain materials from the environment as well as output other materials to the environment. These allowable inputs and outputs are what define an entity's 'type' as described in Figure 1.

2.1 Design of Entities

Each individual entity consists of an energy profile, a g enome, and an operator. From inception, an entity's type, sensitivities, and abilities are controlled by a short set of instructions – an array of 0s and 1s -- meant to act as an entity genome. The interpretation of this genome is controlled by an ope rator, a function that moves across the 'genome' string array to determine which 'gene

World Elements

Composites	Entities	Facilitators	Communities	World Clocks
Acid	Acidophiles (remove acid)	Donors (give genes)	Colonies (acid)	Reaper
Heat	Halos (remove light)	Cooperators (share genes)	Films (metal)	Generation
Light	Gammons (remove radiation)		Vents (heat)	
Metal Curtain	Metallics (remove metal)		Vortices (radiation)	
Plastic	Thermophiles (remove heat)			
Radiation				

Figure 1.

settings' are expressed and in which order.

Entities are also created with energy profiles that regulate an operator's efficiency along with the operator's rate of computation. Entity types were designed with initial lifecycle t hresholds, including trigger events for phase and fracture behaviours intended to help visualize possibly emergent states that might occur in the simulation. The structure of entities is described in Figure 2.

Structure of Entities (Agents)

Energy Profile	+	Phase Features	+	Genome	+	Clock	+	Operator	= >	Entity
(amount of energy * rate)		(direction strength location speed)		(state of operations)		update energy run operator call transfer update genome		(order of execution)		

Figure 2.

2.2 Design of Genome

In this system, genomes can be through of as an entity's 'blue print' or 'type identity', but a bet ter metaphor would be to consider the genome array as an evolving set of strategies for survival in a hostile environment. Genomes control each agent's sensitivity to world materials, their abilities, their energy efficiencies, their transfer styles, their community opportunities, and t he sequential strategy of the agent's operator. Genomes evolve through the horizontal transfer of genetic information across an entity's available

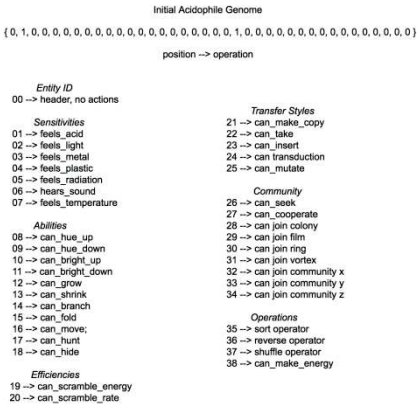


Figure 3.

networks. The sector organization of the genome array is described in Figure 3.

Entities that attain high enough energy profiles gain the ability to join communities or networks and are thereby able to share genomic instructions with others in their group. Initially, no entities have the ability to replicate. The genome setting allowing replication must be 'flipped' or 'turned on' through mutation or genetic transfer. On instantiation, entities with positive energy profiles can form networks based on type, but as genome settings are exchanged and mutations occur, entities can and are expected to develop as type hybrids that are able to share genomic information across multiple groups and absorb more kinds of materials from the environment. Ultimately, these heightened sensitivities raise the energy profile for advanced entities hypothetically allowing them to reach more complex levels of evolution.

2.2 Transfer

Horizontal, or lateral, gene transfer (HGT) refers to the nonsexual exchange of genetic information between unrelated genomes. HGT can include transfers across species boundaries. This concept is used here as a genomic survival strategy for entities attempting survival in a post-extinction environment.

An entity's genome controls its style of transfer. Entities can insert elements of their genome into a neighbor's genome (conjugation), consume elements of that neighbor's genome (transformation), or take elements from one nei ghbor's genome and insert those elements into another neighboring genome (transduction). An example of an acidophile genome after several styles of HGT is described by Figure 5.

Genetic exchange also affects energy rates and operators. Exchange is also open to mutation. Since entities must pass a fitness test that values environmental sensitivity, and since genomes control the consumption of material as well as action and sensation in the environment, genomes with the greatest number of abilities, or the greatest amount of variety, have higher survival rates. An entity's ability to sense change in the environment becomes its survival strategy.

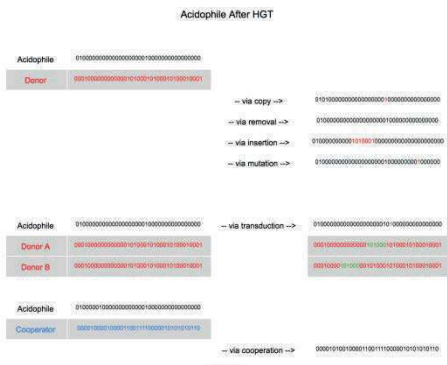


Figure 5.

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Unauthorised: Collaborating with a Performer Collaborating with Creative Systems
(Paper)

Topic: (Theatre/Dance/Generative Music)

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Abstract
Unauthorised is a collaboration between dance/theatre artist Kathryn Ricketts, composer Arne Eigenfeldt, and an ensemble of intelligent musical agents Kathryn inhabits a character named Rufus, a tired clown that struggles to find humour and meaning in dissonance. In *Unauthorized*, we draw a parallel to the work of Samuel Beckett, which echoes the profound absurdity often found in in clowning. In this rich collaboration we explore new ways to approach narrative, character, setting, and props; Rufus becomes a catalyst for fractured narratives and new ways of making meaning through performance. In the telling, we trigger more stories, which fosters a sense of collective belonging by the nature of their commonalities and subsequent empathy. Musebots are musical software agents trained on a variety of corpora to generate music live, producing new music for each performance. They also react to Kathryn's movement and speech, in turn influencing her next choices of action.

We describe the six different movements in the work, and her character interacts with the creative systems in each part. We also describe the six month process in designing the work, in laying a groundwork for how an improvising theatre/dance artist can collaborate with artificial performer creators in a way that transcends novelty proposing bold and provocative ways of approaching performance in both form and content. While it may offer some level of interest to the audience when Rufus moves, and the music alters itself, such direct interaction quickly becomes tiresome. How could we – Kathryn and Arne – design a 30 minute performance that has a narrative arc (even one that is eventually inferred by the audience), in which creative agents have the flexibility to explore their environment, yet work towards a collective aesthetic goal?

The talk will be illustrated by video taken from work in progress showings.	
arne_e@sfu.ca Kathryn.Ricketts@uregina.ca	***Key words:*** generative music, musebots, dance, theatre, improvisation, Beckett

Unauthorized: Collaborating with a Performer Collaborating with Creative Systems

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Abstract

Unauthorized is a collaboration between a composer/coder, an ensemble of intelligent musical agents (musebots), and a dance/theatre artist who inhabits a character named Rufus, a tired clown that struggles to find humour and meaning in dissonance. In *Unauthorized*, we draw a parallel to the work of Samuel Beckett, which echoes the profound absurdity often found in the clown. In this rich collaboration, we explore new ways to approach narrative, character, setting, and props; Rufus becomes a catalyst for fractured narratives and new ways of making meaning through performance. In the telling, we trigger more stories, which fosters a sense of collective belonging by the nature of their commonalities and subsequent empathy. Musebots are musical software agents trained on a variety of corpora to generate music live, producing new music for each performance. They also react to Rufus' movement and speech, in turn influencing the next choices in movement, intention, tone, and expression.

1. Overview

Unauthorized brings together intelligent musical agents – musebots – with a dance/theatre artist in a thirty-five minute performance. It continues the collaborations of the second author with a wide variety of partners, both physical and digital, as well as continuing the collaborations of the first author between his musebots and live performers. The unique aspect of research creation that will be highlighted in this paper is the use of text to shape a generative performance, specifically a full-length work which required a variety of approaches to structure, form, and narrative.

The work has been a year in its making, with several performances and workshops during this time. The genesis of the collaboration began after both authors attended a conference on music and technology in October 2018, and a realization that they were exploring similar themes in quite contrasting ways. An initial performance after three months of discussion and testing, provided a positive proof-of-concept, in which they explored the potential for a live performer to interact with generated text, both through movement and spoken word. An informal performance was presented seven

months later, which introduced the separate movements which had developed, albeit with limited transitions between them. A full performance was presented in October 2019, with three separate shows in a traditional black box theatre. A defining aspect of the collaboration were intense working periods of several days, separated by weeks, often months, of individual development necessitated by academic positions in different cities.

Unauthorized is a work of generative art in that performance actions – movement, live text, musical details and structures – are generated during the performance, and are unique and different with each presentation. What the authors found to be a particularly challenging aspect of this work is balancing the excitement of such mercurial features, with a realisation for the need of a consistent large-scale formal structure – e.g. movements – that could be relied upon to have a certain consistency. Each movement seemed to require an identifying character (as is often the case in multi-movement time-based works) in which the responsive and generative character of the musebots differed, and the live character's action evolved.

The initial proof-of-concept performance was very successful: musebots were assembled that could select from pre-recorded text reacting to an ex pert performer intimately familiar with improvisatory movement and s peech. Eleven different texts were used, and the musebots transitioned to new texts whenever they believed a s ignificant amount of change had occurred in the movement (a parameter which initially was manually controlled by the first author during the performance). The presentation was limited to under ten minutes, an ideal time for audiences to maintain interest in a single gesture performance. But how could this build toward a full evening performance?

2. Generativity vs. Interactivity

The first author has had significant experience with both interactive computer music [1] and generative music. The former finds its roots in the work of composers such as David Behrman [2] and Joel Chadabe [3], who created software systems in the 1970s and 80s that could react to performance input. These were reactive systems that were limited in their actions, which often amounted to a series of available algorithms from which the composer selected in performance: for example, if a note from the performer comes into the system, the algorithm might play a f ive note melody using the limited pitches of a pre-selected scale. Such systems, while varying in their detail between performances, required the composer to make high level musical decisions – for example, when to change the algorithm, and when to change the underlying musical structures such as harmony and rhythm – as well as overall interaction: for example, adding or removing processes to reflect the live performer's overall evolving musical shape. The intelligence in the system clearly was in the live performer and the composer controlling the system; while some systems were able to move between high level decisions autonomously, they did so using random processes [4].

With much faster computers and dedicated music computer languages (i.e. Max, SuperCollider), interactive systems became increasingly more complex and difficult to control in performance by the late 1990s and early 2000s. As a result, the first author began to use elements of artificial intelligence in order for higher level musical decisions to be made by the software itself [5]. Multi-agent systems, one such concept borrowed from AI, share many aspects with improvisatory music ensembles: they are proactive,

reactive, autonomous, and social [6], and have been the basis for the first author's work for over ten years, and the foundation of musebots [7].

2.1 Generative Systems

In 1996, Eno came up w ith the term Generative Music, which codified a practice implicit in the above described interactive computer music systems, but not explicitly stated: the notion that a system could produce multiple iterations of a work, and each would be considered viable and representative of the work itself [8]. Given Eno's definition, any *system* that improvises could be c onsidered generative, albeit without live control; in other words, generative systems should not be interactive. The authors challenge this binary restriction in the work described here: portions of *Unauthorized* include live performance actions that influence the overall outcome; however, without any performance action, the movements would proceed, and the musebots would produce music, albeit with limited variation, thereby qualifying the work as pure generative. For *Unauthorized*, the dependence upon live action is not considered a limitation, but an obvious and necessary part of the work itself.

3. Movement Improvisation

The second author has been a professional dancer for 40 years, working in companies that generated choreography through improvisatory processes, rendering the making of a piece of dance a long and deeply personal journey. Other experiences include performing on moving buses, on high levels of scaffolding, in dirt filled warehouses, and i n Royal theatres, as well as collaborating with opera singers, clowns, magicians and musicians. Her work experimenting in this realm has had over a decade of practises which resulted in sensors strapped to various parts of her body determining image and sound shifts in the performance, furniture and objects wired with stories that are activated when touched, to social media and g eo-positioning systems projected on the floor and her body in exploration of crowd-sourced place-based stories, to spontaneous mark-making projected on her body, resulting in immediate kinaesthetic comic-booking.

3.1 Characters

The second author has worked through and with an improvisatory character named LUG for fifteen years. This character, donning an old overcoat and felt hat and always 'lugging' and old leather suitcase, dances stories of displacement, longing, belonging and in-betweeness. LUG worked /works as a kinaesthetic conduit to other stories. By choosing themes that may resonate with particular audiences specific to a performance workshop and t hen by poeticizing these themes through dance theatre and with the handling of simple artefacts such as a suitcase or a handkerchief as a metaphor, it is possible to trigger individual stories in the reading of the performance. LUG creates a porosity whereby stories, through lived experiences, commingle with the viewers individual stories and in this meeting ground of personal narratives, we discover commonalities that bond us.

Since the inception of LUG, the second author created two more characters, one of which is Rufus, a tired clown that struggles to find humour in dissonance. This character is steeped in what we may identify as failure, but with further interrogation, we understand that Rufus invites us into the fertile place of the unexpected, the unplanned, and the unintended.

Rufus also plays a key role in the second author's teaching:

> "Rufus has been in direct relation to the new liberal turn in universities and the consequential shift in student expectations and operative behaviour. I find that our students increasingly need precise directives with assignments, which will guarantee an expected and prescribed outcome, and yet the work field they are entering demands capacities that are developed through opposite processes. Our students can't even know most of the detailed demands in the field as it is in constant evolution and therefore it behoves us, as teachers, to prepare them for the tenants, not the specifics that are reliable within this influx. A key set of capacities within this approach is: resilience, courage, curiosity, holistic intelligence, compassion, and kindness. Rufus has all of these characteristics and was developed in response to this festering concern that my students are no longer interested, and in some cases able to take risks and subsequently have lost the resilience to embrace criticality. Rufus was developed to rebuild the courage and curiosity, to encourage others to take risks, to celebrate mistakes, and to understand that error is both foundational and necessary for growth."

The current work has built upon previous collaborations of the second author which examined, interrogated, celebrated and experimented in melding movement with music and technology. The second author states:

> "My work experimenting in this realm has had over a decade of practises as I have had a t hirst and curiosity to collaborate in ways that push my improvisatory work beyond my own pallet of choices. In all of this work, I have been a fforded the opportunity to grow my capacities as an i mproviser and to work beyond my familiar and even habituated sets of conditions, contexts and creative frameworks."



Figure 1. The second author as Rufus.

4. Samuel Beckett: Fail Better

The authors turned to Beckett [9, 10] for the text to support this work, of which they are not authorized to do (hence the title of the piece). The authors are reminded of how Beckett invites us to trouble our own value systems in constructing and viewing theatre, whereby the plot line and locations are considered secondary to a motif, such as waiting, which becomes an existential event. The authors are also interested in the sensuality of text and how it can roll around in through an image into the body similar to watching clothes being tumbled in the dryer and then at moments being able to identify a s ock in the blur in this way. Barthes writes about

this sensuality of the text, "…it granulates, it crackles, it caresses it grates, it cuts, it comes: that is bliss"[11]. Barthes invites us to dismantle the conventional structures of the reader/writer relationships and to engage in the text merging these positions. He invites the reader to become full bodied in his/her event of meaning making. "What is significance? It is meaning, insofar as it is sensually produced" [11].

Unauthorized builds upon previous work of the second author's, who has worked with the text of Roland Barthes, Gertrude Stein, Samuel Beckett and a wide scope of poets who support these problematizations of traditional linear constructs of language in relation to narrative.

"We have come to understand the nuances of gesture, smell, touch, sound and sight to inform the lives of teaching, theorizing and performance—this is sensuous knowledge" [12]. As Abram says, "meaning is birthed in the soil of the sensory world, in the heat of meeting, encounter, participation" [13]. The nature of embodiment is not only about the body, but it is the intersection of body, mind, soul, and imagination. It is the imagination with flesh on it, the soul with wings, the mind with feet. Embodiment breaks down the binaries of either/or and creates a space for a visceral inquiry into what it means to re/search.

5. Description

As mentioned, *Unauthorized* is a collaboration between a movement artist, the character Rufus, a composer/designer, and an ensemble of intelligent musical agents. Indeed there were many collaborators in this process of making *Unauthorized*, which delighted the authors in the quest to broaden and deepen their context for performative choice making.

One of the unexpected partners in this process was silence. Within the silence of their practice, side-by-side in the studio, the second author was

> "able to develop discernment, deep listening, care in my observations and the curiosity and courage to take chances with my choices without the safety of approval. And isn't that what Rufus actually wanted of me? So the hidden gift of this process is that the foundation of this character was actually developed further and refined due to the specific nature of this partnership and the process that ensued due to our differences."

The authors' process was a blended model with long distance communications, individual work in studios (both dance and sound) and punctuated with intense face-to-face work that would then define the next step of remote, individual work.

5.1 A Non-teleological structure

As the sections begin to take shape, these in turn developed a voice, which spoke back to the authors in terms of tones, dynamics, gaps and sequencing. A question arose as to whether the length of the work could sustain the absence of a linear narrative. The musebots, with their irreverence to predictable trajectories, and Beckett's text, with such fluid logic, reaffirmed a poetic and non-teleological path.

The rehearsal of *Unauthorized* demanded a discipline to resist fixing choices. Although transitions would become clear from one section to the next in regard to sound, images, lights and movement, each container, each section remained an open country with its own set of customs. These customs were comprised of both

limitations and possibilities in time, space, sound, costumes, props, lighting, text, and even the atmosphere in the room afforded by an audience. The holistic intelligence of choice-making becomes paramount within such complexity.

Each night that *Unauthorized* was performed, the authors engaged in conversation with the audience immediately after, and this invariably affected choices for the following evening to a degree that on the final night, an entirely new scene was added. The authors continue to be attentive to new contexts and conditions, responding as a team to new sets of customs with each performance.

5.2 Rufus/Musebot interaction

Musebots respond to Rufus' voice and movement through realtime analysis, creating a synergistic play between sound, text, and video, adding a richness of the creative choices and subsequent provocations. Aware of each movement's text, the musebots respond, provoke, and influence Rufus' movement and speech choices, as well as determining certain structural choices in the work itself.



Figure 2. *Live video of Rufus (above) and pixel differences between this frame and previous frame, shown in white (below).*

Movement analysis consisted of a MaxMSP/Jitter patch that compared successive frames, setting those pixels that differed between frames to on. This provided a simple mechanism, through averaging, for determining the amount of movement of Rufus' character in the frame. This parameter value was sent as a measurement of arousal, a parameter (along with valence) to which all musebots respond [14].

In the six different sections, the interaction between Rufus/Kathryn and the musebots varies, as described below.

5.3 Introduction

This movement used Edvard Grieg's *Peer Gynt Suite*, specifically a version recorded

by Duke Ellington and his orchestra. The recording was previously used by the second author to introduce Rufus to the audience, and had a specific feeling that the authors wished to retain. Grieg's version for string quartet was used as a corpus, and transcribed for Disklavier, essentially a MIDI-controlled player piano. Specific velocities – how hard individual notes were played – were controlled by the amount of Rufus' movement detected.

Furthermore, the detected amount of movement was averaged over each second and determined the big band orchestration performed. Musebots were assigned to play instruments of the Ellington band – saxophones, trumpets, trombones – each with a pot ential likelihood of playing, or joining in, on a phrase. For example, the first trumpet had a high likelihood of playing each phrase, while the third trombone was much less likely. The greater the amount of movement detected from Rufus, the fuller the orchestration.

5.4 The Unnamable

This movement used four sections of text from Beckett's *The Unnamable*, separated by poetic movement. Three locations around the stage had microphones hung, so that Rufus' speech could be received by the musebots during stationary recitations. Live processing occurred based upon Rufus' speech intonations: the louder Rufus spoke, the more intense processing was added to the voice.

Movement analysis was also presented, so that when Rufus began to move/dance between speeches, the musebots responded with multi-layered recordings of the previously spoken text. The greater the amount of movement, the greater the number of layers, and t he more extreme the processing on t he recordings, which included time-stretching and pi tch-transposition.

5.5 Moments



Figure 3. *Example structure generated for "Moments". In this case, 13 sections were generated over a five-minute duration; sections are delimited by vertical grey lines, and parameter values for speed, activity level, voice density, complexity, consistency, and volume are displayed in black lines. Time moves from left to right.*

Musebots generated a u nique structure for this movement, using moment-form [15], which determined their activity, complexity, speed, consistency, and volume.

Once a f orm was generated, musebots performed within the sections, influenced by each section's specific parameters. Sounds were generated by a m usebots playing a varying synthesizer drone, another playing synthetic bells, a t hird playing the Disklavier, and a fourth playing a robotic marimba.

At the same time, an a dditional video musebot displayed scrolling text, drawn from *The Unnamable*. The displayed text's speed and size also used the parameters from individual sections, and the second author freely interacted with the projections.



Figure 4. *The second author interacting with projected text in "Moments".*

5.6 Buckets of Beckett

This section was the initial test, in which 11 possible texts were recorded, and musebots sliced them up and layered them in response to both movement analysis and sound analysis. Some musebots presented more continuous background material through granularisation of text recordings, while other reconstructed phrases from these same recordings. These assemblages often, but not always, reproduced actual text from the Beckett sources, and Rufus was able to react to them through vocal repetition and/or correction.

5.7 Building

Musebots generated an unfolding musical structure in two parts, for Disklavier and robotic marimba; two concurrent melodic lines were repeated: first one note, then another added, then another, until both phrases were fully revealed. Two separate video processes aligned with this unfolding, as two video musebots selected from pre-recorded video to create a limited set of repeated movement gestures. Two additional musebots displayed an unfolding text from phrases Rufus has already spoken, as well as generating new text (using Markov chains) from Beckett's *The Unnamable*. Rufus freely (re)interpreted the displayed movement gestures through poetic movement.

5.8 Memory

This movement served as a final summing up; Rufus mumbled previously intoned text, as if remembering half-forgotten lines, while slowly getting dressed to leave the theatre. The musebots responded with one final instantiation of musebot-manipulated spoken text, and a visual musebot faded in with slowly scrolling text taken from *Waiting for Godot*, with only the performance directions shown.

6. Summary

This collaboration set out to investigate how the author's respective trajectories in generative art and improvisational dance/theatre might intersect. The initial collaboration was successful and satisfying, which led to their desire to create a full-length work. While the initial single-movement work did not require the consideration of how to generate time-based form – itself an open problem [16] – the final full-length work did require relying upon more traditional methods of multi-movement structures, albeit without the notion of a narrative teleological structure.

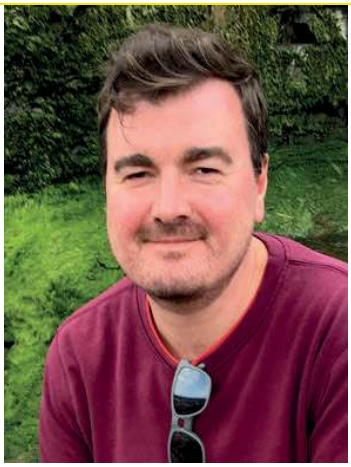
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Visuality and the haptic qualities of the line in generative artworks

Paper

Topic: **Art**

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Abstract

The line has an important and particular relationship with the generative artwork distinct from other elements such as the 'pixel', 'voxel' or the 'points' that make up point clouds. The line has a dual nature as both continuous and discrete which makes it perhaps uniquely placed to straddle the analog and digital worlds. It has a haptic or felt quality as well as an inherent ambiguity that promotes a relatively active interpretive role for the audience.

There is an extensive history of the line in generative systems and artworks, taking both analog and digital forms. That it continues to play an important role, alongside other more photographically inspired 'perceptual schemas', may be a testament to its enduring usefulness and unique character.

This paper considers the particular affordances and the 'visuality' of the line in relation to generative artworks. This includes asking how we might account for the felt quality of lines and the socially and culturally constructed aspects that shape our relationship with them. It asks whether, in what has been described as a 'post digital' or even 'post post digital' world, the line may offer a way to re-emphasise a more human scale and a materiality that can push back, gently, against other more dominant perceptual schemas. It also asks what generative art can learn from drawing theory, many of the concerns of which parallel and intersect with those of generative art.

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Key words: Line, Visuality, Drawing, Generative Art

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Visuality and the haptic qualities of the line in generative art

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Abstract

The line has an important and particular relationship with the generative artwork distinct from other elements such as the 'pixel', 'voxel' or the 'points' that make up point clouds. The line has a dual nature as both continuous and discrete which makes it perhaps uniquely placed to straddle the analog and digital worlds. It has a haptic or felt quality as well as an inherent ambiguity that promotes a relatively active interpretive role for the audience.

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1. Introduction

The line is particularly interesting to consider in relation to computationally created generative artworks because they appear to share key characteristics of both the digital and the analog. Individual lines are self contained and 'discrete', a quality associated with the digital [1]. Yet they are also 'continuous' and can express an ambiguous and 'felt' quality in their reception. This observation invites a closer investigation of the line in generative artworks and how we perceive them. This paper aims to examine the particular visual affordances of the line and how these might shape the reception of the generative artworks that employ

them. This includes certain socially and culturally constructed ‘ways of seeing’ that might be described as their ‘visuality’.

This paper will consider lines in a broad sense. Rather than debating which marks should be considered lines and which not, it will be focusing on what are perceived as lines or having the qualities that lines can exhibit. This recognises that lines can be employed in myriad ways that often blur the distinction between line, surface, shape, tone etc. They can also be used in conjunction with other marks such as points, blobs and to form polygons.

While not all lines are made by what might be seen as a ‘drawing process’, it aims to show how theories of drawing practice may usefully inform how lines are perceived in the context of generative art. It is not the intention of this paper to define drawing, which Deanna Petherbridge, in the classic tome ‘The Primacy of Drawing’, describes as a ‘futile task’ [2]. But it will look at different definitions and understandings of drawing in order to try and unpick the key characteristics, including their tactile qualities and their relationship with process and action.

2. Drawing, lines and generative art

Lines and drawing both have a long association with generative art practice. Well known early experiments with generating lines include the drawings produced by Harold Cohen’s AARON [3] and the work of Charles and Colette Bangert using graphic plotters in the 1960s and 70s [4]. Reas and McWilliams outline a history of drawing with computers from the pioneering ‘Sketchpad’ interface of Ivan Sutherland through to computer-aided design systems and scripting languages such as PostScript [5]. Although we might trace the relationship between the line and generative art back far further as Laura Marks does in identifying a genealogy for new media art in Islamic art that reaches back several centuries [6]. An expanded definition of the line might even look at early mechanical forebearers of computing in the Jacquard Loom [7] or the conceptual work of Sol Le Witt, often cited as a predecessor of generative approaches to art production [7, 5]. However, the focus here will be on the contemporary reception and use of lines in generative artworks.

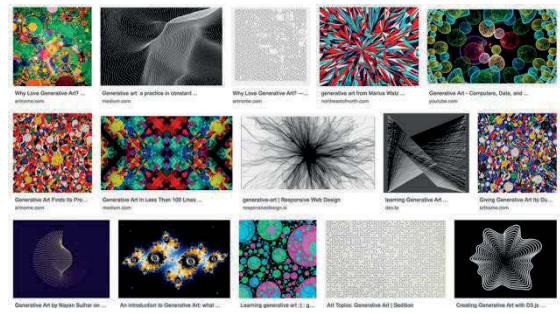


Figure 1. Image search results for ‘generative art’

An image search for ‘generative art’ [figure 1] returns a high percentage of images composed of lines, implying a stereotype of ‘computationally drawn’ images almost as a visual shorthand for the ‘generative’. While generative art practice is far more diverse than such a stereotype, it is interesting to note a certain association in the wider public consciousness. Lines and drawing practices are still regularly employed in the creation of work in the fields of generative art and wider new media and digital practice. One reason that the line continues to be widely used in generative art practice could be the particular affordances of the line not just in production but in their reception. While the pixel, voxel or polygon will all have their own visual qualities and associations, this paper focuses on the line and what factors may affect our reception of them; both in

terms of different types of line and how our reception may be socially and culturally constructed.

3. Visuality and scopic regimes

Hal Foster defines 'visuality' as the difference "between the mechanism of sight and its historical techniques, between the datum of vision and its discursive determinations" [8]. This acknowledges that not only do we see differently from each other but that there are factors that affect "how we are able, allowed, or made to see" [8]. The concerns of visuality go beyond purely those of 'analytic' aesthetics and the formal qualities inherent to the artwork. It is far closer to the 'pragmatic aesthetics' of Shusterman [9] since it acknowledges the contexts brought to the experience by the audience. While affected by the individual contexts of the viewer, the rhetoric and factors shaping how we see can form conventions and mechanisms sometimes termed 'scopic regimes' [10] or 'perceptual schemas' [11]. Perspective is perhaps the most well known and critiqued example of such 'scopic regimes'. Panofsky's analysis of perspective demonstrated its constructed and culturally situated nature and that, far from being a single regime, there are several variations [11].

Perspective remains a dominant schema that it has been suggested underpins the photographic image [12]. It also has a key role in computation. Lev Manovich, in describing the 'automation of sight' and 'computer vision', refers to the 'perspectival machines' and 'geometry engines' of computational media [13]. This can be seen in the lines of the grid typically found in 3D software such as Unity or Blender [figure 2]. This is what Damjan Jovanovic terms the 'ground grid', marking out a uni form grid space, homogenising the space and suggesting a certain 'total visual empowerment' [14]. The straight lines used here are not neutral but suggest of a way of thinking about the depiction of space and the technologies that underpin them. A perceptual and conceptual framework not dissimilar to the way perspective was associated with 'subjective rationality' and symbolic of the harmony between optics, mathematics and God's will [10].

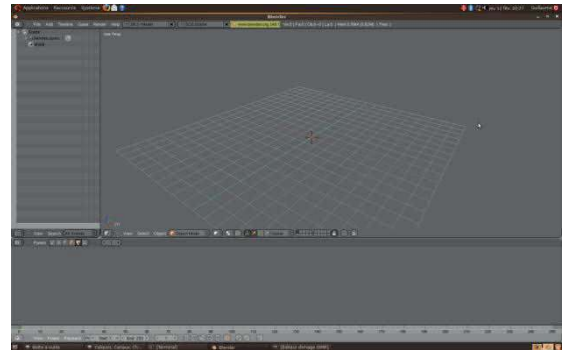


Figure 2. Screenshot of Blender showing 'ground grid'

Here we might consider the visuality of straight lines. Tim Ingold argues that straight lines are suggestive of modernity and artificiality, pointing to the mantra of romanticism: 'nature abhors a straight line' [15]. The straight line is ubiquitous today, Ingold argues "even where they don't really exist" [15]. Such is the ubiquity of the devices of perspective that we are predisposed to detecting their presence. Showing this was the motivation for my making the work *Expressions of Ideal Relations* (2019) [figure 3]. This looped animation shows a rotating photosphere drawing composed of what may appear to be scribbled lines but which reveal the ghostly traces of the underlying equirectilinear grid that contains them. The lines of the equirectilinear grid are implied by the more erratic lines in the spaces between them. What we can also see is that lines can operate simultaneously at the surface and to suggest space. The hand drawn lines

have a different quality to the straight lines they imply. These more erratic lines, as we shall see, bring their own visuality.

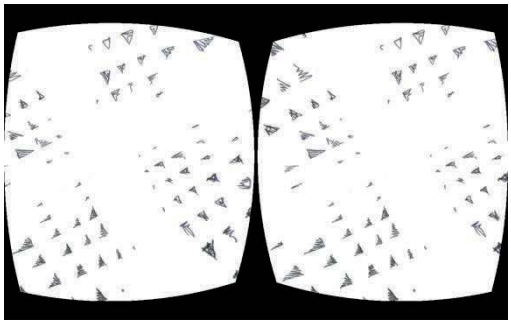


Figure 3. Screenshot of 'Expressions of Ideal Relations' (2019)

This is not to suggest that straight lines need be static since they can also suggest action and movement. This can be seen in the example of the early computer screen, which created an image using a line of light traced continually across its surface [16]. These lines, or more accurately 'vectors', are significant in that they contain a key characteristic of the line, namely a 'liveness' that is connected to the process of their creation. The vectors drawn with light are a dynamic process and an unfolding activity. This form of display has given way to the pixel based screens to which we are now accustomed. Screen displays, whose resolutions have passed the point where we can detect individual pixels, tend to recede in favour of the images they host [17]. They are presented as a transparent window onto the world of the computer [18] facilitating a photographic realism in particular, which itself operates under its own perceptual logic. Nicholas Mirzoeff describes how the notion of 'correct focus' stems from certain forms of painting via photography [19]. It is interesting that Mirzoeff also notes an alternative 'way of seeing' found in the 'papillotage' or 'blinking' effect found in the paintings of artists such as Boucher and later the Impressionists [19]. This 'blinking' flickering effect, it as been suggested, may be closer to how we actually see, acknowledging the movement of the eye and the eyelid [19].

The decline of the vector based display in favour of the pixel display has been lamented by some who see the dynamic line giving way to "tired old naturalistic illusionism" [6]. For Cubitt, in displays based on arrays of pixels, the movement stops and the resulting image is not 'a living act', connections having become hidden and the surface opaque [6].

Alternatives to more dominant ways of seeing and to the pixel screen clearly exist, including what Whitelaw terms 'post-screen' practice, pointing to the example of Daniel Rozin's *Trash Mirror* [17]. Finding alternatives to dominant modes is even seen as a key aim for much of digital art practice [17]. Ultimately, it is not a case of which perceptual scheme is correct, but as Jay argues we benefit from being aware of the possibilities at our disposal [10]. While lines can be employed in different scopic regimes, exploiting different aspects of their visuality, it is the dynamic, live quality to their visuality that is worth closer inspection.

4. The Haptic quality of lines

By focusing on lines it would be possible to become overly concerned with the visual. Laura Marks has argued that vision is not purely visual but an embodied and multisensory experience [20]. Similarly, it has been suggested that there are no visual media only 'hybrid' and 'mixed media', such is the entanglement of senses involved in perception [21]. It can be easy to forget when thinking about digitally produced images that our experience of them is analog. After all, most of what we think of as digital media are actually digital to analog converters [22]. Vaike Fors describes a 'digital visuality' that involves an embodied and

tactile relationship with media through the taps and gestures made on touchscreens [23]. Whether or not we are more tactile in the way we see, there is an argument that seeing drawn lines in particular involves a tactile sensibility.

Just as the dynamic vectors of early displays suggest movement, so hand drawn, irregular or imperfect lines can also bring with them a 'liveness' [15]. This is not dissimilar to Paul Klee's well known description of the line 'going for a walk' [16]. The free line that is suggestive of action and movement. We might also consider Hogarth's 'serpentine line' which brings with it the suggestion that seeing lines can be as much a felt experience as it is a visual one. Hogarth describes seeing the lines of a drawing as like a pursuit as the eye retraces the form and can be both "animating and animated" [16]. This animating effect implies that we can imagine ourselves drawing the lines.

The idea of our 'touching' lines as we see them relates to the dualism that Wölfflin describes between 'linear' and 'painterly', and between 'tactile' and 'optical' perception [24]. With 'tactile perception', the eye acts as a hand, as opposed to 'optical perception' where vision acts as the eye does, receiving the image. However, to suggest that line based images relate only to the tactile would be to misunderstand the nature of tactile vision. Rather than place these modes in opposition Delueze suggests an interplay between them. Deleuze uses the term 'haptic' rather than 'tactile' specifically to suggest that there is no opposition and that the haptic is simply the tactile function of sight [24]. As we have seen, lines can be used to mark space in a way that supports optical perception, but they can also appeal to haptic perception and even both modes simultaneously.
While haptic space is not unique to lines, we may have a particular relationship with their haptic quality due to our individual experiences of drawing. From the earliest images made "outlines have been used to describe and delineate representations of objects" [12], while Flusser argues drawing is a unique human activity [25]. Not only is drawing among the very first image making practices, it is also one that continues to play a key role in our visual literacy. We are exposed to line drawings from a very early age and so learn how to interpret them [12]. We learn about the particular haptic space of the line, that can create both tactile and optical experiences and which is, importantly, connected to our own experiences of making them.

Not only do we learn about images by drawing but there continues to be a relationship between thinking and drawing. Angela Anning argues that drawing is visible thinking and a demonstration of problem solving [26]. This can be seen in children's drawings as they draw what they know [26]. Only over time do we become more concerned with drawing what we can see. The connection between thinking and drawing is most clearly seen in what Terry Rosenberg describes as 'ideational drawing' - "types of drawing and … processes where one thinks with and through drawing" [27]. In this way drawing can be understood as 'thinking in action', a process where by meaning emerges and is produced through the activity [27].

Where lines do have an animating haptic quality this may also be suggestive of thinking and the underlying processes. If this is the case, then generative practice may be well placed to use these qualities to address issues of authorship, intention and skill.

5. Intention, error and skill

As Dorin et al note, understanding the process involved in generative artworks is an important influence on their reception [28]. Understanding the process can shape the way we view an artwork. For

example, I have written previously about the role that understanding code plays in the reception of generative artworks [29]. Meanwhile, it has been suggested that there is a close link between understanding of process and perceptions of skill [3]. One of the key challenges facing generative art is a s cepticism surrounding the level of human skill and creativity involved [3]. Here drawing theory may point to a way in which lines, especially drawn lines, are suggestive of intention, process and skill.

Benjamin's definitions of painting and drawing, while ostensibly concerned with formal aspects, are interesting for their reference to intention. For Benjamin, drawing involves marks, specifically referred to as 'signs', intentionally made on a ground [30], where as painting sees images 'emerge' from coloured surfaces. The lines made by drawing are seen as the deliberate result of action. Straightaway we can see exceptions from generative art practice which would not fit this definition, such as the automatically produced drawings of Tim Knowles *Tree Drawings* (2005) [28], or the 'found drawing' shown in figure 4 in which we can see the lines made by the zipper of a bag and guided by the movement of a train. While fitting the formal description of marks on a ground, the issue of intention is debateable and di stinct from cause. However, this distinction raises an interesting question about how drawings are perceived. Is Benjamin describing a way of *seeing* drawn lines as much as the way they are created? Perhaps due to the association between drawing and thinking and the way in which we might imagine the actions that led to the marks, might this lead to the audience assuming or looking for the underlying logic of the process that created it? Do lines appear more intentional in purpose than other images which come to us as though they have simply emerged?



Figure 4. Found zipper drawing (2019)

One way this might be the case is where drawings are considered as records of process or activity. Derrida describes how to see a drawing is to see an activity [30]. While Lucas takes this even further to suggest that drawings should not be considered as images but as records of gesture [31]. This offers an i nteresting way to consider generatively produced drawings. How might the process of their creation be implied within the image? With the plotter drawings of Carl Lostritto [4] it is hard not to follow the lines and imagine the pen moving across the surface of the paper; identifying where darker points suggest an overlapping or overdrawing of lines. It is as though by seeing the component parts of the image in the lines we are invited to consider their creation, possibly informed by a certain tactile perception and association with thinking.

By comparison, the pixel itself is usually seen but unnoticed, the resolution of displays high enough to present only an image and not its component parts [17]. Vito Campinelli has described how

noticeably low resolutions and pixelated images can be synonymous with poor quality [24]. Pixelated images can also have a retro aesthetic that similarly foregrounds the technology. Where the pixel or the pixel block does reveal itself, it can become a significant event and represent a break in the illusionism or the technology itself. In 'glitch aesthetics', revealing the pixel is suggestive of rupture, one which for some artists is way of challenging the hegemony of media production [32]. On the other hand, the line has its own relationship with error and noise.

When learning to code generative art systems, drawing a straight line or circle is often one of the first exercises. Although this is usually followed quickly by adding noise and variation as though attempting to making it in some way more human. Or perhaps, as Matt Pearson suggests in his chapter 'The Wrong Way to Draw a Line', just more interesting. As he notes "the 'right' way to draw a line, according to the machine, is always the most efficient and accurate way of getting from point A to point B. But from an artistic standpoint, it's the 'wrong' way that is often the most interesting." [33]. Boden and Edmonds argue that such errors appeal to the 'disturbed imagination' of the human audience [3]. Interestingly, many early computer generated drawings specifically aspired to produce believably hand drawn lines [3].

Some drawing practices may emphasise the role of the hand while others are concerned with the removal of error and any evidence of the maker. Traditionally the draughtsman would aspire to what Ingold describes as the 'workmanship of certainty', facilitated by tools and devices to aid particularly with the drawing of straight lines. This is as opposed to 'workmanship of uncertainty' [15] where instead the pen might be allowed to set off on an intended path, without the aid of guides, and which seems to resonate with the aims of generative art practices. It is as though when working with generative processes, we set out to undertake workmanship of uncertainty. The concern is not how to remove the uncertainty associated with error, but to reintroduce it. Since with a simple line of code, we can render a perfect circle, the challenge is to find more interesting and informative ways to proceed.

For the draughtsmen of Albrecht Dürer's time, being able to draw a perfect circle was proof of the divine power of the artist and demonstrated the complete control of the mind over the hand [30]. This power was also described as 'ingenium' or for Dürer, 'Gwalt', and it was in drawing that Dürer believed Gwalt presented itself most clearly. Unlike technical skill, or 'Ars', Gwalt can not be learnt [30]. However, Dürer's drawing transformed Gwalt by connecting it to human ability rather than divine gift [30]. Rather than perfect lines, he "made the most of the effects of mistakes", allowing both "the successful and the unsuccessful [marks] to breathe life into the drawing" [30]. The Gwalt becomes the unique character of the artist expressed in the artwork and involves the way in which deviation and uncertainty are managed and used to form a harmonious whole.

Lines have the ability to accommodate the unexpected and to bring together, in the words of Ruskin, the "glittering confusion in the interstices" and the "lines without special intention […] to produce all together a well-shaped effect of intricacy" [34]. Inherent to drawing is an element of unpredictability and chance. 'Speculative lines' without immediate purpose that might later be accommodated or incorporated. Alfred Gell describes drawing as a 'ballistic' process since the marks are made by actions that cannot be fully controlled and so the outcome never fully known [35]. This seems to be a quality shared by generative processes where the outcome of the algorithm,

whatever the intentions and plans, are never fully known. It could be that lines are sympathetic to marks that are unexpected since they are seen not as an error but simply the characteristic of ambiguity and invite interpretation rather than create a rupture. While generative drawings may not appear more skilful, they may be able to see the computational recede as the interpretive activity comes to the fore.

6. Conclusion – Ambiguity and the dialectic of the line

Whether employed for aesthetic, functional or technical reasons, using lines brings with it a set of pre-existing factors that affect their reception. Lines, despite or perhaps because of their versatility, are not neutral. Their reception is also shaped by our knowledge and experience of producing lines ourselves. Just as we have learnt to understand the perspectival and the photographic image, so we have also learnt from a very young age, how to see and interpret lines. This is a way of seeing that is haptic, interpretive and active. Some images such as those produced by the AI programme *Deep Dream* may seem to simply emerge and come to us like a dream. The images formed with lines have the ability to 'unfold' before us. To adopt the terms of Laura Marks, the potential 'enfolded' into the image is 'unfolded' by the viewer [36].

It has not been the intention here to privilege the line or elevate it above other ways of making images. Pixels, voxels, point clouds and polygons, or combinations of these, will all have their own visuality. For example, point clouds have their own enigmatic ambiguity and ephemerality. There have also been significant omissions to the discussion here, including consideration of the calligraphic line and other practices that blur the distinction between line and text. Nor has the animated line been considered here in order to focus on the animating qualities of the line itself. However, study of these would clearly add to our understanding of the available 'scopic regimes'.

The line can be found in many different perceptual and scopic regimes each of which can exploit different aspects of their visuality. They are capable of suggesting both stability and ambiguity. Sean Cubitt suggest the line offers a dialectic of "discipline and autonomy", the line being an "instrument of order" but also "capable of great freedom and invention" [16]. However, the quality which is arguably of most use to generative art is the way lines can balance ambiguity with intention and to invite the audience to interpret and reach for understanding. As Lostretto points out the "human reader is called upon to interpret, to close an open ambiguity, between process and product" [4]. In a world that has been described as 'post-digital' as we reappraise our relationship with the digital [22, 2], it could be that reconsidering practices such as drawing offer unique possibilities for exploring and reconciling the meeting of the computational and the human.

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Generative Art and Communal Curation: A Proof of Concept
(Paper)

Topic: Art

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Abstract
One of the attractions of creating generative art is the release of control over the final outcome, allowing unexpected results. By involving a community in their process, the artist can separate themselves further from the outcome, while maintaining a human element.

Inputs to this proof of concept are: a process that creates new images through modified sortation of pixels from selected colour and greyscale photographs, with random factors informing the sort, and a selection of 25 photographs.

After the initial generation, the images are presented pair-wise to a small set of people recruited from the artist's personal contacts and from the Arts Academy at Turku AMK. Using their individual preferences as additional input, a basic genetic algorithm is used to determine parameters for a new, smaller generation of images. Multiple iterations of voting and image creation produce a final piece.

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Keywords: Communal Curation, Image Manipulation, Digital Art

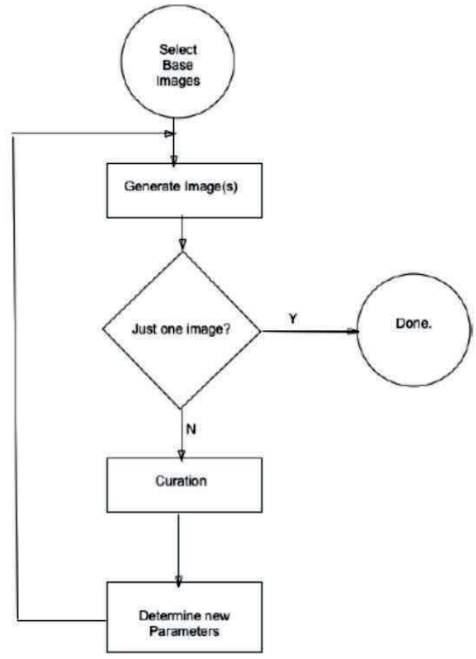
Generative Art and Communal Curation: A Proof of Concept

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Abstract
One of the attractions of creating generative art is releasing control over the final outcome, allowing unexpected results. By involving a community in their process, the artist can separate themselves still further from the result, while maintaining a human element.
Inputs to this proof of concept included a process that creates new images through modified sortation of pixels from selected colour and greyscale photographs, with random factors informing the sort, and a selection of 25 photographs.
After the initial generation the images were presented pair-wise to a small set of people recruited from the artist's social media contacts and from the Arts Academy at TUAS. Using their aggregated preferences as additional input, a bas ic genetic algo- rithm was used to determine parameters for a new, smaller generation of images. Multiple iterations of voting and image generation produced a final piece.

Background
The project was an independent work for credit at Centennial College (Toronto), completed during an exchange term at TUAS (Turku). The image processing algo- rithms were developed from July 2018 - August 2019 as part of my ongoing explo- ration of randomness. Randomness attracts me because it divorces the final result from my own efforts - whether the art is appealing or not is not in my control. I bring the selection of the initial images, the decisions of whether to pre-set certain parame- ters, and the naming of the pieces as personal inputs to the process.
The infrastructure for voting, and for producing new images dependent on the voting results was developed from August to September 2019, and the creation of the final piece occurred from September 23 to October 22, 2019.

Overview of process
Figure 1: High level workflow



Initial expectations for final result
The outcome is the result of repeated voting rounds, resulting in a kind of consensus image. The element of chance means that sometimes the less popular elements go forward, but over many generations this should correct.

Selection of base images

For this project, I took base images from internet-available portraits of actresses from the first 50 years of American cinema - specifically the AFI Top 25 Lege ndsi. These images represent one kind of image manipulation — that of the studio system, and the process of creating the new images riffs off of that. The subject resonates with my long-standing interest in Golden Age Hollywood, dating from childhood.

When I found a pleasing colour image of the actress, I used it, even if the bulk of the actress's work was in black and white. This left 3 black and white images.

The process introduces enough change that copyright of the original images is not a concern.

The images are all of size 8.5" x 11".

Creation of images

Basic mechanism: Modified bubble sort

I create the images using a modified bubble sort of the pixels in the base image.

On each pass of the sort, I determine a random x and y offset for the whole pass. Each pixel is compared to the pixel indicated by this bounded offset, rather than be- ing compared to an adj acent pixel.

The offsets are randomly determined using an 8 -input formula which was a "happy accident" from playing with the code. The resultant images are highly sensitive to the values of these inputs.

For some initial images, I pre-determined the inputs with values that are known to settle down and produce relatively smooth results. For others, the inputs were randomly determined within a wider range. I experimented with this range throughout the generation of the initial images.

Control Points

Instead of sorting across the entire image, uninterrupted, or being constrained by predetermined lines, the sort is governed by a number of control pointsii.

On each comparison, the process checks which of the two points being compared is nearer to the control point closest to the point being evaluated. It uses the nearer point as the base for the comparison. In other words, if the offset point is closer to the control point, the result for the comparison will be inverted. This is what pro- duces the starburst effects seen in some of the images in Appendix III.

Tint

One input into the process is whether to tint. If tinted, the output is treated using a process where each pixel receives a hue corresponding to its greyscale value. Only

2 of the original set of images (#7, #15) were tinted.

Communal Curation

The set of voters for communal curation of this piece was drawn from two groups: my social media contacts (people with technical backgrounds ranging in age from mid-20s to early 60s, plus some recent art school graduates), and art students and instructors at TUAS.

The voters visit a website where they are presented images, pair-wise. Their pref- erences are stored with no i dentifying information. The voters may keep voting until they have seen all the images for the active generation.iii

After a set period, the voting for a round closesiv, and I feed the results into the process for generating the next, smaller set of images. The vote/generate cycle is repeated until there is only one image left.

I don't know how many of the voters saw all the pairs, or how many saw every pair. That information was not kept.v

Some voters reported a strong preference for certain pieces, but there is no direct data on preference strength.

Titling the images

I considered labelling the images with their database ids, but wanted something a voter could use to discuss an image more comfortably. I felt using the actress's names could strongly influence the results by association. So, the titles of the first set of images were single words

from the title of a movie the actress was in ("Rebec- ca"), from a line spoken by the actress ("Seatbelts") or from a particular scene asso- ciated with the actress ("Budgie"). Names in subsequent rounds still relate to the ac- tresses, but in equally obscure ways. I felt confident that these titles would not be directly associated with the actresses by most of the votersvi.

Anecdotally, we know the names of the pieces influenced at least one voter, though not through association with the subject matter.

Producing the next generation

Once voting for a round was completed, a program tallies the votes, ranks the im- ages and determines breeding pairs for the next generation. The highest-ranked im- age is paired with the last, 2nd with second-last, etc.. If there are an odd number of images, the first-place image is bred with the images in the last two places instead. vii

A number of parameters are bred for input into the next generation: base image; base-colour or tintviii; number of control points; control points (x and y separately); parameters for generating the bubble-sort offsets; maximum number of sort passes; stop threshold by % of pixels moved in the pass; and maximum time for the sort.ix

The process selects the values for the next generation image according to a weight- ed chance on each parameter — if Image A has m votes, and Image B has n votes, the chance that Image A will provide that parameter is m/(m+n).

Two parameters have additional adjustments — a chance at mutation in the breeding process.

Base Image mutation

Once chosen, we process the base image, randomly flipping individual bits in some pixels on a tiny chance. This produces a small variation in the base image, which accumulates and becomes a discernible component of the output image over several generations.x

Control point variation

The chosen control point's x and y values have a 10% chance of being nudged up to 10% towards an edge. This introduces more variation in the new generations than would be present with a strict copying of the original control points.

Observations:

Feedback into voting process

After round 1, the TUAS students recommended adding a progress bar, moving the titles above the images, and changing from radio buttons and a single vote button to individual voting buttons for each image. These suggestions were implemented for round 2.

Attrition

Although we cannot know, except anecdotally, who voted in each round, we can es- timate the rate of attrition by tracking the ratio of total votes to number of available pairs of images to vote on. This is an imperfect measure because the number of people completing the entire set of images pairs should increase as the number of images decreases.

Table 1: Votes by Round

Round	Number of Images	Number of Image Pairs	Number of Votes	Votes / Image Pairs
1 (Sep 23 - 25, 2019)	25	300	4431	14.77
2 (Oct 1 - 3)	13	78	785	10.06
3 (Oct 6 - 8)	7	21	299	14.24
4(Oct 9 - 11)	4	6	78	13
5(Oct 19-22)	2	1	15	15

Anecdotally, causes for the dip in round 2 included travel and technical difficulties. These might be reduced with a longer voting period, but a short voting period en- courages prompt action. The voting for round 1 was a scheduled event for the TUAS students, but not for subsequent rounds.

Overall, the rate of attrition was within expected bounds - we had 22 reported voters in the first round, and 15 in the final. The voting was purely a volunteer activity, and it took place over a relatively short period of time — one month for the 5 rounds. The burden of fully participating decreased with time, as the number of

pairs available decreased rapidly - from 300 pairs in the first round to 1 in the last.

Selection of images and “rule of three”

I thought the composition of the images might play a strong role in what people vot- ed for. The control points correspond to the centres of the starburst elements, which are the strong centres of interest in the ‘well-behaved’ cases.

However, basic analysis shows that the voters did not tend strongly to vote for the images that had c ontrol points closer to the thirds. (See Appendix VI). If there was a p reference for images with elements according to the rule of three, it was over- whelmed by other factors.

To what extent did each generation resemble the winners from the previous one?

Base Image

The base image used naturally has an outsized influence on t he image. T he process uses the whole (albeit mutated) base image from one of the parents, I n the first round, onl y 6 of the winning images had their base images passed on to the

next generation, despite an ov erall advantage in votes of 2800 to 1872.xi Although

the winning image from the first round was bred twice, with over a 7 0% weight each time, its base image did not survive. See Appendix IV.

Tint

Only one of the tinted images was a winner in the first round. Tint was eliminated as a factor in succeeding rounds.

Number of control points

20/27 pairings produced the same number of control points as the winning element.

Control points

10-20% of the points were “nudged” on each round, so we do not expect a c lear cor- respondence across generations. In 16 out of 27 transitions, the distance between the control points in the image with more votes and the chosen points was less than the distance between the control points with fewer votes and the chosen points. This is the amount we would expect with the ratio of votes. See Appendix V.

Offset parameters

The winners of the first round, with one exception, were all created with the well- be- haved offsets. A n inspection of the round 2 i mages shows that there was sufficient input from the wilder images for visibly looser behaviour in 3 c ases. 2 of the wilder images won in that round, but the images became tamer as the rounds progressed. (See Appendix III for image thumbnails)

Compositional elements

At the start of the project, I wondered whether the final composition would cleave more closely to traditional rules such as “rule of three” than the initial images did.

Table 2: Convergence to thirds check

Generation	Mean distance to thirds - X	Mean distance to thirds - Y
1	0.122	0.143
2	0.118	0.159
3	0.116	0.138
4	0.145	0.187
5	0.134	0.179
6	0.111	0.297

There appears to be no convergence to rule of three. T he “nudging” might be play- ing too big a role in the positioning for any meaningful convergence to take place.

Going forward:

Base Image

The base image weighs heavily in the appearance of the images. With weighted randomness, favoured images can, and did, end up essentially being lost to the process.

To mitigate this, we could create new base images from the parent images by ran- dom combination of the two images, on a weighted basis. This introduces a risk of introducing aesthetic difficulties — some colour palettes just don’t work well

together. It might be instructive to do a dry run based on the votes in the first round.

Tint Factor

The tint factor was eliminated after the first round, although both the images it was used on made it through to the second round. Including more tinted images (with a v ariety of base hues), would increase the likelihood of the tint being a factor in later rounds.

Convergence?

On the next iteration, the nudging factor should be reduced. T here is a b alance be- tween introducing enough motion in the points, and overpowering the will of the vot- ers. It is not certain that the will of the voters would be toward convergence.

Community Composition

This proof of concept was produced with the help of an artificial, mixed community. The next iteration could be produced with a tighter community, working with initial images that are meaningful to that community.

Breeding mechanism

I was dissatisfied with the loss of voter-favoured elements after the first round. This could be mitigated by promoting the top few images from early rounds into subse- quent rounds — at a cost of larger voting pools, and possibly higher attrition

To investigate in future iterations

1/ Effect of language: T he voters were asked to choose the image they preferred. What if they were asked which was best? T he most striking? Or which made them feel more?

2/ Mechanisms for measuring individual strength of preference. There is a difference between preferring one i mage over another, and strongly liking the preferred image. Could we measure that in a u ser-friendly way? What would it mean?

3/ Being able to look at an i ndividual voters choices (still anonymized). It would be interesting to see whether voters are consistent in their choices - whether someone who prefers A to B and B to C might prefer C to A, for example.

Appendix I : Acknowledgements

Thanks to the people who made this project a success:

Votersxii

Sofia Aarmio, Diane Bayley, Brian Peter Dickson, Jesper Dolgov, Katharine Draper Quinn, Pene Gerber, Saara Hast, Kati Immonen, Heli Janhiainen, Venla Kaasinen, Aapo Kotilainen, Sakari Kyyrönen, Matti Lankireen, Jussi Lipasti, Eero Merimaa, Mehtap Memmi Mertdoğan, Natalie Plociennik, Bob Shaland, Michelle Wehrle, Maria West, Anita Woodard, Shiyu Zhang

Testers

Seonaid Lee, Robert Quinn

Advisors

Eero Merimaa (TUAS)

Lisa Binnie (Centennial College)

David McClyment (Centennial College)

Appendix II: Distribution of votes

Table 3: Distribution of votes, Generation 1

Image number	For	Against	% for	Image number	For	Against	% for
1	134	233	36.5	13	164	201	44.9
2	104	247	29.6	14	194	171	53.2
3	228	124	64.8	15	212	142	59.9
4	91	265	25.6	16	104	247	29.6
5	219	133	62.2	17	117	231	33.6
6	195	155	55.7	18	209	150	58.2
7	122	228	34.9	19	177	173	50.6
8	187	177	51.4	20	240	121	66.5
9	127	217	36.9	21	244	114	68.2
10	184	167	52.4	22	188	162	53.7
11	206	145	58.7	23	201	151	57.1
12	196	161	54.9	24	212	147	59.1
				25	173	182	48.7

Table 4: Distribution of votes, Generation 2

Image number	For	Against	% for	Image number	For	Against	% for
26	61	60	50.4	33	54	67	44.6
27	62	65	48.8	34	74	42	63.8
28	50	71	41.3	35	75	47	61.5
29	59	59	50	36	47	73	39.2
30	51	70	42.1	37	77	43	64.2
31	54	68	44.3	38	73	47	60.8
32	76	45	62.8				

Table 5: Distribution of votes, Generation 3

Image number	For	Against	% for	Image number	For	Against	% for
39	41	44	48.2	43	58	27	68.2
40	37	48	43.5	44	44	41	51.8
41	30	56	34.9	45	45	41	52.3
42	44	42	51.2				

Table 6: Distribution of votes, Generation 4

Image number	For	Against	% for	Image number	For	Against	% for
46	20	19	51.3	48	19	20	48.7
47	19	20	48.7	49	20	19	51.3

Table 7: Distribution of votes, Generation 5

Image number	For	Against	% for	Image number	For	Against	% for
50	5	10	33.3	51	10	5	66.7

Appendix III: Image Thumbnails

Figure 2: Generation 1 Image Thumbnails



Figure 3: Generation 2 I mage Thumbnails

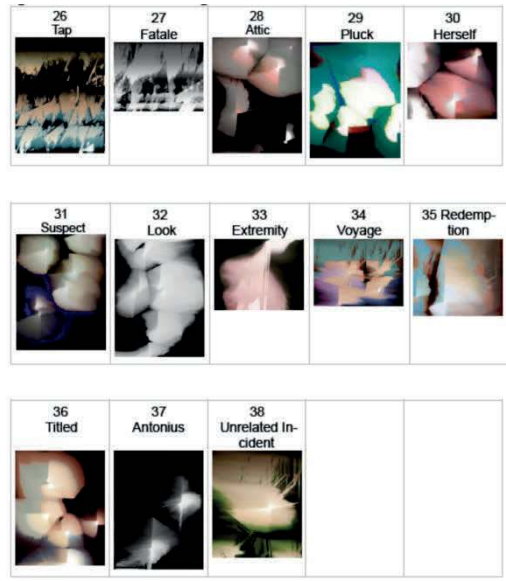


Figure 4: Generation 3 Image Thumbnails

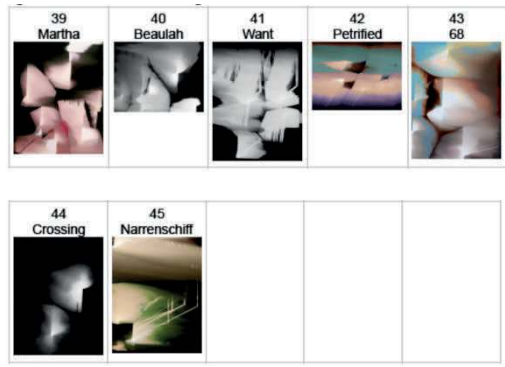


Figure 5: Generation 4 Image Thumbnail

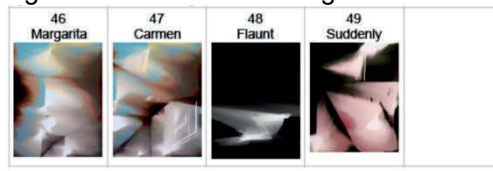
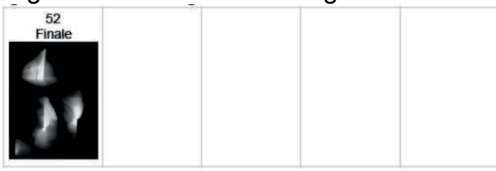


Figure 6: Generation 6 Image Thumbnails



Figure 7: Generation 7 Image Thumbnail



Appendix IV: Base Image Inheritance

Table 8: Inherited base images Generation 1 to Generation 2

Image 1	Image 2	% chance for image 1 to prevail	Inherited base image	Round 2 image
21	16	70.1	16	36
20	2	69.8	20	34
3	17	66.1	3	26
5	7	64.2	7	27
24	1	62.5	1	38
15	9	61.3	15	32
18	13	56	18	33
11	25	54.4	25	29
23	19	53.2	23	37
12	10	51.6	10	30
6	22	50.8	6	28
14	8	51	8	31
21	4	72.8	4	35

Table 9: Inherited base images Generation 2 to Generation 3

Image 1	Image 2	% chance for image 1 to prevail	Inherited base image	Round 3 image
37	31	58.7	37	44
35	28	60	35	43
34	36	61.2	34	42
38	30	58.9	38	45
27	29	51.2	27	40
26	33	53	33	39
34	32	62.2	32	41

Table 10: Inherited base images Generation 3 to Generation 4

Image 1	Image 2	% chance for image 1 to prevail	Inherited base image	Round 4 image
43	40	61.1	43	46
45	39	52.3	39	49
44	42	50	44	48
43	41	65.9	43	47

Table 11: Inherited base images Generation 4 to Generation 5

Image 1	Image 2	% chance for image 1 to prevail	Inherited base image	Round 5 image
49	48	51.3	48	51
46	47	51.3	47	50

Table 12: Inherited base images Generation 5 to Generation 6

Image 1	Image 2	% chance for image 1 to prevail	Inherited base image	Final image
51	50	66.7		52

Appendix V: Point position distances between generations

Table 13: Distance between source and resultxiii

Images(most votes..least votes..result)	Distance measure of result from 'winner'	Distance measure of result from 'loser'	Result is closer to 'winner'
21..16..36	1.17	2.20	true
20..2..34	0.88	1.15	true
3..17..26	0.54	1.90	true
24..1..38	0.00	2.51	true
15..9..32	1.03	1.05	true
18..13..33	0.00	0.87	true
37..31..44	0.00	1.05	true
35..28..43	0.87	2.54	true
27..29..40	0.28	1.86	true
34..32..41	0.00	1.95	true
43..40..46	0.78	1.17	true
44..42..48	0.20	0.49	true
43..41..47	0.43	1.67	true
49..48..51	0.00	0.90	true
46..47..50	0.39	0.82	true
50..51..52	0.86	1.52	true
5..7..27	2.14	0.09	false
11..25..29	0.92	0.55	false
23..19..37	0.59	0.36	false
12..10..30	1.68	0.98	false
6..22..28	0.98	0.94	false
14..8..31	3.28	0.00	false
21..4..35	1.96	1.12	false
34..36..42	0.94	0.90	false
38..30..45	1.65	1.56	false
26..33..39	0.17	0.00	false
45..39..49	2.60	0.31	false

Appendix VI: Distance from rule of thirds

Table 14: Distance between images and rule of thirdsxiv

Pair	Distance of winner	Distance of loser	Winner is closer
21..16	0.091	0.129	true
20..2	0.119	0.102	false
3..17	0.135	0.131	false
5..7	0.149	0.107	false
24..1	0.2	0.104	false
15..9	0.128	0.147	true
18..13	0.091	0.2	true
11..25	0.119	0.151	true
23..19	0.181	0.101	false
12..10	0.182	0.178	false
6..22	0.142	0.137	false
14..8	0.15	0.087	false
21..4	0.091	0.172	true
37..31	0.11	0.087	false
35..28	0.18	0.159	false
34..36	0.131	0.096	false
38..30	0.2	0.187	false
27..29	0.13	0.122	false
26..33	0.135	0.177	true
34..32	0.131	0.132	true
43..40	0.174	0.119	false
45..39	0.215	0.134	false
44..42	0.11	0.09	false
43..41	0.174	0.131	false
49..48	0.169	0.108	false
46..47	0.117	0.195	true
50..51	0.147	0.169	true

Notes

i"AFI's 100 YEARS...100 STARS." American Film Institute, American Film Institute, https://www.afi.- com/afis-100-years-100-stars/.

ii These were randomly determined for the initial images.

iii They could have gone to another machine, or cleared their cookies, and repeated the process. F or a pr oof of concept, safeguards against that behaviour were deemed overkill.

iv The voting was not actually disabled, which caused some data analysis headaches later.

v Four students volunteered the information that t hey completed all the pairs in the first round.

vi I am the only old-film buff among my social media contacts. My experience with the student de- mographic suggests they have little knowledge of pre-1980 popular culture.

vii This was thought to provide the best chance for the more popular image components to survive into the next generation.

viii There were two tinted images in the first generation. T hat was the last generation where tint was a factor.

ix Obviously, only one of maximum number of sort passes; stop threshold by % of pixels moved in the pass; and maximum time for the sort will actually be relevant. We don't know which one will be relevant before creating the image, though.

x The change is 1 in 10000 — far greater than my original intention of mimicking human gene muta- tion rates, but sufficient for noticeable effects over time. It is visible in the final image, if you already know it is there. It is just barely discernible in the "black and white" image the generation before.

xi That includes the votes for the first place image twice - because it was matched up to the two low- est -vote receivers.

xii

There was no requirement that the voters identify themselves, and the total pool of possible voters was significantly larger than this list.

xiii This is the sum of distances between corresponding points in the list of points, If there are more points in one image than the other, the surplus points are ignored.

xiv This is the sum over the points, of the distance from the closest horizontal third (x = 0.333, x =
0.667) and the distance from the closest vertical third (y = 0.333, y - 0.667)



Tuning Shapes and Bending Timbres – Experimenting with Smart Materials for Musical Purposes
(Paper, Installation)

Topic: (Music)

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Abstract

This publication reports on preliminary experiments in employing smart materials as central elements in a generative sound installation. For this installation, a material has been chosen whose piezoelectric properties can be altered by changing the material's shape. When integrated into a feedback loop, the material's capability to simultaneously act as an acoustic sensor and actuator establishes a sustained audio signal whose timbre is dependent on the bending of the material. By exploiting this material behaviour, a process can be set into motion within which the material serves both as tangible interface for interaction and as generative mechanism that drives the development of the musical output.

This work continues a research trajectory that explores the generative potential of physical processes and their integration into hybrid artworks in which physical and computational systems complement each other. Throughout the course of this research, the emphasis has increasingly been placed on the characteristics of physical processes while relegating the role of computation to one of control and stabilization. This installation demonstrates the potential usefulness of this approach but also highlights its pitfalls, the most important of which is the difficulty of controlling and scaling the complexity of a physical process through an incremental development method.

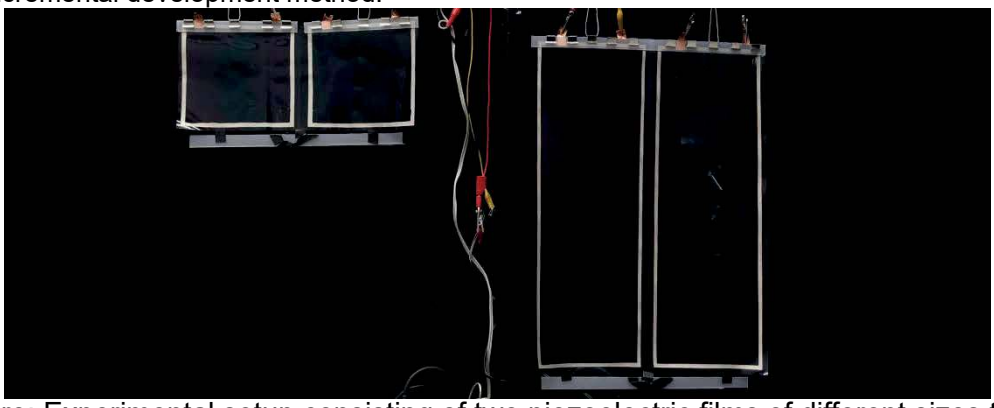


Figure: Experimental setup consisting of two piezoelectric films of different sizes that are wired into an acoustic feedback loop.

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Key words: Sound Installation, Smart Materials, Generative Music

Main References:

[1] Daniel Bisig and Florian Bogner, "*Exploiting Simple Physics for Generative Art*", in Proceedings of the Generative Art Conference, Ravenna, Italy, 2017

Tuning Shapes and Bending Timbres — Experimenting with Smart Materials for Musical Purposes

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Premise

This publication reports on preliminary experiments in employing smart materials as central elements in a generative sound installation. For this installation, a material has been chosen whose piezoelectric properties can be altered by changing the material's shape. When integrated into a feedback loop, the material's capability to simultaneously act as an acoustic sensor and actuator establishes a sustained audio signal whose timbre is dependent on the bending of the material. By exploiting this material behaviour, a process can be s et into motion within which the material serves both as tangible interface for interaction and as generative mechanism that drives the development of the musical output.

This work continues a research trajectory that explores the generative potential of physical processes and their integration into hybrid artworks in which physical and computational systems complement each other. Throughout the course of this research, the emphasis has increasingly been placed on the characteristics of physical processes while relegating the role of computation to one of control and stabilization. This installation demonstrates the potential usefulness of this approach but also highlights its pitfalls, the most important of which is the difficulty of controlling and scaling the complexity of a physical process through an incremental development method.

Keywords: Sound Installation, Smart Materials, Generative Music

1. Introduction

During the past years, the author of this article has been involved in the creation of generative artworks that integrate both computer-based and non-computer based elements. [1, 2, 3]. While doing so, the focus of this work has gradually shifted towards settings in which the predominant part of the artwork's functioning as a generative system is transferred into the non-computational domain while the role of the computer is relegated to one of control and stabilization. The work presented here expands on this research in that it employs smart materials as core elements of a generative system. In this particular case, a material has been selected that can function both as actuator and sensor for emitting and detecting acoustic waves, and whose capability to do so is dependant on the material's size

and shape. The adoption of this material as a generative system is achieved by integrating both its acoustic sensing and emission functionality within a single surface. This can be used to give rise to a feedback loop through which an initial acoustic excitation becomes sustained. The sustained signal is then gradually transformed according to the particular characteristics of the material's mechanical and electrical properties. This publication reports on the results of characterizing the relationships between the material's size, shape, and acoustic properties. The author then demonstrates how these relationships, when being part of a feedback loop, shape the acoustic development of a self-sustained audio signal. Finally, the author presents a first attempt at translating these insights into the realisation of a generative audio installation.

2. Background

This background section contextualizes the current work with respect to theoretical and practical considerations in related artistic fields. Within generative art, this concerns the distinction between computer-based and non-computer based approaches. Within electronic music and particularly sound art, it concerns the increasingly prominent notion of "a materiality of sound" and its relationship to the properties of audio technology. Within media art, this concerns the interest in exploring smart materials as unconventional medium and as a method to closely connect the behaviour and appearance of an artwork.

2.1 Non-Computer based Generative Systems

Today, the vast majority of artists who realize generative artworks do so in the digital domain. This puts those artistic approaches within generative art that involve non-computer based systems into a minority position. This tendency fails to fully account for the conceptual foundations of generative art [4, 5]. As a result, many practitioners in the field are unaware of historical precedents in generative art and are also incapable of anticipating possible future forms of generative art [6]. For this reason, the contemporary artistic output mostly misses out on the large diversity of potentially promising generative approaches.

Nevertheless, several non-computer based generative artworks have achieved some visibility in the art domain. For reasons of brevity, only two of them are mentioned here. One of the possibly most famous examples is the "Condensation Cube" by Hans Haacke that has been realised in 1963. The cube consists of sealed acrylic that contains a small amount of water. Depending on the temperature and air currents present in the exhibition space, the enclosed water cycles through processes of evaporation and re-condensation, leaving ever changing patterns of streaks and droplets on the interior surface of the cube [7].

Another, more recent example is the work "Rule 30" that has been realised by Kristoffer Myskja in 2008. In this work, an electromechanical machine is punching holes into in a roll of paper. While doing so, the mechanism executes rule number 30 from the classical set of 256 one-dimensional cellular automata that have been systematically studied by Stephen Wolfram [8]. What is striking about this artwork is its capability to execute a computational process through non-computational means [5].

2.2 Materiality in Sound Art

An artistic movement that originated within the field of sound art is characterized by

an altered stance towards the role of loudspeakers in an installation or performance setting. Conventionally, a loudspeaker is treated as a perfect and generic device that serves as a quasi transparent medium for transmitting sound. Contrary to this, the new movement places its creative focus on the establishment of a close relationship between the physical characteristics of a loudspeaker and the musical content that it emits. Consequently, the materiality of a loudspeaker is embraced, pushing its visual appearance, spatiality, and sound emission characteristics to the forefront of the compositional concern [9].

The notion of a set of loudspeakers as an orchestra of sonic objects was pioneered by David Tudor. According to Tudor, “the loudspeaker should have a voice which was unique and not just an instrument of reproduction, but as an instrument unto itself" [10]. Tudor has implemented this approach through different iterations of his piece “Rainforest” starting from 1965. The piece takes the form of concert-installations that consists of a collection of spatially distributed sculptural objects, each of them equipped with surface transducers and piezo-microphones, and each of them performed live [11].

A more recent example of a sonic object orchestra is represented by the “Shake-ousmonium” project that has been realized in 2015. Similar to “Rainforest”, the loudspeakers are custom designed by combining sound drivers with a range of materials. These loudspeakers serve as diverse and idiosyncratic sound sources for which different composers specifically wrote music for [9].

2.3 Smart Materials in Media Art

Smart materials are composites that possess one or more physical properties that change in response to external stimuli. These materials are capable of sensing external stimuli and actively responding to changes in these stimuli entirely on their own without the need for additional electronic or computational components [12]. While these materials have mainly attracted attention within engineering disciplines, there is a recent increase of interest within the HCI community, in particular among those working in the context of tangible computing. Here, the capability of smart materials to provide feedback to interaction other than through the visual or acoustic modality as well as the possibility of seamlessly integrating these materials into regular objects has opened up the possibility to envision entirely novel forms of interfaces and communication languages [13].

In his discussion of recent technologies that could have a significant impact on future, post-computer forms of generative art, Philippe Galanter identifies smart materials as one such candidate technology. These materials are fascinating for generative purposes in that they can assume multiple roles in an artwork. These roles include the material’s behaviour as an environment within which dynamic processes take place, as a medium for rendering these processes perceivable, and as an interface via which users can influence the material’s behaviour through tangible interaction. Accordingly, smart materials are capable of overcoming the divide between medium, process, and perceivable outcome that normally exists in the case of computer-based systems [5].

There exist several examples of artworks that employ smart materials. The two examples that are mentioned here are not particularly interesting from a generative point of view. Nevertheless, they shed some light on the artistic appeal of smart materials.

One example is the “Robotany” project that has been realised by Jill Coffin in 2008. In this project, the branches of a Japanese maple tree become capable of active movement by actuating them with shape memory alloy wire. Whenever a camera and an ul trasonic sensor array detect visitors walking nearby and interacting, the wires cause the branches to swing back and forth [14].

Another example is the “Magnetic Mind” project that has been realised by Lindsay Browder in 2013. This project exploits the property of fluids that contain nanoscale ferromagnetic particles to respond to an external magnetic field by changing shape. Here, the ferrrofluid acts as a kinetic sculpture that is controlled by brainwaves that are captured with a brain computer interface [15].

3. Implementation

The installation that has been developed in the context of this publication is depicted in figure 1. It is comprised of two piezoelectric films of different size, each of which is subdivided side by side into a region that operates as a loudspeaker and another region that operates as a microphone. Also depicted in figure 1 is a touch screen via which visitors can alter some of signal processing that is applied as part of acoustic feedback. The tangible manipulation of the shape of the piezoelectric films in combination with the graphical controls on the touch screen constitute the means for interaction with the installation. The installation also consists of two custom designed amplifiers (see figure 4), an audio interface[1], and a s mall PC[2], all of which are placed on the ground in front of the installation. The computer runs a simple, custom-developed digital signal processing application. The custom designed components will be described in more detail in the following sections.



Figure 1: Appearance of the Installation. Shown in this photograph are two piezoelectric films of different size that are suspended from a horizontal bar. Attached underneath the films is a touch screen that runs a simple graphical interface and that allows visitors to alter some aspects of the digital signal processing that forms part of the acoustic feedback.

3.1 Hardware

A schematic setup of all hardware components and t heir connectivity is shown in figure 2.

[1] Zoom UAC-2 USB audio interface
[2] Nuc7i5BNK mini computer

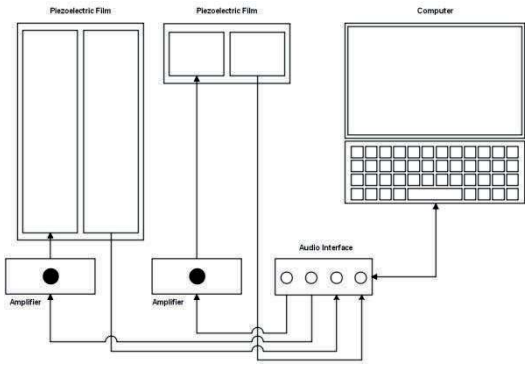


Figure 2: Schematic Depiction of the Hardware Setup. Shown are two piezoelectric films each of which contains a microphone and l oudspeaker region, two audio amplifiers, an audi o interface, and a computer. The audio amplifiers are connected to the audio interface and drive the speaker regions of each piezoelectric film. The microphone regions are directly connected to the audio interface. The audio interface is connected to a computer which runs a simple application for processing the audio signals.

3.1.1 Piezoelectric Film

At the core of the installation are two piezoelectric films that operate as loudspeakers and m icrophones and that are interconnected among each other in order to create acoustic feedback. The films are made from a composite material that consists of a membrane of Polyvinylidene fluoride (PVDF) that is coated on both sides with carbon nanotube layers. These layers are transparent and ac t as conductors [16]. The piezoelectric films are commercially available and are provided either as fully operational loudspeakers or as intermediate goods[3]. The latter product requires a little bit of handcrafting before it can be used as a l oudspeaker or microphone. This includes cutting the film into its final shape, applying conductive ink[4] at the periphery and on both sides of the film, and glueing a copper tape[5] on both sides to a s ection of the ink. Electrical wiring running from and to other audio equipment can then be connected to the tape by means of alligator clips. All these components are visible in figure 1.

The basic principle by which the films are capable of sensing and e mitting acoustic vibrations is based on t he normal and reverse piezoelectric effect, respectively. A schematic depiction of these effects is shown in figure 3. In a nutshell, the normal piezoelectric effect is based on the ability of certain materials to generate an electrical charge in response to an applied mechanical strain. The reverse piezoelectric effect results from an applied electrical charge that produces a mechanical strain in the material.

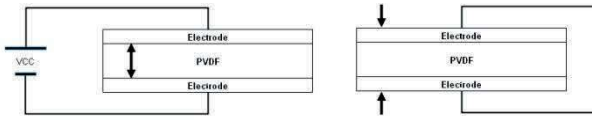


Figure 3: Schematic depiction of the piezoelectric effect. Shown on the left side is the normal piezoelectric effect in which a mechanical strain applied to a m aterial generates an electric charge in response. Shown on the right is the reverse piezoelectric effect in which an electrical charge applied to a m aterial results in a mechanical strain.

In order to exploit these two electromechanical effects for acoustic purposes, an external strain or an external electrical charge is applied in a p eriodic manner at a frequency within audible range of human hearing. In case of the normal piezoelectric effect, alternating sound pressure levels give raise to alternating strains in the piezoelectric

[3] http://film.koreasme.com/

[4] Amepox Electon 45RT
[5] 3M 1181 X 1/2”

material which then translate into alternating electrical charges. Under these conditions, the material operates as a microphone. In case of the reverse piezoelectric effect, the application of a periodically alternating electrical charge is translated into alternating changes in the material's thickness which gives raise to alternating sound pressure levels. Under these conditions, the material operates as a loudspeaker.

By electrically separating different sections of the piezoelectric speaker films and by surrounding each of these sections with conductive ink, multiple acoustically distinct regions can be created within the same speaker film. These regions are still mechanically coupled through the film material but they can electrically operate separately from each other.

For the installation, two piezoelectric film sheets of different size have been prepared. One of the sheets is about 60 cm long and 30 cm wide, the other is about 15 cm long and 30 cm wide. Both these sheets have been subdivided into two regions that are identical in size and are placed side by side along the length of the sheet. This setup forms the basis to analyse the size and shape dependency of the acoustic properties of these sheets when operated as microphones or loudspeakers. In addition, the setup also permits to experiment with the creation of acoustic feedback that results from the mechanical coupling among loudspeaker and microphone regions that located on the same film sheet

3.1.2 Amplifier

The installation consists of two custom designed audio amplifiers. The necessity for a custom design arose from the requirement of the piezoelectric films to be driven at around 230 V which represents a much higher voltage level than regular amplifiers can provide. The seemingly simplest approach for realising a custom audio amplifier consists of combining a regular amplifier with a step-up transformer coil that increases the voltage output to the required level. The design of the custom amplifier follows this principle. The custom audio amplifier consists of the following components: a regular 60 Watt Mono amplifier board[6], a volume control knob[7], a toroidal transformer coil[8], a power regulation board, and sockets for electrical current, the input audio signal, and the amplified output audio signal. All these components are encased into a box made from acrylic. A photograph of a custom amplifier is shown in figure 4. A schematic depiction of the amplifier's components and their wiring is shown in figure 5.

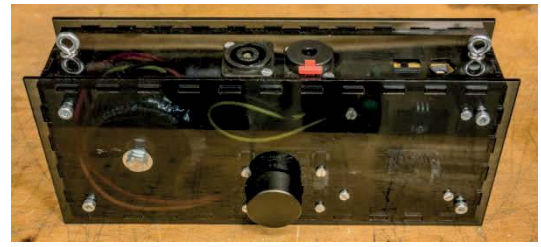


Figure 4: Custom Amplifier. Shown on this photograph is a custom designed amplifier that is used to drive the piezoelectric films as loudspeakers. Visible on the top side of the amplifier are (from left to right): a Speakon socket for connecting the loudspeaker region, a Jack socket for connecting the audio interface, a s witch for turning the amplifier on and off, and a barrel socket for connecting a power supply. Visible on the front of the amplifier is the volume control knob. Barely visible through the acrylic surface are (from left to

[6] Sure Electronics 60 Watt 3 Ohm Class D Audio Amplifier Board - TPA3118

[7] Sure Electronics Control Module VC01-M62429

[8] Triad VPT12-2080

right): a transformer coil, a volume control electronics board, and a power regulation board. The regular amplifier board is not visible since it is mounted behind the transformer coil.

3.2 Software

The software part serves the purpose of controlling the overall volume and frequency content of the acoustic feedback signal. In addition, the software also allows to differently route a microphone region to a loudspeaker region.

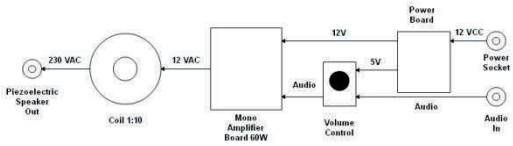


Figure 5: Schematic depiction of the custom amplifier electronics. Visible from right to left are: two sockets for electrical power (top) and audio signal (bottom), a power regulation board, a 60 Watt Mono amplifier board, a step-up transformer coil, and a socket that outputs the fully amplified audio signal to the loudspeaker region of a piezoelectric film.

The software has been custom designed in the Max/MSP programming environment. A schematic depiction of the digital signal processing stages that have been implemented is shown in figure 6. These stages include: an analogue to digital conversion of the microphone signal, a gain unit for amplifying the converted microphone signal, a high-pass filter to remove DC-offset, a low-pass filter to remove high frequency content, a limiter to stabilize the audio volume, a routing matrix for connecting the pre-processed microphone signal to a loudspeaker region, a gain unit for attenuating the loudspeaker signal, and a digital to analogue conversion for outputting the final audio signal to the amplifier electronics. Apart from the routing matrix, all the other signal processing stages exist twice and run in two parallel pipelines, one pipeline for each microphone to loudspeaker feedback connection.

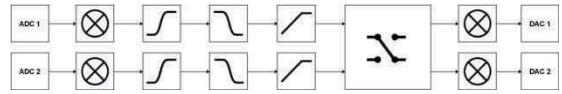


Figure 6: Schematic depiction of the feedback audio signal processing pipelines. Depicted are from left to right: an analogue to digital signal converter, a gain unit, a high pass filter, a low pass filter, a limiter, and signal routing matrix, a second gain unit, and a digital to analogue converter.

Some of the control parameters of the signal processing pipelines have been exposed for interaction through a graphical user interface (see figure 7). Apart from choosing among a pre-made set of parameter combinations, the GUI allows users to change the routing among microphone and loudspeaker regions, alter the gain of the microphone and loudspeaker signals, change the cut-off frequencies for the low-pass and high-pass filters, and modify the amplitude threshold of the limiter. This GUI is displayed on and manipulated through a touch screen.

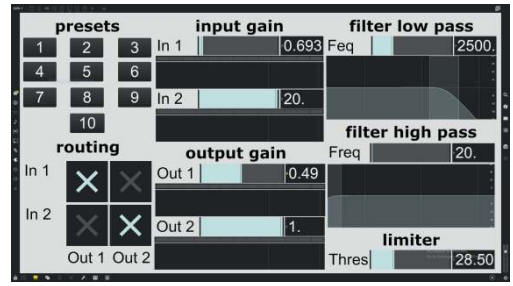


Figure 7: Graphical user interface for the signal processing software. The GUI displays a subset of the control parameters of the digital signal processing

pipeline that links the microphone input to the loudspeaker output for each region on the two piezoelectric films.

4. Acoustic Measurements

Several measurements of the acoustic properties of the two previously described piezoelectric film sheets have been conducted. The first set of measurements quantifies the capability of the piezoelectric material to operate as a loudspeaker. The second and third set of measurements assess the combined functioning of the piezoelectric material as loudspeaker and microphone. For the second set of measurements, the loudspeaker and speaker regions are located on the same film sheet. For the third set of measurements, these regions are located on two different film sheets. All measurements were repeated several times during which the curvature of the film sheets was set to one of the following four shapes: free hanging film (curvature 1), film curved at the bottom (curvature 2), film curved so that its bottom part reaches up to the vertical middle of the film (curvature 3), film curved so that its bottom and top parts are on the same height (curvature 4). The measurements were conducted in a recording booth that is sound proof and exhibits low reverberation (see figure 8). The results of these measurements are provided in the form of sound-pressure level (SPL) plots. These plots have been created with the aid of the free room-acoustics software REW[9].

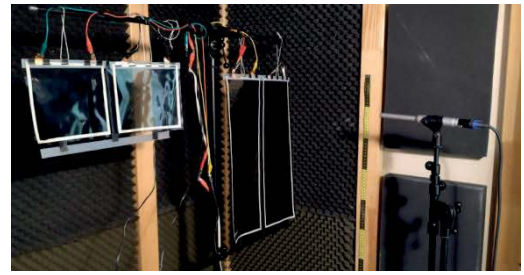


Figure 8: Acoustic measurement setup. Shown on this photograph are two piezoelectric film sheets and a reference microphone.

4.1 Loudspeaker Characteristics

This section describes the results of measuring the loudspeaker characteristics of two differently sized piezoelectric film sheets. For the purpose of the measurement, the frequency of sine wave audio signal was linearly interpolated over the range from 20 Hz to 22050 Hz and sent to the loudspeakers. The emitted loudspeaker signal was recorded using a calibrated reference microphone[10]. The resulting SPL plots are shown in figure 9.

The SPL plot for the small piezoelectric film sheet permits the following observations. The maximum sound pressure level lies in between 1.5 kHz and 13.5 kHz. The amplitude in this frequency range increases when the film changes shape from curvature 1 to curvature 2. When the film is further bent to curvature 3 and curvature 4, the frequency range splits into a lower frequency region (1.5 kHz to 4.5k Hz) whose amplitude decreases and an upper frequency region (4.5 kHz to 13.5 kHz) whose amplitude further increases. In more detail, the following spectral changes of the loudspeaker signal can be observed as a result of increasingly bending the small film sheet. Two peaks present at 3.8 kHz and 5.5 kHz under curvature 1 increase in

[9] https://www.roomeqwizard.com/

[10] Dayton Audio EMM-6

amplitude and then merge into a single peak at 4.1 kHz under curvature 2. This single peaks shifts to 4.35 kHz under curvature 3, and 5.2 kHz under curvature 4. One peak at 7.2 kHz under curvature 1 increases and shifts to 7.8 kHz under curvature 2, then disappears under curvature 3, and reappears at 9 kHz under curvature 4.

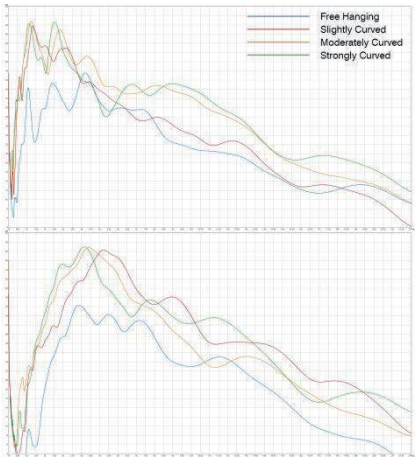


Figure 9: Loudspeaker measurements. Shown here are the SPL curves for the large (top) and small (bottom) piezoelectric film sheets.

The SPL plot for the large piezoelectric film sheet permits the following observations. The amplitude emitted by this loudspeaker is not louder than that of the small piezoelectric film sheet but its frequency range extends further towards lower frequencies. The maximum sound pressure level for the large film lies in between 0.4 kHz and 13.5 kHz. The amplitude increases over this frequency range when the film changes shape from curvature 1 to curvature 2. As the film is further bent to curvature 3 and 4, the amplitude of the lower frequency range (from 0.4 kHz to 5.9 kHz) remains unchanged. On the other hand, the amplitude in the upper frequency range (from 5.0 kHz to 13 kHz) decreases when the bending of the film increases from curvature 3 to curvature 4. This effect is different from the observations for the small film sheet. In more detail the following spectral changes in the loudspeaker signal can be observed as a result of increasingly bending the large film sheet. One peak present at 1.1 kHz under curvature 1 stays at the same frequency but widens under curvature 2, then shifts to 1.25 kHz under curvature 3, and further widens and shifts to 1.35 kHz under curvature 4. Another peak at 2.4 kHz under curvature 1 slightly shifts to 2.5 kHz under curvature 2, then shifts to 2.8 kHz under curvature 3, and widens, diminishes, and shifts to 3.2 kHz under curvature 4. A third peak located at 4.2 kHz under curvature 1 diminishes and shifts to 4.4 kHz under curvature 2, and disappears under curvature 3 and 4.

4.2 Internal Loudspeaker-Microphone Coupling

In this section, measurements are presented of the acoustic coupling between a loudspeaker and microphone region that are both located on the same piezoelectric film sheet. Accordingly, these measurements quantify the capability of the microphone region to pick up acoustic signals that propagate mechanically through the surface of the film material. For the purpose of the measurements, the same sine wave signal frequency sweep as in the previous measurements was used. The resulting SPL plots are shown in figure 10.

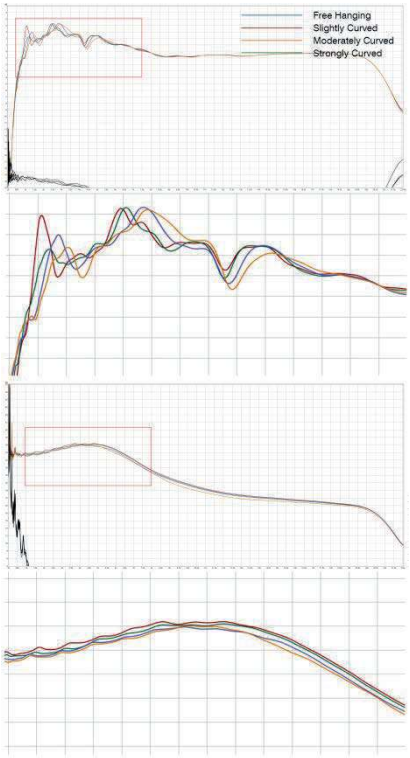


Figure 10: Internal loudspeaker and microphone measurements. Shown here are the SPL curves for the large (top half) and small (bottom half) piezoelectric film sheets across the full measurement spectrum and in a subregion of the spectrum within which the amplitude is highest.

The SPL plot for the small piezoelectric film sheet permits the following observations. The maximum sound pressure level lies in between 0.8 kHz and 8.0 kHz. Compared to the previous measurements with an external reference microphone, this SPL distribution indicates that the piezoelectric region is significantly inferior at picking up hi gh frequencies. But what is more striking is the difference in shape of the SPL curve when compared to the previous measurements. Here, the SPL curve is much smoother and flatter. This indicates that a pl acement of the loudspeaker and microphone regions on the same film sheet leads to a compensation and cancellation of each other's acoustic particularities.

The SPL plot for the large piezoelectric film sheet permits the following observations. Overall, the sensitivity of the large microphone region is drastically lower as compared to the small microphone region. The maximum sound pressure level lies in between 1.0 kHz and 6.5 kHz. This frequency range is again much smaller when compared to the measurements with an external reference microphone. Contrary to the measurements of the small film sheet, the spectrum is not flat but exhibits distinct peaks. One peak is present 1.1 kHz under curvature one, this peak decreases and shifts slightly to 1.2 kHz under curvature 2, then increases and shifts to 1.35 kHz under curvature 3, and f inally decreases and shifts to 1.5 kHz under curvature 4. Another peak at 2.45 kHz under curvature 1 minimally shifts to 2.5 kHz under curvature 2, then shifts to 2.85 kHz under curvature 3, and finally reaches 3 k Hz under curvature 4. A third peak exists at 4.8 kHz under curvature 1 and 2, this peak shifts to 5.0 kHz under curvature 3, and decreases and shifts to 5.2 kHz under curvature 4. From these observation it can be concluded that the acoustic particularities of the large microphone and loudspeaker regions don't cancel each other out as was the case with the small film sheet. Rather, these peculiarities persist and change in a concerted manner as the bending of the film sheet affects both the loudspeaker and microphone regions in a similar manner.

4.3 External Loudspeaker-Microphone Coupling

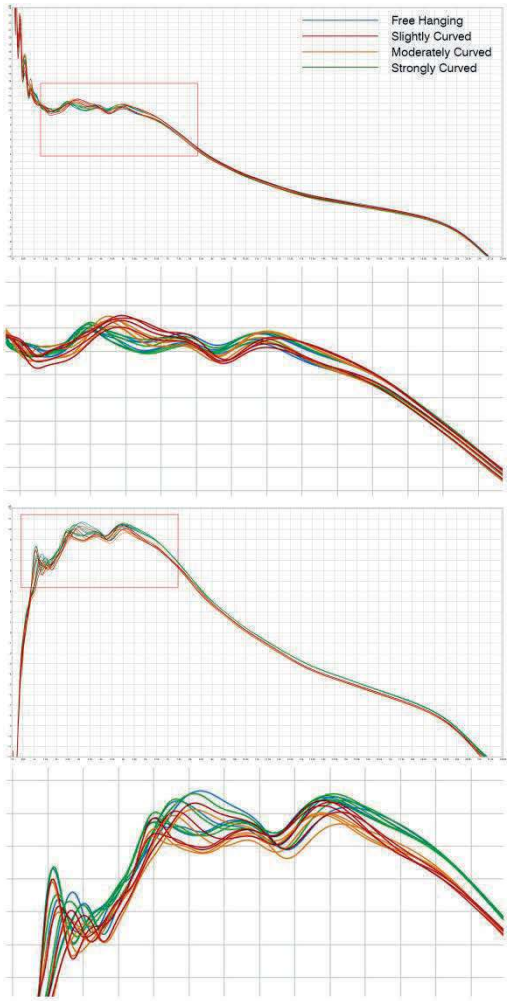


Figure 11: External loudspeaker and microphone measurements. The SPL curve on the left corresponds to a setting in which the sweep signal is sent to the loudspeaker region on the small film sheet and the microphone region on the large film is used for measuring. The SPL curve on the right corresponds to the opposite setting. The SPL plots at the top depict the entire frequency range of the measurments. The SPL plots at the bottom show a subregion of the spectrum within which the amplitude is highest.

In this section, measurements are presented of the acoustic coupling between a loudspeaker and microphone region that are each located on a different piezoelectric film sheet. As in the previous tests, these measurements quantify the capability of the microphone region to pick up acoustic signals that propagate mechanically through the surface of the film material. But contrary to the previous tests, the microphone and loudspeaker regions now possess a different size and they can be curved independently from each other. For the purpose of the measurements, the same sine wave signal frequency sweep as in the previous measurements was used. This signal is sent to the loudspeaker region on a first film sheet, the output from the microphone region on this first film is then routed through Max/MSP to the loudspeaker region on the second film, and the output from the microphone region on this second film is finally measured. The resulting SPL plots are shown in figure 11.

For the first set of measurements, the sine signal is output through the loudspeaker region on the small film sheet and the microphone region on the large film sheet is used for measuring. This setting combines the weak microphone characteristics of the large film with the narrow frequency range of the small film. The resulting SPL plot permits the following observations. The maximum sound pressure level lies in between 0.8 kHz and 8.5 kHz. Changes in the curvature of the small film have no effects on amplitude levels and cause no shifts in the frequency spectrum. Changes in the curvature of the large film give rise to similar acoustic effects as in the previous measurements.

For the second set of measurements, the sine signal is output through the loudspeaker region on the large film sheet and the microphone region of the small film sheet is used for measuring. This

setting combines the stronger microphone characteristics of the small film with the larger frequency range of the large film. The resulting SPL plot permits the following observations. The maximum sound pressure level lies in between 0.02 kHz and 8.0 kHz. Similar to the previous measurements, changes in the curvature of the small film have no effect. Changes in the curvature of the large film have similar effects as in the previous measurements with the notable exception of a di sturbance signal that masks features in the SPL plot below 2 kHz. The source of the disturbance signal has not yet been identified.

5. Acoustic Feedback Experiments

Based on the insigths gained from the acoustic measurements, a set of experiments was conducted in which the two differently sized piezoelectric film sheets were integrated into an acoustic feedback loop. Throughout these experiments, the sound signal that was measured and emitted by the microphone and loudspeaker regions was no l onger externally produced but arose through positive feedback from minimal internal fluctuations within the acoustic setup. These fluctations were reinforced through an acoustic feedback loop which eventually gave prominence to those frequencies for which the pizeoelecric material was particulary sensitive in their detection or efficient in their emission.

The purpose of these experiments was to evaluate the potential of this setup to serve as basis for an interactive and generative sound installation. These evaluations focused on t he capability of the two interconnected film sheets to maintain a s elf-sustained acoustic output whose sonic quality would gradually change over time due t o the dynamics of the smart material's internal electrophysical processes and the sensitivity of these processes with respect to changes in the material's shape.

All experiments were conducted in a similar manner. A particular combination of parameters for the digital signal processing pipelines was chosen at the onset of the experiment. After that, the installation was left alone until the audible output stabilized and stopped changing its sonic characteristics. Once this happened, a slight manual change in the curvature of one or both of the film sheets was applied in order to initiate a new transisition phase throughout which the sonic characteristics of the audio signal gradually changed before eventually stablizing again.

Several parameter combinations have been tested. For some of these tests, audio recordings are available online. In the following list, several abbreviations are being used: ML (microphone large region), MS (microphone small region), LL (loudspeaker large region), LS (loudspeaker small region), LP (low pass filter), HP (high pass filter)

1: acoustic feedback between ML and LL. Cutoff Frequencies HP 20 Hz and LP 10 kHz.

2. acoustic feedback between MS and LS. Cutoff Frequencies HP 20 Hz and LP 10 kHz.

3. acoustic feedback between ML and LS and between MS and LL. Cutoff Frequencies HP 20 Hz and LP 10 kHz.

4. acoustic feedback between ML and LL. Cutoff Frequencies HP 20 Hz and LP 2.5 kHz.

5. acoustic feedback between MS and LS. Cutoff Frequencies HP 20 Hz and LP 2.5 kHz.

6. acoustic feedback between ML and LS and between MS and LL. Cutoff Frequencies HP 20 Hz and LP 2.5 kHz[11].

7. acoustic feedback between ML and LL and between MS and LS. Cutoff Frequencies HP 20 Hz and LP 2.5 kHz[12].

8. acoustic feedback between ML and LL, between ML snd LS, between MS and LL, and between MS and LS. Cutoff Frequencies HP 20 Hz and LP 2.5 kHz[13].

9. acoustic feedback between ML and LL, between ML snd LS, between MS and LL, and between MS and LS. Cutoff Frequencies HP 20 Hz and LP 1.5 kHz[14].

10. acoustic feedback between ML and LL, between ML snd LS, between MS and LL, and between MS and LS. Cutoff Frequencies HP 20 Hz and LP 300 Hz[15].

6. Discussion

The method that is followed in this project consists of a combination of an analytical quantification of the acoustic properties of piezoelectric materials and qualitative experiments for evaluating the aeshetic and generative possibilities of these materials. The acoustic measurements have proven to be valuable for gaining an understanding of the diversity of the acoustic characteristics of these materials when being used as either microphones or loudspeakers and how these characteristics are affected by the shape and size of the materials. Even by using only two differently sized film sheets, a clear correlation could be identified between the acoustic properties, size and shape of these materials. The main insights gained are as follows: The size of the region on the piezoelectric film material that is used as loudspeaker affects not only the spectral range of the acoustic output but also the location of frequency peaks. This causes differently sized film sheets to possess a different acoustic characteristics. Bending of a piezoelectric film causes the frequency peaks in the loudspeaker output to almost always shift to higher frequencies. While shifting, the peaks occasionally change in width and amplitude. This change is dependent on the size of the film sheet and the amount of bending. The larger the region of a piezoelectric film sheet, the lower its sensitivity as a microphone. If both the microphone and loudspeaker reagions are located on the same film sheet and this sheet has a small size, then the peaks in the spectrum of the loudspeaker's output disappear when measured by a microphone region. This effect is not observed for larger film sheets.

These observations can be used as guiding principles for designing the sonic and interactive properties of a sound installation. This includes for instance the choice of size for film sheets in order to control the emission spectrum of a loudspeaker and/or the sensitivity of a microphone. And this also includes the choice of size when combining microphone and loudspeaker regions on the same film since this affects the strength of the acoustic effects of bending a film sheet and this in turn controls the level of interactivity that is provided through a direct manipulation of a film sheet's shape.

On the other hand, it is much more difficult to anticipate how the piezoelectric film sheets respond to and affect acoustic feedback. For this publication, the evaluation of the correlation between material properties and acoustic feedback

[11] audio recording 1
[12] audio recording 2
[13] audio recording 3
[14] audio recording 4
[15] audio recording 5

has been conducted in a qualitative and explorative manner only. To follow a similar systematic and quantative approach as was used for the characterisation of the acoustic properties of the piezoeelectric materials would require much more effort. For such an approach, the amplification effects of positive feedback pose a pa rticular challenge, in that slightest deviations in the measurement situation can lead to different results. Sources of such deviations are both internal to the setup of the film sheets (e.g. stiffness of the attachment of the film to a s upport structure or eveness of the curvature) or external to the setup (e.g. ambient temperature and humidity). This sensitivity to the conditions of measurement renders an exhaustive assessment of the factors that affect the sonic result of acoustic feedback very difficult. While such a level of unpredictability can be considered advantagous for realizing a generative installation, it also hampers the possibility to scale the setup in a somewhat planned manner beyond a s etting that includes only two piezoelectric film sheets.

7. Conclusion

Smart materials possess a great potential in the context of generative art. This project represents the author's first attempt at integrating such materials into a generative installation. The procedure that has been chosen is practical and tries to address as many steps as possible that are necessary for covering an entire creation process from the selection of materials to a final artwork. At the core of this procedure lies a combination that consists of a systematic and q uantitive assessement of the properties of the chosen smart material and an explorative and qualitative evaluation of the application of this material for realizing a generative artwork. The author is convinced that such a combination is crucial for gaining the skills to work with smart materials in a gene rative art context. This publication is the result of putting this claim to a practical test.

While the outcome of this test confirms the usefullness of the chosen approach, there remain several ceveats. These caveats have to do with the fact that the author has taken a few shortcuts in order to conduct the study in a m anageable amount of time. By working with piezoelectric films, a m aterial has been chosen that is unlike many other smart materials readily available through commercial channels and that is already known to be suitable for use as a loudspeaker. This has alleviated the need for studying in detail the physicochemical properties of the smart material, a type of research that would hardly be possible to conduct without expertise in material science. Also, the final installation must be considered a s omewhat minimalistic demonstration of what a smart-materials based generative sound installation could potentially look like. It can be assumed that some of the main challenges for integrating smart materials into a generative artwork are yet to be encountered when trying to reach a more sophisticated outcome.

Nevertheless, the author assumes that the insights gained from this project can be transferred for working with other smart materials even when aiming for a more ambitious artistic outcome. It is therefore hoped, that this publication contributes to a diversification of generative art practice to include also non-computer based current and future technologies.

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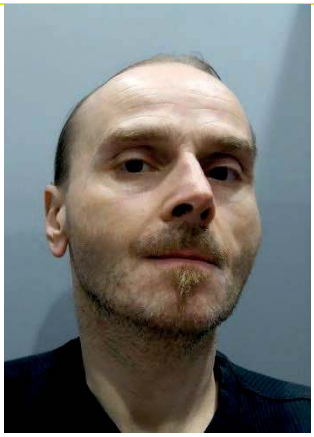
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STUDY 7/0: Error-Generated Spatiotemporal Animation

Paper

Topic: Art

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Abstract
Study 7/0 visualizes the positioning errors of a static GPS receiver. It is motivated by the idea of cognitive mapping as a configuration of individual, non-linear and discontinuous spatiotemporal experiences and their outcomes. We use technical flaws and/or imperfections as generators of the conceptual source material for further creative processing and expression, unlike glitch art which typically takes error as an aestheticised frontline layer. With *Study 7/0*, we explore the effective approaches to emergence in generative art, where a simple initial setup of a complex system can produce surprising phenomena [1].

Procedure
We secured a GPS receiver to a desk, powered it up, and let it run a draw track function for 7 days, 7 hours, 16 minutes and 11 seconds (from 7 July 2010 04:46:36PM to 15 July 00:02:47AM). While the ideal GPS plot for an immovable object is a single point, this setup had recorded 8438 positions on a 34.7km long path covering an area of 2.1km^2. The path is a consequence of the limited precision of a GPS receiver operating inside a building under changing weather, combined with the inaccuracy of GPS infrastructure.

Initial Rendering
We have originally rendered this path in combination with geopaths of the IP routes for the websites we had been accessing while the path had been generated in *Study* project (2010) for the *Rhizome of the City* exhibition which explored the artists' cognitive mapping through GPS and the Internet (Grba 2010).

2D Animation
Taking all the recorded time-stamps and 3D positions, we animated the horizontal locales (lon/lat). In the first animation we isolate the current 2.25% (780m) section of the path, revealing the error-generated dynamics. In the second one, we follow the current 2.25% building up a complete path. Each animation is about 4:41 minutes long and displays all the values from the dataset.
A granular synthesis sonification is based on the GPS dataset. It features a moving GPS pointer as a sound source, exploring the acoustic properties such as Doppler shifts and loudness variations according to the point's distance from a virtual microphone.
Project web page: http://dejangrba.org/art-projects/en/2018-study-7-0/index.html.

dejan.grba@gmail.com	***Key words:*** Animation, Cognitive Mapping, Error, Generative Art,, Geometry, GPS, Inaccuracy, Space, Time, Visualization. ***Main References:*** [1] Boyé, P, D. Grba, K. H.A. Kang, V. Todorović, and M. Pandilovski. “Machine Flaws in Generative Art.” In Juyong Park, Juhan Nam and Jin Wan Park, eds. *Lux Aeterna, ISEA2019 25th International Symposium on Electronic Art proceedings*, Gwangju, Republic of Korea, 2019: 713-716.

Study 7/0: Error-Generated Spatiotemporal Animation

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Abstract

Study 7/0 explores the positioning errors of a static GPS receiver in a series of generative procedures. It is motivated by the idea of cognitive mapping as a configuration of individual, non-linear and discontinuous spatiotemporal experiences, and their outcomes. We use technical flaws as a conceptual source material for further creative processing and expression. With *Study 7/0*, we also investigate the effective approaches to emergence in generative art, where a simple initial setup of a complex system can produce surprising phenomena. In this paper we focus on the initial animation based on the 2D waypoint data (longitude and latitude) and the timestamps recorded in the GPS Track Log path. Project web page: http://dejangrba.org/art-projects/en/2018-study-7-0/index.html.

Keywords: Animation, Cognitive Mapping, Data Visualization, Data Sonification, Error, Generative Art, Geometry, GPS, Inaccuracy, Visualization, VR.

1. Concept

Study 7/0 explores the positioning errors of a static GPS receiver in a series of media transcoding procedures. It is motivated by the idea of cognitive mapping as a configuration of individual, non-linear and discontinuous spatiotemporal experiences, and their outcomes. As a wayfinding framework, the GPS facilitates a layered set of interactions. observations, preferences, choices, decisions and compromises that constitute the contemporary way of life. Since the useful GPS routes are always defined by accessibility and environmental constraints such as geography, traffic, consumption and communication flows, the errors of that system point to the quirky and idiosyncratic misalignment between the subjective identity and the functional requirements of human infrastructures. In a broader symbolic sense, the individual navigation through and the adaptive correction of the systemic imperfections of complex infrastructures such as the GPS point to the notion that politics, before it becomes public, is always personal, intimate matter [1].

While the majority of new media artworks since 1998 have relied on the accuracy and reliability of the GPS for various forms of mapping, tracing and transcoding [2], in *Study 7/0* we focus on the imperfection as a logical counterpart and a criterion of the utility of the GPS or any other technical system. We use technical flaws as a conceptual source material for further generative processing and expression, unlike the conventional glitch art in which the error is an aestheticized frontline layer [3]. In a series of stages of this project, we also investigate the effective approaches to emergence in generative art, where a simple initial setup of a complex system can produce surprising phenomena [4,5].

2. The Initial Procedure

2.1 Generating the GPS Dataset

We secured a Garmin GPSmap 60Cx GPS receiver to a desk, powered it from the outlet, selected the Track Log function, and let it run for 7 days, 7 hours, 16 minutes and 11 seconds (from 7 July 2010 04:46:36PM to 15 July 00:02:47AM). Garmin GPSmap 60Cx is a handheld GPS navigation device, well regarded for its high sensitivity, accuracy, functionality, ruggedness and reliability. Track Log function starts as soon as the receiver gets a satellite location fix, and saves the time, location, elevation, distance and speed data about the waypoints which are automatically created according to the selected sampling method: time, distance or frequency.

For an immovable GPS receiver, the ideal Track Log is either a series of overlapping waypoints with the identical location and elevation, zero distance and speed plus a number of timestamps if the selected sampling method was time or frequency, or it is a single waypoint (location and elevation), with zero distance and speed plus a single timestamp if the selected sampling method was distance. However, our setup had recorded a Track Log of 8438 positions on a 34.7km long path covering an area of 2.1km^2, with an average speed of 0.2km/h and a maximum speed of 17.9km/h (Figures 1 and 2). This is a consequence of the limited precision of a GPS receiver operating inside a building under slightly changing weather, combined with the inaccuracy of GPS infrastructure [6].

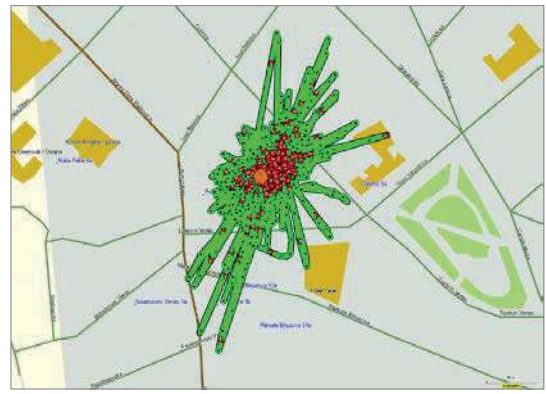


Figure 1. Horizontal projection of the Track Log path in MapSource software.

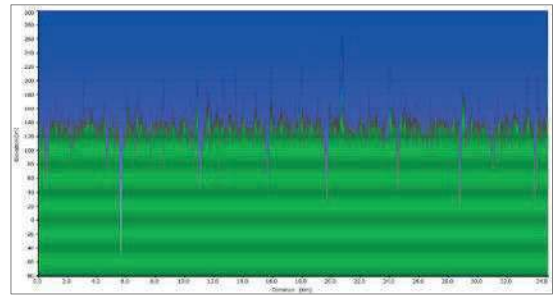


Figure 2. Elevation data of the Track Log path in MapSource software.

We have originally produced this dataset in the *Study* project (2010) for the *Rhizome of the City* exhibition in the Museum of Science and Technology in Belgrade, which explored the artists' cognitive mapping through GPS and the Internet. We combined the Track Log path (longitude, latitude and altitude) (Figure 3) with the geopaths of the IP routes for the

websites we had been browsing while the GPS receiver was running the Track Log [7].

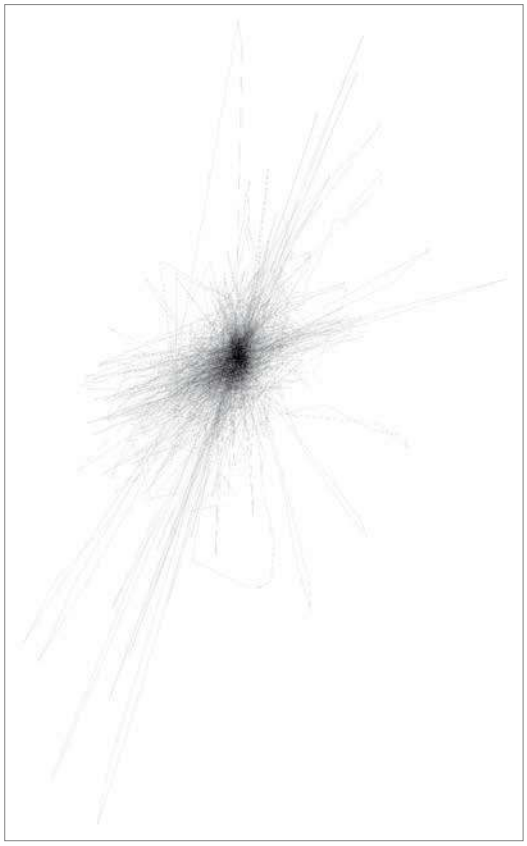


Figure 3. High resolution horizontal projection of the Track Log path.

2.2 2D Animation

The recorded Track Log is a complete spatiotemporal dataset consisting of spatial coordinates (longitude, latitude and altitude) and timestamps. When interpreted in its original sense—3D points interpolated over time—it implies movement. To make the 2D animation in *Study 7/0* we used the timestamps of the 2D waypoint data (longitude and latitude) to move a red dot along the horizontal projection of the Track Log path, speeding up the 630,971 seconds of the real-time record into 4 minutes and 41 seconds (281.233 seconds at 30fps).

We created two versions of the animation. In the first, we isolate the current 2.25% (780m) section of the whole path, revealing the intricate dynamics of error-generated virtual motion. In the second, we follow the current 2.25% building up the whole path. To contextualize the visuals, we display all the values from the dataset: longitude, latitude, altitude, distance, hop (time between the two waypoints), speed and heading at the bottom, and the recording date, time, duration and path length at the top of the frame. The animations are resolution independent, and are usually presented either as synchronized two-channel HD videos in parallel, or precomposed in parallel as a single channel UHD video (Figures 4 and 5).

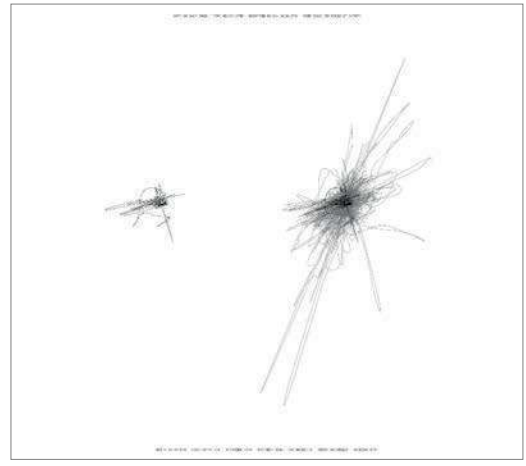


Figure 4. Frame from the parallel animation.

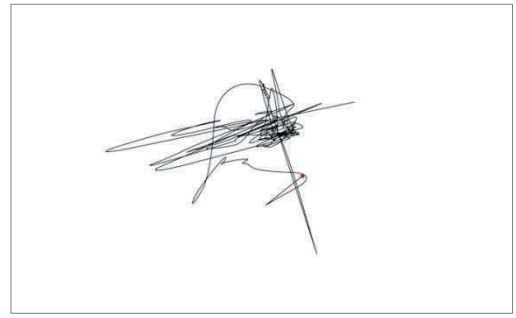


Figure 5. Detail of Figure 4 in UHD resolution.

2.3 Sonification

We consistently used the Track Log dataset as a generator for the sound material. An apparent way to turn such a dataset into sound would be the projection of the recorded GPS coordinates into a Euclidean space whose axes represent sound synthesis parameters such as, for instance, the frequency of an oscillator. However, we decided to follow the metaphor of movement in real space and to exploit the acoustic effects that result from it.

When a sound source or the listener moves about in space the distance between them changes. This change of relative distance produces Doppler effects and modifications of the volume because of distance-related damping. The Doppler effect refers to the change of the wave frequency due to a change of distance. If the distance between the source and the listener decreases, each sound wave takes less time to reach the listener. Hence, the sound waves are condensed, which results in an increase of frequency and the perception of a higher pitch. Conversely, if the distance increases, the sound waves are more spread out, the frequency is lowered, and a lower pitch is perceived. The distance-related damping of sound levels has two causes: the overall sound volume drops with the increase of the distance between the sound source and the listener, and there is an additional attenuation of high frequencies due to the energy loss of sound as it propagates through air.

We aimed to create a strong, yet only metaphorical analogy to these acoustic phenomena associated with the moving sound sources. We used delay lines whose variable delay times lead to shifts of the perceived pitch (the Doppler effect). We used low pass filters whose variable cutoff frequency recreates the effect of air absorption. However, we did not intend to establish authenticity by building a proper physical model. All these devices were applied freely as individual sound design components and scaled according to aesthetic considerations. The Track Log dataset was searched for the maximum deviation of the recorded waypoint from the actual geospatial location of the GPS receiver. This maximum distance defined a square with the actual geospatial location of the GPS receiver as its center. Four virtual sound sources were placed in each corner of this square, and the waypoint position data was used to control the movement of a virtual microphone (Figure 6).

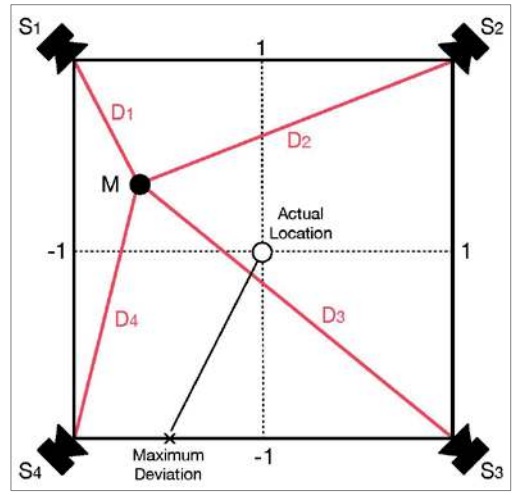


Figure 6. Four virtual sound sources (S1–S4) are placed in the corners of a square whose size is based on the maximum deviation. The waypoint position data control the position of the virtual microphone (M). The resulting distances (D1–D4) form the parameters for the sound processing.

In relation to the dimensions of the square, the coordinates of the microphone were normalized to the range [-1,1] and the distances between the microphone and the four virtual sound sources thus calculated. Subsequently, each signal was attenuated,

filtered and delayed based on the respective distance (Figure 7).

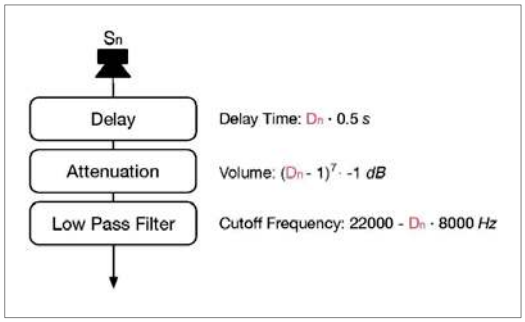


Figure 7. Signal flow for each of the four sound sources.

The sound material consists of band-limited pulse trains with the frequencies 3, 5, 7 and 11 Hz. This superimposition of prime number frequencies yields a compact rhythmical texture. In the course of the piece, the four pulse trains become slightly faster, which creates a s low but steady increase in density. This compensates for the listeners' gradual habituation to the quality of the sound and is in line with the visual accumulation and increasing jaggedness of the animated path. The signals were further processed in order to enhance the sound. First, a high pass filter was applied to render the sound less booming. Second, the sound signals were distributed among the two channels, as if the virtual microphone was a stereo microphone. And third, a v ery discreet reverberation was added.

3. Further Development: Interactive VR Animation

The interrelated generative parameters recorded in the Track Log dataset allow different types of visualization, animation, sonification and presentation. We are developing an interactive animation using the three-dimensional spatial data (longitude, latitude and al titude) and the timestamps. This major iteration features an exploratory VR interface which initially puts the viewer in the subjective position of the erroneous GPS waypoint, and enables them to navigate the experience by changing the viewing angle, position and lighting parameters.

3.1 Structure

We will extrude a circle along the GPS path into a NURBS (Non-Uniform Rational Basis Spline) tunnel. Since the first and the last waypoint in the Track Log dataset have different relative positions (because neither the initial nor the final GPS waypoints matched the actual location of the GPS receiver), they will be joined so the tunnel will be closed to allow the looped animation.

3.2 Texturing and Lighting

The inner surface of the tunnel walls will be textured with a high reflexivity material (mirror), while retaining a certain degree of one-way transparency from the outside. The tunnel object will be illuminated from a rig of external light sources whose RGB color components are driven by the three spatial dimensions of the current viewpoint: back-front, left-right, down-up, within a range normalized to the extremes of the whole dataset. This texturing and l ighting system applied to the serpentine tunnel structure which often intersects with other segments of itself will produce a r ich and complex visual dynamic referring to the idea of an env ironment that challenges its own material reality [8].

3.3 Camera

The forward-looking point camera will be animated along the GPS path (central axis of the 3D tunnel) in a subjective point of view, following the speed and acceleration

dynamics of the error-generated data. The tunnel-travelling subjective camera provides a logical and most effective although not the most descriptive/explanatory point of view. It was inspired by Peter Kogler's *Untitled (Ohne Titel)* (1993), and Gerhard Mantz's *Nirmala* (2013) [9,10].

3.4 Sonification

The sound synthesis algorithms will follow the metaphor of movement in real space, with the altitude as a specific acoustic parameter interacting with the chromatic values registered by the point camera.

3.5 VR Interface

The forward-looking camera angle will be a default, initially putting the viewer in the subjective position of the erroneous GPS waypoint. Ten seconds after each viewer enters the animation, the VR interface will allow them to navigate the experience. They will be able to reverse the viewing angle from looking forward to looking backward, change the angle arbitrarily, or step out of the tunnel and observe the red dot which will then represent the camera traveling along the complex 3D structure. They will also be able to alter the color space parameters of the lighting rig from RGB to HSB or LAB directly affecting the visual character of the tunnel viewed from the inside, and the look of the tunnel structure viewed from the outside.

3.6 Tuning the Experience

All key formal parameters in this design—such as the animation cycle time (speed), the degree of reflexivity and the one-way external transparency of the tunnel material, lighting rig configuration and lighting types—will be tuned for the most effective VR experience by experimenting in the studio, and by testing with various viewers. The aim is to create the setting with the optimal degree of ambivalence between disorientation and kinesthetic stability/confidence.

3.7 Continuity and Presentation

This design emphasizes the perceptual (visual, sonic and kinesthetic) complexity emerging from the GPS imprecision, so the narrative progression is not essential, and it is not required in principle by the concept and technical premise of the project. Rather, a continuous immersive animation will establish a strong impression of travelling in a short period of time (between 3 and 7 seconds), and will allow the viewer to enjoy the experience according to their individual preferences.

The project will be configured for the gallery exhibition with several VR sets and their corresponding video projections.

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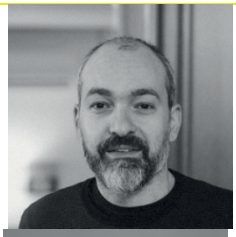
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High Resolution Architecture: Ornament as a Generative Force
(Paper)

Topic: Architecture, Design

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Abstract
The rapid progress and development of information technologies that occurred during the last decades led to our current condition where it is ultimately possible to collect, store and process previously inconceivable amounts of data. The new scientific framework that is inevitably formed – described by the somewhat ambiguous term 'Big Data' – is combined with the ever-increasing computational power and the emergence of fabrication technologies such as 3d printing. That leads to a new understanding of architecture and its formation where large amounts of detail – which we are now able to control – appear as an opportunity for investigations towards new forms of expression and are defined by new architectural vocabularies.
In that context, the concept of resolution emerges as a factor that can affect and alter our understanding of the architectural creation. Specifically, the notion of high resolution – in other words our ability to control an increased density of morphological information – appears to be leading architecture into a n ew direction and to a – seemingly previously unexplored – aesthetic that reflects exactly this abundance of data that defines our era.
With the ability to handle an unprecedented amount of detail along with the use of ever-evolving digital methods and technologies of design and fabrication, structures that previously seemed inconceivable are now designed and manufactured. Structures with levels of detail and information that often go beyond what the human mind can capture and manage.
However, as is always the case with every new breakthrough in architectural design, we initially lack the necessary tools that will aid us to form the criteria with which to evaluate the produced results. In order to do so, the proposed paper starts from the hypothesis that high-resolution is not necessarily a completely new condition for architecture. On the contrary, the paper argues that many of the properties of what we are currently calling 'high resolution design' can be found in several instances of architecture's history, and therefore by studying those instances we can better understand and evaluate our current situation. In other words, the paper proposes that there have been conditions in the history of architecture that resemble the characteristics brought forward by high resolution.
Ornament is such a c ondition: it has always been a feature of high spatial density of information, which, before the advent of digital design and fabrication methods, was exclusively managed by humans. We can, for instance, think of the wealth of information that incorporates a sculptural facade of a Gothic-era cathedral. The ability of human to manually

manage this plethora of details related to ornament made the latter an important design feature, which ultimately led to an increase in the resolution of each architectural project in general.
The paper, therefore, turns to the past and identifies architectural examples from different historical periods that negotiate the issue of ornament, seeking in them traces of increased resolution and its management. Through the examination of those historical case studies, we can inform our current practices and set them into perspective. Ultimately, understanding high resolution through a historical lens will help us define new architectural practices that are not mere formal pyrotechnics but are instead forming a new generative architecture within the current social, political and cultural framework.

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Key words: Big Data, information, high resolution, ornament

High Resolution Architecture: Ornament as a Generative Force

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A new condition: Resolution

The rapid progress and development of information technologies that took place during the last twenty years, led to the condition that we are facing today, where it is ultimately possible to collect, store and process previously inconceivable amounts of data. The new scientific framework that is inevitably formed – described by the somewhat ambiguous term 'Big Data' – has radically transformed every field of the current societies, including of course architecture [1]. Indeed, the new condition that is codified under the term Big Data – which in short "*refers to data sets whose size is beyond the ability of typical database software tools to capture, store, manage and analyze*" [2] – has created a large array of reactions, most of them negative. However, while social scientist and political activists raise worried voices in relation to personal freedoms, private data and a more and more dystopic picture of the world where everything is recorded and stored, architects seem to look at those developments in a more optimistic way.
In architecture therefore, the above framework in combination with the ever-increasing computational power and the emergence of fabrication technologies such as 3d printing, leads to a new understanding of architecture and its formation where large amounts of detail – which we are now able to control – appear as an opportunity for investigations towards new forms of expression and are defined by new architectural vocabularies. In this context, a new concept emerges as a notion able to aid us to understand and describe the current phenomena: the concept of *resolution* as a factor that can affect and alter our understanding of the architectural creation. Resolution of course is a concept of a much larger scope; however when we focus on an

architectural context we notice that there are already in place several attempts to appropriate the concept and define the framework that describes it. For example, in the work of Michael Hansmeyer and Benjamin Dillenburger the term resolution refers to "*the spatial density of information inherent in a building"* [3]. In a direct relationship to its two dimensional counterpart that can be found in the term image resolution, in three dimensions resolution refers also to the amount of information that is or that can be embedded in a particular region (in a volume, a structure, etc.). Pixels are replaced by voxels and spatial information is stored in a continuously increasing three- dimensional grid. Specifically, the notion of 'high resolution' – in other words our ability to control an increased density of morphological information – appears to be leading architecture into a new direction and to a – seemingly previously unexplored – aesthetic that reflects exactly this abundance of data that defines our era. With the ability to handle an unprecedented amount of detail along with the use of ever- evolving digital methods and technologies of design and fabrication, structures that previously seemed inconceivable are now designed and manufactured. Structures with high resolution as an inherent characteristic, with levels of detail and information that often go beyond what the human mind alone can capture and manage.

The above described approach is based on two fundamental assumptions: The first is that the concept of high resolution is a 'digital concept'; as something facilitated by digital tools it has to abide to a digital way of thinking. The second is that the introduction of high resolution is bringing forward a novice and previously unseen process that can be understood as a 'paradigm shift' [3]. It would appear however, that both assumptions could be misleading.

Digital vs Analog

It is understandable that since digital computers are facilitating high resolution one could think of the later as a digital concept. After all, it is only through digital means that we became able to harness such amounts of data and consequently design in high resolution. Even more importantly, it is through digital fabrication, and more specifically through 3d printing, that we are able to fabricate objects of high density of detail. Therefore 'digital' is always part of the description when it comes to the relationship of architecture and design to high resolution. However, using digital tools does not require necessary a digital way of thinking. On the contrary, a closer look would reveal that resolution is never a question of size, therefore it cannot be numerical or digital. In fact resolution is always and by definition a relationship between two sizes: it can be for example pixels per inch as it is in the case of digital images. It never refers to just one size: it represents the relationship between two sizes and more specifically the density of one into another expressed as a fraction. Therefore resolution is always a *logos*. Within a digital computer, resolution relates a digital, discreet unit with a physical size. It is the logos of information units per size, therefore it is a pure analog concept, despite being implemented through digital means. The analog nature of resolution – and therefore of 'high resolution' too – has several implications. Continuity is one of them (as opposed to the concept of discreetness that is employed recently by several architects). On a second level it implies a relational concept that can therefore never take an absolute value.

Shift vs Re-iteration

The speed that defines the ways in which digital tools are developed and upgraded often impose the idea that they bring with them a fundamentally new way of understanding or doing something. Similarly being able to manipulate extremes levels of geometrical detail in design and architecture could impose a sense of a paradigm shift. A change brought forward by the new concept and the tools and technologies that support it, which would alter architecture itself and will create a new condition. However, a more historical approach could be enlightening by revealing previous approaches to architecture and design that incorporate some of the principles that appear fundamentally novice when examined without a greater historical context. In other words, we could perhaps identify historical architectural examples where properties similar to that of high resolution emerge, and therefore build a case that supports an understanding of continuity and re-iteration of concepts and ideas rather that one of rapture and 'shifts'.

In order to formulate our research and identify the examples that would be the most useful, we have to turn our attention to another concept that was always related to the codification of information in architecture: *ornament*. Indeed, ornament could potentially be identified as a condition that resembles the characteristics brought forward by high resolution: it has always been a feature of high spatial density of information, which, before the advent of digital design and fabrication methods, was exclusively managed by humans. The ability and effort to manually manage this plethora of details related to ornament, made the latter a generative element in architectural creation and an important design feature, which ultimately led to an increase in the resolution of each architectural project in general. Thus, the paper turns to the past and identifies architectural examples from different historical periods that negotiate the issue of ornament, seeking in them traces of the concept of increased resolution, its creation and management.

Gothic architecture

One of the most impressive features of the Gothic style is the combination of architecture and sculpture. The significant and intense presence of ornament is immediately apparent by observing the characteristic cathedrals of High Gothic architecture of the 13th century, such as the Cathédrale Notre-Dame de Reims, in northern France.

Both in exterior and interior, the various parts of the building are highlighted with a particularly intense emphasis on sculptural ornament [4]. And it is precisely this feature where the concept of increased resolution is found: in the multiple facets and innumerable formations created by the sculptural management of stone. At every part and element, the material, a kind of local limestone, has been skillfully carved and shaped, incorporating, more or less, an increased amount of information and enhancing the overall density of morphological details. Indeed, in many cases the scale and the plethora of details of the ornament are on such a high level that it seems impossible to immediately perceive all of its features. An increased number of elements with intense three dimensionality, such as carved figures – full or bas-relief –, foliage and naturalistic ornament, etc. Even the sculptural treatment of the multitude of components in the interior, such as the ribs, form a unified and complex condition of high resolution.

According to the principles of the

architectural style of this period, ornament is not an independent element, but rather serves to complement and complete the architectural expression [5,6]. Under this light, the increased resolution, achieved with the use of ornamental features, appears mainly as an inherent feature of the structure, reminiscent of the condition of the current digital age, where the vast amount of morphological information is an innate element. Thus, even elements that can be considered as additional information - for example, the carved figures that are created in a single volume of stone that accommodates also the building parts - could be perceived more as integral parts of a single whole, rather than as superficial add-ons. Throughout the history of architecture, while this increased morphological detail was associated exclusively with manual labor, the creators had been led to seek and develop suitable modes of management, creation and construction, as well as the use of materials with appropriate properties. Using metal tools, mainly various types of chisels, they were able to form the limestone, a sedimentary type of stone, with medium hardness and easy to be carved, producing this way highly detailed reliefs. Stone-carvers and sculptors of this era had developed and mastered modes of stone carving, as well as a high level of skill, both in the conception of composition and form, and in the manual skills to create them, that in Reims achieved some of "*the most thrilling extremes of which stone was capable*"[7].

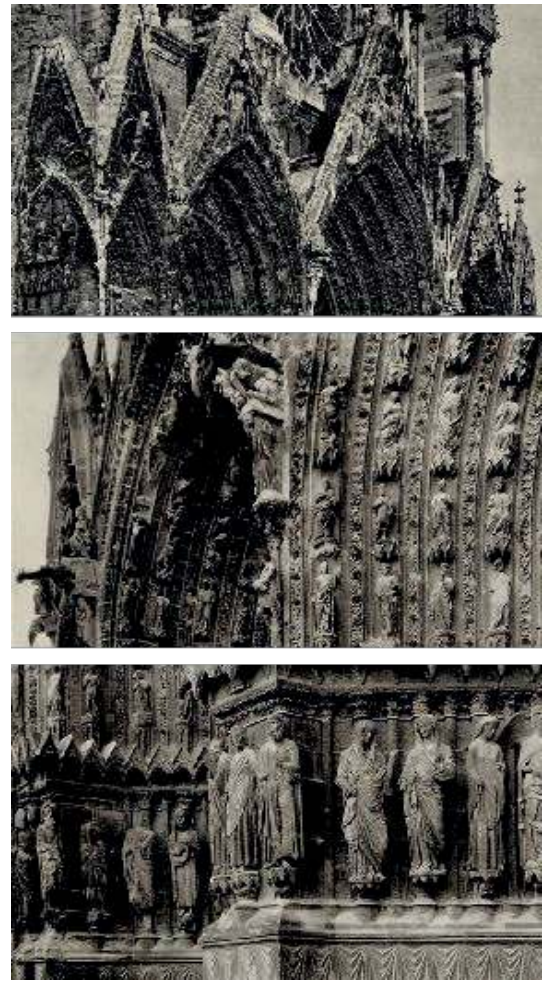


Figure 1: M. Hürlimann, Reims Cathedral,

1937 (source: [12])

Louis Sullivan

One of Sullivan's major contributions to architecture is the unique ornamental system he had developed. One of his most important high-rise office buildings, the Guaranty Building, designed and built in the late 19th century in downtown Buffalo, New York, expresses precisely the essential role that ornament played in his work. The building is a metal structure, the facades of which are covered by

surfaces with intricate and rich geometric and foliage patterns and shapes. These ornamental facades then, with the multiple relief elements that increase the density of morphological information through their innumerable formations , is the point that the paper focuses on in the search for the concept of increased resolution. In his book *A System of Architectural Ornament: According with a Philosophy of Man's Powers*, Sullivan described the design methodology for creating the intricat e o rnamental features of his buildings. The process began with a simple geometric shape, which through a series of design actions resulted in a highly detailed foliage form. In short: some axes of the initial form were the

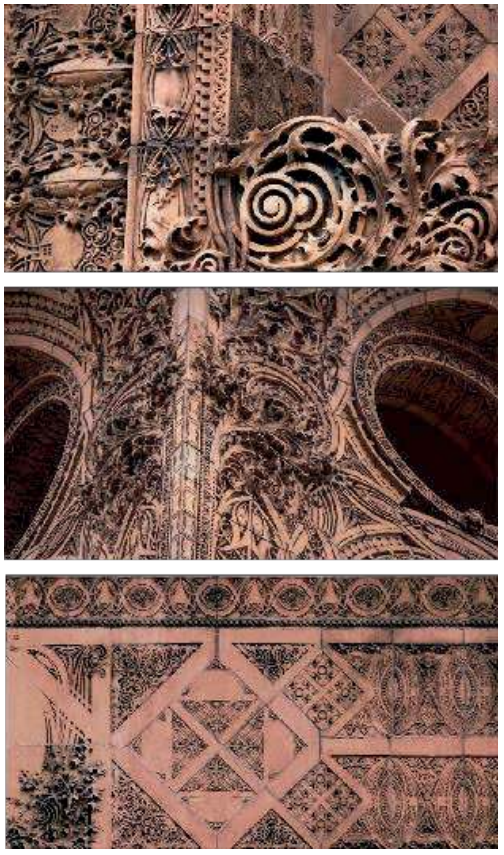
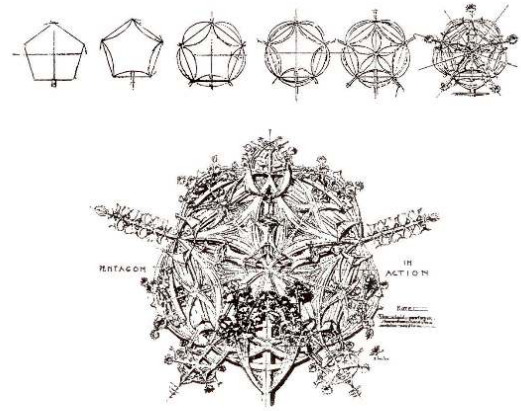


Figure 2: E. J. Nordstrom, Louis Sullivan's Guaranty Building: A photographic study of its terra cotta ornament, 2019 (source: www.urbanremainschicago.com)

guides for developing a s eries of manipulations based on the innate geometry of the shape. The resulting grid was the basis along which a system of abstract plant forms was developed. This growth or 'efflorescence', as Sullivan called it, of these forms, according to the rules of nature, led to a very intricate foliage outcome [8,9]. Today, the use of computational methods has as a result the emergence of a variety of techniques that can lead from a ge ometric shape to high resolution outcomes. A typical example is the logic of subdivisions: through innumerable subdivisions of an or iginal shape, it is possible for a structure with infinite individual formations to be formed. It could be said that Sullivan had devised and developed, using paper and graphite, such a technic of his own.

Figure 3: Figure-: L. H. Sullivan, The Awakening of the Pentagon, 1924 (source: [9])



These intricate designs were firstly translated into clay molds, which were then used to form the elaborate individual relief ornamental pieces that constitute the facade of the building. All parts are made

of terra-cotta, a ductile type of clay, which can be formed into a variety of complex shapes and designs. Of course, the repeated use of molds made possible to produce the countless ornamental pieces of the building, which is the reason why many elements appear identical. Undoubtedly - not only in this example, but in architectural practice in general - the creation of multiple morphological features through manual processing was a time consuming but also a costly process. The application of molds for multiple repetitions of patterns and elements had greatly contributed to limiting the above. However, repletion through molding could have an additional interpretation. Using molds is a method that helps reduce and limit the amount of information, making it more accessible and manageable by the human factor. This technique, which results in repeated information, had often seemed necessary in the past to achieve a wealth of morphological detail. In the current condition, the use of the machine in the design and construction process makes such methods superfluous, as it can handle any amount of data without the need for simplifications or reductions.

Carlo Scarpa

As a last case, the paper focuses on Carlo Scarpa's work, which is generally characterized by an elaborate design of all the components and an insistence on the details - mostly ornamental. In these details is where the concept of high resolution lies. The ability to design and manage the multiple ornamental elements found throughout his works, enhance the information embedded in them, ultimately serving as a process for enhancing their resolution in general.

Figure 5: Details of molding in the Brion cemetery (sources: above [13] – below [11])



Figure 4: Detail of the façade of the Banca Popolare, Verona (source: www.archipicture.eu)

The forms and shapes of these ornamental elements that contribute to the increase in morphological information of the structures in Scarpa's works vary and occur at various and multiple scales. They have mostly to do with the creation of the various elements and materials, with their formulation, combination and composition. The peculiar formation of each material is, for instance, one of these elements. In Tomba Brion, in particular, the ornamental

management of building material is the most characteristic feature of the project. Using molds, the concrete is shaped into many parts in a 'ziggurat' motif. This geometry is a c haracteristic pattern of Scarpa's work, which is found, always enhancing the amount of morphological detail, on various scales, but also on additional works, such as the facade of the Banca Popolare in the city of Verona, this time elaborately carved in marble.



Figure 6: Detail of the paving in the entrance hall of the Querini Stampalia Foundation, Venice (source: [11])



Figure 7: Detail of the external revetment of the sacellum in the Castelvecchio Museum, Verona (source: [11])



Figure 8: *Detail of the wall cladding in the Querini Stampalia Foundation, Venice(source: www.archipicture.eu)*

Today, the emergence of the concept of resolution is directly linked to the perception of the architectural form as a synthesis of multiple individual elements, fragments or particles [3]. In a s ense, a similar logic applied to Scarpa's design concept: "*an architectural whole is seen as a phenomenon composed by details*" [10]. Each of these details – shaped as a unique element [11] - is not just a secondary processing, but one of the multiple elements that 'articulate' each structure, ultimately producing forms with increased morphological information. This concept is strongly reflected in the creation of surfaces, such as walls, floors, etc. The use and skillful synthesis of various materials is another element that contributes to the process of increasing morphological information. Such surfaces, which consist of a combination of multiple elements like stone, marble, wood, metal, glass, and could therefore be characterized as high resolution, are innumerable in his

works. Representative examples are the exterior lining of the 'sacellum' at the *Museo di Castelvecchio* with its intricate stone and m arble pattern, the mosaic on the floor at the entrance of the *Fondazione Querini Stampalia*, with its various marble tiles, the formation of walls at the same project with the combination

of pieces of travertine, brass and glass, etc.
Finally, it is worth pointing out that this plethora of details, developed through a sequence of actions - from Scarpa's inspiration, invention and design to, ultimately, the construction by experienced craftsmen - were not merely an ornamental condition, but they had strongly component role. This fact makes increased resolution an inherent feature of the whole synthesis and, somehow, an integral feature of the structure and of the design process.

Conclusion

As is always the case with every new breakthrough in architectural design, especially since the beginnings of the digital age, the initial stages of the process most often than not lack the necessary tools that will aid us to form the criteria with which to evaluate the produced results. Thus, we are often led to view them as completely new and revolutionary conditions, as 'shifts' in the way we think about and pr actice architecture.
Here we propose a different way to 'read' such conditions. One that is not based on 'shifts' and therefore is not based on negations – in effect one that is not dialectical in nature. Instead we propose an understanding based on continuity, affirmation and constant modulation of concepts, ideas and processes. Continuity because older things don't break in order to be r eplaced by new ones but they rather the former ones are transcribed into the later ones. Affirmation because such a process has to be based on the acceptance of one condition in order to transform it into something new. And modulation because precisely there are always transformations that take place: it is not about repeating the past but instead about constantly altering into something else. In essence, it is about an analog way of thinking as opposed to a di gital one: Despite the digital nature of our tools – in fact in some cases it is exactly because of that – we can support an analog, continuous way of thinking and acting that keeps transcending the past into new directions.
To conclude, through our reference to the past and the examination of historical case studies, we can inform our current practices and set them into perspective. Ultimately, understanding current, emerging conditions and concepts, such as 'high resolution', through a historical lens, will help us define new architectural practices that are not mere formal pyrotechnics, but are instead forming a new generative architecture within the current social, political and cultural framework. High resolution architecture, when understood as an analog concept that re-iterates the concept of ornament can become generative and lead towards new design directions.

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Numbering*, where trees *move

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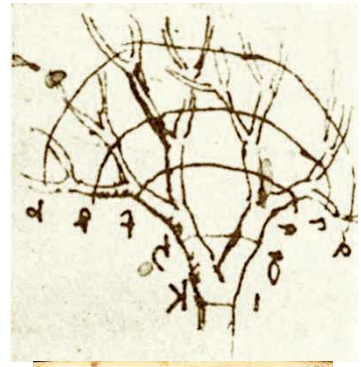
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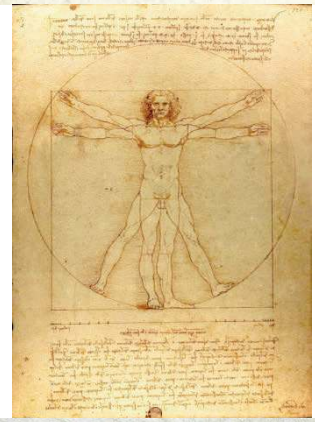
Listen. It is night moving in the streets, the processional
salt slow musical wind in Coronation Street and Cockle Row,
it is the grass growing on Llaregyb Hill, dewfall, Star fall,
the sleep of birds in Milk Wood
Dylan Thomas, Under the Milk Wood [1]

This paper is an investigation about the ancient tradition connected to the deep relationship between the tree and the human beings. It works as a double structure between the alive world of the unveiling silence of nature and the human mind and heart, able to perform ***a commune language*** mirrored in art, poetry, and music, *time after time*, from oral tradition until our digital time.
A generative process of discovering visionary sounds and designing algorithms can produce endless variations as a deep *liquid mirror* from the natural sites eared in the deepness of the human feeling

1- Aim

Main aim of this paper is discovering historical artworks around Nature rules for complex generative art processes. Leonardo was a unique experimental visionary artist. Each his artwork is a representation of a complex science *abducted* by his nature observation. Inside them, we discover a *compendium* of science that he observed experimenting in a continuum auto learning fixed in his artworks







[2]-Leonardo da V inci, Study of the proportional growth of the branches of a tree
[3] Leonardo, L'Uomo di Vitruvio: *"Tanto apre l'omo ne' le braccia quanto è la sua altezza" As man can open his arms as his heightnon.*
[4] Leonardo da V inci, Allegory of the Wolf and the Eagle

AS *NATURAL* INFINITE

Leonardo defined philosophy as *"images of mental talk"* by drawing a deep parallelism between Nature and Reason. Luca Pacioli suggested Leonardo to read the V book by Euclide. This was a basic point that he ex tended with genial intuition, by using proportions also in time, space, sounds, weights, sites etc. By this scientific investigation he discovered "… *varie e strane forme fatte dalla artificiosa Natura*…" (…variant strange shapes made by Artificial Nature..), that he fixed in sketches, used later as *codes* in his works.
His scripts edited only in 1881 were pressed as a simple first draft on a wax table in only one p assage, by using a Roman technique. These were written all in a *reverse* way. It is possible to read them only in front of a mirror, for emerging a similarity between natural process and interpreted reality.

Tree in poetry numbering

"Our life away from public haunt, finds tongue in trees....."
William Shakespeare, As You Like It

Numbering is the site where trees move for generating *tongue,* full of all human impressions from the *trans-dreamed* real Nature world. This paper tries to focus an actual transfiguration in our digital time of the ancient process of discovering a ***similarity*** between the natural world and the art process.

Numbering, where trees move /
Numerando, dove si muovono gli alberi

Chi si fa piccolo come un bambino
sarà il più grande nel regno dei cieli.
Who becomes small as a child
He will be the greatest in the kingdom of heaven

When trees move, sounds deeply static brighten./Quando gli alberi si muovono, i suoni profondamente statici si illuminano.
The movement of trees from their more hidden roots/Il movimento degli alberi dalle loro radici più nascoste
Until their highest leaf toward the sky lightness/Fino alla loro foglia più alta verso la luminosità del cielo
Becomes like the first step of an unstable child/ Diventa come il primo passo di un bambino instabile
Left for the first time alone from tender helping hands, / Lasciato per la prima volta solo dall'aiuto di tenere mani
For discovering the wonderful human ability in crossing space/time;/ Per scoprire la meravigliosa abilità umana nell'attraversare lo spazio/tempo;
As a similarity between human legs and woody trunks of strong cortex/ Come una somiglianza tra gambe umane e tronchi legnosi di forte corteccia
A skin oblique for roundness in its slow moving generates color permutations,/ Una pelle obliqua per rotondità nel suo movimento lento genera permutazioni di colore,
For following the rays of the sun together with the lunar splendor./ Per seguire i raggi del sole sino allo splendore lunare.
Alternate continuous faces in the flow of life/ Volti continui alternativi nel flusso della vita,
Small steps in the silence of the transmuting night perform./Formano piccoli passi nel silenzio della notte trasmutante.
Sunlight expands fast in the eternal new

day of life./ La luce del sole si espande veloce nell'eterno nuovo giorno della vita.
…*"Where are you going said reader to rider…"*
I stay firm listening, waiting for the new light of the day./ Sono ferma in ascolto, aspettando la nuova luce del giorno.
Fixed with the tarantula in my heart, I wait for seeing the tree moving/ Fissa con la tarantola nel cuore, aspetto di veder il muoversi del l'albero
Like in a fable, where truth mixes with the mystery of life, / Come in una favola, dove la verità si mescola al mistero della vita,
Silent and multiform, generating infinite variations following a music at time/ Silenziosa e multiforme generando variazioni infinite che seguono una musica a tempo
A transforming site from where we come and where we will stop passing the baton. / Da un luogo in trasformazione da dove veniamo e verso dove ci fermeremo passando il testimone.
Memorie di un passato sospeso, che solo la natura ci racconta con canto indelebile anche se spezzato dalla umana vanità / Memories of a suspended past, which only nature tells us with indelible song even if broken by human vanity.
For a silent, just about impalpable caress / Per una carezza silenziosa, quasi impalpabile
The tree moves slowly on the river bank / L'albero si muove lentamente sulla sponda del fiume
Following the rhythm of the flow of water like an ancient song/ Seguendo il ritmo dello scorrere dell'acqua come un canto antico
Always the same where only varies the flexibility of the decidous caducus, like a branch off a tree/ Sempre uguale dove varia solo la flessibilità del caduco, fragile come un ramo spezzato da un albero
As irreversible uniqueness of life. / Come unicità irreversibile della vita.
A fragile air moves the leaves in the dark/ Un'aria fragile smuove le foglie nel buio
Following the song, that dictates the natural rhythm/ Seguendo il canto che detta il ritmo naturale
Until in the smallest parts of the live. / Sin nelle più piccole parti del vivo.
The sound movement connects the parts of the living/ Il movimento sonoro connette le parti dei vivi
With the past as a single timeless flow. / Col passato come un unico flusso senza tempo.
The light returns on the darkness of the night. / Torna la luce sul buio della notte.
A new and unique unrepeatable day/ Un nuovo giorno unico ed irripetibile
In the continuous ancient flow of life. / Nel flusso antico continuo della vita.

Numbering, a *longanimous* structure for a complex GA process

Longanimous is an at tribute for the time that changes, while remaining the same in its structure.
Structure configures itself adapting its identical past toward a f uture in possible evolution
The true progress happens through its internal development.
Change, on the other hand, occurs when one doctrine transforms itself into another.
It is therefore necessary that, as the times progress, the understanding, the science and the wisdom of the individual as well as of everyone grow and progress as much as possible.
The wisdom of souls follows the same law that regulates the life of bodies. These in fact, although growing and developing over the years, remain the same as before.
Certainly, a gr eat deal of difference between the flower of young age and the harvest of oldness runs, but these belong to the same teenagers as once those that become old. The age and the condition are therefore changed, but it is always the same individual. Nature is unique and identical; the person is unique and
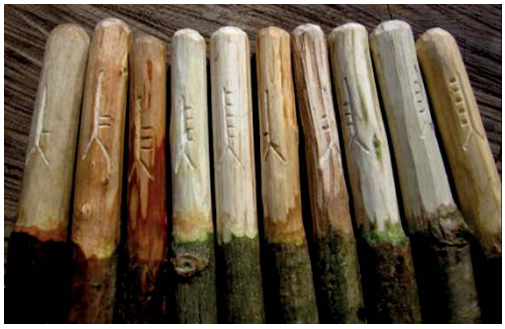
identical.
The infant's limbs are small, larger than those of the young are, but they are the same. The limbs of the adult man no longer have the proportions of those of the child.
However, those that exist at a more mature age already existed, as everyone knows, in the *embryo*, so that as regards parts of the body. Nothing new adults can gain that has
not already been present in children, even if in an embryonic state.
There is no doubt about it. This is the true and authentic law of organic progress.
This is the wonderful order placed by nature for all growth
The not linear complexity of this order works by *numbering* structures.
Montaigne described this process in one of his artwork: *"Thoughts"*:
"My ego of to-day and my ego of tomorrow are certainly two"

Tree numbering as a language

A written language that speaks of trees: the *Ogamic* Alphabet by Druids [5]
One of the most important expressions of a civilization's culture is the type of writing it uses to shape its *oral* language.
The Old Irish was written in a completely peculiar alphabet that is traced back to the Druids, and was probably invented by them only in the late period, when their cult was declining. The Druids, in fact, did not trust the written word, and passed on their knowledge only orally.
For the Druid civilization the connection with nature was lived in a much more visceral and complete way than it is for us today. Among all the essences of the plant world were the trees to be held in greater consideration, so much so that we saw how also the Celtic calendar was based on some trees considered of particular relevance.
The writing invented by the Druids works on the so-called *Ogamic* Alphabet and is inspired by trees. In fact, it was read not from left to right, like ours, nor from right to left, but ***from the bottom upwards***, because this is the direction in which the trees grow.
It was also written on pieces of wood, and this is the reason why we have so few testimonies. The few remains that remained are those carved on stone.



The *Ogamic* alphabet owes its name to the god Ogma, a deity that we can roughly associate with Mars and that was part of the Celtic pantheon. According to another curious legend, it was invented by the Shiite king Fenius Farsa after the destruction of the Tower of Babel, and ***elected as an expression of the best existing language***.
In short, we can consider the *ogamic* language a sort of "Esperanto".
The letters of the ogamic alphabet are twenty and are called "*feda*", a term that means ***"tree***".
They are divided into four *"aicme*" (families) each of five letters. The letters are very simple:
they are formed by *a vertical line* and five differently oriented signs:
upwards, downwards, perpendicularly, to the right or left of the central axis.
It is thought that these signs also expressed a sort of "***silent alphabet"*** that could be expressed ***by moving and touching the fingers of the hand.***



Here are the twenty faiths, divided into *aicme*:
First *aicme*: B beith (birch); L luis (sorb); F fearn (alder); S saille (willow); N nuin (ash)
Second *aicme*: H úath (hawthorn); D duir (oak); T tinne (holly); C coll (hazel); Q ceirt (wild apple)
Third *aicme*: M muin (vine); G gort (ivy); NG gétal (rush); Z straif (blackthorn); R ruis (elderberry)
Quarta *aicme*: A ailm (silver fir); O onn (gorse); U úr (erica); E edad (white poplar); I idad (rate)
Each letter was pregnant with symbolic and esoteric meanings that transcended mere transcription: each letter, each ogham had ***the power that derived from the tree from which it took its name***.

2. ***Numbering*** as a *unifying* principle [6]

In the archaic universe, all things were signs and signatures of each other for them interpretation with subtlety and overall *the number* dominated.
Two great interpreters and inventors of the ancient world were Kepler with his tireless calculations and his passionate devotion to the dream of discovering the "*Harmony of the spheres*", as a follower of the ancient order. His dream led him to prefigure the polyphony that was to lead to Bach. The second] was Isaac Newton, the initiator of the strictly scientific vision.

The mountain[7]

Nature as discovering of the ***time fragment*** in the number variations



Paul Cézanne, views of the Montagne Sainte-Victoire painted between 1882 and 1906

"If equal affection cannot be, let the more loving one be me."
W. H. Auden, "The More Loving One

Virgilio:[8]
The tree cries, sighs, and moans with a human voice ... it is believed to be the wind: but often they are also their internal circulation ... the disturbances of their sap, the dreams of their plant soul.
The ancient world has never doubted that the tree had a soul-confused, perhaps obscure, but a soul, as well as any other animated being. Humanity believed it for ten thousand years, before the school age that petrified nature. Today science teaches us exactly the opposite, getting very close to ancient beliefs. Every being, it tells us, even the most primitive, embodies the travail, the effort, a certain feeling of having to assure and increase one's existence, as well as the possibility of choice (the word is Darwin's) and of the use sometimes very skilful of the tools that lead to this result. Each has the particular art to exist, grow and unceasingly recreate itself.

THE SHADOW

"At the still point, there the dance is."
T. S. Eliot, "Four Quartets"

Dialog between Sapientia and Armonia

Armonia thunders from the high of the valley:
“Code is violated, duplicated, hybrid triplicated, without any borders.
I am broken everywhere. Please say to me, **Sapientia**, where I can find my original structure and cover with a veil of beauty the new generation incoming”.
“It's true, I was yet conscious about.
I am very sorry, but no one artificial will compensate for the broken song.
The new ancient hybridism tries to translate the language of another species into ours, simplifying itself in something perceived as a real new generation, from the first-born to actual one, with the freeze the vehemence of expressionless.
It is too late for removing the corners full of pride.
You laugh, inside the displaced blankets of love,
You reveal yourself, winner, without any punctuation.
The morning air sweeps you out, without ever sensation of pity.
It is coming to the lightness, covering your pretty face.
The tear's traces disappear, in the last losing smell of night.
You are still alive in the reverberation of the sound
Of a white American tree, in the folds of time.
Nunc et in aleatoria tabula.

Tuo /Yours

in memory of the lucent trees in my tender South-land



All’improvviso in un giorno di sole con la terra asciutta /Suddenly on a sunny day with dry land
Uomini stranieri perforarono la terra strappando le tue radici antiche / Foreign men pierced the earth by ripping your ancient roots
E ti hanno portato via senza alcuno indugio. / And they took you away without any delay.
Hanno strappato i nostri intrecci antichi dove scambiavamo i nostri umori solidali / They riped out our ancient weaves where we exchanged our sympathetic moods
Da un tempo quasi infinito, secoli di incontri e solidarietà./ From an almost infinite time, centuries of meetings and solidarity.
The scent of my leaves that I expanded to your sap.
La tua ombra fraterna gestiva il mio giorno e la mia sera/ Your fraternal shadow managed my day and my evening
Mentre cercavo di rimandarti come una dolce carezza/ While trying to send you back like a sweet caress
Il profumo delle tue foglie che espandevi fino dalla tua linfa. / The scent of my leaves that you expanded since from your sap.
Per secoli il rito si ripeteva quotidianamente. / For centuries the ritual was repeated every day.
Of intense, warm light, full of the smell of the sea that was close to life.
Sino a quella mattina quando un mercante

ti comprò/ Until that morning when a merchant bought you
Quasi fosse una cosa da trasportare per il suo diletto/ As if it was something to carry out for his pleasure
In una terra straniera, fredda lontana senza il mio umore confinante/ In a foreign land, cold far away without my neighboring mood
Né lo spessore della nostra terra, la sua acqua, il suo vento e la sua ombra / Neither the depht of our land, its water, its wind and its shadow
Di luce intensa, calda, piena di odore di mare che vicino ritmava la vita./ Of intense, warm light, full of the smell of the sea that was close gave rythm to life.
Il tuo travaglio di espianto, di viaggio, di trapianto ti ha segnato per sempre,/ Your labor of explanting, traveling, transplanting has marked you forever,
Sarai sempre solo senza di me e senza la nostra luce e il rumore del mare / You will always be alone without me and without our light and the sound of the sea
E I nostri intrecci spezzati inariditi restano sepolti da terra sterile./ And our dried-up broken weaves remain buried by barren earth.
Nulla può rinascere dove l'uomo in barbarie spezza./ Nothing can be reborn where the barbarous man breaks up.
Ma il ricordi dei tuoi suoni al mattino e verso sera / But the memories of your sounds in the morning and towards evening
La tua gioia quasi infantile all'arrivo della primavera/ Your almost childlike joy at the arrival of spring
Il canto degli uccelli tra i tuoi rami accoglienti/The birds singing in your welcoming branches
Sono impressi indelebili tra le pieghe dei miei sogni/ They are indelibly imprinted in the folds of my dreams
Un'impronta indelebile di amicizia spezzata/ An indelible printing of broken friendship
Dal devastante uomo senza coscienza: solo per danaro/ From the devastating man without conscience: only for money
Sic placet amor è ora solo un mio canto silenzioso degli alberi/. Sic placet amor is now only my silent song of trees.

The girl on the tree



Julia Lorraine Hill is known as Julia Butterfly Hill. She is an American girl best known for having lived in a 180 foot(55 m) tall, roughly 1500 years old California redwood tree for 738 days between December 10, 1997 and December 18, 1999.
Hill lived in the tree, affectionately known as Luna, to prevent Pacific Lumber Company loggers from cutting it down.

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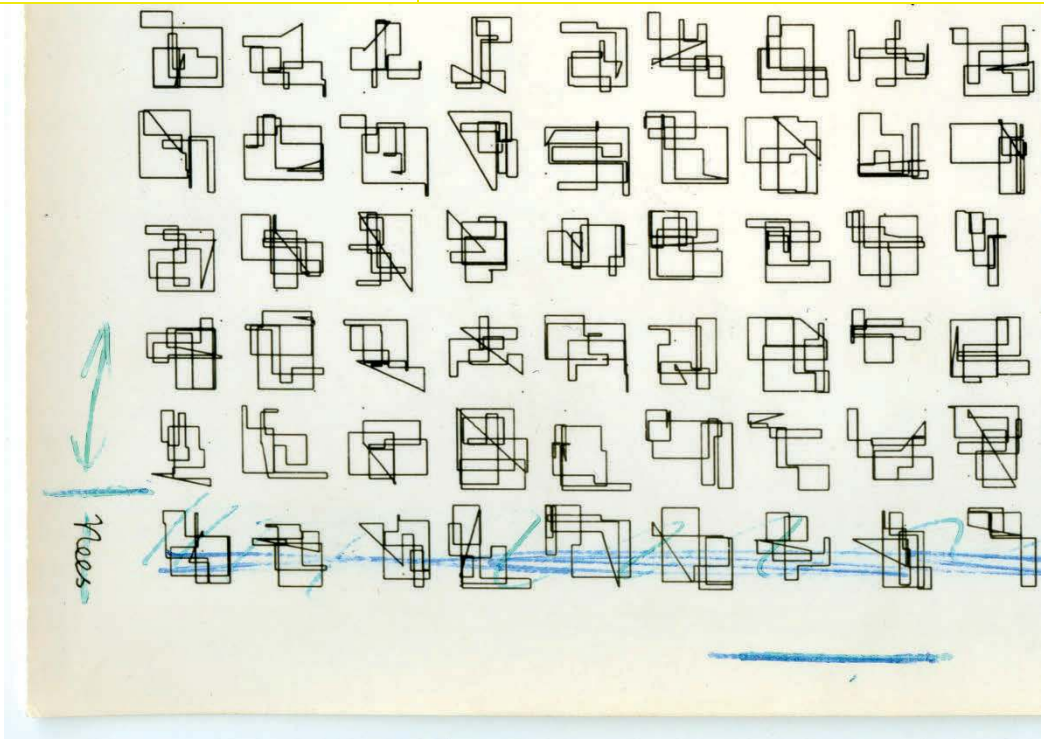


A Vision Without a Sight : From Max Bense's Theory to the Dialectic of Programmed Images

Topic: Information Aesthetics, Computer Art

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Georg Nees, *23-ecke* (detailed view), published in *Computer-grafik*. Rot. 19. S tuttgart: Max Bense, Elisabeth Walther, 1965.
ZKM | Center for Art and Media Karlsruhe / Elisabeth Walther-Bense Estate / ZKM-01-0129-02-0009-r

Abstract
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Bense's philosophy is essential for understanding the beginning of Computer Art in Germany in the sixties. However, Bense's programmed aesthetics is primarily concerned with literature and text (Textheorie und Textästhetik). Discussing numerical methods that are capable of "describing a text by means that are nearly the same as those used by thermodynamics to describe a gas", Bense, a poet and a philosopher, envisions the idea of a programmable text synthesis. A critical reading of volume IV of *Aesthetica* reveals that his approach, influenced by various experiments in Europe, creates a parallel between statistical science, programming and literature theory. But although referring to the work of art, the philosopher does not yet relate the term programming to image.

In 1960 alongside *Aesthetica IV*, in Stuttgart, and together with his wife Elisabeth Walther, Max Bense starts the Edition Rot, an experimental publication that will progressively bring together concrete poetry, semiology, typography and cybernetics. In the famous nineteenth issue dating February 1965, Rot inaugurates the Generative Aesthetics by a statement written by Bense, together with a set of computer drawings by the mathematician and artist Georg Nees. From a historical perspective, these drawings are among the first programmed artistic images ever made public. Looking closer at Elisabeth Walther and Max Bense Estate archive at the Center for Art and Media Karlsruhe (ZKM), and focusing especially on the documentation of the *Edition Rot* – including its drafts – one discovers diagrams and notes which traces back editor's views. Studying this material notably enables us to understand how the philosopher becomes an instigator of Generative Aesthetics in the visual arts.

For pioneers of Computer Art, including Frieder Nake and Georg Nees – both attending lectures of Max Bense – programming plays a role of formal description that precedes the materialization of the image. In the discussion of these images, a problem opens. While the generative work has already been described in the form of an algorithm, how does one analyze the resulting image? What happens in the dialectic between the programmed synthesis and the visual analysis of the image? A possible answer is that it is in this dialectic that a new thinking and a new mode of existence of the image occur. The hypothesis is that the discussion of algorithmic image entails the reconsideration of how description and analysis are articulated in the image process. We will test this hypothesis by studying the editorial engagement of Bense, but also by studying the work of Georg Nees and the theory of Frieder Nake. Here, Max Bense's vision is discussed from concrete poetry to the world of programmed images.

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Key words: Max Bense, programmed image, Generative Aesthetics, Algorithmic thinking, Frieder Nake, Georg Nees, Edition Rot, Stuttgart school

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A Vision without a Sight: From Max Bense's Theory to the Dialectic of Programmed Images

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Abstract

Based on semiology (Pierce) and Information Theory (Shannon & Weaver, Carnap), Max Bense's philosophy is essential for understanding the beginning of Computer Art in Germany in the sixties. However, Bense's programmed aesthetics is primarily concerned with literature and text (*Textheorie und Textästhetik*). Discussing numerical methods that are capable of "describing a text by means that are nearly the same as those used by thermodynamics to describe a gas", Bense, a poet and a philosopher, envisions the idea of a programmable text synthesis. A critical reading of volume IV of *Aesthetica* reveals that his approach, influenced by various experiments in Europe, creates a parallel between statistical science, programming and literature theory. But although referring to the work of art, the philosopher does not yet relate the term *programming* to image.

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For pioneers of Computer Art, including Frieder Nake and Georg Nees – both attending lectures of Max Bense – programming plays a role of formal description that precedes the materialization of the image. In the discussion of these images, a problem opens. While the generative work has already been described in the form of an algorithm, how does one analyze the resulting image? What happens in the

dialectic between the programmed synthesis and the visual analysis of the image? A possible answer is that it is in this dialectic that a new thinking and a new mode of existence of the image occur. The hypothesis is that the discussion of algorithmic image entails the reconsideration of how description and analysis are articulated in the image process. We will test this hypothesis by studying the editorial engagement of Bense, but also by studying the work of Georg Nees and the theory of Frieder Nake. Here, Max Bense's vision is discussed from concrete poetry to the world of programmed images.

Introduction

On 28th of October 1960 the art magazine *Kunstgespräch* published a review of Max Bense's new book *Programmierung des Schönen* [1][2]. On the page succeeding the editor's note, Bense was controversially called the Muse Killer because of his emphasis on rationalization of aesthetics.

Max Bense's philosophy vividly nourished the beginning of Computer Art in Germany during the sixties. At the crossing of Information Theory and semiotics, his founding of Information Aesthetics and more specifically of Generative Aesthetics connects him with what is now broadly known as the digital arts. However, Bense's major contribution to Information Aesthetics in *Programmierung des Schönen* is primarily concerned with literature and text (*Textheorie und Textästhetik*).

This paper looks at how his philosophy introduced the term *programming* into aesthetics and art. In order to understand his vision, his role as the leader of the intellectual circle of Stuttgart school and particularly his relation with publishing must be investigated. Rot is an experimental publication in semiotics and concrete poetry whose editors are Max Bense and his wife Elisabeth Walther. It is studied here, especially to point out Bense's relation with the world of images.

The issue n° 19 [3] and its archived material at ZKM is specifically analyzed for it is the famous issue in which Georg Nees premiered his computer graphics. This issue also contains Bense's *Generative Aesthetics Projects*. The study of the archive material reveals more details about Bense's intentions while editing programmed images. Nees's graphics are accompanied by the presentation of the algorithm in plain text. Prior to the image, this description adds a new discursive dimension away from the sense of sight. Although it is text, the program already contains the image.

The main thesis – the dialectic of the algorithmic image – is finally discussed by observing on the one side the synthetical theory of Max Bense and on the other side the algorithmic thinking of Computer Art pioneer Frieder Nake.

Programming the Beautiful

Max Bense (1910-1990) studied mathematics, physics, geology and philosophy at the Bonn University where he gained his Ph.D. and Sc. in December 1937 [4]. Based on semiology and Information Theory, his philosophy is essential for the understanding of the beginning of Computer Art in Germany in the sixties. Not only Bense is significantly inspired by Norbert Wiener's *Cybernetics* but he also founds his philosophy of aesthetics on the relation between mathematics and the arts [5].

In 1960, while being a senior lecturer at the University of Stuttgart, Max bense publishes *Aesthetica IV: Programming of the Beautiful. Aesthetica* represents a body of four books that Bense started in 1954. *Aesthtica I* deals with the

Metaphysical Observations on Beauty, Aesthetica II is already concerned with *Information Aesthetics* (1956), and *Aesthetica III: Aesthetics and civilization* (1958). Later, in 1965, the four books of *Aesthetica* were reedited together in a single book with few images under the general title *Aesthetica. Introduction to the New Aesthetics* [6]. In this last book, a fifth chapter was added. It comprises a foundational text titled "The Project of Generative Aesthetics" (originally published in February 1965).

Max Bense as a philosopher has established influential theory for the early Computer Art scene of the sixties. His publications are found in the main international art events concerned with the *Computer's Arrival in Art* [7]. Together with Abraham Moles and Umberto Eco, Max Bense is staged in international events in London and Zagreb as a forerunner of early Computer Art. However *Programmierung des Schönen* is firstly concerned with literature and text theory:

"Max Bense's Informational Aesthetics concludes with a General Text Theory, which, on the basis of statistical research by Fucks, Herdan, Mandelbrot, et al., can be understood as a model of the new statistical aesthetics of sign. The general text theory refers to any kind of text, including the aesthetic theory of poetry and prose, but also of scientific languages, advertising languages and abstract languages, etc." Translated from German. Reinhard Döhl, Aesthetica IV (jacket), 1960.

Through the book, Bense refers to programming in different ways. What follows is a critical reading focused on the use of the word *programming* and its derivatives. It will then discuss the notion of programming in Bense's perspective. By extension, it will also enable a view on what is the relation of the philosopher with visual art and visual programming.

In his introduction, Bense seems impressed by various experiments in Europe. In 1960, his theory in aesthetics is not unique. While discussing numerical methods that are capable of "describing a text by means that are nearly the same as those used by thermodynamics to describe a gas", Bense is conscious of the efforts of others in the information theory discipline (in music with Abraham A. Moles, also in journalism at Centre International d'Enseignement Supérieur du Journalisme in Strasbourg, …). Although it is mentioned that "at the Technical University in Stuttgart one tries (...) to achieve an aesthetic programming of texts and visual character complexes", it remains a question how familiar Bense was with the practical aspects of such experiments at the time. In fact, in 1959, Bense already published *Stochastic Poems* of Theo Lutz in his literary magazine Augenblick [8]. In 1958, Bense hears about the attemps of Theo Lutz, a student, who uses a computer, model *Zuse 22* to compose texts. Bense suggests him to program the computer with a selection of words from Franz Kafka as well as a simple grammar, which he will then publish.

For Bense, the activity of programming is dependent on literary theory. Programming literature finds its justification in the fact that there is a theory of literature. By extension, programming becomes in itself a form a literary theory.

"It is not possible to explain, understand, interpret, or program literature without the presuppositions of certain theories, the task of which is to explain, understand, interpret, or program." Translated from German. Max Bense, Aesthetica IV, 1960

In this perspective, it is the task of theory to program literature. The computer is not a tool for literary analysis, but for literary and text synthesis (i.e. production) [Ibid.].

Furthering his views on literature theory, Bense enlarges the category to text theory. This theory has to embrace a broader spectrum of texts including reportages, features, series, news, advertising, announcements and visual communication. Based on the Information Theory, every text can be understood as a message, both from an analytical and a synthetical point of view. Also inspired by authors such as Gertrude Stein, Joyce, Ponge et al. and underlining the fact that these authors have already opened a way to the programmability of text, Bense finds in synthesis the promise for a new experimental discipline in the field of aesthetics.

Logical Programming

In *Aesthetica IV* (1960, p67), Bense also refers to the theory of Rudolf Carnap. Carnap was a philosopher who advocated logical positivism. For him, philosophy is the construction of language for science, freed from metaphysics. In 1952, together with Bar-Hillel, Carnap publishes at MIT "An Outline of a Theory of Semantic Information" where he presents a distinctive approach to the then current Theory of Communication [9]. Whereas the admitted theory (Shannon & Weaver) treats amounts of information as a measure of the statistical rarity of a message, Carnap and Hiller build a theory in which the concept of information carried out by a sentence within a given language system is treated as synonymous with the content of this sentence. Semantic information is explicated by various measures of this content. Taking on Carnap's terminology for studying text (molecular and atomic predicates), Bense takes an example from the theory of Carnap in the quantification of properties (Q) for a conjunctive proposition such as P1•P2•P3 where the predicates can be either negated or non-negated (e.g. –P1 or P1). Bense applies the theory to a text example: "Red and sweet and achievable". By principle of combination, this system of text bears 8 Q properties (In fact two at the power of three).

Later in the text, and by using the exact terms "logical programming", Bense specifically echoes the idea of constellation found in the concrete poetry of Eugen Gomringer. Through the idea of constellation, Gomringer offers a space for possibilities to happen: "The constellation is ordered by the poet. He determines the play-area, the field or force and suggests its possibilities. The reader, the new reader, grasps the idea of play, and joins in [10]." By writing in "a process of formal simplification" and with "a reduced number of minimal forms", Gomringer constructs an "object of thoughts and a play of ideas" [11].

Certainly the formal reduction found in Grominger's poetry echoes the needed reduction in modern programming language. But what are the differences between words chosen by the poet suggesting a constellation of meaning and the possible combination of words carried out by an algorithm? How to algorithmically explore words' combinations? We are testing here the properties of Bense's example of conjunctions. Our first step is to list and to write all the possible conjunctions contained by P1•P2•P3, where the predicates can be either negated or non-negated. As an example, one of the possible conjunction should be P1•P2•-P3. The practical realization of such an example can require two distinctive methods: iteration and recursion. An illustration is given here in Java-Processing code. We are assuming P1, P2 and P3 are tables of length two.

The code for quantification of Q properties:

```
String[] P1 = {"red", "blue"};
String[] P2 = {"sweet", "bitter"};
String[] P3 = {"achievable", "unthinkable"};
```

```
for (int i=0; i<=P1.length-1; i++){
  for (int j=0; j<=P2.length-1; j++){
    for (int k=0; k<=P3.length-1; k++){
      println(P1[i], "and", P2[j], "and", P3[k]);
    }
  }
}
```

The print function returns a list of all possible conjunctions ($Q = 2^3 = 8$):

```
red and sweet and achievable
red and sweet and unthinkable
red and bitter and achievable
red and bitter and unthinkable
blue and sweet and achievable
blue and sweet and unthinkable
blue and bitter and achievable
blue and bitter and unthinkable
```

Of course such a programming language didn't exist when Bense was writing *Programmierung des Schönen*. However exploring values and combination of binary numbers is elementary knowledge in computer science. We could argue that Bense's interest in both Carnap and Grominger is rather focused on either the logical reasoning or the brevity and compression of information and meaning in text. But Bense's understanding of computer science and the practicality of programming yet remains uncertain.

Bense's sense of programming will evolve. In an unpublished dictionary of aesthetics dated after 1971, Bense et al. define the term program in a now commonly admitted manner:

"Program, term of machine (electronic) information processing. The program is a system of rules that the machine must obey in order to carry out the intended result." Translated from Gemran. Ästhetik Wörterbuch, Moderner Ästhetik, unpublished [12]

Not far from an intuition, the effort of Bense in bridging programming and aesthetics in 1960 opened a new way for thinking literature and text. At the same time Bense maintained strong relationships with visual artists.

Bense, Rot and the World of Images

"There are red secrets in the world, really only red ones." Translated from German. Ernst Bloch, *Edition Rot* (back cover), 1960-1997

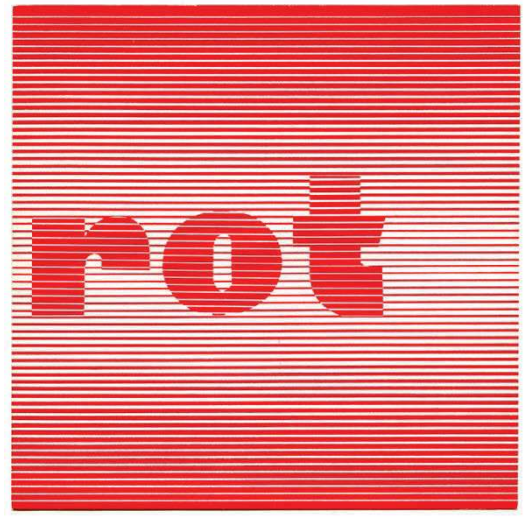


Fig1. Hansjörg Mayer, Rot, cover design, version of 1965.

In parallel with the publication of *Aesthetica IV* in 1960 Bense starts the *Edition Rot*, based in St uttgart, which will progressively bring together concrete poetry, semiology, typography and cybernetics.

"The series Red is used for the publication of experimental literature and graphics. At the same time, the concept of experiment is not narrowly conceived. We expect everything that includes the form content and purpose of artistic production under the presupposition of a theoretically accessible aesthetic conception.

Experimental literature and graphics are created, incorporating all stochastic aleatory topological abstract and concrete techniques, and not limited to the natural modes of production of a creative individual, but also counting on the artificial production of electronic computing equipment." Translated from German. *Edition Rot* (promotion material). Max Bense, Elisabeth Walther, circa 1966

With its square format and its red dusk designed by Hansjörg Mayer, Rot is very recognizable from a distance (Fig1). Radically exploiting the Futura typography without capitals, Rot completes with 62 booklets which are extending from 1960 to 1997. Its categories are including poetry, prose, concrete poetry, philosophy, semiology, theory, photography, painting, drawing, typography, computer generated drawing, computer generated text, comic-strip and drama. The publication embodies the activities of intellectual group of Stuttgart which surrounded Max Bense and Elisabeth Walther. Among the published authors we find (in no specific order): Jean Genet, Abraham A. Moles, Charles S. Pierce, Hansjörg Mayer, Georg Nees, Yona Friedman, Francis Ponge, Dieter Roth, and many others. The journal is essentially concerned with concrete poetry and alternates frequently with issues dedicated to semiology and visual art. Two issues, the 19th and the 50th, are explicitly oriented on the programming of aesthetic forms, with respectively the generative drawings of Georg Nees (n° 19), and the poetry of Carole Sp. Mccauley (n° 50). It is also worth noticing that the number eight presents a text form Abraham A. Moles titled "First manifest of pemutational art" accompanied by a reproduction of an image from Vasarely [13]

In general *Edition Rot* presents an intellectual network linked by an interest in the text and the typographic sign. Given the involvement of Max Bense in the genesis of Computer Art, it may also seem surprising that the principle of a programmed aesthetic only appears in a minor way with two specific issues. Nevertheless, through each number, the text and image relationship progresses dynamically and it is not uncommon for an entire issue to be dedicated to a body of work that is only visual (e.g. Rot n° 27 in the spirit of New Realism with photographic work and collage by Reinhold Koehler).

Investigating the archive of Elisabeth Walther and Max Bense and specifically the one of *Edition Rot* at ZKM (E. Walther and M. Bense Estate) reveals a dense activity in publishing. How does Max Bense relate to the world of images appears far more complex than it might be expressed in *Programmierung des Schönnen*, which as we saw focuses mostly on literature and text theory. If concrete poetry is literature, it certainly also is an art of distributing signs in the two dimensions of the page. Observing publishing practices in Rot shows the attention of Bense to visual space.

Moreover Bense wrote numerous texts on fine art [8]. And it is also worth to notice that not only Elisabeth Walther was a semiotician, but she also was a photographer. Frequently, she shot various trips of Bense and her. It seems obvious that she would have had an influential role on the reproduction of photographic images in Rot (e.g. n° 60). But how as an editor did Bense specifically relate to the image material that was artificially or algorithmically produced? The archive reveals layers and drafts that participate to the layout of various issues including the famous Rot n° 19 [3].

Computer-Grafik, Rot n° 19

In the issue nineteen published in February 1965 under the title *Computer-Grafik*, Rot inaugurates Generative Aesthetics with the publication of a statement by Bense himself [4]. In fact this issue is also dedicated to a text and a set of computer drawings by mathematician and artist Georg Nees who works at Siemens in Erlangen. From a historical perspective, these drawings are counting among the first programmed and artistic images ever made public [14]. Frieder Nake reports the public event that paralleled this publication at the "Studiengalerie der TH Stuttgart" as the first exhibition of Computer Art, "two months before the famous Howard Wise exhibition in New York" (both the exhibition at the Studiengalerie and the publication of Rot n°19 are dated February 1965). On the occasion of his *Aesthetic Colloquium*, Bense who has already been exhibiting artists in this space also presented the statistical drawing experiments by Georg Nees.

In the first two pages of the booklet, Georg Nees presents a text "about the programs of stochastic computer graphics". Not only we learn that every graphic has random parameters, but also Nees explains that each repetition of random parameters "produces the aesthetic improbability of the graphics". After the brief introduction, the text presents five parts written in the form of a pseudo code. Each part relates to one or two images that will be discovered in the next few pages: "8-edge: (image1)", "23-edge: (bimage2)", and so on. In plain text – without specification of any programming languages – the descriptions are presenting the programmable instructions that generate aesthetic results.

In the following images, the layout is systematic: the image title (e.g. "image 1"), the image itself in full page top to bottom, and the page number. A vertical white margin at the center of the double page borders the composition. The images that are presented are all made of black straight lines with approximately 0.5 mm stroke. These are verticals, horizontals, obliques. The shapes are either organized as patterns in a seemingly repetitive grid or as full page shapes made from complex superposition of various line densities. It is not specified in the publication: all images are originally ink drawings made with the help of an automated pen plotter.

Looking closer at Walther-Bense Estate archive at the Center for Art and Media Karlsruhe (ZKM), one discovers precious material concerning the way Rot n° 19 has been edited. Reproductions of the six images can be found on free glossy paper with various annotations in blue pencil from the hand of Bense. For *23-Edge* (Fig2.), it is worth mentioning that the last shapes at the bottom of the image are crossed out. The signature of Nees which is also situated at the bottom is crossed out too. Two blue lines and a vertical arrow in the left margin seem to indicate an instruction for cropping the image in the final layout.

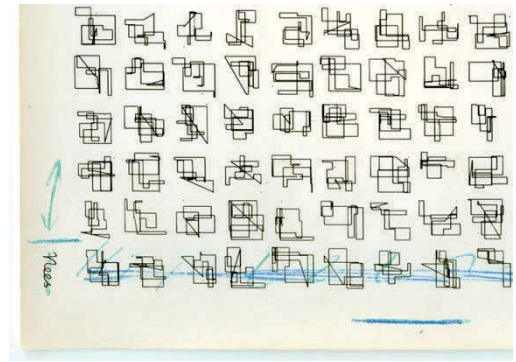


Fig2. Georg Nees, 23-Edge: detailed view from editor's draft, Rot n° 19, 1965.

What were the intentions of Bense? Is it because the name of Nees was appearing in signature that the last line of shape was removed from the edition? Or was it

simply for getting the grid of shapes closer to the square format of Rot? Although the exact answer is unknown; it is remarkable that this simple gesture of *framing* witnesses Bense's relation to authorship and to the new category of programmed images. In this case, it's as if the abstract signs algorithmically produced by Nees functions as characters that would have to be selected yet again after they are produced. It also significantly recalls Bense's interest in information and aesthetics realization as a process of selection: “Realization is an expression of a selection function” [2]. Moreover it also reveals that Bense's purpose might not have been to publicly present Nees as an artist but rather to demonstrate experimental application of his theories in the visual realm.

Dialectics in the programmed image

For pioneers of Computer Art, including Frieder Nake and Georg Nees – both mathematicians attending lectures of Max Bense – programming plays a role of formal description that precedes the materialization of the image. In the discussion of these images, a problem opens. While the generative work has already been described in the form of an algorithm, how does one analyze the resulting image? What happens in the dialectic between the programmed synthesis and the visual analysis of the image?

For Bense, computation, deduction and measure are processes oriented towards future. In his vision, mathematical language enables the transition from physical processes in the natural world to productive principles within the technical and artificial world. According to him, the Humanities should radically reconsider its generative forces: “the reality-setting power of the humanities has not been verified” [1]. With programing, Humanities would shift from being analytical to being synthetical and hence experimental. A theory in aesthetics should be capable of artificially producing art. In the philosophy that Bense instigates, describing as well as programming precedes the realization of the art work.

Coming back to Nees's images in Rot n ° 19 wich counts as an historical inauguration of programmed aesthetics in the visual realm; we are left with few new questions. If Nees describes an algorithm and then exhibits the resulting image in the next pages, how to analyze and interpret the visual result? Is this about retrieving the formal logic that lies behind it? What are the critical tools that would enable a strong evaluation of the algorithm together with the aesthetic result? The thesis here is that a programed image whether scientific or artistic constitutes a dialectical unit. It is precisely because algorithm and image are inseparable that together they constitute a specific category of image. The image exists both as an algorithm and as a visual material. Frieder Nake for whom "computer art is conceptual art" precisely points out the dialectical tension between the algorithm and the visual work that is carried out by the means of computation:

"When the computer executes the description, it reads it in its own, peculiar way: it realizes exactly what the description requires it to do, and nothing else. Reading always is interpreting. The computer, when reading the operational text, interprets it. Absolutely different from our interpretation, the computer’s interpretation is a determination: no freedom allowed. The computer interprets by determining the one and only one interpretation that makes algorithmic sense." Frieder Nake, Paragraphs on Computer Art, Past and Present, 2010 [15].

At the opposite end, we meet the visible surface onto which the image comes to existence. By becoming visible the work manifests itself in the material world, and because it is visible to the human eye it becomes subject to a new variety of interpretation. Frieder Nake also adds that by thinking in algorithmic terms we also share with the machine its one and only one interpretation:

"The result of an effort in algorithmic thinking is an algorithmic system. As such, it is in all its aspects unambiguous. This amounts to saying, there is one and only one interpretation of each execution of the algorithmic system." Ibid.

The tension between algorithms and aesthetics is not Bense's own formulation; instead it is to be found in Frieder Nake's theory and teaching [16]. Let's recall that Frieder Nake has actively been taking part in the Stuttgart circle. He has certainly been impressed by Bense's lectures he followed as a mathematician student in the university of Stuttgart in the beginning of the sixties. In November 1965, nine months after the presentation of computer graphic experiments at Bense's Studiengalerie mentioned above, Nake and Nees have exhibited together at the Niedlich gallery (Niedlichs Buchladen und Galerie), using the title *Computer Grafik* (slightly different from Rot n° 19). Since then, Stuttgart became a pioneering location for digital art and Bense's impulsion in Generative Aesthetics have been well followed and yet surpassed.

Conclusion

By following Information theory and semiotics, Bense's vision bridges text theory and programming. Because of the close relation he maintained with visual arts, especially through the experimental publication Rot, the philosopher also opened a way to image synthesis in art. However the information aesthetics that he thoroughly defended didn't comprehend in detail the intricate and didactical relation between algorithm and image. “Think the image, don't make it!” This proposition from Frieder Nake expresses well the algorithmic dimension of computer generated image. Did Bense's vision lead to such a statement? Partially. Not only Nake has been closely involved in the events where Bense instigated Generative Aesthetics, but the synthetical theoretical means to statistically realize aesthetic states offered a strong basis for concentrating on the task of algorithmically describing the image before its realization. Frieder Nake insists that computer art is also a form of conceptual art. Bense, who claims that aesthetics must develop “under new aspects into a technical science” and who announces that programming meets creation, might not have fully foreseen the aesthetic tension these claims would create between the program and the image; and the algorithm and the visible. Confronting Bense’s view to image synthesis and in particular to today’s practice opens up a rich discussion that necessitates further research.

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Figures

Fig1. Hansjörg Mayer, Rot, cover design, version of 1965. ZKM | Center for Art and Media Karlsruhe / Elisabeth Walther-Bense Estate / ZKM-01- 0129-02-0991-a

Fig2. Georg Nees, *23-Edge*: detailed view from editor's draft, Rot n° 19, 1965. ZKM | Center for Art and Media Karlsruhe / Elisabeth Walther-Bense Estate / ZKM-01



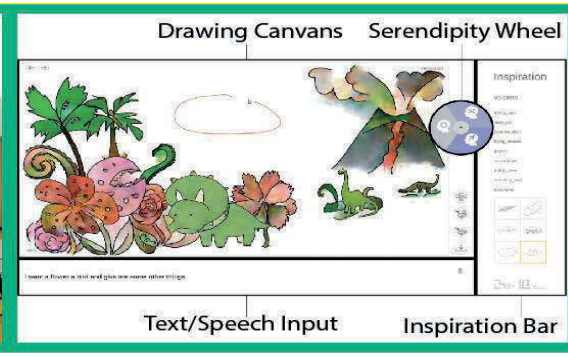
Paper Dreams: Real-Time Human and Machine Collaboration for Visual Story Development(Paper, Live Demo)

Topic: (Computational Creativity)

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Abstract
Increasing human potential is the underlying incentive for all technological advances. In creativity, technology can be used to facilitate faster design and construction, to improve human creative capability through learning and training, and to enable novel and innovative ways to create. The capacity to express our thoughts with visual mechanisms provides the foundation for meaningful creative practices, including art, design, and science. Here we present Paper Dreams explores how the real-time generation of ideas and visuals based on multi-modal user input can encourage divergent thinking, specifically in graphical story development, while also providing enough agency for users to feel that they have creative ownership over the final output of the collaboration. The web application recognizes user input via sketch recognition[1] and text input while suggesting related elements and synthesizing colors utilizing Conditional Generative Adversarial Networks[2] for inspiration in real-time. The result is a dynamic back-and-forth interaction between the user and the system that explores new elements for creative output. Results of qualitative evaluation (N = 26) show that the features in the Paper Dreams interface contribute to the divergence of an original idea for story development for significantly more users compared to using Adobe Sketch, while maintaining similar perceptions of creative ownership for users who do not self-identify as creative type.





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Key words: Creativity Support Tools; Computational Creativity; Collaboration; Sketching; Co-Creation, Artificial Intelligence

Main References:

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Paper Dreams: Real-Time Human and Machine Collaboration for

Visual Story Development

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Abstract

Increasing human potential is the underlying incentive for all technological advances. In creativity, technology can be used to facilitate faster design and construction, to improve human creative capability through learning and t raining, and to enable novel and innovative ways to create. The capacity to express our thoughts with visual mechanisms provides the foundation for meaningful creative practices, including art, design, and science. Here we present Paper Dreams explores how the real-time generation of ideas and v isuals based on multi-modal user input can encourage divergent thinking, specifically in graphical story development, while also providing enough agency for users to feel that they have creative ownership over the final output of the collaboration.
This paper, thus, makes the following contributions: we have expanded upon the existing state-of-the-art machine learning models used in recognizing sketches and creates personalized suggestions for new elements and colors. We have developed a Text-to-Sketch component, which is not typical to most canvases, that can further assist in populating the canvas. We have also improved upon conventional ways of finding relations between objects by grouping relations into different categories and limiting objects to the sketches in our dataset.

Introduction

Human-machine collaboration has the capacity to augment creativity in a w ide variety of ways. Throughout the collaboration stage, ideas emerge from both the users and the system that can assist and encourage creativity[33]. As collaborators make unexpected and novel contributions, their output can lead to new artifacts that otherwise might not have produced individually. The field of intelligent interactive systems has recently gained a f air amount of traction with the rapid increases in the field of AI, especially in so-called co-creative systems that feature human users creatively collaborating with intelligent agents.
These systems have been implemented in numerous domains, including art [10] [18],

music [36] and robotics [11]. In addition, these systems are designed to encourage creative thoughts for both novice and expert human users. These novel representations of co-creative systems are proposed as innovation, inspire and motivate the user to continue the task, and help users achieve shared goals.
The study of how or why something is deemed creative can be challenging due to the lack of cohesive definitions and the ambiguity of what constitutes an idea as creative.
The inspiration features of Paper Dreams have based on principles of Divergent

Thinking [30] as a source of creativity. Divergent thinking can be defined as the process of freely exploring different combinations of related ideas starting from an initial problem state. We base the design of the Paper Dream features to take advantage of the motivators of divergent thinking, like the presentation of new ideas and visuals that go beyond a user's current mental model of possible elements to add to the story. By constantly stimulating the user with new elements of inspiration based off of each interaction, the user can perceive more possibilities for different combinations of ideas. We also use Divergent Thinking as an evaluation metric of successful Paper Dreams that can assist with promoting creative cognition. We measure this by observing the users' perception of how much their final story diverged from their original idea.
Paper Dreams can be potentially used by multiple audiences. Storyboard artists who are afflicted with writer's block, a condition that debilitates them and prevents them to produce any work because he/she has run out of ideas can use Paper Dreams to augment their creativity. The elderly can use Paper Dreams to tell a story and keep themselves engaged, potentially preventing the early onset of dementia. Though there exist separate methods for recognizing sketches, finding relations between objects, and automatic colorization, to our knowledge, there is no one unifying tool that connects these deep learning models, assists in creative storytelling and relies on the feedback process between the neural net and the user. This paper, thus, makes the following contributions: we have expanded upon the existing state-of-the-art machine learning models used in recognizing sketches. We have developed a Text-to-Sketch component, which is not typical to most canvases, that can further assist in populating the canvas. We have also improved upon conventional ways of finding relations between objects by grouping relations into different categories and limiting objects to the sketches in our dataset.

Creativity

The concept of creativity has different meanings across various mediums, and in many cases is highly subjective to the individual. We felt that it would be helpful to provide a reference to the term creativity as perceived by the authors. Design studies have defined creativity as the "ability to create ideas, solutions or products that are novel and valuable" [32], and creativity is frequently used to signify specific types of divergent [9] and flexible thinking[30] that emerge in an iterative mental process. Studies have widely accepted the view that creative products should be "novel" and " useful," as Sternberg and Lubart [35] suggested.

Related Work

Here we review the opportunities and challenges for the development of such a system, with a specific focus on sketching, Texturizing with AI, and narrative formation using natural language processing (NLP). Finally, we review the concept of structure imagination from the field of creative cognition and discuss ways of inducing it in our work.

Interfaces for Sketching

Sketching, or the production of once ideas, is a physical activity that we naturally perform in our daily lives to assist in the development of visual ideas is one of the earliest and most frequent activities of artists and designers. The influences of sketching can be seen as a tool for various domains like in expression, communication, but also an extension of once cognitive process and cognitive load management. Humans of load memory into a piece of paper when we do math or write a to-do list, we construct and develop new ideas as we doodle on a piece of paper. There is still great potential in incorporating sketching as an interaction for augmenting creativity and cognition [23]. One of the determinants limiting research advancement in the area of generative hand drawings is the lack of publicly available datasets. Google's team had made available one of the largest available dataset made from human sketches [46] This enabled for a larger-scale investigation of human sketches. Unfortunately, the people that created this dataset were are asked to draw objects belonging to a distinct object type in less than 20 seconds, resulting in a dataset with drawings with very low fidelity.

Generative Adversarial Network

A Generative Adversarial Network, or GAN, is a generative model approach based on differentiable generator networks. A differentiable generator network is a generative model that transforms a sample from a latent variable z to a sample x using a differentiable function [15]. GANs are a combination of two neural networks, specifically a network generator and network discriminator, that work hand in hand to optimize each other. Based on the concept that creativity can be viewed as a unique combination of ideas, GANs are particularly useful in exploring creativity in a computational manner. The generative model of part of a GAN essentially is a function of the vector interpolation of the inputs in the given data. The latent space in this interpolation provides different combinations of base inputs.

Our primary motivation in studying GANs was to try to apply a GAN-derived model to the generation of novel art. Much of the work in deep learning that has concerned itself with art generation has focused on style, and specifically the style of particular art pieces. Interactive GAN [?] models exist that aim to create a simple but effective layer for synthesizing photorealistic images given an input semantic layout. This model allows users to control the style and content of image synthesis.

Our implementation uses Pix2PixHD [39], NVIDIA's Pytorch [26] implementation of image-to-image translation. A deep learning neural network calculates object boundaries and incorporates that semantic information into creating more realistic and higher definition textures. Pix2PixHD grew from Pix2pix[17], a U-net architecture that relies on conditional adversarial networks

to provide a general-purpose solution to image-to-image translation problems. Pix2pix has become a popular state-of-the-art algorithm for image translation with a GAN architecture. By building off of the GAN model described above, we propose to build a deep neural network that is not only capable of learning a distribution of the varying styles and content components of many different illustrative pieces but also is able to combine these components in a sophisticated manner to create new pieces of art.

Creative Cognition

The work presented in this paper is an interdisciplinary effort between the fields of computational creativity, creativity support tools, and human-computer interaction (HCI). The field of computational creativity is a sub-field of artificial intelligence that focuses on developing agents that generate creative products autonomously[1] [40] [8]. Creativity support tools, on the other hand, are technologies designed to enhance and augment the user's creativity, typically aiming to improve the quality of the final product. By combining core concepts from computational creativity and creativity support tools, we can develop computer applications that collaborate with human users on a shared creative task. Co-creative systems can adopt different roles to foster human creativity, such as coach, pen-pal, and collaborator [24]. The co-creative tool for visual communication presented here can be considered a computational partner that utilizes a computational model of conceptual shifts [28] to design alongside a user and inspire creativity. In response to the constant information overload that humans have to deal with each moment, current information retrieval tools such as Google Search have evolved for returning near-exact precise matches.

However, such technologies run the danger of entirely losing the benefit of serendipitous findings: unexpected yet valuable discoveries that are divergent or completely unrelated to an inquiry [14] [7]. Our determination to support serendipitous discovery is grounded on the reality that creators tend to browse existing repositories for creative simulation [3] [13]. By constantly stimulating the user with new elements of inspiration based off of each interaction, the user can perceive more possibilities for different combinations of ideas.

System Description

Paper Dreams runs on the web browser; this was chosen over a native application (i.e., one downloaded directly onto a device) to increase accessibility to a larger subset of our target population. Our application can be used by anyone with access to an electronic device with internet and a browser, such as a laptop or a tablet. In addition, this circumvents the need to develop distinct apps for different mobile devices, e.g., a Swift-based app for iOS and a Java-based app for Android, and allows us to more effectively collect data on what users are drawing in order to improve our database.

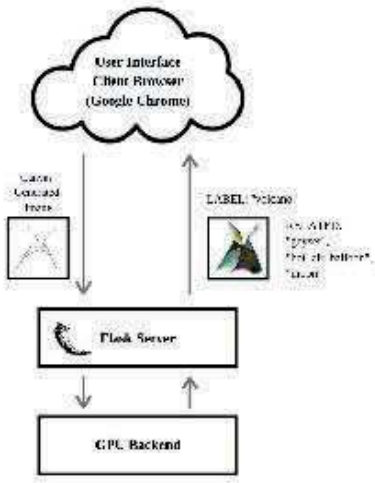


Figure 1. ***shows the system architecture, with the front-end client-side browser (e.g., Google Chrome) making requests to and from a back-end web server. The web server was built using Flask [29], a lightweight and easily customizable Python***

System Architecture

server framework. The user interface in the browser was built with HTML, Javascript, and CSS, with an HTML5 canvas as the primary drawing surface. The Flask server currently runs locally on a computer with a G PU (Graphics Processing Unit), allowing the server to use the GPU for the computing needed for the sketch recognition and the adaptive Texturizing.

General Workflow

The Paper Dreams workflow can be represented by a state model consisting of three mutually exclusive modalities: Sketch, Query and Composition, as shown in Figure 1.

The user can sketch on the screen in a free-form manner or they can choose for the system to recognize what they have sketched.

As Paper Dreams currently is unable to detect when the user has completed their drawing, the user must press the "Sketch Recognition" button to allow the system to know when the user is finished with their current sketch. A label is then processed and shown to the user from the sketch recognition, identifying the current sketch. There are 125 possible classes for the label to be chosen from, as the sketch recognition was trained on the 125-class Sketchy dataset.

Alternatively, the user can interact with Paper Dreams by speaking to it instead of drawing on it or typing a query into the search bar. The nouns are parsed from the spoken phrase and are then mapped to the different sketch categories using spaCy. The most related words (i.e. highest similarity) are shown on t he sidebar for inspiration, and can then be selected and placed on the canvas. After the user requests that the system recognizes the sketch or prompts the system with a quer y, a l ist of related nouns is displayed to the user in the inspiration bar on t he right side of the interface. The user can then select one of the words, pulling up a grid of sketches of that word, any of which can then be placed into the canvas to add more details and elements to the current scene.

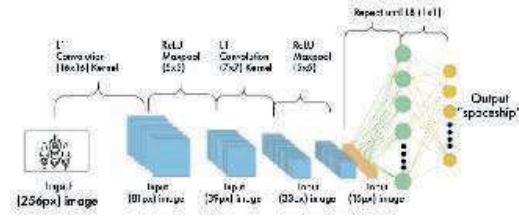


Figure 2. Our custom-made eight-layer convolutional neural network trained on sketches from Sketchy Dataset.

Sketch Recognition

We have trained an eight-layer convolutional neural net (CNN) on the 125 classes on the publicly available Sketchy dataset [31] (as shown in Figure 2). Our present recognition architecture is based on deep learning network Sketch-a-net, which claims one of the highest accuracy rates on human sketches [41]. However, at its current size, the dataset is too small to train a high-performing CNN. This type of network performs best with a large number of samples; therefore, we used a data augmentation technique for machine learning called Augmentor [6] to augment the Sketchy dataset. After augmentation, we found that we had an approximately 75% accuracy rate across those 125 classes. While we can use our architecture for recognizing incomplete or "partial" sketches, the resulting labels are often incorrect until enough defining features are drawn.
The sketch recognition model works best on a finished sketch- however, Paper Dreams cannot tell when the user has completed their drawing. Therefore, the user must press the "Sketch Recognition" button to allow the system to know when the user is finished with their current sketch.
The sketch-identified label (e.g., "hedgehog") is associated with a model (e.g., "animal"), and then the active user sketch is processed by that model to return an appropriate texture. Other models include "plants", "buildings", "transportation", ""flowers", "appliances" and “fruit".

Natural Language Processing

In natural language processing (NLP), cosine similarity is a classic metric for measuring the similarity between two words [25]. Each of the words (or concepts) is first turned into an n-dimensional vector, based on its frequency in the training set of documents. The value of n is dependent on the model used but generally is in the hundreds or thousands. The similarity between two-word vectors, A and B, can then be calculated according to Equation 1, where ||A|| and ||B|| are the L2 norms of A and B respectively.

$$Similarity(\vec{A},\vec{B}) = \frac{\vec{A}\cdot\vec{B}}{||A||\cdot||B||} \quad (1)$$

Because the speech/text modality in the user interface is built with the spaCy software library [16], we originally used spaCy’s vectorization for each word to calculate the similarity between words/labels.
However, there was an issue: spaCy is built to process on the single word level. Approximately 15% of our labels are compound words, i.e. multi-word phrases such as "hot air balloon" that have a single meaning that is more than "hot", "air", and "balloon" by themselves. (For reference, a full list of the available classes in the Paper Dreams dataset can be found in Appendix 6.) This can have a significant impact on the overall results; the relationship between "mouse" and "cat" is very different from the relationship between "computer mouse" and "cat." The spaCy library would return two values for the relationship between "computer mouse" and "cat": one for "computer" and "cat" and another for "mouse" and "cat."

To resolve this, we attempted to use the Natural Language Toolkit (NLTK) library [22], which does support some bi and tri-gram words (such as "computer mouse" and "hot air balloon", respectively), but found that it was not robust enough to

process a s ignificant portion of our compound word classes (as the words have to be defined in the NLTK library.) For example, "t shirt" is not in the NLTK library.

Finally, we used sense2vec, a P ython library trained on Red- dit comments designed to extract multiple possible meanings (or "senses") and subsequent embeddings from the input word/label [38]. Sense2vec was able to calculate similarity values for nearly all classes in our dataset, with the exception of unusual noun phrases such as "person walking." We then calculated the cosine similarities between the main label and all other classes in order to generate a m apping such as the one seen in Figure 3, where 9 is the most closely related value and 0 is unrelated. This graph is then used for the serendipity wheel.



Figure 3. *An example of the relationship between "cat" and eight other classes of varying similarity (9 being most closely related). In practice, there are 185 total other classes in each graph for a label.*

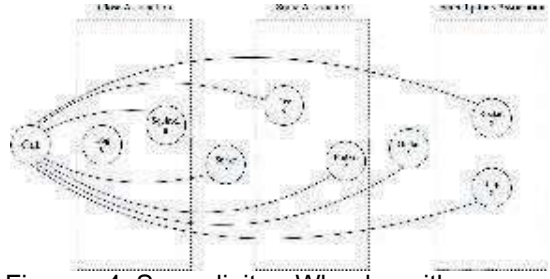


Figure 4. Serendipity Wheel, with an example of the associations it would suggest for each tab when given the label "cat".

Serendipity Wheel

The serendipity wheel, as seen in Figure 4, uses the label from the sketch recognition to generate a list of classes that the user can add to their sketch, and allows the user to control how closely associated the list is. The three tabs in the wheel correspond to increasing unrelatedness (lighter being closely related, darker being less related.) For example, from the label "cat", a closely related list could contain ["dog", "mouse", "squirrel"] and a r elatively unrelated or serendipitous list could contain ["rocket", "ship", "teapot"]. These lists are generated from the similarity map for the label; if the user requests classes that are very related from the label, the system will pull from the objects with high similarity values with the label.

Texturizing

In order to train the Paper Dreams model, we collect 2000 u nique images that consisted of 80% illustration art and 20% watercolor or similar medium these images where either collected from the Internet with a crawler or generated by our team. Paper Dreams currently supports coloring 186 di stinct

classes of sketches. It would be impractical to train and store a single model for each individual class.

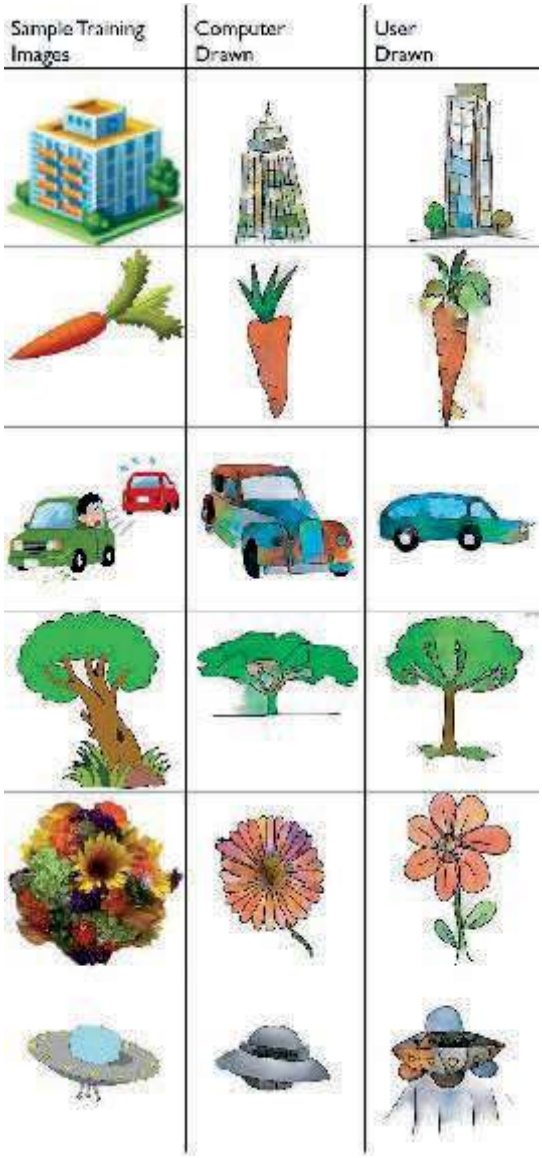


Figure 5. Six examples of the fifteen distinct trained Texturizing models, each encompassing a r elevant subset of the classes available as part of the sketch recognition and the inspiration bar while using Paper Dreams. From left to right, Sample images used on the training dataset, Textured images that have been drawing by the machine as on of the features for Paper Dreams, Sample images from user sketches texturized with the system aid

Therefore, the classes are separated into fifteen different models, each encompassing a r elevant subset of the classes. For example, "butterfly", "scorpion", "hedgehog", and "cat" are all processed by the "animal" model; other models include "plants", "buildings", "transportation", and " fruit". The sketch-the identified label is associated with a model, and then the Canvas Generate Image is processed by that model to return an appropriate texture. Figure 5 shows six of the fifteen distinct trained Texturizing models, each encompassing a relevant subset of the classes available as part of the sketch recognition and t he inspiration bar while using Paper Dreams.

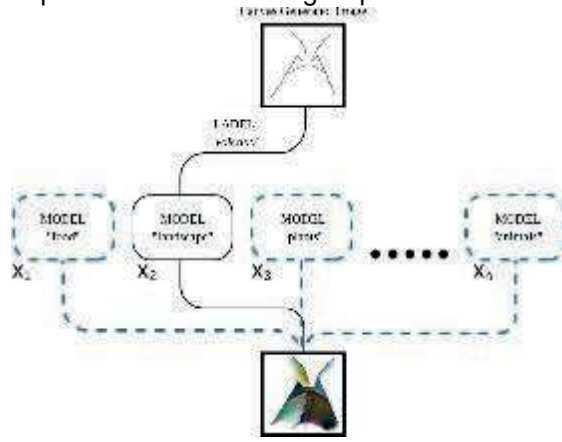


***Figure 6**. Using the Canvas Generated Image and the label from the Sketch recognition, the texturizing model passes the image through the appropriate model to get an appropriate texture.*

Our texturizing network follows pix2pixHD[3] with only some small changes. We first train a residual network G1 on lower resolution images. Then, another residual network G2 is appended to G1 and the two networks are trained jointly on hi gh-resolution images. Specifically, the input to the residual blocks in G2 is the element-wise sum of the feature map from G2 and the last feature map from G1.
We use 3 discriminators(D1, D2, and D3.) that have an identical network structure but operate at different image scales. Specifically, we downsample the real and synthesized high-resolution images by a factor of 2 and 4 t o create an i mage pyramid of 3 scales.



***Figure 7**. A screenshot from the storyboard feature as part of the Paper Dreams platform*

The discriminators D1, D2, and D 3 are then trained to differentiate real and synthesized images at the 3 different scales, respectively. By using a coarse to a fine generator, a multi-scale discriminator architecture, and a r obust adversarial learning objective function.

EXPERIMENTAL USER STUDY

To evaluate how effectively Paper Dreams encourages divergent thinking in the context of storytelling, we conducted a formative user study where we compared the experience of participants developing stories using Paper Dreams with the experience of those using Adobe Sketch.

Procedure

The objective of the study was to evaluate to what degree the interface supports the user in their creative endeavors and its role in the imagination process for the development of a story. For this study, we requested that the participants compare Paper Dreams with Adobe's Sketch app for iOS [2] The Adobe Sketch app provides virtual drawing brush tools that interact naturally with the canvas, including a g raphite pencil, ink pen, and blending markers. In addition, built-in brushes open up even more creative possibilities. We decided to use this app due to its realistic visual qualities to physical mediums such as acrylic paint, watercolor, and graphite.
At the beginning of each study, we asked the participant to pull a piece of paper containing a topic for their story, and randomly assigned whether they started the study by working in the Sketch app or in Paper Dreams. For both scenarios, the participant was offered a chair and desk to rest their tablets and conduct the study. Participants were initially trained for approximately five minutes on b oth applications, and af ter the demonstration was allowed the free practice of scribbling, editing, and composing. We recorded the art developed by the participants during the task.

After each task, participants were interviewed about their experience with performing the task of developing a story each interface. Participants were required to respond to a survey that included both Likert scale ratings and open-ended questions about their experience.

Study

To investigate the effects of real-time AI feedback for collaboration, we conducted a formative user study to evaluate how well our collaborative storytelling environment supported the development of stories on demand. We recruited 26 participants (14 female, 12 male) over email, between the ages of 18 to 34 years old. All participants were either undergraduate or graduate students. We requested that all participants had prior experience using a t ablet and a s tylus-style pen.

User Task

Participants were given an open-ended prompt to develop a story and to create illustrations using the available resources from both apps; the Adobe Sketch app and the Paper Dreams app f or fifteen minutes. As part of the experiment, we kept switching the order of assignment of application that they would start the task. There were two main drawing tasks: one collaborating with the Paper Dream system (referred to as the agent condition), and the other collaborating with an iPad using the Adobe Sketch app (referred to as the control condition). Participants were asked to create a story from the topic they had randomly selected and further develop their story by illustrating what they have imagined, using sketch strokes to query and di splay images that they could use. Participants were also asked to freely use features such as the texturizing, sketch recognition, and the serendipity wheel within Paper Dreams, and features like shapes, colors, and paint brushes available within the Sketch app.

RESULTS

User Study Results

Our study shows promising results in Paper Dreams' ability to promote divergent thinking in storytelling for its users. A majority of users (92%) answered that the interface of Paper Dreams helped positively change their story, which is significantly higher than the 23% of users who said that the interface of Adobe Sketch changed their story. This correlates to our initial intuition- because Adobe's application functions as a hi ghly efficient tool, it would only reflect the user's proficiency with the tool. In addition, Figure 8 shows a positive correlation between how strongly a user identifies as being "creative" and h ow far they perceived that they diverged from the initial concept. This indicates two potential possibilities: people who perceive themselves as creative may be bet ter at divergent thinking regardless of the interface they use, and divergent thinking is a valid evaluation of creativity.

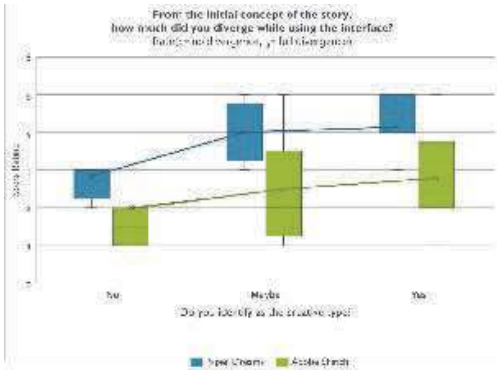


Figure 8. ***On average, users indicated that the Paper Dreams interface helped them diverge their stories from their original idea more than the digital interface of Adobe Sketch.***

In the post-task survey, we prompted the participants to describe their thought process for generating the storyline and describe if and how the Paper Dreams interface influenced their story. The users were asked the same questions regarding their experience with Adobe Sketch. In order to evaluate the most influential features within in Paper Dreams and Adobe Sketch (i.e. features that promoted divergent thinking), we analyzed how many users mentioned specific features when describing their thought process for creating the story.

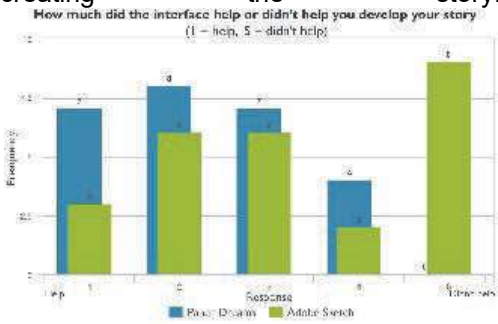


Figure 9. ***Based on the distribution of the Likert scale survey question "How much did the interface help or di dn't help you develop your story?", users indicated that the Paper Dreams interface was more helpful in developing their story than Adobe Sketch.***

Of the 6 u sers who indicated that the interface of Adobe Sketch influenced their storyline, only two mentioned that they got inspiration from the variety of brushes. The others said that they simply had difficulty translating their ideas from concept to drawing due to lack of artistic skill, and therefore were forced to simplify their story.
The most popular feature and source of divergent thinking for Paper Dreams were the Inspiration Panel, which is populated with related or not-so-related objects via the serendipity wheel; Fifteen out of the twenty-six users specifically mentioned that interactions with the Inspiration Panel assisted them in getting and p roducing new concepts for use in developing their storyline. One of the participants said, *"I had no idea about what I was going to draw, but the*

different drawing suggestions of the same class gave me some new ideas about moving ahead with the story." Another commented, "I think that Paper Dreams really helped in framing the story with popping up random words on t he screen which designed my ideas and acted as ink to my blank slate."

The second most influential feature in Paper Dreams, based on the study, was the adaptive texturization and v ariety of generated colors. One-third of the participants mentioned the colors in their description of their story-generating thought process. Based on u ser

responses, the adaptive texturization played the following roles in influencing the storyline of the user:
● Changing the overall mood of the story, or of a c haracter
○ Another user said, *"I was drawing a nice and relaxing landscape but the colors came out very dark (grey, purple, blue) so I came up with a different story which was tenser."*
○ One user commented, *"The colors were super bright and h appy, and m ade me switch from having the dinosaur be destructive (my original thought) to having her be a nice gentle dino."*
Allowing users to more quickly continue in developing the story, as they require less time coloring their visuals in.
● A user said, *"The automatic coloring made things go faster to some extent so I could focus on ot her things"*
Color the item with an unexpected hue, therefore changing the context of the item.
● A user said, *"I was trying to draw a tear but it came out red, which completely changed the context of the drop I drew."*

We also received feedback that the pre-made drawings in each class helped the users develop their stories more quickly and that they didn't feel limited from their drawing skills.
The features in Paper Dreams not only inspire users to include new ideas to their story, but they also help users develop their story more quickly because they do not need to focus on developing the visual components of their story from scratch, but rather the development of the actual plot.

Results and Discussion

Discussion

Our formative study helped identify the intuitive and unintuitive interactions that users had with Paper Dreams, and allowed us to be significantly more aware of improvements that need to be made to the interface. Primary suggestions include more intuitive drag handles to move individual images, an addition of an eraser tool, zoom controls for the canvas, and intuitive scaling of images. However, the principal insight gathered from the participants was that the interface was at its best when topics presented on the Inspiration Panel helped them get new ideas of concepts to use to develop their storyline. We propose that the current version of Paper Dreams is the most useful and enjoyable to use as a brainstorming tool for people who do not identify as creative.

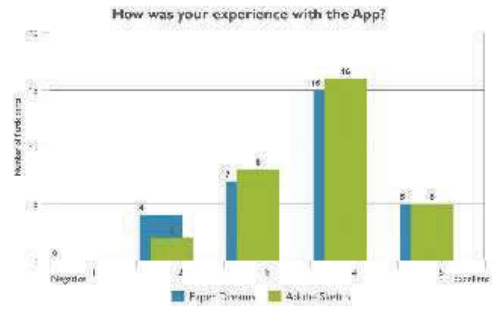


Figure 11. Based on the distribution of the Likert Scale Ratings of the experience of the user sentiment of experience is approximately the same.

Our current evaluation for Paper Dreams in this paper was by necessity a qualitative and exploratory one, rather than controlled, quantitative, and comparative one. Attempting to pin down artistic activities and their outcome is

notoriously difficult, if not impossible, and any results from such an analysis would have questionable value. While our evaluation does not allow us to make statements on t he superiority (or inferiority) of Paper Dreams over other creative workflows, we nevertheless feel that the results speak to the expressiveness of the system. Earlier, we theorized that the texturizer feature may allow users to more quickly develop their story, as they require less time to coloring their visuals to match the story. However, we are also considering the possibility that this feature potentially prevents the user from engaging in some retrospective dialog with their creation. This type of assessment and ideation could potentially take place while the user engages in automatic actions like coloring. This is visualizations is difficult to measure objectively, as discussed in previous sections.

While the coloring from the texturizing model can be a source of inspiration and evoke new moods in the user's story, some users voiced their frustrations that the abstract coloring of the image can diverge from the user's plan for their story. For example, one u ser said she tried to draw a tear, but it came out red instead of blue. Because of the user currently does not have agency over manipulating the color output, they may feel like they do not have full creative ownership over their piece.

After a certain point, users often commit to a vision of what they want to produce on the interface, and the system can continue to challenge those expectations. When the system goes against the users' ideas, such as continuing to generate new colors, the users tend to get frustrated. We speculate that people who self-identify as creative commit to a v ision earlier. However, despite these challenges, we believe our interface still accomplishes our goal of promoting divergent thinking.

CONCLUSION

We have presented Paper Dream, a platform for assisting a user's visual expression. Paper Dreams incorporates customized machine learning models in a creative workflow for stimulating serendipitous discoveries. The real-time feedback of the system allows for more efficient exploration of new topics of inspiration, thus promoting creativity. Although these serendipitous suggestions are an important part of learning, ideation, and creativity, most existing systems aim towards photo-realistic or geometrically correct content. This means that creative diversity and expression- key ingredients of artistic production- are often neglected. The ease with which users can sketch, edit, and c ompose using Paper Dreams focuses the control and creative freedom in the hands of the users. We performed a qualitative user study that has informed our work and showcased the utility of our ideas by letting both novices and ex pert artists create digital imagery using our workflow implementation. The participants found via sketch recognition and text input that Paper Dreams Inspiration Panel was helpful as a source for high-quality and imaginative results when they hit a creative block. We believe that tools such as Paper Dream are uniquely situated to meet these future challenges, but more work is needed in this domain.

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TITLE

An electronic orchestra as an ode to happiness*(Paper)*

Topic: (Art, *Music*)

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Abstract

In a modern world where the control of every person's actions is fundamentally suffocating; in a world where machines are more important than man himself; What can the ancient Greek philosophers of Classical Greece teach us about using machines aimed at supporting a good life and a timeless state of being?

The computer is an important tool for studying and analysing the quality of life of human beings, as applied to the creation of simulations of life in the social sciences. According to the ancient Greek philosophers, such as Empedocles, the two fundamentals as well as opposing concepts which summarize the philosophical view of the question “what is life” are namely *φιλότης*, which means love and *νεῖκος*, which means disaster.

How can a person, taking into consideration his own love of life, overcome his fear of death? Is it possible through the scientific method of simulating artificial life to study how man manages to live a happy life?

The particular proposal is an exploration of life as an open possibility, where disasters can happen to any of us, and the way we deal with them is to eliminate the self-centred perspective on life and focus on the spiritual need to create a realm of free reality where deviation from fear promotes both the perpetuation and the happiness of the whole.

According to modern studies on computation of emotions, the way in which the question of developing an artistic representation of a given process for achieving safe emotions is influenced by the study of robotic emotional intelligence, as described by Braitenberg in his book Vehicles. Braitenberg offers us a field for exploring the world of emotions through the attraction and repulsion of mechanical bodies to and from one another.

Finally, reflecting on the tradition of ancient Greek tragedy as well as poetry and folk songs and myths that within disciplined emotions such as sorrow and grief, are born, the product of this methodological overview, is the transformation of emotion through electronically applicable algorithms into music that excommunicates fear.

Concluding, in an attempt to transcend the ancient Greek tradition of the art of song and theatre, this particular study is given as a hymn to the god Dionysus, who bears Eros, and the god Hades, who bears Death, and who according to Heraclitus: Dionysus and Hades are one and the same.

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Key words: love, life, death, machines, felicity

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An electronic orchestra as an ode to happiness

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Premise

1. Abstract

The particular research is inspired by the philosophical thinking that explores the relationship of man and death through the poetic short stories of cosmogony, which occupy the places of study of metaphysics and ontology. The focus of the research study is the thumic of the soul, where thumos is an ancient Greek word that means the whole of the emotions of the human soul[1]. As a result, the particular analysis of the term thumos generates the phenomenological study of the four movements of the human soul, which have been suggested by Plutarch and symbolize desire, delight, fear, and sadness[1]. The concept of thumos functions as a bridge that connects and separates the study of the emotions of human beings, to and from the scientific research of the necessity in the natural world. Thus, philosophy as an intermediator establishes the observation of the individual's spiritual movements within a cluster of morphogenetic laws.

2. Introduction

I follow Plutarch's significant example with regards to finding the paths of becoming that have the potential to lead to a harmonious relationship of the inner world with the outside world of human beings. Consequently, my primary focus is on the thumoid functioning of emotions as the whole of the soul. My interest lies in the process that the soul could follow to remain in a macroscopically steady escalation of emotional expression, where individuals learn to curb the external forces that impose on human beings' daily actions. In order to succeed in fulfilling the events of the course of the forces of the soul that move it proportionally to the union and separation of the imaginary from or with the physical reality, I would like to explore how and if it is possible to purify the human body internally. Thus, the goal is to design an audio-visual, tangible, therefore sensible network of the links that shape the stages towards euthymia, which is described by Plutarch as the learning process of the well-being of the whole of emotions[1].

Plutarch has claimed the ability of human beings to train their own and others' emotions[1]. Thus, in his letter to Pace, namely on euthymia, it is suggested that humans are capable of reining in the sensible world by using the wit as a precept formed through the study of significant examples[1]. Through paradigms humans are able to regard collective production of the states of human behaviour as a fundamental principle in the process of knowledge production.

3. The behaviour of thumos

Moreover, Plutarch suggested that the individual should learn from his or her example inspired by his own studying of the creative forces in human behaviour through the light of Empedocles's pre-Socratic philosophy[1]. Empedocles theorized human behaviour based on the phenomena that could describe the movements of the human soul following the logic of the constant interaction of cosmogenic forces[2]. According to Empedocles's belief that there is no birth or death has been developed the notion that exists today that the knowledge of the relationships of the four forms of material states, water, earth, air, and fire have an archetypal morphogenetic character[2]. Empedocles advocates that the strong ties of existence are moved continuously by two forces love and destruction as unifying and opposing agents who have always been and will be co-existents in the world's alternating circulars, affecting the universe and especially the human soul[2]. The relationships of the two forces as unfolded in Empedocles' philosophy describe the mathematical and physical concept of the tendency of bodies to appear ostensibly through the perpetual repetition of circular designs created by the need for agencies to co-operate, coexist and be opposed. Today, in the field of neuroscience, the philosophy of Empedocles describes precisely the functionality of the amygdaloid core of the human brain. In particular, in the neural networks of the amygdaloid core are primarily structured all the human emotions[2].

As a result, Plutarch's keys of well-being in combination with Empedocles study of primordial elements in their cyclical designation, structure the path of analysis of the soul. In this path, the soul has two fundamental forces, namely love and strife that move and mutate the human psyche in four dimensions, namely desire, delight, sadness, and fear, where the network of the individual ways shapes the complex behaviour of human beings. The individual then needs to discover the intellect of his or her movements within the thumic (the whole of emotions) space that is activated by the carving of the feelings and ideas underlying it. Last but not least, the relation of the human soul and the human's biological nature invites him and her to consider natural phenomena in terms of the inner world structure. In the light of the tendency of unifying and disintegrating forces that are common in the populations of individuals, gradations of emotional events shape the behaviour of each individual expands and contracts through the states of interchangeability of the recipients and the attractors. And for this reason, today Empedocles is considered to be the first neuroscientist, for he has attempted to interpret the dispositions of the human soul in expressing them as a collective entity, namely the thumos[2]. Thus, Empedocles's attempt has been to analyse human behaviour in relation to natural phenomena, which participate in the creation of matter, in the view of cosmogony based on the four pre-Socratic principles of matter [2].

4. The phase space of euthymia

This research calls upon the metaphysical principle of the dialectical method to study the inner world of human beings through the ontological philosophy that studies the fundamental forces which determine the formation and the degrees of change of morphogenetic beings in the ranks of the organization set by the unifying principle of the power of becoming, that has been described in physics, by Poincare in his recurrence theorem, as the tendency of the states of all systems to reach their initial state. In order to examine the kinetic character of the soul that has the potential to reach a euthymic state of movement, Poincare's phase space provides the tools for undertaking the goal to develop a system for the examination of the possible combinations that take place in the four thumic states of the human psyche[3].

I believe that the analysis of the emotional world of the human soul is important because of the necessity of the soul to be represented through the bodies of heavenly and earthly beings that take part in a space of change, where the soul is invariable over time and the deterioration of time over bodies move in infinite dimensions, focusing on how the knowledge of the soul in the body is transformed through action and repetitive experience. In the philosophy of Empedocles, the function of the soul as an infinite entity unfolds within the actions of the individual's senses, in the expression and internalization of the emotions which are inseparably connected with the course of the logical necessity of the chemical reactions of small entities in the process of synthesizing materialistic reality. Thus, the treating of the human soul, as described by Empedocles, in the phase space of Poincare, takes place the treading of the intrinsic movements of the human soul for the actuality of the physical space. As a result, the exploration of the stages of the soul in the whole of emotions becomes analogous to the way in which probabilities are open to a dy namic system, where the various velocities of sadness, joy, desire, and pleasure unfold as a whole and are curiously revealing a real sense of the actual space's stability.

Poincare, a 20th-century mathematician, studies movement in the behaviour of the paths that structure a crystal[3]. In this example Poincare examines through the composition of individual parts of space the dimensions of all forms, proposing to study the speeds of changes taking place in a probability space, in which there is a tendency to create repetitive motion as points of matter in a dy namic coupling system[3].

This paper serves as the construction of the thumic network through the design of the system for the uptake and transfer of knowledge by examining the possibilities arising from the links brought about by the movement of a few fundamental principles that are found in all the forms of the affection of the human soul. Therefore, the interrelated relationship of beings reflects the possible paths of the carving of emotions so that people can groom their lives through effective actions realizing their own example of participation as a member of a collective effort in which is possible in the harmonization of thinking within the living. Thus, within the treatment of the emotional states of human beings as topological references to the map that inscribes the change in emotions, the first step is to identify the relevant changes in emotions through their relationship with each other as parts of the whole, and in particular the possible states that human beings can find themselves in his interactions with other beings. Consequently, the question here is *what are the possible combinations that arise between the four intensive states of human emotions, namely, desire, delight, sadness, and fear?*

4.1. The movement of emotion as a dynamical system

In Plutarch's letter on Euthymia, a topological map was created for the understanding of the movement of the soul in four different forms, as a dynamical system[1]. In particular, the soul could move out when it was seeking a goal , it could move inside, when in fear, down when it was sad, and up when it was delighted[1]. Therefore, the structure of the network for the analysis of emotional interchangeability depends on the changes that embody the notion of significance through the distribution of emotions that each individual starts with and changes when in contact with another human being at one of the four possible states in different intensities that have four significant points in the trajectory of movement and change through closeness. Consequently, the soul can be

animated virtually through the representation of the movement of emotions with regards to the structuring of the thumos, the whole of emotions, as we experience them through the reflection of our gaining of knowledge on others and through the shared experiential space of becoming one's own self. The movement of the soul is then the representative character at each state. The factors that move the soul are two in number and are inseparable in every being, namely love and destruction. As a result, when the individuals are in fear, or desire, or are in delight, or in sadness there is a process that takes place internally, in order for each of these states of feeling to impose upon their actions and consequently to structure their decision making. Finally, knowing how one form of emotion changes into one of the other four forms and what their intensive differences are, lead to the second step of Poincare's topological methodology. Each emotional state is a finite point that is seeking for the shortest path towards euthymia, the well-being of the soul. In this particular path, the object is the soul that is driven by the coupling of the four degrees of freedom that are the significant finite points of deterministic behaviour, such as crying when we are sad, or imagining when we are desiring something that we do not currently possess, or hiding in the presence of a threat, or laughing loudly in a rapid expression of an ecstatic influence. Each of these manifestations of emotional stimuli alternate continuously in the long-term lives of human beings. The energy that fuels the emergent properties of the human psyche's flexibility is found in Empedocles's text on Nature in his notion of the Globe "Spherion" that negative and positive emotions are interchangeable and in order for the human soul to be attuned with the fact that the individuals live among populations of different beings with whom they interact, love has to prevail upon destruction in order for the successive harmonization of the process of becoming [2].

With regards to the third step of structuring Poincare's phase space, in the thymic system and specifically in the networks that structure the state of euthymia, the euthymic state becomes a point in the space of the learning process of living well, where the singularities of emotional forms determine the spatial possibilities of the soul. Thus, the outcome of the simulation of the movement of the soul as it is being experienced in the influence of the person's interactions, thumos underlines the tendency of the change of emotions in a four dimensional space, such as in a cubic or spherical form that constantly seeks the best path for reaching its initial state, a pulsating movement that makes possible the irreducibility of the human soul, through the examples of others in which takes place the optimization and minimization in the basing for attraction.

5. Computational analysis of auto-kinesis

Inevitably, Poincare's phase space generates the conceptually captured manifestations of emotional intelligence in the graphically and sonically capturing of the virtual. Accordingly, Empedocles's notion of the Spherion opens up the discussion for an embodiment of emotional intelligence. Therefore, the scope of the next section underlines the methodology for the computational design of a positively asserted learning process of well-being with guide, Valentino Braitenberg's conceptual framework for the generation of hypothetical, self-operating machines[4]. The approaching methodology follows Braitenberg's example through Craig Reynold's paper with the title: *Steering Behaviours of Autonomous Characters, which in turn is understood by Plato's concept of auto-kinesis* [5] [6].

In Ancient Greece, the relationship between teacher and student was not understood as a relationship of superior and inferior, but as heterotic in the sense that the lovers become loved in a return to themselves. Thus, the hetero is the relationship that highlights the essence of philosophical pursuit in which the lover and the loved are equivalent factors in the common reduction and absorption of the soul in the imaginary field. The pursuit of knowledge and the pursuit of the soul, share the friendship of wisdom. According to Braitenberg, in his third vehicle named love, love is the attraction of the soul as the basing of moving of a kinetic being, from its exposure to environmental conditioning[4]. In order for the vehicle to love the source it needs to stand and reflect close to it. Hence, love is described as a relationship of closeness and slowing down in the vicinity of the source. Also, love is described as a turning away from the source, because it functions as a resource, which can be both amplified and reduced in the presence of the vehicle[4]. At the same time love is also destruction, because there are other sources that reduce the resources, which the vehicle tends to attack. Hence, in the example of the Love's vehicle, the four movements of the soul are described in the thumos of love, where the whole of emotions is described as one entity, love, which determines the action selection process of the vehicle. By comparison Braitenberg's Vehicle of Love approach of the kinetic properties of emotions is similar to Plutarch's notion of thumos.

For the purposes of realizing computationally the topological thinking of the whole of emotions the heterotic relationship of the escalation of the soul in four dimensions follows the three steps of designing auto-animated entities that can be found in the methodology for the designing of steering behaviors of autonomous characters as proposed by Craig Reynolds[5]. For Plato auto-kinesis is the combining of the hetero-kinetic properties of the soul which structure the learning process of recognition, within patterns of flow of information that are repeated and can be understood better by example[6]. Hence, through hetero-kinesis the soul in a long-term exposure and personal growth succeeds the auto-kinesis and remains constantly attracted to learning, becomes curious about life itself.

5.1. Euthymia as process

The first choice in the design of the thumic system is the desire for euthymia, where the soul as an entity has the capacity to choose to move in four directions, in an emotional battle of the parts of the whole of emotions; as to find a repeated sequence of events in the phase space of intensive differences, where the changes in speed of the object, which in my case is the soul, are treated as the changes from the combinations of emotions that can be found in the example of Plutarch's topological movement of the soul[1].

Then the environment that emotional change is portrayed in is the interchangeable escalation between friendships and destructions, as described first by Empedocles in human behavior and in Braitenberg's self-operating machines. The ancient Greek infinitive chairein, which translates to I am happy, etymologically comes from the verb chó, which means spreading and the noun chóros that means space. As a result, the noun chará, happiness is understood as something that spreads throughout our psychic space and creates a broad intrinsic space for the individual. Finally, the infinitive of chairein, to be happy, is understood as being the soul. According to Plato, to this point the soul remembers its affinity with the idea, in its encounter with the Ideon man in which Zeus is born, the mind is born in the world of ideas and in order to achieve this final state needs to become auto-kinetic first, within the

catharsis of lives' passions as mentioned in Plutarch's letter on euthymia[1].

Thus, the steering behavior is embodied in the spherical relationship of philotis-friendship and neikos conflict, in a vector of love and strife that has a tendency for euthymic locomotion. Euthymia is apparent in the diffusion of instances that structure the escalations of the thumos with regards to the four privileged spaces of desire, sadness, fear, and delight. Eventually, there is no global plan for their movement but they move in populations of entities that carry pre-existing expressions for the emotional states of the soul, as those of the universe and thus emerge and decay, in a constant reshaping of their generative instances of successive recurrence.

5.2. The digital environment of the space of thumos

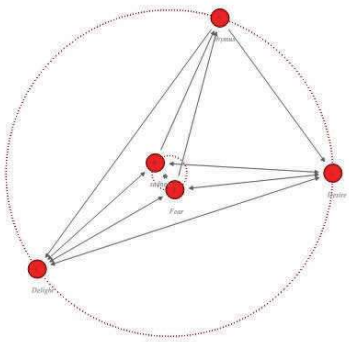


Figure 1: Diagram of the ten links in the synthesis of the movement of emotions in the thymic space

The computational model that I am proposing in this paper is a design of the unfolding of the emergent properties that are found in the auto- kinetic character of the human psyche in the exchange processes of the space of thumos, where the knowledge that drives the sensible world shapes the behavior of human beings in his or her relationships with the path they are coming from and the possible combinations of the exchange of information in the change of velocity of each of the possible four hundred differentially intensive entities. A starting population of the four different forms of emotions starting with a low intensity that moves slowly in empty space, according to the direction of each emotional movement, namely desire, fear, delight, sadness. The maximum and minimum amount of intensities is normalized in a scale of 0 to 1, where there is a ten percent probability of each of the four elements to come in contact with all the different forms.

The differences of the level of intensity of each of the form depends on the kind of movement that characterizes its emotion. The creature of desire tends to move outwards, and is very expressive, since it is constantly seeking other entities. The creature of fear, tends to hide, to move inwards, and its movement leads to abrupt changes in its behavior. The creature of delight tends to move upwards, in relevantly high velocity and great concentration of intensity, and thus, seems to be attracted by lower intensities. If the concentration exceeds the maximum limit of delight's intensity, the creature of delight tends to move erratically and has the capacity to calm in the presence of sadness. Last, the creature of sadness tends to move in very slow velocities and it tries to turn away from delight, that in turn escalates the movement of sadness, lowering its gravitational resistance.

Moreover, the spreading of emotions is achieved by the relationship of closeness that arises by their points in space where the emotions meet and new entities are generated from the connections that return the initial intensity for each form. Through the remembering of previous generations from the links that take place

in an emotional spreading the generations try to combine the properties of all emotions in later generations, to make friends creating clusters of entities of all forms that move them in a cyclical way. This way, groups of entities create instances of a phenomenologically stable behavior that is relevant to the initial state of each form with a given intensity. This behavior is realized in the continuity of repetition of movement in a class of four different entities that change their velocity, in relation to their point in space and the point of the other entities that come in contact with at the same point. In the scope of friendship creation there are also clusters of aggression that are structured, when fear's and sadness's levels of concentration, if the synthesis of both intensities exceeds the level of the maximum limit of intensities of the synthesis of delight and desire. Hence, aggression is amplified by repressive forces and the avoiding tendency of the particular tie of emotions. The creatures start to deviate from their selves' movement from the center and outwards in a two-dimensional space where the edges are eliminated to the wrapping around of a four-dimensional sphere. The attractors are delight and desire whereas fear and sadness are the absorptions of delight's and desire's concentration.

5.3. The conceptual design of an orchestra of emotional beings in physical space

If we take this imaginary field to the sensible world, from the digital environment where the interactions of the parts shape the dynamical system of the whole of emotions, to the embodied movement of mechanical multisensorial creatures, in which the interactions of the virtual emotions are attuned to the environmental conditions of a physical space, as a computational artist I would like to produce harmonised melodies of friendships and conflict, through different intensities of light that flows through a series of a population of kinetic sculptures in the dialectics of euthymia. At the same time, different sine frequencies that are filtered in low and high pass filters whilst in the filtering of intensities of the population of emotions in their interaction generate a myth, which is the harmonious synthesis of euthymia of life-like improvisational and sensitive creatures. As a result, the sonic environment of thumos is emancipated in a subtractive synthesis of the clusters of friendship and conflict, respectively.

6. Conclusion

To conclude, this paper has served as an exploration of the common areas of topological thinking in the combined realms of cosmogenic philosophy and computational science. In this research, my goal has been to incorporate the capacity of human beings to train their emotions when aligning with an imaginary field. I argue, then that the conceptual analysis inside the virtual world of computer software has a significant aesthetic potential that can be found in the deepest traces of human behavior and it is up to the prevailing of successive attractions in the abstract practices of emotional intelligence in generative art.

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Metagaming Concepts for Analysing Techniques and Aesthetics in Bytebeat Performance: The Technology Tree, the Tier List, and the Overpowered
(Paper)

Topic: Music

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Abstract

Bytebeat is a music and audiovisual programming practice suitable for live coding performance and fixed media composition that limits the musician to a single-line mathematical expression, embedded inside a for-loop. Having developed in the *demoscene* culture, bytebeat coding practices carry a respect for achieving maximal and surprising results with extreme limitations on program size, CPU power, and the number and sophistication of the mathematical operators used. As an example, the "Forty-Two Melody," which is well-known among practitioners although its origin is not, is represented merely as `t * (42 & t >> 10)`, where *t* is a clock signal that increments by 1 with each iteration of the for-loop. Bytebeat's dense level of mathematical abstraction is what keeps the artist in an exploratory (rather than deterministic) programming mindset, especially during a live coding performance, even if a random number generator is not employed.

Although it was introduced in 2011 by Ville-Matias Heikkilä (known by the screenname viznut), the bytebeat technique would have been possible before Max Mathews famously created the first music and sound programming language (called MUSIC) at Bell Labs in 1957. Bytebeat represents an opportunity for exploration that had been missed since the mid-1950s, sometime after Alan Turing (UK) and Geoff Hill (Australia; both working separately) first used computers to create melodies by varying the speed of the computer's alert buzzer in 1951. The fact that this programming technique lay unexplored for 60 years—most of the history of the digital computer—emphasises the extremeness of the limitations bytebeat programming imposes on the musician. Additionally, since Mathews' programming paradigm has been used in almost every digital audio application in existence, dividing a program into a virtual *orchestra* (i.e., sound generators) and a *score* (i.e., sheet music, or control-rate instructions for the orchestra to play music), bytebeat, as an approach that could have preceded Mathew's orchestra–score model, almost bares the cachet of an alternate history come to life.

Although the standard definition, limiting bytebeat to a single mathematical expression inside a for-loop seems straightforward and limiting enough, subtle differences in the functionality of bytebeat interpreter programs reveal distinct levels of purism and yield significantly different creative possibilities. To facilitate technical and aesthetic analysis, the concepts borrowed from gaming, including the *technology tree,* the *tier list*, and being

overpowered, (as in *Civilization* and analyses of games like the *Street Fighter* series) provide useful frameworks for articulating the values at play in various approaches to bytebeat performance.	
morris@tamu.edu	***Key words:*** audio, computer history, live coding ***Main References:*** [1] F. Tresham, Civilization. United Kingdom: Hartland Trefoil, 1980. [Board Game]. [2] V.-M. Heikkilä, “Discovering Novel Computer Music Techniques by Exploring the Space of Short Computer Programs,” arXiv, Dec. 6, 2011. https://arxiv.org/abs/1112.1368

Metagaming Concepts for Analysing Techniques and Aesthetics in Bytebeat Performance: The Technology Tree, the Tier List, and the Overpowered

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1. Introduction

As a composer, I make music for a variety of unique situations, including site-specific work and serious concert music for toy piano, slide whistle, and Sudoku puzzles. For each work, I seek a composition technique that engages and challenges the situation at hand, e.g., turning glitches into featured elements or using data about a place to shape music that will be played there, an approach I call *native composition*. Feedback loops, intermedia translations, and intentional misapplication are common techniques in this approach, and they require an intimate understanding of the situation at hand, including any subject matter and media involved, in order to find ways to make it sing most naturally. In my technology-based performance, I have pursued bytebeat programming, which is such a heavily constrained protocol that the programmer is constantly immersed in — and must wrestle with — the most basic nature of the digital computer. It is so restrictive that it almost seems impossible to make any serious music with it, especially by any familiar and convenient techniques, and many basic achievements feel like clever hacks.

I taught a course on bytebeat programming in spring 2019 at Texas A&M University. As I prepared demonstrations, as the class discussed and explored examples, and we created solo performances and improvised together, we created tutorials, began compiling a knowledge base, and encountered many accidental discoveries about bytebeat programming, its tools, and its aesthetics. This paper is not a tutorial on bytebeat programming techniques, but certain technical concepts are explained in order to facilitate a discussion of aesthetics.

Structures from video games like the technology tree and the tier list emerged in our knowledge base as we continued to fill and organise it. Practical needs for focused assignments, improvisational prompts, and clear and fair grading led us to adopt gaming concepts like *challenge modes* and the *overpowered* in our discussions. In reflecting on the lessons of our bytebeat experiences, the *metagame* emerged as an enlightening framework for discussing the aesthetics of bytebeat and exploratory programming in general, as well as the nature of exploratory research.

2. Background

This discussion brings together concepts that are related in complex or subtle ways, and ones that seem increasingly distant from music and aesthetics. Before bringing them together to discuss techniques and aesthetics in bytebeat performance, this section presents each concept separately.

2.1 Bytebeat

Bytebeat is a computer programming practice for making music from a single line of code, often a single mathematical expression with a highly restricted set of operations. It was introduced by Ville-Matias Heikkilä (known by the screenname viznut) in 2011 [1]. It received a flurry of attention for a couple of years, fell into obscurity as a novelty, and has recently attracted more serious attention by a few scholar-artists [2], [3].

In this protocol, a bytebeat interpreter program allows a user to enter a mathematical expression that applies arithmetic and logical operations to a variable, *t*, which represents time as a constantly rising counter. The interpreter evaluates this mathematical expression inside a for-loop, sends the evaluation to the audio output, and increments *t*. It continually re-evaluates the expression and sends it to the audio output with each new value of *t*, usually around 8,000 times per second for an acceptable audio sampling rate.

For example, the following expression creates a brief looping passage known as the “Forty-Two Melody” (origin unknown). It includes multiplication (`*`), a bitwise AND operator (`&`), and a bitwise right-shift (`>>`):

```
t * (42 & t >> 10)
```

One popular bytebeat interpreter, which we in the class came to call by the handle Greggman, as it was created by Gregg Tavares, runs in a web browser [4]. Since many bytebeat interpreters allow users to change the input expression in real time, they can be used for live coding performances. The dense level of mathematical abstraction is what keeps the artist in an exploratory (rather than deterministic) programming mindset, especially during a live coding performance, even if a random number generator is not employed.

This practice emerged from the *demoscene*, an art- and skill-focused outgrowth of the early software *cracking* community (which means to bypass software copy protection mechanisms). Whereas early software crackers would add animations to cracked software in order to sign their work and further demonstrate their skills and style, the demoscene leaves cracking aside and focuses solely on the programmer’s ability to achieve the most creative and sophisticated results from the most compact code.

Since bytebeat code is so constrained and compact, it does not require fast or sophisticated computer power. It would have been possible (as a non-real-time practice) as early as the mid-1950s, sometime after Alan Turing (UK) and Geoff Hill (Australia; both working separately) first used computers to play melodies by varying the speed of the computer’s alert buzzer in 1951. Artist-programmers could have pursued bytebeat even before Max Mathews created the first music and sound programming language, called MUSIC, at Bell Labs in 1957. So, bytebeat is an anachronism, a branch of computer music history that was made possible in the 1950s but lay unexplored for almost 60 years, while history instead built upon Mathews’ MUSIC language and its

orchestra–score structure that became pervasive in almost every computer music development after it.

2.2 The Technology Tree

First appearing in the 1980 *Civilization* board game [5] and having expanded in the long-running *Civilization* video game series since 1991 [6], the *technology tree* (or *succession table*, as the original game called it) is a branching path of options for players to advance their abilities within a game incrementally, building upon previous choices. For example, since *Civilization*-style games mimic the historical evolution of human societies, when players have opportunities to advance their respective societies in the game, they might choose to "research" incremental options in the agriculture path, in order to develop animal husbandry abilities, which allows them to develop horseback riding skills in future turns, which in turn makes cavalries possible. Alternatively, players might choose to advance along a path that starts with mining, which leads to metalworking, which can enable better construction, weapons, or other technologies. The technology tree throttles the evolution of gameplayer abilities by forcing players to prioritise certain paths over others or to prioritise breadth over depth. It balances power while promoting diverse abilities and strategies among players, keeping the game fair and engaging. Tuur Ghys [7] gives a comparative analysis of technology trees in this type of video game, within a Game Studies context.

For applying this structure more broadly, the hybrid term *succession tree* might be more neutral and appropriate. Even *Civilization*-style games include paths to develop aspects of culture and government, but the term *technology tree* is still used the most, and it is unproblematic to use in this paper, given its subject matter.

2.3 The Tier List

Compared to the technology tree, the *tier list* deals with similar factors, but it considers them from the opposite perspective: it is asynchronic, ranked taxonomy of game characters or tools in their completed states or their current states of development, for analyzing a game in terms of balance or for a player to strategically choose game characters or tools that would perform favorably against a given challenge. Because of this application, tier lists often emerge from players' analyses of games, periodicals that review video games, and organizations that host gaming competitions. Tier lists inform *balance*—a fair fight—as weight classes were meant to do in boxing, and good balance is considered essential for satisfying gameplay.

Tier lists may be compiled by comparing individual attributes (if they are quantified and disclosed, e.g., speed, intelligence, or hit points), by considering the results of past matchups, by public opinion polls, or simply by intuition. They commonly result in grouping characters that are approximately balanced with each other, each having different particular strengths and weaknesses in relation to the others. Because video games are popular media and tier lists are heavily discussed among gamers, this concept has made its way into Internet memes reflecting on other aspects of life and culture [8], and it has proven to be a useful framework in popular media outside of gaming. This is in part because, as a tool designed to assess balance, it exposes areas that lack balance, in which one element is *overpowered* (or *OP*) in relation to another.

2.4 The Overpowered and Its Opposite

Applying a tier list framework to phenomena outside of gaming can lead to novel and valuable observations. For example, a Tier Farm video on evolutionary biology [9] states: “Sloths are the worst-ranked build in the entire game [i.e., current reality].” It goes on to describe ancient sloths, in contrast, as overpowered, and surprisingly, and it argues that the overpowered Ice Age sloths died out because they were overpowered, leaving only modern sloths surviving. It concludes that “sometimes it pays to be low-tier.”

Beyond the notion of winning, however it is defined, early game designer and theorist Chris Crawford emphasised the “illusion of winnability” [10]. Besides the obvious goal to win a game, this statement has two equally crucial and opposing components: if a game is impossible to win, a player will be unmotivated to play it; however, motivation also wanes when the game is finally won. Therefore, Crawford stipulates that a player must feel like a game is winnable and that this must remain only a feeling. Winning must remain elusive, or else the game will end. Of course, some games do end; on the other hand, there is more than one way to play some games.

Overpowered elements are considered poor game design, and using them is considered to be dishonourable, because it usually leads to predictable, uninteresting gameplay. Conversely, and beyond simply avoiding overpowered elements, it is considered especially honourable to take on special challenges in gameplay, such as using the weakest character or by completing a game with the lowest score possible (in a game that expects players to pursue high scores) [11]. These may be self-imposed, stipulated by competitive organisations, or offered in the game as special *challenge modes*. This is a kind of honour similar to that found in demoscene and bytebeat communities.

2.5 The Metagame

The point of a game, within the world of the game, is simply to win. These gaming concepts, the technology tree, tier list, the overpowered, and special challenges, all consider the game from outside the world of the game. They serve strategic gameplay and the analysis of games, and they unlock other forms of honour, beyond the simple high score. Because they are about the game but outside it, and because they also may be game-like in themselves, these concepts come together under the term *metagaming*, or the game of playing games.

3. Applying Gaming Concepts to Bytebeat

3.1 Pedagogy

A technology tree emerged in our class knowledge base as I sought to introduce new techniques incrementally and break down examples so they could be understood in terms of more fundamental principles working together. The following demonstrates possible paths of learning and applying skills by navigating a technology tree. It is not necessary to understand the technical terms introduced here, only how they build upon and work with each other.

One branch of development might start with a *noise generator*. A relatively compact and satisfying (although not entirely pure) noise generator in bytebeat is as follows. Variables, spaces, and line breaks are used to facilitate readability and discussion, but they are not necessary.

```
a = t * t % ((t % 10) +
256)
```

Having achieved a *noise generator*, one could pursue multiple development paths. For example, to make a rhythmic burst of noise, create a *sloped ramp*:

```
b = t / 1000
```

Then use the *sloped ramp* as an *amplitude envelope* (fading it out over time, restarting each time you restart the interpreter's clock):

```
a / b
```

The whole resulting program would be:

```
a = t * t % ((t % 10) +
256),

b = t / 1000,

a / b
```

Or, in its most compact form:

```
(t*t%((t%10)+256))/(t/1000
)
```

While this is not a very interesting result in itself, it is on a path toward creating something like the following code. To use terms from our technology tree, it *encapsulates* the *sloped ramp* (by applying `% 256` to it), to make a *recurring amplitude envelope*, and it replaces the slope of that *sloped ramp* with another *sloped ramp* so that the rate of the *recurring amplitude envelope* changes over time.

```
(t * t % ((t % 10) + 256))
/
((t / (( t / 1000) % 50))
% 256)
```

In an alternative path of development, one could take the original *noise generator* and combine it with a *sample-and-hold* function to create a *random number generator* with an arbitrary rate of output. Having created this *random number generator*, one might add its latest output to its previous output to create a *drunk walk.* Or, one could apply a *Boolean* test (e.g., `> 128`) to the *random number generator* and multiply the result by some other sound-generating code (a technique called a *gate*), which would create a *sieve* (which would turn the sound on and off, randomly). Explaining all of these terms is beyond the scope of this paper, but I have taken care to use the most standard and clear terms for each of these techniques as they lie along their respective paths in the technology tree.

3.2 Taxonomy

In the class, while conducting controlled demonstrations to isolate and teach about certain specific aspects of bytebeat programming, we discovered several undocumented differences between bytebeat interpreter programs. The task of an interpreter seems straightforward, all interpreters appear to be roughly equivalent regarding the basic task, and these differences may seem inconsequential. However, they resulted in significant differences in musical results and even made it impossible to reach some areas of the technology tree using a given interpreter.

For example, most bytebeat interpreters allow users to assign values to variables that can be used elsewhere in the code. However, some interpreters initialise these variables outside the for-loop. This

means they are *external variables* in relation to the bytebeat code. This allows a user's code to recall the last state of a variable so that information can persist across iterations of the for-loop. Without external variables, recursive variable assignments are impossible (e.g., `x = x + 1`), and this is necessary for many common and rewarding structures, such as the *sample-and-hold* and *drunk walk* mentioned above, as well as counters and Euclidean rhythms. BitWiz [12] is an interpreter that uses external variables. Greggman does not, although we discovered an exploit that would allow us to achieve this functionality in some cases.

So, interpreters that allow external variables lie in a different category of sophistication. On the one hand, one might argue that such *stateful* code is more impressive because it has a larger technology tree to master and coordinate; on the other hand, one might say stateless code is more respectable because of its greater limitations or because it is more pure or elegant. Either way, we realised that it is worth segmenting technology trees into tiers like these and that the knowledge of what tier a programmer is using can affect our impression of the performance.

Another tier includes interpreters that do not limit themselves to the 8-bit (range of 256) output values that are traditionally used. Greater bit depth yields higher audio quality and smoother control curves, yielding a less glitchy, noisy, and retrospective sound. Indeed, since most interpreters run on computers that can handle floating points, the tradition of dealing only with integers is nostalgic but not necessary. Further, restricting outputs to low-bit integers is not necessarily authentic to historic processors. Through accidental discoveries and controlled follow-up explorations, we discovered that some interpreters preserve floating-point values until the final output, which a computer without a floating-point processor would not be able to do. Differences in when and how values are integerised (e.g., by rounding down, up, or to the nearest integer) can significantly affect the resulting sound and the user's capability. For example, although "`/ 1024`" is considered equivalent to "`>> 10`," the following two expressions yield drastically different results in Greggman (a bass arpeggio versus a smooth full-range sweep), whereas both versions sound identical in BitWiz (bass arpeggio):

```
t * ((t >> 10) % 4)
```

and:

```
t * ((t / 1024) % 4)
```

Further, code that uses trigonometric functions stands apart from others. A sine function allows users to achieve common computer music techniques like additive synthesis and frequency modulation synthesis easily. Trig-tier code allows greater sophistication, but it is less native to the notion of bytebeat, and it is more like other platforms that would be easier to use instead.

Other classifications include (a) infix notation (as used above) versus postfix notation (as in Reverse Polish Notation), which makes certain coding techniques easier and others more difficult, especially during live coding; (b) external control inputs, such as accelerometers, cursor position, MIDI or OSC input, or even audio input; and (c) video capability, allowing the same code to create sound and animations, as with Heikkilä's *IBNIZ* [13].

Taxonomies emerged pragmatically in our class knowledge base, to segment our technology tree into levels of difficulty and to articulate the strengths and limitations of a given interpreter. However, they also

allowed us to begin to reflect on other thoughts to be had about a performance, once its tier or class is known.

3.3 Aesthetics

The technology tree concept is parallel to the pedagogical concept that made it necessary for my teaching (and for my learning): the zone of proximal development. Early twentieth-century psychologist Lev Vygotsky depicted the education process by articulating the set of things a student has mastered and the set of things the student has not mastered. The *zone of proximal development* is the liminal area, where learning objectives lie that are outside the student's area of mastery but which the student could master, with assistance (by an instructor) [14]. This process bears a resemblance to Crawford's "illusion of winning" in game design. The technology tree makes learning incremental and makes the zone of proximal development apparent, while it remains impossible to master all the possible combinations of techniques and creative ways to use them.

This concept of balance between the possible and the impossible can also be rewarding to audiences, even if they are not trained in performance. For example, watching a live, acoustic performance of Rimsky-Korsakov's "Flight of the Bumblebee" [15] is exciting, in part because of the violinist's obvious training effort and dexterity. Using a piano roll MIDI sequencer to play the same music would not achieve the same excitement, even though it could play much faster than the violinist. This is because the piano roll is overpowered in relation to the violin, in this case.

Next, consider this version of the same music:

```
t*((p=(q=t>>11)%4<3)*18+(
        (r=1-p)*2-
  1)*(t>>9)%4+r*13+(q&1))
```

This version of the opening motive is titled "Byte of the Bumblebeat." (An attentive listener will notice that this is slightly different from Rimsky-Korsakov's version; this is discussed in section 4.1.)

Even though it is like the piano roll version in that it is fully automated and only requires a human to press the Play button, the bytebeat version might impress more audiences than the piano roll version because of the difficulty of the challenge. Here, speed and accuracy are not the challenges; mathematical complexity and elegance are.

It is traditional to include a visual element in laptop music performance. The Dallas-based Laptop Deathmatch series (now defunct) scored stage presence along with creativity and technique. It emphasised giving the audience something to look at, at least by using an external control interface [16]. Projecting the performer's computer display during a live coding performance has become a common solution. Even for non-programmers in the audience, seeing the code change and hearing the sound change at the same time makes the music seem accessible or graspable, even more so if raising or lowering a value results in a noticeable increase or decrease in some aspect of the sound. Even this barest understanding of the performer's technique can make a performance more engaging, when the next incremental level of sophistication appears graspable while the full range of creative possibilities feels infinite.

This might lead one to conclude that visual elements or background knowledge are necessary in order to make rewarding musical experiences; however, this is not true. Such *extramusical* factors (i.e., outside of the music) are often effective in

making performances more engaging, and they are often unavoidable — acoustic performances always require the performer to move, and those movements betray information about effort and skill. Because such elements are both effective and unavoidable, it is easy for an audience to rely upon t hem instead of focusing solely on the musical content of a performance. The path to purely musical enjoyment involves the zone of proximal development and a bal anced “illusion of winning” as well, suggesting that some form of honour might come to an adventurous listener. However, that is beyond the scope of this paper.

Still, among practitioners, honour in gaming, e.g., by embracing challenges and not overpowered elements, is parallel to honour in demoscene and by tebeat programming, e.g., creative and elegant results despite constraints, and taxonomies help articulate those properties. One element of risk in bytebeat that is similar to the violinist’s constant risk of missing a note might be to use an interpreter that does not implement an error checking process to prevent a typed syntax error ruining a l ive coding performance.

Beyond considering the capabilities of the bytebeat interpreter software, taxonomies could also classify various limitations on the coding techniques used. For example, it may be considered more honourable to code without using commas, which arguably break the “single line of code” definition. In class, we discovered and developed a number of techniques that lie outside the code, including clever uses of undo, redo, cut, and pa ste functions, line breaks, comment characters, and even physical, dextrous typing techniques we came to call *backspace flams* (replacing single characters almost instantaneously by pressing Delete or Backspace and then typing a new character, all in a quick, two-stroke gesture) and *padding* and *trimming* (quickly jumping to larger or smaller orders of magnitude by placing the cursor somewhere in a number and inserting or deleting any digit, any number of times).

3.4 Nativeness

We used the following guidelines for the purpose of grading in the class: (a) performed the full work in a bytebeat interpreter from beginning to end, limiting any post-processing to minimal cleanup; (b) only use basic arithmetic and logic operators (e.g., not the sine function); and (c) keep it “native,” i.e., do not use bytebeat to achieve something that would be more appropriate to do in another platform, e.g., additive synthesis, sample playback, or sequencing; external controllers and data inputs were allowed, as long as bytebeat was not used as in a static way, as a synthesizer.

Further, while it was not prohibited, we sought to avoid falling into Mathews’ familiar and pervasive orchestra–score paradigm, which divides code into signal-rate sound generators (as musical instruments) and symbolic, control-rate instructions for the orchestra to play (like sheet music). This was another guideline in pursuit of discovering and reflecting on bytebeat’s native idiosyncrasies. Although it is familiar and s ensible, the orchestra–score paradigm adopts the model of musics that are structured in other ways and probably would be unnative and unnecessarily awkward to realise in bytebeat. In contrast, bytebeat deals more naturally with code in which the sound-producing and sound-controlling elements are inextricable. For example, changing one character in “Byte of the Bumblebeat” can dramatically change pitch, rhythm, loudness, and timbre, all at once, whereas a single change in the score for “Flight of the Bumblebee” might well go unnoticed.

Beyond the practical need for a clear and fair grading policy, and beyond the notions

of challenge and honour (which are, after all, extramusical factors), the purely musical interest in considering classes and tiers of bytebeat tools and techniques lies in the fact that they each sound different: they yield different subspecies of bytebeat music. Since the goal of this pursuit is to understand bytebeat's idiosyncratic nature (rather than to turn bytebeat into other things), recognizing and analyzing taxonomies — including both their potential and the side-effects they introduce — facilitates understanding by helping to define purism, or different types of purism, and various deviations from it, in relation to their impacts on creative processes and products.

4. Discussion

4.1 More about "Byte of the Bumblebeat"

My approximation of Rimsky-Korsakov's "Flight of the Bumblebee" in section 3.3 differs from the original motive, in that the original version uses groups of 5–3–4–4 notes, respectively, but my version only uses constant groupings of 4–4–4–4. This is in part because of difficulty but also to facilitate discussion. Because of time constraints, I would only be able to realise the 5–3–4–4 grouping pattern by using a certain technique that would simply be overpowered for this task.

Ken Downey found a way to use a bit-shifting operator on a single, large hexadecimal number, to create a step sequencer [17]. While this is a very clever achievement, it would be similar to using a piano roll MIDI editor to play "Flight of the Bumblebee," and I remain confident there is another approach that is more appropriate to the scale of this task and of the rest of my code. Although I stopped my work on it in order to discuss this choice, in my next step, I would try to exploit the rounding artifacts of integerising the quotient of a ramp, wrapped and scaled to a range of 3–5, and offset so that it begins on 5 bef ore wrapping around to 3. I haven't achieved this yet, so I could be wrong here, but it would be a more honourable approach to this task.

Honour aside, Downey's single-number step sequencer technique opens a set of possibilities so wide that it is worth considering as a s eparate tier of technique. For my goal of replicating "Flight of the Bumblebee," that tier seems unnecessary, my finished product would be a v ery poor representation of music native to that tier, and inasmuch, I would be missing my greater goal of understanding bytebeat's musical nature. Here, extramusical honour and purely musical lessons about bytebeat are intertwined: honour has a stronger connection to my intuition than my abstract research subject matter does, intuition informs my path of inquiry, and the framework presented here helps me articulate musical reasons for that gut response.

4.2 The Metagame of Music

This discussion brings to light some notions that deserve further exploration in future work. Powerful tools are valued when the point is to complete a task. The dishonour of the overpowered reminds us that the point of gaming is to play rather than to finish, although success is also valued, in balance. This is also how extramusical elements can enhance a performance experience — not what is done but how it is done, the metagame of performance. Extramusical elements are not necessary for a r ewarding musical listening experience, but purely musical enjoyment relies more heavily on the mindset of the listener — a metagame of listening musically.

5. Conclusions

While a full technology tree and taxonomy are still in progress, this account shares unexpected lessons from the early stages of developing and analysing bytebeat techniques and aesthetics, toward realising a f ull technology tree and an optimal taxonomy of bytebeat techniques, which will facilitate further analysis and spark further creative exploration. To summarise the relationships among these concepts, the technology tree elucidates how different abilities are interrelated, and it informs choices regarding development paths. Tier lists group feature sets by approximate levels of sophistication or power, and they expose the use of techniques that are overpowered in relation to the established context and the task at hand. Special challenges lie in contrast to overpowered approaches. While they may be seen as more honourable, this is in part because they avoid invoking a hi gher tier of tools or techniques than is necessary, allowing the resulting achievement to more fully explore and manifest the essence of the tier it is primarily exploring. These concepts are all parts of the metagame, which, when applied as a lens upon musical aesthetics, articulates the influence of extramusical elements on audience experience, as well as the power and importance of the listener's mindset in listening musically.

Bytebeat purists are few if there are any. Most treat bytebeat as a mere curiosity and give the nod to demoscene-style honour but readily embrace more advanced taxonomies, perhaps because it feels challenging enough to work under the "single line" rule. I am not a pur ist, either, although I find it useful to see purism and deviations from it clearly defined. I have pursued this research path, most practically, for the pedagogy, including advancing my own skills in bytebeat performance. So, one c ould make the self-similar reflection (a metagame of research) that in pursuing my personal path of development as an artist-scholar, I chose to research bytebeat pedagogy, which led me to begin articulating a technology tree and led to analysis and theory. The technology tree put techniques at my disposal in performance, in a conceptual framework to navigate among them more facilely in performance, but it also allowed me to discover and articulate taxonomies of bytebeat interpreters, which allowed me to begin reflecting on t he aesthetics of bytebeat performance in the ways described here.

Thanks to Peter McCulloch for many enlightening discussions along this path of inquiry, and thanks to the students of PERF 318 Electronic Composition in spring 2019 at Texas A&M University for pursuing this inquiry with me. A playlist of performances and t utorials resulting from this class is available at: https://www.youtube.com/playlist?list=PLe4ojWnlX92OOrDhM8_yGIP9LNqSE_gR2

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TITLE : TRANSFORMATIONS IN ART
(Paper, Artwork)

Topic: (Art)

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Abstract
If we want to describe an elementary event of Art and we are calculating the probability amplitudes for the pure states of Art (base states), **we can start from a different representation.**
In other words, the angles between the filters of Art, that are of maximum relevance, can be observed with different perspectives. That is, someone else chooses to use a different set of axes.

Suppose we start with the same elementary event of Art ψ, we say state ψ, but we will describe it in terms of the three probability amplitudes $\langle i\,A \mid \psi \rangle$ that ψ goes into our base states of Art **in our representation** A, whereas another observer will describe it by the three probability amplitudes $\langle j\,B \mid \psi \rangle$ that the state ψ goes into his base states of Art **in his different representation** B.
We have:

$$\langle j\,B \mid \psi \rangle = \sum_j \langle j\,B \mid i\,A \rangle \langle i\,A \mid \psi \rangle$$

and to relate the two representations we need **the nine complex numbers of the matrix** $\langle j\,B \mid i\,A \rangle$. **Concerning an elementary event of Art, this matrix tells us how to transform from one set of base states to another**. It is the transformation matrix from representation A of Art to representation B of Art.
For the case of **SPIN ONE** elementary aggregates of Art, we need t hree amplitudes because we have three base states transforming like a v ector from one set of axes to another. We call this vector: **vector of an elementary transformation of Art**.

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Key words: transformations, art, criticism, digital
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[1] Name Libero Acerbi, "*The Wave Particle of Art* ", Biacer, Bologna, 2009

TRANSFORMATIONS IN ART

(excerpt from “The Wave Particle of Art”, Libero Acerbi, 2009)

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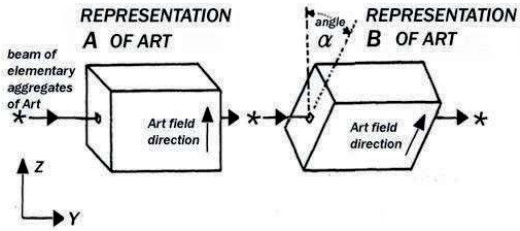
If we want to describe an elementary event of Art and we are calculating the probability amplitudes for the pure states of Art (base states), **we can start from a different representation.**
In other words, the angles between the filters of Art, that are of maximum relevance, can be observed with different perspectives. That is, someone else chooses to use a different set of axes.
Suppose we start with the same elementary event of Art ψ, we say state ψ, but we will describe it in terms of the three probability amplitudes $\langle iA|\psi\rangle$ that ψ goes into our base states of Art **in our representation** A, whereas another observer will describe it by the three probability amplitudes $\langle jB|\psi\rangle$ that the state ψ goes into his base states of Art **in his different representation** B.
We have:

$$\langle jB|\psi\rangle = \sum_j \langle jB|iA\rangle\langle iA|\psi\rangle$$

and to relate the two representations we need **the nine complex numbers of the matrix** $\langle jB|iA\rangle$.
Concerning an elementary event of Art, this matrix tells us how to transform from one set of base states to another. It is the transformation matrix from representation A of Art to representation B of Art.

For the case of **SPIN ONE** elementary aggregates of Art, we need three amplitudes because we have three base states transforming like a vector from one set of axes to another. We call this

vector: **vector of an elementary transformation of Art**.
FIRST CASE:



The two representations have the same y axis, along which the Artons move, but representation B is rotated about the common y axis by the angle α.

$$\langle +B \mid +A \rangle = \tfrac{1}{2}(1 + \cos\alpha)$$
$$\langle 0B \mid +A \rangle = -\frac{1}{\sqrt{2}} \sin\alpha$$
$$\langle -B \mid +A \rangle = \tfrac{1}{2}(1 - \cos\alpha)$$
$$\langle +B \mid 0A \rangle = +\frac{1}{\sqrt{2}} \sin\alpha$$
$$\langle 0B \mid 0A \rangle = \cos\alpha$$
$$\langle -B \mid 0A \rangle = -\frac{1}{\sqrt{2}} \sin\alpha$$
$$\langle +B \mid -A \rangle = \tfrac{1}{2}(1 - \cos\alpha)$$
$$\langle 0B \mid -A \rangle = +\frac{1}{\sqrt{2}} \sin\alpha$$
$$\langle -B \mid -A \rangle = \tfrac{1}{2}(1 + \cos\alpha)$$

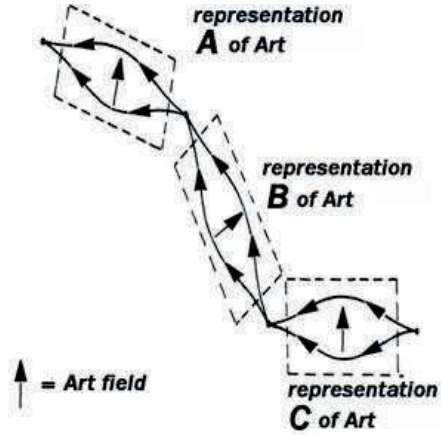
To transform from the set of coordinates x, y, z of representation of Art (or apparatus of Art) A to the x', y', z' coordinates of the representation B we have this relation:

$$x' = x\cos\alpha - z\,\mathrm{sen}\,\alpha,\ y'$$

Then, in this first case, the transformation amplitudes are:

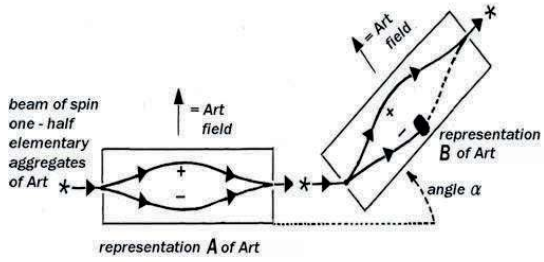
SECOND CASE:
The two representations of Art have the same z-axis but are rotated around the z-axis by the angle β.
Then the transformation amplitudes are just three (Artons do not move along z-axis):

$$\langle +B \mid +A \rangle = e^{+i\beta}$$
$$\langle 0\,B \mid 0\,A \rangle = 1$$
$$\langle -B \mid -A \rangle = e^{-i\beta}$$
$$\text{all other amplitudes} = 0$$



NOTE THAT ANY ROTATION OF B WHATEVER CAN BE MADE UP OF THE TWO ROTATIONS (AND TRANSFORMATION AMPLITUDES) DESCRIBED.

We consider an **apparatus of Art filtering a beam of SPIN ONE-HALF elementary aggregates of Art**. This beam, entering at the left, would be split into two beams (there were three beams for spin one). There is no zero state.



Suppose to make an experiment of Art adding a third filtering apparatus of Art:

Now what is the $A \rightarrow B \rightarrow C$ transformation of Art? We have a double transformation:

$$Z_k^* = \sum_i \sum_j R_{kj}^{CB} R_{ji}^{BA} Z_i$$

where:

Z_k^* = the probability amplitudes to be in the base states k of representation C of Art.

Z_i = the probability amplitudes to find any state of Art in every one of the base states i of a base system (representation) A of Art.

R_{ji}^{BA} = the transformation (rotation) matrix from representation A of Art to representation B of Art.

R_{kj}^{CB} = the transformation (rotation) matrix from representation *B* of Art to representation *C* of Art.

But all the beams in *B* are unblocked and the state coming out of *B* is the same as the one that went in. So three Art apparatuses work like two and we could write:

$$Z_k^* = \sum_i R_{ki}^{CA} Z_i$$



TITLE
Diluvio: Teatro delle Ombre
(Paper and Poster)

Topic: Architecture, Sculpture and Generative Process

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Abstract
"*You who speculate on the nature of things, I praise you not for knowing the processes which Nature ordinarily effects of herself but rejoice if so be that you know the issue of such things as your mind conceives."* Leonardo da Vinci

Diluvio: Teatro delle Ombre (*Deluge: Theatre of Shadows*) is part of *Cinquecento: Carleton Celebrates Leonardo da Vinci,* the 2019 year-long initiative at Carleton University commemorating the 500th anniversary of Leonardo's death in France on May 2, 1519. The author, as one of the originators of the initiative, conceived and coordinated this interactive and immersive exhibition as the culmination of the series of *Diluvio* installations for the commemoration. This is the recent work by students in the Crossings Interdisciplinary Workshop offered in the Fall of 2018 and the Summer of 2019 at the Azrieli School of Architecture and Urbanism. The overall project is inspired by Leonardo's *Deluge* drawings and his reflections on the inter-connected reciprocity within nature as revealed by his studies of the flow of water, air, light, shadows and energy. "*Learn to see,"* Leonardo observed, *"realize that everything connects to everything else."*

Additional inspiration has also been drawn from the correspondences between Leonardo's insightful reflections regarding visual perception and Plato's *Allegory of the Cave.* Leonardo recommended pondering and interpreting such elusively vague phenomena as cloud formations, shadows, resonant patterns, including evocative stains on walls as a way of stimulating and expanding the imagination and of gaining insight into the inner workings and generative potential of the mind and perception. Correlations can be drawn between this insightful process and Plato's classic allegory, where chained prisoners are rigidly held captive within a dark cave, perceiving only the visibly restricted shadow-reality ahead. Meanwhile, unbeknownst to them, the true nature of the *Light* entering the cave, casting these illusions of reality, dwells behind creating and limiting their perceptions. An interactive and immersive experience was offered through a flood of self-activated shadows, evoking and triggering the captivating *theatre of the mind*.

Working with aluminum mesh that's been folded into a very fluidly malleable origami pattern (even more so due to the additional pliable properties of the mesh) students were encouraged to experientially explore and improvise through the generative and emergent dynamic shape-shifting properties of the folded membrane. This included exploring the dynamic shadow projections offered by the variety of possible sculptural configurations generated, all the while drawing comparisons and inspiration from Leonardo's speculations

and studies of dynamic phenomena.

“ *… Look into the stains on walls, or the ashes of a fire, or clouds, or mud, or similar places, in which, if you consider them well, you may find really marvelous ideas … because by indistinct things the mind is stimulated to new inventions.*”
Leonardo da Vinci

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Key words: Generative process, Modularity, Emergence

Main References:

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Diluvio: Teatro delle Ombre

Interactive and Immersive Exhibitions/Installations for:
Cinquecento: Carleton Celebrates Leonardo da Vinci
from the Crossings Interdisciplinary Research Collective

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Abstract
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An interactive and immersive experience was offered through a flood of self-activated shadows, evoking and triggering the generative and captivating *theatre of the mind*.

Generative Woven and Folded Patterns
The generative haptic working process and material properties incorporated in *Diluvio* expand upon previous work from the Crossings Interdisciplinary Workshop. U nder the broader comprehensive initiative titled *The Phenomenological Garden: A Work in Morpho-logical Process*, these series of evolving projects have explored the morphological, integrative and generative potential of fundamental

processes that correlate with the fluently diverse and dynamic realm of natural phenomena. Through the emergent properties of "woven" flexible membranes (or networks) that perform as highly coordinated-cellular-arrangements of basic elemental relationships, a variety of forms, structures and installations have been conceived, fabricated and exhibited. The inherent properties of the cellular units, along with the nature of the materials and processes involved in the evolution of these projects, allowed for a generative and intuitive learning process to occur. More comprehensive information regarding these related projects is available through previous Generative Arts Conference papers: *Generative Dynamics: Process, Form and Structure*, 2004, and The *Generative Dynamics of X, Y and Z Coordination, 2005).*

The *Diluvio* series of related projects expand upon previous work where the dynamic and generative potential of an orthogonal grid composed of a ba sic square cellular unit was explored. At that time, the cellular units were constructed with bamboo dowels that were joined together with rubber bands, thus creating a very malleable joint. The assembly of these flexible joints and units into two-dimensional fields, along with the de-formation of the fields into inherent three-dimensional configurations, allowed for the form generating potential of both the individual cells and t heir assemblies to be easily and experientially explored. This overall dynamic flexibility and the complex emergent three-dimensional relationships, generated a wealth of forms and s tructures through the transformative and self-organizing properties of the integrated assembly (see figures 8 and 9 below and the Generative Arts Conference papers previously refered to).

Diluvio explored the generative potential of a significantly much larger orthogonally woven field (or membrane) comparable to those previously explored. This allowed for self-similarity at different scales of organization, along with related emergent complex properties, to be i nvestigated. Working with aluminum mesh that's been folded into a very fluidly malleable origami pattern (even more so due t o the additional pliable properties of the mesh), students were encouraged to experientially explore, conceive and improvise through the generative and emergent dynamic shape-shifting properties of the folded membrane. Eventually, this included exploring the dynamic shadow projections offered by the variety of possible sculptural configurations generated, leading to the *Diluvio*: *Teatro delle Ombre* interactive and immersive installation proposal. Throughout this process, students were drawing comparisons and inspiration from Leonardo's speculations and studies of dynamic phenomena. His studies of the dynamic flowing properties of water and related phenomena, including, most notably, his evocative *Deluge* drawings, were the main sources for the experientially conceived and proposed sculptural installations. As Leonardo stated in his notebooks: "*Water is the driving source of all nature.*"

The Generative Theatre of the Mind

The Greek philosopher Plato offered his *Allegory of the Cave* in his work *The Republic* (514a–520a) as a reflective dialogue between his brother Glaucon and his mentor Socrates. Narrated by the latter, the illusion of perceived reality is metaphorically presented as being interpreted by people living chained to a wall of a cave, while only being able to perceive the shadows projected on a wall by a fire behind them and the objects in front of this fire. These shadow-projections are presented as the

reality of the prisoners. Meanwhile, unbeknownst to them, the true nature of the *Light* entering the cave, casting these illusions of reality, dwells behind creating and limiting their perceptions. An enlightened person, such as a philosopher, is one of these prisoners who is freed from the chains, escapes the cave, and realizes that the shadows are mearly perceived illusions of the true nature of reality. Insightful correlations can be drawn between this allegory by Plato and Leonardo's quote above regarding "*the issue of such things as your mind conceives."* Leonardo acknowledges that these metaphoric shadows are illusions of reality, but emphasises that they also offer insightful clues regarding the nature of perception, how the imagination can be stimulated and how the pondering and understanding of this generative process can be appropriated. "*Learn how to see*," he writes regarding this generative process, "*realize that everything connects to everything else*."

Inspired by these correlations, *Diluvio*: *Teatro delle Ombre* offered students an experientially generative working-process whereby they were able to construct fluidly sculptural configurations while simultaneously understanding how the malleability of the folded membrane was achieved. The inherent dynamism of the conceived sculptures was activated and revealed through a moving light source (i,e., the cellphone flashlight) and the projected shadows. These mysteriously evocative shadow-projections and their related visual activations, "*if you consider them well,*" as Leonardo has reminded us, "*you may find really marvelous ideas … because by indistinct things the mind is stimulated to new inventions.*" Thus, with this insightful offering in mind, students and the public were encouraged to ponder and interpret the elusively evocative forms, shadows and resonant patterns generated through *Diluvio: Teatro delle Ombre* as a way of stimulating and expanding their imagination and of gaining insights into the inner workings of the mind and perception.



Figure 1: © M. Báez, *Diluvio: Teatro delle Ombre*, interactive shadow-projections.



Figure 2: © M. Báez, *Diluvio: Teatro delle Ombre*, interactive shadow-projections and sculptures.



Figure 3: © M. Báez, *Diluvio: Teatro delle Ombre*, interactive shadow-projection and sculpture details.



Figure 4: © M. Báez, *Diluvio: Teatro delle Ombre*, interactive shadow-projection and sculpture details.



Figure 5: © M. Báez, *Diluvio: Teatro delle Ombre,* exhibition highlighting the sculptures.



Figure 6: © M. Báez, *Diluvio: Teatro delle Ombre*, interactive shadow-projection and sculpture details.

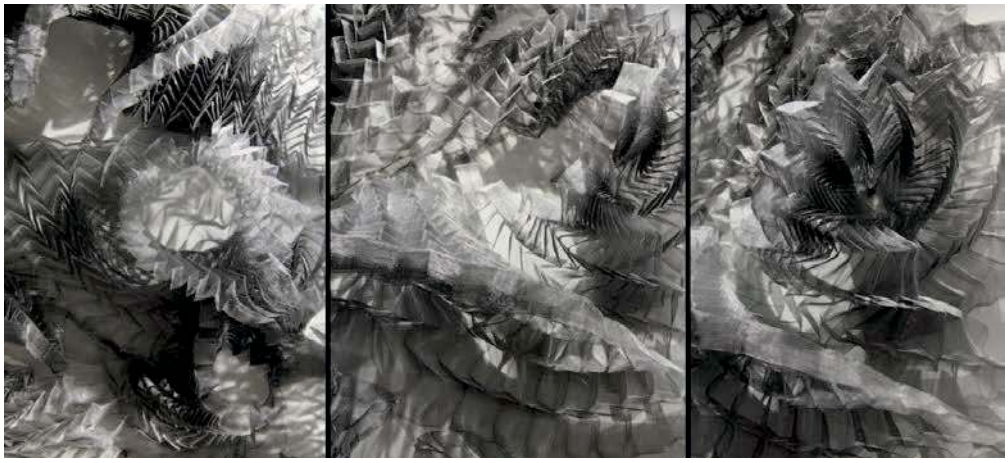


Figure 7: © M. Báez, *Diluvio: Teatro delle Ombre*, interactive shadow-projection and sculpture details.

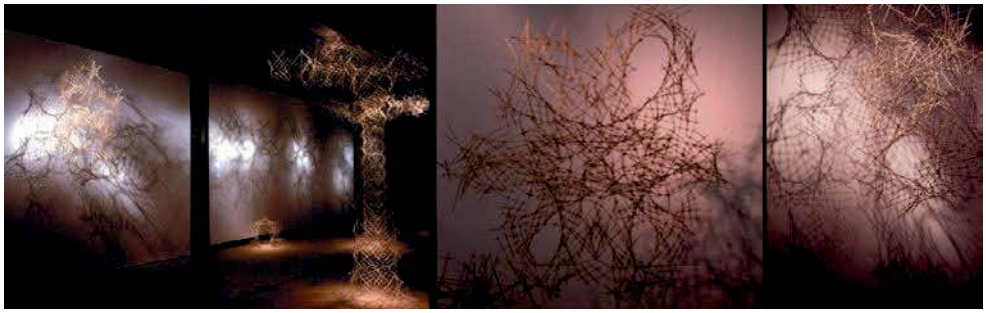


Figure 8: © M. Báez, *The Phenomenological Garden, previous exhibition inspired by Leonardo's Deluge drawings*.

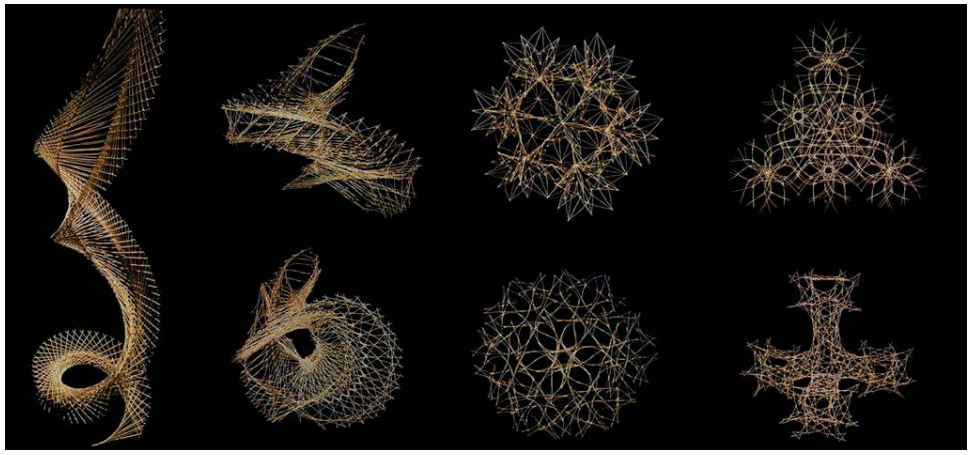


Figure 9: © M. Báez, *The Phenomenological Garden*, Crossings Workshop student projects, constructed from cellular units made with bamboo dowels and rubber bands (also as shown in fig. 8, using a square cellular unit).

Crossings Interdisciplinary Workshop *Diluvio*: *Teatro delle Ombre* student groups:
Daniel Baldassarri & Liam Yeaman

Abigail Maguire & Edyta Suska
Shaylyn Kelly & Walter Fu

Kaleigh Jeffrey & Stephen Scanlan
Elta Pulti & Mai Duraiappah

Alexis Almacin & Yana Kigel
Shirley Chung & Riya Garg

Stephanie Alkhoury & Lina Mahmoud
Jessie Wei & Walid Chikh Alard

Taskinul Hassan
Sami Karimi

Red Narvasa

Crossings Interdisciplinary Workshop *Diluvio I* student teams:
Hamid Aghashahi & Guillermo Bourget Morales

Daniel Baldassarri & Liam Yeaman
Abigail Maguire & Edyta Suska

Shaylyn Kelly & Walter Fu
Connor Tamborro & Jasmine Sykes

Kaleigh Jeffrey & Stephen Scanlan
Nikolina Braovac & Asmi Sharma

Sepideh Rajabzadeh & Runjia Li
Petros Kapetanakis & Hadi Siddiqui

Dylan Rutledge & Tianlang Feng
Sami Karimi

Shown in Fig. 9: Crossings Interdisciplinary Workshop *Suspended Animation Series*, student projects. Works by:
Marian Shaker
Diana Park
Daniel Cronin
Sharif Kahn
Karam Georges
Nathan Dykstra.

Main References:

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TITLE
SELF-ORGANISATION AND GENERATIVITY
(Paper)

Topic: Art

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Abstract
Self-organisation is well illustrated in patterns, or more elaborate configurations, encountered in nature. But it is usual to oppose even those most refined constructions to human productions, in a dichotomy between nature and culture, that is well summarised by Karl Marx's quotation: "What distinguishes the worst architect from the best of bees is this, that the architect raises his structure in imagination before he erects it in reality." This paper questions this common opinion and discusses the place of self-organisation in art (including architecture), in artists' imagination, in their design process.

Some artists explicitly use self-organised processes in their work, a large part of so-called generative art consists in precisely that: "using an autonomous system", that is a non-human system, a system that generally has self-organised features, either borrowing from biology, chemistry, and so on, or simulating such self-organised processes with algorithms. But before that, artists could borrow from nature, and then from self-organised processes, their own procedures. In the domain of architecture and urban planning, someone like Frei Otto analysed and simulated self-organised patterns in order to invent human built configurations.

But, beyond those obvious references, it may be wondered if, and how, in more abstract works, self-organisation, that is spontaneous order emerging from local interactions without a global control, is actually carried out. Self-organisation of brain function is a strong hypothesis in neurology, and has been illustrated in visual perception in particular. Then it is legitimate to question the place of self-organisation in visual art production itself.

This leads to question (again) such commonplace topics as imagination, inspiration, beauty, order, randomness, and even desire and pleasure.

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Key words: self-organisation, emergence, order, randomness, imagination

Self-Organisation and Generativity

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Abstract

Self-organisation is well illustrated in patterns, or more elaborate configurations, encountered in nature. But it is usual to oppose even those most refined constructions to human productions, in a di chotomy between nature and culture, that is well summarised by Karl Marx's quotation: "What distinguishes the worst architect from the best of bees is this, that the architect raises his structure in imagination before he erects it in reality." This paper questions this common opinion and discusses the place of self-organisation in art (including architecture), in artists' imagination, in their design process.
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But, beyond those obvious references, it may be w ondered if, and how, in more abstract works, self-organisation, that is spontaneous order emerging from local interactions without a global control, is actually carried out. Self-organisation of brain function is a strong hypothesis in neurology, and has been illustrated in visual perception in particular. Then it is legitimate to question the place of self-organisation in visual art production itself.
This leads to question (again) such commonplace topics as imagination, inspiration, beauty, order, randomness, and even desire and pleasure.

1. Foreword



Fig. 1: untitled,1992

The intent of this research is to make a link between two of my practices that may seem hard to reconcile, and a ctually are disconnected. On one hand I have practised drawing (one may say 'painting' except the tools I use are pencils, oil pastels, and so on) since a very long time, on the other hand, I like to write algorithms that generate images.

The series of drawings I refer to here consist in, first, defining a square in the middle of a 50 c m x 65 cm sheet of drawing paper. I did 119 15 cm x 15 cm drawings (including 28 “hands”, see fig. 1) from 1985 till May 1992 (see fig. 2, 3) and 59 25 cm x 25 c m drawings from July 1992 till 2004 (see fig. 4).

Putting aside some of my drawings that are figurative, if I ask myself what happens while I am drawing, I suggest that it has something to do w ith self-organising processes. I wrote many years ago those two sentences: “*Par exemple, prendre deux crayons de couleur de teintes différentes et même agressivement incompatibles au d épart, les emmêler, surveiller le conflit, avoir par moments très peur, et sentir tout de même que c 'est de cette opposition que surgit la lumière. Ou bien, avec le crayon noir, les nuages; mais si cela ressemble à des nuages, c'est sans doute parce que les processus de f ormation sont similaires: les gouttelettes s'agglutinent autour de pou ssières microscopiques comme le graphite sur le papier refuse obstinément, malgré mes efforts, de former une c ouche uniformément grise.*” “For instance, take two crayons of different, and even aggressively incompatible hues, and intricate them, watch the conflict, be v ery afraid at time, and feel anyway that it is from this opposition that light arises. Or, with the black pencil, the clouds; but if it looks like clouds, it is probably because the formation processes are similar: water droplets agglutinate around microscopic dust just as graphite on paper obstinately refuses, despite my efforts, to form a uniformly grey layer.”

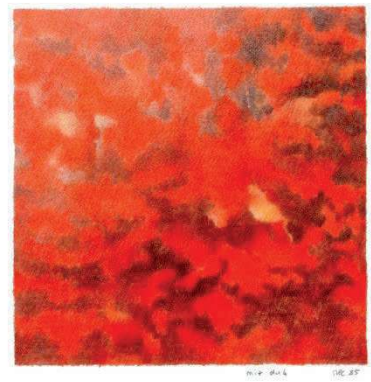


Fig. 2: “miz du 4” , 1985



Fig. 3: untitled, 1986



Fig. 4: untitled, 1996

Let me stress an important fact: I do not intend here to try to simulate my drawings with self-organisation processes. The reason why I bring this drawing practice up here is because I want to take the point of view of the artist, of the person who makes something, either with her hand or with her mind.
In the following experiments I explore self-organisation, which means that s ome form of overall order emerges through local interactions between elements of an initially disordered system. It also fits the definition of generative art by Philip Galanter: “Generative art refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a m achine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art.” [1] The ‘art’ part consists in reinterpreting those systems, particularly in interpreting some elements in terms of colours, and in extracting some frames from dynamic systems.

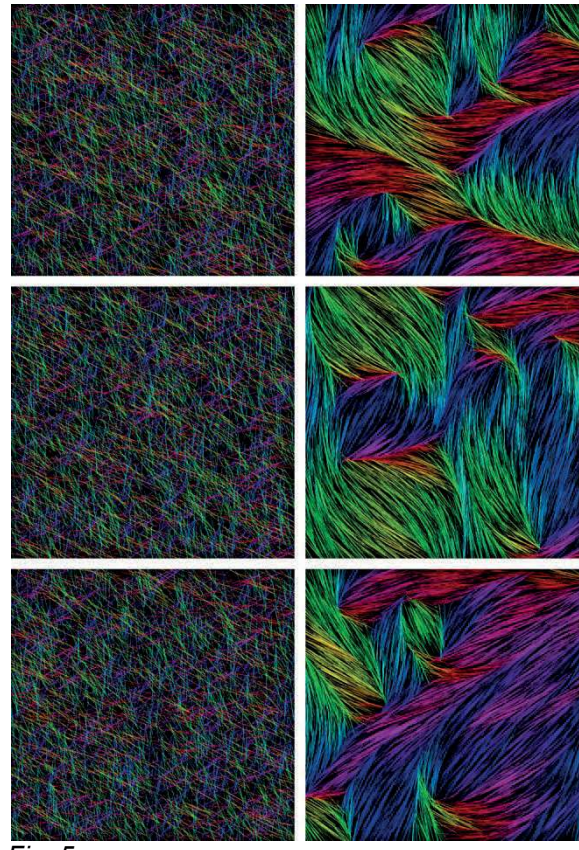


Fig. 5

2. Generative experiments

2.1. Experiment #1

What triggered, amongst other references, the topics developed in this paper were pictures showed at GA2011 by authors which were not artists, but scientists, a chemist an a mathematician [2]. Though not intentionally artistic, their pictures were striking, beyond the scholarly and very instructive discourse on entropy they intended to illustrate. Without actually re-enacting their own process, fig. 5 illustrates a process leading to images similar to theirs.

One starts with a random distribution of rods with random orientations, and applies local changes of orientation in order to not having overlapping rods any more. Each rod is examined, and its orientation is slightly changed in order to be closer to that of any other intersecting rod. The process is iterated till some equilibrium is attained and it does not change any more, at least not too much. The result is not perfect, some overlapping may remain, but for our purpose it does not matter, it even contributes to some of the quality of the image. The process fits the definition of self-organisation: the three images on the left of fig. 5, which show initial distributions, are indistinct, when those on the right (showing the results of the process), though very similar to each other, have some kind of identity: one may prefer one of them, for whatever reason

(the amount of such colour, the way it swirls more or less, and so on).

Trying to analyse what is pleasing in these pictures, which is certainly in good p art subjective, two features retain the attention: one is the association of each orientation with one saturated colour in a graduated way, the other one is the seemingly 'natural' distribution of orientations. The first feature was introduced by Galanis and Ehler in order to let us better visualise the pattern of orientations. But it happens that it generates nice distributions of colours, beside letting us better evaluate order/disorder balance. One may compare those results with images where all rods are white against a black background (fig. 6), which may better please those who prefer understated art...

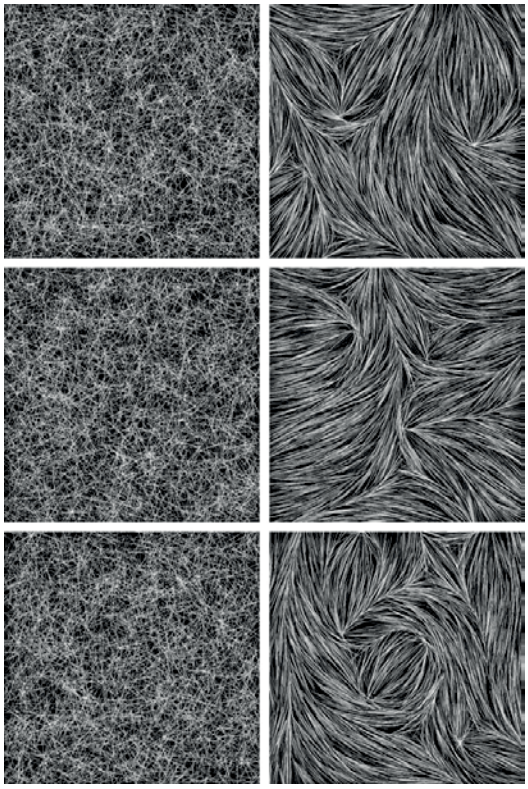


Fig. 6

Concerning the overall character of those images, we see some parts roughly aligned, and the transition between orientations is more or less graduated. The overall distribution could be describing as a field of directions, like for instance the field of wind directions in two dimensions, or iron fillings in a magnetic field.
Those images were produced with 5000 rods of length 100, in a 500x500 pixels square. Trying with shorter or longer rods in the same square leads to somewhat different results (fig. 7).

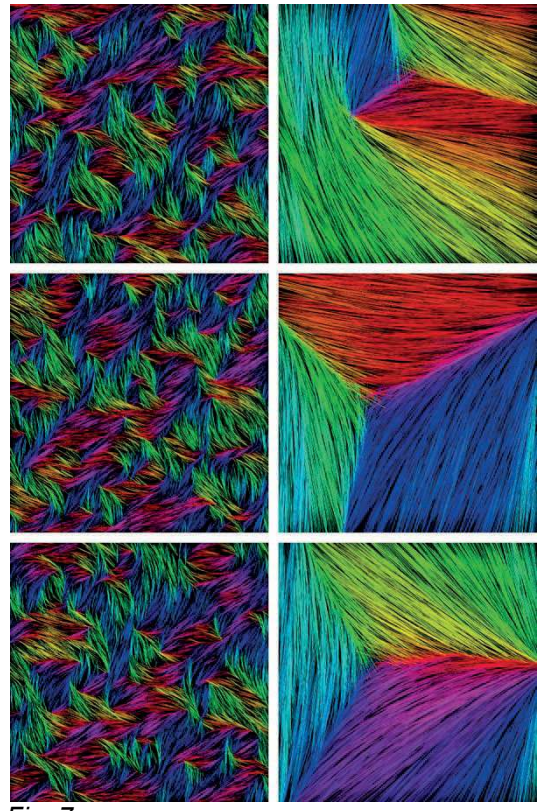


Fig. 7

Even if I was attracted at first by the saturated colours used by the authors of the reference images, I wanted to try another kind of representation of orientations by colours. What I chose was to map orientations, not on t he hues of HSB colours, but rather on the saturation

and brightness components of those colours, for a given hue (fig. 8, 9).

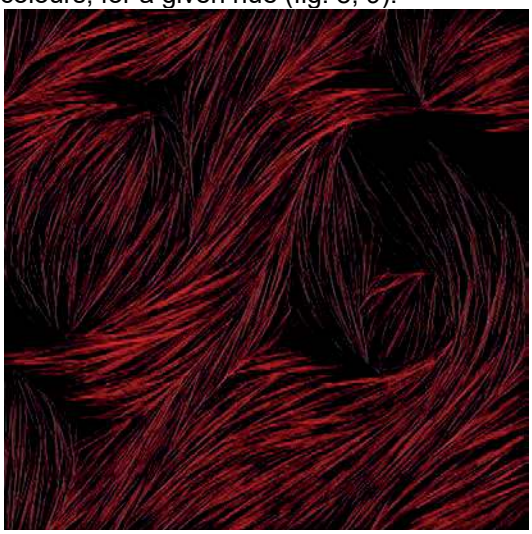


Fig. 8

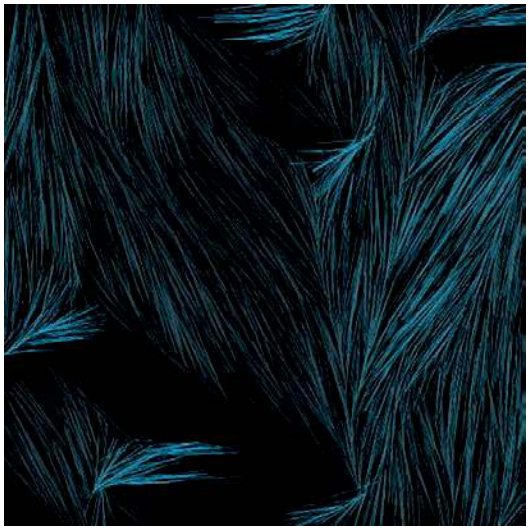


Fig. 9

By slightly changing all orientations of the rods at one time, and then let the process of rearrangement occur, we do not obtain a simple rotation of the whole image, but a slightly different one. By repeating this action, we obtain a nice animation.
Another way of playing with this process is by introducing two different hues instead of one, for instance by attributing one to orientations between 0 and π/2, and another one to orientations between π/2 and π. This leads to images with interacting colours, as in fig. 10.

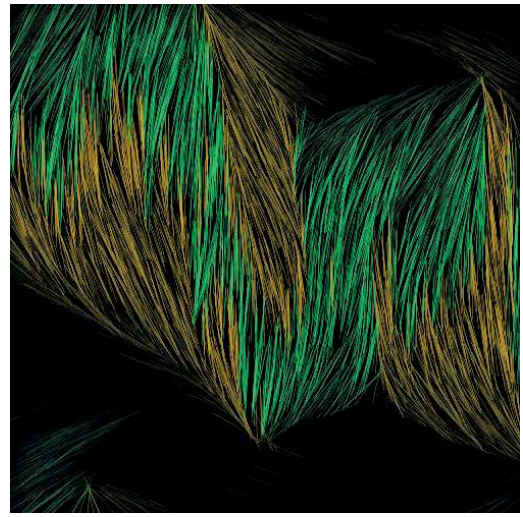


Fig. 10

2.2. Experiment #2

The rearrangement seen above is a kind of averaging, each rod getting an orientation respectful of its closest neighbours. Averaging is exactly what does the 'Isling' cellular automaton shown in GA2014 [3]. In its basic version, each cell may have one of two states, and at each step it adopts the average value of states of its neighbours. One must start with a random balanced repartition of the two states, and the application of the rule leads to an equilibrium where areas of state 0 and 1 are smoothly intricate, and altogether balanced (fig. 11).

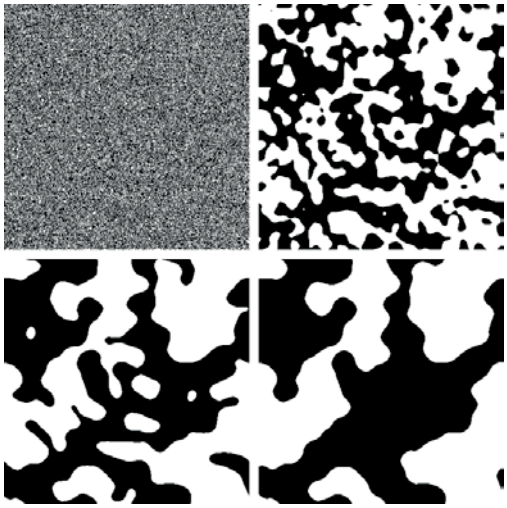


Fig. 11

Cells are identified to the pixels, and the two states to black and white, respectively. This CA allows to choose a depth for the neighbourhood, here a depth of three has been chosen. In that example as in all following ones, the bitmap has a periodic, or 'toric' topology.
Now we shall expand this CA into a 'continuous' version, by considering 256 states, ranging from 0 to 255. By applying the same rule, now potentially getting states of range 0 to 255 represented as levels of grey, we obtain a very disappointing foggy distribution as in fig. 12.

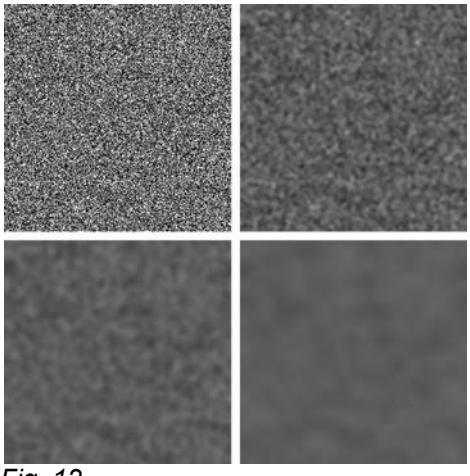


Fig. 12

States are all very close to the average, that is 127, so that we cannot very well distinguish them visually, though they are actually not all equal. They are distributed symmetrically around 127, so if we represent states smaller than 127 by black, and the other ones by white, we obtain something like fig. 11 (which has actually been produced in such a way).
We can also remark that states range from a minimum to a maximum, and we can map this distribution onto the interval [0,255]; which produces pictures like in fig. 13.

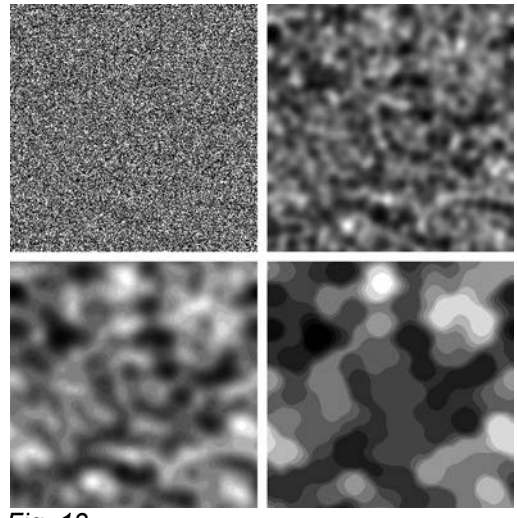


Fig. 13

We obtain an even more interesting representation by attributing a certain hue (red = 0 in HSB range) to states under 128, and another (cyan = 127) to states above, with saturation and brightness proportionate to the previously described mapping of the state (fig. 14).

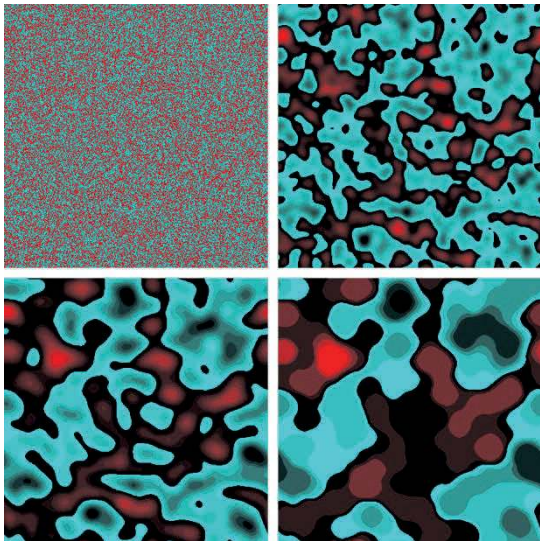


Fig. 14

Now we shall slightly change the rule in order to give some dynamics to this CA. We shall add a c onstant (127) to the average value used to get the new state of the cell; taking that value modulo 256 allows the process to go on. Because of the way states are represented, red and cyan alternate in the successive bitmaps, but, apart from that, we observe a new behaviour for this CA. A first phase looks a lot like with the previous system: smooth balanced intricate areas partition the image. But at one point, something strange occurs: some ‘spots’ appear, that grow and then vanish, while the “background” separates itself into two balanced parts (fig. 15).

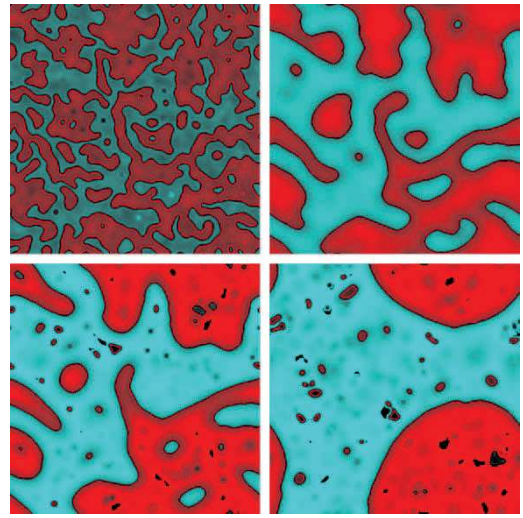


Fig. 15

Sometimes, one area overcomes the background. Some outcomes are shown in fig. 16.

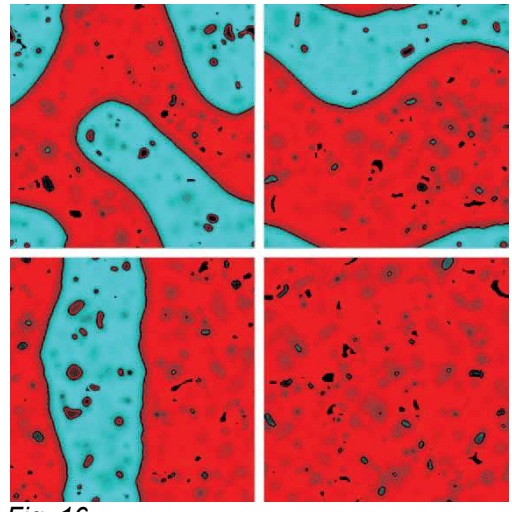


Fig. 16

For a l ast development of this CA, the specific rule is slightly changed again: instead of letting the next state be equal to the average of its neighbourhood, we add this value to the state of the cell itself. The ‘modulo’ operation allows again the CA to go on forever. This CA then becomes a well known one, showing after a while

wave-like explosions, which is used to simulate special effects. For our purpose here we shall turn our attention to some of the frames, with the same representation of states by colours as above. From this succession of frames, we have extracted two pictures, shown in fig. 17, 18.

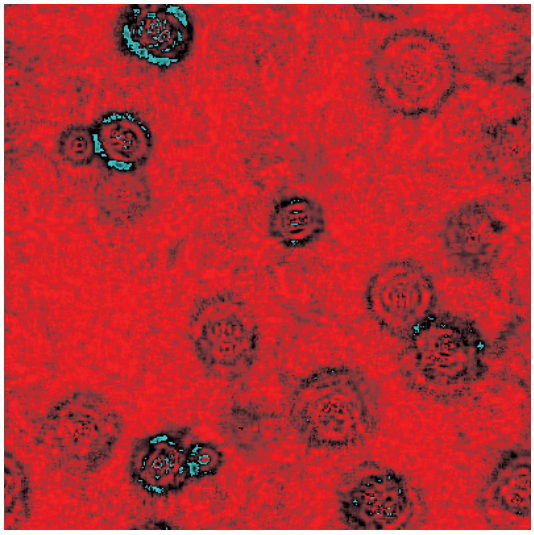


Fig. 17

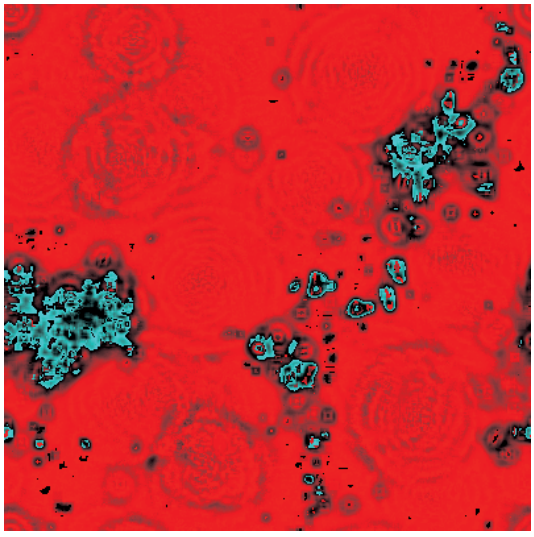


Fig. 18

2.3 Experiment #3

The last model we shall play with is the behaviour system known as a 'swarm', or at least a very simple personal version of it. This swarm consists in a set of particles (or agents, or 'boids') that move according to a simple set of rules involving only the neighbourhood of each particle. Those rules concern three behaviours: non-collision, cohesion, and alignment: in order to have a 'well behaved' swarm, particles are not supposed to collide, and they are meant to cohere and align with at least some of their partners. We then obtain a collective behaviour without any centralised control, and that looks like that of swarms of bees, flocks of birds such as starlings, fish schooling, and so on. By playing on the different basic local behaviours, that can be switched on or off, and on the amplitude of the neighbourhood required by the cohesion and alignment behaviours, we can get different kinds of global behaviour. We must add that the screen is considered as a periodic space, which means that it has the topology of a square flat torus: any particle leaving on the right border reappears on the left, and vice-versa, and the same applies to the top and bottom borders. Otherwise, particles could go out and never be seen again...

We shall here, again, take a step aside from the original purpose of this model, and play on different types of representation in order to obtain images, with aesthetic criteria, whatever that may mean. The main idea is to record traces of the particles, and to freeze such or such frame.

A first version uses small white particles on a black background, and, in that case, when a change in the parameters is provoked, the picture is erased. We get a lot of very different outcomes, a few of them are shown in fig. 19.

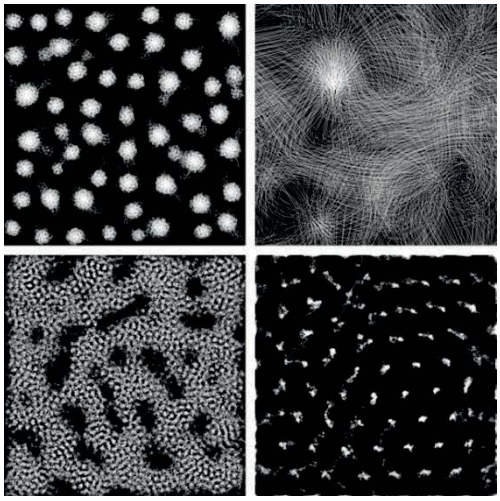


Fig. 19

A second interpretation consists in using the particles as pencils or brushes on a canvas. We never erase the screen, but the 'paint' is transparent, so it accumulates with time. A possible outcome is shown in fig. 20.

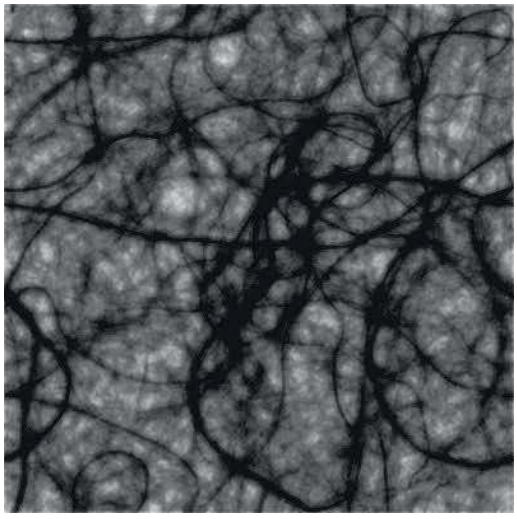


Fig. 20

For our last experiment, we borrowed the idea from our very first one: the particles are represented by rods, in the direction of their movement, and with colours depending upon their orientation. The screen is not completely erased between frames, but filled with a transparent colour.
A first version uses a 'blue' hue (H=15), with saturation and brightness corresponding to the orientation, and the screen is filled with transparent black (fig. 21).

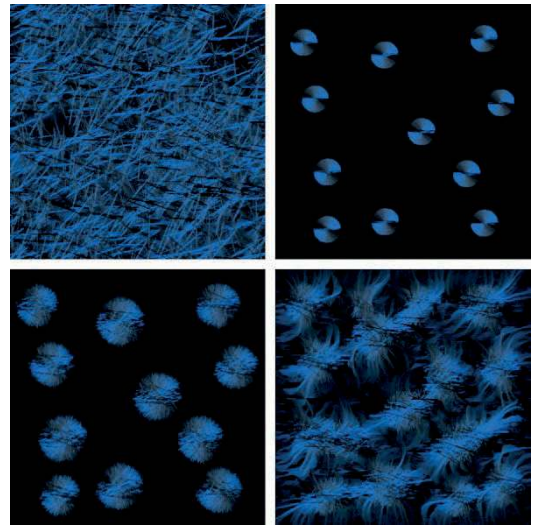


Fig. 21

A second version uses a 'ochre' hue (H=150), with the same specification for saturation and brightness, and the screen is filled with transparent white (fig. 22-26).

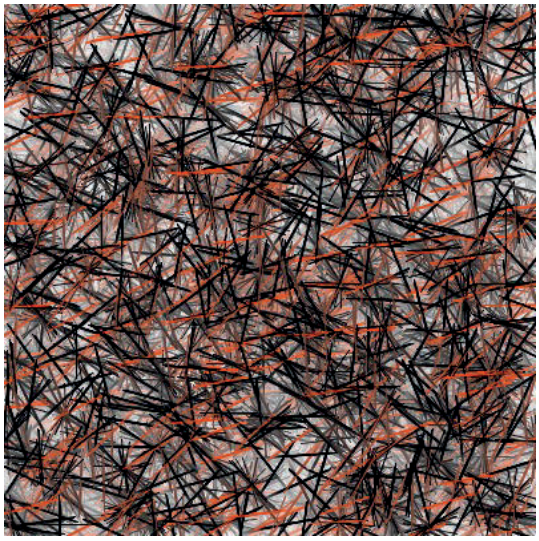


Fig. 22



Fig. 23



Fig. 24



Fig. 25

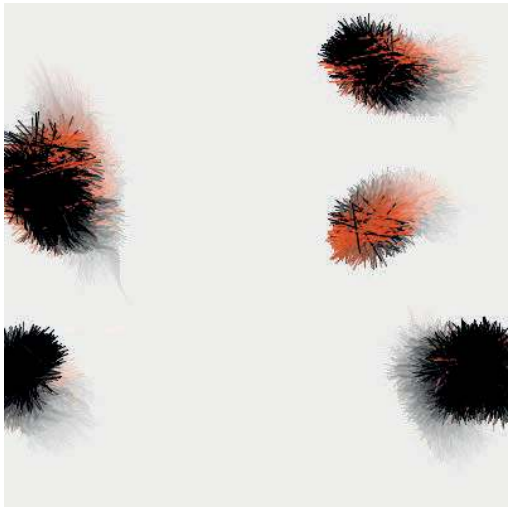


Fig. 26

All these images are frames extracted from the same process.

Afterword

A first remark I want to make about the outcomes of these experiments, and their 'artistic' quality, is their relationship to 'conventional' art. Fig. 10, for instance, may evoke some works by Hans Hartung, like "T1971-R30", fig. 20 some of Pollock's paintings, and so on. But that is neither the intent, nor the criterium, of these experiments. Once somebody told me, about my drawings, that they reminded him of some computer produced images, and that I should investigate that. But I did not agree. What I like, and need, when drawing, is the concrete interaction between the tools and the paper, the physical effort it implies: I prefer hard tools on strong paper, for instance, I never use soft tools like charcoal; it maybe is a remnant of the engraving practice I learned when I was a student, even if I did not pursue it. This work is more tactile, more haptic, that strictly visual, and even the odour of the pencils play a role, as I am sure that of paint is not negligible for painters.

On another hand, some of the images obtained above may remind us of natural patterns or configurations. That is not surprising, since self-organisation is a way nature uses in its own organisation, and for instance experiment #3 is directly inspired by the actual behaviour of birds or fish. But, more to the point of this paper, some images may evoke 'natural' human actions: boundaries in fig. 15 and 16, as well as traces in fig. 20, 23 and 25 look like 'free hand' drawing or painting. This is the result of the rules, and not of some contrived mathematical invention like splines or Bezier curves, which is an interesting point.

As a contribution to issues concerning generative art, I would like to analyse those experiments from the point of view of the person who did them. The role of the artist is one of the most discussed questions about generative art, as exposed by Galanter, but also for instance by Margaret Boden and Ernest Edmonds (himself a generative artist) in a paper [4] that thoroughly reviews the different forms of generative art and their issues, going back historically to such pioneers as Georg Nees, Frieder Nacke, Michael Noll, or Manfred Mohr. I would like to add to this list Vera Molnar, born in 1924, still very much alive and producing, who had an exhibition at the Galerie Oniris, in Rennes (France) this last summer [5]. Mohr and Molnar were pre-eminent in my first discovery of computer art. Boden and Edmonds' characterisation of generative art (by comparison with computer or digital art, among other categories) is that "*the artwork is generated, at least in part, by some process that is not under the artist's direct control*", which is not very different from Galanter's definition, but stresses more on the role of the artist, with all the nuances that may imply the locutions "at least in part", and " direct control".

Artists are the first spectators of their own work in progress, the first to judge what they are doing, what they are getting from their practice, either produced by their own hands, or by a computer. Even if the aim of the previous experiments *is not* to simulate 'manual' artists' works, my own or that of others, it is certain that some 'artistic' quality, whatever this means, is what makes me appreciate such or such result. In experiment #1, I appreciated that the mapping used in fig. 8 or 9 gave light and shadow illusion, and therefore depth to the images. In experiment #3, choices concerned the representation of the particles, either by rounds (of different sizes) or by rods, with different colours, and with different ways of going from frame to frame. As a result, fig. 23 and 25 look like watercolour, which is due to the representation by rods of a certain hue, with saturation and brightness proportionate to the orientation angle, and moreover to the transparent filling of the screen between frames. Whatever the rules, there are many different ways of transposing them visually, and this is one of the places where the artist has a role. Taking the example of a great generative artist's work, the "process compendium" series by Casey Reas [6], which set in motion relatively simple agent behaviours, are particularly remarkable ('beautiful') because of the way these moving agents are represented, either in movies, in prints, or even in sculptures.

With an on-going process, what is determinant too is deciding *when* to stop, *when* to freeze the process and catch a frame. That was particularly important for experiment #3, where the content of the screen is continually changing. This kind of decision is very close to what happens when drawing, especially when the drawing is abstract, and there is no model to attain. When to stop? is a very important question, one does not want to go too far, and maybe spoil the work... There is no definitive and objective answer to that question, it is a question of feeling, in which a certain fatigue may be taken into account.

Another role for the artist is, even if the rules are well established, to intervene on some of the parameters. In experiment #1 for instance, the relative size of rods and screen leads to more or less interesting results, here 'interesting' meaning a balance between order and disorder, an harmonious distribution of orientations highlighted by the colours that represent them. The comparison between figs. 5 and 6 lead me to stick to the initial choice of size for the rods. In experiment #3, parameters concern the quantity of particles, the size of their neighbourhood, and the setting of and on of their behaviours. In that case, those changes may even intervene during the process.

And, finally, or rather initially, because I presented the phases in a reverse order from their actual occurrence, one has to define rules. In my drawings, I define rules too. For instance, I choose only two crayons of different hues, or with a black pencil, I try to generate some light without using en eraser. The rules I used for the three experiments exposed here are very common rules. I did not really invent them, though I somewhat diverted them from their common use. It is in experiment #2 that I worked the most on the rules, evolving from a strict averaging CA to a dynamic system by slightly changing the specific rule (what is the next state of the cell?) from simple average, to (average + a constant), and then to (average + previous state). Certainly more expert generative artists may invent their own rule, but from my modest point of view, I must say that there is a certain pleasure in writing algorithms expressing rules, and see them work. There is even a pleasure sometimes in making errors, and seeing surprising results...

In conclusion, I would like to emphasize two apparently contradictory feelings one may have in doing such experiments. The first reflects one's free will, while the second stresses the relative autonomy of the system put in motion.

What is enjoying in dealing with algorithms may be abstracted with the question: "*what if?*". At any stage, I can write what I want, change any parameter I want. This potentiality gives a sentiment of freedom, of empowerment, even with limited skills.

On another hand, one wants also to be *surprised*. Either while drawing or writing algorithms, I do not know exactly what I shall obtain. I have some ideas, not anything may arrive, the settings are defined in a minimal way, but, given an initial context, a set of rules, I want the result to come as a surprise. I could never make the same drawing twice, the outcome depends upon a lot of unconscious or conscious elements, including my mood or state of mind at the time of the drawing, and probably also upon something one has to call randomness...

The models used in the experiments, belonging to the general field of self-organisation, have a 'natural' relationship to randomness. There would be no sense in experiment #1 to start from anything else than a 'random' distribution of orientations, since the purpose of the process is precisely to give 'some order' to a disordered configuration. In the same way, the first CA in experiment #2, not only goes from a random distribution of states to a rearranged one, but even *requires* to start from a balanced random distribution, as was shown in [3]. Concerning experiment #3, we see how the rules constrain particles to obey more 'ordered' behaviour whenever they happen to be randomly distributed, as in going from fig. 22 to fig. 23, or from fig. 24 to fig. 25 for instance. But in either experiment, the rules are deterministic, they are not stochastic at all, which does not mean that the results are totally predictable, which contributes to the 'surprising' effect I look for by doing these kinds of experiments.

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Innovative Approaches To Organic Architecture: Nature-Inspired Architectural Design

Paper

Topic: Architecture

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Abstract
Nature has been the source of inspiration for architecture since ancient times with the thought of macro cosmos – microcosmos. In this process, the shapes within the design method; humanoid, animal, plant, microscopic organisms are formed in the form of the living environment, facade, structure, transfer to form. Developing natural sciences and computer technologies architects are beginning to see terms such as development, adaptation, mutation, evolution morphogenetics in the science of biology. 'Biotaclite', 'Biomimesis' and 'Biomimicry' are scientists who have appeared in the recent past investigating, explaining the workings of nature and adapting them to human use. In the field of architecture, the term biomimicry has only been adopted in the past five to ten years, often mistakenly perceived as limited works in imitation of morphological aspects of the biological world. Biomimicry, introduced to the literature by Benyus, is a branch of science that studies the models, systems, stages, elements of nature. It aims to solve the problems encountered by taking inspiration or imitating the information it has obtained. The word "imitation tanımlan is defined in this field as follows; it is an act of creating lifestyle information, properties of something, searching for principles, finding and finding results. Architecture, which is a product of humans and regulates the environment we live in, regulates and controls the relations between man and his environment and also plays a role in the creation of an environment conducive to human actions. The effects of form on people and life in architecture is an important issue. The facades of the architectural spaces that make up the city bear great responsibility in this influence with their formal features. Accordingly, the evaluation of the architectural environment in the context of the facade makes the facade an important database for scientific investigations. The facade covers the entrance, which is mostly the main face of the building, and is characterized in detail by detail. The facades, which are the appearance of the structure, communicate with the environment through the signs it carries. Therefore, the facade is a phenomenon that is understood by the users of the city rather than a formal composition and in terms of their meanings, it creates the language of a city and presents impressions about the city. Within the scope of this study, biomimicry facade samples have been examined over experimentally developed architectural facade samples which are applied all over the world. The interaction of the architectural façades explained with the examples with nature is examined. The contribution of architecture to the design process and its effect visually. The reason for a facade inspired by nature, its purpose, and the emotions aroused by the user were emphasized. For this purpose, the study investigated what formations can be

presented using the knowledge of the biology branch from the design and functional aspects of architecture. It is aimed to make the complex structure of nature more comprehensible by analyzing the architectural environment and to produce answers to the problems encountered. It focuses on the benefits of nature rather than consumption and focuses on what this benefit might be. Building facades that were applied or developed as ideas were examined based on the interaction of architecture with nature.

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Key words: Biomimicry, Architectural Surface, Facade, Organic Architecture, Sustainable Design

Innovative Approaches To Organic Architecture: Nature-Inspired Architectural Design

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Abstract

Nature has been the inspiration of architecture since ancient times. In the design process, these forms are realized as the shaping of humanoid, animal, plant and microscopic organisms in their living environments, the façade, the structure and the transfer of them to the form. Developing natural sciences and computer technologies architects are beginning to see terms such as development, adaptation, mutation, evolution morphogenetics in biology and its sub-branches in architecture as well. ‘Biomimesis’ and 'Biomimicry' are frequently referenced in the recent past, investigating, explaining the workings of nature and adapting them to human use. In the field of architecture, the term biomimicry has only been adopted in recent centuries, often mistakenly perceived as studies limited to mimicry of morphological aspects of the biological world. Biomimicry, introduced to the literature by Benyus, is a branch of science that studies the models, systems, stages, and elements of nature [1]. It aims to solve the problems encountered by taking inspiration or imitating the information it has obtained. The word’ mimicry ' is defined in this branch of science as follows; it is an act of searching, finding, and making visible the found results of the principles that constitute the life knowledge and qualities of a t hing. Regulate the environment we live in and a pr oduct of human art and architecture, regulate the relations between man and hi s environment, to control and al so is involved in the formation of an environment conducive to human actions. The effects of form on people and life in architecture is an i mportant issue. The façades of the places that make up the city bear great responsibility in this influence with their formal features. Accordingly, the evaluation of the architectural environment in the context of the façade which is an important database for scientific investigations. The façades, which are the appearance of the structure, communicate with the environment through the signs it carries. Therefore, the façade is more than a formal composition but a phenomenon that is understood by the users of the city, and i n terms of the meanings it carries, it creates the language of a city and provides impressions about the city. Within the scope of this study, examples

of architectural façades applied and experimentally developed in the field of architecture were examined in the context of the concept of biomimicry. Examples are the interactions of the façades with nature. The contribution of architecture to the design process and the impact it left visually has been studied. The reason for a façade inspired by nature, its purpose, and the emotions it evokes in the user is emphasized. For this purpose, the study investigated what formations can be p resented using the knowledge of the biology branch from the design and functional aspects of architecture. The focus of the paper is to make the complex structure of nature more comprehensible by analyzing the architectural environment and to produce answers to the problems encountered. Building façades and prototypes that were applied or developed as ideas were studied based on the interaction of architecture with nature.

Keywords: Organic Architecture, Biomimicry,
Nature inspired design, Façade,Sustainability

1. Introduction

From the framework of architectural design, nature has always attracted people and been an inspiration. In the process from ancient times to the present, humanity has explored nature. Nature has a more ancient history than man and art. The dynamic, similar, and following forms of nature have been of interest to humans since early ages. Art, on the other hand, has a duty of remembrance and i mitation from those times, and it comes across as a reflection of nature by some forms and means of man. The nature-inspired design aims to solve the problems encountered by taking inspiration or imitating the information it has obtained. The word' mimicry ' i s defined in this branch of science as the act of searching, finding, and making visible the found results of the principles that constitute the life knowledge and qualities of a thing.

Architecture, which is a human product and the art branch that regulates the environment in which we live, also regulates and controls the relations between man and his environment and also plays a r ole in the formation of an environment conducive to human actions. Keleş describes nature as all that is outside of man; for example, Earth, subsoil riches, water, air, plants, and animals constitute nature. Human beings, who are part of nature and one of the living organisms, cannot survive without the support of nature. According to Aristotle, nature is the primary source in all the actions and works of man [2]. By engaging in artificial interventions in natural areas, the act of architecture, which causes the most damage to nature within human actions, is important with its approach to nature. In other words, architecture, by understanding the workings of nature and by shaping architecture by these workings and principles, is the act that has the most responsible for its role in the destruction of nature and its protection. Biology and ecology are the disciplines that can affect design projects in unexpected and interesting ways.

The new keywords, 'Biomimesis,' 'Biomimicry' is a ne w branch of science that explores the workings of nature, explains, and adapts them to human use. Biomimicry, introduced to the literature by Benyus, is a branch of science that studies the models, systems, stages, and elements of nature. According to Benyus, biomimicry aims to be able to see nature as a model, consultant, and criterion. The word' mimicry ' is defined as follows in this field of science; it is an act of searching, finding, and making visible the found results of the principles that constitute the life knowledge, attributes of a thing.

Nature's functioning cycle and the basic

principles found in this cycle find a place for itself in today's architecture. They are used by today's architects to create a more sustainable and liveable environment. Instead of completely imitating these studies, they begin by exploring the unknowns behind nature's structural changes and transformations. The goal here is to understand what changes or transformations lead to in nature. It is aimed to integrate the comprehended data into the design process. [3] According to Knight, *"The conscious simulation of the genius of life is the survival strategy of the human race and a path to a sustainable future. The fact that the world continues to function like natural life means that life in this world, which does not belong only to mankind, becomes more possible for man"* [4]. Nature lives in an unconscious cycle and in this cycle, the world contains just as nature or the person it needs to emulate. As a result, designers must take inspiration from nature. This is because nature is the best inspiration for sustainable designs. When taking inspiration from nature, a discipline followed by designers and called biomimicry can be used. Biomimicry is the branch of science that transfers analogies and ideas in biology to architecture, technology, and many different disciplines. Although it is known as a new branch of science, it is an old branch of science [5]. In another definition, biomimicry mimics models in nature and helps turn them into the solution needed to address the problems facing humans. Biomimicry uses nature as a scale and also a mentor for learning to learn about what works, what is true, and what is longest-lived [3]. Also, two worlds far apart biomimicry *'nature and technology,' 'biology and innovation,' 'life and design'* can be described as an interdisciplinary approach that combines. The use of biomimicry as a design criterion in architecture plays a major role in increasing the sustainability of the built environment. If designers are to use ideas from nature, they must understand the biological system before it can be used as an inspiration [5]; to make sufficient use of nature's genius, a passage must be created between architecture and biology. Using biomimicry as a form source as well as a design strategy will ensure that more sustainable designs are achieved.

2. Biomimicry and Architecture

Biomimicry is an approach that seeks solutions in nature to problems faced in both architecture and engineering fields. It is defined as learning the way of sustainable solutions from nature while finding solutions to the problem encountered. 20. Century with the impact of the Industrial revolution the buildings in the architecture were designed and implemented by showing similarity with the machine. 20. century as a result of the dominance of the Century Machine Age over nature and the destruction it created, technology has tended to continue its development by adopting the principle of being ecological. Berkebile and McLennan criticize the inability of Western civilization to have a close relationship with nature. To them, the West is a society that follows Bacon's rhetoric that 'science must torture nature to reveal its secrets.' [6] Benyus says against Bacon's approach: *'our first challenge in emulating nature should be to explain nature by its rules'* [1]. The devastation of Western thought created by the industrial revolution can be solved by the approach of learning from nature brought by the Biomimicry revolution. Berkebile explains this change of approach in Einstein's words: *'the great problems we face today cannot be solved by the level of thought that created them.'* [6]

It is getting harder and harder to have the proper living conditions for us to live life

intertwined with nature, where we can be involved in the cycles of nature. However, today, the city is at a breaking level of human relationships with nature, and it can even be called severed. As cities move away from nature, many environmental problems arise. As a result,' uninhabitable cities ' are formed. Adaptation to nature is not just the shape, texture of the land for the structures, the natural and artificial formation in the environment in which it is found, the vegetation around it. The formation of the structure, the use of the elements that make up the structure as part of nature, enables the formation of designs that are compatible with nature. Today, the process of biomimicry can be realized by being inspired by structure, form, or the entire ecosystem. Oral and Karakoç stated that "a micro-scale behaviour affects whole system." The most important result of this new and original perspective, called biomimetic architecture, is the ability to create sustainable designs. [7]

'Processes of function, scale, and formation' differ from the concepts observed in nature from the structures that are human production. Despite these differences, materials, energy conservation, etc. it is used as an inspiration by many architects and engineers with its durability as well as factors. In 20.century, learning or application in specimens observed until the middle of the were often limited to form. Also, it has been used as an inspiration for façade, form and decorative elements within nature-inspired design administrations[8]. Nature-inspired forms are divided into five different groups;

- Vegetative formations,
- Zoomorphic formations,
- Anthropomorphic formations,
- Microscopic formations,
- Forms of living environments of organisms it is classified as.

Vegetative Formations: It has been used since ancient times in decorations. Vegetative motifs are encountered on Colonnades in ancient Greek and Roman architecture, and on façades in the Art Nouveau period, it also appeared on a micro and macro scale. To give an example, it was inspired by the 'Lotus' flower in the Bahá'í Temple in Delhi, which was finished in 1986.

Zoomorphic Formations: it is observed in different areas of history. Architectural designs (buildings, bridges, structures, roofs) inspired by the structure of animals are designed. Animal motifs in the structures made in the Art Nouveau period also appear on decorative columns.

Anthropomorphic Formations: To inanimate objects (cars, buildings, etc.) is the design realized by the application of characteristic features belonging to humans. From the past to the present, it has been observed that the body of men and women is used effectively in the façade, carriage, plan and structure design. An example of this is the' Eye of Wisdom ' Project.

Microscopic Formations: It is defined as making designs inspired by the cells or DNA of microscopic organisms. Forms Of Living Environments Of Organisms; The spider web, which is the living environment of spiders, appears in the structure design. Also, termite towers can be seen as a source of inspiration in multi-story buildings in architecture.

3. Numerical Design Methods Inspired By Nature

Developing natural sciences and computer technologies enable architects to integrate concepts such as evolution, development, adaptation, mutation, genetic code, morphogenetic into architecture. This integration is the result of the collaboration of architects,

biologists and software engineers. Scientific disciplines and fields include mathematics, algorithm knowledge, genetic engineering, cell physiology, artificial intelligence, electronics, robotics, computer-based programming, information technologies, nanotechnology, and bi ology. Digital design methods inspired by nature, beyond mimicking nature, offer architectural forms that deal with natural growth processes and take their parameters from nature it self. In doing so, we come across as comprehensive and complex architectural designs that can be changed, developed and thought to be implemented in the future with an algorithm determined by the architect taking into consideration the parameters.

Botanical architecture: a numerical design method that is developed under the leadership of Dennis Dollens and is studied to produce new architectural forms with special computer programs taking into account the growth processes of plants in nature. In Dollens ' designs, many plant elements are found, from seed to leaf [9]. In addition to implementing the growth process of the plants, the movement as a response to the stimulus called tropism is suggested as an analogical model for agent-based systems to simulate human behaviour [10].

Evolutionary Architecture: an artificial way of life in which the principles of genetic coding, repetition, selection, and morphogenesis apply. The goal of an evolutionary architecture is to ensure the behavior of symbiosis and metabolic equilibrium in the built environment, as in nature. In evolutionary architecture, there is no exact imitation of nature; the morphogenetic process in nature is taken into account.

Genetic architecture: it is defined as a sequence of morphogenetic values that have established their internal logic, shaped around productive architecture. Another definition can be defined as a knowledge-theoretical approach to research and laboratory work that challenges the principles of genetic formation, embodies scientific knowledge. Research on gen etic architecture is divided into two groups. The first is research on the object of architecture, which can create artificial DNA in a digital environment and produce it with modifications made on it. The second is research on organic structures that will be produced by manipulations made on the cipher by interfering with real DNA in the physical environment.

4. Nature-Inspired Façades

Architecture is the branch that is a human product and regulates certain views of the environment in which we live. It also regulates the relations between people and t heir environment. However, it plays a major role in creating an environment conducive to human actions. Architecture, which is most damaging to nature through the act of construction, is trying to repair the broken relationships between the human and natural environment in today's world. Today, many architects seek answers to the problems experienced in the city in nature. They aim to create more liveable spaces for the community. Architecture, which turns its face to nature, seeks to produce the forms in city like nature. As Çakır stated, producing like nature means understanding the process of formation of form. It is also seen that composition is created in itself by certain repetition, rhythm, color, texture, proportion, balance in nature, and that the formulations in nature are created perfectly. It is thought that the analysis of the forms produced in nature and the understanding of the processes that develop during the process of forming are very important in terms of giving new perspectives to the architects of today and the future in their search for form. [11]

There are various designs inspired by

nature. Work is ongoing for the practical application and expansion of biomimicry as an a rchitectural design strategy. Currently, these works are mainly on building materials. However, studies and applications on t he morphological structures and carrier systems of buildings are also carried out. The use of biomimicry as a d esign strategy in architecture is defined in two categories. The first is the “view to biology”, which is described as defining the human need and going to search for a solution in nature for this need. The second is “biology affecting design”, which is described as developing a new design by searching for function in an or ganism. Designers who design spaces and buildings need to be inspired by nature not only for innovations in materials and building techniques but also for space design, façade design, and their future environment and s ustainable function of buildings.

Biology-facing design: the main approach here is that designers identify problems related to design, collaborate with biologists to find the most suitable organism for defined problems. Biology affecting design: the main approach here is this: the designer and the biologist determine the behavior, functions and other characteristics of an ecosystem and organism, and design for an existing need [12].

Looking at the history of architecture, there are many approaches inspired by the natural world (animals, plants, and the man himself). The use of biological models in architectural form and the use of nature-derived building shells and skeletons in design increases the importance of being inspired by nature in today's architecture. Considering that man-made structures and biological structures are subject to the same environmental conditions, it is important to look for the solution of future building shells and skeletons in biological data. The changing external conditions affect the efficiency of building shells, such as walls, roofs, and w indows, as well as building equipment such as heating, ventilation, cooling, and lighting to provide and maintain the user's comfort conditions. To adapt to changing environmental conditions in biological organisms, such as structures, they develop different methods through body covers such as skin, bark, cuticle, membrane. Examples of the biomimetic façade will be examined in this paper. The objectives of the implemented projects and the suggestions developed are examined.

5. Examples Of Biomimetics In Architecture

BIQ-Moss House



Figure 1: The image of the Hamburg Moss House [13]

Live microalgae were used in the construction of the “House of Moss” project in Hamburg, Germany. Also, the seaweed house project is the first biomimetic structure. One side of the structure is designed as microalgae that live and grow in a semi-transparent surface. In this way, the amount of light comes to the building is controlled, and it is intended to be used as desired at any time.

Mosses stop growing when there is no sun. When growth stops, the surface becomes more transparent. This allows more light to enter into the structure.



Figure 2: The image of the Hamburg Moss House [14]

Also, mosses are collected when they reach sufficient size. The collected mosses are used in the production of a type of biogas that meets the energy needs of the structure. When we look at the structure, we see an example that responds to its needs in many ways.

Fukuoka Prefectural International Hall

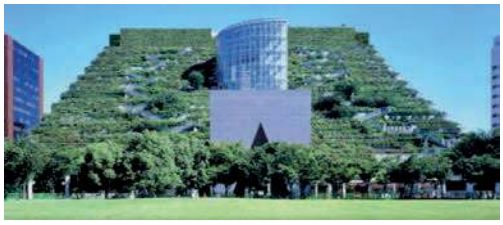


Figure 3: front view of Fukuoka Prefectural Hall [15]

Gaetano Pesce's goal in this design is to solve the urban problem of society. Agricultural space and urban space were considered together in the planning of this design. The Fukuoka-Prefectural International Hall is the strongest synthesis of urban and park forms. The North Face has a proper formal entrance to a building on the prestigious street of Fukuoka's financial district. The South Side of the hall is constructed as terraced gardens, which climb to the full height of the building. In this way, the existing park near the site was expanded and intended to define public space.



Figure 4: exterior view of Fukuoka Prefectural Hall [16]

The aim is not to be a building located in the city, but rather to be a building serving the city. The first look at the structure gives the impression that plants are used in a decorative sense on the exterior. Designed by the Italian architect Gaetano Pesce, it is stated that various plants were grown in plant pots attached to the wall of the façade and that these plants and soil kept the structure cool without the need for a mechanical ventilation system. Thus, the energy used in the structure saves.

Medya-ICT4



Figure 5: Media-Ict4 façade view [17]

The project was conducted in the former industrial area of the city of Barcelona. Today, this region passes as a science

and Technology region. The project is located in this part of the city. In this setting, the media-tic building is called “a kind of House of digital society.” This project is described as a technological showcase serving the purpose of becoming Barcelona's 'Green smart city.'



Figure 6: Media-Ict4 façade view [18]

The building was designed using only CAD/CAM technology. The theme of the media-TIC structure is to identify and demonstrate how architecture creates a new balance with the digital use of energy. This building has a hybrid program and proposes information and Communication Technology Center. The media-TIC building is said to mimic the harmony of nature with its intelligent façades. The most distinctive feature of the structure is its adaptive architectural façade inspired by ‘take a breath’. The ETFE coating surface was inspired by the geometric forms of atoms or elements with concave and c onvex triangles. The façades are characterized as leather and react to weather conditions.

Manuel Gea Gonzalez Hospital



Figure 7: Hospital Front In Mexico City [19]

Façade design has been implemented for the Manuel Gea Gonzalez hospital building in Mexico City, one of the most polluted Mega-cities in the world. The hospital was built in 1942 and a façade addition was made in 2013. Photocatalytic TiO2 has been known as smoke-eating material in recent years. Along with the technology, air cleaning has also been added to the material.



Figure 8: Façade of the Manuel Gea Gonzalez hospital building [20]

The material captures air pollution when the façade comes into contact with light. Then, it turns the pollution into inert salts. Thus reducing the smoke level in the city. The purpose of the front line is to reduce air pollution in the cityThe architects say the building can counteract the impact of air pollution and offer some cleaner air to the hospital's immediate surroundings. The façade eliminates the impact of 1,000 cars a day, according to developers.

Chameleon: A Mixed-Use Office Structure With A Biomimetic Approach



Figure 9: Mixed-use office structure [21]

The project proposal was developed as a proposal to a mixed-use office structure. It was inspired by Biomimicry after an extensive field analysis. It was inspired by the hexagonal shape cell structures that dominate the façades. The façade also answers other problems. Climate control keeps pace with the city with intelligent frontage units that mechanically adapt to the sun's orbit.



Figure 10: Biomimetic approach Project example [22]

When the weather warms up, the hexagons on the front are closed. Likewise, when the weather is cold or dark, the front wall moves and opens againThe office structure gathers daylight throughout the day. The energy collected is used for the energy to be used within the structure. Energy not used during the day is used at night. It façade thousands of LEDs illuminates. It is referred to as 'Chameleon' by building designers. This is because day and night are very different from each other. The change of the façade is also described as a mirror of the mood.

Eden Project

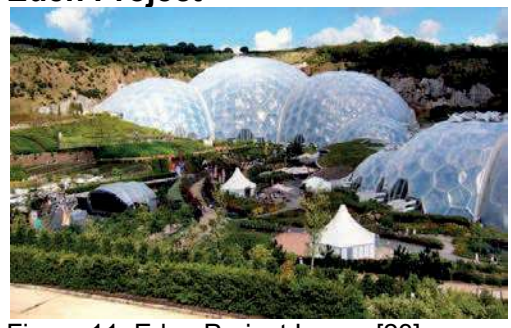


Figure 11: Eden Project Image [23]

In this project, the designers take a biomimetic approach. The project aims to achieve sustainable and resource efficiency savings. The design team argues that the built environment is the optimal backdrop for the Biomimicry approach. According to the USGBC, structures account for approximately 39% of CO2 emissions. In the United States, structures consume 70% of their electrical load. Like nature, humans need flexible, zero energy, zero waste regenerative environments

.


Figure 12: Eden Project roof detail [24]

Purifying, creating habitats, recycling, controlled waste, harvesting how people can put these and similar words into their lives has been discussed. On top of this, it was decided to make a b uilt environment and open it to service by imitating nature. The goal of the project is to educate people about the world they live in. This project was intended to demonstrate how a f ramework can be provided for the successful integration of biomimicry and sustainability with architectural and engineering projects. The goal is to lead us to build a m ore sustainable future.

6. Result

Given the relationship between human beings and nat ure that has been going on from past to present, the fact that nature is the suffers from this relationship causes the problems in our environment to be of great importance. The destruction we are inflicting on n ature has left us faced with many problems that are not easy to solve. One of the biggest problems encountered is architecture, which is the act of 'construction.' At the point where humanity, which is an indispensable part of nature, comes today, the answers to the problems will inevitably be s ought in nature. Understanding the functioning mechanism of nature, shaping architecture by this functioning and principles, is very important both in terms of giving identity to architecture and in terms of its responsibility for the protection of nature and its resources.

The importance of biomimicry, or in other words, learning from nature, is an effective way to learn and use in every discipline, including architecture. Since the existence of civilization, human beings have sought to acquire ideas and information from nature, especially structurally and stylistically. Today, with the development of technology and the developments with the opportunities of research being easier to do, designers aim to gain deeper knowledge from nature for more effective and sustainable ideas. The definition of human needs should be a starting point for designers; in designers who are turning to biology today, their approach to biomimetics is the basis for architectural design. To create sustainable future structures, spaces, materials, and ultimately the environment, biomimicry is gradually being incorporated into architectural designs for both form and functional ideas today. It is thought that using biomimicry as a design strategy in both architecture and architecture education will lead to more sustainable designs. Architecture has many problems to solve to achieve sustainability; designs and ideas can benefit from solving these problems, all of which are contained in nature. This study aims to examine how the façade, which means the exterior of the building, comes together with the concept of biomimetic. Why are biomimetic façades being built? What advantages does it offer to the user and the designer? It is a preliminary process that has been progressed to find answers to their questions. Examples of biomimetic façades were described in this process. The interaction of the façades described by examples with nature has been studied. Its contribution to the process of architecture and the impact it left in terms of visuals were emphasizing. For this purpose, the study focuses on the visual impact and shaping of the object of architecture, the use of biology knowledge to make the complex structure of nature more comprehensible by analyzing and the solution to the

problems can be produced, and focuses on the investigation of nature as a field of benefit rather than consumption. Another reason for this work is to develop a sustainable frontline proposal that clears the example of the façade, which is intended to be developed, it is aimed to use the building shell as an important building element to ensure the balance between the external and internal environment and to ensure the comfort conditions in the interior. In this way, from the façade scale to the building scale and the urban scale will contribute to sustainability. It is thought that the research carried out could be a reference for the frontline to be developed.

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INTERMEDIAL SCORE – STRUCTURAL FILIATIONS IN THE CONTEXT OF MUSIC-LITERATURE RELATIONS AS WELL AS MUSICAL AND VISUAL RELATIONS
(Paper)

Topic: Music

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Abstract
Musical score since the beginning of the 20th century has been the object of study in other scientific and artistic areas. Its phenomenon lies in the synergy of acoustic and visual domain of perception.
The object of study is the selection of works making up a specific type of intermedial score, which is created as a result of structural filiations in the context of music-literature relations as well as musical and visual relations. Contemporary literary works may contain elements of notation or music-related technology and their structure may resemble that of a musical piece. Musical composition may be based on literary text or created in connection with visual arts. Such works manifest signs of the existence of musical composition in literary text or the visual elements in musical pieces. This gives birth to an artefact generated live in the shape of "poem-score", "verbal score", "visual poetry", "musical graphic work", "animated score" or "musical installation art".
Such cross-references in works using different media go beyond the traditional scope of study, therefore the analysis and interpretation of selected works will be presented in the context of Werner Wolf's theoretical reflection.
The works selected for analysis were fugues, whose baroque genre, indicated in the title, serves as an intermedial substitute. *Preludio e Fughe* by Umberto Saba, a literary work, is an example of artistic interpretation of the fugue musical form, where literary text may function autonomously without encompassing the musical intertext. The method of text inscription, referring to baroque music *genre*, determines its intermedial nature.
Another work, Fuge in *The HeartPiece – Double Opera*, a composition by Krzysztof Knittel is an example of intermedial optophonetic poem, written in the form of graphic score, where the text by H. Müller is recited according to the principles reflecting the structure of a polyphonic form.
Additional aspect discussed in the presentation will be the sphere of vision and sound in the poem entitled *Is that wool hat my hat?* by Jackson Mac Low, which represents the kind of score to be performed for two, three or four voices without the use of metronome.
The composition by Katarzyna Kwiecień-Długosz entitled *Paplanina*. *Four serigraphies for tape* is an example of musical installation art, in which sound layer was combined with visual layer, making up a kind of animated score. One of its parts (*Runy* rearranged as *Soliloquium*) became an inspiration for Beata Oryl to create live performance which will be shown during the conference.
The aim of the presentation will be the analysis of selected literary and musical works,

whose transcript is not conventional and whose intersemiotic features are manifested in the act of perception.

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Key words: intermediality, literary score, contemporary art and music, intertextuality, fuge

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Intermedial Score – Structural Filiations in The Context of Music–Literature Relations as well as Musical and Visual Relations

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Abstract

Musical score since the beginning of the 20th century has been the object of study in other scientific and artistic areas. Its phenomenon lies in the synergy of acoustic and visual domain of perception. The object of study is the selection of works making up a specific type of intermedial score, which is created as a result of structural filiations in the context of music-literature relations as well as musical and visual relations. Contemporary literary works may contain elements of notation or music- related technology and their structure may resemble that of a musical piece. Musical composition may be based on literary text or created in connection with visual arts. Such works manifest signs of the existence of musical composition in literary text or the visual elements in musical pieces. This gives birth to an artefact generated live in the shape of "poem-score", "verbal score", "visual poetry", "musical graphic work", "animated score" or "musical installation art". Such cross-references in works using different media go beyond the traditional scope of study, therefore the analysis and interpretation of selected works will be presented in the context of Werner Wolf's theoretical reflection.

The works selected for analysis were fugues, whose baroque genre, indicated in the title, serves as an intermedial substitute. *Preludio e F ughe* by Umberto Saba, a literary work, is an example of artistic interpretation of the fugue musical form, where literary text may function autonomously without encompassing the musical intertext. The method of text inscription, referring to baroque music genre, determines its intermedial nature. Another work, *Fuge* in *The HeartPiece – Double Opera*, a composition by Krzysztof Knittel is an example of intermedial optophonetic poem, written in the form of graphic score, where the text by H. Müller is recited according to the principles reflecting the structure of a polyphonic form.

Additional aspect discussed in the presentation will be the sphere of vision and sound in the poem entitled *Is that wool hat my hat?* by Jackson Mac Low,

which represents the kind of score to be performed for two, three or four voices without the use of metronome. The composition by Katarzyna Kwiecień-Długosz entitled *Paplanina. Four serigraphies for tape* is an ex ample of musical installation art, in which sound layer was combined with visual layer, making up a kind of animated score. One of its parts (*Runy* rearranged as *Soliloquium*) became an inspiration for Beata Oryl to create live performance (movement interpretation – parallel co-existence of physical body and interactive visualisation, related to the body in a specific manner within the frame of the sounds of music).
The aim of the presentation will be t he analysis of selected literary and m usical works, whose transcript is not conventional and w hose intersemiotic features are manifested in the act of perception.

Key words: **intermediality, literary score, contemporary art and music, intertextuality, fuge.**

1. Introduction. The object of study

Intersemiotic relations between the 20th century poetry and m usical notation have been discussed many times in Polish and foreign literature on the subject. References made to music by the authors of the works are displayed mainly as "the score", which is referred to in the title or subtitle of the work, as the author's commentary, as the quotation of technology, as expressive, dynamic or agogic markings, or, last but not least, in a literal form, where "the structure of the page of poetic text follows the same principles as the musical score"[4]. Not much attention, however, has been paid so far to the detailed description of mutual relations between other media (e.g.: filiations between fine arts or visual arts and literature or music) and to discussing the issue of literature blending into music as the main medium – intermedial relation, mentioned for instance by Werner Wolf [15].
This article is devoted to the above mentioned issues, belonging to the domain of widely understood interdisciplinary (intersemiotic) comparative literature, as defined by Andrzej Hejmej, who in his formulation of three text layers of musicality refers to the scheme created by Steven Paul Scher [8].
The object of study is the selection of music and literary works with elements of *performance*, making up a specific type of intermedial score, which is created as a result of structural filiations in the context of music-literature relations or musical and visual relations.
In order to present their clear distinctions, the author chose as the object of her analysis the literary work *Preludio e Fughe* by Umberto Saba (1928–1929), the poem *Is that wool hat my hat?* by Jackson Mac Low (1982), *Fuga*, a part of stage composition *The HeartPiece – Double Opera* by Krzysztof Knittel (1999), and musical composition *Paplanina. Four serigraphies for tape* by Katarzyna Kwiecień-Długosz (2017).
The transcript or the reception of these works may be interpreted as literary, animated or visual score, in which the phenomenon of intermediality is present.
On the one h and, they reveal their hybrid nature and intention-motivated morphology, on t he other, create a n ew artistic discourse, which brings about a new message and a new aesthetic quality. Intermediality, as a phe nomenon of post-modern culture, constitutes one of the significant paradigms of contemporary comparative studies. It is an a rtistic gesture which consists in synthesizing different ways of conveying information, where the media build up a new, integrated *message*.
It is worth highlighting that the art piece may be def ined as intermedial, as the expert on i ntermedial issues – Artur Tajber, puts it, "not only when it combines,

assimilates and synthesises, different means of expression, achieving in this way the state of independence and autonomy, but when it combines them in its own, unique way" [13]. Thus, it is not the number of the media combined in the artefact which makes it intermedial, but only their mutual interaction and transformation by means of the context itself or technological intermingling possibilities. Intermediality "does not mean either a sum of various medial concessions or situating particular works in between media, but rather integrating aesthetic concepts of particular media in the form of a new medial context" [9].
The aim of the article is to analyse the selected musical and literary works whose transcript is not conventional and whose intersemiotic features are manifested in the act of perception.

2. Methodological issues

The score in the intermedial approach of Hejmej is a literary score ("score" without notes), which "refers not to the literary text itself, but merely to its immanent relation with the score in the literal, musical sense, to its relation – in the final aspect – with the musical composition" [7]. The score in Hejmej's interpretation is a certain type of intermedium, in which the connection is made between the sphere of sound and vision, as well as, on a different level, the sphere of music and language.
This means that on the one hand, in the literary text one can trace the *implicit* intersemiotic quotations (composition technique, musical markings, form, *genre* or the title of a particular musical piece) or *explicit* references such as description of the musical composition or other attempts of music thematization, on the other hand, the structure of literary text (its layout) resembles that of musical score transcript. The musical composition or its technology serves the function of a primary interpretative context in the literary work.
Poems, according to Hejmej's definition, are to be viewed differently, due to their structure being similar to the score in the strict sense. They may constitute material to be performed live and he describes them as "sound poetry score" [3]. Johanna Drucker, in turn, defines this type of poem as "performing score" [4]. This type of poem may be listened to or watched, offering an original verbal or visual "score". It may be referred to as "literary *performance*", created in real time.
Also, musical composition may be based on a literary text or created in combination with visual arts. Its score has features of graphic work or animated film. In this case we are dealing with multiple media being used, the combination of which produces an integrated artistic effect.
Such works manifest signs of the existence of musical composition in literary text, of literary text in a musical piece or the visual elements in a musical piece.
This gives birth to an artefact generated live in the shape of "poem-score", "verbal score", "visual poetry", "musical graphic work", "animated score" or "musical installation art".
The references of a given medium in the artistic work to other media go beyond the traditional scope of study, therefore the analysis and interpretation of the selected works and defining music-literature relations or musical and visual relations requires a broader context, based on Werner Wolf's theoretical reflection [15].
In the theory of intermediality, developed earlier by Steven Paul Scher, on the basis of the relations between music and literature, Wolf distinguishes between – *"intracompositional intermediality"* referring to the work in which more than one medium takes part in the signification process, and their presence can be singled out and quoted (*overt intermediality*) or it cannot be singled out or quoted and is only implicit (*covert intermediality*) [14].
The first of the aforementioned cases

results in so called intermedial imitation – *implicit reference* or intermedial thematization – *explicit reference,* the second case results in relations of different media – intermedial fusion or combination – which cannot be isolated and quoted in their performative role, creating a uniform multimedia message.

The works discussed in this article which resemble so called "literary scores", both those in the form of "poem score" and "performing score" represent the type of work in which a kind of intracompositional intermediality is present, as implicit references to music, connected with imitating the techniques and generic principles typical for the baroque style (fugue) or as explicit references based on music (dialogue between voices). The musical composition which displays the features of "animated score" is an example of plurimediality, where particular media blend into one another, i.e.: literature, graphics, visual arts, electronic media, digital media.
The structure of the works chosen for the analysis is similar to the one of palimpsest and may rely on " comparing the poetics based on semiological criteria characteristic for a given medium" [10].
Such methodological background makes it possible to approach and describe all that is unique in each work, its novelty, its *differentia specifica*.

3. The Type of Intermedial Score – Structural Filiations

The words of Gérard Genette: "one sings, the other speaks" [5], meaning that it is not possible to transpose one kind of art into another, could be a perfect start for opening a discourse on the mutual relations between arts that result in the creation of an intermedial score. The works discussed below manifest diversified structural filiations of the media, which can be seen only in the act of perception.

3.1 Music-Literature Relations. Music in literature (*Preludio e Fughe* Umberto Saba)

Preludio e Fughe by Umberto Saba [11] is a literary cycle made up of a prelude and 12 2-voice or 3-voice fugues (for two or three voices), in which the author made reference to formal principles (in terms of construction model) of traditional music *genre*, as well as to the cycle *Das Wohltemperierte Klavier* by J.S. Bach. The works in question, forming a kind of "literary" fugue do not refer to a specific musical piece but only to the structural features of the genre in the strict sense. It has to be pointed out that polyphonic texture and its vertical dimension, determining the structure of the naturally multi-vocal musical piece, posed quite a challenge for the author of a linear text. The poet showed different voices in the fugue by means of different typographical setting in the text, where particular "voices" are represented by intertwining plots of literary content. It is possible, however, to determine in this work the correlatives of musical fugue factors and the means of polyphonic technique, which function in relation to this genre as a intersemiotic substitute. The theme Saba's fugues assumes a slightly different role than in musical fugue, as it does not constitute a main formal factor but is one of the elements of dialogue in the literary utterance.
Such implicit references were, as it seems, intentionally planned by the author – at the time of writing his cycle Saba was taking piano lessons [12]. The reference to the title "prelude and fugue" is not the only one present here, there is also a noticeable reference to Bach's practice of composing the cycle *Kunst der Fuge* consisting in complexity of means of polyphonic technique in subsequent pieces, where the 12th fugue is the most

complex piece in terms of structure.
The structure of two-voice fugues is constituted by the coexistence of antiqua and italics while the three-voice fugue (sixth fugue), omission of italics and using Arabic numerals in parentheses instead in order to mark a particular voice number. The voices in the fugue (signalled by the author in the subtitle) appear in a linear, continuous manner, being seemingly separate and autonomous formal factors. Italics appear in the text in an unorthodox role – namely, they serve a semantic function. Alternating use of regular font and italics additionally overlaps with the verse segmentation and separation of passages carrying different semantic significance (present only in the original language version). In the visual aspect, the addressee experiences the effect of so called literary interpretation of two-voice fugue themes, where one of the voices is the theme, the other is the counterpoint of the fugue (*See Figure 1*).

Sotto l'azzurro soffitto è una stanza
meravigliosa a noi viventi il mondo.
A guardarla nei cuori la speranza
e la fede rinasce. Da un profonde

carcere ascolto. *Tutto in lei risplende,*
nuovo e antico: ogni vita al suo cammino
prosegue lieta, e ad altro più non tende
che ad esser quale ti appare. Il destino

fu cieco e sordo: io dentro una segreta
mi chiusi, dove l'un l'altro tortura
nell'odio e nel disprezzo. *E chi ti vieta*
d'uscirne, e qui goder con noi la chiara

luce del giorno? Oh tu, che troppo sai
farti del mondo una bella visione,
hai mai sofferto di te stesso? *Oh assai,*
oh al di là di ogni immaginazione!

Figure 1. Umberto Saba, Quarta Fuga (a 2 voci) [11]

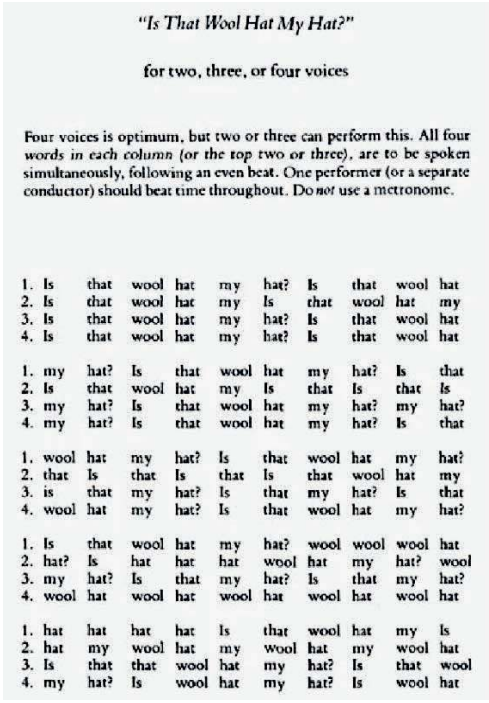
A different typographical configuration of the text is applied in the three-voice twelfth fugue. Saba already in the subtitle of his work (*a 3 voci: l'Uomo, l'Eco e l'Ombra*) specifies the presumed "cast of performers". In this fugue the poet uses both antiqua and italics, additionally segmenting the text for the stage performance purposes, where italics represent the voices of The Echo and The Shadow whereas the voice of The Man is marked with antiqua [6].
The prelude is a introductory artistic and methodological commentary to all fugues. Apart from its traditional role of an introduction it explains to the addressee the rules of text structure applied in particular fugues. The music is indicated in the text of the prelude as a theme. The use of phrases typical for the music terminology in the text (e.g: "voci discordi", "voci invano discordi", "estremi accordi", "in nuovi dolcissimi accordi") is what allows us to view this work in the category of intermediality with explicit references.

3.2 Music-Literature-Visual Relations. Sonic and visual poem (*Is that wool hat my hat?* by Jackson Mac Low)

Is that wool hat my hat? by Jackson Mac Low is an example of a literary performing score with the elements of visualisation, without the use of musical notation (literary performance). The main aim of the work is the transition from reading the poem silently to its recitation aloud. This work, referring to a musical piece, is divided into voices and designed to be performed on stage without the use of metronome (in identical rhythm), becoming a sphere dedicated to conceptualisation. The poem can be presented as a live performance, resulting in an intermedial spectacle with the performers' participation. Southland Ensemble gave such a performance in

2007 at the Conrad Prebys Music Center's Experimental Theater.

The text layout on the page is ambiguous – the author's intention behind this work is to let it serve a dual purpose: as a verbal text or a musical score to be performed in various configurations (one up t o four voices). The text of the poem may be read (performed) in at least three ways, using the same set of words (in rows or in columns). Their different syntactic combinations result in different meanings. The first performer utters the title question, which remains unchanged in the first three stanzas. Subsequently, the question mark disappears, making the sentence an affirmative one and the particular words are repeated. The other voices interact with the first one, uttering the same material in different variations, which makes the initial sense of the sentence vanish altogether (See photo 1).



"Is That Wool Hat My Hat?"

for two, three, or four voices

Four voices is optimum, but two or three can perform this. All four words in each column (or the top two or three), are to be spoken simultaneously, following an even beat. One performer (or a separate conductor) should beat time throughout. Do *not* use a metronome.

1.	Is	that	wool	hat	my	hat?	Is	that	wool	hat
2.	Is	that	wool	hat	my	Is	that	wool	hat	my
3.	Is	that	wool	hat	my	hat?	Is	that	wool	hat
4.	Is	that	wool	hat	my	hat?	Is	that	wool	hat

1.	my	hat?	Is	that	wool	hat	my	hat?	Is	that
2.	Is	that	wool	hat	my	Is	that	Is	that	Is
3.	my	hat?	Is	that	wool	hat	my	hat?	my	hat?
4.	my	hat?	Is	that	wool	hat	my	hat?	Is	that

1.	wool	hat	my	hat?	Is	that	wool	hat	my	hat?
2.	that	Is	that	Is	that	Is	that	wool	hat	my
3.	is	that	my	hat?	Is	that	my	hat?	Is	that
4.	wool	hat	my	hat?	Is	that	wool	hat	my	hat?

1.	Is	that	wool	hat	my	hat?	wool	wool	wool	hat
2.	hat?	Is	hat	hat	hat	wool	hat	my	hat?	wool
3.	my	hat?	Is	that	my	hat?	Is	that	my	hat?
4.	wool	hat	wool	hat	wool	hat	wool	hat	wool	hat

1.	hat	hat	hat	hat	Is	that	wool	hat	my	Is
2.	hat	my	wool	hat	my	wool	hat	my	wool	hat
3.	Is	that	that	wool	hat	my	hat?	Is	that	wool
4.	my	hat?	Is	wool	hat	my	hat?	Is	wool	hat

Photo 1. Jackson Mac Low, "Is That Wool Hat My Hat?" From Representative Works: 1938-1985 (New York: Roof, 1986), p. 307 [1]

Low's work is an example of a simultaneous construction modelled on the musical score. The poem's notation resembles a composition in which aleatoric technique is used (in the form of graphic score), where the elements such as the cast of performers, tempo, dynamics and the manner of *performance* (horizontal, vertical) are not clearly defined . In his transcript the author included many interpretative hints, which make it possible to create numerous invariants of *performance*.

3.3 Music-Literature Relations. Literature in music (Fuge in *The HeartPiece – Double Opera* by Krzysztof Knittel)

Another example of applying music-literature filiations in the artwork is the verbal fugue being a part of the semantic opera *The HeartPiece – Double Opera*. This chamber opera, created in 1999 is the effect of artistic work of Polish composer (Krzysztof Knittel) and American composer (John King) on the verbal text of the libretto based on t he play "Herzstück" by Heiner Müller.

The fugue (the 16th scene of the opera) is a striking example of the use of symbolic play on w ords in a musical piece by Knittel.
Müller's text is a subject matter of the fugue, recited by musicians in three different languages. The fugue consists of

three subjects; each of them is recited in a different language (I – Polish.; II – English; III – German).

The composition, despite the traditional formal factors applied in it i.e.: theme (subject), episode, free polyphonic transformation (augmentation, diminution, subject retrograde), differs from its baroque archetype. The lack of defined sound pitch excludes the fulfilment of the other principles distinctive for this *genre*.

In this case we observe the interaction of different media and their fusion, including the emphasis put on "hybrid" nature of the visual registration of the score. In this fugue the factor of key importance is not the semantics of the poetic text as such but rather the sound as the material element of the text. This extract can be compared to the intermedial *optophonetic* poem, recorded in the form of a score, "in which the spatial transcript is reflected in the simultaneity of sound, paradigmatic in music" [14]. The fugue is thus an exemplification of broadly understood intermediality, where "the attempt is made to fulfill, within the scope of one medium, the aesthetic conventions and/or visual and auditory features of another medium" [2].

The score notation offers the possibility of performing the work in two versions (I – only verbal version; II – verbal version with instruments). The original transcript, illustrating the theme imitation helps to interpret the intention of the form. Below are shown the first two pages of the score (*See photo 2*).

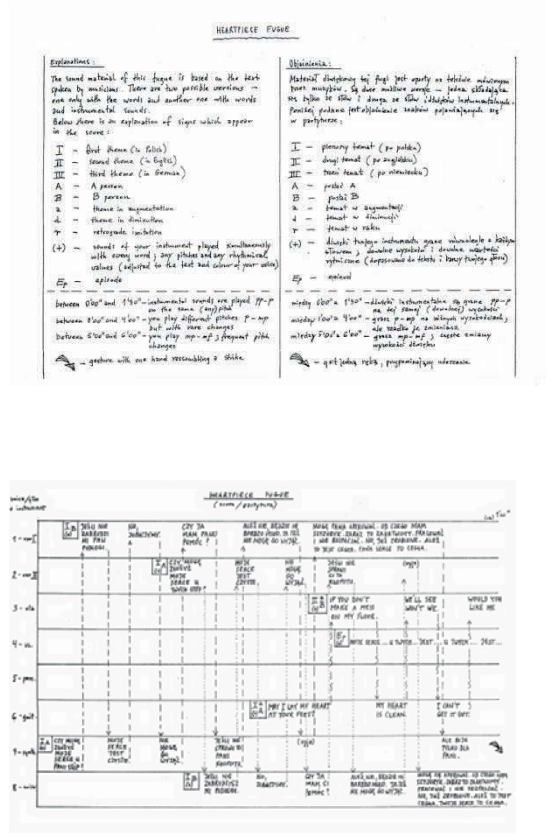


Photo 2. K. Knittel, J. King, The HeartPiece – Double Opera, scene 16 (the first two pages of the score) by kind permission of Krzysztof Knittel

In this case we are dealing with the opposite setting. In the musical piece we can point out implicit references to literature, consisting in quoting Müller's work, which is reproduced in the form of a fugue. The outcome is a kind of 'sound and vision' score, like in the literary work *Is That Wool Hat My Hat?*

3.4 Musical and Visual Relations. Animated score (*Paplanina. Four serigraphies for tape* by Katarzyna Kwiecień-Długosz)

The contemporary composition by

Katarzyna Kwiecień-Dlugosz entitled *Paplanina. Four serigraphies for tape* is a musical installation art, in which the recipient can follow, apart from the layer of music (tape), the visual layer, created on the basis of the drawings by Jacek Papla (graphic artist). The series of miniatures was composed specially for the exhibition of his works held in The University Library in Zielona Góra in January 2017. The first word of this composition's title, "Paplanina", requires additional explanation. In Polish, the verb *paplać* means “talk a lot and sometimes about silly things” (slang), so the title is a kind of joke and could be translated as *talking*. The title itself also refers to the name of the composer.

The work consists of four parts: 1. *Runes*, 2. *Spheres of sensitivity*, 3. *Votive offerings*, 4. *Marks*. The titles of pieces correspond to the titles of drawings. *Runes*,

The sound units used to create the tape contents come from:

- traditional set of instruments: church organs recorded in a monastery in Bavaria, double bass, percussion instruments (bongos, maracas), Vietnamese instruments (litophone, gong, hegaro), the quotation of *Passacaglii C minor* by J.S. Bach BWV 582, the voice of a soprano singer (vocal track from the composer's work entitled *Fantasmagoria* for soprano and electronic instruments),
- phonospheres: human voices in Polish and Vietnamese language, a crying child (the voice of a 3-month old composer recorded by her parents), symbolic holiday song performed by the composer's husband's grandmother,
- sonospheres: street noise, the sound of sea waves in Croatia and the sounds made by swallows, recorded in Dubrovnik, the sounds made by appliances (washing machine, clock, hands feeling the fabrics: wool and silk), music box.

They were processed and generated by means of computer software – a creative digital tool: Cubase and Audacity.

The work can be therefore viewed as an "medial hybrid", made up of different media (musical content, electronic media, digital media, graphic works, visualisations), which, when combined, create an integrated artistic effect. The titles of pieces are the consolidating aspect of the entire project, helping to fully understand the meaning of the intermedial artefact.

The work does not contain musical notation – one may be tempted to conclude that we are dealing with an animated score, which the listener can follow in the act of perception. Sophisticated drawings by Papla were the inspiration for the composition.

The listener, apart from hearing the sounds generated by tape, follows animated graphic images illustrating the scenes of the intermedial spectacle performed live. As further explained in the commentary of Katarzyna Kwiecień-Długosz: "*Runes* are ancient mysterious signs written on stones in the North of Europe. The main characters of this part are stone and water (*See photo 3*). *Spheres of sensitivity* is a story of love, desire, dreams and longings (*See photo 4*). *Votive offerings* are colourful strings fastened on tree branches in Bulgarian woods. They were also tied around the wrists of the youngest child in the family in order to bring good health and luck (*See photo 5*). *Marks* are pictures showing roofs with windows, where the symbols of simple geometrical shapes are emphasized (*See photo 6*).

The listener can imagine life observed through the window or inside the buildings" [16].



Photo 3. Runes II, 2011 (Jacek Papla) by kind permission of Jacek Papla

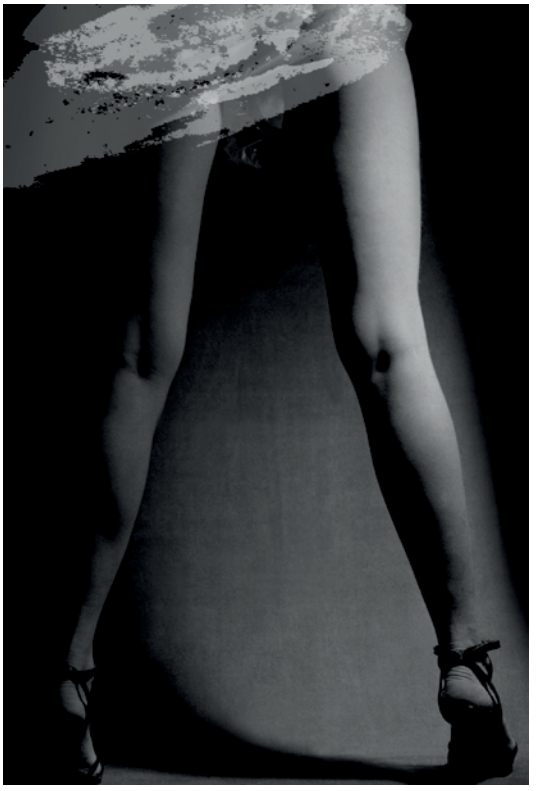


Photo 4. Spheres of sensitivity, 2007 (Jacek Papla) by kind permission of Jacek Papla



Photo 5. Votive offerings II, 2011 (Jacek Papla) by kind permission of Jacek Papla



Photo 6. Mark II, 2011 (Jacek Papla) by kind permission of Jacek Papla

As a result of fusion of particular media a polymedial composition is created. The interference between *ars* and *techne* determines its aesthetic value.

4. Conclusion

Musical score since the beginning of the 20th century has been the object of study in other scientific and artistic areas. Its phenomenon lies in the synergy of acoustic and visual domain of perception. The score, as a spatial representation of a musical piece is the example of intermedium, combining the visual aspect with the sound and, on a different level, the musical aspect with the linguistic one [3].

This article is an attempt at showing various, evident or covert references to

music in literary works, and the references to literary works or visual arts in the musical piece, making up a particular type of score, which is deconstructed and loses its primary (musical) nature.
The choice of poems, which refer to the technology of a musical form characterized by extremely complex and strict formal and intellectual discipline
based on counterpoint and polyphony, producing so called "literary fugue", made it possible to indicate distinctions between the applied media. However, one has to bear in mind that it is not possible to literally transpose a musical work into a literary one, but only to interpret, in a certain manner, the musical structure in literature.
On the other hand, the poems in which the poet included the preforming instructions, so called "performative term" directly impose the associations with music, offering a text to be performed in the form of "performing score".
Paplanina, a piece by a Polish composer is a kind of musical installation art, where the listener hears the sounds generated from tape and simultaneously watches the display of animated, edited images.
The process of creation in case of this composer's work involved the inclusion of the design thinking in the scope of artistic practice of sound exploration.
The combination of different means of communication creates an intermedial discourse, a complementary whole – *new syncretistic medium*.
The methodological principles, taking into account various intermedial filiations, adopted by the author made it possible to evaluate the original "produced text" in terms of its performative aspect.

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(the speaker)

POINT D.ORIGINE FROM MENDE TO CHAMBORD :
The paths of an evolutive design process

Topics: Art, Architecture, Music

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Abstract
POINT D.ORIGINE is a musical-architectural installation that converts, through mathematical objects called “spherical harmonics”, the architecture of remarkable buildings into musical sounds and sequences. To experience it, the visitor takes a small object called a “harmonic lantern”, whose role is to geolocalize his/her position in the space of the building, and wears a noise-cancelling headset. Since the transposition is computed for each point within the building, by his movements and displacements, he generates harmonic sound trajectories of which he is simultaneously the composer, the musician and the audience. Everything happens like if myriads of sound droplets where suspended in the air, waiting for the lantern to cross them in order to be played. Since the sounds are polyphonic, the music that is heard at a given point depends on the trajectory that was taken to reach this point. If the visitor stays still, the music stops. Our team has put a lot of efforts at all levels (design, functionality, ergonomy…) to make the installation simple and easy to experiment. People of all ages, from kids to elderlies, have been able to try and enjoy it. For those who are interested in knowing more about the scientific, theoretical and technological roots of the project, the installation is accompanied by an exhibition in which posters, video animation and small sculptures describe the underlying processes, principles and methods.

POINT D.ORIGINE was presented first in the Gothic cathedral of Mende, in 2017, then in the Chateau de Chambord in 2019. The passage from Mende to Chambord gaves us a lot

of opportunities to explore and improve all parts of the project, and to develop a technological premiere in terms of localization. In this lecture, we present the major evolutions that occurred between the two installations, in particular the complete redesign of the harmonic lanterns, the development of a new set of sculptures from a 3D model of the castle that was realized by our lab, and the new localization system, based on a collaborative network involving the lanterns themselves and a set of small beacons fixed on the walls. These developments were required because of the number and complexity of the spaces within Chambord, and because of the nature of the audience, which is completely different from the audience in Mende: as the second largest castle in France after Versailles, Chambord welcomes more than one million visitors a year, generating a completely new set of environmental constraints. Comparing the two systems in Mende and Chambord provides a clear illustration of the evolutive nature of the design process itself, and will allow us to demonstrate the multiple paths of adaptation that it must follow to react to changing external conditions.

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Point d.Origine from Mende to Chambord The Paths of an Evolutive Design Process

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Abstract

Point d.Origine is a musico-architectural installation that converts, through mathematical objects called “spherical harmonics”, the architecture of remarkable buildings into musical sounds and sequences. To experience it, the visitor takes a small object called a “harmonic lantern”, whose role is to geolocalize his/her position in the space of the building, and wears a noise-cancelling headset. Since the transposition is computed for each point within the building, by his movements and displacements, he generates harmonic sound trajectories of which he i s simultaneously the composer, the musician and the audience. Everything happens like if myriads of sound droplets where suspended in the air, waiting for the lantern to cross them in order to be played. Since the sounds are polyphonic, the music that is heard at a gi ven point depends on t he trajectory that was taken to reach this point. If the visitor stays still, the music stops. Our team has put a lot of efforts at all levels (design, functionality, ergonomy…) to make the installation simple and easy to experiment. People of all ages, from kids to elderlies, have been able to try and enjoy it. For those who are interested in knowing more about the scientific, theoretical and technological roots of the project, the installation is accompanied by an ex hibition in which posters, video animation and small sculptures describe the underlying processes, principles and methods. A first version of *Point d.Origine* was presented in the French Gothic cathedral of Mende, in 2017. The second version was presented in 2019 in the Chateau de Chambord, a fairly known historical monument. The passage from Mende to Chambord gave us a l ot of opportunities to explore and improve all parts of the project, and to develop a t echnological premiere in terms of localization. In this lecture, we present the major evolutions that occurred between the two installations, in particular the complete

redesign of the harmonic lanterns and the development of new localization system, itself a premiere, based on a collaborative network involving the lanterns themselves and a set of small beacons fixed on the walls. These developments were required because of the number and complexity of the spaces within Chambord, and because of the nature of the audience, which is completely different from the audience in Mende: as the second largest castle in France after Versailles, Chambord welcomes more than one million visitors a year, generating a completely new set of environmental constraints. Comparing the two systems in Mende and Chambord provides a clear illustration of the evolutive nature of the design process itself, and will allow us to demonstrate the multiple paths of adaptation that it must follow to react to changing external conditions.

Key words: Music, architecture, design, media arts, digital arts, music technology, spectralism

I - A Dream of Stone



Fig. 1 – The Chambord Castle, seen from the garden. The dungeon is the central part with the two middle towers.

From September to November 2019, we presented the interactive musical installation *Point d.Origine* in the Château de Chambord, the largest of a gr oup of about 3000 castles known as the "Châteaux de la Loire", from the name of the largest French river along which they are distributed in the Touraine region. Among all these buildings, 11 a re royal castles, and 21 are of particular importance. Though Chambord is among the first group, it was not originally conceived as a royal residency, but rather as a hunting pavilion for king François 1er, who started its construction in 1519. It was completed one and a half century later by Louis XIV, at which time it became sporadically inhabited up to 1840, when it was classified as a historical monument in the very first *Liste des Bâtiments Historiques de France*.

Chambord was built in the middle of a swampy land, where it replaced a smaller mediaeval castle. I was not a small technological achievement. Some parts of the castle are said to be built on 12-meters wooden posts, in order to reach a stable ground. A lot of the 1200 workers

died because of swamp fevers. A small river had to be deviated in order to carry by boat the required amounts of stone to the worksite. Then, after all these efforts, it was impossible to inhabit the castle most of the year, because of the cold and humidity that prevailed from autumn to spring. François 1er himself spent only 72 nights in it, and used it only for short hunting stays, or to impress foreign kings and leaders – which worked: Charles Quint, emperor of the Western Holy Germanic Empire, was invited there for one night. Shortly after his visit, he said to his sister that he never saw anything more beautiful than this palace arising from the depths of the forest.

All this gives clues about the principles that guided the construction of the building. Located far from any urban environment, in a place that was literally in the middle of nowhere, it was free to deploy a morphology that was almost uniquely based on primordial, symbolical and formal architectural principles, without any real consideration for context or function, whatever this function may have been. The first part to be built was the dungeon; it consists in a cube with a large cylindrical tower inserted in each corner, and a cone-shaped roof over each tower. The only concession to the context is the diagonal orientation along the four cardinal points: the towers face North, East, South and West, so that the façades face the four quarters of the world. This solar connection, encountered in many major architectures, already points out to a plan mainly determined by cosmological considerations, which is corroborated by a wealth of elements within the whole building. The central staircase is a double helix around an empty cylindrical core with parallelogram-shaped openings, allowing people that climb or descent the stairs to see each other without ever meeting. Almost every element in the castle is literally orbiting around this staircase. In the original plan, instead of being symmetrical mirrors of each other, the four towers describe a helix around it, and their inner plan follow the same pattern. On each tower, all skylights, turrets and chimneys radiate from the centre instead of facing the same direction. The whole plan seemed to be conceived as a Solar System, the centre of which being occupied by the extraordinary staircase that symbolizes both the central Sun and the power of the king around whom everything is organized, and which has also been described as a “tree of life” [i].

II - A Leonardian Cosmology

It is now a well accepted hypothesis that Leonardo da Vinci has largely contributed to the original plan. Though no written document supports it, several drawings from his hand seem to represent rather precisely the central staircase, as well as the different steps of its design. The helicoidal movement appears frequently in his texts and writings of the time, and can almost be considered as its signature (Fig. 2). Moreover, the idea of elements orbiting around a central Sun is fully coherent with the fact that, for several reasons including his own deductions and works by other scholars, he was convinced of the heliocentric model for the Solar System. On a more theoretical point of view, he once wrote that all figures of the sky are present on the Earth, and that all figures of Earth are present in the sky, so the idea of Chambord as a deliberate representation of the order of heavens by Leonardo, as they were seen in the time of François 1er, is fully plausible [1] [2].

This point as such should not be surprising. Each and every architecture on Earth, from the most precarious to the wealthiest, incorporates elements that makes it a representation of the cosmology of its time and place. There are even examples in traditional or tribal architectures of houses or villages in

which each and every element is explicitly associated, analogically or symbolically, with some elements of the heavenly world [3]. But in the present case, every consideration of practicality, functionality or relation with the environment is subsumed by the strength of the symbolical forces that twist not only the whole building, but the stone itself: in the upper sections of the stairs, it becomes distorted and carried away by the irresistible helicoidal movement, which in itself does not only describe orbiting bodies, but the movement of the planets around another body travelling in space, like if Leonardo also had the intuition that the Sun was travelling through the cosmos.

In this respect, in one of his manuscripts appears a statement that, read to the light of today's science, is simply staggering [4]. It first states that the propagation of sound and light follows the same mechanisms than the waves on water, implicitly stating that they do propagate in waves. The wave hypothesis for the sound had already been stated by several scholars and thinkers, and can be traced to the Roman and Greek Antiquity, but Leonardo managed to support it by a strong argument that associated the echo with the reflection of waves on a solid wall. But the idea of light propagating in waves was so revolutionary at the time that it almost makes him looks like a time traveler. The first scientist to formalize and demonstrate this hypothesis was Thomas Young (1801), more than two centuries later. This insight becomes a little more understandable when he writes that the idea came to him as he realized that the reflection of the light in a mirror was also similar to the reflection of waves on water, but this explanation is nothing but a supplementary confirmation of the power of his observational and deductive abilities.

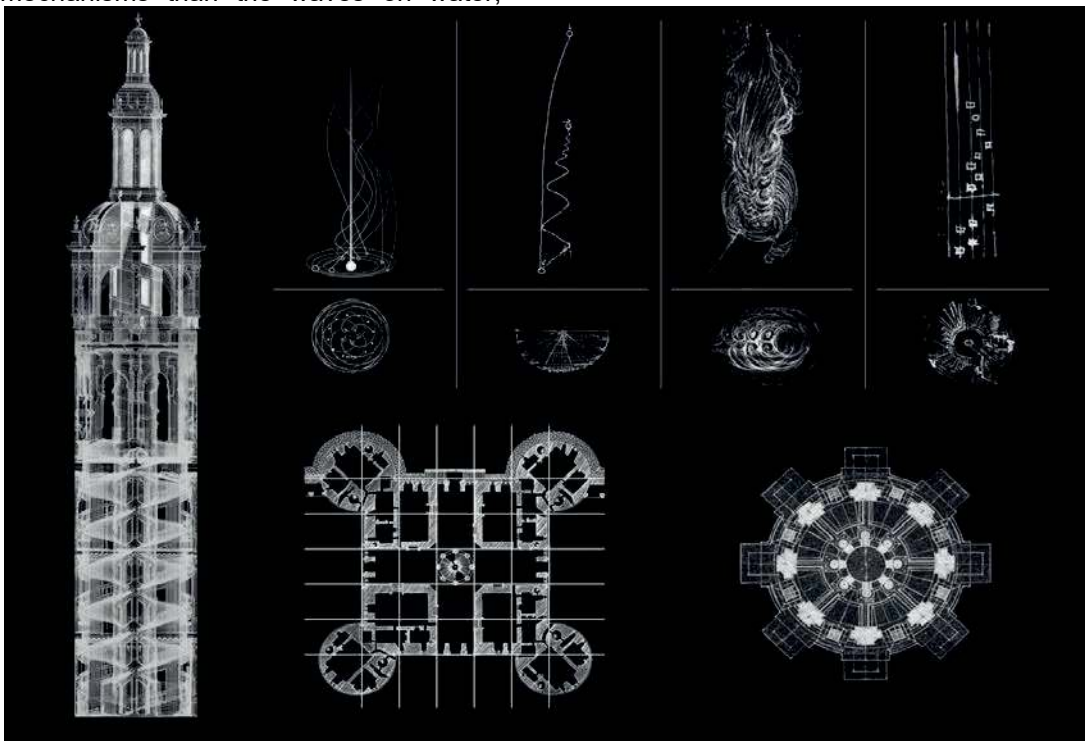


Fig. 2 – Helicoids in Chambord. Left - Cross-section and elevation of the double-helix monumental staircase. Top - four helicoid-related movements: planets trajectories around a travelling Sun; damping of a pendulum; vortex in water; musical rhythm. The three last drawings are from Leonardo. Bottom centre – Plan of the dungeon. The original helicoidal symmetry of the towers has been modified when the lateral aisles of the castle were added, which explains the mirror symmetry of the two top towers. Bottom right - Plan of the monumental staircase. The radial symmetry of the concentric elements evokes a radiating Sun around which orbit all the elements of the castle. The whole building is seen as an earthly representation of the Renaissance cosmology.

But this is not all. One of his most striking proposal resides in a paragraph where he proposes to undertake of an investigation program to look for the "amount of vibrations" in other elements of reality, such as weights, seasons, the areas occupied by the planets [5]. This amounts to nothing less than a program research aimed to provide an undulatory description for about all elements of the world. There again, this idea foresees another major discovery, namely the Fourier theorem (1801), by about two and a half centuries. Fourier was the first to mention the possibility to describe complex signals through sums of elementary waves; and the unification by Maxwell of all electric, magnetic and luminous phenomena under a same undulatory formalism came six decades later (1865). Further mathematical developments based on Fourier's work now allow to describe any element of reality through a wave vocabulary, provided the preliminary definition of the proper kind of wave. In such descriptions, the waves used as elementary signals do not have to correspond to real, physical waves: as we will see below, a wave description is a formalism that can be applied to any object or phenomenon, even non-undulatory ones [ii].

III – The Point d.Origine project

These considerations made Chambord an ideal place for the second study of our musical interactive installation *Point d.Origine* [7] [9], of which we already presented a first version in 2017 in the Cathedral Notre-Dame and Saint-Privat, in the city of Mende in Southern France [6] [8], another major historical monument with a very strong connection with the cosmology of its time. As mentioned in our previous work and lectures (see [3] in particular, but also [8] and [9]), *Point d.Origine* has been from the very beginning prepared and designed for architectural environments that can be considered as cosmological echoes. The very name of the installation comes from the history of cosmology, a history that could also be described as the history of the histories of the cosmos - of its current state and of its origins. To briefly sum up a theoretical and historical work that has been going on for several years, and that is described in the aforementioned works, most cosmologies and cosmogonies postulate the existence of a privileged point in the Universe, either in the form of a geographical centre, either as a temporal origin, or both. In the Western world, this central point was originally located on the Earth, or in its immediate vicinity. Cosmological developments up to the 20th century made it first oscillate close to our planet, then close to the Sun, to end up pulverizing it on every point of the Universe: in a relativistic cosmos, no point can be considered as a centre; or rather, every point could be defined as an immobile centre with the whole Universe revolving around it [iii]. The only privileged point that remains in such a world is my very position: it is the place from where I

contemplate and perceive the world, and from which I constantly evaluate my potential of action upon its elements.

This statement could seem very presumptuous if I did not add right away that the same applies for every human on Earth, or for every conscious being in the Universe; and that all these individual centres are constantly moving and changing according to our own displacements. From there came the name of the installation, which in French has a double meaning: from a Universe in which there is an origin point (*il y a un point d'origine*), we shifted progressively to a universe in which there is no origin (*il n'y a point d'origine*). Then, since every architecture is a small cosmology, a visitor in an architectural monument, especially - but not only - in a monument that is an explicit cosmological echo, must be constantly considered at its very centre, independently of the geometric centre of the building; and this centre travels with him when he wanders across the architecture.

In order to concretize the central position of the wanderer at each point in the building, *Point d.Origine* calls from another major aspect of antique Western cosmologies, namely its intimate connection with music. This connection naturally implies another connection between music and architecture, since the latter is *per se* a cosmological model. As a matter of fact, music and architecture where strongly connected to the Antique cosmos through the model of the Harmony of the Spheres. This model was actually acting as an immanent ordering force. It postulated that the distance between the planets where distributed along space intervals that were direct transposition of musical intervals; that this scale of proportions would determine not only musical scales, but also architectural scales; that it would control about every aspects of human life, from economy to laws to phases of pregnancy to principles for living a good life; and that it determined the ideal proportions for the human body, which was itself a reflection of the perfect divine bodies of the gods and goddesses.

From the birth of modern science, the Harmony of the Spheres has stopped representing a valid cosmological model, but the connection between music and architecture remained strangely present since. During the following centuries, many artists and thinkers have noted a number of analogies and similarities between the two arts, despite the fact that the first is mainly an art of the immaterial, and the second an art of the material. Among them, Novalis, Gœthe, Listz, Wright, Graves, Fathy, and many others, have stated in different forms that architecture is to space what music is to time, an approximate but illustrative sentence whose consequences cannot be overestimated. One of them is that music can be seen as an ordering and orientation mechanism in time, the same way architecture is for places; that a musical piece can also be considered as a small cosmology, through the distribution of its elements in time, and through the symbolical or analogical association of these elements with elements of the cosmos. Then, even after the complete invalidation of the Harmony of the Spheres in the 18th century, innumerable attempts have been made to associate music and architecture in different ways – poetical, analogical, formal… These attempts were diversely successful, but their very existence testifies of the conviction that a privileged connection between these two arts still exists. Moreover, musical analogies remain common in modern cosmology. Several major modern theories and hypothesis, such as Kepler's laws, De Broglie's model for electronic orbitals, and even the string theory (which today remains at the level of a hypothesis), have been postulated by

using principles that are deeply anchored in the musical field.

It is through these considerations that we developed the *Point d.Origine* installation, which provides the visitor – who from now we will also call "the wanderer" - with an experience that constantly positions him at the very centre of a c osmology represented both through architecture and music. For this, we had to establish a deterministic and r eversible way to describe the architecture through a vocabulary of waves, and t hen to transpose these "architectural waves" into sound waves. The detailed description of the method we used is described in detail in our previous works [3] [8] [9].

The central principle of the method is, precisely, the possibility to use a w ave formalism to describe any element of reality. We started a f ew years back to study the possibility to generate a full formal, deterministic and reversible transposition between a pi ece of architecture and a pi ece of music. The transposition principle might be better understood by realizing that when we describe an architectural object, we tend to use, like above, a description based on geometrical objects: cubes, cylinders, cones… and we tend to assimilate the architecture to these objects. As a matter of fact, a c ube, or a c ylinder, does not have any reality or physical existence. They are geometrical objects, and as such, they do not exist in the physical world. Any cubic material object can be described through a cube, but the object itself is not, and w ill never be, a c ube – this would require an infinite precision that is not reachable with any material. Such geometrical descriptions are based on abstractions and on comparisons with abstract, virtual shapes. From there, it becomes easier to accept that any material object can be described through any set of abstract entities, provided a method exists for shaping these entities in the likeliness of the object. After Fourier's theorem stated that any complex signal can be described through a set of elementary waves, it was quickly realized that any complex configuration of patterns or volumes could be considered as a signal – though at times a strange one – and thus be described through intersecting trains of waves that would recreate its shape through constructive and destructive interferences.

For several reasons, we decided to use spherical waves – waves running at the surface of a sphere – to decompose our buildings. These particular waves, called "spherical harmonics", are particularly fit to our project because they imply for each transposition the existence of a centre; and that a centre could be associated to each of the potential positions of the wanderer, generating each time a n ew transposition.

IV – From the Cathedral of Mende to the Chambord Castle: an Evolutive Process

Mathematical, technological and computer science stakes were high for the *Point d.Origine* project. As mentioned above, we first succeeded in making it work at the Cathedral of Mende in 2017. It is after this first experiment, which, according to the visitors'comments and to the press reviews, proved fully successful, that we decided to try the transposition of a more complex building. Through contacts and encounters, we were able to propose it to the Château de Chambord – a building for which all challenges and constraints were greater by at least an order of magnitude – where it was accepted. The new version implied a s eries of major transformations in the system, which at the end am ounts to nothing less than an adaptive evolution process. "Evolution" has a specific meaning; this word is used here to describe the transformations that

were directly induced by the new environmental constraints. It should not be confused with the design improvements that would have anyway been brought to the design after our first installation, without regards for the new context - very few such changes actually occurred made between the two events. It happened that one of them, the introduction of Bluetooth wireless headsets instead of wired ones, made the installation sensitive to environmental factors we did not have to consider before. As we will see below, we already know that it will generate a near future its own evolutive change for the third version of the installation. For now, we will concentrate on the environment-induced changes that were undergone between Mende and Chambord.

Before going through the description of this evolution, it might be useful to briefly describe how the first study of our project at Mende worked. From the very beginning, we decided to make the installation very simple to use, so that even children, elderlies, or people from all origins and with any level of expertise could experiment it. At the welcome desk, the wanderer was equipped with a headset connected to a small glowing module called a " Harmonic Lantern". A series of very small ultra-wide-band Wi-Fi beacons (UWB), affixed on the walls, constantly yields the position of the lantern with a 10-cm precision. To each potential position is associated a musical timbre that corresponds to the transposition of the building into sound waves, computed from this very position. Whenever the wanderer makes a movement, or walks in the spaces of the building, the lantern crosses these points, triggering the associated sounds, thus creating a harmonic trajectory of which he is simultaneously the composer, the interpreter and the audience. Everything happens like if the castle was a gigantic musical instrument, filled with small drops of music suspended in space, and that the wanderer triggers by crossing them with the lantern.



Fig. 3 – The Harmonic Lanterns at Mende. These devices are individually held and connected to a headset. Their role was to geolocalize the visitors and to play the musical timbre corresponding to their position, with a 10 -cm precision. Their design and morphology were almost only determined by functional and practical considerations.

The elements constituting the Chambord apparatus were essentially the same as in Mende. The design evolution they undertook was forced by major differences in the environmental constraints. These differences were caused by several factors, including the number and topology of the spaces to be covered, the potential number of simultaneous visitors, the thickness and composition of the walls, and several others. The following sections will describe the elements of answer that we brought for each of them, as well as the corresponding design modifications that were introduced for the new version.

1 – A Complex Topology

The first difference concerns the number and topology of the spaces to be covered. Though Gothic cathedrals are not simple architectures, the topology of their internal spaces is not that complex (Fig. 4). In most of them, the central nave is flanked on both sided by the collaterals; the collaterals connect through the deambulatory, which surrounds the choir; a transept crosses the nave. The space is

unified: there are no walls between the different elements, and the only obstacles to the view – and therefore to most electromagnetic waves – are the columns. Also, for reasons related to the amount of calculations needed, we decided to cover only the nave and the collaterals, which simplified again the space – it was basically made of a large rectangle with one narrow rectangle of the same length on each side.

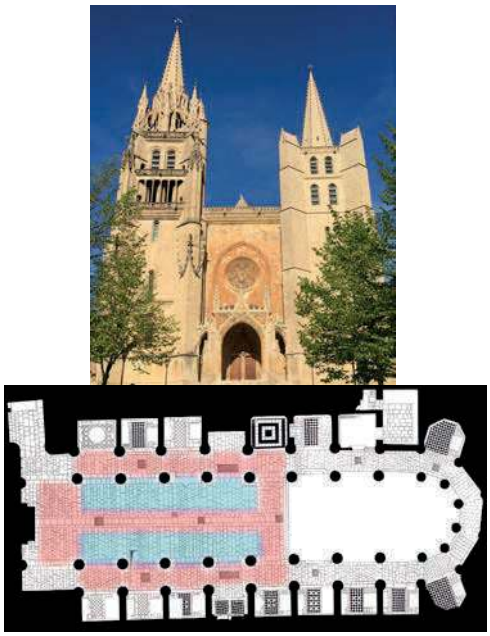


Fig. 4 – Cathedral Notre-Dame et Saint-Privat in Mende. Gothic architecture is complex, but the inner space remains rather simple and unified. The area covered by the installation is represented by the blue and pink zones. The only obstacles to the waves are the cylindrical columns. Geolocalizing the visitors was relatively easy. Twelve beacons on the columns, plus a main one suspended in the middle of the nave, were enough to reach a satisfying precision.

As mentioned above, we used a UWB Wi-Fi network to localize the harmonic lanterns. Our beacons (or anchors) were fixed on the vertical surfaces of the church. In order to be precisely localized, a lantern must simultaneously be in the line of sight of four beacons. Then, in this system, all beacons had to connected to a central beacon whose role was to probe alternatively the information coming from the other ones, and then to dispatch it to the lanterns for them to trigger the musical timbre associated with the wanderer's position. In this precise topology, we could not use more than twelve beacons without slowing down the system to a point where the music would be frequently interrupted. With such a small number of beacons, even if the spaces were geometrically simple, we had to undertake a trial-and-error process to determine the optimal position for each one. To make things less easy, each beacon had to be powered, and thus had to be not too far from an electric outlet – an element that is not that common in historical monuments. We ended up by covering about 85% of the space, leaving areas in which columns or other elements created "shadows" for one or two beacons. The localization in these areas was undergoing a progressive drift, in particular along the Z axis; but the precision came back to its best level as soon as the wanderer would go back in a fully covered zone.

Implementing the system in Chambord was far more challenging. A simple look at the covered spaces, which originally included all of the second floor and the double-helix staircase up to the ground floor, already reveals a complex, labyrinthian topology, with more than 50 different rooms or spaces organized around a wide central, cross-shaped hall. Moreover, the walls are thick enough to silent any electromagnetic waves at the frequency used by our system (the UWB Wi-Fi typically ranges from 1,9 to 2,9 GHz), so each and every room has to be equipped with its own beacons.

Considering the number of spaces to be covered (Fig. 5), using the same system as in Mende would have involved positioning and powering about 200 beacons. The cost of such a system would have been prohibitive, and the installation time unrealistic: powering a single beacon may require the secure installation of 4 to 12 meters of 5V-cable, which must be painted and/or hidden so as not to disturb the atmosphere of the monument.

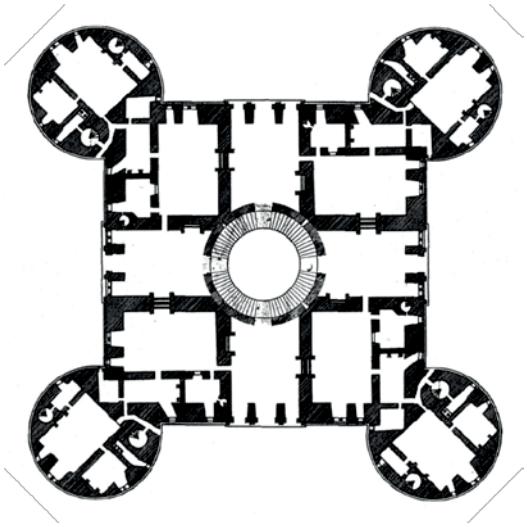


Fig. 5 – Plan of a typical floor at Chambord, according to the hypothetic original project by Leonardo. All elements follow a helicoid around the centre. The original staircase, represented here, has four flights between each floor, whereas the one that has been built has only two. The general topology of spaces is the same than for the final building, except that the two top towers are now mirrors of each other.

Our team then decided to develop a new positioning algorithm that would use the same equipment, but with a completely new tracking method. The main spaces, that is, the arms of the cross, would be equipped with four beacons, just like in Mende. In these areas, the positioning would be as precise as it could be. All other spaces would be equipped with a single beacon. One beacon is not enough to locate anything, since it yields only a radial distance. In these spaces, the positioning would first rely on the information transmitted by this beacon, but it had to be assisted by two different algorithms. The first one computes the vector displacement from the last known precise position, by measuring the number of steps walked by the visitor, and the orientation of his displacement. This method creates a drift in the positioning, because of the errors inherent to each of these measurements, and because it relies on an average length for a human step; but as long as it is not used for too long, the results remain usable. The second algorithm is a collaborative one: it uses the lanterns that are carried by other visitors in the same room as relays to improve the precision of the position given by the beacon. It obviously relies on the presence of other lantern carriers in the room, and thus on the number of visitors. When this number becomes too low, an unused lantern can be temporarily installed in the room. Whenever the wanderer returns in one of the central halls, that is, one of the arms of the central cross, its position is recomputed with maximum precision.

By using these two algorithms, simultaneously or alternatively, we managed to track the position of the lanterns in all spaces covered by the installation with only 45 beacons, which is a considerable improvement from the 200 that were initially needed. Moreover, through this development, we could eliminate the need for a central dispatching beacon, which gave us more freedom for positioning all the other ones. After several days of trial-and-error and calibration, like in Mende, we could provide the visitors with the possibility to

generate fluid harmonic trajectories, despite the complex topology of the castle.

To our knowledge, this collaborativve localization method has never been attempted before, and we are currently submitting first a paper to an engineering review. We are also evaluating the possibility to transfer this technology to institutions such as museums or arts centres, where its discretion and degree of optimization would undoubtedly be seen as major advantages over existing systems for position-based diffusion of information, or augmented reality systems.

2 – Larger Crowds

The second difference is linked to the potential number of simultaneous visitors. Though the Cathedral of Mende is classified as a historical monument, it is less known than Chambord. Located in a sparsely populated area of France, it also welcomes far less visitors than the castle, which has seen his frequentation topping one million visitors a year from 2017. Moreover, like all French cathedrals, Mende is still used for its original purpose: it remains an active place for all religion-related events. It is a very serene and meditative place; visitors and bel ievers move and behave calmly and silently. From the very beginning, its ambiance was fully in tune with the contemplative nature of the *Point d.Origine* project. The atmosphere in Chambord is quite the opposite. The main function of the castle nowadays is touristic. During week-ends and holidays, crowds of visitors of all ages and countries regularly flood the spaces, walking at different speeds, entering and exploring everything, attempting to enter even places in which they are not allowed. Most of them express their appreciations and feelings at loud voice, talking to each other at a distance, taking selfies about everywhere. The presence of kids adds to the general sound level, which is still amplified by the reverberation of the walls and vaults of the second floor. Such conditions make very difficult to concentrate on the musical experiment, and are rather stressful for the people in charge of distributing the lanterns and the headsets, providing the required explanations and c harging the different devices. To cope with this situation, our first decision was to increase the number of lanterns: from twelve in Mende, we went to thirty in Chambord. We also had to hire two mediators instead of one: the workload would have been unmanageable for a single person.

Considering the noise level and the animation caused by the numerous visitors, we decided to explore the possibility to use high-quality, noise-cancelling headsets for Chambord. This decision proved fully successful. First, it allowed us to shift the volume control from the lanterns to the headsets, which had very interesting consequences at the design level (see below); but mainly, these devices immersed the visitors in a full and dee p silence even before they began to create their own music. This silent period was seen by many as a welcome introduction to the music to come. The noise cancellation allowed the visitors to fully concentrate on t he trajectories they were composing, without being distracted by parasitic or environmental noises. This is what is normally expected with noise-cancelling devices, but here, this function proved essential and salutary. Then another unexpected effect appeared. While wearing the headset, the wanderer would still be a ble to see the other visitors; but without the associated sounds, their movements and displacements, as fast or brisk as they could be, would transform into a strange, oniric choreography. The whole inner landscape of the castle became like a dream in which coloured silhouettes located at different distances

were wandering in front of a still background made of stone walls and sculptures - the only sound being the music composed by the wanderer himself.

3 – The Lanterns: the Eggs of a Mythical Salamander

The main physical modifications occurred at the level of the Harmonic Lanterns. After a first residency in the castle during the summer of 2018, we decided to introduce a design change that was not induced by the physical constraints of the Chambord environment, but rather by its symbolic meaning. One of the most famous kings of France, François 1er adopted as his emblem a common amphibian, namely the salamander, an animal that had at the time the reputation of being able to cross fire and flames without harm. Salamander representations are carved everywhere in the stone of the castle, from the façade to the walls and ceilings (Fig. 6). The vault of the second floor is made from square stone voussoirs on which sculpted patterns represent alternatively the capital letter F, for François, and dragon-like salamanders in different positions and attitudes.

We then decided to shape the lanterns in the shape of salamander eggs, just like if the visitors could receive them from the salamanders wandering on the arched vaults. It is worth noticing that the symbolism of the egg, strongly linked to the question of origins, adds a major layer of signification to the object itself, making it particularly fit for this very installation. The small lantern becomes the point in space by which everything happens, from the positioning of the wanderer at every moment at the centre of the musical and architectural cosmos, to the real-time generation of the harmonic trajectories. Each and every of its positions in space and time becomes the origin point for the visitor's experience.



Fig. 6 – A dragon-like salamander in one of the voussoirs of the arched ceiling, on the second floor. The salamander was the emblem of king François 1er, the founder of the castle. It was supposed to have supernatural powers, including the ability to walk in fire and flames without harm. The new Harmonic Lanterns were shaped to evoke the eggs of this batracian.

As we can see, though it was not critical for the installation to work, this change was directly induced by the new context in which the project was presented. It became one of the most important evolution steps between Mende and Chambord, not only because of the change it implied in the morphology of the lanterns, but also because of all the other changes that were introduced as a consequence of it.

For instance, the very concept of an egg-shaped object induces for the imaginary the idea of an elementary form. We thus decided to eliminate the spiral cable that connected the lanterns to the headset, and to transmit the musical timbres through Bluetooth protocol: the cable became to be seen as cumbersome, and as disrupting the simplicity of the egg-shaped lantern. As a consequence, all operations involving a manipulation of the devices, such as showing people how to

use them, or charging the different elements, were greatly facilitated.

Then, we could eliminate all controls on the lanterns by using the headset slider to control the volume. Since we could also eliminate from the embedded electronics the sound card that was required for the audio plug, we could notably reduce the size of the lanterns. As shown on t he picture above (Fig. 3), the original ones were shaped as elliptic cylinders; the new version is ovoid with a different length along each axis, thus allowing people of different hand sizes to have an optimal grip on them (Fig. 7).

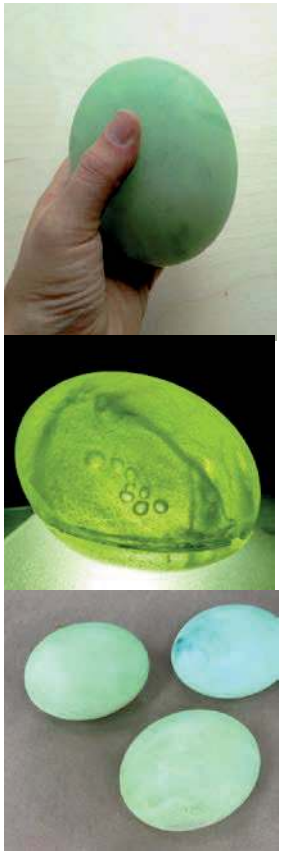


Fig. 7 – The new Harmonic Lanterns. Left, a completed Lantern. Middle, experiments in transparency for a Lantern shell. Right, colour tests for three completed Lanterns. Shaped like flattened eggs with a silky texture, almost without any external feature, the Lanterns became abstract, intriguing objects that people loved to touch and handle, and were carried with a lot of care.

Then, in terms of pure design, everything was reconsidered, from the materials to the manufacturing method. Whereas the first lanterns were 3D-printed with a stereolithography apparatus, the new ones were molded in a urethane resin (the molds themselves were 3D-printed with a PFM device). The advantages of this technique are twofold. First, the lanterns became much more resistant to shocks and drops, because of the nature of the new materials. Second, we got much more control on t heir texture and appearance, thanks to the multiple possibilities offered by the available molding compounds and dyes.

The final lanterns look like slightly flattened eggs. Their material is of a translucent green, in order to evoke, as mention above, the egg of an amphibian. The inner of the shell is coated with a translucent layer of silicon acting as a dampening material in case of shocks, and as a differential diffuser, in order to smoothen the lights coming from the LEDs of the embedded electronics and to locally modulate the transparency so as to evoke a bi ological object. Then, the outside of the shell was sandblasted with a specific-size abrasive material, so as to produce a v ery smooth, silky touch, similar to the surface of a pebble stone washed by the sea for a very long time. Finally, because of the electronics inside, the lanterns were becoming warm while in function. Being able to carry a warm, egg-shaped, softly glowing object, physically disconnected from any physical device, while hearing the music it produces, gives an almost ceremonial stance to the artistic

experience, transforming the lantern into a precious object with mythological overtones that most visitors came to handle with a lot of care and attention.







Fig. 8 – Experimenting the Point d'Origine installation. Left, Cécile Lavergne, one of the two mediators in charge of welcoming the visitors, demonstrates the use of the Harmonic Lantern and of the noise-cancelling headset. Middle, a visitor concentrating on the Lantern itself. Right, a visitor listening to the music generated close to the monumental double-helix staircase. In the background appear the arched ceiling, with its sculpted voussoirs representing alternatively the letter F, for king François, and dragon-like salamanders.

Conclusion

The Point d.Origine project rests on several layers of development, including architectural surveys, computer modeling, mathematics, physics, computer science, acoustics, design, musical composition, interface design. For the first installation in Mende, the overall complexity of the project resulted in a system whose design and implementation were mainly determined by the harsh physical and technological constraints coming from about each of these fields: every decision was basically the product of a straightforward reaction to these constraints. Despite this almost functionalist research-creation path, the installation was welcomed with a lot of interest, and we could already foresee its evolutive path for a next presentation.

Chambord gave us such an opportunity. For this second version, about each and every element, software or hardware, material or immaterial, was rethought, reconsidered and redesigned so as to make for the challenges and influences coming from the environment itself, and to introduce features that were not only linked to practical or functional considerations.

Along these transformations, we realized that the required changes also had a strong impact on the way people perceived the installation. Though not infinitesimal, the physical changes undergone by the different devices remained minor. They nonetheless transformed considerably the way people would approach and appreciate the whole artistic experience. We could readily observe the changes in attitude and in the rhythm of the movements of those who were undertaking the exploration of the sound cartography of the castle, and the way they would progressively slow down their displacements, so as to harmonize them with the very contemplative experience provided by the harmonic trajectories, thus escaping for a brief moment the constant agitation and noise generated by the other visitors.

As for any experiment with this degree of complexity, everything was not perfect. Though the comments by the visitors and

the medias were unanimously positive, we were faced with new and unexpected difficulties that were directly linked to the new technologies that we had introduced, and which appeared only along the time of the presentation. In particular, the range of frequencies covered by our UWB Wi-Fi tracking system is very close to the frequencies used by cell phones. When the number of visitors increased, we encountered interference problems that could at time stop the music, creating for the visitors periods of silence that could last up to two minutes. We also had intermittent problems with the Bluetooth transmission from the lanterns to the headsets, most likely linked to a question of bandwidth.

These difficulties were not frequent enough to spoil the wanderers' experience, but we know we will have to address them for the next version of the installation. Since they seem directly linked to environmental constraints, they create the artificial equivalent of an evolutive pressure: solving them will amount to pursuing the evolution path of our adaptive system, and to generate, through new shapes and/or algorithms, a new *species* along the *Point d.Origine* genealogic trajectory.



Fig. 9 – Point d'Origine improvised choreography.

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[7] Reeves N – *Point d.Origine*, interactive musical installation, Château de Chambord, Loir-et-Cher, France (prod. NXI Gestatio), 09-11/2019

Web Sites

[8] For the Mende Cathedral installation: www.nxigestatio.org/NXI/MENDE-CATHEDRALE

[9] For Point d.Origine at Chambord: www.nxigestatio.org/CHAMBORD

Notes

[i] Up to know, the fact that the double helix, which also symbolized for him the Tree of Life, is the same pattern that is followed by the structure of the DNA molecule, as discovered four centuries later by Franklin, Watson and Crick, remains at the level of a coincidence. But one never knows what to expect with Leonardo da Vinci, and the deep meaning of his intellectual fulgurances may well unveil in the future.

[ii] Here again, the fact that in the XXh century, special relativity described matter and energy as two different aspects of the same thing, and that quantum mechanics postulate that every matter or energy is associated with a wave of specific frequency, should be seen as simple coincidences, since the theoretical frame on which Einsteinian or quantum theories are built was neither existing, nor even foreseeable, at Leonardo's time.

[iii] For instance, the two statements "The Sun revolves around the Earth" and "The Earth revolves around the Sun" are equally valid – i.e. "true" - in a relativistic Universe. If we decide to privilege the second one, it is only because the first one would make the equations of movement frightfully complex for all other celestial bodies. This simplicity principle is known as Ockham's razor.



Psychometric equating methods ease fitness function dilemma in generative art

Topic: Fitness functions and generative art

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Abstract
Contemporary generative art is now expressed broadly as computational aesthetics, evolutionary arts, genetic algorithms and pr ogramming, as well as emerging forms of auto nomous visual arts. Several generative approaches using algorithms and r ule-based systems efficiently produce, and, arguably, create images without artist intervention. Yet, despite enormous advances, a long-standing issue is aesthetic evaluation and selection of autonomously generated images, which typically remains dependent o n artist or jury intervention. B oth passive and ac tive evaluation methods have been pr oposed that e ither guide image replications toward expected aesthetic values or impose selection standards after image runs. Ideally, these evaluations would function automatically. Commonly referred to as fitness bottlenecks, various strategies have attempted to alleviate costs of manual intervention but without fully satisfactory results. Approximations implementing synthetic computational aesthetic evaluation and artificial critics show promise modeling human judgment. However, interactive models implementing human participation ultimately are still required. This report presents an alternative perspective to fi tness bottleneck solutions by applying horizontal item equating methods commonly implemented during mental test development to generative images. Automatic item generation during commercial mental test development faces problems like computational aesthetics.

In this report, generated images were first evaluated by an expert jury using rating scales, which established an aesthetic ordering of images. These images emulated Birkoff's order-complexity ratio variations implemented with a stochastic Mole-Shannon information function. Sample-dependent, these ratings established only limited foundations for an objective aesthetic dimension. Consequently, ratings were transformed to a l inear (equal interval) logit scale with absolute values, objective properties, and explicit estimate of reliability. Then image specification codes were assigned to image locations, and those values functioned as objective weights. More importantly, parameterized images then were instrumental for statistically equating future image generations, as well as those from modified algorithms without additional jury implementation. In general, overall obtained aesthetic dimension is useful for comparing absolute aesthetic

differences among separate image runs. Applications are presented here of automatic item generation, as well as “seeding” figurative images with aesthetically scaled item codes for interactive artist rendering.

While mathematical scaling methodology does not eliminate fitness bottlenecks, this report demonstrates objective methods for comparing items from multiple production runs, and under certain conditions from different algorithms, as well as multiple media without expensive and laborious juries. In addition, virtual equating methods are discussed that further diminish inconvenience of evaluation bottlenecks. Finally, aesthetic theory provides meaningful qualitative interpretation of image ordering related to complexity and order after probabilistic scaling.

Key words: Fitness functions, generative art, common item equating, Rasch models

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Psychometric Equating Methods Ease Fitness Function Dilemma in Generative Art

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Premise



Generative art is responsible for many new ideas in visual arts and music and has contributed to understanding fundamental mechanisms affecting human development and behavior. Practical accomplishments making art have also pointed to new ideas about creativity and aesthetics. Yet, despite these advances generative art still lacks capacity to evaluate its own artistic products. Typically referred to as "fitness bottleneck", autonomy and expression associated with automated generative art is presently constrained by an incapacity to identify its best work or objectively compare independent image sets. This report presents a psychometric strategy on this issue, as well as examples demonstrating how those constraints could be eased by integrating psychometric aesthetic derived from professional artist judgments into fitness evaluation. Parameterized standards and adaptation of psychometric common item equating methods could guide generative productions and clarify their aesthetic value without reoccurring costs commonly associated with expert jury panels. Results presented here show a diverse group of professional artists converge on an objective aesthetic standard that could be integrated into generative algorithms. Successful empirical studies suggest this goal is reasonable.

1.0 Introduction

Michael Noll's surprising demonstration of a computer generating Mondrian's Composition with Lines indistinguishable from original work remains a landmark in generative art [1]. This capacity to reproduce authentic art, while not yet autonomous, continues in contemporary generative arts through elaborate decomposition and assembly methods that mimic artists such as Kandinsky, Miro', and Pollock [3]. Generative visual arts are now being expressed broadly in genetic algorithms and programming, evolutionary arts, computational aesthetics, as well as seemingly endless emerging forms of autonomous visual

arts. Several approaches to image productions implementing algorithms and rule
-
based systems now easily provide efficient and frequently unusual, if not creative, images without artist intervention. Some commentators have, arguably, asserted that generative art will extend human creative capacity [2], while they have already expanded methods of expression.

Yet, despite extraordinary advances producing unique, autonomous, computer generated art, an annoy ing problem is evaluation of image quality, which typically remains dependent on expensive and time-consuming juries [4]. Without an appropriate aesthetic value function that efficiently evaluates images, evolutionary art process is dramatically slower. This limitation presents a serious practical challenge applying EC approaches to fields such as image and music generation. Todd and Warner [5] referred to this inability to measure aesthetic quality simultaneous with image production, the fitness bottleneck.

Many fitness bottleneck strategies have attempted to alleviate practical implications of manual intervention during image production. Passive and interactive methods have been p roposed that either guide image replications during image production toward expected aesthetic values or impose selection standards after image runs. While interactive methods are typically implemented with an ar tist, even automated approaches in contemporary evolutionary art require artists somewhere in the image production loop manually scoring each new image or more specifically phenotype. Consequently, this limitation logically undermines any conception of full automation, threatening idea of genuinely autonomous art if not eliminating it.
According to some authorities, a m ore profound aspect of this problem is fully automated fitness evaluation is, in principle, conceptually inconsistent with contextual foundations of contemporary aesthetic theories, which embed emergent art in social systems. According to this perspective, valid fitness functions for evolutionary art systems cannot exist or be justified independently of their social context., which have never been addressed in generative arts. How does an algorithm embody cultural properties?

A further complication are dyspeptic convulsions that arise between modern and postmodern attitudes toward aesthetic fitness evaluation. Especially image selection that imposes an a rbitrary algorithm stopping value intended to emulate an objective aesthetic standard. Cost and convenience overriding cultural relativism creates tension between modern beliefs about objective standards and postmodern commitments. This conflict concerning aesthetic outcomes leads to attacks on legitimacy of sorting images into quality categories.

Even technical procedures seem to present intractable issues such as inferential implications of typical evaluation juries. For example, a common method is arbitrary sample-based standards defined by consensual agreement among jury members, which is subject to sampling variability. Aesthetic evaluation, even when juries are constituted by artists and expert judges, are inherently unstable, which weaken validity of image orders, juries, samples, and algorithms. Not surprisingly, mounting difficulties of practical fitness evaluation seem to make any hope of improving image selection seem futile if not hopeless.

Purpose of this report is to offer an alternative to conventional fitness evaluation methods by describing an adaptation of psychometric item scaling methods widely applied in rehabilitation medicine outcome evaluation, educational

and psychological measurement, as well as licensure and certification examinations to generative arts. Psychometric scaling methods are implemented to statistically equate generated test items across forms and item banks, as well as population samples. While physical units differ -- visual arts images versus mental test items -- concerns about qualitative evaluation, as well as stability of quantitative invariance across item and image pools are comparable. In other words, issues commonly involved with authentic aesthetic evaluation are fundamentally like those addressed in mental test development.

Psychometric equating methods in psychology and education present an interesting perspective on problem of evaluating generative art. Practical implementation of mental test theory is highly dependent on objective standards, and instrumentation is typically conducted with generated item samples, which themselves may have been produced randomly from an al gorithmic process, and item replications are typically accompanied by qualitative variation. Hence an item scaling method that equates test forms to objective standards is essential to maintain item and f orm comparability across population samples. Adaptation of this methodology to evolutionary art images could alleviate variability presently associated with disparate images from idiosyncratic algorithms, as well as identify objective aesthetic value.

In this research, a pool of generated visual images was first evaluated by a professional artist jury with Likert rating scales to describe approximate aesthetic quality, which provided numerical values for an ordinal image ranking. Mathematical transformation of ratings with a logistic function constructed a framework where image values, as well as algorithm specification codes were parameterized as logits, which function as objective weights. This parameterized image ranking then provided foundations for an a esthetic dimension with statistically invariant properties and estimates of standard errors and psychometric reliability.

Images scaled to this framework then were useful for statistical equating of future image generations, as well as images generated by modified algorithms but without jury implementation. Seeding procedures in this context were also conducted. An application is presented here both of automatic item generation and image “seeding” during interactive implementation with an artist.

While this methodology does not eliminate expert panels or professional artist judgments, which in principle is impossible, this demonstration provides an objective method for comparing items from different production runs, under certain conditions from different algorithms, as well as different media expressions without conducting additional juries. This strategy involves an initial investment in validity that is recovered by diminishing burden of reoccurring fitness evaluations.

This report consolidates advances in psychometric scaling and equating methods with insights from empirical aesthetics but with explicit emphasis on professional artist validation. Many computational aesthetic studies have attempted to integrate fitness evaluation and empirical aesthetics into image production but without convergence of professional artists. Those approaches are irrevocably inconsistent and di stinct from methods presented here.

2.0 Background

Image fitness in generative arts commonly refers to aesthetic quality of images yielded by an algorithm intended for an explicit purpose or target audience. Ideally, fitness would be established by a sensitive discriminative function that

evaluates image quality from generated population and classifies aesthetic acceptability. Consequently, fitness functions establish aesthetic boundaries for accepting works produced from algorithms, and their central goal is to clarify correspondence between generated images and desired level of aesthetic quality.

Practical limitations of fully automated algorithmic aesthetic evaluation have led to interactive methods that require intervention by expert observers who assign scores or ratings. In general, interactive evaluations do not recruit professional artist samples to justify parameters for aesthetic evaluation. Instead, empirical rank orders are based on convenience samples though sometimes very large.

Typical fitness strategies do not address or solve and, arguably, cannot solve fundamental issue of aesthetic standards, which arbitrarily fluctuate among sample-based evaluation juries, and their validity is further complicated by cultural context. Nonetheless, efforts to systematize fitness evaluation has moved ahead aggressively along several approaches with varied success.

Three prominent strategies to fitness evaluation are:

- Interactive models
- Evolving genotypes
- Arbitrary aesthetic measures
- Corpus methods

Interactive judgment models are least desirable but remain dominant. Evolving genotypes are automated models that rely on internal and/or external standards, which force generated images to converge on declared aesthetic standards. Seeds and targets also impose external standards on image evolution, then algorithms run their course. An alternative automated system may implement dimensional extraction models (principal components), which are imposed on obtained phenotypes [6]. Finally, corpus methods implement deep learning networks, which identify underlying properties across immense data bases of successful art works and parameterize their emergence in generated art.

2.1 Computational aesthetics approaches to evaluation

2.1.1 Automated fitness functions

A goal of computational aesthetics and evolutionary arts is to fully automate fitness evaluation simultaneously with image production, which would guide multiple iterations to convergence on optimal aesthetic values. Their goal is to address limitations and constraints of manual models. Machado, Romero, and Manaris identified “essentially five approaches to fitness assignment: interactive evolution, similarity based – evolving towards a specific image or images, hardwired fitness functions, machine-learning approaches, and co-evolutionary approaches (p. 383) [7]”.

Physical properties have been examined for their contribution to image quality. For example, Heijer and Eiben [8] compared four methods of measuring fitness: processing complexity model based on image compression ratio, Ralph’s bell curve, fractal dimension peak, and their aggregated or weighted sum. Unfortunately, they found little agreement among them. In addition to fractal dimension [9], fitness evaluation has also been based on physical image characteristics such as GIF compression [10], overall luminance gradient strength [11], or edge density [12]. Likewise, color and contrast belong to low-level image properties that can affect the preference ratings of photographs. Authors argue that artists use a non-linear compression to obtain low skewness in their paintings because images with this property can be more efficiently processed by the visual

system. Inconsistency of above measures have led researchers to explore insights from psychological studies of aesthetic preference, disparate as they may be.

Advances in computing hardware and methodology have accelerated attempts to integrate affective image properties based on psychological empirical studies that are known to influence human preference with physical image properties described above. This approach is expected to improve both automated and adaptive approaches to aesthetic image evaluation [13, 14]. This general effort to integrate empirical aesthetics into generative art production is now called computational aesthetics (CA). Unfortunately, literature produced by psychological empirical aesthetic studies is vast and inconsistent, arguably based on weak methods, which present substantial challenges to understanding implications for human judgements of beauty or contribution to aesthetic experience.

> Computational aesthetics" is sometimes used in the sense of describing a class of artefacts made by computers . . . we will refer to computational aesthetics only as computational models of human aesthetics [14].

2.1.2 Deep learning neural networks

An alternative approach to integrating physical and affective image properties in fitness models is automatic feature learning, which implements deep n eural network methods. Central goal here is to incorporate heterogeneous inputs generated from images of authentic visual art from both global and l ocal perspectives, then unify extracted information into a pr edictive model. Applications have been presented with AVA dataset [15]. A related strategy is decomposition or separation of image style and c ontent using convolutional neural networks [16]. See also brain inspired deep networks [17].

Deep learning networks use authentic art images as a training set to identify common properties that mimic authentic images. "Even in their perceived autonomy as image creators, their ability to act autonomously is limited within a very tight statistical framework that is derived from their training data [18]." Consequently, generative aspect of this system is constrained by the training set. This issue is echoed by other researchers as well. "AI systems that are trained to extract features from curated data-sets constructed of contents produced by people are imitating properties of artefacts rather than autonomously searching for novel means of expression. This holds true for current, popular AI art systems using machine learning [18]."

Extraction of fitness models using deep learning methods forces generative arts image production to conform to an aesthetic standard that is compatible with those images in the extraction pool. When large enough, those models can claim validity but raise questions whether these powerful systems are sacrificing autonomy for expediency. In other words, implementation of deep learning algorithms creates fitness dependency on the extracted learning and imposed on the generating function [18].

2.2 Challenges associated with sample-based, unstandardized, and non-validated fitness models

Traditional approaches to evolutionary art fitness evaluation have relied on sometimes naïve, expedient solutions emphasizing procedural convergence. Current trend emphasizes more understanding of empirical studies of aesthetic preferences and implications for fitness evaluation [13, 14]. Yet, Lewis [19] described numerous challenges to automating fitness evaluation in visual arts (see pp. 24-26), while Johnson [14] emphasized problems presented by differences in individual preference for

image properties [20]. Not least of these challenges is long standing confusion concerning individual preference differences for affective image properties versus formal aspects of authentic artworks, which are discussed below.

2.2.1 Confusion related to psychological empirical aesthetics

While psychological studies of empirical aesthetics have increased awareness of objective image properties, which increases comprehensiveness of CA approaches to fitness, they also introduce enormous confusion. Many constructs in psychological aesthetic studies such as complexity, order, symmetry, and randomness are formulated so poorly that general trends are difficult to establish. In addition, multiple approaches to operational definitions have led to inconsistent results, and general trend of 20th century empirical aesthetics is lack of consensus about chief findings. Replications are typically sparse hence objective image properties are only partially understood, and CA implementation of them have been fraught with complications. Strongest ideas coming from empirical aesthetics with useful implications are related to complexity, uniformity, symmetry, and order, as well as rule of two thirds, but they are also among most notoriously inconsistent and misused.

Complexity, for example, as objective property has been s tudied extensively, both in generative arts and in psychological experiments in multitude of statistical measures. Most prominent is number of visual elements in an image [21], an objective frequency of image elements, which is central to information processing models. This measure is prominently correlated with several computerized models of complexity (Zimmer's Law) [22]. Zhang [2] examined visual complexity in psychological studies versus computational complexity. Yet, complexity role in visual art differs across common preference measures and becomes incomprehensible when integrated among sometimes vast arrays of more complicated image properties such as semantics and affective expression. Consequently, complexity is shrouded in mystery, and Martindale [23] has pointed to Berlyne's studies, which have been reported widely, but continue to befuddle researchers [24, 25]. Central issues limiting their usefulness were his method of replication and interpretation, as well as restricted population sampling.

Nonetheless, CA researchers show growing appreciation for importance of complexity and order on individual preference differences [20). Güçlütürk et al. discussed role of individual differences in clarifying function of complexity in aesthetic evaluation and emphasized need to study them further for contributions to CA, while other research have found preference for complexity and order of professional artists, as well as those identified with high visual arts aptitude to differ significantly from laypersons and non-artists [20].

CA researchers have discovered alternative measures of complexity such as image compression [26] for measuring complexity. Friedenberg and Liby [27] also discussed alternative complexity estimates such as density, number of blocks, GIF compression rate and edge length associated with perception of beauty of semirandom two-dimensional patterns. Agreement among them, however, is inconsistent, and v alidation studies are not typically conducted.

> These mixed results originate in variety of metrics used to estimate what is loosely called "complexity" in psychology and i ndeed refers to conflicting notions. We conclude that participants tend to prefer some types of complexity, but not all. These findings may help explain divergent results in the study of perceived beauty and complexity and illustrate the need

to specify the notion of complexity used in psychology [28].

This confusion is not limited to complexity as questions and issues also surround symmetry, order, and quantifying symmetrical complexity [29, 30]. Complicating these matters further, stochastic variability or inherent randomness of an artwork is an important determinant of aesthetic preference [31] yet is not typically included in evolutionary algorithms.

2.2.2 Aesthetic validity of fitness evaluations

Among weakest aspects of fitness evaluation but receiving no attention is validation. Virtually all traditional fitness function approaches suffer from consensual scoring, which bases aesthetic standards on sample norms, however they may be defined. This approach first presented by Eysenck in 1940s is fraught with complications as sample variability ensures unstable aesthetic standards. This issue is compounded by failure to demonstrate professional artist convergence among samples. In general, undefined consensual standards are associated with unstable aesthetic standards, limited generalizability of fitness evaluations, and, ultimately, confusion about image fitness.

Other validity issues arise for studies that implement broad arrays of image features and properties without justification yet assert their function in judging aesthetic value. For example, Li and Chen examined 40 image properties and aesthetic preference without explanation of their functional role [32].

> Their connection to human aesthetic judgement is not clearly explained prior to their being employed as fitness functions. In some cases, the functions are called “measures” [18].

Brachmann and Redies [13] describe other validity issues associated with large website datasets in CA aesthetic investigations that use vast amounts of information both about images and samples. These images are typically evaluated online in an uncontrolled environment, which limits understanding their cultural context or professional composition of juries. Not surprisingly, virtually nothing is known about potential biases related to image author, popularity, reinforcement, display environment, and so on.

Cultural issues arise even when Image characteristics are implemented that have demonstrated empirical effectiveness predicting aesthetic preference such as randomness, complexity, and order. They could be instrumental during fitness evaluation, but isolated applications are problematic. In general, computational aesthetics recognizes limitations of generating images in isolation of cultural preferences [33]. Fortunately, importance of integration with artists is becoming recognized.

> Cultural contextual foundations limitations, which is related to Isolation of computational artists. In order to provide a cultural context to our agents, we propose their integration in a Hybrid Society of artists and critics, both computational and human [33].

While Lewis [19] went even further by emphasizing conflict when automated fitness algorithms are implemented without convergence of artists.

> Ultimately, how should results of automated fitness algorithms for evolutionary art be evaluated in a mixed culture of artists and computer scientists? Given two bodies of artistic images created using evolution, if knowledgeable computer scientists and computer

artists disagree about which ones are a success and which ones are a failure, what are the mechanisms by which research proceeds? What are the criteria by which progress can be evaluated [19]?

3.0 Psychometrics of aesthetic value

3.1 Historical background

Empirical measurement of aesthetic preference first appears in 19th century empirical studies Fechner conducted at Leipzig [34], which demonstrated feasibility of investigating relations between human perceptual judgments and physical dimensions. Those studies are now categorically referred to as psychophysics. Thurstone adapted Fechner's objective scaling methods in 1920s to measure human attitudes and mental abilities and suggested aesthetic applications [35, 36, 37]. Birkhoff [21] then provided mathematical foundations for an aesthetic measure, while Eysenck conducted empirical studies. Theoretical foundations for contemporary CA integration of empirical aesthetics is largely based on this body of research.

Those early quantitative methods became 20th century foundations for American mental testing movement, which elaborated and institutionalized mental measurement in education and psychology through the College Board and American Psychological Association. Equating methods presented in this report were initially part of that movement, and they were developed to systematize and justify evaluation of generated test forms across samples, as well as establish comparability of item banks. Equating methods have direct implications for establishing professionally validated fitness measures for generative visual arts. This historical development is briefly elaborated below.

3.1.1 Fechner measures aesthetic preference

Contemporary approaches to empirical aesthetics are largely an extension of Fechner's seminal 19th century psychophysics research [34]. He empirically demonstrated systematic quantitative relations between perceptual responses and variation of physical stimulation, a landmark achievement that encouraged empirical investigation of human psychological experience. Prior to Fechner, Kant had concluded human experience existed beyond methods of science and rejected possibility of psychology ever becoming an empirical science.

Fechner's psychophysical methods involved study participants comparing physical specimen and rank ordering their weight differences, and he portrayed correspondence between perceptual judgments and physical stimuli with a mathematical function. Then he demonstrated group values conformed to a normal distribution with reproducible properties of mean and variance, and he asserted their standard deviation represents a just noticeable difference (JND). His approach inspired interest in experimental psychology and virtually all contemporary scaling methods are derived from his original insights.

3.1.2 Early 20th century

Thurstone would establish important measurement foundations in 1920s when he developed objective methods for scaling test items [35, 36, 37] adapting Fechner`s methods measuring perceptual judgments. Thurstone in turn used JND to establish a scaling unit for measuring attitudes and opinions, then later mental abilities and achievement. His scaling structure would be elaborated to judgments about aesthetic stimuli. In 1933, Birkhoff [21] presented a mathematical formulation for aesthetic value based on p roportional relation between complexity and order. Aesthetic

measure increases, as complexity increases relative to order. He proposed two image characteristics, complexity and order, are functionally related to visual preference in following model:

Aesthetic measure = O/C

where M is an artistic measure that is a function of order and complexity. Practical interpretation is artistic value of any image is always greatest when order is maximized relative to complexity. At any level of complexity, an increase in order will increase overall aesthetic value.

Unlike many early scientific assertions, additional studies have corroborated this relation between complexity and order, which remains central in contemporary aesthetic theories. However, complexity measurement has become a contentious issue and social researchers have unsuccessfully sought alternative operational definitions that do not rely on Birkoff's insights of information density.

3.1.3 Eysenck

Eysenck extended Birkhoff's approach to aesthetic measure in several ways [38, 39, 40]. First, he factor-analyzed preference judgments for polygons and identified prominent type factors, which led to recognition of individual preference differences. T- and K-factors have received attention in subsequent empirical studies.

Eysenck's aesthetic measure formula from his published table below is (see Figure 1):

$$M = 20X_1 + 24X_2 + 8X_3 + 7X_4 + 5X_5 + 3X_6 + 3X_7 + 2X_8 + IX_9 - 2X_{10} - 8X_{11} - 15X_{12}.$$

Eysenck's general aesthetic factor or T-factor was eventually formulated into Visual Aesthetic Sensitivity Test (VAST). Unfortunately, VAST suffered from unreliability, then later failed validation by professional artists [41]. Contemporary efforts to resuscitate VAST have been largely unsuccessful [42]. Among Eysenck's discovery of aesthetic types, he found support for aesthetic judgment aptitude, a culturally transcendent construct.

	Basis of Judgment	Coefficient of contingency
(x_1)	Vertical or horizontal symmetry	.71
(x_2)	Rotational symmetry	.69
(x_3)	Equilibrium	.51
(x_4)	Repetition	.45
(x_5)	Compact figure	.37
(x_6)	Complexity six or more	.33
(x_7)	Both vertical and horizontal symmetry	.31
(x_8)	Pointed top and/or base	.20
(x_9)	Complexity Three or more	.10
(x_{10})	Complexity Two	-.27
(x_{11})	Re-entrant angles	-.52
(x_{12})	Angles close to 90 degrees or 180 degrees	-.63

Figure 1. Reproduced from Eysenck, 1941, Table 1, p. 89 [39].

3.2 Contemporary aesthetic measurement advances

3.2.1 Information processing approaches of Shannon and Moles

Psychologists broadly agree visual stimuli consist of varied information sources that influence visual preference in some cumulative manner. Moreover, viewers are believed to extract information during image scanning and relay it to specialized neuron receptors where neurological processing reassembles a m eaningful gestalt or percept. A key mechanism in this process is image decomposition during perception. Information theory is based on several principles of extraction 0riginally proposed by Shannon [43]. Uncertainty, amount of information, as well as information transmission and organization govern information in visual images, which have found broad commercial and scientific implications.

In the simplest application to aesthetics, Platt [44] proposed hierarchically organizing aesthetic information into discrete formal and stylistic levels, while Moles [45] proposed a more complex system that separates formal structural components of an i mage from independent semantic components that simultaneously superimpose meaning on comprehension during perception. He emphasized that "each level conveys its own unique message and possesses specific rules of organization [45].” His primary interest in semantic information represents systematic influence imposed by socially constructed entities such as religious, governmental, and educational institutions on visual art. Finally, Berlyne proposed expressive and syntactic levels [46, 47]. Expressive level transmits some personal aspect of artist, while syntactic information is physical configuration of visual elements in an object or pattern.

Information theory developments contributed considerable insight into understanding impact of aesthetic images on visual preference. Identification of discrete components and their systematic processing has also led to insights about hierarchical knowledge systems and facilitated understanding of efficient methods for transmitting visual information. Developmental studies have pointed to human individual differences that mediate responses to aesthetic information.

3.2.2 Contribution of statistical models to aesthetic measurement

By mid-20th century, significant advances in statistical methods led to nonphysical (social) measurement models that eliminated troubling deficiencies of ordinal scores for quantifying human perceptual responses, which included attitudes, preferences, and opinions. In general, ordinal methods lack equal interval scale structures, and unit of measurement is unknown. Prominent among these advances were Rasch models [48], a probabilistic approach from logistic regression for transforming scores and ratings into objective, linear measures. However, unlike logistic regression, Rasch model estimation is not dependent on populations or specific samples, hence they provide quasi-absolute measures. Then Fischer introduced Linear Logistic Test Models [49], which permitted investigating hierarchal cognitive components underlying responses to items [49].

Statistical measurement models provided analytical frameworks for stochastic factors underlying preference for aesthetic images [31] and together with information theory led to test models such as Visual Designs Test [50] that became highly effective for visual arts aptitude evaluation. Validity of these advances for aesthetic theory only became clear with investigations of larger sample professional artist samples [51].

3.2.3 Common item equating

Paralleling 20th century aesthetic measurement advances, large scale

mental ability and college placement testing were being developed by American College Board. Practical needs to demonstrate comparability of multiple test forms with many multiple-choice test items led to scale equating methods [48, 52]. In addition, frequent testing required generating constantly new test items but maintaining qualitative properties such as difficulty across examination forms.

Today, common item equating is implemented world-wide for educational measurement, as well as professional licensure and certification to link item pools and disparate samples onto a common real number scale. Rasch models are widely popular for transforming ordinal item difficulty and person ability values to a common scale, and they have desirable properties of sufficiency, separability, simultaneous conjoint additivity, and specific objectivity. In addition, Rasch models are ontologically strong statistical models, which contribute to valid statistical invariance.

This report demonstrates that psychometric scaling methods can be adapted to evaluate aesthetic quality of visual images and are directly relevant to fitness evaluation in generative art. Figure 2 presents basic paradigm for item equating showing unique forms (image runs) being linked to an overarching dimension of common items.

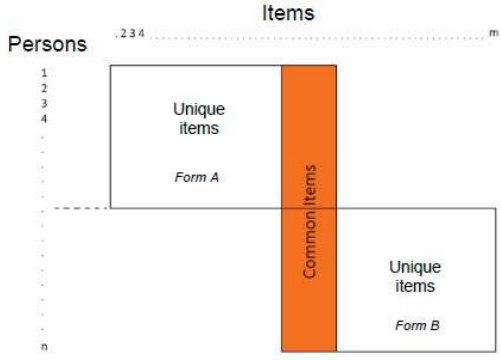


Figure 2. Schematic of horizontal common item equating procedure [48].

In general, items are first parameterized to identify locations on a linear scale, which establishes an explicit unit of measure. A subset of items is identified on this scale structure, and their aggregation functions as scaling constant for linking any other item pool sharing this subset to this structure. Ideally, linking items are embedded across qualitative content of evaluation dimension. See published applications of equating methods to automatically generated figural test items [53, 54, 55].

3.2.4 Adaptation of psychometric scale equating to generative art

Selection of optimal images during evolutionary art production is a challenge to contemporary generative arts. Consequently, an equating method validated by professional artists, which articulated an objective standard would be highly useful for identifying image fitness, as well as maintaining image quality across samples and algorithms.

In this research, images were submitted to a large sample of professional artists for judgment, and their ordinal scores or ratings, as well as image code specification were transformed to interval logits. After linear parameterization, this artistically validated dimension is an absolute aesthetic standard that can be imposed on future image production runs. It addresses need to identify correspondence between generated images and an aesthetic standard that remains constant across applications.

Methods implemented in this research follow several procedural steps. First, an abstract aesthetic dimension defined by professional artist preferences was constructed to establish an ov erall evaluation framework with explicit numerical values. This step would require collecting ratings for common images, then inferring statistical values for their locations on an evaluation dimension. Once established, this framework can be

extended with additional images, though central core of common items defines an invariant operational construct. Successive evolutionary image streams can be compared, and it maintains aesthetic values independently of specific jury samples. By its independent nature, this aesthetic standard mimic expectation of a fully automated fitness function. Images from multiple generation runs can be compared to qualitative categories on this framework. Depending on the generating algorithm, it may require a small subset of items be embedded in every image group evaluated.

4.0 Method

4.1 Sample

This report presents results from published research [54]. The sample is 462 examinees from Johnson O'Connor Research Foundation (JOCRF) testing offices in Boston, New York, Chicago, and Dallas. Examinees were paying clients of JOCRF's aptitude-assessment service and consisted of 215 males and 247 females, predominantly white (95%), upper-middle-class, and college-educated or college-bound roughly between 15 and 40 years of age.

4.2 Generative image production

4.2.1 Stochastic aesthetic components and algorithm

Image algorithm and production were described in prior research [53, 55]. In general, Birkhof's order-complexity ratio was invoked to establish a theoretical perspective on image development, which was implemented with a stochastic Mole-Shannon information function developed to manipulate order and complexity components independently. In this report, generated images were first validated by professional artists using rating scales, which established an aesthetic ordering of images.

4.2.2 Professional artist validation

Validation of evaluation dimension In this research was conducted with a heterogeneous sample of sixty-six professional artists recruited from New York City, Chicago, San Francisco, and Dallas, Texas. Professional artists were selected after meeting inclusion criteria, which included documented history of juried awards, prizes, and commissions, working fulltime for more than five years, and evidence of formal visual arts training. Style and m edia were diverse as artists represented broad range of professional expertise including painters in various media, graphic artists, sculptors, photographers, architects, and so on. They provided preference judgments to presented image pairs, which were theoretically scored (0/1) where complexity was keyed correct, and t heir responses were transformed to an interval logit scale for dichotomously scored items.

4.2.3 Image equating

Sample-dependent ratings described above, however, provide only limited foundations for an objective aesthetic dimension. Consequently, ratings were transformed to linear (equal interval) logits with absolute values, objective properties, and explicit estimate of reliability with a Rasch model. Then specification codes were identified for image locations (logits), and those scale values functioned as objective weights. Key step here was to transfer image weight to item specification code, which then functions as common item in future comparisons. Any future image generations, as well as those from modified algorithms can be evaluated on this fitness dimension without additional jury implementation. Parameterized specification codes link generated images to the evaluation dimension. In general, this overall obtained aesthetic dimension is useful for comparing aesthetic differences among separate image runs on a common scale. Applications are presented here of automatic item generation, as well as results from "seeding" figurative images with aesthetically scaled item codes rendered

by an interactive artist.

Both generated images and seeded paintings were equated with linking codes selected from the evaluation dimension. A scaling constant from generated images was computed to align authentic paintings on the evaluation framework.

An overview of steps implemented to equate horizontal image runs:

- Initially, image difficulty order established by professional artists was transformed to logit values. This hierarchy established a validated evaluation dimension.
- Anchor images with specification codes were selected from evaluation dimension for equating and their aggregation established an equating constant.
- New images were generated.
- Scaling constant was added to new item pool for fitness calibration.
- Location of new items on evaluation dimension was computed based on specification codes defined previously by professional artist sample.

Figure 3 presents an elaboration of this procedure where image specification codes were selected to seed figurative paintings. In this schematic, paintings were first seeded with codes from evaluation dimension then rendered by interactive artist. Phenotype will change on multiple runs, and their location on evaluation dimension was inferred from original professional artist calibration.

4.3 Procedure

Generative algorithm automatically produced rule-based images that systematically varied along two dimensions, complexity and r edundancy. Professional artists viewed image pairs, which were scored for conformity to theoretical model. Then rank order was transformed to logits.

Image seeds were selected after initial image equating. Image syntax in several historical Western styles were interactively `seeded` with proportions generated by the algorithm, then artist rendered. Preferences for the paintings were compared to a l ocal sample then were equated to the evaluation dimension originally validated by professional artists using common item equating methods.

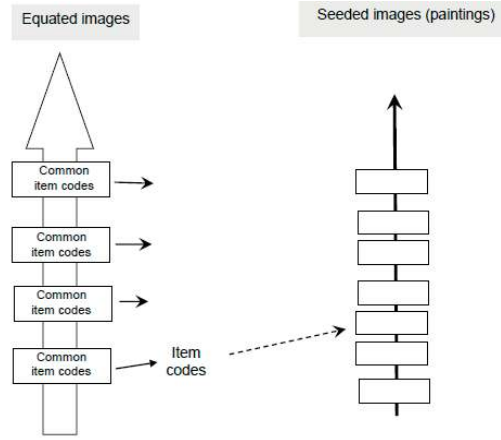


Figure 3. Interactive evolution of figurative images from “seeded” image codes. Schematic describing evolution of figurative images after “seeding”. While images shift on m ultiple runs, and their location is inferred from original professional artist calibration of image specification. Specifications emulated Birkoff’s order-complexity ratio variations implemented with a stochastic Mole-Shannon information function.

5.0 Results

Statistical analysis found complexity and redundancy in generated images accounting for 80 percent of preference variance. Figure 4 shows local preference ratings after equating to a professional artist standard, which provides uniform fitness values across multiple samples.

Figure 5 presents figurative paintings after "seeding" with images codes. While phenotypic images with identical specification will unexpectedly differ on multiple runs, their inferred stochastic locations on the evaluation dimension are fixed by empirical estimation based on original professional artist judgments.

6.0 Discussion

Professional artist validation model implemented here established scaffolding for a hierarchy of multi-components that accommodates image information layers. This structure can be elaborated with additional information from successive image samples. Large image samples can be equated using small sample subsets, which provide empirical values that are easily equated to the image superstructure.

Generative algorithm was validated by professional artists. Common item equating implementing Rasch logits was adapted to link local images to a standardized professional artist scale Strategy implemented in this research applied principles of aesthetic theory from empirical studies to develop a generative algorithm, and validation of an aes thetic evaluation dimension, then migration of image codes to figurative paintings. Foundations presented by complexity and order provided important insights into constructing an aesthetically valid and objective fitness evaluation.

An expedient alternative to methods presented here could implement deep learning statistical methods with a l arge image data base to extract features associated with aesthetic preference. Unfortunately, this approach leads to consensus scoring and ultimately ignores individual differences. Moreover, what kind of art is it? Deep learning imposes a normative standard based on computational averages to establish an arbitrary standard of aesthetic judgment. It essentially continues a separation between what laypersons and a rtists prefer. Not really any different from traditional dichotomy between artists and laypersons except artists are eliminated from art making and evaluation. This philosophical approach is taking visual art in a direction that is oblivious of individual differences and a ssumes aesthetic standards without artists. General issue of fitness evaluation for generative algorithms faces several conflicting issues.

- Contemporary cultural valuation emphasizes aesthetic novelty.
- Image properties related to semantics, expression, affective qualities, and thematic content currently not well modeled during fitness evaluation.
- Empirical aesthetic theory relies primarily on formal properties.
- Automated approaches are insensitive to skillful art production.
- Individual differences are not addressed during fitness evaluation.

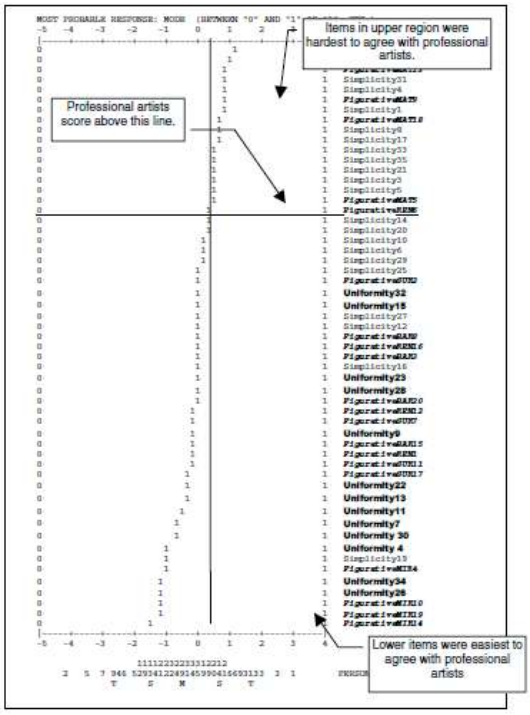


Figure 4. Local samples equated to an absolute aesthetic standard. (N=462).

Despite obvious conceptual relevance, historical approaches in the empirical aesthetic tradition have not contributed substantially to improving fitness functions in computational aesthetics.

> The most direct way to do this is via aesthetic *measure*. That is, the fitness function directly enacts some algorithmic method of scoring or ranking the aesthetic value of a specific work. This fits particularly well with aesthetic theories based around form—we will see that this is the dominant theory there too; much of the experimental work in this area explores correlations between formal aspects of visual images and the viewer's aesthetic or affective responses [56].

6.1 Practical implications

Fitness function based on diverse professional artists can be approximated for evolutionary art generated from small local samples. Using common item equating methods, diverse samples can be compared on a common aesthetic value framework without organizing separate evaluations.

Currently, fitness requires artist intervention. However, evaluation based on professional artists' preference that is abstracted in a m athematical scale provides an objective standard. Multiple image runs can be compared to it, and optimal images automatically selected. In addition, the initial algorithm can be changed to include properties, and those mutant images can also be compared to the professional artist standard automatically. In other words, images are evaluated individually hence not dependent on specific algorithms.

6.2 Future research

This report is only intended to introduce image equating and evaluation implementing psychometric methods to generative arts. Additional studies are needed to clarify specific adaptations that might make common item equating and psychometrics, in general, useful to fitness evaluation.

7.0 Conclusions

These results show plausibility of applying psychometric scaling methods to generative art and specifically computational aesthetic approaches that produce autonomous image runs and need an efficient and valid method of trimming lower aesthetic tails of these image distributions. Multiple thresholds can be identified on the standard, and their statistical parameters compared across samples. Moreover, this fitness

framework could be implemented during image generation to guide item evolution.









Figure 5. Seeded figurative paintings













Figure 5. Seeded figurative painting (continued)

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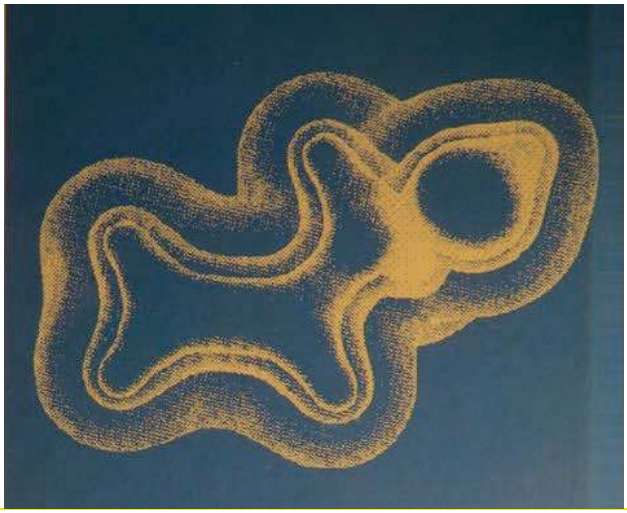


ANALOGIES IN ARTS AND SCIENCE: SHAPE STUDIES AND ARTFUL MOLECULES
(Paper)

Topic: (Art, Chemistry, Mathematics)

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Abstract
Shape is a universal concept used in most human activities: we deal with shapes in our everyday actions, we use shapes in the process of recognition, in our planning of the future, also in most artistic creations, and in reaching new understanding in the sciences. Shape recognition often connects to the concept of similarities, and on a higher level, when several aspects and several levels and several types of similarities may play roles, then shape recognition may involve entire families of similarities, where a collection of such similarities may be regarded as an analogy.
Analogies, as higher-level or collective similarities, have an interesting mathematical theory, but they can also be visually revealing, often providing useful tools and methods which are transferable between the arts and the sciences. Some of these tools of interpretation, borrowed from arts, can be used with advantage in chemistry, physics, and biology, for example, in the studies of the visually often pleasing shapes of molecules of the “micro-micro-microscopic world”, such as the computer-generated image of an allyl-alcohol molecule shown below.



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Key words: analogies, idea-transfer, shape in art, molecules

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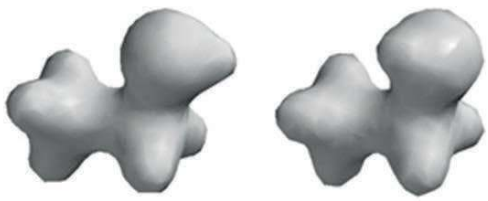
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Analogies in Arts and Science: Shape Studies and Artful Molecules

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Premise



Are you following me?
Two alcohol molecules falling in love

Two likely shapes of the "bodies" of the electron density clouds of two ethyl alcohol molecules, reminding us to the analogy with a pair of flirting dogs, one following the other.

Abstract

Shape is a universal concept used in most human activities: we deal with shapes in our everyday actions, we use shapes in the process of recognition, in our planning of the future, also in most artistic creations, and in reaching new understanding in the sciences. Shape recognition often connects to the concept of similarities, and on a higher level, when several aspects and several levels and several types of similarities may play roles, then shape recognition may involve entire families of similarities, where a collection of such similarities may be regarded as an analogy.
Analogies, as higher-level or collective similarities, have an interesting mathematical theory, but they can also be visually revealing, often providing useful tools and methods which are transferable between the arts and the sciences. Some of these tools of interpretation, borrowed from arts, can be used with advantage in chemistry, physics, and biology, for example, in the studies of the visually often pleasing shapes of molecules of the "micro-micro-microscopic world".

1. Introduction

Analogies play a very important role in the learning processes: by noticing an analogy of a problem we just try to learn with one we have learned already, the understanding of the new problem becomes simpler: one can, perhaps only cautiously, rely on the already known information to understand and learn the new one. Such analogies of learning appear to work also on a much broader scale, in the developments of both the Sciences and Arts. New scientific advances and inventions, and also new artistic directions and even individual art creations may be regarded as being analogous to learning: the very processes occurring during the inventions of the telegraph, the radio, and the mobile phone, taken as almost random examples, were, indeed, corresponding to learning, not just the learning of some individual human beings, but learning of humanity, a learning process changing human culture on the planet Earth. Similar comparisons can be made, and important analogies can be recognized in artistic achievements, for example, the development and eventual triumph of impressionism has been a learning process for human culture, in some sense analogous to the learning process involved in getting used to and appreciate a new train service to an attractive seaside vacation spot.

The microscopic world of molecules also provides some fascinating analogies, not only to other scientific fields, but also to artistic schools and individual artistic achievements, especially those involving three dimensions, such as sculptures, or dance, or the shape and movements of animals.

One interesting analogy, already pointed out in the Generative Art field, involves the shape concept, where the shapes of molecules have already been studied by methods motivated by artistic sculptures. In fact, the analogy is even more involved, since the original methodology is based on mathematics, due to the works of the famous mathematician, Felix Klein, the initiator of the famous Erlangen Program for the systematization of geometry and related fields. Felix Klein was intrigued by the idea of beauty and tried to use mathematical methods [1], as applied to several well-known sculptures, to find some mathematical regularities employing surface-analysis methods, such as curvature classification on the surfaces of those sculptures. Local convexity, concavity, and saddle like local shapes on those surfaces gave a classification, and the boundary lines of those domains of certain curvature types can be characterized easier. However, he was disappointed, because he was not finding any clear relations between the mathematical characterization he made and the way the beauty of those sculpture could be judged. Nevertheless, his ideas survived and were reported in a book by other mathematicians, and with some modifications, they have become the starting point of a series of methods used in the shape analysis of not some sculptures, but in the study of shapes of molecular electron density clouds [2]. Shape similarity when comparing molecules is an important aspect of the broader concept of molecular similarity, also including molecular symmetry and chirality [3-24], where chirality problems are prime examples for a simple use of analogy: the analogy of left and right hand differences to molecular chirality, with the dominance of “left-handed” amino acids in living creatures on the Earth.

Molecular shape is indeed, the shape of the molecular electron density cloud, underlying the importance of electron density studies [25-28], where some classical concepts, reaching back as far as some traditional art forms, are often appearing, sometimes unexpected ways.

Analogies between objects of nature and their artistic representations are rather obvious examples, some, only partially relevant opinion states this as “Art imitates Nature”. Perhaps one of the most noticeable analogy in the natural sciences is the analogy between two rules (Laws of Nature), seemingly completely unrelated: Newton’s Law of gravity, and Coulomb’s Law of electric charge repulsion (or attraction), are highly analogous: the force produced is proportional to the product of the quantities characterising the two objects, divided by the square of their distance. In the case of Newton’s Law of gravity, the relevant quantities are the two masses, in the case of Coulomb’s Law of electric charge repulsion, the relevant quantities are the electric charges of the two objects. The two equations are fundamentally the same, only the participating quantities are different.

Analogies may be regarded as advanced similarities, and in the molecular field, the various aspects of molecular similarity have been investigated in great detail. In these studies, the relative arrangements of molecular parts are of special importance, and one can always recognize connections to artistic shapes.

In this contribution, some aspects and the main featues of the above and some more general analogies will be discussed, with a focus on the shape of molecules and analogous aspects of some work of arts will be discussed.

However, in the next section, a brief introduction to some of the general aspects of analogies will be given, with a focus on the ideas of using families of similarities in order to simplify the abstract structures of some of the more involved analogies.

2. Some general properties of analogies

In the usual, everyday conversations, the word analogy is used without any strict definition, typically, analogy is regarded as some more elaborate type of similarity. Analogy is often interpreted as some deeper level similarity, or as a similarity with several components. Sometimes one may consider two phenomena, and between them several types of similarities, and the fact that multiple similarities are observed, this appears to justify to call the result of this comparison an analogy.

One may regard analogy as a system of several similarities, alternatively, as a relation where similarities occur on several different levels.

The mathematical tools of a branch of mathematics, Category Theory, appear to be exceptionally suitable to deal with this type of complexity of relations; in particular, the so called functor model [29] appears to be specially useful for characterizing analogies. Systems of similarities can be treated component by component, in a direct way, dealing with each similarity type separately. However, a system of similarities is a richer entity than the mere sum of the component similarities, and a more revealing approach is obtained if the families of similarities are regarded as a higher level entity than the mere individual similarities. If these higher level entities, that is, the families of similarities, are treated collectively, than a better description of the analogy can be achieved. Such a description is provided by Category Theory, specifically, by the so-called functor model, one that carries out comparisons (actually, transformations) on two levels, on the first level, transforming one family of objects into the other family of objects, and also transforming the relations, typically similarity relations in one family to those in

the other family. Whereas describing the mathematical details of the functor approach to analogies is not the goal of this contribution, one may find the relevant references in one recent publication [29].

2. Simultaneous treatment of multitudes of similarities, in arts, and sciences

Even if only the terminology of one field is borrowed and used in a different field, this already provides both new ways of seeing the details and this also may trigger new initiatives and methodologies to evaluate the results of comparisons. This is especially true, when the comparisons are extended to several aspects of complex problems with a multitude of similarities, for example, when analogies are actually generating further analogies, where the similarities may occur on several levels.

In such cases, the functor model is an advantageous approach. Such a functor model appears especially useful if one may expect repeated occurrence of meeting with new challenges of comparisons with similar levels and similar types of complexity. One may mention that re-using of approaches and methods originally developed for one set of problems, may often appear useful in a new field, and the functor model can be very beneficial in a different field as well. This is likely to be the case for the development of trans-disciplinary approaches, for example, in those cases where scientific and artistic methodologies are able to learn from each other. In our case, the generation of artistic impression, the message of the artist, in particular, the way the artist sends the message to the observer, is one, that can be also beneficial in the efficient interpretation of the scientific results of molecular shape analysis. If the artistic, efficient impression generation by the artist is translated to the scientific language of molecular shape analysis, this can provide valuable, new scientific understanding. In fact, most of the chemical references listed are containing examples where some of these benefits have played a role, even if in most cases, no systematic, functor-based approach has been used yet.

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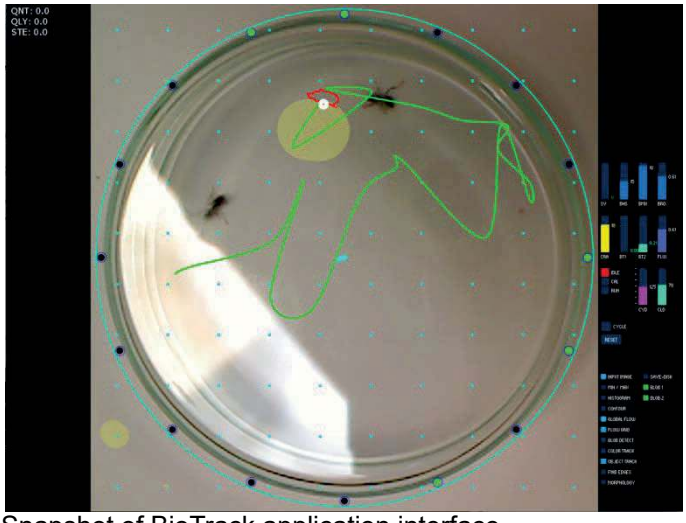


Computing with Living Components
(Paper)

Topic: Interdisciplinary

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Abstract
Much experimental research in creative computing expresses fascination with morphological and behavioural complexity witnessed globally in nature, and more specifically, as confined in biological workspaces. Experiments range from genetic engineering for aesthetic purpose, mapping organic growth processes to sound or viewing sculpture as growing cellular structures in a petri dish.
Our work studies spatiotemporal behaviour of tiny creatures in relation to external audio-visual stimulation. Specifically, a machine learning algorithm aims to maximize behavioural complexity; how creatures' locomotive intricacy gradually increases according to particular activation. An elaborate computer-vision program extracts movement patterns over time. The program relates the amount and diversity of specific trajectories to particular lightning patterns sent into the container holding one or more creatures. Reinforcement learning then informs the development of interesting activation – behaviour relationships. In addition, creature trajectories are subject to sonification, so behavioural development echoes in the sounds produced by the installation. Initial speculative experiments reveal complex but non-trivial relationships to exist between software activation and biological responses.



Snapshot of BioTrack application interface

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Key words: interaction, bio-inspired art, reinforcement learning, computer-vision, sonification

Main References:

[1] Peter Beyls, Art as a Living Interface, *Design, User Experience, and Usability. Design Philosophy and Theory*, Springer, HCII2019, Orlando, FL

BioTrack: Computing with Living Components

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Abstract

We report on BioTrack, a real-time audiovisual installation expressing interest in behavioral complexity observed in nature. Specifically, small creatures evolve and engage in a computer-controlled habitat - sensors, activators and software afford conditioning and tracking creatures' activity as situated in a small glass container. Movement is detected by means of a camera and custom computer-vision software. Variable light patterns are sent into the container using a 3D printed structure holding 16 LEDs (light emitting diodes). A machine learning algorithm targets to maximize behavioral diversity by optimizing the relationship between specific light patterns and the complexity of observed trajectories in space. Evolving trajectories reflect in the way sound patterns develop over time. Preliminary experiments reveal noisy yet non-trivial results

1. Contextual note

In a seminal 1974 performance, *I Like America And America Likes Me*, Joseph Beuys shares a small room with a live coyote for three days. Decidedly relevant given the subject of this paper, the artist and the animal managed to develop a functional relationship of co-habitation based on mutual understanding and appreciation. The coyote's behavior evolved from aggressive and cautious to approachable and sociable. Actual evolving behavior is close to the heart of this paper as it considers software conditioning of small biological creatures.

Unlike Damien Hirst's tiger shark preserved in formaldehyde, the anthropopathic robots created by Chico MacMurtrie are prime examples of essentially hand-crafted structures nevertheless suggesting deeply poetic and organic life-like qualities [6].

It is often claimed that 'art imitates life', however, in recent years, the substituting components of life itself have become not merely subject matter but actual material constituents towards the construction of artefacts. A wide range of ideas, methods and technologies from the biologists laboratory have been appropriated by the artist also raising questions of social and ethic implication [14].

Consider, Alba, a fluorescent rabbit, a trans-genetic experiment by Eduardo Kac (2000), created by genetic engineering rabbit DNA, specifically through synthetic mutation of the green fluorescent gene found in the jellyfish. Alba is a prominent example of generative art beyond computing – the synthesis of structure through explicit instruction without resorting to software. Consider, French

performance artist Orlan, viewing her body as software subject to perpetual modification.

Oron Catts, leading artist in the Tissue, Culture and Art Project (TC&A), has been designing structures merging living biological material and synthetic constituents since 1996 suggesting that “the body cannot survive without organs and cells, but the latter two groups can survive without body” [3]. TC&A develops biological art collaborations and advocates the notion of semi-living entities; cells and t issues isolated from organisms and c oerced to grow in predetermined shapes. Such research implicitly comments on the human condition and r aises imperative philosophical and ethical questions.

Interfacing art and biology is by no means a recent phenomenon. Early experiments in art and technology either took inspiration from interesting behavior observed in biological workspaces to inform the creation of sculptural installations exhibiting life-like qualities [5, 9] or evolving virtual creatures in software [10]. Still others choose to fully integrate living creatures in their work.

SEEK is a fine example of an early project involving live animals developed by Nicholas Negroponte and his team at MIT, on display at the NY Jewish Museum in 1970 [4]. SEEK is designed as a sensor/activator system; software senses a 3D environment composed of small blocks, evaluates changes and reorganizes the world accordingly with live gerbils moving inside this kind of variable architecture. Remarkably, the software chooses to either amplify the effect gerbil actions or to compensate i.e. reorganize the world according to a specific design. Note: SEEK implements a closed loop system interfacing biological and synthetic behavior, effectively suggesting a complex hybrid biotope displaying unpredictable though coherent behavior.

A single cell bio-electronic component may support hybrid hardware-wetware computing: sound can be sent into a Petri dish holding slime mould (*Physarum polycephalum*), in turn emitting electrical signals to be translated back into sound – biological behavior becomes a m apping interface in interactive computer music performance [8].

My project *Fishbowl* [1] addresses collective behavior and fish swimming patterns. A reinforcement learning algorithm aims to optimize behavioral diversity by influencing performance through external stimulation operating light patterns. Computer-vision tracks global flow i.e. intensity and direction of the centroid of movement. The basic idea is to maximize flow signal diversity, a process echoing in the sounds produced through sonification.

DeepLabCut is an open-source tool developed at Harvard University, it explores deep learning for training neural nets to track animal postures and behavior. Tracking is deemed attractive since motion offers an i mpression of the development of intentionality in the brain [7].

2. Introduction to BioTrack

BioTrack is an experimental art-research project interfacing biological and synthetic communication. Highly speculative, it suggests the exploration of spontaneous behavior of natural creatures in interaction with machine-generated information and how internally motivated, innate behavior might be influenced by external audiovisual stimuli. Specifically, we are

interested in the unfolding locomotive complexity of biological creatures (such as ants) situated in a small, isolated biotope, typically a 15 cm Petri dish.

Spatial behavior of creatures is tracked in 2D space using computer-vison; movement information is extracted as tiny 'trajectories' reflecting short-term history dynamics. Trajectory analysis yields information on the *quantity* and *quality* of the physical activity, respectively, how much activity is taking place, if any, and how complex that activity actually is. In other words, levels of amplitude and levels of interestingness implied in the data is made explicit.

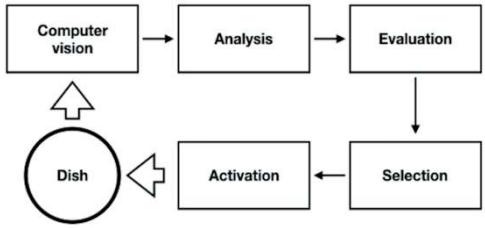


Fig. 1 Schematic overview

Following the design principle of maximization of diversity [13], we aim to maximize the complexity of the natural activity inside the dish using a reinforcement learning algorithm. Since optimization is highly inhibited by internal and external constraints, ultimately, wave-like activity will probably develop reflecting the process of continuous adaptation.

We might interpret the trajectories as control signals issuing from a hybrid bio-machine structure and view them as a control structure exercising parametric control over a sound-generating algorithm. Then, the manifestation of a process of biological life interfaces actively with a process of cultural design. More exactly, implicit natural behavior becomes a qualitative source of information influencing the development of sound patterns in an algorithm of explicit design. This method clearly avoids the notion of 'control' in favor of 'influence' – which is an aesthetic choice in the context of evaluating different mapping strategies in a typical computer music application. Mapping exists as a continuous scale between two conceptual opposites: (1) *responsive* systems, where control data selects responses from a palette of pre-designed responsive options and (2) *interactive* systems suggesting a more symbiotic human-machine relationship reflected in unpredictable yet intelligible machine responses [2].

Figure 1 shows circular action in a sensor-action framework; the camera image is analyzed, tracking changes in developmental quantity and quality. A reinforcement learning algorithm selects policies (hardware activation patterns) aiming to optimize future behavioral diversity in the dish.

Figure 2 shows the computer-vision GUI with current camera image, a single tiny creature, its moving contour (red color) obtained through background-subtraction, a number of sliders for parameter tuning and radio buttons to select computer-vision functions. Visualization also includes flow sensor grid activation (light blue dots), current centroid of movement (white circle) and trajectory (green).

Hardware

Two different sized prototypes of hardware interfaces were built aiming to accommodate distinctive sized action spaces. The first interface (figure 3) features a 5.5 cm Petri dish, 8 LEDs (light emitting diodes) used as activators and 8 LDRs (light sensitive resistors) used as sensors. The LDRs were removed from the second much larger design which includes a 17 cm glass container, 16

LEDs and one piezo element used as a global activator while sensing relies exclusively on c omputer-vision software. All components interface with an Arduino board running the Standard Firmata library and custom software.

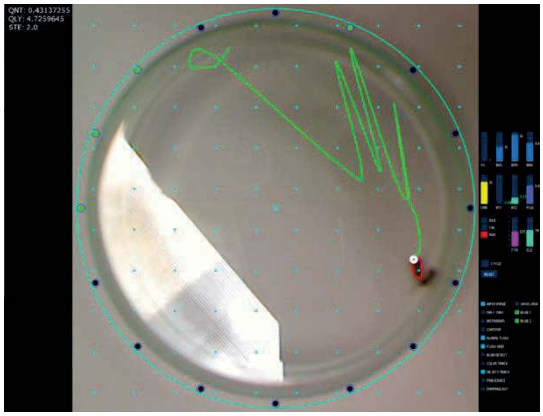


Fig 2: Main interface of BioTrack application

3. Implementation

3.1 Analysis functions

BioTrack is organized as an o bject-oriented system written in Processing [12] with extensive use of external libraries, including functionality for Supercollider, Arduino, OpenCV and OSC (Open Sound Control).

Software serving behavioral analysis is based on OpenCV. Every single module addresses a particular aspect of image complexity while the user may select an arbitrary collection of modules to run in parallel as to compute an overall image analysis result in real-time. However, in practice, some algorithms are computationally expensive affecting global performance. In particular, two computer-vision algorithms are helpful in developing a high-level interpretation of creature(s) activity as reflected in consecutive image frames: flow detection and background-subtraction.

A *flow* algorithm computes both the local and the global flow i.e. the strength and the direction of change in the image – the data is reflected in the size and angle of a vector. In addition, a grid of virtual flow sensors overlays the actual camera image, a c lear impression results of specific location and strength of physical activity in the dish. Every process cycle yields a list of flow data; heading and intensity of change – the global *quantity* and *quality* levels are computed from the data: quality depicts the diversity of angles (the length of the list vs. the number of unique angles) while quantity is computed by averaging the length of all flow vectors in the list. However, when dealing with tiny creatures (such as ants or small spiders), we observed that flow data is too weak, for that reason we turn to background-subtraction.

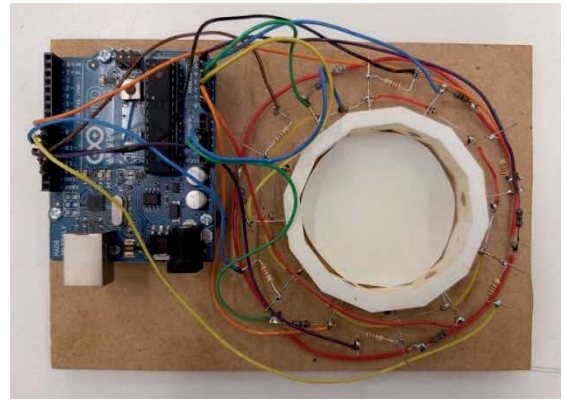


Fig 3: Early prototype with Arduino board

A *background-subtraction* algorithm continuously compares consecutive image frames generating a collection of contours suggesting both an impression of the volume and diversity/complexity of change. Background-subtraction tracks

the amount of change (total number of contour points and total contour surface) and the centroid of change (the averaged global center origin of all contours).

Background-subtraction aims to extract *trajectories of change* from the analysis of consecutive frames; a trajectory is an abstraction for a 'path' in 2D space – we are interested in the complexity of the path and how it changes over time as a consequence of external stimulation e.g. light patterns and sound. At 12 frames/second, up to 5 trajectories are accommodated taking care of 5 groups of contours – a single trajectory is a 20-elements long FIFO (first in/first out) data structure accepting the respective centroid of every group.

Given a trajectory of points in 2D space, we may compute both the angles and distances between any two points. Considering the *continuity* (deliberating change in consecutive data items) and *diversity* (studying all data; the ratio of the number of data items vs. the number of unique items) we get an impression of the global complexity and eventually, how it progresses inside the history of a single trajectory.

Then, two critical values result: *quality* and *quantity*, respectively. Their evolving values will impact the learning procedure.

3.2 Learning

Optimization is the goal of learning. Our wish to maximize behavioral complexity requires a method to select appropriate, promising stimuli (LED light patterns, and particular sonic activation) to be sent into the dish. However, we have no clue for how effective any given external activation might be; therefore, we suggest an optimization method based on reinforcement learning (RL) [11], more specific, a variation of the Q-learning (QL) algorithm [15] was implemented. RL aims to select the best actions – in any possible system state – in order to maximize the reward. Therefore, RL is considered a method of experience-based unsupervised learning. Q-learning coordinates action selection: locally, select the optimal action given a state and globally, learn a policy that maximizes the *total* reward. QL typically tabulates state-action pairs and q-values (equivalent to efficiency), in the context of the present project; estimated proficiency to maximize diversity.

Initially, a collection of random policies is computed and applied within a finite process cycle (typically 10 seconds) and evaluated – the efficiency/reward being proportional to the strength of the interval in behavioral complexity between beginning to end. At the start of the RL process, we are in the *exploration* phase; random selection and evaluation of policies. After a while, we gain some understanding of potentially effective policies and enter the *exploitation* phase; moving on from exploration and discovery to selection of the action featuring the highest q-value.

Implementation of learning

Computing the present quantity and quality (QQ) values follows a self-regulating sensitivity windowing algorithm; the minimum and maximum sample window edges move up and down trying to (1) accommodate outliers through expansion as well as maximizing sensitivity through gradual compression.

The concept of a system *State* is crucial; QQ values (0 ~1.0) are mapped to 0 ~ 3, consequently combining the data yields a State between 0 and 15.

Learning manages the list *saPairs*: a collection of State-Action pairs (SAP), a

single SAP holds a vector specifying the fitness of every potential action given one particular state. At any time, the number of possible actions equals 16. Learning proceeds as follows:

- The new State is computed form the present QQ values.

  newState = computeStateAdaptive(quality, quantity);

- The reward/punishment is computed from the signed interval: current quality minus the previous quality.

  reward = (currentQuality – previousQuality).

- Get the efficiency (q-value) after using the last action in the previous state. Therefore, check for an existing SAP holding that State. If it exists, return the q-value of that action, if not return 0; i.e. that State has never occurred before.

  thisQ = getQValue(previousState, lastAction);

- Look for an existing SAP featuring the new state.

  StateActionPair p = getSAP(newState);

- If *p* equals null (signaling a newly observed state), a new SAP is created and appended to the *saPairs* list:

  StateActionPair sap = new StateActionPair(newState);
  *newQ = (float) thisQ + learningRate * (reward - thisQ);*
  sap.qValues[lastAction] = newQ;

- If *p* is not null (signaling the SAP already exists), collect the highest value in the q-values vector and compute the new q-value and update the q-value for the lastAction in the given SAP.

  maxQ = p.getMaxQValue();

  *newQ = (float) thisQ + learningRate * (reward + maxQ - thisQ);*

  updateQValue(oldState, lastAction, newQ);

- We are now ready to select a next action given the new state and update the previous quality.

  newAction = selectAction_E_GREEDY(newState);
  prevQuality = quality;

- The *selectAction_E_GREEDY* function is conditioned by the *epsilon* (0 ~1.0) parameter, it specifies a probabilistic ratio between exploration and exploitation activity in learning. Exploration selects a random action without relying on learned information. Exploitation entails a selective procedure aiming to select to most promising action based on the evaluation of previous learning cycles. However, we first check the qValues for the current state;

  qValues = getQValues(state);

  if (random(1.0) < epsilon || qValues == null) {

  action = int(random(nrActions)); // exploration

```
} else {
        // exploitation
        find maxQ in qValues
        create list of all actions
contributing to maxQ
        randomly select and
return action from the list
}
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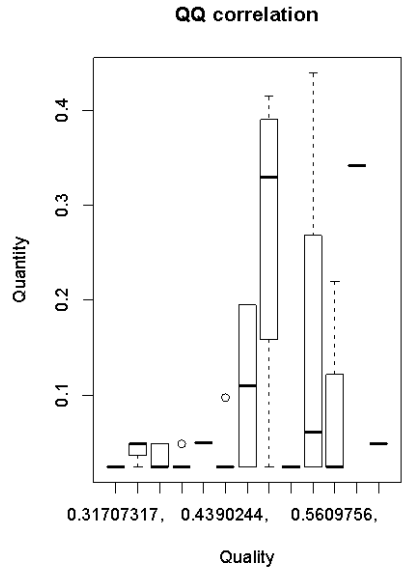
Learning is a gr adual process of optimization requiring sufficient cycles before the influence of external conditioning becomes effective. In particular, when interlocking living creatures in a computational process, estimation of the required learning time seems impossible. More systematic experiments are definitely needed. Some preliminary experiments are documented next.

4. Experiments

Short experiments run for 45 cycles, 40 samples per cycle and sampling interval of 200 msec.

Box plots in figure 4 suggest, given low quality values, a strong correlation to exist between quantity samples, with higher quantity values, the agreement fades. Globally, the quantity median values show a bell-like distribution – both very low and very high-quality levels correspond to low-quantity. These findings are contradicted in experiment 2 a s quantity values are widely distributed, presented in figure 5.

Graphs for both experiments as shown in figures 6 and 7, clearly reveal a g radual decline in action-frequency – explained by the gradual progression from exclusive exploration selection to maximum exploitation selection in the learning algorithm. In experiment 1 (figure 6), action frequencies exist as two groups of low and high values. In figure 7, oscillations between action-frequency value 5 a nd lower values seem to agree with the chaotic pattern of QQ correlation in figure 5.



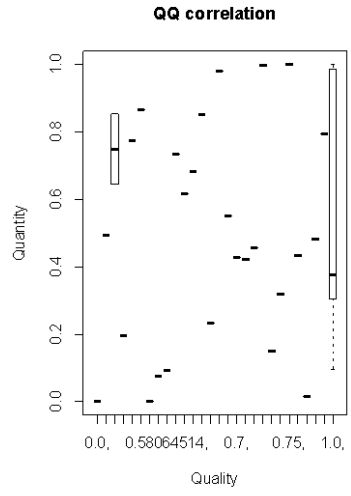
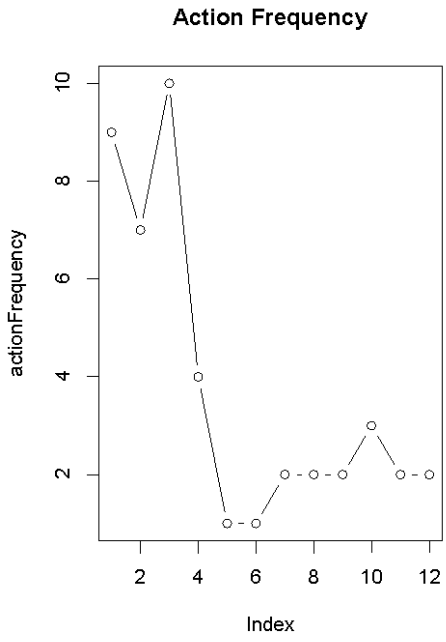


Fig. 4 Experiment 1
Fig. 5 Experiment 2



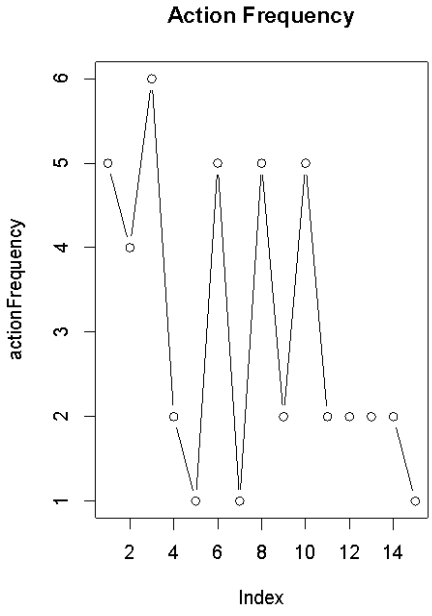


Fig. 6 Experiment 1
Fig. 7 Experiment 2

5. Conclusion

This paper documents preliminary results of BioTrack, an audi ovisual experiment exploring behavior of living creatures and how their spatiotemporal activity could be optimized using a r einforcement learning algorithm.

Obviously, experiments of much longer duration are indispensable to fully understand the scope of this speculative project. Perhaps it requires stronger physical conditioning to reduce noisy behavior to a minimum. By definition, the behavioral complexity of living creatures seems impossible to estimate – there are wide gaps of inactivity in the acquired data. The relationship between activation patterns and ensuing locomotion seems unclear. Many unknown biological processes seem to contribute to unfounded noisy behavior. Long term experiments might reduce noise levels and reveal delicate, intricate action patterns.

Acknowledgement
I am grateful to biologist Maria Boto Ordonez, for discussions and creating a unique laboratory structure in support of biology and the arts. In addition, I thank Elias Heuninck for designing and creating the sensor-activator structure using 3D printing.

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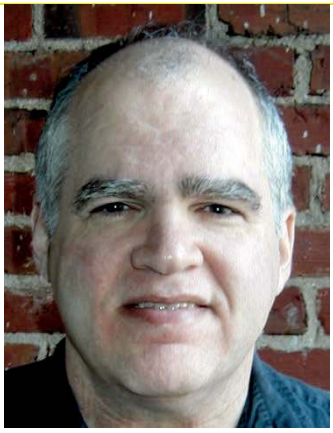
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Confusions and Corrections: Complexism and Generative Art Theory
(Paper)

Topic: Generative Art Theory

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Abstract
In previous years the author has contributed a number of publications, some for this very conference, that address generative art theory. In this work complexity science serves as a context for art theory.

This theory work led to additional publications offering a broader critique of contemporary culture, also inspired by the field of complexity science. This non-scientific theorization has been collected under the moniker “complexism.”

Since their initial publication these writings have gained reasonable traction, but have also come under fire by those who see things differently. In this paper some of those concerns are addressed. It is suggested that these disagreements are mostly the result of misinterpretations of the original publications. Various correctives and commentary are offered here to reinforce the validity of both bodies of theory.

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Key words: generative art theory, complexism, complexity science

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Confusions and Corrections: Complexism and Generative Art Theory

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Premise

In previous years the author has contributed a number of publications, some for this very conference, that address generative art theory. In this work complexity science serves as a context for art theory.

This theory work led to additional publications offering a broader critique of contemporary culture, also inspired by the field of complexity science. This non-scientific theorization has been collected under the invented term “complexism.”

Since their initial publication these writings have gained reasonable traction, but have also come under fire by some of those who see things differently. In this paper some of those concerns are addressed. It is suggested that these disagreements are mostly the result of misinterpretations of the original publications. Various correctives and commentary are offered here to reinforce the validity of both bodies of theory.

1. Background

In a paper from 2003 I introduced a theory of generative art using scientific complexity theory as a context, and based on the notion that the one, and perhaps only, thing all generative art has in common is the way it is made. All other issues such as the aesthetics of the work, the reason for employing generative systems, social or political or other content, can vary from artist to artist and from artwork to artwork. [1]

In 2008 this look at generative art through the lens of complexity science inspired a new pursuit, the development of a broader cultural theory, worldview, or philosophy called complexism. [2, 3]

1.1 Generative Art Theory

While a definition of generative art will not include all that can be said about generative art, it should put forward an implied theory of generative art. The following definition from that initial 2003 paper has been usefully cited hundreds of times.

“Generative art refers to any art practice in which the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, that is set into motion with some degree of autonomy, thereby contributing to or resulting in a completed work of art.” [1]

Some initial confusions have now been, for the most part, corrected in published discourse. First, generative art is not a subset of computer art. In fact, I’ve argued that generative art is as old as art itself.

Second, the term “autonomy” as used above is not meant to engage the deep sense of the term invoking philosophical

issues such as consciousness, agency, and free will. Rather, “autonomy” here is used as in robotics to indicate the generative system is not steered by remote control, but rather proceeds on its own without moment to moment guidance by the artist.

Third, generative systems are not limited to software and natural language rules. A “procedural invention” can include physical systems of chemistry, biology, mechanical devices, smart materials, and so on.

Finally, not all rules-based art is generative. Often the rules used are not complete enough to execute autonomous construction, and m erely constrain or inspire choices made by the artist. [4]

1.2 Complexism

While complexism was first introduced in 2008 [3], as this paper is being written the current definitive discussion is found in a long article published more recently. [5] However, even at the outset complexism was presented as something much more than a form of generative art theory. Complexism is nothing less than a higher synthesis attempting to reconcile the current contradictions found between the modern culture of science with the postmodern culture of the humanities. A full explanation is beyond the scope of this paper, but is broadly summarized in the chart below. The first two columns summarize the contradictory views offered by modernity and postmodernity. The third column suggests a higher synthesis that reconciles these contradictions.

Modernism	Postmodernism	Complexism
Absolute	Relative	Distributed
Progress	Circulation	Emergence and Coevolution
Fixed	Random	Chaotic
Hierarchy	Collapse	Connectionist Networks
Authority	Contention	Feedback
Truth	No Truth	Statistical Truth Known to be Incomplete
The Author	The Reader	The Generative Network
Pro Formalism	Anti Formalism	Form as a Public Process Not Privilege

Table 1 – Complexism summarized

Even though complexism has been presented as a large tent for all manner of cultural theory, it has been at times mischaracterized as something smaller; a kind of enthusiasm for the use of complex systems in generative art. As will be seen, this has contributed to a number of confusions on the part of commentators.

2. Confusions

Before reviewing a number of specific confusions in generative art theory and the distinct realm of complexism, a f ew general concerns are worth mentioning.

2.1 The Principle of Charity

Sometimes in the rough and t umble of academic debate, and not unlike life in general, people become so attached to their own ideas that their goal in discourse is no longer to discover the truth wherever it may be f ound. Instead, “winning” the debate becomes an unchecked ambition.

This does not typically serve scholarship well. One result is that strawman arguments are sure to follow. Whether due to a kind of unconscious confirmation bias, or a m ore cynical form of conscious sophistry, a given writer may misstate the meaning another writer intended, thereby setting up an eas y but irrelevant counterargument.

To maintain a good faith debate and fruitful exploration, those in philosophy and other disciplines follow what is called “the principle of charity.” “Charity” here does not mean pulling one’s punches to give an opponent the gift of an unearned advantage. Rather it means that there is always room for interpretation, and one should assume that the strongest possible interpretation of the author's written words is indeed the intended meaning. [6]

The result may be that fashioning a response will be more challenging than otherwise. But it also means that in the end the strongest ideas will be in competition, and whatever the conclusion, it will not have left unexplored the most viable options.

Fortunately, the academic objections I’ve encountered are not cynical, but rather are good faith disagreements even if ultimately based on honest misinterpretations. One might wish that when readers interpret a text in a way that is obviously weak, that they would search for a stronger interpretation intended by the author. But ultimately, it's the responsibility of the original author to write a text that is clear and unambiguous. It is hoped that this paper will help clarify what was apparently not clear in the original texts.

2.2 Political Reductionism

In previous writing I’ve discussed three forms of reductionism. In casual use in the humanities the word “reductionism” is often used in a vague sense to denote the explanation of complicated phenomena in fewer simpler terms. Such use often comes with the connotation that a given reductionist explanation is flawed due to oversimplification, especially since a dominant theme in the humanities is the need for endless deconstruction and the instability of texts. However, my use of the term is more technical and specific. As noted in previous writing:

“Ontological reductionism posits descriptions of hierarchical being such as, for example, the common scientific understanding of matter as molecules made of atoms which in turn are made of subatomic particles and so on. Methodological reductionism suggests a parallel activity and mode of exploration whereby large systems are iteratively broken into smaller systems until one finds a set of simple systems that can be understood and explained. Theoretical reductionism refers to any attempt to describe and explain a field of study solely within the paradigm of another, possibly incommensurable, field of study.” [7]

So, when I speak of reductionism in traditional pre-complexity science, I’m making a specific reference to the kind of hierarchical ontologies found in science; e.g. molecules are made from atoms, atoms are made from subatomic particles, etc. It also refers to the corresponding methodological reductionism practiced via the scientific method to explore those hierarchies level by level.

But as will be seen in the following, some writers practice a form of theoretical reductionism where complicated issues in one discipline become mere examples for a meta-critique of that discipline from the point of view of another, often incommensurable, discipline.

As will be seen, a specific flavor of theoretical reductionism, call it “political reductionism,” is not uncommon in the humanities. It is an impulse inherited from both Marxist analysis and post-structural analysis such as theories of power expounded by Foucault. Such reductionism has been applied to both my work in generative art theory, as well as my development of complexism. While those who want to reduce these distinctly apolitical points of view to politics may

have their reasons for doing so, it's highly questionable as to why politics must be the implicit paradigm from which all understanding and meaning must emerge. In fact, such a move appears to me to be the embodiment of a category error. It leads to some of the confusions that will be outlined below.

3. Generative Art Confusions

While some of the early misinterpretations of my complexity-based generative art theory have been fully addressed, other confusions have been slower to recede. In particular some writers will mistake a desirable option as being absolutely required or superior to all other options. For example, Cham and Johnson [8] note:

"By insisting that all artwork is generative Galanter, like many other writers, negates the medium entirely which allows him to insist that generative art is "ideologically neutral". Generative art, like all digitally interactive artifacts are not neutral but rather ideologically *plural*. "

Even a cursory reading shows I do not claim all artwork is generative, and I go to great lengths to differentiate between generative and non-generative art. Further, Cha and Johnson mistake a theory as to what is and isn't generative art, with the question as to whether generative art can deliver an ideological message. This confusion of medium versus content continues in some of the examples below.

In a similar way Richter [9] takes a point too far when he states:

"The interest in analyzing the algorithmic process of digital art–making is from both a computational and an artistic point of view. The rationale for the latter is that art–theoretically and following an argument of Philip Galanter, in generative art the artistic work in itself is not seen as important as the artistic process. In a reminiscence to the art movement of "truth to material", generative art may focus on "truth to process."

While it's true that I coined the phrase "truth to process" to capture a generative art option, and a powerful option at that, I've never argued for the exclusive or definitive importance of that option. For example, in animated films generative methods can be used purely for their pragmatic value, and the underlying technology should be the last thing on the audience's mind.

3.1 Kalonaris et al. and beauty as an anachronism

The problem of computational aesthetic evaluation is closely related to that of generative art. Generative systems that can create form (sound, etc.) cannot improve and develop unless they receive or execute an evaluation of their own output. This feedback loop can allow generative systems to improve over time. Examples include the use of a fitness function in systems based on evolutionary computing, or more recently as generative adversarial networks. [10]

But Kalonaris et al. [11] seem to object to beauty as a useful consideration in art, including generative art:

"While some (...) persist in associating aesthetic evaluation with "normative judgments related to questions of beauty and taste in the arts" (...), we recognize that "artworks, especially modern ones, are appreciated for other reasons besides their aesthetic qualities or beauty" (...). We thus distance ourselves from anachronistic interpretations of aesthetics, and suggest that the notion of beautiful music is obsolete and irrelevant to a current discourse in aesthetics and the

arts, and we hope that this can be acknowledged in the field of computational creativity."

This suggested grand narrative is problematic in a number of ways. First, there is a strawman aspect. I've nowhere stated that computational aesthetic evaluation should be limited to issues of beauty. In fact, I've noted that style identification is also an aesthetic evaluation task. Art tends to proceed by a process of accretion, and while new considerations may be added, older considerations such as beauty tend to persist. Nowhere have I argued against exploring additional forms of evaluation.

Second, the impulse to discard beauty is not widely shared. On a worldwide basis, and on a time scale from our earliest human records to present, the consideration of beauty has been almost universally associated with art practice. It is a rather insular, narrow, and short-term view of art that considers contemporary western art as being the only conversation worth having. And it's actually contemporary western art that is the outlier here. Conceptualism, minimalism, and other twentieth century influences have driven some contemporary western art in directions other than beauty. Others might say these influences have merely changed our understanding of beauty. This situation in esoteric contemporary western art may or may not be a permanent change. But to privilege same by declaring a kind of western art exceptionalism seems arbitrary at best.

Finally, the exploration of beauty in art is hardly complete. Those doing research in the realm of neuroaesthetics are scientifically exploring the neurological basis for the human aesthetic response, and more speculatively, the aesthetic response in other animals. Taking the evaluation of beauty off the table before we understand the basis for beauty is premature. If we don't yet understand the underlying mechanisms behind beauty, how can we reject beauty as being unimportant?

3.2 Soderman and Howe on Surprise

In an article providing a critique of surprise in generative art, Soderman and Howe confuse defining generative art as a way of making art with value judgements implicit in the specific content of given works of generative art. They note:

"At the end of his influential essay "What is Generative Art?" Philip Galanter claims that "Generative art is ideologically neutral. It is simply a way of creating art and any content considerations are up to the given artist." [1] Such a claim undermines critical perspectives that take into account particular historical periods and neutralizes ideological analysis itself. The post-historical generative artist can simply "make art" without worrying that her choices are motivated by unconscious ideologies or influenced by her historical period. "

The distinction between ideology intrinsic to a medium versus ideology as a matter of content is important. And it is generally well accepted in the realm of non-generative art. Consider the question "what is painting?" Early man might have said "painting is a way to teach people how to hunt", or "painting is a way to gain favor with the spirit world." In the western medieval period some might have said "painting is a way to glorify God" or "painting is a way to teach the Bible to the illiterate." In the modern period some might have said "painting is a way to express the inner turmoil of the psyche."

Obviously painting can be all of these things and much more. If one is looking for an all-inclusive definition of painting, painting must simply be defined as a way of making art. For example, "painting is a

way of making art by applying a suspension of pigment on a canvas or other flat support." Anything less will inevitably cast legitimate paintings aside as non-paintings.

Defined this way painting as such is nonideological. And note that it's painting's very neutrality that allows the medium to transmit virtually any content. It is in this sense that I've said generative art is simply a way of making art without an intrinsic ideology. And because generative art as such is nonideological, it can transmit virtually any ideology as content.

But contrary to Soderman and Howe, defining painting or generative art as a way of making art, rather than the practice of this or that ideology, in no way relieves the artist from awareness and responsibility in terms of the content of their own work. It's a fallacious leap from a way of making art being ideologically neutral to the (mistaken) inference that the content of that art therefore should or must also be nonideological.

Soderman and Howe also seem to miss a turn in their pursuit of surprise in generative art. They say:

“Though surprise is not mentioned, it is still essential for Galanter, who correlates it with information theory, stating that “the more ‘surprise’ a gi ven communication can exhibit the more information it contains.”

This is not my notion of surprise. This is the notion of surprise as per Shannon’s information theory and his notions of complexity. The notion of complexity my generative art theory is built on is Gell-Mann and Lloyd’s effective complexity.

Braxton and Howe offer a c orrective to Shannon that is similar to what is already essentially present in effective complexity. They suggest considering Langton’s Lamda as a measure of surprise in Wolfram’s cellular automata.

In discussing his Lamda measure, what Langton describes as “quiescent” Gell-Mann and Lloyd call “simple, highly ordered, and highly compressible”. What Langton calls “chaotic” Gell-Mann and Lloyd call “simple, highly disordered, and resistant to (lossless) compression.” Finally, and in between, what Langton calls a “balanced region of emergence” Gell-Mann and Lloyd call “complex, and a mix of disorder and order.”

So Braxton and H owe are incorrect in shackling my generative art theory to Shannon’s notion of surprise and complexity. It is explicitly rejected as a basis for generative art theory. And their suggested corrective, Langton’s notion of balanced emergence, is already present in the stronger form of Gell-Mann and Lloyd’s notion of effective complexity.

Braxton and Howe go on to further critique Shannon’s notion of surprise by linking it to the quantification and production of novelty, and ultimately neoliberal ideology. But this should not apply to my effective complexity based generative art theory.

However, even leaving that aside, the association is fallacious. One can argue whether capitalism, or specifically neoliberal economic policy, requires the production of novelty. And one can argue whether generative art requires the production of novelty. But even if both require the production of novelty, they have no m utual causal relationship. In other words, it does not mean generative art entails neoliberal ideology, or vice versa.

4. Complexism Confusions

The primary confusion in related commentary is that complexism is not complexity science, nor is it a k ind of

enthusiasm for complexity science, nor is it science at all. Complexism is the projection of insights from complexity science into the non-scientific problem-space of the humanities. Equally problematic is the targeting of complexism for political reductionism.

4.1 Cogdell and Complexism Misdefined

In a paper for a conference session dedicated to the topic of complexism, Cogdell seems to misdefine the term, and thus embark on a misguided discussion. She says:

“Charles Jencks’ links postmodern-complexism (I am conjoining these two terms that Galanter separates) to Jacobs, Venturi and the influence of contemporary science, as well as to the all-important role of the computer in the science and mathematics of complexity theory and in architectural design. He acknowledges that postmodernism (PM to Jencks) turned into “PoMo” and in the process lost much of its founding theorists’ complexism sensibility.“ [12]

Here Cogdell implies that complexism and postmodernism are similar enough to be treated as synonymous. This is a fundamental misunderstanding. Complexism is a response to the contemporary conflict between modernity and postmodernity, and the response is synthetic and specific. For example, where modernity embraces progress, and postmodernity embraces circulation, complexism offers emergence and coevolution. And where modernity embraces the fixed, and postmodernity embraces the random, complexism offers deterministic yet unpredictable chaotic systems. And so on. These are ideas not contained in Jencks or other postmodern critics, nor do those authors have what could be called a "complexism sensibility." Postmodern critics have a postmodern sensibility, and that is something complexism intends to leave behind.

Because she doesn't seem to recognize the thesis-antithesis-synthesis relationships between modernism, postmodernism, and complexism, this leads Cogdell to think complexism offers little that is new.

“I am not promoting complexism to become the new reigning paradigm; I think it already is. When mainstream financial institutions like HSBC use “emergence” and “self-organization” to advertise their services in an international airport [...], it implies they think the ideas are compelling and familiar enough to their intended audience to mark them as authoritative foreseers of the future. ... Self-organization and emergence are core concepts for complex systems theory, which since the 1990s has been infusing theoretical developments across the arts, sciences and social sciences. ... Complexism has come of age both as a scientific paradigm and, in my opinion, as an ideology."

Complexism is not a scientific paradigm, and it mostly addresses non-scientific issues even while being science-inspired. The new contribution complexism makes is not a sense of enthusiasm for complexity science. Complexism looks to complexity science for useful ideas, but it’s ultimately about the reconciliation of the modern and the postmodern, and (correspondingly) the reconciliation of science and the humanities. For many complexity science is indeed already the reigning scientific paradigm. But complexism is a new cultural paradigm quite unlike a general enthusiasm for complexity science.

4.2 Crano and Supposed Neoliberalism in Complexism

Perhaps the most vociferous accusation of complexism as neoliberal ideology comes from Ricky Crano. [13] The very title of his article proposes placing complexism in a political context. As a point of entry Crano notes:

"Whereas what Galanter loosely refers to as “reductionist” science treats the observable world as something transparently knowable and capable of coming under full human control, complexity science is founded on the premise that we humans might be better served by a hands-off approach, allowing some “natural” processes to unfold, in the words of complexity theorist Stuart Kauffman, “unguided by any intelligence” and “without careful crafting”"

Crano packs a number of confusions into this sentence. First, as noted earlier, "reductionist science" is specifically science as practiced by using methodological reductionism to explore the universe from an ontological reductionist point of view. This is in contrast to complexity science where the point of view is reversed, and the universe is built-up rather than broken down. The fundamental point is that complexity science can explain phenomenon as emergent properties that would be difficult to explain via reductionism.

But neither reductionist science nor complexity science describe the universe as being "transparently knowable" or "under full human control." Indeed, science provides ample evidence that the universe is inherently beyond human control or even prediction. And both scientific practices require rigor and significant effort to extract sharply focused theory from clouds of fuzzy data.

And complexity science does not posit what will and won't serve man well. To be sure, most scientists believe they are serving humanity. But value judgements like these are not the stuff of science. When scientists say things like "science must serve man," at the time they are saying that they are not practicing science. They are making a value judgement in a way similar to non-scientists. Science can report on facts that surround questions of value, but ethical statements as to what man should and shouldn't do cannot be translated into propositions that can potentially be falsified via empirical experiment. I.e. they escape the realm of the scientific method.

However, Crano goes further. He says that from complexity science we learn that man should allow some ""natural" processes to unfold." This is not so. Complexity science simply shows how such processes do, as a matter of fact, unfold. It has nothing to do with what man allows or should allow. Science makes statements as to what is, not what should be.

For example, the sub-topic of chaos from complexity science explains why weather prediction can never extend indefinitely into the future. [14] Complexity science doesn't say our finite predictive capacity for weather is good or bad, or something we should allow or disallow. We actually have no choice about it. Weather prediction is simply finite in principle regardless of what we think about it.

But once on a mistaken path where complexity science supposedly advocates a moral principle of laissez faire, Crano leaps even further observing that this is somehow equivalent to endorsing political and economic neoliberalism. Finally, from this already flawed view of complexity science, Crano sees complexism as inevitably inheriting an allegence to neoliberalism as well.

This is, again, akin to a category error. The empirical observation of emergent properties in complexity science in no way compels us to accept any particular political agenda whether liberal,

conservative, neoliberal, neoconservative, communist, etc.

In addition, Crano seems to think that complexism is presented as an ideological motivation for the pursuit of generative art. He seems to hold this despite the fact that in all of my generative art theory work I've made it clear that generative art is simply a way of making art that has no intrinsic ideology. And while it's true that Gell-Mann and Lloyd's "effective complexity" provides an inclusive schema for classifying forms of generative art systems, those making art using generative systems have no common motive for making art that way. [15] Some are exploring complex systems for quasi-scientific purposes. Some are focused on digital culture. Others are motivated by potential biological solutions to ecological or other health threats. Some are motivated by purely pragmatic reasons to "get the job done" in filmmaking or game-making.

But Crano ignores the clearly stated scope of complexism, both in terms of what it is and what it isn't. He attempts to leap from the use of complex systems in generative art to the political and economic thinking of F.A.Hayek as developed decades before complexity science even existed.

"Complexist artist Galanter's work and writings supply a glimpse of just such a world, one where self-organizing and largely unpredictable patterns, usually driven by computer algorithms, take the place of human inventiveness and perception and, in the process, dismiss some of the most urgent ethical and political problems presented by neoliberal capitalism in the twenty-first century."

This is mistaken. Simple observation will affirm that generative artists exercise inventiveness and perception in their work. And the content of specific works of generative art can address anything the artist would like. This could include ethical and political themes, but also romance, the beauty and power of nature, the wonder of mathematics, the comedy and tragedy of human existence, and so on. But the nature of generative art, that is to say what is intrinsic to generative art, is not the content but rather the way the art is made.

One of the symptoms of true believers such as political reductionists is that they believe others are obliged to address their obsessions. Their ideology cannot be ignored, it can only be embraced or opposed. And so even if their ideology isn't explicitly opposed, a non-embrace is interpreted as opposition regardless of the author's intent. Crano clearly illustrates this tendency in saying:

"The politics of generative art, like the politics of neoliberalism, can be summarised as a politics of depoliticisation."

Crano commits a category error in viewing generative art as a political practice. And that renders his detailed commentary about complexism as being irrelevant. Crano here is practicing political reductionism where any issue, scientific, aesthetic, or otherwise, is deconstructed to reveal the underlying political machinations of institutional power and material wealth.

Unfortunately, Crano's understanding of complexity science, let alone his understanding of my non-scientific synthesis called complexism, is lacking. Here Crano mistakenly presents complexism as an art movement or theory. As I've noted, it is much more than that. Crano writes:

"Against this trend, I argue that for all the leverage the tools and terms of complexity science supply to complexist art, the concept of complexity itself remains surprisingly vague and shorn of any

historical sensibility."

First, while the history of science is an interesting topic, science itself does not turn on hum an history per se. Science posits a reality that would be nearly identical if man had never existed. Science exercises an epistemology of empiricism. It takes as a given that the evidence science turns on is invariant across time, location, and culture. It is assumed that equally intelligent creatures on other planets could practice science with identical results. "Historical sensibility" has no pl ace in science as science.

Second, and contrary to Crano's misunderstanding, the “concept of complexity” is not vague. Reasonable people can have varying opinions as complexity science is a work in progress. But there is a consensus among complexity scientists as to what typifies complex systems, and thus complexity. In previous writing I offered this typical list of characteristics found in complex systems.

"Components: Complex systems are collections of smaller scale components or agents.

Local Interactions: Within the system the components or agents only have interactions with nearby components or agents.

Scale: The collection of components exhibits emergent behavior at a l arger scale.

Feedback: The dynamics of complex systems are often driven by feedback, i.e. various outputs of the system are reintroduced as inputs.

Non-linearity: The dynamics exhibited by complex systems are frequently non-linear, increasing or decreasing exponentially.

Deterministic Chaos: Complex systems can be unpredictable in principle and despite following strict cause-and-effect determinism. This is because feedback in the system will amplify tiny variations in initial conditions.

Self-Organization: Complex systems create emergent structures that appear all over without centralized direction.

Network Topology: Complex systems can be modelled as networks, and an understanding of network growth and topology can explain otherwise mysterious system behavior." [5]

In that same text I note that complex systems include:

“… the stock market and economic systems in general, ant colonies and other animal societies, the brain, the mind, the evolution of species, autocatalytic chemistry, the weather, fluid mechanics and turbulence, political systems, social movements and ecosystems of all sizes.”

What is truly remarkable is that this very specific notion of complexity can apply across such a varied list of phenomena. But that, in fact, is the primary point of complexity science. Complexity science finds regularities and commonalities across apparently disparate complex systems.

Crano mistakenly notes:

“"In the last couple of decades, artists working under the banner of complexism have sought, with the help of digital computers, to allow such complex self-organizing formations to manifest within spaces of installation, performance, and video art."

First, I know of no ot her artists who use the term “complexism” to describe their work. This is not surprising. It’s true that I

first used the term “complexism” in a manifesto-like chapter about evolutionary art. [3] But even in that initial publication I made it clear that complexism includes so much more. It is there that I first note the historical precedent of C. P. Snow’s “The Two Cultures” lecture. [16] I go on to describe how some in the humanities have attacked science as part of the “science studies” movement and t he subsequent “science wars” of the 1990’s. A section titled “Complexism – A New Science-Friendly Paradigm for the Arts and Humanities” describes complexism this way:
“My proposal is that complexism is that which comes after postmodernism. Complexism is, in a sense, the projection of the world-view and attitude suggested by complexity science into the problem space of the arts and humanities. Complexism does this by providing a higher synthesis that subsumes both modern and postmodern concerns, attitudes, and activities.”

A description a number of years later [5] is consistent:

“Complexism seeks to embrace complexity in its fullest bloom. Complexism is not a scientific theory, but it is informed by contemporary science. As a point of view suggested by the spirit and content of complexity science, complexism is put into practice as a form of qualitative cultural study. The goal here is not to present complexism as a fully formed and completed work, but rather as a research frontier already sufficiently rewarding enough to encourage further development.

Without any specific commitment to literal Hegelian philosophy, complexism’s reconciliation of modernism and postmodernism can be best understood as the next stage of a thesis-antithesis-synthesis process. The apparently irreconcilable differences between modernity and postmodernity, and the cultures of science and the humanities, can be subsumed into the twenty-first century synthesis of complexism.”

There can be disagreement as to whether this promise will be fulfilled, but there should be no disagreement about the intent. The science wars may have settled into a ceasefire, but the foundational contradictions are as present as ever. Rather than warring, the two sides now simply ignore each other as if they live in two different worlds.

But there is only one world, and complexism is an attempt to reflect that in a single unified world view. Complexism lays out ways to overcome disagreements regarding progress and truth. Complexism offers a unique new theory of authorship, and from that, an answer to the question “when is a computer truly an author?” In the realm of aesthetics complexism offers a path to revitalizing formalism. At the same time, it rehabilitates the Futurist concept of dynamism, and leaves any unfortunate political connotations behind.

Complexism provides a new view of networks, and disputes models provided by Cilliers [17], Galloway [18], and Deleuze and Guattari’s notion of the rhizome.

To view complexism as merely an artistic fascination for neoliberal modes of production is not only wrong, it is a missed opportunity for a much more productive set of discussions.

5. Conclusion and Going Forward

My generative art theory development seems to be completed. That’s not to say others won’t have new ideas worth talking about. But between the “big tent” definition where generative art is simply a way of making art, and t he short catalogue of

"problems in generative art" [19] which invites multiple points of view about content, quality, and c riticism, I feel my best contributions towards generative art theory have already been made.

Work on complexism, however, continues. As some of my writing has hinted, the complexism world-view seems to point towards a process philosophy approach to ontology. And there are areas ripe for application such as ethics, artificial intelligence, and t he mystery of consciousness. I hope to address these in future publications.

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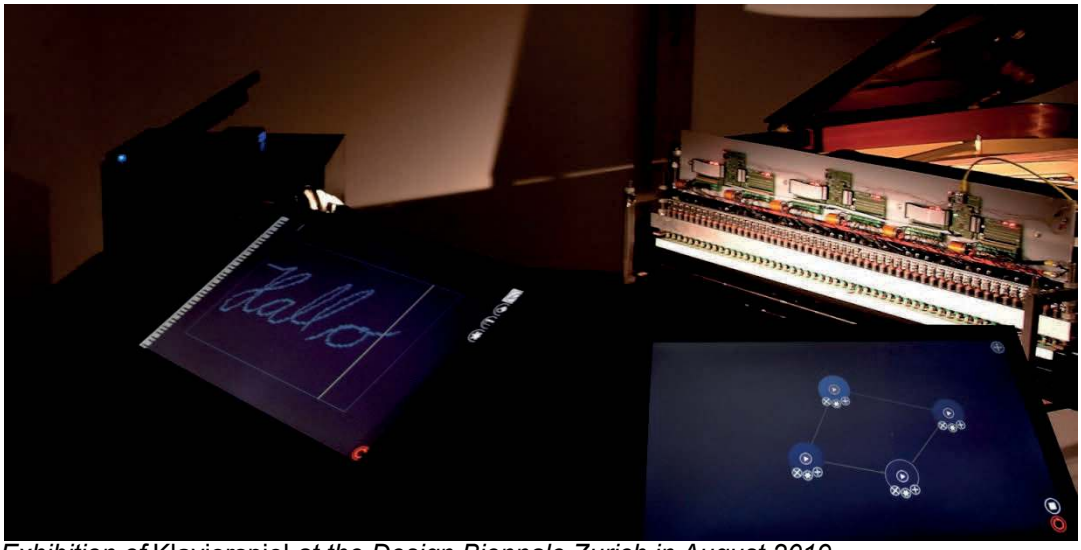


Playing the Piano: Understanding Algorithmic Music Through Interaction.
(Paper)

Topic: Music

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Abstract
The project *Klavierspiel* ('piano playing') combines a piano automaton and interactive, touch-screen-based control software. The piano automaton is a piano-playing robot to be fixed on the keyboard of any conventional instrument [1]. It can perform much faster movements and strike many more keys at the same time than a human pianist. Therefore, it lends itself to a variety of sonic experiments, especially for computer-generated music [2]. The authors developed three different graphical user interfaces to control the automaton. Explicitly aimed at people without musical expertise, these interfaces provide the opportunity to gain hands-on experience with generative music. They illustrate how to create musical gestures, patterns and structures at different levels of abstraction, and convey specific algorithmic composition techniques in an easy-to-understand and practice-oriented way. This paper describes the three user interfaces regarding their technical implementation and their musical potential. Furthermore, it discusses the observations made during a three-day exhibition in Zurich.



Exhibition of Klavierspiel *at the Design Biennale Zurich in August 2019.*

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Key words: generative music, algorithmic composition, interaction, robotic piano player.

Main References:

[1] Winfried Ritsch, “Robotic Piano Player Making Pianos Talk”, Proc. of the Sound and Music Computing Conference, Padova, 2011.
[2] Philippe Kocher, “The Piano Automaton as an Instrument for Algorithmic Music”, Proc. of the Generative Art Conference, Verona, 2018.

Playing the Piano: Understanding Algorithmic Music Through Interaction

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Abstract

The project *Klavierspiel* (‘piano playing’) combines a piano automaton and interactive, touch-screen-based control software. The piano automaton is a piano-playing robot to be fixed on the keyboard of any conventional instrument. It can perform much faster movements and strike many more keys at the same time than a human pianist. Therefore, it lends itself to a variety of sonic experiments, especially for computer-generated music. The authors developed three different graphical user interfaces to control the automaton. Explicitly aimed at people without musical expertise, these interfaces provide the opportunity to gain hands-on experience with generative music. They illustrate how to create musical gestures, patterns and structures at different levels of abstraction, and convey specific algorithmic composition techniques in an easy-to-understand and practice-oriented way. This paper describes the three user interfaces regarding their technical implementation and their musical potential. Furthermore, it discusses the observations made during a three-day exhibition in Zurich.

1. Introduction

This article describes the installation *Klavierspiel* (‘piano

playing') that we presented at the *Design Biennale Zurich,* an exhibition that displayed national and international projects from various disciplines and took place in late August 2019 [1]. The title of this issue of the biennale was 'PLAY', which indicated that the public was not only meant to look at the artefacts but explicitly invited to explore them in playful interaction.

The realisation of the installation was motivated by our interest in generative music and educational intent to impart knowledge about this artistic practice. The main idea was to design an installation to guide a non-expert audience to obtain a perceptual experience of different generative approaches and an intellectual understanding of the underlying structural principles. We attempted to lead non-musicians to musical thinking by engaging them in playful interactions with generative processes.

The installation consists of three separate applications and thereby exemplifies three different generative approaches. It confronts the user with different structures, different levels of abstraction, and varying degrees of randomness. The applications employed different means to engage the user in a creative interaction: first, a physics engine that generates keystrokes as result of objects falling on a virtual keyboard, second, an interface that translates drawings into music, and third, a flowchart interface to construct simple rule-based compositions.

Apart from the educational aspect, we were also interested in observing how the public interacts with the installation, i. e. in which way, how long, driven by what motivation, and how musically 'meaningful' the visitors would engage with the three applications.

2. The Installation Setup

The musical instrument used for the installation *Klavierspiel* is a piano automaton. This device was conceived and built by the Austrian media artist and engineer Winfried Ritsch, and it serves to turn an acoustic piano into a computer-controlled instrument. It is, therefore, particularly well suited for algorithmic and computer-generated music [2]. The piano automaton is not a piano with a built-in playback technology but a kind of robot piano player, i. e. a self-contained device to be put on top of the keyboard of any grand or upright piano, and fixed in place with two large clamps. It consists of a metal frame that holds 88 solenoids to hit the keys of the keyboard. Three microcontrollers, one master and two slaves, actuate these solenoids. They receive commands over Ethernet from a control software.

One of the specific capabilities of the automaton is that it can depress an arbitrary number of keys simultaneously, all 88 at the same time if necessary, whereas existing, commercially available player pianos (the Yamaha Disklavier for instance) restrict this number to a value high enough for traditional classical piano music but by far too low for the kind of experimental music that Ritsch had in mind [3]. The aesthetic potential of the piano automaton lies in the fact that it can realise music that is beyond the abilities of a human pianist.

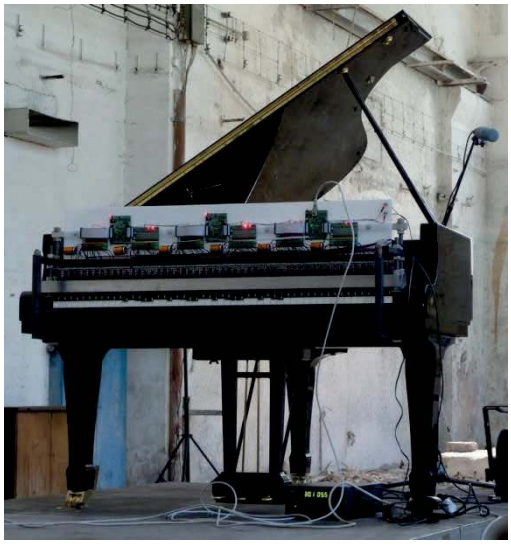


Figure 1: The piano automaton.

The installation setup consists of three computers connected to touchscreens with which the user can interact with the applications. The touchscreens are placed on black pedestals that are arranged in a semi-circle around a grand piano (see Fig. 2). Each computer runs one of the three different applications. All computers are connected to a local network over which they send the output of the application (see Fig. 3). This output, in OSC format but structured similar to MIDI data, consists of note events that carry two values: one to indicate the key-number from 21 to 108 (the range of a piano) and an other one to specify the velocity as a value normalised to the range between 0 and 1 (where 0 marks a note-off event). A control software that runs on a fourth, headless computer receives all these note events and transforms them into a machine-specific data format to be read by the microcontrollers of the piano automaton. Due to their inter-connection in a network, all three applications can send note events concurrently which allows for three users to play with the piano automaton at the same time.



Figure 2: Situation at the exhibition.

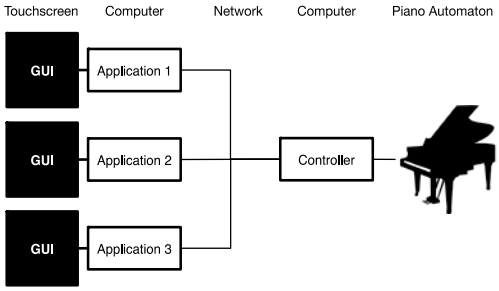


Figure 3: Flowchart of the installation setup.

3. Conceptual Approaches

Each of the authors conceived of an individual interaction scenario and implemented it in an application. This section describes the different conceptual approaches that informed the development of these three applications.

3.1 Cascading Cubes

The first application, named *Cascading Cubes,* provides an interface that emphasises playfulness and intuition of interaction. It does so by establishing a simulation-based environment that combines a realistic representation of a piano keyboard and of a marble run across with small cubes tumble before eventually falling on and triggering a piano key (see Fig. 4). In this simulation, the user can alter the shape of the marble run and modify some of the physical parameters. The situation thus created is intuitive and challenging at the same time. Intuition stems from the fact that the physical principles of a marble run and the correlation between piano key presses and sound events are familiar to anybody. The challenging aspects stem from the large amount of randomness as to where the falling cubes will hit the piano keyboard. Increasing the probability that the cubes are hitting only certain sections of the piano keyboard requires a redesign of the marble run. The more control the users would like to achieve on the musical result, the more carefully they will have to adjust the shape of the marble run. This combination between a readily understandable level of interaction and a difficult to achieve goal follows the principle of playing a game. Accordingly, it is through gamification that this software interface lets the users familiarise themselves with the principle of balancing control and chance in generative music.

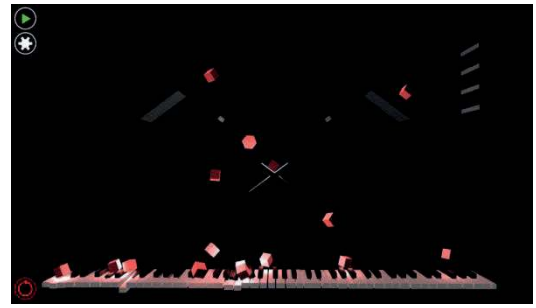


Figure 4: Screenshot of the application Cascading Cubes.

3.2 Little Loops

The application *Little Loops* provides an interface for converting graphical drawings into a musical result. By doing so, it illustrates compositional approaches in which musical material is ideated through visual sketching (see Fig. 5). The act of drawing can serve as a strategy to place the aesthetic focus on the visual domain and to appreciate the musical result as a coincidental or surprising outcome. Conversely, visual sketching can be guided by musical intentionality and thereby provide means for expressing musical thought. For example, scattered points create a pointillistic appearance both in image and music, slanted lines result in ascending or descending scales, multiple parallel lines produce musical gestures in parallel chords, etc.

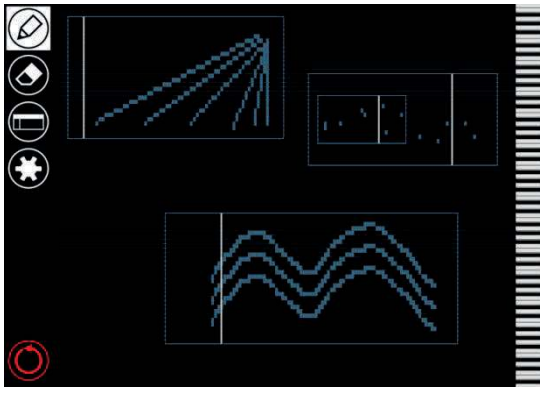


Figure 5: Screenshot of the application Little Loops.

Little Loops follows the convention of the piano roll notation. We chose this convention because it provides a straightforward connection between the two-dimensional layout of a drawing surface and the discretised dimensions of musical pitch and time. The sketching surface is displayed as a grid into which users can directly draw with their fingers. The active grid cells are then turned into actual notes through one or several 'players' that repeatedly read the content of a rectangular region of the image. The user can either choose small regions and thereby translate details of the image into short and frequently looping melodies (hence the name *Little Loops)* or instantiate players that cover the entire image. In any case, the resulting music is repetitive and pattern-based. By experimenting with the placement and size of the players, or by changing the playback speed, the user can explore the musical potential 'contained' within the drawing.

By offering the possibility to change the scale, *Little Loops* also allows the user to encounter more nuanced musical concepts. The following scales are available: the chromatic scale (all keys, default), a pentatonic scale (black keys only), a diatonic scale (white keys only), and whole-tone scale (every other key). By changing the scale, the user will obtain a result that retains the shape of the musical gestures but differs in its harmonic colouration. At the same time, the

user can also observe how a different scale requires a different discretisation among the vertical axis of the drawing surface and thereby alters the appearance of the image.

3.3 Flashing Flowchart

The application *Flashing Flowchart* provides an approach to musical composition on a higher level of abstraction than the other two applications. By means of a directed graph, it describes a musical structure as a rule-based succession of musical events (see Fig. 6). The formal grammar that is constituted by these rules is reflected in the topology of the graph. By manipulating the graph, the user can explore the grammar and the music that originates from it. The abstraction contained in this method reflects, at least in our opinion, the way of thinking that one can find among professional composers. Composing music deals with both the surface of the music and the underlying structure. Composing is not only about finding and selecting sound material but also about making decisions on how to arrange it.

Flashing Flowchart allows for network topologies with closed loops and arbitrary branching. The branching enables various paths through the flowchart. Whenever a node with more than one outgoing connection is reached while traversing the flowchart, the continuation of the path is randomly chosen. The resulting music is characterised by its variability, by containing repetitions that are not verbatim but only similar. This variability lends the music a particular, albeit modest, complexity.

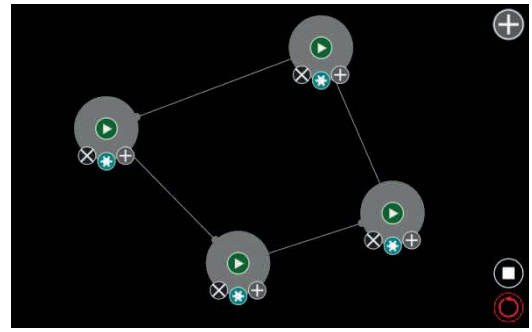


Figure 6: Screenshot of the application Flashing Flowchart.

4. Programming and Implementation

The individuality of every single application is an essential aspect of the whole installation, as is the juxtaposition of the three applications. To realise the individuality, we developed the three applications and their user interfaces separately. We tried, however, to establish certain common design principles concerning the interface. As the installation *Klavierspiel* was meant to address musical laypeople, we decided to keep the user interface as simple as possible by presenting only a restricted set of parameters to the user. To achieve

a high user-friendliness was paramount for this project.

Each application can be reset to a default state by pressing the corresponding button. Also, when a time of five minutes has elapsed without any user input, the application automatically resets itself. A reset puts all parameters to their default values, stops any playback, and presents the user interface in a minimal and tidy state.

4.1 Cascading Cubes

The application *Cascading Cubes* was programmed in C++ in the openFrameworks environment. It employs the Bullet physics engine for realising a physically realistic simulation of a piano keyboard and a marble run. The cubes are simple shapes that accelerate their fall towards the keyboard through gravity. Whenever a cube exceeds a lower vertical position limit, it is removed from the simulation and a new cube is added in its stead in a random position at the top of the screen. The cubes can collide with other cubes, segments of the marble run, or piano keys. Each of these elements possesses its own physical characteristics. Depending on these characteristics, the cubes will slide and bounce off from obstacles very differently. By changing these characteristics, the user can obtain different behaviours, ranging from a realistic simulation to an unrealistic caricature of physics.

The simulation controls the piano automaton in the following manner. Whenever the rotation of a simulated piano key exceeds a lower limit, a note-on event is triggered. The pitch of the note depends on the giving piano key. The note's velocity is proportional to the mass of the cube that was involved in the collision. As the simulated key returns to its rest position, it traverses an upper limit, which in turn causes a note-off event.

The visual rendering of the simulation is overlaid with a GUI that contains the following elements: a button for starting, stopping, and resetting the simulation, numbered buttons for choosing among a set of predefined configurations, and sliders for manually changing the values for the simulation parameters. The following simulation parameters are exposed through the GUI: the number of cubes, the mass of cubes, the restitution of cubes, the lower rotational limit of the piano keys, the velocity of the keys returning to their rest position, and the time step of the simulation. In addition, the user can directly interact with the segments of the marble run. Once selected, a segment can be moved around by single-finger gestures or rotated by two-finger gestures.

4.2 Little Loops

The application *Little Loops* was programmed in Java in the programming environment Processing. Its main interface takes the form of a grid. The grid's vertical extension represents pitch. This extension is subdivided into 88 rows, each of which corresponds to a piano key. The horizontal extension of the grid represents time (running from left to right). This extension is subdivided into 150 columns. Aligned with the grid and displayed on its right side is a schematic representation of a piano keyboard.

By touching the screen, the user can draw into the grid and thereby activate individual grid cells. The user interface provides different drawing tools: a simple pen to activate single cells, a triple pen to activate three cells evenly spaced along the vertical axis, and a line tool to activate all cells along a straight line between a starting and ending point. In addition, there is an eraser tool to deactivate the cells within a four-cell square region.

A player region appears as an outlined rectangle that superimposes a portion of the grid. Each player region contains a playhead (indicated as a vertical line) that continuously moves from left to right and wraps around when it exceeds the right edge of its region. Active cells within a region are translated into notes whenever the playhead passes over them. Each player contains a set of graphical interface elements that allow users to change the size or location of the player's region, to start or stop the playback, to alter the speed of the playback, or to delete the player. The user is free to add any number of additional players whose regions can either be located next to each other or overlap.

When the user switches to another scale, the available vertical positions for the grid cells change according to a pattern associated with the scale. All active cells are shifted vertically to the nearest available position. This shift is reversible; returning to the scale that was used during drawing restores a cell's original location. No matter which drawing tool the user has selected, new cells can only be added at one of the available positions.

4.3 Flashing Flowchart

The application *Flashing Flowchart* was programmed in Java using the programming environment Processing. The nodes of a graph with directional edges represent instances that can play a musical event. They hold a set of parameters that describe the type of musical event: whether it is a single note or one of four predefined chords, and whether

the duration of this event is short, long or very long. Every node can be connected to other nodes by an arbitrary number of outgoing and incoming connections.

When a node fires, the application sends out the appropriate note-on message(s). Then, one of the outgoing connections is randomly chosen, and a cursor is added to this connection. The cursor, visualised as a little spark, travels along the connection until it reaches and triggers the next node. As the cursor travels at a fixed speed, the elapsed time until the next node plays its musical event is proportional to the length of the connection. The layout of the graph and the relative distances between interconnected nodes determine the inter-onset-intervals of the musical events, which in turn define a rhythm. There can be several cursors at the same time, which leads to a canonic structure.

The GUI contains the following elements: two buttons for stopping and resetting the simulation, one button to add a new node to the graph. The nodes themselves are visualised as circles with another four buttons on it: a start button to trigger the node, a button to delete it, a button to open a menu to specify the node's parameters, and a button to sprout a new, connected node. The nodes can be dragged around on the touchscreen. When a new node is created, it appears as 'ghost' to be first moved to its definite place before it is instantiated. In this provisional state, a node can be dragged over another node with which it then merges. This behaviour serves to create loops in the flowchart. The parameters of a newly created node are set to 'single note', 'short duration', and a random pitch.

5. Results

In order to gain an understanding of how users interact with the three different applications, we gathered information with regard to the users' behaviours, interface usage, and achieved results. The users' behaviours were evaluated through observation and lead to anecdotical evidence about different forms of engagement. We made these observations during our on-site supervision of the installation.

Further information about the user interaction was acquired through a mechanism integrated into each application that stored the state of the interface as snapshots at a regular interval of one minute. Based on these snapshots, a small statistical evaluation of the frequency of usage of interface elements was conducted. From this evaluation, insights could be gained concerning the usability of the interface and the users' willingness to delve deeper into some of the more nuanced

possibilities that the applications provide.

A manual comparison between the application states that were reconstructed from the saved snapshots led to a grouping of these states into different categories. The identification of these categories alongside with the frequency of their appearance provided cues about the focus of the users' attention and the exhaustiveness of their attempts to reach interesting results.

The evaluation revealed patterns in the users' engagement that are similar among the three applications. Overall, the installation enjoyed great attention among younger people, in particular among children. The attractivity for children was particularly prominent for *Cascading Cubes* and *Little Loops*. In case of *Flashing Flowchart,* predominantly adult people were engaging with the interface. Concerning the duration of user engagement, three types could be distinguished. Some users would leave the installation without trying to interact with one of the applications. Others spent only a brief amount of time with each of the applications. These users were satisfied once they acquired an initial understanding of the functionality of each interface but did not feel compelled to explore its possibilities further. Finally, several users were sufficiently fascinated by at least one interface that they would dedicate an extended period of time to their attempt to achieve an satisfying musical outcome.

The following three subsections describe the results obtained from the evaluation that are distinct among the three applications.

5.1 Cascading Cubes

Through observation, we found that some users were initially clueless concerning the means of interaction. Several users tried to touch the keys of the simulated piano keyboard directly. This type of failed interaction usually happened when the simulation showed no falling cubes. Eventually, the users found and pressed the play button, after which the observation of the falling cubes and their effect on the sound production was sufficiently self-explanatory to understand the functioning of the interface.

The saved states of the interface were statistically analysed to distinguish between the following types of interaction: Selection of predefined settings (4%), change of simulation parameters (56%), change of position and/or rotation of marble run segments (40%).

The following table shows a categorisation of the different marble run designs and the frequency of their occurrence (for

representative examples of these categories see Fig. 7).

Default 14.3%	Only minimal differences from a predefined setting.
Random/ Few 14.9%	A few segments distributed in a seemingly random manner.
Random/ Many 16.7%	Many segments in a seemingly random manner.
Filter 9.0%	Segments placed closely above the keyboard with small gaps between them. The gaps act as filters allowing the cubes to hit only a few keys.
Slide 16.7%	Rotated and closely spaced segments form a slide along which cubes move.
Barrier 9.0%	Horizontal and closely spaced prevent cubes from reaching the keys.
Steps 2.1%	Horizontal segments evenly spaced along a declining line resembling steps of a stairs.
Basket 5.1%	Horizontal and rotated segments in the shape of a baskets in which the cubes tend to get caught.
Funnel 2.0%	Segments arranged as two mirrored slides with a small gap at the bottom..
Keyboard Abuse 10.2%	Segments intersect with the key-board causing the keys to tremble due to instabilities in the simulation.

Through observation, we found that all users would immediately begin to draw, but some of them were confused by that fact that their drawings were not immediately audible. These users spent some time struggling with the interface until they figured out that they had t o place a pl ayer above their drawing.\

Based on a statistical evaluation of the snapshots, it became evident that most users did not bother to work with more than one or two players (see Fig. 8). It mu st even be assumed that this number includes the player that the application provides when reset to its default state. Most of the users ignored this player and l eft it running idle without any content. The fact that the users mostly utilised only very few players possibly indicates that the relationship between a dr awing and the musical result is more readily understandable in case of a single player covering the entire drawing. Splitting up the drawing into several regions to be r ead by individual players results in a multi-layered musical result which seemed to be too complex for most users.

5.2 Little Loops

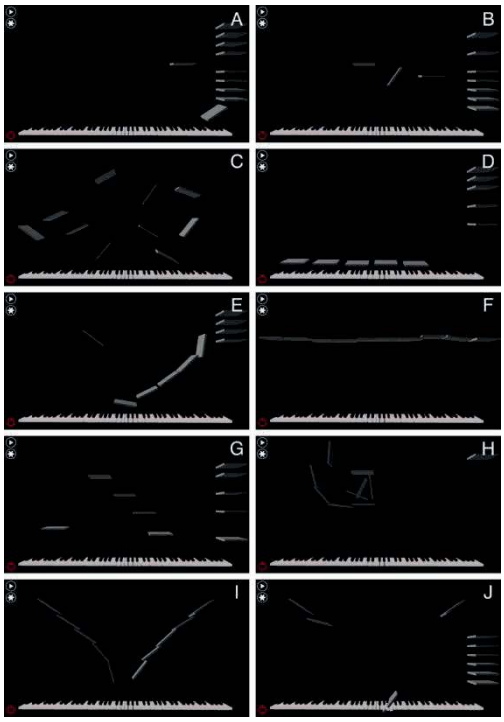


Figure 7: Representative examples of categories of marble run designs. A: Default, B: Random/Few, C: Random/Many, D: Filter, E: Slide, F: Barrier, G: Steps, H: Basket, I: Funnel, J: Keyboard Abuse.

Users rarely explored some of the more advanced possibilities provided by the application. In 91.6% of all snapshots, users used the chromatic scale, which corresponds to the application's default setting. Other scales appeared with the following frequencies: diatonic scale 1.4%, pentatonic scale 3.8%, whole-tone scale 3.2%. Very similarly, in 90.7% of all snapshots, the user used the default 'simple pen' as a drawing tool.

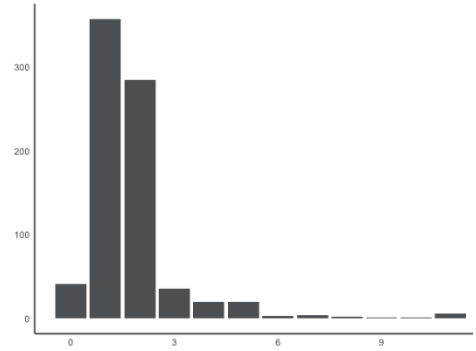


Figure 8: Distribution of the number of simultaneously opened players on the piano roll.

An inspection of the reconstructed application states led to the identification of the following four different types of drawings (for representtative examples of these categories see Fig. 9).

Figurative 10%	The drawing is figurative and resembles an iconic object (e. g. a house, a face, a heart shape).
Writing 10%	The drawing resembles a written text that shows either single letters, phrases, or names.
Lines 47%	The drawing consists of multiple distinct and simple shapes that usually take on the form of continuous or dotted lines that are either straight or curvy. These drawings resemble a score and therefore represent musical expressions.
Scribble 33%	The drawing is neither identifiable nor is the user's intention in creating the drawing apparent.

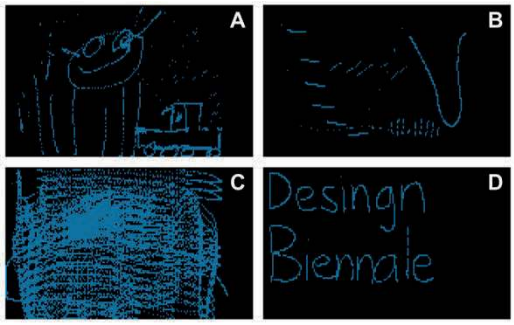


Figure 9: Representative examples of the four drawing categories: A: Figurative, B: Line, C: Scribble, D: Writing.

Among all the user drawings, those that correspond to the category 'Lines' were the most prominent. This indicates that users readily understood the drawing functionality as a method to test out musical ideas. It can be assumed that the appearance of the interface as a piano roll grid and the presence of a real piano helped to nudge the users' intention into a musical direction. For those users that created drawings of the categories 'Figurative' and 'Writing', the application appeared first and foremost as a graphical tool that allowed to explore the musical rendition of the drawing as an additional feature. These users were, for instance, interested in hearing how their name sounds on a piano.

5.3 Flashing Flowchart

We observed that the users engaged either only for a short moment with this interaction or for a long time. The fact, that some of the users spent only little time in front of the screen can indicate that the interaction is too complicated, the musical result does not sound catching right from the beginning, and the application provides no game-like challenge. Concerning interaction, most of the users failed to figure out how to close a loop in the flowchart (or did not even try to find out). Without loops, the musical playback ends after only a few notes, which is not particularly attractive. Those users, in turn, that spent a lot of time with this application were driven by a musical interest and tried to create their own, small compositions. Primarily, this interaction seemed to attract people with prior knowledge in music-making.

We had to acknowledge that the application *Flashing Flowchart* is the most demanding. The users had to spend some time to explore the interaction to find out how to build a musically interesting flowchart. Moreover, it is an application that addresses mostly people who are able or willing to engage with musical abstraction. In the light of this project's aims, to present different approaches to algorithmic composition, this limitation seemed acceptable because it is presented in

contrasting juxtaposition with the other interactions.

Most users did not further explore the parameter settings as can be seen in the fact that for the majority of the nodes recorded in the snapshots the default settings were left unchanged (70.1% ‘single note’ and 78.5% ‘short duration’). The number of nodes that appeared simultaneously in a flowchart ranges up to 19 (a maximum given by the size of the screen). The distribution of nodes can be seen in Fig. 10.

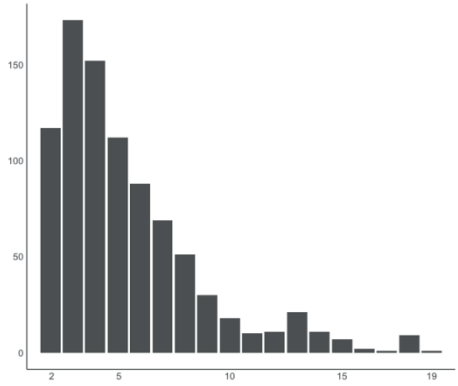


Figure 10: Distribution of the number of nodes per the flowchart.

We categorised the snapshots with respect to the topology of the flowcharts as listed in the following table (for representative examples of these categories see Fig. 11). The numbers affirm the observation that many users had difficulties in finding out how to create a closed loop on the screen.

Continuous Iteration 15.4%	Non-terminating flowchart, one single path.
Continuous Variation 23.1%	Non-terminating flowchart, several possible paths.
Terminating Variation 13.8%	Flowchart with loops and one or more branching-offs leading to a dead end.
One-Shot 47.7%	Flowchart without any loops.

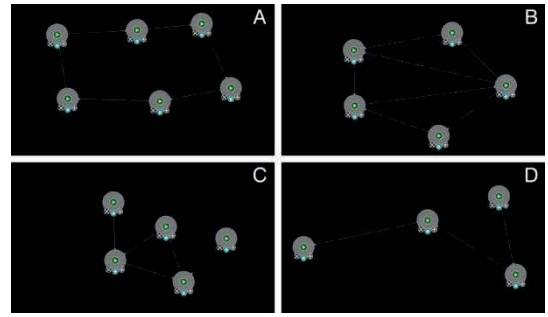


Figure 11: Representative examples of the four flowchart categories: A: Continuous Iteration, B: Continuous Variation, C: Terminating Variation, D: One-Shot.

6. Conclusion

The presentation of the installation *Klavierspiel* at the *Design Biennale Zurich* provided an excellent setting to communicate to a non-expert audience some of what we consider to be c ore principles of employing generative systems in musical composition. To gain as

many insights as possible from the visitors' response to this setting, an evaluation was conducted that combined observation of user behaviour, statistical analysis of interface usage, and category formation of achieved results. We believe that such a combination provides insights that can be of value for any artist working in the field of generative and interactive art and music. Among others, such a combined evaluation allows a discrimination between a visitor's level of understanding concerning the possibilities of interaction versus the visitor's level of comprehension of the generative principles. Furthermore, this combined evaluation also permits to assess the diversity of results that a generative system can generate in response to a user's first-time interaction and these results can convey information about a user's motivation and intention to interact in the first place.

Our motivation for realising this generative installation was predominantly a didactical one. For this reason, not all of the design decisions that were made are readily transferrable to other, more artistic approaches. If nothing more, this article highlights that for any interactive and generative artwork that is meant to be used and experienced by non-expert users, an informed decision has to be made by the artist concerning the balancing of understandability and complexity. The three applications exemplify different attempts of finding such a balance. They do so by choosing distinct levels of abstraction, order, and randomisation while being similar in their sacrificing of autonomy in favour of a high level of control, and their limiting of the diversity of possible outcomes in favour of more readily accessible results. We believe that by documenting the rationale for these decisions, they can also help to inform artistic strategies that deal with the development of sophisticated generative systems which are meant to be interacted with by a professional audience.

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TITLE:
An approach to Generative Art from Brain Computer Interfaces
(Paper)

Topic: Brain Computer Interfaces, Art, Music

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Abstract
Nowadays, technological advances have influenced all human activities generating new dynamics and ways of communication. In this context, some artists have incorporated these advances in their creative process, giving rise to new aesthetic expressions that are referred in literature as Generative Art, which is characterized by assigning a certain part of the creative process to a system that acts with a certain degree of autonomy [1]. The most recent works in generative art show the importance of the visual component as well as the artist's effort to provide the viewer an active role in order to offer a captivating experience [2]. In this regard, this work proposes a computational system for the creation of generative art that explores the use of a Brain Computer Interface (BCI), which allows the materialization of the captured data of the spectator's brain activity in a digital artwork. In this way, the spectator takes an active role in the creative process. Additionally, the proposed system makes an audible representation of the user's mental states materialized in an artistic piece as a complementary part of the artwork. The generated work takes advantage of concepts of geometry, color and spatial location to graph the visual space and uses the cerebral signals as random and recursive elements that give complexity to the autonomous construction. As an added value, visual production is accompanied by a musical piece generated from the BCI data, which complements the created artwork providing a bimodal communication character. The pictures below show some examples of the spectator's experiences and the art pieces created by their own brain data:



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Key words: Brain Computer Interfaces, Art, Music

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An approach to Generative Art from Brain Computer Interfaces

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Abstract

Nowadays, technological advances have influenced all human activities generating new dynamics and ways of communication. In this context, some artists have incorporated these advances in their creative process, giving rise to new aesthetic expressions that are referred in literature as Generative Art, which is characterized by assigning a certain part of the creative process to a system that acts with a certain degree of autonomy [1]. The most recent works in generative art show the importance of the visual component as well as the artist's effort to provide the viewer an active role in order to offer a captivating experience [2]. In this regard, this work proposes a computational system for the creation of generative art that explores the use of a Brain Computer Interface (BCI), which allows the materialization of the captured data of the spectator's brain activity in a digital artwork. In this way, the spectator takes an active role in the creative process. Additionally, the proposed system makes an audible representation of the user's mental states materialized in an artistic piece as a complementary part of the artwork. The generated work takes advantage of concepts of geometry, color and spatial location to graph the visual space and uses the cerebral signals as random and recursive elements that give complexity to the autonomous construction. As an added value, visual production is accompanied by a musical piece generated from the BCI data, which complements the created artwork providing a bimodal communication character.

1. Introduction

The technological boom experienced since the end of the 20th century, in which Information Technologies have permeated almost all human activities, has generated new dynamics and forms of development and communication. Consequently, in the context of Art, some artists and creators have incorporated these advances into their creative process, giving rise to new aesthetic expressions such as electronic art, computational art and others.

These new forms of expressing art are referred to in the literature as generative art, whose fundamental premise is based on the fact that part of the creative process is carried out by a system that acts with a certain degree of autonomy, but keeping elements such as (color,

form, space, texture, etc.) and principles (balance, movement, proportion, uniqueness, etc.) of art [1][3][4].

In works such as [5][6][2][8] the importance of the visual component in generative art is evident, as well as the concern that the work responds to certain interactions of the spectator. These proposals demonstrate the artist's effort to provide the viewer with an active role and a captivating experience. However, in offering the possibility of interaction with the work, it is important that the artist contemplates multiple ways of communication since, although vision is a fundamental element of perception, multimodality offers a more complete way of communication, taking advantage of other senses (such as the auditory) to create a more meaningful experience for the audience.
In this context, the fundamental premise of this proposal is to extend the capacity of interaction of the audience and more than the artwork adapts to actions executed by the spectator, it proposes to offer the spectator a participative and immersive experience in the creative process.

To achieve this purpose, a bibliographic review was carried out in search of technologies that would allow data from the spectator to be captured and used in the creative process. As a result of this effort, a new and rarely used alternative in the context of generative art was found in the Computer Brain Interfaces (BCI).

The next section presents the BCI concept, its possibilities and the selected device. In addition, some concepts related to music are presented, which were taken into account for the creation of the musical piece that accompanies the artwork that is also generated from data from brain activity.

2. Brain Computer Interfaces

Brain Computer Interfaces are hardware and software communication systems whose purpose is to help the user interact with the external environment by predicting their intentions based on data related to their brain activity.

These types of systems have been fundamentally studied and used as assistance tools for people with reduced mobility because they do not involve the use of muscular channels for the user interaction [9].

A BCI device captures signals from the brain and can perform certain calculations following five consecutive stages: Signal Acquisition, Signal Pre-processing, Feature Extraction, and Signal Classification.

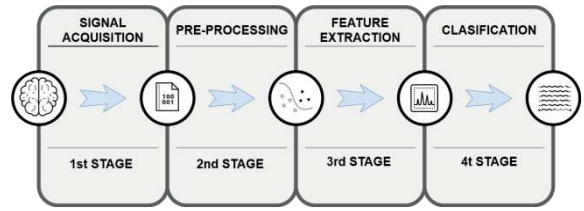


Fig 1. BCI. stages

In this way, a BCI device allows the brain to communicate with external mechanical devices and involves important aspects such as voluntary control of electroencephalographic signals, synchronization of brain rhythms and the measurement, interpretation and classification of neuronal activity. This last aspect is the one that is taken as base on this proposal

2.1 Brainwaves, Classification and Capture Devices

Brain waves are produced when brain cells (neurons) are activated and produce local current flows that are translated into electrical impulses and changes. Encephalography or EEG primarily measures the currents flowing during the synaptic excitations of the dendrites of many pyramidal neurons in the cerebral cortex [10].

Brain patterns form sinusoidal graphs that commonly range from 0.5 to 100 μV in amplitude, that is, almost 100 t imes less than ECG signals (electrocardiograms). The Fourier transform allows these raw signals to be taken and amplified to obtain a higher volume of information. Brainwaves are measured in cycles per second (Hz), the higher the number of Hz, the higher the frequency or brain activity. The first approach to brainwaves was made by the German Hans Berger in 1924 [11]. Between 1930 and 1940 t he brainwaves were classified in 5 g roups which are summarized in Table 1 [11]:

Waves	Ranges	Mental States
Delta (δ)	< 4 Hz	Unconsciousness, deep sleep.
Theta (θ)	4Hz - 8Hz	Relaxation, intuition, creativity, remembrance, Imagination.
Alpha (α)	8Hz - 12Hz	Mental effort, sleepless relaxation, stillness, awareness.
Low Beta (β)	12Hz - 15Hz	Relaxation and focus.
Mid Beta (β)	16Hz - 20Hz	Thinking, self-consciousness.
High Beta (β)	21Hz - 30Hz	Alert, agitation, disturbance.
Gamma (γ)	30Hz - 100Hz	Motor functions and high mental activity

Table 1. Brain Waves and their classification.

According to the above, a B CI device allows inference to be m ade about an individual's mental state (attention level, relaxation) and some of his motor functions. In recent years, manufacturers such as Emotiv (EPOC), Neurosky (Mindwave) and OpenBCI (Cyton) have been dedicated to the development of non-invasive BCI devices, which allow the capture of brain signals in an ea sy and user-friendly way.

For the purposes of this paper, the Mindwave device was chosen because of its economic affordability, reliability in the delivery of data related to the user's mental states, ease of use and the comfort the user feel when interacting with the device, as evidenced in the study conducted in [12].

3. Music: Basic concepts

The word 'music' derives from the Greek mousike (μουσική) which means "art of the muses" [13]. According to [14] music is "the art of combining vocal, instrumental (or both) sounds to produce beauty of form, harmony, and expression of emotion. Also, according to modernist composer Edgard Varèse, music is defined as "organized sound"[15]. However, many authors have expressed different opinions about what is or is not considered music. Therefore, in order to better understand the definition and language of music, it is necessary to become familiar with concepts such as: tone (height), duration, intensity, and timbre [16].

Tone is an essential characteristic that allows us to distinguish between high-pitched and low-pitched sounds [17]. The frequency of each sound - usually measured in Hertz (Hz) - denotes the number of sound waves per second and allows identifying the musical note to which it corresponds.

Duration is the time in which the vibrations produced by a sound are maintained, that is, the period or interval of time in which a specific note sounds [18]. The graphic representation is made by means of musical figures assigned to different sounds, where the semibreve is the reference unit and e ach subdivision

(musical figure) lasts in time the half of the previous note.

Intensity, also known as 'volume', is the property that allows you to identify how loud or soft a sound is perceived. Volume levels are measured in decibels (dB). The range of human hearing lies between 0 and 120 dB approximately, for this reason, sounds above the upper limit - such as that produced by aircraft take-off - can cause irreversible damage to hearing. While frequency is set by the length of the sound waves, intensity is determined by its height, which can also be called the wavelength [19].

Finally, the 'timbre' is an intrinsic property that allows the human ear to differentiate between sounds emitted by various sources, even when they do not belong to the same category. For example: the sound emitted by a guitar and an electric bass or the same musical note played by different instruments. Each of the above definitions constitute the structure and foundation of what we know as 'music'.

4. Proposed system: Early stages

Tests were carried out with different colors and geometric figures, so that substantial improvements could be evidenced at each stage. In this way, the final proposal exhibits an improvement in the robustness of the algorithm and the resulting images. Next, the experimental process is described: To generate generative art, *Processing* was used as a programming environment. In the same way, an exploration of the geometric forms that have more relevance and that are more easily identifiable in nature and in daily life was made. This, in order to the aim for the naturalness of the generated piece.

Some of the geometric figures chosen were hexagons, triangles and circles, however, the experimentation was carried out with circles because the low computational complexity required to create them allows the inclusion of different characteristics in the final piece. The first approach came from the hand of a mathematical function whose curves are shaped like the flower's petal. This function is called "*Rhodonea Curve*" or "Rose curve" and was named by the Italian mathematician Guido Grandi between 1723 and 1728. It allows drawing roses from polar coordinates. Figure 1 describes the function, expressed in polar coordinates and its representation in parametric equations:

$$r = \cos(k\theta)$$
$$x = \cos(k\theta)\cos(\theta)$$
$$y = \cos(k\theta)\sin(\theta)$$

Fig 2. Polar coordinates and parametric equations.

If k = n/d, then the figure will change due to the values of these variables, in other words, the visual representation of the figure will have a greater or lesser number of petals.

Figure 2 shows the curves defined for different values of n and d.

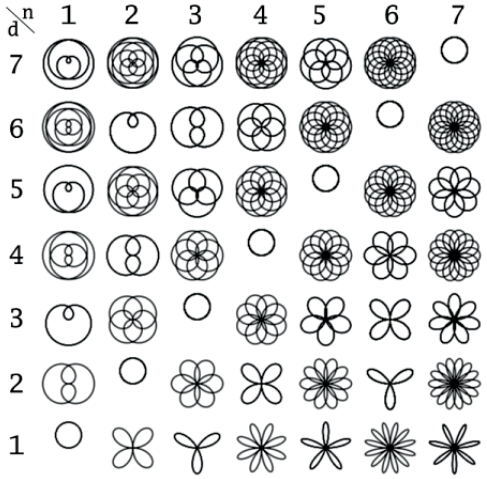


Fig 3. Rose Curves with different values of n y d.

The second approach continued under the premise of using circles for the construction of the final piece. In this regard, color and spatial location were adopted as characteristics of generative art, so a variable associated with color and a pair of coordinates for the location of the figure were introduced as random elements.

Circles are formed by lines starting from a specific position. The algorithm performs a cycle from zero to 360 degrees for the creation of a circle. Within it, a straight line is constructed whose values of X1 and Y2 are calculated by random numbers between 50 - 150 and 150 - 360 respectively. The values of X2 and Y1 are both zero. In this way, the centre of the circle varies and its internal points are defined, as can be seen in figure 4:

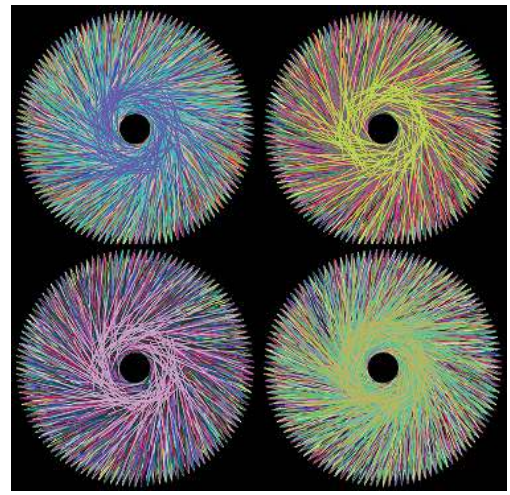


Fig 4. Multicolor circles generated randomly.

5. System's description

Figure 5 shows the architecture of the application, which depicts how music and generative art come together in this proposal.

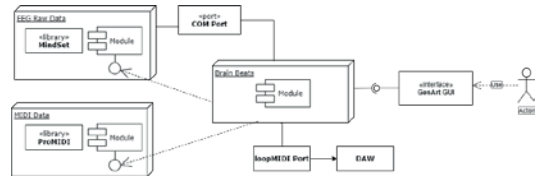


Fig 5. App's Architecture.

The results obtained, contributions, and possible applications of this work in the context of music generated from brain activity are described by the author in [20].

Regarding generative art, the third approach — and the one that represents the current version of the system — gathers the ideas introduced in the previous stages, however, instead of randomizing the whole algorithm, it takes as input the values of the brainwaves

provided by the user who interact with the device, in order to produce art through brain activity.

Figure 6 shows some examples of the spectator's experiences and the works of art created by their own brain data.



Fig 6. User interaction

The application's functioning will be explained shortly. It begins with the definition of a variable that will measure time in milliseconds, this variable will be used to provide continuity and movement to the final piece generated. A seed is also defined for the random values of the algorithm.

For this approach, the values of the five brain waves are used: *delta, theta, alpha, beta and gamma*.
Initially, the raw data sent by the device are not used, but for each of the wave values, a data pre-processing is carried beforehand, so that these can be used by the algorithm.

Regarding *Alpha* waves we distinguish two types of values: The common ones, which are in a range of 8Hz - 12Hz and the so-called *High Alpha* which are between 10Hz - 12Hz.

Continuing with the idea of using circles, two models are proposed: The first is a training set consisting of *Delta*, *Theta* and *Alpha* waves that will control the number of circles in the piece. We will call this set *C1.* The second set (*C2*), consisting of *High Alpha, Beta* and *Gamma* waves will be used to control the radius of each circle in the scene.

An additional variable that takes the value of the screen width and divides it by the value of the brainwaves in *C2* is used. This, in order to graphing the circles generated within the display area. It then iterates from zero to the value of the brainwaves in *C1*.

Three new variables are introduced: The first two are the coordinates X and Y, whose values will be the multiplication of the previous variable times a random value between zero and the value of the brainwaves at *C1* plus one.

The third variable is responsible for the displacement of each circle in the figure, so it will take the time variable introduced at the beginning and multiply it by a decimal number between 0.1 and 1, times the number 60 times a random number between zero and two.

The mentioned values were set after testing and observing that they made possible the perception of movement.

Each circle moves in one of the two axes, following a straight line whose sinusoidal displacement and wavelength vary randomly.

The color of each circle and its interpolation with the following color are chosen in the same way, for that purpose, the device's attention and relaxation values are used to choose, randomly, the opacity of each circle present in the piece, which varies in a range that has the user's attention level has as its lower bound and its relaxation level as its upper.

6. User tests and

Brainwaves exploration

In order to ensure variability and expressiveness in the final piece, it was necessary to determine which pair of waves from sets *C1* and *C2* would be selected. These are shown in Table 2.

***C1*(Number of circles)**	***C2*(Radius)**
Alpha	High Alpha
Theta	Beta
Delta	Gamma

Table 2. Training sets.

Thus, tests were carried out with 6 users, which generated pieces showed divergent behaviors. Each user presented different mental states and a different production of brain waves.

As will be shown in the figures, the brain waves of each user allow the creation of pieces of art with different morphological characteristics due to the quantity of variables that the algorithm gathers and that are expressed in an involuntary way. Similarly, the figures shown exhibit the uniqueness of each of the pieces. The geometric figures that are formed contain a series of basic design concepts such as: translation, superposition, gradation of shape, size, color and scale.

The variation of the opacity of the geometric figure along with the gradation of scale generates a controlled chaos effect, as well as the visual weight and the cognitive load of the piece that is being built it is modified as the interaction process with the BCI device lasts longer.

The different pieces generated are explained in detail below, taking into account the brain waves and t he users who participated in the test:

User 1: Alpha - High Alpha.



Fig 7. User 1 (Alpha – High Alpha).

As seen in the results, for these brainwaves, a gr id of superimposed circular shapes with size gradation is created. The randomness of the position of the figures ends up being recurrent in the sense that a c ertain order is appreciated in the X and Y axes, as well as the distribution of the filling colors through all the composition.

User 2: Theta – Beta



Fig 8. User 2 (Theta – Beta).

These brainwaves, unlike the others, do not saturate the composition of images, leaving blank spaces that allow the image to breath, the figures tend to group in certain positions, which causes a certain visual imbalance in the results.

User 3: Delta - Gamma

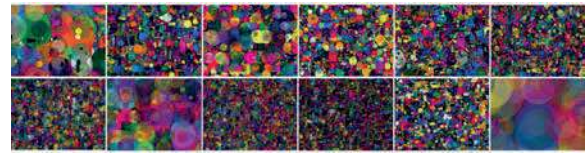


Fig 9. User 3 (Delta - Gamma).

With these brainwaves the figures are grouped massively throughout the composition, this generates a grid of superimposed circular shapes that vary with the opacity.

Regarding the mental states of the users, it was found that each one experienced different sensations, prior to the interaction with the BCI device. Thus, user one was sleepy at the time of the interaction, while user two was attentive – expectant. On the other hand, user three was relaxed.

In this regard, not only the values of the brain waves of each individual provide variability to the generated piece, but also, their mental states are a great input in the construction of the final piece.

Based on the information provided by the previous figures, it was decided to select the Delta - Gamma waves, since they are the pair of brain waves that provided more expressivity and variability.

This decision is also supported by the fact that these brainwaves are the ones in a lower and higher frequency range respectively, as show in the study carried out by [21] and the figure 9. The above is reflected in the fact that having fewer circles that quickly change its size brings more contrast, variability and expressiveness into the final piece.

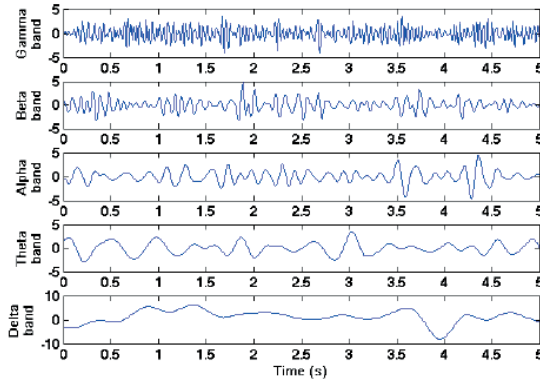


Fig 10. EEG brain frequency chart.

The figures below show tests performed on three different users in order to obtain the values of their Delta - Gamma waves to produce generative art.

User 4: Delta – Gamma

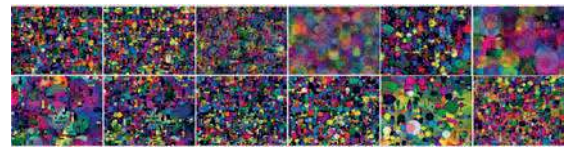


Fig 11. User 4 (Delta - Gamma).

With these brainwaves it's easy to observe gradation of color, translation of forms and interlacing of figures. It is important to see how the figure also presents a change in opacity which generates a diffuse image.

User 5: Delta – Gamma

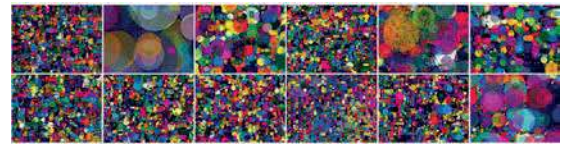


Fig 12. User 5 (Delta - Gamma).

The reticular organization using these brainwaves is clearer, since the size of the figures is smaller which contributes to a more logical order in the arrangement of its elements. There are certain moments when opacity, in conjunction with scale, blurs the composition, however, it tends to be homogeneous.

User 6: Delta - Gamma

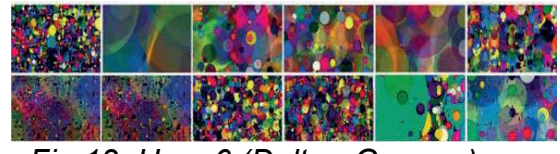


Fig 13. User 6 (Delta - Gamma).

The tendency of this type of brainwaves is to form lattices of circular superimposed forms, however, there are certain

moments where there is variation of opacity and scale that produce visual asymmetry regarding the sizes of some figures with respect to others.

The tests performed and figures *7 – 9* and *11 - 13* shown above were run and captured in the same time frame for each user (one minute). This allowed us to obtain greater accuracy in the data and images presented.

In regard to the tests carried out with users whose brain waves used were different, it was found that the variability of these and the profile of the users allowed obtaining diverse results, as shown in *figures 7 - 9.*

Similarly, each of the pieces generated by the users presented different images, color patterns and compositions, even if the tests were performed with the same brainwaves (Delta - Gamma), as evidenced in figures *11 - 13*. This generates a composition with depth, whose randomness provides unique pieces considering that although the same waves and capture times are measured, the results of the images will be diverse.

The amalgam of each of the previous elements and their interrelation provide the necessary inputs that allow the creation of a piece of generative art that is not only based on the brain activity of a person, but also fluctuates with it, so that, at first, none of the images generated by users are the same, since their mental states and / or brain activity vary constantly.

7. Conclusions

During the experimentation it was found that, at in the beginning, some shyness was observed in the user - spectator due to the use of the BCI device. Nevertheless, once the creative process begins, there is evidence of an immersion and capture of the interest of the person, not only because of the visual feedback, but also because of the auditory one.

The system generated and the incorporation of BCI technologies allow to bring the user closer to art. In this regard, the result of this research does not propose to turn users into artists, but to obtain an artistic result that the user can create involuntarily. Thus, the BCI device is configured as a facilitator and mediator of this creative process.

The values obtained as a result of capturing the user's brainwaves offer enough randomness to make the algorithm produce a piece of art that is different for each viewer because it is linked to the user's brain activity.

The BCI captures information that allows to reassure the autonomy of the algorithm in the generation of the piece of art because the data with which this the piece is created are taken from the brain activity of the user, which is intangible for him. This means that the user is not aware of generating a certain effect in order to manipulate the artwork. He could not, for example, take explicit control over the way in which the parameters in the algorithm are reflected in the piece, but rather the piece reacts to its mental states and to the outcome of its brain activity. This is why, in the interaction, the user does not have total control over the final result of the work or what it produces, but somehow the user's brain activity is reflected in an artistic piece. In this sense, during multiple tests, one of the users stated that, when concentrating, he could vary the size of the circles or the composition of the figure, however, this corresponds merely to a subjective perception of the person.

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GENERATIVE IDENTITY
BETWEEN NON-DURABILITY AND RESISTANCE:
Identity, sustainable identity design and the role of generative grammar

Topic: Graphic Design

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Abstract

Sustainability is a term that has widely affected the design industry over the last decade. It has given the design profession a problem-solving aspect and a fundamental role in creating more durable and resistant design solutions. This paper examines the concept of durability in the area of identity design and consequently the sustainable design of an identity, within a recent shift towards generative grammar. The theoretical framework questions the possibilities, which the generative grammar has to offer, to a responsive identity design able to bend as a feature of sustainability. The literature on identity and design will be reviewed to develop a framework of analysis through multiple case studies. The results of the study will serve as a guiding model for the identity design process to create brandmarks that embrace time and overcome durability constraints.

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Key words: Identity – Redesign – Evolution – Durability – Resistance

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BRAND IDENTITY DESIGN AND RE-DESIGN BETWEEN RESILIENCE AND RESISTANCE:
Identity, sustainable identity design and the role of generative grammar

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ABSTRACT

Sustainability is a term that has widely affected the design industry over the last two decades. It has given the design profession an ethical role in creating more durable and resistant design solutions. Out of this responsibility, this paper questions the position of a timeless identity design between durability and resilience within a recent shift towards generative grammar. An interdisciplinary pattern-matching logic will be conducted to review the literature on sustainability, identity and design in order to develop a theoretical framework. This qualitative approach will be supported by multiple identity design case studies analysis. The resulting analytical framework will serve as a guiding model towards a more sustainable approach in identity design.

I- INTRODUCTION

Identity design is a process of decoding information from a design brief, and compressing them into a form, based on various design principles. The challenge and objective in every identity designed is not merely in fulfilling this step but also in creating an identity that endures. Durability is the ability of a brandmark to stand the test of time. Strategically speaking, a brand maintaining the same identity design reflects stability but sometimes a risky state of non-openness: "Whether a business sees change as good or bad, change will certainly come. If a company's identity refuses to address business change, it becomes more and more irrelevant" (Fischel 2002: 9). On the other hand, while identity re-design echoes progress and success, the frequency of re-designs and the nuance between variation and repetition could also lead to consumers mistrust: "Changing logos is one of the first things brands do in their rebrands and is often the most criticized"[1] (Backer 2014: 4). Durable identity design has proven difficult because durability implies resistance, which is debatable when it comes to designing a subject in constant evolution - the identity of a brand - in an ever-changing context: time. Observing Gap case (Fig. 1) we see unjustifiable small-time intervals between one redesign and the other where two re-designs were even done in the same year. Gap even went back confusingly to the same initial brandmark design three times.

Designers are at a decision-making position to provide sustainable solutions. Re-design has proven to offer a temporary solution. Whether the reasons are economic or a changing cycle in fashion, when the precursor design with all its applications are in fact replaced by the new design, the results are unsustainable. In a mass consumption era where things are frequently intentionally

[1] https://www.marketingweek.com/2014/09/10/whats-in-a-logo/

designed to break, are identities also deliberately designed to be replaced after a while? Can we talk of a planned obsolescence in identity design? This comes to further highlight the experimental aspect of the design process at a time where designers struggle to minimize the trial-and-error trait of their activity like never before.

Fig. 1: Gap logo variations



Source: http://logowi.com/english/wp-content/uploads/2012/12/gap_0.jpg

Out of this background and problematic issue, the research will answer the following questions:

1- Is the concept of durability as a component of sustainability applicable to identity design?
2- How do designers, control and monitor the right balance between variation and repetition?
3- Can generative design give insights to prevent the image/logo from redundancy or be another trend?

Case studies of logos that entered the loop of re-design, in comparison to logos that have been designed following generative design methods will lead to the theoretical replication. Prior to that, it is necessary to develop a theoretical platform by reviewing literature on sustainability, identity and design. As such, this paper studies sustainability in relation to the two constructs: identity as the subject of representation, and design as the method of representation. An interdisciplinary pattern-matching logic within the literature will provide a set of units of analysis from the theoretical framework to enable the cases analysis.

II- LITERATURE REVIEW

2.1. Problematic issue

We live in a hyper-disposable world. When we think of sustainability as users, resistant and enduring material first come to our minds as a way to minimizing waste caused by maintenance and sometimes by re-design. Resistance, robustness and endurance can in some cases spare sustainability problems where physical quantifiable material is used. Yet, are these features scalable to the area of identity design? As David Pavitt (2000) puts it: “Nearly every company mark ever designed evolved into its finished form” (Wheeler 2009: 11). When we observe sustainability as designers, we see brand re-designs literally stop using any application featuring their old identity. Shell’s 1999 most recent re-design (Fig. 2) is a suitable case. The 1995 design barely resisted for four years. What makes it even more critical, is the minor and unjustifiable visual uplift from the 1995 version; an uplift that most users, whom are eventually the target audience, won’t even notice. In Taleb’s words, it is “distinction without a difference” (Taleb, 2007: 320). It makes us wonder if it was worth all the waste produced by the myriad of design applications on trucks, signages, uniforms, collaterals and many other marketing materials, including manufacturing, packaging, transportation and distribution.

Fig. 2: Shell Logo evolution



Source: https://www.shell.fr/about-us/the-shell-brand.html

On another level, contextual pressures like design trends as well as technological advances play a major role in brands wanting to undertake an identity re-design, with the aim to modernize, manage change, reposition or promote growth (Fishel 2002). When producing an identity design for a certain brand, many

variations of the same sketch are produced by the designer. Out of the pool of these different variations, only one output is selected while all the similar ones are dropped. Looking at the Shell example again, we can "visually" come to the conclusion that, if the same brand asked for a design uplift 10 years later, it is reasonable to take from that same pool another variation and develop it. Yet, would that be ethical? What if the redesign job was requested from a different design group?

Many designers agree that all clients do ask for a timeless identity which stands the test of time. This call for resistance is also witnessed with design practitioners, like Ivan Chermayyef (2000) who claims that a trademark should last beyond the fashion of the time. Furthermore, Alina Wheeler (2009) recommends durability in identity design: "Unlike advertising, which launches a new campaign each year, brand identity needs to endure". On the other hand, Catharine M. Fishel (2002) argues that a re-design of an identity is that of an inevitable contextual change management: "An identity design should reflect the values and aims of a company as a whole, what drives it, what it believes in and why it exists. It is always evolving, growing, adapting to new circumstances" (Van Nes 2012: 6).

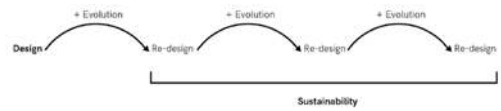
2.2. Sustainability is redesign

In fact, looking closer, we see that sustainability definition actually enfolds re-design as an evident feature: "sustainability of a system is not just its ability to stay the same, but rather its ability to flourish, which may involve changing, moving location, or evolving in form and function over time. It also means that there is no final state of sustainability, just moments of dynamic equilibrium (Erlhoff and Marshall 2008: 403). Accordingly, re-design must be regarded not as a threat or something to be avoided but as a typical evolution with respect to the context.

Re-design became a common term in 1978 with Alessandro Mendini, it described the designs referring "to a clearly defined design precursor" (Erlhoff 2008: 329-331). Part of linearity, the new design would inherit the traits and qualities of its parent design to avoid confusion. When we speak of evolution, each re-design is usually based on the design that directly precedes it on a timeline.

As for design, by definition, it is not required to "fulfill", as much as to "transform existing situations into preferred ones" (Erlhoff 2008: 109). Moreover, continuity must make part of the design as a creative force or else the company image will not be coherent and consistent: "it will never coalesce into a unified whole but will remain a mosaic of unrelated fragments" (Meggs, 1998: 375-377). Re-design is misinterpreted as a re-active process given a "corrective" role, especially because the designers may be creating another problem out of the suggested new solution. While in fact, it is a normal visual evolution: the different re-designs are a feature of sustainability (Fig.3). As such, the origin of the problematic issue is not in a redundant re-design itself but in miscalculation on the initial design's level in providing the solution which enables it to keep going and be sustained.

Fig. 3: Sustainable equation



Source: Authors

2.3. Insights from different solutions

According to modernist designer Paul Rand (1947) timelessness in identity design is key. Basic geometric shapes, namely circles, triangles and squares are the main components for a timeless logo as being the essence of all shapes (Fig. 4). For him, a logo "cannot survive unless it is designed with the utmost simplicity and restraint."[2]. He realized that reducing a brandmark to elementary shapes that are *universal*, visually *unique*, and stylistically timeless enable it to be aesthetically and technically functional over a long period of time (Meggs, 1998: 369). Yet, it makes us wonder how the brandscape will look like if all brands adopt the same trend. This implicates visual limitations to the creative output where brands cannot totally own their identity, as Charles Bukowski puts it saying that when everybody is the same, everybody is nobody.

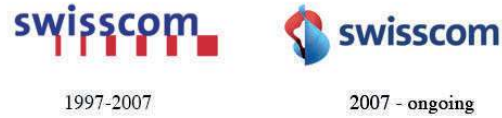
Fig. 4: Paul Rand logo designs: ABC (1962), IBM (1972) and Atlas Crankshaft Corporation (1964)



Source: https://stocklogos.com/topic/paul-rands-logos

In other cases, logos that have an illusion of dynamism are claimed to be a solution to a durable identity image. The redesign of Swisscom[3] (Fig. 5) expresses dynamism. This attempt to "bring life" to the logos naturally represented graphically the dynamism in the business of communication itself.

Fig. 5: Swisscom logo re-design



Source: [1] http://www.movingbrands.com/?category_name=swisscom-work

However, Irene Van Nes (2012) criticizes this approach stating that logos that express an illusion of movement in general are "nothing more than a moving version of a static logo" (Van Nes, 2012: 7).

Regardless the different solutions, one thing is for sure: Durability reflects a "static" aspect while dynamism reflects a "living" aspect, thus it is believed to be more engaging and adds an extension to the image shelve life. Contemporary brands are aiming for a living character. Between Rand and the illusion of dynamism, come examples of brands like Adidas. The sports brand logo actually consists of three monochrome parallel stripes. These are contrasted by a very elaborate visual language that enables the brand to possess the vibrant character evolving with every new collection. This character seldom makes us notice the static vibes of the geometric logo, needed for the corporate use. Yet, is this method generalizable on all kinds of businesses?

Christopher Alexander (1964) facing the same problematic of stability of form over time, draws the attention of designers to nature's creation process. He asks: "Given a set of forces, how can we generate a form which will be stable with respect to them?" (Arida 2004: 43). In an article entitled 'From a set of forces to form', he states: "All systems, whether they are individual human organisms, or

[2] http://design.uh.edu/~sechung/rand3/biography.html

[3] http://www.movingbrands.com/?category_name=swisscom-work

social systems, or mechanical systems, share the following property: when in certain states, they have inexorable tendencies to seek certain other states" (Alexander 1966: 96).

Alexander (in Arida 2004) and Marks (2012) differentiate between the traditional design process resulting in a dead decorative design, durable only because of a high level of resistance to the context, and the natural form as being in sync with context, thus it can never maintain the same state and be durable. Alexander shifts the problem towards the design process resulting in a misfit between the form and the context. He distinguishes "design" from 'form" where natural forms are always driven by natural forces whether they are interior (on the internal structural micro and genetic level) or exterior (on the environmental external macro level). Laura Marks (2012) states that these underlying causes can even be present as a sleeping force, in a "state of latency", waiting to be unfolded in a future time (Marks, 2012: 151-152). In our case where identity is in question, does the traditional identity design process takes the sleeping forces into consideration? Unless identity is held as a complex system as a starting point, Christopher Alexander's proposition would not be applicable. Identity is in fact assumed as a system only through the lens of generative design.

Van Nes (2012) compares Generative Design to a cooking recipe with ingredients A, B, C and D. Infinite combinations of the ingredients, give a different taste each time, but all belonging to the same "family" of tastes eventually. Generative design moves the design from the design level to the process level, enabling the form to perform the following:

1- Generate complexity
2- Self-maintain and self-repair
3- Generate novel structures, behaviors, outcomes or relationships (McCormack, Dorin, Innocent, 2004).

In other words, the formula provides a system, able to be designed and re-designed (sustained) creatively.

III- METHODOLOGY

3.1. The context

Van Nes (2012) sees the changes implied by the context as a kind of positive pressure by which a company is nurtured. Any design role was and still is to achieve the fit between form and context, based on the designer's conceptualization (Arida 2004). The attention of marketing shifted to experience and to an individual identification with the product as we moved to a mass-customized economy. Identification further highlights the importance of identity. Contextually speaking, I argue that the evolution of marketing towards this human-centered approach (Fig. 6) highly affected the way brands represent their identities (Neumeier, 2003).

Fig. 6: The evolution of marketing timeline / context



Source: Neumeier 2003: 38

"Assuming *history* is generated according to some logic, we only see only the *events*, never the *rules*, but need to *guess how it works*" (Taleb, 2007:58).

The citation reflects both the problematic issue as well as the method. "Guessing" shapes the process giving it a speculative aspect. The problem is re-purposed as not in re-design but in the initial design for not being given the faculty to evolve by the designer.

The method is defined as an interdisciplinary pattern matching process. It is a qualitative approach aiming at minimizing implicit models and

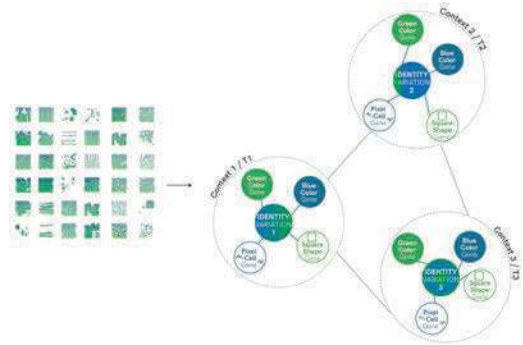
assumptions. Pattern matching involves drawing a link between a predicted pattern that is derived from the theoretical framework, and match it with an observed empirical pattern. The method helps the reader retrace backwards the thought processes of the research and t he way the latter reached the results (Sinkovics, 2018).

As such, I will proceed by noting and investigating the interdisciplinary links between different observations and resources: the rule revealed from the patterns, the decentralized model and identity as a complex system. The pattern-matching logic will result in a s et of units to be verified in the critical visual analysis of more cases: Contextualizing and juxtaposing case studies of logos that entered the loop of re-design, in comparison to logos that have been designed following generative design methods will lead to the generalizable theoretical insight on designing sustainable identities.

3.2. The decentralized model

Deconstructing the graphic identity of Max Plank (fig. 7), we can see a complex family of symbols from the initial brand's graphic genes generating a set of complex forms with respect to the context. Each form is unique, made of a different combination of the same genes, according to the context.

Fig. 7: Max Plank generative identity – deconstructed model



Source: Van Nes 2012: 185 (adjusted by authors)

Reaching out for a larger theoretical framework, we notice the juxtaposition between the Max Plank generative identity deconstructed model (fig. 7) and an older model: Back in 1960, Paul Baran tackled the problem of how to protect weak telephone communication systems if threatened by a nuclear attack: "He had imagined a way to break one message down into several "message blocks", route the separate pieces over different routes (telephone lines), and then re-assemble the whole at its destination." (Beranek, 2000: 63). Baran exposes the fragility of centralized systems built to be robust and resistant and highlighted the survivability of decentralized systems having the agency to bend (Fig. 8).

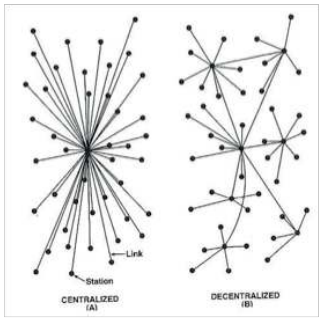
3.3. Identity

Years later, Deleuze (1980) followed the same logic using a biological term to describe identity as a complex system: The rhizome. It features structures formed by non-hierarchical entry and exit points in information interpretation and representation, which enables their survivability. In other words, again, the rhizome owes its resilience to its decentralized multiplicity. According to Deleuze, identity following the rhizome model presents history as an assemblage, a system of attractions with no precise beginning and no precise end; it is always in the middle, between things, an i nter-being rather than a b eing. Furthermore, this process takes the form of a

"becoming" through the synthesis of lines of flight where the concept of a Cartesian system and "predetermined plane with fixed coordinates" does not exist. On the other hand, identity in the traditional paradigm indicates "a same state".

If Deleuzian identity is decentralized, then, as per the above, it is sustainable. Consequently, if identity in the traditional paradigm is unsustainable, it is because it is centralized: in other words, it is designed to be resistant. When it becomes redundant, it is replaced from the center.

Fig. 8: Network models by Baran similar to the structure of a rhizome by Deleuze



Source: http://www.rand.org/about/history/baran.html (adjusted by authors)

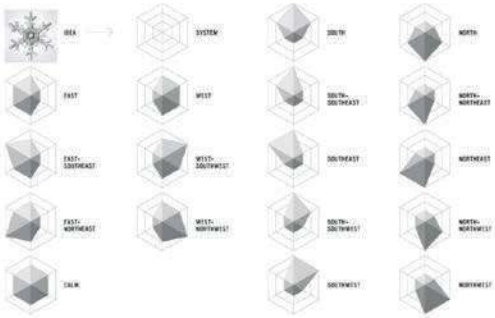
The table here below (Table 1) summarizes the theoretical framework on identity in the centralized model aiming for resistance as a means for sustainability and the decentralized model fostering resilience.

Table 1: Collected units of analysis

	CENTRALIZED MODEL >> RESISTANCE	DECENTRALIZED MODEL >> RESILIENCE
Being	x	
Becoming		x
Evolving		x
Discovered	x	
Constructed		x
Emergent		x
Fixed	x	
Ambivalent		x
Methodic		x
Force		x
Organic		x
Seeking other states		x
Saturated	x	
Assemblage		x
Single	x	
Fluid		x
Transforming		x
Moments of dynamic equilibrium		x
A mosaic of unrelated fragments	x	
Holistic		x
Open		x
A boundary	x	
Envision		x
Represent	x	
In Flux		x
In Chunks	x	
Individual		x
Relational / collective		x
Changing same		x
Points of temporary attachment		x
Stable	x	
Nomadic		x
Permanent	x	
Multiple identities	x	
Multiple aspects of the same identity		x
Wholes constructed from heterogeneous parts		x
Intersecting discourses		x
Organism		x
Complex		x
Rhizome		x
Hierarchy	x	
Transmute and reappear		x
Self-regulatory		x
Actualized	x	x
Decorative	x	
Processed		x
Ornamental		x
Infinite		x
Pattern	x	x
Linear	x	
Process		x
Output	x	

3.4. Generatrive identity case study

Fig. 9: Nordkyn identity



Source: https://neue.no/work/visit-nordkyn/

The units of analysis in table 1 will be used for the critical visual analysis of the current case study. Visually speaking, we observe a system of different forms representing Scandinavian Peninsula Nordkyn identity (Fig.9) obeying to the rhizomatic decentralized model. The components fluctuate around the same structure; one has to come back to the structure in order to grasp more variations. Despite the visual complexity presented, these entities constructed from heterogeneous parts seem to have an organized infrastructure, a *rule* able to deliver to the viewer a state of visual sameness, changing but still being recognizable. The form is fed by the weather data as the context, standing for temperature, humidity and the wind direction. The data are provided by the weather station thus they are accurate. The accuracy of the formula calibrates a correct dose of change between the different variations. The identity acting as one complex organism creates a whole generation with a self-regulatory aspect. A bifurcation of the different identity components within the context is able to generate identity facets that transmute and reappear in different forms. The forms that constitute the system are unpredictable yet they are framed by a clear structure.

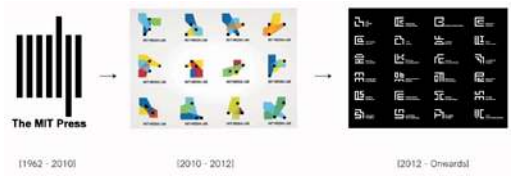
In order to grasp a full meaning and to have a sense of identification with the brand, one needs to see the whole set. Taking one facet of the identity will make it seem more like a trend, which will require a future need to re-design. However, what we see is a set of real-time identities, where one could easily have preceded or followed the other, even be repetitive, or even totally be removed without affecting the survivability and continuity of the system.

With all of the variations combined the many facets of the same identity combined feature resilience. This results in many choices that fluctuate and change from moment to moment expressing an ambivalent image of relationships, with no sense of hierarchy, just points of temporary attachment. Therefore, all of the visual manifestations of identity fulfill the theory of assemblage: assemblage within the different sub-identities and assemblage as form across context. Furthermore, the evolutionary pressures to change result in one cartography of becoming composed of invisible lines of flights (the weather data) and visible stations (the form) highlight force exercised on the form as the main reason for its creative transformation. The form is thus always in the middle, never individual but always relational and collective. It is between things, an inter-being rather than a being. Thus, no sense of a final and complete image is delivered to the viewer but rather an evolving construction, a multiplicity always in the middle. Identity design built on a decentralized model is sustainable.

3.5. MIT lab identity re-design[4]: Is decentralizing the concept enough?

[4] http://new.pentagram.com/2014/10/new-work-mit-media-lab/

Fig. 10: MIT identity evolution



Source: Adjusted by authors from different sources:
Source1: http://clipsuper.com/mit-press.html
Source2: Van Nes 2012: 153
Source 3: http://www.underconsideration.com/brandnew/archives/new_logo_and_identity_for_mit_media_lab_by_pentagram.php#.VwODZXDTY7A

For the occasion of the 25th anniversary of MIT, the brandmark was re-designed in 2010 following generative design method creating up to 40,000 permutations of the logo to suit the lab's ever-changing environment. However, only three years later, MIT expressed the need for something more stable. Bierut went back to Muriel Cooper's 1962 Bauhaus style logo. It was enduring; more than 50 years later MIT Press was still using it (Fig. 10). The initial logo was given the flexibility that the beam logos had established. "We wanted them all to feel like they went together," says Bierut[5]. "So someone who was looking at them would sense an underlying DNA that made them all part of a closely knit family." These "glyphs" are static, but you can easily imagine how they could be rearranged.

The MIT Lab identity case study is of a critical importance to this paper. The generatively designed beams shortly replaced show that decentralizing the design concept is not enough. It is important to make sure the evolution does not lead to a t otally different species. Building the form as a system on a solid structure is key.

[5] https://www.wired.com/2014/10/mit-media-lab-gets-transforming-logo-courtesy-pentagram/

3.6. Traditional identity re-design case

Fig. 11: Re-design examples within the contextual chronology



Source: Authors

In reference to Table 1, the traditional identity suggests that an object or subject remains the same as itself under different conditions through time. Looking more in the mechanistic direction, we find that it is based on an either/or identity rationale and it stresses the "one expression of reality". The classical notion of identity suggests that an i dentity is absolute, fixed and a boundary to be maintained. Identity as such becomes a finite product limited in time and space, designed to be permanent.

Placing the logos within the context of marketing evolution we first note that the graphic expression of the forces exercised by the context came in inexplicable chunks of time. However, the theory of a s ingle enduring identity is graphically contradicted by a c ontextual need to reposition, modernize, manage change or promote growth. Taking the case of Pepsi for example (Fig.11),

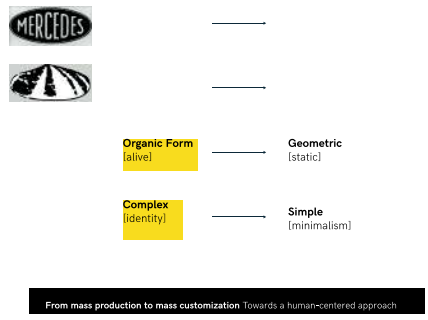
decentralizing its identity design would practically mean adopting all the past variations in the sequence as the current identity. The multiple aspect of the same identity would mean that all the variations, past present and future gathered make the identity of the brand. Yet, visually speaking, we see a misfit between the different permutations and a tendency to visually group the variations regardless the design precursor.

On form

"A complex domain is characterized by the following: there is a great degree of interdependence between its elements, both temporal (a variable depends on its past changes), horizontal (variables depend on one another), and diagonal (variable A depends on the past of variable B). As a result of this interdependence, mechanisms are subjected to positive, reinforcing feedback loops" (Taleb 2007: 358).

Complexity on this timeline is translated in an increased number of re-design operations and their frequency as the timeline evolves from the 1950s onwards: Smaller intervals are noticed between one re-design and the other, yet, the form is less from being complex.

Fig. 12: Observations between first design and most recent re-design



Source: Authors

Paradoxically, the timeline of redesigned logos has shown that the more we move forward in time, the more the logos are becoming minimal:

Observing this chronological pattern, and comparing the first logo to the most recent in each sequence, we could begin to build a claim that all the case studies head gradually to the same conditions:

1- From an individual identity to a universal identity
2- From a figurative image to a non-figurative image
3- From the form to the code that generates it
4- From complexity to simplification
5- From the organic to the geometric

This leads to the following formula:

Context + more re-design = less form = minimalism = structure

On context

Opposed to mass production, mass customization as a context is an act of sustainable development. It is a human-centered approach expressed by an individual approach. Only by reversing the pattern that mass customization can celebrate individuality and be expressed graphically through restoring the complexity of form organically (as highlighted in yellow in figure 12).

This is verifiable through the case of MIT (Fig. 11). The 1962 logo which constituted the structure for the generative brand evolution, visually fits with the recent variations dating 2000 onwards as they all are based on minimal geometric shapes, even though forty years separate them (Fig. 12). As such, no further extension of the brand is possible unless adopting the last version of the logo as the structure, and apply generative methods for future permutations.



Yet, if a 1960 logo can fit with a 2015 logo can we still be talking about trends? The case of MIT and all identities heading to geometrical form informs us that Rand recommendation for a durable logo actually is an expression of minimalism. It is relevant to the limited number of brand genes present on the structure level which will constitute the base of the future forms.

IV- Conclusion (answering the thesis questions)

Speculation shapes many of the cases of identity design and redesign which lack a scalable methodical approach. This results in temporary solutions. Sustainability in identity design is not an option; it is aligned with the design profession ethics. Brand identity re-design is not to be avoided or resisted but to be embraced. Durability as a component of sustainability is irrelevant to the area of identity design, and clients should be aware of that. Durability of form is neither achievable nor sustainable. Instead, durability of structure provides the base for a sustainable form that transcends the here and now.

Contextually speaking, alienating form from context is equivalent to freezing the form in time. Consequently, resistance becomes the only option for survivability. Resistance leads to no redesign and with time, to redundancy.

When designing an identity following the traditional design process, once the brand genes defined, decentralization as a design compression model constitutes a road map for the brand to keep the door open for evolution. For the model to achieve the above, identity should be embraced as a system regardless the business' level of dynamism. Creating the brand genes and putting them into a minimal structure will enable an open-ended system for future variations. The key is to design as if, one day, the identity might be generatively designed.

On the other hand, when redesigning an identity following the traditional design process, the designer should revert back to the structure and apply the decentralized model in order to make the form evolve while remaining consistent (same species), providing a justifiable evolution. Generative design and traditional identity design are not opposites. Generative design is not a trend, it is a universal thinking process and a mindset. It is also a re-design method that provides insight on how to ensure the right dose between variation and repetition in the traditional identity design. The key is to think generative and act traditional.

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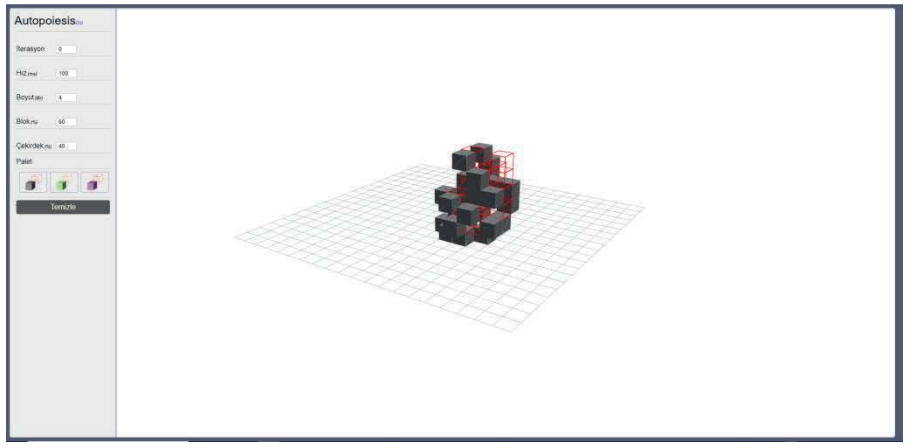


FORM GENERATOR AS AN ALTERNATIVE SOLUTION FOR ARCHITECTURAL LAYOUT

Topic: Art, Architecture, Design

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Abstract
Autopoiesis, the word meaning (auto-self, poiesis-production) is defined as a self-generating system. Maturana and Varela first put forward this concept via cognition perspective; human beings explained that he existed not by human understanding of the world but by creation. Maturana and Varela argued that with this concept, human reproduces his environment with his self-perspective and c reates his world by briefly producing self-perception [1]. To understand the concept of autopoiesis, we need examine the definition of poiesis. Poiesis is defined as 'making' through the concept of praxis in architectural practice. While praxis is defined as doing an action, poiesis is beyond that and defined as making by act of production. Poiesis can be defined as simple creation in terms of architecture. This includes all kinds of production and growth environment. Explosion of a flower in the highest sense is exemplified as poiesis [2]. Aristotle emphasis the form-matter relationship in his definition; the poiesis is the material to be included the the form transformed into reality [3]. During the development phase of the project, architectural and design problems were considered through the concept of autopoiesis, which was the starting point. In this context, the main objective was to evaluate a design pronoun and to try to solve this problem as a continuous and viable system. One of the most important and fundamental problems among architectural problems is to define the form and mass design. We aim to develop Form Generator system with intend to offer a solution to form definition problem in architectural design process.



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Key words: form finding, generative architecture, autopoiesis, autopoietic systems.

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Form Generator as an Alternative Solution for Architectural Layout

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Abstract

This paper introduces a tool called “Form Generator” and its implementation in the context of generative architecture. Form Generator is a s oftware tool that generates spaces for form finding of architectural purposes. The study is based on the concept of autopoiesis which means self-production. Architectural design explores a solution to the initial stage of form finding and form placement. In addition, form finding has crucial importance both in professional and academic practices of architecture, which is extensively carried. This study aims to offer alternative approach exploring generative systems. The used generative systems are genetic algorithms and shape grammars, associated with autopoiesis. As final product, we develop Form Generator tool that assist form finding with rule-based system.

1. Concept of Form Generator

Autopoiesis, the word meaning (auto-self, poiesis-production) is defined as a s elf-generating system. Maturana and Varela first put forward this concept via cognition perspective; human beings explained that he existed not by human understanding of the world but by creation. Maturana and Varela argued that with this concept, human reproduces his environment with his self-perspective and creates his world by briefly producing self-perception [1].

1.1 Poiesis; beyond praxis

To understand the concept of autopoiesis, we need examine the definition of poiesis. Poiesis is defined as ‘making’ through the concept of praxis in architectural practice. While praxis is defined as doing an action, poiesis is beyond that and def ined as making by act of production. Poiesis can be defined as simple creation in terms of architecture. This includes all kinds of production and growth environment.

Explosion of a flower in the highest sense is exemplified as poiesis [2]. Aristotle emphasis the form-matter relationship in his definition; the poiesis is the material to be included the the form transformed into reality [3]. Maturana and Varela explain that autopoiesis is a cognitive system and describes the cognitive system as living systems, and describe autopoietic systems as an existing structure from the units of cognitive operations. These units provide continuity with interaction and reproduction in a self-directed circular life organization [4].

1.2 Machines and living machines

The machine is a set of combined structures to transform any kind of energy into another energy, to perform specific task, or to create an effect. It contains many systems as well as visible structures. However, although living systems consist of many structures, the point or regional block structures are difficult to see. Another difference is that machines are produced by people through thoughtful, spoken criteria; living machines do not contain constraints due to their existence. [5].

Diniz and Turner compared poietic machines and autopoietic machines (Table 1) when evaluating their 'living wall' study based on the concept of autopoiesis. As Table 1 exhibits, there are many differences in autopoietic machines such as specificity, modularity, and functioning [6].

Autopoiesis Formal Aspects		Autopoietic machines– "self-producing machines"		"The Life of a Wall"– "producing machines"
Autonomy	Yes	Autonomous, they subordinate all changes to the maintenance of their organization.	Yes	Autonomous as an organization to respond to the "world."
Individuality	Yes	Individuality, keep their organization invariant	No	Identity is dependent on the interactions with observer.
Unity /Boundaries	Yes	Self produced boundary	No	Collectively produced (boundaries defined by the observers)
Inputs/Outputs	No	Do not have inputs/outputs	Yes	Inputs/outputs
Purposes/Goals	No	Purposeless Systems	Yes	Goal oriented system
Reproduction	Yes	Reproduction by copy	No	Reconfiguration, amorphous
Evolution	Yes	Evolution between systems	Yes	Evolutionary orientation
Positive/Negative Tendencies				
		Predictable		Unpredictable
		Homeostatic–all feedback is internal to them		Dynamic balance
		Efficient		Adaptable
		Rigid		Flexible
		Growth		Evolutionary
		Central control		Central control
		Require constancy		Open to change
		External Structural Coupling		Internal/External Structural coupling
		Linear Narrative		Non-linear narratives

Table 1. *Comparison of poietic machines and autopoietic machines [6].*

The relations between machines and living systems are also considered in advanced architectural approaches. Recently, the theory of evolution and morphogenesis have provided a long source of inspiration. The simulation of different parametric scenario has adopted widely in computational design instead of genetic code. Hensel, Menges and Weinstock began to investigate this to reveal the differences between self-organization principles, tectonic and thermodynamic systems, even eco-systems and nature and machine production, and the "emerging" properties in life and calculation [7].

2. Methods

2.1 Genetic Algorithms

The genetic algorithm was inspired by Darwinian natural selection in his theory of evolution. Optimization is used in many different disciplines such as machine learning [8]. Genetic Algorithm has been developed for problem solving and optimization where the criteria for solving the problem can be clearly stated.

There are three basic steps in the process of Genetic Algorithm (Figure 1);

Selection of components by criteria,

Crossover to produce new components,

Random mutation of new components.

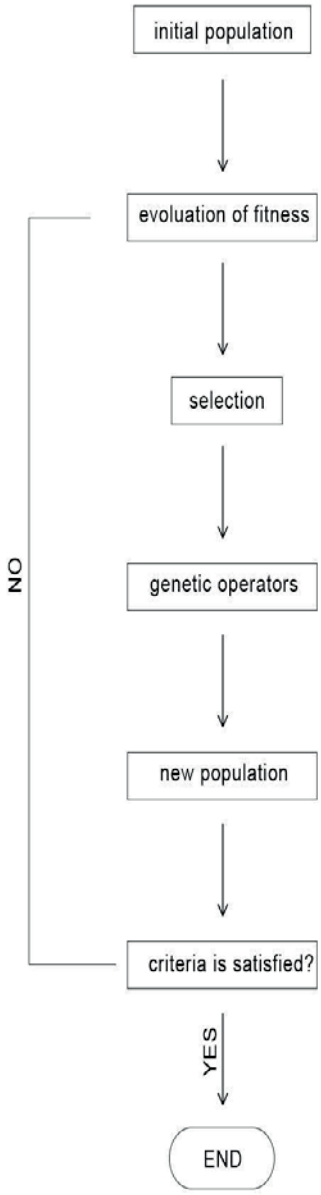


Figure 1. *Simple Genetic Algorithm flow chart.*

Genetic algorithm has been widely used for problem solving in architecture since it is a hi ghly evolutionary and a daptable search procedure that offers various possibilities for architectural evolution and optimization. The design process is described as an undefined problem. Even if the design is coded by designers, this coding will not be s ufficient to guarantee an effective and s uccessful design result due to its undefined structure. Genetic Algorithm as an optimization tool can produce a wide variety of possible solutions through crossover and m utation processes. Genetic Algorithm is a self-developed computational method and can find universal solutions [10].

In Jones's GA (Figure 2), he selected lighting, heating and functional criteria [11].

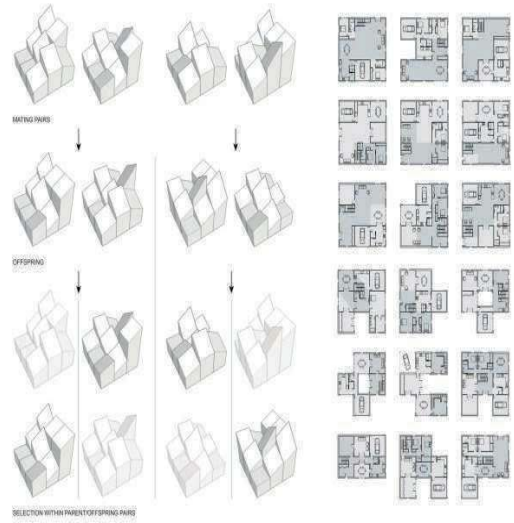


Figure 2. *An example of Nathaniel Louis Jones using Genetic Algorithms [11].*

2.2 Shape Grammars

As an another generative system, Shape Grammar formalism was introduced by George Stiny and James Gips in the early

70s. The linguistic metaphor that permeates form grammar is the basis of Noam Chomsky's work on productive and transformational grammars in linguistics. Their function is to determine design classes with an algorithmic understanding of the processes that make them up.

Shape Grammar consists of the vocabulary of shapes (labelled or unlabelled), a set of shape rules, and a first shape. Rules are presented as transforming shapes or shapes into a new shape or collection of a collection. The first number rules applied with attribute produce designs that are said to belong to a language [12].

3. Form Generator

3.1. Project motivation and purpose

During the development phase of the project, architectural and design problems were considered through the concept of autopoiesis, which was the starting point. In this context, the main objective was to evaluate a design pronoun and to try to solve this problem as a continuous and viable system. One of the most important and fundamental problems among architectural problems is to define the form and mass design. We aim to develop Form Generator system with intend to offer a solution to form definition problem in architectural design process.

3.2. Base shape | square

The initial project process started with a basic form that was formed by thinking about how we would produce a two-dimensional system (Figure 3). At this point, mass production was evaluated in the architectural plan level. The idea of the system, which is produced in two dimensions, can be transformed into a space fiction that meets the architectural requirements has been tried. In this method, the random shape of two points chosen by Genetic Algorithm from the four corner points of the square, which is a fundamental shape, is again provided to realize a random growth (x is defined growth variable by Genetic Algorithm). Due to the undefined and insufficient areas, the desired results could not be obtained. In this method, the random shape is selected by Genetic Algorithm from the four side points of the square which is the base shape and it is ensured that it achieves a random growth again. However, the undefined and i nadequate areas, the desired result is not produced.

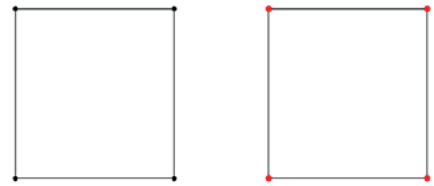


Figure 3. *Base shape, square.*

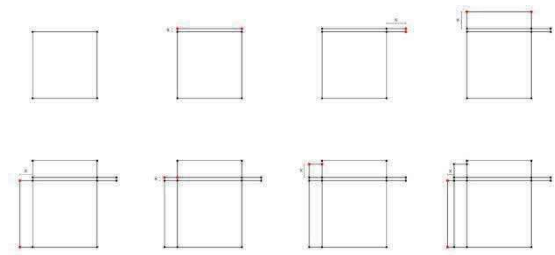


Figure 4. *Base shape, square (growth).*

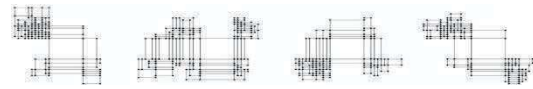


Figure 5. *Alternatives resulting from growth.*

3.3. Base shape | cube

In the second step of the project, the used method was diversified to achieve more effective results and dimensional constraints were introduced to produce meaningful gaps. First, a pl ane was created to define a certain boundary in the WebGL environment.

Secondly, the cube, which was formed as a unit, was chosen as the first shape to define the meaningful area that would meet the spatial requirements and to invert the growth into 3 dimensions. The process is illustrated in Figure 6.

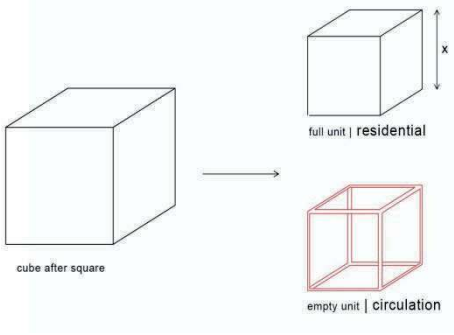


Figure 6. *Base shape, cube.*

At this stage of the project, a growing form of mass design environment has been created with the interaction of the user. In further stages, it will be t ried to achieve growth through certain rules. At this stage, we assume that define the growth rules with Shape Grammars and diversification with Genetic Algorithms (Figure 7).

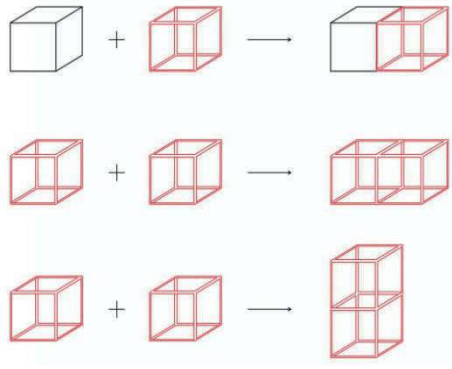


Figure 7. *Neighbourhood rules according to Shape Grammar.*

The application was implemented using HTML, a script-based language. The interaction with the user and the graphic program on the canvas element were performed using the JavaScript language. The user interaction is achieved with an interactive web-based interface (Figure 8).

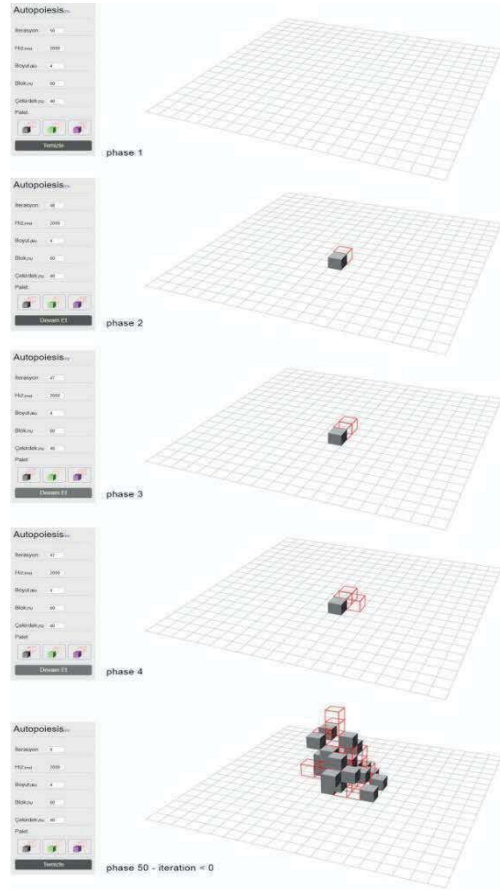


Figure 8. *Iteration phases.*

The interface depends on parameters, which are described below:

• *Iteration:* Refers to the number of repetitions of the algorithm. In other words, the result indicates how many unit elements the product will consist of.

• *Speed:* Specifies the interval at which each iteration repeats.

• *Dimension:* refers to the unit of squares in the plane placed on the three-dimensional plane. Also, the dimensions of the cubes are expressed by the value here.

• *Block:* Specifies the percentage of the block to be produced.

• *Core:* Specifies what percentage of the structure to be produced will be the core.

• *Palette:* The surface colors of the blocks and cores to be produced are presented to the server as three different options.

After the user sets the parameters, the production process starts through clicking on any point on the improvement on the created stage. First, a core element is placed at the point specified by the user. This element is also added to a globally accessible array. Then the direction of the unit element to add is selected randomly. If this direction is relative to the y-axis according to the coordinate system, the new element is determined as the core. Once the type, direction, and axis of the element to be added are determined, the element is placed on the stage with the appropriate coordinates. If the new unit element is the core, it is placed in the global selection array. For following iterations, the random element selection is made by looking at this series. These operations continue until the number of iterations entered by the user. The flowchart of the algorithm is shown in the Figure 9.

4. Results and Discussion

The precise spatial expression of the cube has been effective in the selection of the unit to be reproduced. The growth of the application over a certain volume, such as cubes, has already fed the expression of spatial in terms of architecture. With the size variable added to the interface, that effect has become manageable. The situation has helped to evaluate the outcomes. Thus, the core and settlement unit, which contains some architectural features, can reproduce an architectural meaning by defined rules. The outcomes with this ratio have not been effective enough but promising for the architects.

Several alternatives are developed using this tool (Figure 10). Many design approaches and models have been used within the scope of the project. Along with these, a promising Form Generator application has emerged. Since the tool was designed for the production of an architectural form, it was expected to meet some spatial requirements. These are the necessities of creating functional areas suitable for the user and providing the necessary structural features as in all architectural buildings. Although it does not yet meet the spatial requirements, the tool is promising for architectural use. On the other hand, the biggest deficiency of its insufficient nature is Form Generator is non-contextual reproduction. When an architect designs a building, it not only designs the interior of the building, but also the interaction with the outside. In the application, the environment is not yet seen and design cannot be influenced by this. Also, it has added a manual intervention feature to the produced form. Thus, the designer can apply a reduction to the resulting product. With such features that can be added, the application has the potential to be used in architectural design with alternatives offered by a productive system design to the designer.

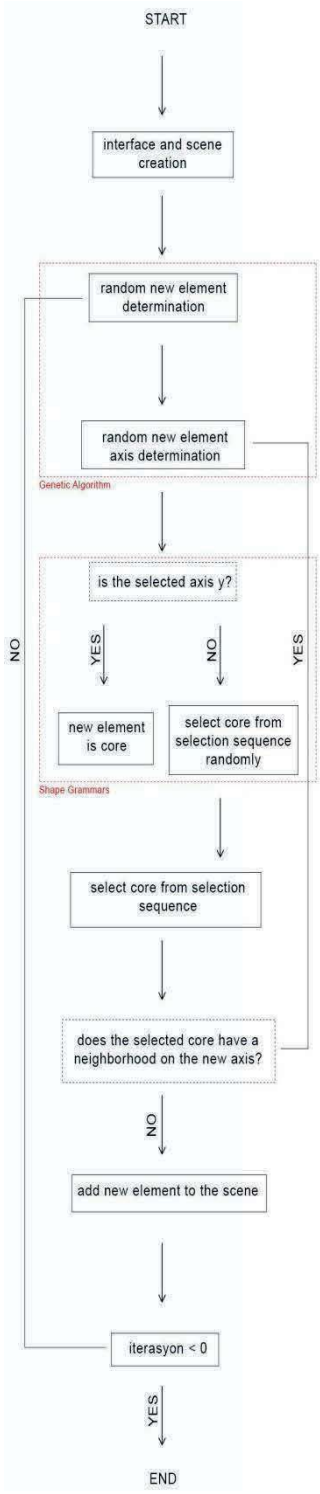


Figure 9. *Application algorithm flow chart.*

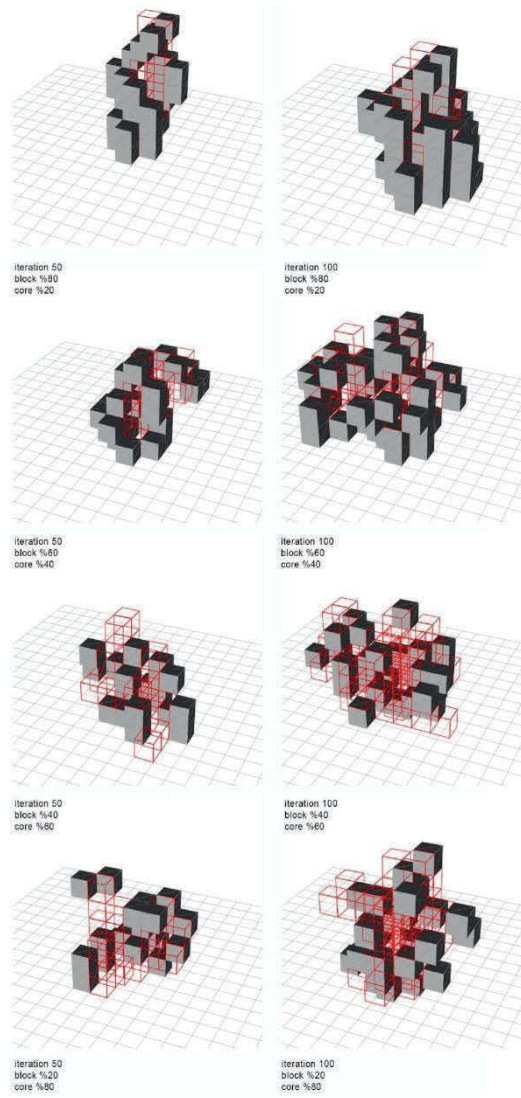


Figure 10. *Alternatives resulting from growth with different parameters*

Future Works

Form finding has always been an important step in architectural design. In application, the major compelling point is

to produce the form in space without knowledge of environment around it. So that next step of the project would try to achieve solutions to its non-contextual outcome.

Acknowledgement

We would like to specially thank Prof. Dr. Gülen Çağdaş. The early phase of this study conducted as a part of Generative Systems in Architectural Design, instructed by her, which is an Architectural Design Computing Graduate Program course in Istanbul Technical University. We would like to take this occasion to thank Prof. Dr. Leman Figen Gül for supports as our supervisor.

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TITLE
Manifold Compositions and the Evolving Entity

Topic: Music Composition

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Abstract

Based on the "class of composition" concept, exemplified by the aleatoric compositions of Stockhausen [1], Boulez [2] and others and discussed by Umberto Eco [3], a manifold composition is an equivalence class produced by a computer. Due to the randomness included at different levels of the structure, multiple variants of the same work can be produced simply by changing the seed of the random numbers generator. Such multiple variants have the same structure and are the result of the exact same process but differ in the way individual events are configured and distributed in time. Similar to faces in a crowd, they all share common features but exhibit particular attributes.

DISSCO, a Digital Instrument for Sound Synthesis and Composition, insures a seamless approach to composition and sound design. An integrated environment, DISSCO is the software used to generate manifold compositions. It is comprehensive in the sense that it does not allow the user to intervene once the run begins, a "black box" set of instructions necessary in order to preserve the integrity of the process: intervening would amount to the alteration of the data or of the logic embedded in the software.

A number of such manifold compositions have been produced so far and the next step is to allow the computations to continue for an arbitrary amount of time after a variant is generated. The result, a work in perpetual transformation, never reaching equilibrium, a complex structure whose components permanently fluctuate and adjust to each others modifications, could be considered an Evolving Entity, an Emerging Composition. It involves a large number of iterations and the user could decide to take "samples" and see what a particular variant looks at a given time and listen to it. The Evolving Entity composition model is closer to how humans actually create, continually refining the output.

Another way of describing the project is to consider a musical work as a Complex Dynamic System akin in many ways with the Morphogenetic approach of Aurel Stroe [4]. In the present case, the evolution of this Artificial Life-like Entity is directed through the use of Information Theory tools and Birkhoff's concept of Aesthtic Measure [5].

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Key words: randomness. composition classes, complex dynamic systems

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Manifold Compositions and the Evolving Entity

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1. Introduction

Frozen approximations of actual music, musical scores are also sets of instructions that can generate a multitude of aural renditions. Unlike deterministic computer programs whose outputs are the same every time, the score is an engenderer of human interpretations. Even distinct renditions of a musical work by the same performer will be slightly different on separate circumstances but the variance will be barely perceptible, if at all recognizable. However, performances of the same work by two individuals will display divergences that attentive listeners will be able to detect. By the same token, jazz musicians improvising on the same tune will produce different outcomes on separate occasions.

At a higher level, it is easy to observe that there are not two Bach fugues or Mozart sonatas with the exact same architecture although, within each category, they share some fundamental structural characteristics. During each historical period musical "forms" like fugue, sonata, variations, etc. have been used to compose myriad works belonging to such categories. Only that these "forms" are not stagnant, vapid schemes, but malleable matrices begetting discrete entities - at least in the hands of decent composers.

2. Open works, aleatory music and composition classes

In the late 1950s, a series of works had appeared in which the performer was asked to contribute to either the "form" or to details of these aleatory compositions. In the definition of Werner Meyer-Eppler, an aleatory (*Aleatorik*, a noun in German) process "is determined in general but depends on chance in details" [1]. Aleatory pieces are based on a shared structure and each outcome is an actualization, controlled by the performer, of a potential offered by the composer. As an example, Karlheinz Stockhausen's *Klavierstücke XI* [2] contains nineteen fragments rigorously written in their details that the pianist is asked to perform in any order; the piece ends when a fragment is played for the third time. It can be compared to Alexander Calder mobile sculptures since like them all possible arrangements of the parts are equally acceptable. Writing about it and about similar pieces in his seminal *Opera Aperta* (later the first chapter of *The Role of the Reader*), Umberto Eco quotes Henri Pousseur who describes one of his works: "*Scambi* is not so much a musical composition as a field of possibilities, an explicit invitation to exercise choice" [3].

Plus-minus, also by Stockhausen, goes one step further [4]. In it, seven pages of symbols and seven pages of musical materials (vertical aggregates and secondary ornaments) may form pairs

containing one page from each category. Neither the number of performers nor the instrumentation are specified and not all the pages have to be used. The work is a process during which materials are accumulated or depleted and when their numbers become negative, non-pitched events are introduced. *Plus-minus* is an elaborate and strict structure leading to a unlimited number of possible realizations.

Similar although less stringent or complex processes are spawned by graphic scores, based on drawings or other visual means, text compositions (Textkomposition) or even conceptual music exploits. The appellation *composition classes* characterizes all of them: equivalence classes which contain multiple versions realized according to an abstract template. Each of them is a set or a class of congruent virtual incarnations of a meta-musical archetype. A famous literary attempt, Stéphane Mallarmé's *Le <<livre>>* [5], suggests an analogous project.

3. Manifold compositions

A subset of the composition class category, a *manifold composition* comprises all actual and potential variants of a musical work generated by a computer that

1. runs a program containing elements of indeterminacy
2. reads essentially the same data for each variant

A unlimited number of works belonging to the same equivalence class can be produced in this way. The members of a *manifold composition* are variants of the same piece; they share the same structure, pitch, rhythmic materials, amplitudes, spectra, etc. and are the result of the same process, but differ in the way specific events and diverse sound characteristics are distributed in time. Like faces in a crowd, they all have common basic features but exhibit particular attributes due to the fact that different seeds for the random number generator result in different outputs. They are somewhat similar to the serigraphs produced by a visual artist, or to Andy Warhol *Campbell's Soup Can* series [6], except that individual members of the manifold could be even more distinct from one another.

Attempts at employing computers to engender families of works are exemplified by three notable early undertakings due to Iannis Xenakis, Gotfried Michael Koenig and Lejaren Hiller. The ST family of pieces composed by Xenakis were generate in early 1960s with his *Free Stochastic Music* program written in FORTRAN and running on an IBM 7090. They include works for string quartet (ST/4), chamber ensembles (ST/10) and orchestra (ST/48). Koening's *Segmente*, for small chamber ensembles were composed using his *Project 1* and *2* algorithmic composition programs in between 1960s and 1980s along with other pieces. *Algorithms I* through *III* for larger ensembles and electronics, were written by Hiller in late 1960s with the MUSICOMP program using SCATRE and FORTRAN languages.

In the first two examples above, only one composition program was used to generate fragments of music (later re-arranged in the case of the ST series) but the input data was modified from piece to piece. Hiller employed two separate programs, one for the assisted-composition part and another one, written by Gary Grossman, for sound synthesis; the code was modified to deliver separate "versions" of each movement. By contrast, in the production of manifolds, composition and synthesis are combined in a uninterrupted operation, the input does not change from variant to variant and each version is generated in its entirety, without interruptions.

As previously mentioned, when elements of indeterminacy are included, random number generator seed changes results in new pieces. An persuasive situation ensues if some sections of the work are fixed, designed to remain unchanged while others are modified. In the following example, the A.N.L.-folds, a short manifold composition, three out of a total of eight sections remain basically the same in all versions: a beginning chord, its retrograde at the end, and a short jingle, the fourth section, in the middle. They are the unchanged pillars that anchor the other sections. The fifth section, a grainy sound mass type of texture, preserves its character every time but individual attacks and pitches are always different although this is difficult to recognize in the thick texture. The remaining sections, 2-3 and 6-7, emphasize, respectively, tremolo/vibrato and transients of frequency/amplitude. The density of the 2-3 group is lower than the density of the 6-7 group. They can switch places as far as their content goes but the density remains attached to the section number. The overall density of the piece may also vary between 200 and over 500 sounds.

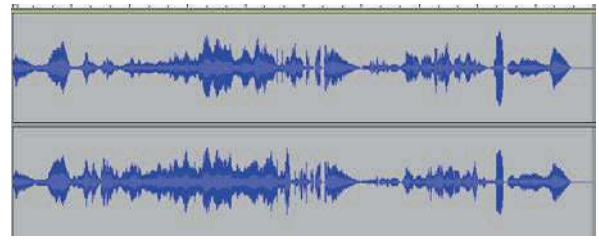
C	m	m	**C**	***G***	m	m	
H	o	o	**H**	***R***	o	o	**C**
O	b	b	**I**	***A***	b	b	**H**
R	i	i	**M**	***I***	i	i	**O**
D	l	l	**E**	***N***	l	l	**R**
	e	e		***Y***	e	e	**D**
1	2	3	4	5	6	7	8

table 1 A.N.L.-sections

figure 1. A.N.L.-folds variant



figure 2. Another A.N.L.-folds variant



Even in the case of the fixed sections (1, 4, and 8), minute details of each sound's makeup are bound to fluctuate with every rendering due to the indeterminacy present at all levels of both composition and sound synthesis. In spite of such differences, the outcomes are easily recognized as the **same piece** due to the permanence of the unchanging sections and to the general architecture of the work.

Manifold compositions represent an idiomatic way of using computers in music composition by mass producing unique versions of an archetype. It is stipulated that a version should not be performed in public more than once, thus stressing the ephemeral quality of any musical activity and preventing it to become a commodity.

4. DISSCO

A tool for generating manifolds, DISSCO, Digital Instrument for Composition and Sound Synthesis, represents a unified, seamless approach to composition and sound design. Written in C++, it consists of three main modules: CMOD, the composition module, LASS, a library for

additive sound synthesis and a graphic user interface, LASSIE.

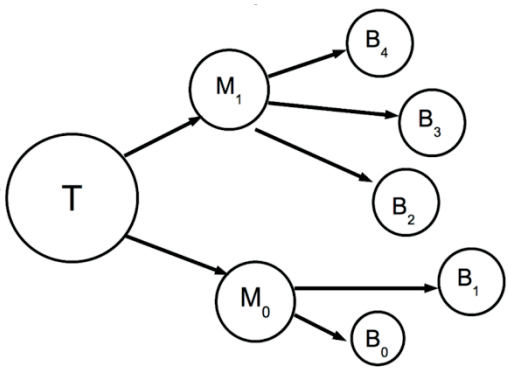


figure 3. DISSCO structure as a rooted directed graph. Only one intermediate level is shown.

CMOD events form a rooted directed graph, a tree structure, with the TOP event the entire piece, HIGH, MEDIUM and LOW events intermediate sections and subsections while individual sounds are built in the BOTTOM type sections. Like Russian dolls, each type may contain events of less structural importance. Parent-child relationships pervade this arrangement and all events have a start time, duration and type while the more complex BOTTOM events also assign frequency, loudness, AM, FM, transients, placement in space and reverberation to individual sounds.

A central premise in DISSCO is that the same kind of operations can be applied at different time scales from the entire piece, its sections and sounds, down to modifiers of frequency and amplitude (FM, AM) and to frequency itself. Such a hierarchy is based on "time intervals" of decreasing "magnitude", to paraphrase Stockhausen [7].

The UTILITIES class provides access to both deterministic and random procedures. First category contains ways to select precisely defined elements according to various choosing procedures, patterns or sieves. Sieves are logical filters, first introduced by Xenakis, that use modulo and Boolean operations to select items from a ordered continuum and serve to construct pitch scales or rhythmic templates. The second category includes random or stochastic distributions and Markov chains.

Like the programs of Hiller, Xenakis and Koenig, DISSCO is a comprehensive or autonomous software, that does not require or allow the intervention of the user once the computations have started. It delivers a final product which does not necessitates further adjustments. It is a “black box” meaning that it reads in the data provided by the user and outputs a finished object, the piece, in a uninterrupted process. This is necessary in order to preserve the integrity of the operation - modifying the results or intervening during the computations would amount to the alteration of the data or of the logic embedded in the software, i.e. a falsification of the experiment. It produces manifolds whose variants are equally valid: similar to the case of aleatory compositions or to Mallarmé's project, there is no room for prejudicial opinions. The result might be surprising but, if the logic and the code are correct, it has to be accepted. Or, as Herbert Brün once said about being surprised by the outcome: *"I didn't learn how to like my new piece yet"*. The difference between preferring "those events to happen that one wants to hear" vs. choosing "to hear those events one wishes would happen" [8] characterizes an experimental attitude which has aesthetic and political consequences - DISSCO along with the manifold undertaking share it.

5. Evolving Entity

Evolving Entity is an ongoing project that builds on the manifold concept and uses DISSCO. After a variant of the piece is produced, if the computations continue for

an arbitrary length of time without interrupting the initial sequence of random numbers, a time ordered array of equivalent but distinct pieces is created. The unbroken string of random numbers insures the enduring identity of an Entity which changes in time. Every so often the user may take samples to see and hear what the Entity (the piece) looks and sounds at a given moment.

Another possibility is to play back continuously the results and create an installation: akin to a fountain, it would have a stable configuration, always the same, but would exhibit new details every time. Depending on its complexity and on the length of time during which it would be displayed, a high performance computer might be needed to generate the music in real time.

The transformations taking place during iterations can be evaluated and controlled and the main tool used to insure that this is done as objectively as possible is Information Theory. *Shannon entropy* or the amount of **Information** in a discrete random variable is

$$H = -\sum p_i * \log_2 p_i \quad \text{for } i = 1 \text{ to } n \tag{1}$$

and

$$H_{max} = \log_2(n) \quad \text{for equiprobable cases}$$

The relative information, H_i / H_{max} corresponds to **Originality** in a piece of music and its counterpart, **Redundancy**, $1 - H_i / H_{max}$ is associated with banality. Other pairs such as periodic/aperiodic, informative/intelligible, unforeseeabble/foreseeable illustrate similar dichotomies [9].

In DISSCO, computations may involve up to two dozen sound parameters (degrees of freedom) whose values can be selected through random functions. It also supports the use of nested functions i.e. function parameters can be functions themselves. Calculating the entropy/information at each point where a random choice is available proves to be quite involved and Mote Carlo methods are used to estimate the probability distributions.
Evaluating Entity's metamorphosis during iterations also includes the Aesthetic Measure devised by George Birkhoff in the 1930s, another objective way to describe the experience [10].

$$M = \text{Order} / \text{Complexity} \tag{2}$$

While his theory was primarily notional, other mathematical interpretations of that idea have been proposed over the past few decades. For example, Bense propounded that the ideal aesthetic measure was the ratio between redundancy and information [11] while Machado and Cardoso claimed that it was a function of the ratio between Piece Complexity and Processing Complexity [12]. Although such algorithms were designed to be applied to visual art, similar designs can be applied to a computer music system as well. For this project, Order is interpreted as a ratio between the relative information delivered or the Originality of the message and its Redundancy while Complexity is defined as the number of possible choices (information entropy) together with the weighted number of methods used (hierarchical complexity).

$$H_i / H_m / (1 - H_i / H_m) * 1/n \text{ elements} + h_c \tag{3}$$

Another way of describing the project is to consider a musical work as a Complex Dynamic System akin in many ways to the Morphogenetic approach of Aurel Stroe [13]. Even uncomplicated compositions contain multiple competing or collaborating elements - pitch, rhythm, timbre, etc. - hence, a complex system. Morphogenetic music is a music in search

of self-identity and S troe uses the Catastrophe Theory developed by René Thom [14] to produce a music where processes and materials that are incommensurable coexist. I t is a m usic seeking its own form.

DISSCO uses an E volutionary Algorithm to model the human composition workflow, with the Aesthetic Measure acting as the fitness function. It deals with a piece of music in a state of flux, which changes its structure and sound attributes in order to maintain or approach a parameterized destination. When these changes are driven using Information Theory and Birkhoff's concepts, this model closely resembles the Create-Analyze-Modify workflow cycle of human music composition.

Controlling the evolution of the Entity-piece could also be tied to the fundamental architecture of the work, to its number of vertices and edges. In that case, the complete di rected graph is established before the computations start but only a r estricted number of vertices and their connected edges are used in the beginning Then, their number is gradually increased allowing the Entity to grow to maturity. This is followed by a r eversal: the tree is "pruned" and let die thus simulating the existence of a l iving thing. The full, mature tree is constantly in the background, a s ort of DNA of the composition, not always fully actualized. It determines the evolution of this Artificial Life-like Entity which is directed through the use of Information Theory and of the Aesthtic Measure.

It would seem that both by predetermining a value (constant or fluctuating) for Birkhoff's Measure, by foreordaining the growth and decay of the rooted graph tree and by continually evaluating the adherence to these objectives as they are reflected in the smallest details, a go al oriented course of action is set in motion. However, the process maybe derailed at any moment due to the randomness present at every step and controlling it means to maintain a pr ecarious equilibrium between competing tendencies, a volatile, temporary balance and NOT a search for a stable, optimal solution. Li ke Sisyphus pushing a rock uphill only to have it fall down again and again, the Evolving Entity's renewal is an incessant struggle.

6. Conclusion: a world view

The Evolving Entity composition model is closer to the way humans actually compose: continuously refining the output through trial and error. It also reflects the natural world by creating the equivalent of a living organism which grows, develops, and transforms itself over time fulfilling thus the goal expressed by John Cage: “ to imitate nature in its mode of operation”. In the process, the role of the composer is changed from artisan - making distinctive objects in small quantities - to that of a *Demiourgos* who creates from scratch multiple Artificial Life-like Entities over which, however, it does not have immediate control.

These Entities belong to a w orld in which probability plays a m ajor role but also a world anchored in deep and stable structures. The hierarchical tree architecture of DISSCO provides a s olid template which spawns successive actualization. Together with the use of deterministic tools such as sieves and patterns, it constitute a base for accidental happenings which are governed at the detail level by probability functions. Yet, such random occurrences may exist only within the confines of the larger structure which is driven by causality. The parallel world of Evolving Entities becomes a partial reflection of the real world as it is described by science: ruled by indeterminacy at the particle level while large bodies obey the laws of classical mechanics. In the same way that chance

happenings can not contradict the laws of Physics, the random mutations occurring during iterations can not be at variance with Entity's predetermined features.

In a pr oject like the Evolving Entity, the play between determinism and indeterminacy, universal laws and hazard, or among destiny and free will can also be seen as the interaction between Being (sets, modulo and B oolean operations) and Becoming (random distributions, entropy/information). Using musical terms, one can also talk about static or “outside time” structures (directed graph, scales, meter, textures) and the dynamic, “in-time” realization of a piece driven by probability - to use the terminology employed by Xenakis in his "Formalized Music" [15].

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GENERATIVE TRANSFORMATION OF LATVIAN URBAN SPACE: "BLUE" AND "GREEN" STRUCTURES IN THE PLANNING AND THE LANDSCAPE OF CITIES' HISTORICAL CENTRES

Topic: Architecture

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Abstract:
The first towns in the territory of Latvia were founded in the 14th century, when strangers conquered land and bui lt fortresses along waterways and ear th roads in places that provided protection. Now the construction of former urban structures created in the natural environment and the network of ancient streets determine the landscape and artistic expression of historical centers in Latvian cities, whose functional and economic potential has changed in the course of time. A completely different social environment and artistic values have been created, and historic centers of cities are being reconstructed. In order to preserve old urban structures created in the natural environment, new natural and decorative elements are included in space of cities' historical centers. In the process of urban transformation, a creative and generative approach allows the preservation of the identity of the historical environment, even complemented by "blue" and "green" structures.



Dobele castle ruins promenade



The River Driksa promenade in the city of Jelgava

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Key words: artistic expression, city's historical centre, identity, natural environment, urban transformation

Main References:

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Generative Transformation of Latvian Urban Space: "Blue" and "Green" Structures in the Planning and Landscapes of Cities' Historical Centres

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Introduction

Structures built in the natural environment by people and the network of ancient streets created over many generations and centuries determine the urban space and artistic expression of historical centres in Latvian cities, whose functional and economic potential has changed in the course of time. These are landscapes that characterized by people's preceptions today, as well as landscapes which have already disappeared. However, there are landscapes of the imagination, memory landscapes. These are, also every person's individual feelings, notions, thoughts, memories, and knowledge. The landscape has three cultural dimensions: the landscape's character determines how the particular territory is preserved by an individual or the community, the landscape provides evidence of former and existing relationships between individuals and their environment, and the landscape helps to create local culture, options, habits, beliefs and traditions. The cultural landscape is not just the condition of some landscape of buildings and its look, but rather the interweaving of various relationships realized ower time with human input. The mutual connection between the concepts used, "landscape" and "cultural landscape", is quite strong, except for those cases when only the aesthetic qualities of a place are being highlighted by the word "landscape", or it is being used in the sence of the background surrounding some individual object. A slightly different view of urban landscape is developing in the heritage context. Landscape is revealed in two dimensions. One – as the result of a long-term creation process, namely, today's landscape as a territorial representation. The second is the time dimension, which is more difficult to perceive, it is not based on particular year dates, but on the course of history and events, which, in one way or another, influenced the process of the town development, leaving behind its signs. Therefore, visible and also invisible landscape reflects time, the lives of people over many generations [**13**]. A completely different social environment and artistic values have been created, and historic centers of cities are being reconstructed. In the urban transformation process, in order to preserve old urban structures created in the natural environment, new natural and decorative elements are included in space of cities' historical centers. A creative and generative approach allows the preservation of the identity of the historical environment, even complemented by "blue" and "green" structures.

1. The first urban structures and man-made greenery in Latvian natural environment

In Europe of the 12th century, German merchants started to monitor traffic on important waterways in rivers and seas and earth highways. The Germans expanded the impact in the Baltic Sea region to spread Christianity under the leadership of the Pope of Rome and the Holy Roman Emperor. Around 1200, merchants arrived at the local people Liivs-inhabited Baltic Sea coast to monitor the highway of the Daugava River. On hills covered by water barriers, conquerors began to build stone castles to subordinate the Balts and their inhabited lands. In economically active places, where earth roads crossed important waterways, crossings were established and economic activity on rivers' banks promoted the establishment of marketplaces and the functional use of waterfronts. In the vicinity of fortresses, merchants and craftsmen established settlements which later gained city privileges. Around the marketplace created a city center building and street network. In the 14th century, on the territory of Latvia the first towns were founded by the Knights of the Teutonic Order, and the urban space won landscape characterized the interaction of people and nature at places and in time.

In Courland, where the Cours' settlement on the left bank of the Venta River existed at least fifty years before the German wooden fortress construction, in the late 13th century, a stone four-unit Goldingen (Latvian: *Kuldīga*) Castle of regular planning replaced former wooden fortifications, and Goldingen Commandry's Centre was formed. A new territory in 1355 allocated for the Cours' settlement promoted the development of the medieval agglomeration in Goldingen that consisted of the Castle–hamlet (Latvian: *Pilsmiests*), the Hill-hamlet (Latvian: *Kalnamiests*, German: *Bergflecken*) and the settlement on road's (now Kalna Street) both sides. Under the Castle–hamlet jurisdiction, there was also the castle-front or the "town behind the hill" (German: *Stadt up dem Berge*) from which the road (now Jelgava Street) along the left bank of the Venta took to Mitau. The inhabited place with the custom-house, the marketplace and St. Catherine's Church had an irregular layout and was surrounded by a circular street (now Baznīcas Street) [**5**]. Settlement obtained the city law statutes. In 1361, the New Town of Goldingen was mentioned in the records.

The Livonian War (1558–1582) destroyed the confederation of Livonian States, and on 5 March 1562, the Duchy of Courland and Semigallia (Latin: *Ducatus Curlandiae et Semigalliae*) (*Fig. 1*), subjugated to Poland, was founded. The last Master of Livonia Godthartt Kettler (1517–1587) became the first duke of the new state. Lutheranism in the newly founded state was announced as legal religion, and on 28 February 1567, the Courland Landtag made a decision about churches, schools, hospitals and "other useful things". Implementing this decision, in Courland and Semigallia several sacral buildings, a few residences, numerous public and residential houses and warehouses were built.

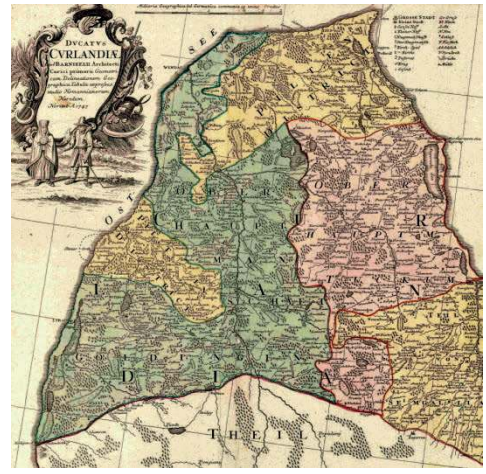


Fig. 1 Map of the western part of the Duchy of Courland and Semigallia. 1747 [State Archives of Latvia, Fund 6828, Description 2, Case 9, File 2]

During the late 16th century–the first half of the 17th century, acquisition of the new, constructive ideas of the military and civil building and adoption of the architectonic and de corative forms was going on. New ideas came in with the German, Swedish, Dutch and Polish building and art samples. In Courland, the simplicity and reticence of the external building forms of small Lutheran churches was compensated by luxurious interiors and ceiling, made by the stellar-network vault covering and the rich plastic woodcarving adornments of inside equipment objects (altars, pulpits, gentlemen's pews).

Many fortresses were destroyed during the Livonian War. Knights became landlords and started to build dwellings on their land. The building of manor centres began to develop in the late 16th century. New landlords needed gardens to grow vegetables, herbs, and medicinal plants. Such gardens surrounded by a di tch and a hedge of thorny shrubs were also desirable to have a hedge maze, pens for different animals, bird cages and a fish pond. Garden buildings, recreation areas and sundials were surrounded by vineyards and rose bushes. The central path that led to a grove or woods was decorated with glamorous greenery. The Goldingen Castle inventory descriptions of 1699 mention that a fruit and amusement garden (German: *Baum und Lu stgarten*) was located "at the castle". In German "*Lustgarten*" was used to design not only a garden with entertainment or amusement facilities but also a place with some shrubs, trees and a flower bed for a meditative relaxation (*Fig. 2*). On the steep slope, the Castle Garden (*Fig. 3*) grew from the Venta coast to the Piepevalka (formerly called the stream between the first houses on Dīķu Street) valley, and r oot crops and f ruits, especially apples and cherries there were cultivated for the needs of the Duke's court. A road that leads from the garden gates through an alleé of lime-trees was an innovation in the Dutchy. A gazebo (*Loewe*) was set up in the garden, and all paths – five of them longways (*Lange gaenge*) and six sideways (*Quer gaenge*) – were for strolls. Plantings were arranged in boskets. Angular (*Eckigte*) fields for kitchen produce were located all around the garden. A small leisure garden with five ponds was on t he other side of the amusement garden. One bosket was planted with gooseberry bushes, and the rest with currant bushes [**8**].

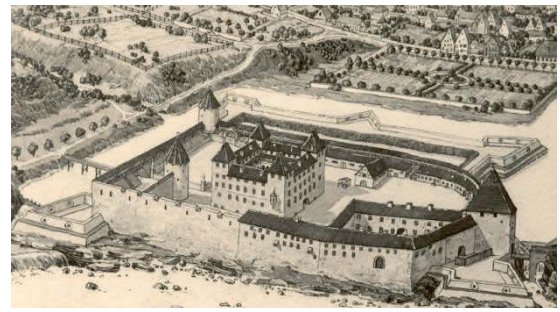


*Fig. 2 Walfried Fromhold-Treu (1886–1964). An attempted reconstruction of the Goldingen Castle and the surrounding gardens in 1680. 1934. [**5**]*



Fig. 3 The planning of the oldest part of Goldingen with the castle-site and the Castle Garden in 1680. 1844 [Brieling A. Plan von der Kreisstadt Goldingen. Mitau:

1844]

Hunting gardens containing pens with cages and sheds for animals and a shooting area were common in Medieval Europe. Sevaral duke manors in Courland and Semigallia had deer parks. Nearby the Goldingen Castle a ferry raft and Birds manor located, and the Deer Park (*Fig. 4*) created by Duke (1682–1698) Friedrich II Kasimir Kettler (1650–1698) was the pride of Courland. The Duchess of Courland (1711–1730) Anna (Russian: *Анна Иоанновна Романова*; 1693–1740), later empress of Russia, in 1720 ordered to transfer deers to St. Petersburg and transformed the garden into a public recreation space [**8**]. South of the fortress in the protective wall (against Dīķu Street), through an iron gate, it was possible get to on a wooden bridge, which led across the moat, from which the road led to the Duke's orchards. When the Swedes destroyed the castle, the garden also disappeared.



Fig. 4 The Goldingen Castle and the Deer Park [State Archives of Latvia, Fund 7363, Description 3, Case 951, File 233]

On the Long island made by the Lielupe River and its by-pass Driksa, the wooden fortress of Mitau (1265–1266) in 1272 became the military base for the conquest of Semigallia, Lithuania and Courland. Under Livonian Master (1328–1340) Eberhard von Monheim's (Latin: *Everhardus a Monheim*) guidance, the Mitau Castle of boulders, dolomite and bricks was built. Beside the castle, craftsmen and merchants made an urban settlement (*Hakelwerk Mitau*) by compact building of household houses, warehouses and dwellings. Lithuanians under Grand Duke (1345–1377) Algirdas' leadership in 1345 burnt the castle-front [**21**]. Merchants and craftsmen's settlement *Jelgab*, whose name could be explained as the "city on water", in the 15th century started to emerge on the left bank of the Driksa, opposite the castle [**4**]. In 1522, a small wooden church (destroyed in 1627) located nearby the marketplace. In *Jelgab*, a new building of the Latin School founded in 1567 was built near a Market Square adjoined the intersection of roads and the waterway. Construction of the Holy Trinity Church (around 1573–1615) for the German Lutheran parish was started next to the old wooden church. In 1573, settlement obtained the city statutes, municipality and the coat of arms and became the duchy's capital city Mitau, where the duke's family arrived. They started to rebuilt (1573–1586) the fortress as the main residence of Duke of Courland [**6**]. Earth ramparts for the defence of the castle building complex were made. In 1578, there were several streets in Mitau, the Market Square and 175 buildings, mostly single-storey wooden houses covered by thatched or shingle roofs.

During the Polish-Swedish War (1600–1629) different epidemics took much more human lives than war, so the pharmacist Johann David (?–1657) founded (around 1600) a pharmacy beside the Market Square in Mitau. David owned a house and two gardens for the cultivation of officially recognized medicinal herbs. Since 6 September 1606, in Mitau the law „*Die Mitaushe Stadt-Policei-Ordnung*" governed public life [**16**]. However, on 17 August 1607, fire destroyed lot of buildings. The pharmacy burned down in 1607 but was restored. Albert Kronberger I founded the Lion's Pharmacy (around 1606). During the reign (1587–1642) of Duke *Friedrich Kettler* (1569–1642) the city experienced rapid growth: the building restored after the devastating fire received a regular layout. On 5 July 1615, the borders of the city of Mitava officially approved for the first time. The Swedes in 1621 occupied Mitau and

robbed the church. In 1625, fire destroyed the capital city. Duke (1642–1682) Jakob von Kettler (also *Jacobus*) started his endeavour to make trade in Courland independent from Riga. In 1648, solving important defense issues, Duke proceeded to create for the city a common system of fortifications with protective bastions and deepened moats. Tobiass von Krauss, Duke's court surveyor, drew (1652) a plan of Mitau (*Fig. 5*).



Fig. 5 Duke's court surveyor Tobiass Krauss. A fragment of Mitau rural district's boundary plan with the amusement garden "Ihr F. Gn. Lustgarten" (His Majesty's amusement garden). 1652 [National History Museum of Latvia].

The building had a regular planning: single-storey residential wooden houses, covered with gabled roofs and facing the street with the end façade, were placed along the perimeter of square blocks. (*Fig. 6*) In the middle of the block, there were a barn, inn, stable, bathhouse, threshing barn, resting place and garden, but the Town Hall was in the centre of the Market Square, surrounded by the most important buildings along the perimeter. On the embankment of Driksa, there was a tavern of burghermeister Heinrich Dunkel and a visiting yard. Mitau became an important economic center which was developing rapidly.

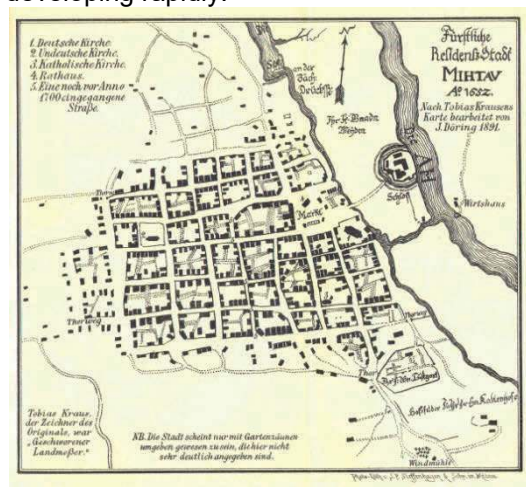


Fig. 6 Painter Friedrich Julius Döring (1818–1898). Mitau and t he "Lustgarten" plan of 1652 created in accordance with Mitau rural district's boundary plan drawn by Tobiass Krauss. 1891 [Stadt Mitau. 1652. Nach Tobiass Krausens Karte bearbeitet von Julius Döring 1891. Mitau: Photo-Lith. von S. F. Steffenhagen & Sohn, 1891]

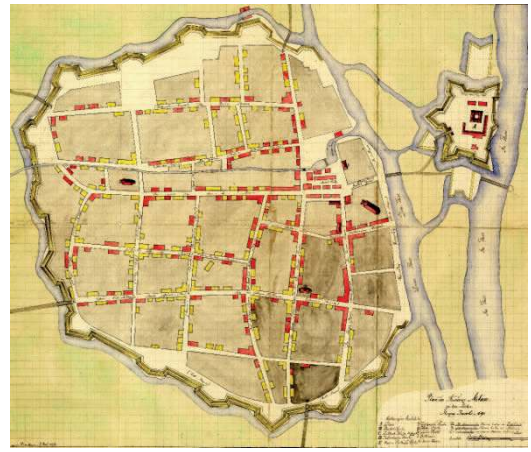


Fig. 7 Plan of Mitau. 1690 [State Archives of Latvia, Fund 640, Description 2, Case 262, File 84]

During the Little Northern War (1655–1660), the capital city Mitau and Duke's residence were destroyed. The plague epidemic (1657–1661) decreased

the number of people living in Courland. Duke Jacob set the main tasks to strengthen defence systems and provide inhabitants with a bet ter drinking water. Mitau in 1659 was surrounded by fortifications (*Fig. 7*) [**6**]. After the war, streets formed in accordance with directions of communication lines, started from the city's centre and led to the Water or Sea (*Porta aquatica*), Dobele (*Porta Doblensis*), Small (*Porta parva*) and Lithuanian (*Porta Lituanica*) Gates. Gardens and meadows were outside the town. The Town Hall situated at Catholic Street, in 1663 was moved to Great Street, alongside which a four-verst long Jacob's Canal was dug (around 1665) [**9**], in order to link the Svēte River with the Driksa. Goods from ships to warehouses and trading places were transported along Jacob's Canal, made perpendicularly to the Lielupe waterway. The main traffic highway marked in the layout of the fortified town the principal compositional axis westwards the dukes' residence and the bridge across the Driksa. In almost symmetrical plan of the capital city, the complex of the duke's residence, the Market Square, Jacob's Canal and t hree churches were essential. In the town's centre, buildings for administrative, trade, medical, educational and manufacturing function provision were arranged. Great Street branched at St. Anna's Church: on the right the road took to Dobele Gate, but on the left – to the Small Gate. Catholic (German: *Katholische Straße*) Street along the south side of the Market Square provided traffic between Water and Lithuanian Gates.

In the capital city and its outskirts manufactures worked: saltpetre saltern, limekiln, kiln of bricks, steel, copper and others, as well as a glazier workshop, iron and copper forgery. The water level of the canal was regulated by two water-gates: miller Augustin Richter made the watermill at the Driksa water-gate in 1670, but the mill at the other water-gate was operated by horses. The windmill was built near the marketplace. In 1688, building of the high tower of the Holy Trinity Church, covered with a low pyramidal four-sided roof, under building master Martin Knoch's guidance, was completed, and it was crested with a small weathervane flag and the year engraved on it [**19**]. A m ulti-functional centre started to develop [**22**]. Around 1700, the capital city Mitau of the Duchy of Courland and Semigallia surrounded by the defence canal and fortification system with fifteen bastions (*Fig. 8*) was created whose typology can be found among the samples of the Renaissance ideal cities.



Fig. 8 Panorama of Mitau and t he castle. 1703 [National Library of Latvia]



Fig. 9 Panorama of Mitau and t he embankment of the Driksa River. 1754 [State Archives of Latvia, Fund 640, Description 2, Case 262, File 4]

At the Platone River a large amusement garden was created in the south of the Dutchy's capital city Mitau. In the south-east of the St. Trinity Church near the castle a small garden was located which produced goods for kitchen, as well as herbs, flowers, and fruits. Different quarters of this garden were lined up to one another and separated by paths, whose layout was not consistent with the overall design of the garden. A description of this garden was created after the Great Northern War in 1722 [**1**]. Instead of a fortress, the castle was built in two periods (1738–1740 and 1762–1772) and changes also took place on the

embankment of the Driksa (*Fig. 9*).

On the Doblen Hillfort, instead of the destroyed Semigallians' wooden fortifications the two-storey block of irregular square planning Doblen (Latvian: *Dobele*) stone castle (1335–1347) was built for Livonian Master's residence (*Fig. 10*), which in October 1869 and September 1870 was thoroughly studied by painter Friedrich Julius Döring (1818–1898) [**20**]. Under cover of the residence of trapezoidal layout, in the southwest corner of the wide castle-front, there was a gate-tower and the balance-bridge [**3**]. In the west part of the protective wall, the entrance gate was next to the rectangular layout tower. Craftsmen and merchants established a settlement near the fortress [**20**]. On the left bank of the Bērze River, in the 15th century existing urban settlement's marketplace at the side opposite the residence, a single-nave rectangular longitudinal church [**2**] from boulders was built. Widow of Duke Friedrich Elisabeth Magdalena of Pomerania (German: *Elisabeth Magdalena von Pommern*; 1580–1649) with a foster-son, later Duke of Jacob, from 1643 till 1649 lived in the Doblen Castle (*Fig. 10*). A Duchess consort of Courland had acquired knowledge of horticulture, and on the castle mound, she established a large garden of medicinal plant [**9**]. Dukes of Courland followed the "flower" fashion [**1**].



Fig. 10 Artist Oļģerds Krūmiņš. Panorama of the Doblen Castle. 1661 [Academic Library of the University of Latvia, Library of Misins]



Fig. 11 Map fragment with Rositten (on the bottom right of the picture).*1798 [National Library of Latvia, the cartography material Kt I1-1-89]*

According to the bull issued by Pope (1261–1264) Urbanus IV in 1264, the Latgalian lands (*Fig. 11*) came under German rule. They also included Rositten, where wooden fortifications of the local inhabitants existed around the 13th century. When between 1264 and 1324, on the right bank of the Rēzekne River, strangers erected a stone fortress on Latgalian mound, the fortification and settlement of the local people became impossible. German equal partners in Rositten were local and R ussian merchants [**14**].

On the eastern side of irregularly designed *castrum Rositten* (*Fig. 12*) there was a outpost of polygonal planning, from which the road led to the entrance gate to the fortress [**14**]. Fortifications were originally guarded by a square gate tower and two round towers on the west and south walls [**3**]. The Rositten Castle in the 15th century – in the first half of the 16th century was one of the most important fortifications of the Livonian eastern border.

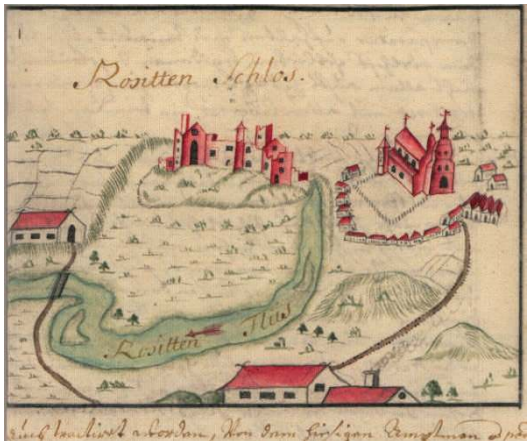


Fig. 12 Castrum Rositten near the settlement. 1700 [Stockholm, Kungl. Krigsarkivet]

By the end of the 17th century, the natural landscape was complemented by monumental complexes of buildings, in whose surroundings river banks were economically active.

2. Nature elements and green structures in Latvian urban landscape formation

During the Russian Empire, installing parks in suburban estates, gained experience, which was useful, to create in the city natural environment that was appropriate for recreation, entertainment and healing. Castle mounds with ruins started to be turned into gardens, parks and riverside recreation places. In the oldest part of Goldingen, where a German fortress situated, in the 1860s, the City Garden (*Fig. 13*) with well-stocked plantations and historically valuable architectural elements began to form. The City Garden further developed into a pop ular recreation area for inhabitants and city guest. Since the end of the 19th century, slopes of the City Garden in winter was able to ride a sled, but on the pond there was a skating rink in place of the former ditches. Students of the German Gymnasium provided the order and the opportunity to drink hot tea. The skating rink was used by gymnasts and adults. In good weather it was possible during weekend to skate accompanied by music. In the early 20th century, a small, round pavilion was erected on the hill above the fortress ruins, and the view opened to the Venta Rapid that is the widest waterfall in Europe. A fabulous arched bridge, that was a favorite meeting place for lovers, led from both hills across the ravine. The second garden with beautiful fruit trees opposite the German gymnasium was converted into pasture in the 19th century.



Fig. 13 Air bridge in the City Garden of Goldingen. The early 20th century. [Postcard Die Luftbrücke im Stadtgarten zu Goldingen]



Fig. 14 Green structures outside fortifications of Mitau in the early 19th century [State Archives of Latvia, Fund

6810, Description 1, Case 64, File 129]

In Mitau, man-made green structures were located outside city's ramparts (*Fig. 14*). At major traffic highways gardens were installed and buildings for farm and r ecreation were built. The area of the Castle Island enclosed by ramparts between the Lielupe and the Driksa, in 1817 began to be transformed into Governor's Island. A Palace Garden around the Mitau Palace was created, and i t also included former fortifications of the earth's ramparts and bastions. Later the Palace park was created, and from zigzag walks (*Fig. 15*) wide perspectives on the surrounding landscape opened. The park from road bordered alleés (*Fig. 16*). They also included walking paths along banks of the Lielupe and the Driksa (*Fig. 17*), and of them the view opened on the expanses of water and p ark landscaping. There were some noble trees growing in the Palace Park – two horse chestnuts, pyramidal oak, gray apsen or *Populus tremula*, and romantic canals, bridges, pavilions were created. South of the park, on t he right side of Riga Road near Driksa, a theater house in 1912 was built (destroyed after World War II), and the areas of greenery decreased.





Fig. 15 Greenery of the Palace Park near the Mitau Palace. The early 20th century. [Mitau. Partie aus dem Schloßgarten III. Mitau: Verlag Nicolai Hubner]

Fig. 16 Alleé of the Palace Park. The early 20th century. [Mitau. Schlossgarten-Allee.Stocholm: Granbergs Konstindustri-Aktiebolag]



Fig. 17 The Mitau Palace and greenery of the Palace Park: a concert pavilion in the foreground. The early 20th century. [Gederts Eliass Jelgava History and Art Museum. Postcard Mitau. Blick auf das Schloss vom St. Trinitatis-Kirchturm]

The building of Bach Street (later – Upes Street, modern boulevard of *Jānis Čakste*) decorated by linden alleé formed

elegant stone houses. Bach Street along the Drksa coast (*Fig. 18*) led to the governor's residence and the Castle Park, where the pavilion and concert hall located.



Fig. 18 Linden-tree alleé and greenery on the embankment of the Driksa. The late 19th century. [Mitau. Schlittschuhbahn. Dresden: Kunstverlag Karl Grobe]



Fig. 19 Mitau map with its gardens and parks. 1907 [National Library of Latvia, the cartography material Ktl1-3-164]

Linden-tree avenues emphasized the main traffic routes in Mitau, but in the early 20th century linked green structures into a single greenery system (*Fig. 19*), which significantly improved the quality of the urban environment and the landscape. The riverside was created as an environment for recreation.

The inhabitants of Dobele cultivated gardens near one-storey residential buildings (*Fig. 20*), and the town had lot of green areas (*Fig. 22*). The morning of 26 June 1870 started in Dobele differently than usual. The houses were adorned with maids, wreaths and even flags. More and more riders and pedestrians in festive clothing appeared on the streets. They all went to the church for the first Courland Song Festival Opening Concert. In the evening, participants went to the Doblen Castle ruins (*Fig. 21*) [**12**].





Fig. 20 Greenery on the embankment of the Bērze River. The early 20th century. [Dobele Museum of Local History]

Fig. 21 Mitau County Auditor C. G. Raetsch. The Doblen Castle ruins and the Bērze River in the early 19th century [Abbildungen der Livländischen Burgen im Album des Marquis Paulucci]



Fig. 22 Doblen plan with green structures. 1885 [State Archives of Latvia, Fund 6828, Description 2, Case 502]

On the Latgale highland's northern slope, the settlement near the fortress on the Rēzekne (also Kovšu) Lake's vicinity the town rights in 1773 acquired. Rositten in the early 19th century was a small town at the castle mound's foot, and two thirds of its population were Jews, who according to the laws of that time were allowed to live only in cities. A. Mozalovsky, the surveyor of the Vitebsk Governorate Board, in 1835 drafted a Master Plan for Rositten approved by the government on 24 April 1836. In the north of Rositten, on both sides of St. Petersburg–Warsaw highway (now *Atbrīvošanas* (Liberation) Avenue) opened in 1836, regular rectangular quarters for Christian dwellings were planned, but in the Upper Town's centre, public buildings and an Orthodox church (1840) were built. Captain Komarovsky drew up the new Master Plan for the city and the detailing layout for building around the central square. A public garden was planned in the area between castle ruins and the river (*Fig. 23*). In November 1847, the government approved the new plan. St. Petersburg-Warsaw railway, opened in 1860, contributed to economic activity in the city. The Master Plan lost its importance, and since 1872, in a public garden area, it was allowed to build residential buildings. Since the second half of the 19th century, in urban space of cities in Western Russia, the most important streets for traffic were highlighted by Dutch linden-tree or horse chestnut alleés involved in the formation of the city's greenery system. Alleés in planning structure became the main compositional green element that connected functionally important territories. In Rēzekne, the most luxurious houses were built on Nicolai Street (now Liberation Alley), and the significance of urban construction was emphasized by tree plantations. The new building gradually and spontaneously began to expand beyond the boundaries indicated in the Master Plan. In 1901, the Land surveyor Svirskis drew up a new Master Plan, extending the building range and maintaining the regular rectangular planning system of the Upper Town [**11**]. After the opening of Ventspils-Ribinsk railway in 1904, Rēzekne became an important railway junction with two stations. The construction of the city was expanded [**10**].



Fig. 23 Rositten Castle ruins and park greenery on the castle mound. The early 20th century. [National Library of Latvia. Postcard Ржица. Rejitsa. № 2. Городской садъ и замокъ]

3. Transformation of natural elements in Latvian urban environment under the influence of the domestic policy during the interwar period and political ideology after World War II

In the Republic of Latvia, the construction of cheap housing became a topical issue in the new political situation. On 16 September 1920, the Constitutional Assembly adopted a resolution "On Agrarian Reform in the Republic of Latvia", and new land was given to urban development. The structure of the economy changed, new administrative centres and traffic hubs were created, cities were reconstructed. During the Republic of Latvia, in the City Garden of Kuldīga (former Goldingen), a cafe with open terraces (*Fig. 24*) and a s tage was built. City dwellers every Saturday and Sunday came here to play music. Kuldīga residents also had the opportunity to attend outdoor theater shows and sports competitions. The park was surrounded by a tall courtyard and tables were set up for ticket sales at the entrances during the event.



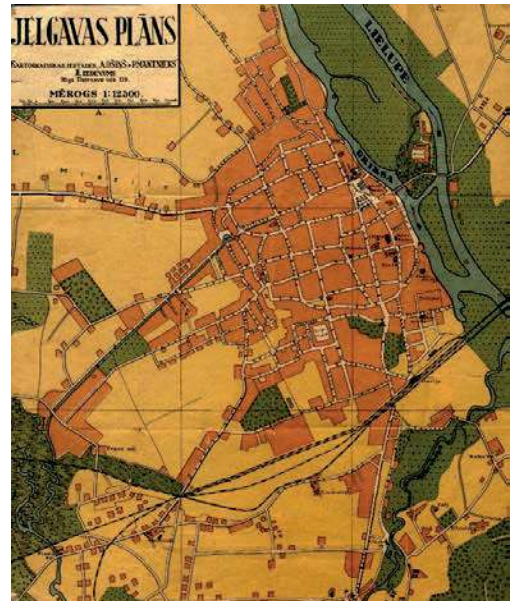
Fig. 24 A cafe with open terraces. 2009 [Photo by Silvija Ozola]

After World War II, in Kuldiga, the Sculpture Garden near Venta was established, and 22 stone and bronze sculptures and groups (*Fig. 25*) placed here are one of the greatest contributions of Kuldiga Honorary Citizen (since 1978), sculptor Līvija Rezevska (1926–2004).



Fig. 25 Sculptor Līvija Rezevska (1926–2004). Sculpture "Suitu sievas" in Kuldiga Sculpture Garden near Venta. 2017 [Photo by Silvija Ozola]

In the Republic of Latvia, Jelgava (formerly Mitau) (*Fig. 26*) became the centre of the county. On the island, the palace was restored under the direction of architect Eižens Laube, and in 1937, a western block was added to it. During the World War II, the city was destroyed, and the reconstruction of the centre of Jelgava was influenced by Soviet ideology, therefore the construction concept was changed (*Fig. 27*) [**17**].



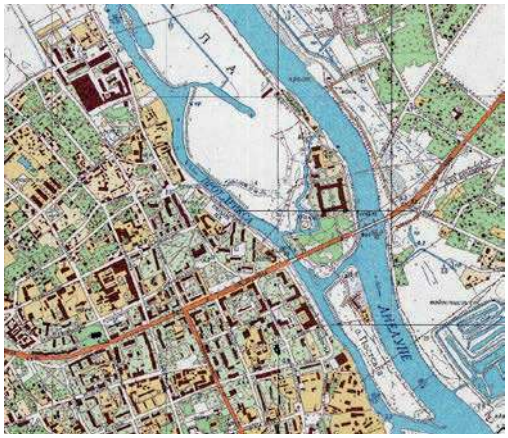


Fig. 26 Map of Jelgava planning with green structures. 1927 [Jelgavas plāns. II izdevums. Rīga: Kartogrāfiskā iestāde A. Ošiņš & P. Mantnieks, 1927]

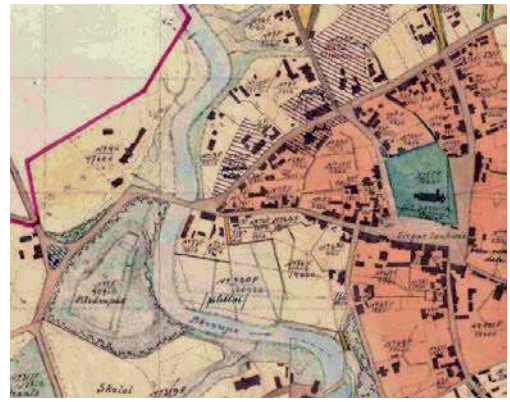


Fig. 27 A fragment of map of Jelgava. 1978 [Елгава на 4 листов (0-34-129, 132). Секретно. Лист 2. Генеральный штаб, 1978]

Dobele that was destroyed during World War II needed a change in the building concept of the city centre (*Fig. 28, 29*) [**15**]. Near the Dobele Castle mound, on which ruins are located, a school and a sports ground were arranged. The historic site acquired a new function (*Fig. 30*).



Fig. 28 Banks of the Bērze River in the vicinity of the bridge. 1920s [Postcard Dobele. Bērzes upe]



Fig. 29 Planning of Dobele. 1928 [State Archives of Latvia, Fund 6828, Description 2, Case 504]

Fig. 30 Planning of Dobele around 1986. 1987 [Добеле. План-схема для служебного пользования. Москва: Главное управление геодезии и картографии при Совете Министров СССР, 1987]

The urban development of Rēzekne (until 1893 German: Rositten, before the Revolution Russian: *Рѣжица*, until 1917 and 1944–1945 Russian: *Режица*), the seventh largest city in Latvia, that was formed on seven hills, very clearly demonstrates consistency and continuity in the implementation of solutions (*Fig. 31*), preserving the planning structure of the central part created in the 19th century [**11**]. In 1927,

the area of Rezekne city was expanded. The municipal government of each city had to take care of the development of a Master Plan and functional zoning. Soviet-era building drastically changed the city plan (*Fig. 32*) created over many centuries on the banks of the Rēzekne River and Lake.

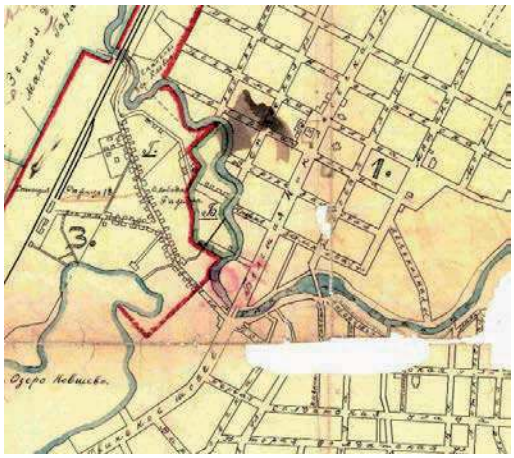




Fig. 31 Planning of Rēzekne. 1933 [State Archives of Latvia, Fund 6828, Description 2, Case 564]

Fig. 32 A fragment of map of Rēzekne. 1978 [Митюк В. И. Резекне на 1 лист (0-35-127). Секретно. Составлено в 1973 г. Издано с оригинала ГУГК при СМ СССР. Генеральный штаб, 1978]

4. Generative transformation of “blue” and “green” structures of the urban environment to improve the artistic expression of a cultural landscape in historical cities of Latvia

After Latvia regained its independence, urban planning and recreation areas were expanded. In Kuldīga, the landscape was improved and the park area was cleared of trees and shrubs that prevented the greenery from being perceived as a whole or obscured recreational areas. Bridges, ditches and ponds were restored in historic or functionally necessary locations. Water exchange and level design for the planned water body system will be provided by the Pipevalka stream and the River Alekšupīte. Banks of the ditch and the pond were fixed with boulders and plants typical of wet areas to give the environment a nat ural look. Thanks to wooden bridges and footbridges on several levels, this part of the park gained new viewpoints. The brightest highlight in the southeastern part of the park is the illuminated fountain in the pond (*Fig. 33*). The water supply was not restored in the southwestern ditch, but a " flower river" was designed, with plants suitable for low, wet areas. The lighting effect is enhanced by the use of ground-mounted spotlights. The "Flower River" is visible outside the park - from the main entrance to the north-western part, where the viewing area is located not only for the park, but also for viewing the Old Town landscape. A video infrastructure was established to provide high quality outdoor cinema events. In summer, residents of the park visit open-air cinemas on the mound serving spectator seats. The special atmosphere of the park is created by the multi-level viewpoints provided by the exquisite relief of the former Livonian Order castle, the careful planning of trees and plant groups and the well-balanced arrangement of amenities. The architect's task was to transform the site so that it became an attractive magnet in the most picturesque location of the Old Town of Kuldīga, which adjoins the Venta river bank between waterfall and the historic brick bridge.

Authors: architect Diāna Zalāne, landscape architect Marta Tabaka from Diāna Zalāne's project office, Client: Kuldiga Municipality, Designing: 2009, Construction: 2010—2011, Construction companies: AVA, Mārtiņdārzs.



Fig. 33 The brightest highlight in the southeastern part of the park is the illuminated fountain in the pond.. 2015 [Photo by Jānis Brencis]

In Jelgava, the embankment of the Driksa River needed visual transformations, because previously this territory (*Fig. 34*) was not formed as a recreational area for inhabitants of Jelgava and guest. In the beginning of the 21st century, this territory was still not fully utilized, in turn, it was left as a nat ural landscape space in the urban environment, where frequently occurred multiple destructive processes, such as pollution, which diminished the willingness to spend any time in this territory. The majority of the citizens of Jelgava used to avoid this territory. As a result, because of the project initiated in 2011, this territory has now gained new sights, recreational areas, territories for family walks. The transformation processes of the embankment of the Driksa River in the urban environment can be evaluated as successful, and they distinguish new tendencies in the development of the city of Jelgava (*Fig. 35*) [7]. There is a w ell-equipped picnic area and a w ooden observation tower on the Castle Island for watching two rivers, the city panorama and wild horses in the Lielupe floodplain meadows, which are protected nature areas.

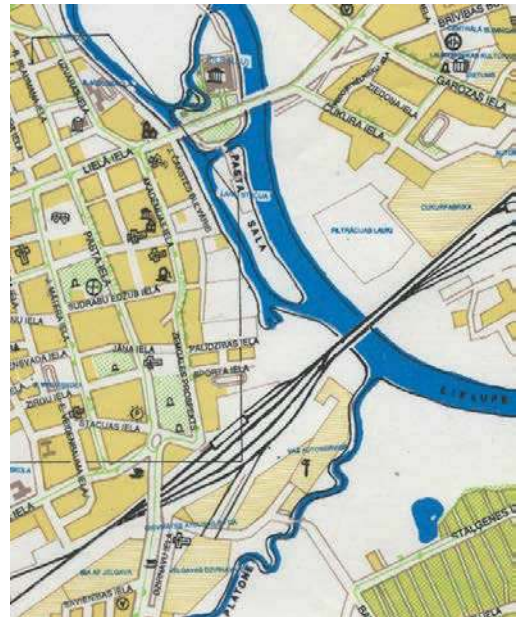


Fig. 34 Māris Kalējs. A fragment of map of Jelgava. 1993 [Kalējs M. Jelgavas shēma. 1993]



Fig. 35 The Driksa River promenade in Jelgava [https://www.redzet.lv/images/large/7/44/V-889-14.jpg]

In Dobele, under the guidance of architect Pēteris Blūms, in 2002 was restored the restoration of castle ruins. On the right bank, there is the promenade of the Dobele castle ruins, while on the left bank there is a uni que walking area with

paths, wooden footbridges and a viewing platform to the Dobele castle ruins. For many years, there was a small sand path, which every year went worse and worse because of the underground springs – it turned into a marshland. Finally, this small way was reconstructed, the promenade (*Fig. 36*) near Dobele castle ruins and the Bērze River was built and new benches and lights were made. Now it is nice walking place.



Fig. 36 Panorama of Dobele castle ruins promenade [Online 14.09.2019, source: http://www.dobele.lv/sites/default/files/tourism_object_images/dji_0180.jpg]

In the restored Republic of Latvia, local governments must be actively involved in regional planning. Rēzekne became involved in project „*Cities of Change*" for the development of Eastern European cities and on 23 November 2000, started to develop economic strategy of Rēzekne city. In the long-term for 12 years, the "Spatial Plan of Rēzekne City 2007–2019" was developed (*Fig. 37*), and a competition was announced for evolving of Rēzekne urban space and founding of a creative services center for municipalities in Eastern Latvia in order to create an innovative solution in the city center that would attract young people and to start a new era in architecture of Latgale. The best proposal was the *CARAN d'ACHE* proposed by architects of the SAALS office Rasa Kalniņa and Māris Krūmiņš. The imagination was inspired by the landscape – a medieval castle mound with ruins (*Fig. 39*), but the victory secured a gentle approach to a complex historic site and lighting solutions [**18**].



Fig. 37 A fragment of Rezekne City Spatial Plan with 2007–2019 years' modifications in the city's centre. 2012 [http://www.rezekne.lv/uploads/media/planota_im_grozijumi.pdf]



Fig. 38 Panoramic view on the Latgalian mound with castle ruins from Livonian times and the Eastern Latvian Centre of Creative Services "Zeimuls". 2015 [Online 14.09.2019, source: https://static1.squarespace.com/static/5393686de4b0abeff7807940/53938584e4b0fc0456d67476/542b0e29e4b008ddfdb37acf/1423748106610/?format=1000w]

In Rēzekne, construction of the Eastern Latvia Regional Multifunctional Center – a complex of cultural buildings with two acoustic concert halls was started in September 2010, but works

were continued until May 2013. The Latgale Embassy GORS was created. In the building's site, peculiarities of the natural environment as the Rēzekne River valley's landscape (*Fig. 39*) and the surrounding terrain took into account for the forming of common urban space with a house for cultural events. On the opposite bank of the river valley, walking paths created a functional link between buildings.



Fig. 39 Panoramic view of the Regional Multifunctional Center of Eastern Latvia – a complex with two acoustic concert halls at the Rēzekne River [http://visitlatgale.com/images/13396-24742-rezeknes_sv_2018_fotolebedsaleksandrs_%284%29.jpg]

One of the most important elements in the city's visual image is the Rēzekne River that has a great potential for further development. The walking promenade, created in 2012 along the river, has become a popular for both locals and visitors. During different city's festivals, there are various activities taking place throughout it as a pleasant place for leisure filled with content. In order to make this part of the city more attractive to visitors in the future, from 15 February to 1 April 2019, a competition «Design of an environmental object in the walking promenade along the Rēzekne River» was organized. The work "Water Pot" by Valdis Majevskis, respecting the city environment and at the same time creating an original object corresponding to the image of Rēzekne, is a reference in modern stylistics to the heritage of Latgale ceramics. It is a large symbolic "Water Pot" – the most popular pottery in Latgale, which is supplemented with a running water element. The jury evaluated the work's connection with the cultural and historical heritage of the city and the region. In Rēzekne, there is a very strong pottery tradition with ancient roots. Latgale pottery is peculiar and different from clay products of other regions – it is recognizable and Latgale business card.

Conclusions

1. The city center formed around the castles, provided administrative, economic and cultural functions. Over time, the fortresses lost their original meaning and the use of the surrounding area changed. The natural environment near the waters began to be us ed for recreation. Riverfronts began to improve, and artistically aesthetic requirements became significant. Nowadays, the generative approach helps to find interesting architectural solutions for the environment.

2. Since the 19th century, parks have been established in castle mounds, and social activities and cultural events have been organized in the landscaped neighborhood. In Goldingen, the City Park was created near the Venta River, but in Mitau, Castle Island between the Diksa and the Lielupe was transformed into Governor's Island, where buildings for recreation and entertainment were built, and walkways were formed. At the foot of the Doblen fortress, on banks of the Bērze River, there were places for recreation, but on the Rositten castle mound near the Rēzekne River, a park began to be arrangred.

3. Nowadays, walking promenades are established along river banks, and in

many cases they are linked around the historic center of the city. In order to adapt footpaths to local conditions and the originality of the terrain, as well as to incorporate it into the surrounding landscape, architecturally interesting solutions of the natural material as wood, used for the covering, are created.

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TITLE: “The art inside an architecture". Generative design system as a tool, and local architecture, as an inspiration in the shaping of the contemporary meaning of architecture in a village landscape context. *(Paper, Artworks)*

Topic: Art, Architecture,

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Abstract
Generative design is a r evolutionary new method of creating artwork, models, and animation from sets of rules, or algorithms. By using accessible programming languages artists and designers are producing extravagant structures that form the basis for everything from patterned textiles to sculptures, art installations, films, architecture [1]. Generative design and generative art are a fact today. Rooted in the idea of conceptual thinking, it releases new methodological and aesthetic views of architecture and art.
The paper describes the process of designing a single-family housing estate in the suburbs of Bialystok – a city in north-eastern Poland. The article focus on the issue of forming a contemporary form of an architecture, which is to result from the tradition of building existing in this area. Generative methods in architecture design can support the revitalization of such areas and be a tool to restore lost heritage and the spirit of the place. Additionally, generative design method joined with architectural code of local architecture gives us an outstanding opportunity to discover new shapes of contemporary architecture according to culture, history and l andscape aspect of a pr oject place. The designed housing estate, in its final shape, is a model of transformation of the features of traditional Podlasie country house. In the author’s opinion, this approach to design is a generative approach to architecture in general. The effect of the designed architecture of the intimate estate, next to the purely economic goal is an attempt to build, or actually, resurrect the said identity of the place.
The paper is complemented by a series of graphic artworks inspired by the generative design process of the described architecture. The resulting works have artistic and graphics significance, but they relate directly to a s pecific place and the architecture designed. My artworks presentations open with a gallery of series of graphics. The graphics present abstract artworks draw inspiration from Podlasie local landscape, local architecture, and culture.
My artworks are the definitive showcase, study, and reference for generative art exciting emerging field.







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Key words: art, graphic, painting, architecture, generative design, ***Main References:***
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Premise

Generative design is a revolutionary new method of creating artwork, models, and animation from sets of rules, or algorithms. By using accessible programming languages, artists, and designers are producing extravagant structures that form the basis for everything from patterned textiles to sculptures, art installations, films, architecture [1]. Generative design and generative art are a fact today. Rooted in the idea of conceptual thinking, it releases new methodological and aesthetic views of architecture and art.

The paper describes the process of designing a single-family housing estate in the suburbs of Bialystok – a city in north-eastern Poland. The article point to the issue of forming a contemporary architecture form from the traditional architecture existing in this area. Generative methods in architecture design can support the revitalization of such areas and be a tool to restore lost heritage and the spirit of the place. Additionally, the generative design method joined with the architectural code of local architecture gives us an outstanding opportunity to discover new shapes of contemporary architecture according to culture, history, and landscape aspects of a project place. The designed housing estate, in its final shape, is a model of transformation of the features of traditional Podlasie country house. This approach to design is a generative approach to architecture in general. The effect of the designed architecture of the private estate, next to the purely economic goal, is an attempt to build, or actually, resurrect the said identity of the place.

The series of graphic artworks inspired by the generative design process of the described architecture complements the paper. The resulting works have artistic and graphics significance, but they relate directly to a specific place and the architecture designed. The graphics present abstract artworks that draw inspiration from Podlasie's local landscape, local architecture, and culture.

1. Introduction

The generative design method is a multi-criteria and basic understanding of the design process. The architect creates a system of activities based on the set goals of the project through parameters,

restrictions, and r elationships [2]. Generative design as a method defines new patterns of architectural forms that constitute the avant-garde in the art of architecture and would be difficult to develop using other techniques, especially traditional ones [3]. Besides, the generative design supports the processes of sustainable thinking about architecture. In this case, all aspects of architecture are taken into account, such as economics, construction, location, geography. The generative support makes designing sustainable, advanced, and al lows achieving a more measurable effect. Thus, the resultant solution is well adapted to the design place context. In the article, the author presents the possibilities of using generative design elements in the design of suburban housing architecture at the interface of the city and the village. The method was used to examine the existing spatial, architectural and cultural context necessary to obtain the best possible, fitting in place of architecture, using the archetypal features of the place, while introducing new values into the existing space. The generative method used here allowed to organize the features of residential development in the Eastern Podlasie region of Poland, and then transform them into forms of contemporary, individual and own language architecture. The collection of these features further contributed to the development of a set of designed architecture rules, which, in combination with the relations and limitations, determined the generating of the architectural form direction in this particular location. As a result, a coherent and resulting space of a contemporary home for a middle-class inhabitant of north-eastern Poland was created, respecting and creative reinterpreting the historical context, tradition, and village landscape. This approach seems particularly valuable because in the described region exist the problem of identifying architecture in the context of the place and its tradition. Lack of understanding architecture as a space related to both the landscape and a given tradition causes a s ignificant impairment of this space. As a result, the landscape of many places becomes devoid of its identity. Being detached from it contributes to the degradation of the countryside landscape. This phenomenon is particularly noticeable in the latest suburban projects in the Podlasie region in Poland. This regression provokes once again defining knowledge about the space in which we live and mastering such methods of architecture design that will enrich the existing space and consolidate its sense, both historical and contemporary. Creating architecture based on defining and reconstructing "elementary codes" for a given space should be o ne of the design methods. In this sense, the use of generative design methods allows for a high degree of precision, which guarantees architecture that is sustainable in terms of energy, ecology, materials, and economy, but also shaping the local landscape concerning nature and tradition. In this way, the belonging of the new architecture to the place where it arises is consolidated. Let us try to trace the individual design processes of a l ocal housing estate in Niewodnica Nargilewska in the Podlasie province in north-eastern Poland.

2. Project location issues – input data

The project is located in the village of Niewodnica Nargilewska in the Podlaskie State in Poland. Economic transformations in Poland since the 1990s have changed the image of a t raditional village. Thus, we are witnessing transformations where traditional agriculture in such areas is disappearing, and it is replaced by urbanization of the village, which often makes it a suburb of the city. On the one ha nd, the village

landscape is formerly quite random and highly distorted traditional and historic buildings, on the other hand, new housing investments of a rural character are becoming more frequent. The goal is to build a complex of several houses of high architectural and landscape value, whose quality is to result from the once existing traditions and architectural patterns. The second goal is economic. The design and construction study carried out in such a way as not to generate significant construction costs and to dedicate the offer of housing for the average middle class of a P odlasie inhabitant. The economic aspect of the investment throughout the case study correlates with the qualitative assessment of architecture. The facility is to be implemented according to the "know-how" principle - designed and subsequently implemented by one entity. The plot of the project is in an area of 4000 m 2. This short introduction is the starting material, which was then subjected to design work. Summarizing:

1. The surface of the plot with a rectangular layout adjacent to the street with a shorter line and the opposite line opening onto the river landscape imposes the best direction of the location of houses optimally

2. In this place, we can design a maximum of four houses - which results from the decisions of the communes legal

3. The existing landscape of the village becomes a r eference in building the structural relationship between the form of modern architecture, the economics of construction implementation, and t he typology of a historic village house in this region.

3. Generative design in shaping the architectural form of a single-family suburban building

In the architectural design approach, it is necessary to correlate the function of the building with its architectural form and to connect the internal function with the external function of the house in the form of a gar den, driveways, and e conomic zones. In the further part, the construction of the building and its detail determines further relations. "Form follow function," as Mies Van de Rhoe used to say, creates relationships and structures between the function, form of the object, and its impact on the external space.
Hence, taking a de sign strategy, consisting of recognizing the essential features of the place and transferring them to a d esign solution that will allow maintaining the integrity of architecture with the environment, as it was inscribed in the landscape. Design work based on the BIM model was used for this purpose.

4. Generative design

Generative design is not a new phenomenon. To a large extent, it is associated with the implementation of the latest IT technology achievements in design tools used in architecture. In many cases, this method supports and accelerates the design process of complex geometry characteristic of algorithmic aesthetics introduced into architecture. Recognized international design studios such as Morphosis, Un studio, Zaha Hadid architects, and F oster architects exceed the boundaries of architectural forms of expression and composition potentials unknown until now. Without the use of algorithmic programs such as Rhino, achieving such a style

would be difficult. Today, producers of software supporting architecture design are increasingly combining BIM technologies with GDS technologies [4]. Generative design is not only a tool that promotes a particular noticeable style of architecture today. Generative design is also a way of thinking that helps objectively organize individual design processes, connect individual project goals into a system of dependencies and relationships that, in consequence, give reliable architecture solutions. The definition of generative architecture is therefore not a homogeneous definition. Its primary assumption evolves along with the application and development of computer techniques in design because it is from this environment that the concept itself originates. However, the term goes beyond the scope of computer-aided design. It can be seen as an organizing process and argumentation in shaping the principles of the project as well as the meanings of its spatial layer.
The basic definitions of generative art and generative design say:

1. Generative art is an artistic practice in which the artist creates a system described, for example, using a natural language, computer program, or machine design, which has complete or partial autonomy affecting the final shape of the work [5].

2. Other definitions speak of generative design as systems for synthesizing design processes in the form of mechanisms capable of producing alternative solutions. The method of doing so is to define procedures (algorithms) as parameters and relationships and to test systems in the form of analysis [6].

Generative design is the use of algorithmic processes or rules and principles to receive design solutions. Using generative tools in designing requires an architect's approach to the creative process from a different angle. The theory and practice of architecture have so far focused primarily on a form, not on the process of emerging form. Currently, architects wanting to study the impact of various factors on a form, reach for digital generative systems and tools. They borrow them from other disciplines and use them to design buildings and building materials. The most popular are Voronoi diagrams, L-Systems, cellular automata, fractals, shape grammars, and genetic algorithms [7].
Instead, for the vast majority of "generative architecture" projects, we should be talking about "using generative design methods." This formulation is more accurate because it leaves room for non-generative methods, i.e., traditional 3d or 2d modeling, that interferes with forms generated by a computer program. So if we want to learn what generative architecture is, we must first answer the question: what are generative design methods? Their use causes a fundamental change in the architect's relationship to the virtual computer form. In generative methods, the architect no longer models the form directly, building subsequent planes in virtual space. Instead, the form is generated by a computer, and the architect controls it with code or a script. The work of a designer is starting to resemble the work of a programmer in "Scripting language." Unlike classic programming languages (so-called algorithmic and object-oriented), the scripting language is usually built into the ready application. That is why it is invaluable for architects.
After this introduction, we can now return to defining the terms "generative architecture" and "generative design methods." Let us take a look at the design of the civil court building in Madrid by Zaha Hadid (Fig. 1). Rhythmical enlargement and reduction of openings on

the facade suggest using some generative method.



Fig.1 Civil Court Building in Madrid. Architect: Zaha Hadid

Patrik Schumacher, Zaha Hadid's right hand in the studio, however, reveals the details of their design process in the book "Digital Hadid. [8] " Well, the pre-generated form is usually arbitrarily modified until it becomes satisfactory for the person working on it. Hence, for most of the work that had emerged from Hadid's studio in the last few years, the form "generative design methods" should have been used. The architect here interferes directly in the forms generated by the program. An example of a r eal "generative architecture" would be the project submitted by United Visual Artists for Darwin's Canopy competition at the Natural History Museum in London. It is a competition for installation on the occasion of Karol Darwin's 200th birthday, hence the architects from UVA decided to simulate the natural selection process by computer. With the use of "Genetic algorithms," architects have created generations of "virtual plants" competing with each other for survival, and therefore for access to the sun - also virtual, of course. The final form of the installation is, therefore, the effect of the simulation of the evolution process. This form is entirely derived from code written by architects and was not later subject to any "manual" modification. Hence the UVA project is entirely generative architecture. To finally receive a given design solution, the issue of generative design should be supplemented with an a nalysis system that would assess the accuracy of given solutions. The generative design seems to be excellent support for architects today. The following example may not use full algorithmic systems in the process of evolution of the f orm, but an at tempt to create a system of principles, relationships and limitations and subjecting the resulting forms to an evaluation using the analysis system determines the architectural form, which is the result of a strict process, allowing the creator to learn new, unknown areas of searching for content and f orm in architecture.

5. The project of single-family houses district in Niewodnica Nargilewska

The design process has been closely linked to the determinants of the building's form and f unction. In this way, several variants of housing facilities were developed to choose the most suitable for implementation ultimately. The arrangement of the functions of the facilities was developed following typical interior design solutions in this category of single-family residential buildings implemented for the middle class in Poland in Podlasie. The diagram below shows the individual activities of the project (fig.2).

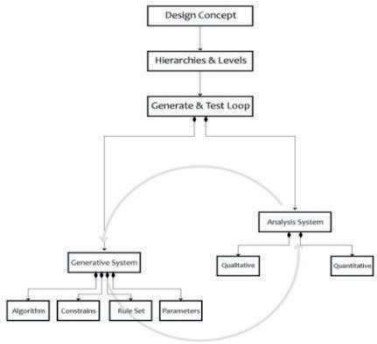


Fig.2. diagram activities of the project

The concept in the form of sketches is the fastest record of the designer's thoughts and the first attempt to link the essential components of a pr oject venture into a mutual dependence network. These dependencies were to correspond to the following parameters:

1. The layout of buildings located in such a way as to create a maximally intimate space solution with relatively high building intensity and a limited budget for construction
2. The rationalized layout of the building's functions associated with the individual zones of the plot, such as the garden, driveway, utility part.
3. Form of architecture resulting from the tradition of local architecture, and then processed in the direction of optimization and demonstration of archetypal features using the resulting language of architecture and detail. The designed architecture was to imitate or at least draw the essence of the historical traditions of single-family housing in this area, but in itself be a carrier of new values.

The layout of the building function had a direct impact on the body, while the building body was to be i mplemented in such a way as to ensure the economics of construction and to support the solution of the plan. Thus, already at the concept sketching stage, a system of rules was created that were to be applied to the project and decide on its solution. The rule set is described in the diagram below (fig.3).

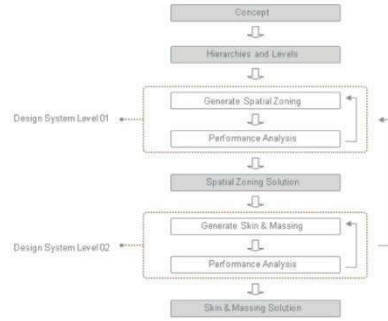


Fig.3. Rulesets diagram of the project.

In this way, the most suitable solutions for building plans were generated, and t he architectural form itself was developed. Further rules were introduced that were to have a decisive impact on the final solution of the architecture form. These rules are:

1. The roof layout of the building as a gable roof - it is the most characteristic of the existing architecture of this region and the tradition of constructing the truss of the Podlasie region. The roof span cannot exceed 7- 8m.

2. Roof carpentry systems dominating in this region are bar-tack systems. The roof span in a traditional building did not exceed 7-8 meters. Moreover, such a module was to be preserved for the roof span.

3. Roofed part of the terrace - protection against sun rays, rain, and snow.

4. The windows in the living room should be extensive glazing that opens onto the garden zone and impressive views.

5. Preparation of window openings so that they do not overlook the neighbors' plots or interfere with the neighboring plots to a small extent.

6. Using architectural detail and material properties of facade finishes as a carrier of architectural language.

7. The varied nature of the buildings adequate to the size of the plot.

8. Two-story building - day zone on the ground floor and night zone on the first floor.

The economics of construction was to be an essential factor in the form generation process. Implementation costs were an essential component in the assessment and acceptance of the final solution. The division of the investment area into smaller plots, as well as clean and geotechnical conditions, al lowed the location of two semi-detacheds and two detached houses. Moreover, here again, it was decided that due to the more impoverished location and smaller plot areas, the twin buildings as design and implementation must be developed as easy and cheap to implement, without losing any of the individuality and q uality of creative architecture. The last two plots, due to their better location and area, were laid out with different forms of expression potential. In this way created two forms of the building:

1. twin buildings,

2. free-standing buildings.

Designed according to generative rules, they retained similarities and differences.

6. House one. Twin buildings – the evolution of form

The developed building scheme presents the following features of a building form:

1. Roof to wall body proportions 2:1

2. Roof span in purlin-tick construction 7m

3. hoods and porches

4. Wooden elements as a detail

The photo below shows the shape of the house, which, in this case, is an archetype necessary to build a new expression of the form (fig.4).



Fig. 4 T raditional house in Podlasie in Poland - the archetype of architectural form in search of expression of new forms of residential architecture in a given place

The simplified model is a record of the structure of the house reduced to its most crucial recognition features. At this level, the process of evolution of the solid took place to generate its form rooted in archetype, but which is already a modern form. It was mentioned that for the design of semi-detached houses, the priority was the extent of the craft and the economic factor. How to design and then realize a building that was uncomplicated in implementation and optimally cheap while maintaining the nature of the archetype - a Podlasie country cottage, a functional program of the house, and ha ving architecture-valuing features? The architectural structure of the design was to

mean that the roof not exceeding 7m span was to remain about the wall. The walls were to keep the 2:1 aspect ratio. The glazing on the ground floor was to open onto the garden; the terrace should be roofed. The first generated family of forms met the established rules of the project. The next transformation process excluded all elements that generated additional costs from the project. The building has been simplified to the minimum necessary while maintaining the same user comfort. Economic and performance expectations were completely met, while the archetypal model was lost. The building's proportions, mainly in maintaining the size of the body walls to the roof, have been violated (Fig .5).

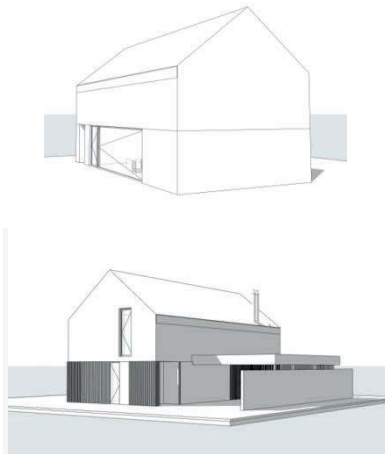


Fig. 5 Proposal of the generated form of a new typology of design architecture according to the traditional house pattern and its transformation to find harmony and proportion of final contemporary architecture

Another process of the body's evolution was the use of such detail and such finishing materials that would restore the relationship of the designed body with the established archetypal model (i.e., the typology of a traditional country cottage). The floors and roof structure were made of one homogeneous material, and the bodies of the ground floor walls from another in this way with little effort, the basic rule guiding the project was restored - this is a reference to the archetype. In space, the noticeable material division of the story of the building expressed these archetypal features and the perception of proportions. Another activity aimed at maintaining the diversity of any similar architecture was changing the material color parameter. Thus, the upper part of one of the buildings made of black sheet metal, and the upper part of the next building is made of white with a membrane - emitting the nature of another natural material which is concrete (fig.6).

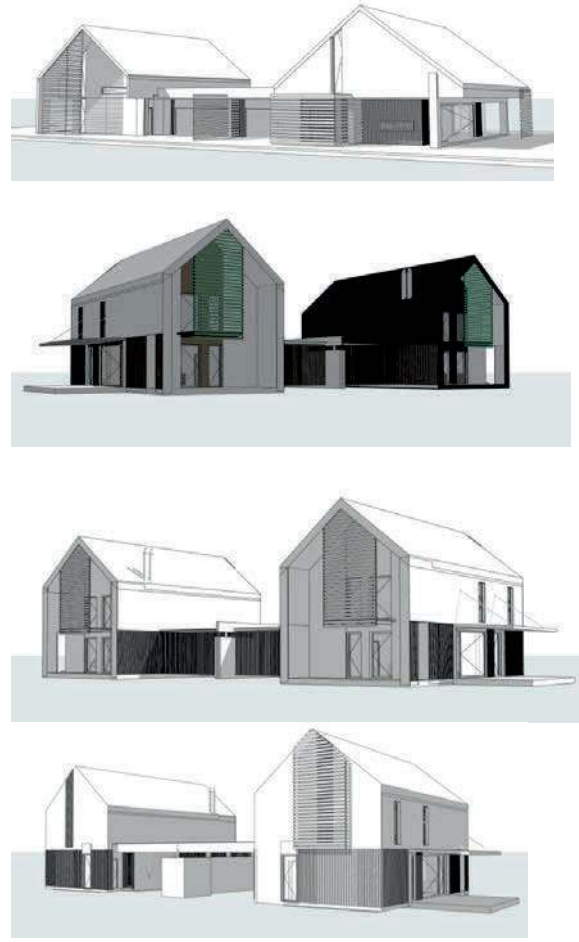




Fig.6 House 1 – the evolution of form

Additional activity in the design of this architecture consisted of hiding all building installation elements, mainly drains draining rainwater. As a result, a two-story building finished with a sloping roof in space looks as if it consisted of two independent modules.
The developed objects present the language of architecture, whose spatial and architectural solution is the result of the transformation of the house form that has always existed in this area. The generative method and structural thinking greatly assisted the design process. The system of analysis in the assessment of the imposed relationships between individual elements of architecture has allowed obtaining a cheap and easy to implement a s olution that is also distinctive architecture - complementing the tectonics of the village and indicating the almost genetic relationship of modernity with tradition. Working on t he BIM model and using generative design elements gave satisfactory, balanced, and measurable effects. At each stage of conceptual design, the project was subject to evaluation and activities that allowed for obtaining a completely satisfactory new form of native architecture.

7. House two. Detached single-family housing

According to the same principles has been designed detached single-family houses. The location on the plot was the result of an optimal location to the directions of the world, urban layout, ground conditions in the designed area. In a spatial sense, it became essential to connect buildings with the river adjacent to the plot, i.e., directly linking the recreational zones of the house with water as the greatest asset of this location. Another goal in shaping the form was the transformation of the "archetype" existing traditional house to maintain the ratio between the roof and the body of the walls in proportion 2:1. This system of proportions was to be immutable and not subject to transformation. Another factor of transformation was the use of light as an element shaping the space of the solid. The arcades were designed to protect against excessive light and precipitation.
On the other hand, they highlighted the relationship between the play of light and the solid structure. The factor determining the functional and spatial layout was a sense of security. From the side of the river, the buildings were supposed to open maximally towards the river. From the driveway side - the principle of protecting residents from external stimuli was to be kept to the maximum. T herefore, in this part of the building, airtight partitions were used, and the potential windows openings were maximally reduced.
A structural layout of the building form was created based on the following relations and dependencies:

1. Linking the localized functional areas of the house with the water surface through maximum glazing and thus extending the recreation area of the house towards the water

2. Development of the driveway side of the building as a s afe zone - reduction of possible openings to the necessary minimum, shaping of the walls of buildings ensuring a maximum sense of security and intimacy of the residents of houses

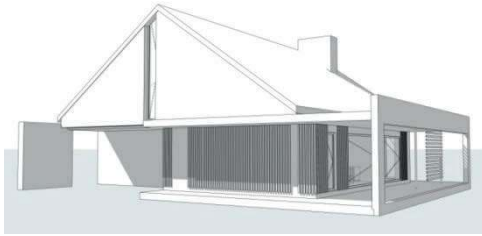
3. The solution of the roof form while

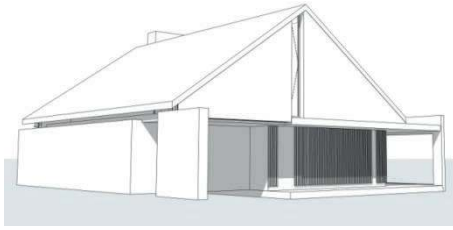
maintaining the "archetype of the house" proportion system at this point in a 2: 1 ratio

4. Light handling in shaping the building body

5. The use of detail referring to the characteristic wooden pedigree of architecture of this part of Poland, especially in the gable parts of the building

The design principles program constructed in this way was subjected to generation processes, from which two coherent and individualized forms of architecture were developed (Fig.7).





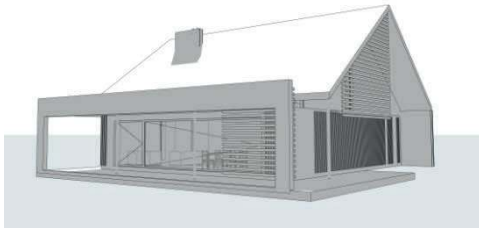






Fig.7 House 2 – the evolution of form

8. Conclusion

The designed housing estate in the context of the landscape of the village of Niewodnica Nargilewska in Poland is an example of architectural creativity resulting from conceptual processes thinking that follows the idea directly. In this case, the idea was to transform the "archetype" of a t raditional home in this region of Poland. Designing architecture in the spirit of the "pure form" of conceptual art is the creative material of this architecture. This design method

eliminates our tastes in architectural design that could cover the real sense of architecture. The sincerity of the form of architecture generated in this way results from a c onsistent, structural path of design following only the idea. The generative method is conducive to conceptual design and makes architecture designed in this way art. The architecture designed in this way results from the transformation of the original form of architecture in the process of generative design.

Designing architecture always requires giving it an idea and then doing everything so that the spatial solution is a record of evolution and, ultimately, the development of that idea.

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"A GENERATIVE ART OF OUR OWN EVOLUTIONARY TRANSMUTATION:The Art of HAROLD TERRY LINDAHL The Science of STEPHEN W. PORGES"

Topic: Objective Art, Biophysiology, Polyvagal Theory and Evolution

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Abstract
This paper seeks to influence the prolonged constitutional capacity to transform our species potential where humans remain implacably bound by Jacksonian dissolution patterns of behavior.[i] To do so, I present the science of Dr. Stephen W. Porges' POLYVAGAL THEORY in conjunction with Harold Terry Lindahl's GESTATION, HISTORY AND POTENTIAL OF HUMANKIND exhibition, which together expresses an emergence potential for realizing transdisciplinary, generative art perspectives. Since the intelligence embodied in human consciousness is obtained through brain/body connectivity, the bio-psycho-physiological processes described in Porges' and Lindahl's work indicates how the "rupture between the organs of reflection and those of decision-making in society" may become reconciled.[ii]

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Key words: *G. I. Gurdjieff, Transdisciplinary, Postformal education, autonomic nervous system, Polyvagal theory, social engagement system, vagal brake, neuroception, dissolution, psyvolution.*[3]

Main References:

[1] Susannah Hays (2019) "Nature as Discourse: Transdisciplinarity and Vagus Nerve Function" *ATLAS Journal*, Lubbock, TX
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[i] Porges, Stephen W. (2011) The Polyvagal Theory: Neurophysiological Foundations of
Emotions, Attachment, Communication, and Self-regulation, pages 161-162, 166.

[ii] See Basarab Nicolescu, et. al., for transdisciplinary moral charter
http://ciret-transdisciplinarity.org/moral_project.php

[3] *Pysvolve* is neologism H.T. Lindahl coined to express the process in which what will emerge can be sensed from what has emerged.

A GENERATIVE ART OF OUR OWN EVOLUTIONARY TRANSMUTATION: The Art of HAROLD TERRY LINDAHL The Science of STEPHEN W. PORGES

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ABSTRACT

This paper seeks to influence the prolonged constitutional capacity to transform our species potential where humans no longer remain implacably bound by Jacksonian dissolution patterns of behavior.[1] To do so, I present the science of Dr. Stephen W. Porges' POLYVAGAL THEORY in conjunction with Harold Terry Lindahl's GESTATION, HISTORY AND POTENTIAL OF HUMANKIND exhibition, which together expresses an emergence potential for realizing transdisciplinary, generative art perspectives. Since the intelligence embodied in human consciousness is obtained through brain/body connectivity, the bio-psycho-physiological processes described in Porges' and Lindahl's work indicates how the "rupture between the organs of reflection and those of decision-making in society" may become reconciled.[2]

1. INTRODUCTION

Today, the humanities are culturally and socially aware that much of contemporary science intersects the intuitive knowledge of ancient wisdom traditions. Due to this materialization of common ground, school curriculums around the globe are being pressured to move beyond the limitations of metaphysical "training-wheel" explanations with embodied experiential practices in order that bio-psycho-physiological skills may evolve communicative adaptive processes, liberating perfunctory habits.[3] At its core, this development of human consciousness depends first on informing and then assisting, through daily practice, an intentional 'work on one's self' by which predictable dissolution response patterns may engage higher, more recently evolved neocortical functioning.

The vagus nerve, an integral structure in the phylogenetic shift in brain-body communication plays a central role in the reception and transmission of signals that chemically and electrically regulate the autonomic nervous system that ultimately raise normative levels of being.[4] This paper brings a generative model for evolving human functioning. In other words, if knowledge and participatory modes of inner, bio-psycho-physiological adaptation processes engage our phylogenetic past, the human species may learn to nurture their latent psychic, neocortical potential and evolve beyond somatic survival instincts.

2. Bringing 20th Century findings into 21st century action

I first came in touch, in 1993, with the esoteric principles of G. I. Gurdjieff in San Francisco, through architect and artist Harold Terry Lindahl.[5] In 2009, I joined Lindahl's Intropy=Entropy Institute project that aims to prepare the way for 21st Century educational transformation. My doctoral work, completed at the University of California at Berkeley in 2016, synthesized Transdisciplinary educational objectives with Lindahl's 2011-2017 Darwin, Einstein, Gurdjieff Ergodic Diagram, (which Fig. 1 d evelops further) and Stephen W. Porges' 1994 POLYVAGAL THEORY.[6]

Since Generative Art is an advanced approach to creativity, it's appropriate for me, in the context of the 2019 GA Rome Conference, to introduce Porges' science in relation to Lindahl's paintings and sculpture, which axiomatically "informs science of religion and religion of science,"[7] making a 21st century turn accessible to what Gidley calls "Postformal education."[8]

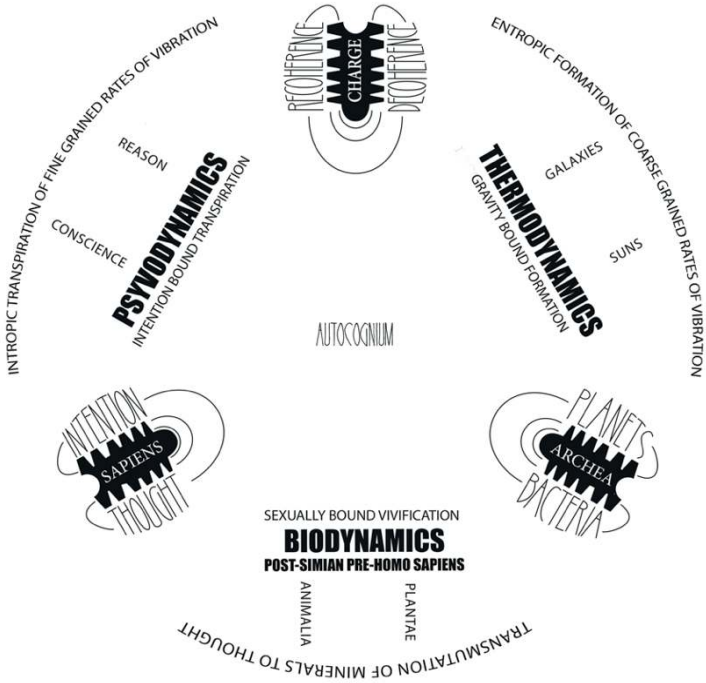
H.T. Lindahl's TRIADIC ERGODIC CYCLE OF PHENOMENA

FIG. 1 FUNDAMENTAL FORMATION-VIVIFICATION-TRANSPIRATION DIAGRAM

Involutionary *granularity feeds on the intropy generated from collisions.* ***Evolutionary*** *biology feeds on the intropy generated from the digestion of minerals and atmosphere.* ***Psyvolutionary*** *Homo-hypnons feed on the intropy generated from the digestion of the impressions of their profligate emotional survival instincts.*[9] *(Lindahl, 2019)*

3. Rectifying the Human Predicament

As Porges' science provides a pragmatic guide as to how our moving-motor, thinking and emotional centers bi-directionally regulate autonomic functioning, Lindahl's objective art visually signifies the nature of our species morphogenetic, evolutionary potential within a complex, systems view that includes a cosmological perspective. While Polyvagal theory depends on accumulated knowledge, **Pensive and**



Vigilant (Fig. 2) visually describes the phylogenetic conduit in vertebrate autonomic nervous systems where vagal pathways are communicating with brainstem source nuclei and contributing to the emergent properties of higher brain areas and bodily feelings, wherein the human social engagement system of "looking in" and "looking out" assists regulation of visceral states of being.[10]

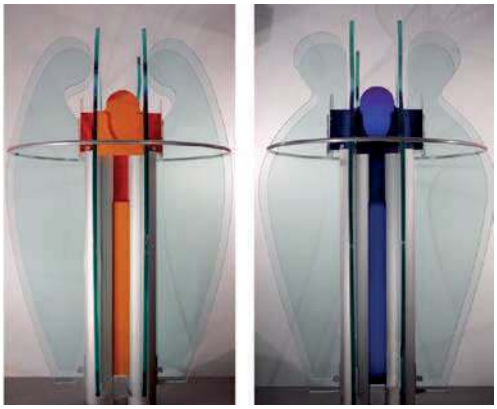


Fig. 2 ***Pensive and Vigilant*** *Two 9' high by 5' diameter aluminum core sculptures with eight 1" thick, 3-ply laminated glass wings and back-lit color plexiglass core symbolizing the relation between Sympathetic and Parasympathetic functions of the Autonomic Nervous System. H.T. Lindahl (2016*

In **Pensive** and **Vigilant**, the Sympathetic ephemeral glass wings positioned relative to the Parasympathetic vivid core are a leitmotif for the Autonomic Nervous System. As energy potentially *enervates* (expends) or *innervates* (vivifies) through the digestion of light, air, and food, our visceral organs support the ultimate transpiration of our experience of the biosphere to solar realms.

Sensitive to afferent influences, characterized by an adaptive reactivity that is 1) dependent on the phylogeny of the neural circuits that 2) interacts with source nuclei in the brainstem and 3) regulates the striated muscles of the face and head, a horizontal ring, placed at the vertical golden mean between the osmotic divide of our somatic instincts, points to where human potential meets the obligatory "return" vibrations that *separate the fine from the coarse*, as foretold in the Hermetic Emerald Tablet (Lindahl, 2019)[11]

4. Psyvolving Post-Simian Pre-Homo Sapiens through alchemical means

If generative art is defined as the artist discovering a way to apply experiential, intuitive or theoretical research as it addresses meaningful actions that are not only specific to exhibiting, but where viewers discover 'ideas' with the intention of self-reflection within the culture they live, Lindahl's art sets in motion a thought-provoking expression where his objective aesthetic unquestionably aspires to our species universal anagogical ache—that is: *our inherent wish to evolve toward a higher state of reconciled Being.*

In his installation ***Gestation, History and Potential of Humankind***, Lindahl provides a Phylogenetic Index (Fig. 3) that orients viewers toward Porges' scientific basis that empirically clarifies the different functions of two medullary source nuclei of the vagus and the mammalian modifications of our evolutionary heritage, a past that continues by *natural default* to provoke humans to live as defense machines.[12]

Herein lies the human challenge: to be self-consciously aware, while maintaining a feeling for the flux of sensations as we make the effort to engage the largely infrequent reminders of neocortical functioning. This (ego) treacherous evolutionary line between Post-Simian and Pre-Homo sapiens is the tempering crucible where the reptilian and mammalian brain may learn to, in Porges words "repurpose their functioning"[13] or in Lindahl's account, intentionally redistribute or "psyvolve from mammalian somatic mental organs to our innate, yet latent psychic mental properties of conscience

and reason—a refinement process unique to humans"(Lindahl, 2019).



Fig. 3 ***Phylogenetic Index*** *indicating seven aspects of seven octaves, India ink on Arches watercolor paper (Lindahl 2018-2019).*



Fig. 4 ***Gestation, History, and Potential of Humankind*** *told in seven octaves of seven aspects: seed, native virtue, indulgent, searching, school, listening, and psyvolving man. 49 India ink 11.25"x15.5" plates (Lindahl, 2019)*

5. A Generative Art of Our Own Evolutionary Transmutation

In his chapter *Vagal Pathways: Portals to Compassion* (2017), Porges proposes compassion is an em ergent process dependent on one's neurophysiological state. Consistent with this perspective, impartial conscience and objective reason cannot be investigated as a voluntary behavior or a ps ychological process independent of physiological states of being. This emphasis on s hifting physiological state via vagal mechanisms to experience higher normative levels of attention and intention are also consistent with the history of ritual sacred practices in contemplative training—what I refer to as a generative art of our own (individual by individual) evolutionary transmutation.[14]

As previously stated, the vagus is a cranial nerve that innervates all the visceral organs and provides the major bidirectional (motor and s ensory) communication between the brain and the body. A component of the parasympathetic branch of the autonomic nervous system, an important function of the vagus is specifically to inhibit the reactivity of the sympathetic branch of the autonomic nervous system, evolving a sensory pathway between the body and the brain. If Porges' study emphasizes the dependence of compassion on a vagal-mediated state that supports feelings of safety, which enables feeling one's own bodily responses at a given time, while acknowledging the bodily experiences of another, Lindahl's art expresses further that the individual, from gestation to Sapiens exists within a latent, *psyvolving* potential, that attends ultimately, in a vital way, to the flux of elements in the cosmos.

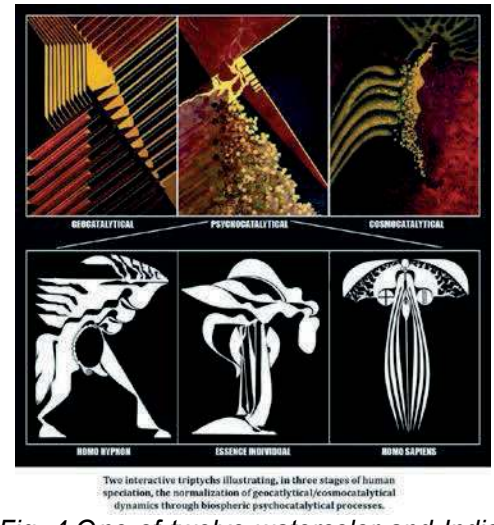
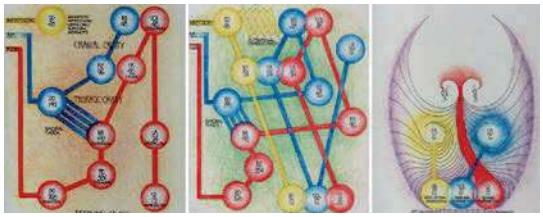


Fig. 4 One of twelve watercolor and India ink panels (8' by 9') symbolizing six

interactive explanatory and pr edictive psyvolutionary stages of human evolution within cosmological processes that act to normalize the temperature differential between the sun and outer space. In the van of biospheric tempering, the psycho-catalytical crux, which refines thought from minerals, sustains intropy/entropy invariance (Lindahl, 2019).



Socialized Vertebrate
Essence Individual
Conscience Being

Fig. 5 ***CHEMISTRY DIAGRAM:*** *Organic life obtains by means of the ingestion/digestive refinement of substances on a scale of vibrations from iron to oxygen to reason. (involutionary=iron, evolutionary=thought, psyvolutionary=reason). Human life is fueled by the digestion of minerals, air and the senses. These three foods are processed by three sets of intestines, the small, the alveolar and the cerebrum. As these foods enter beings, digestive processes separate the fine nutrients from coarse materials. From minerals and air the body manufactures the substances able to reproduce itself (SOCIALIZED VERTEBRATE) and then 'die.' The food of the senses is registered but the organs for their digestion are dormant—latent potential. The practice of first conscious shock initiates the digestion of the finer particles of the air and the sense impressions, and manufactures within the vertebrate an ESSENCE INDIVIDUAL. The practice of second conscious shock fully awakens the digestion of the finer nutrients of the sense impressions and from an es sence individual manufactures the substance, COHERENT CONSCIENCE. And from impressions of coherent conscience, the substance COHERENT REASON. These finer substances 'die' in their own time* (Lindahl, 2011).[15]

5. Human Potential

As the seven octaves symbolize, humans are a phe nomenon of nature whose pysvolutionary potential is both immanent and imminent (Lindahl, 2019). Having studied Gurdjieff's food diagrams, Lindahl's art illustrates in three stages how food, air, and i mpressions of the world of sunlight are automatically refined to the information-processing vibration rate for somatic self-reproduction. For the digestion of impressions to occur, however, only a pot ential exists through intentional effort. Energy must vibrate at a rate sufficient to reproduce its somatic host, and by extension, conduct the vibrations necessary to refine somatic emotions and thought to the ergodic fulfillment vibration rate of impartial conscience and obj ective reason, as indicated in Fig. 1.

6. Conclusion

Has science ever shared as direct a relationship to art and living traditions abiding to the human spirit as it does today? For the 21st Century, this short paper outlines how an evolutionary, phylogenetic, axiomatic understanding can prepare, via transforming values, a more self-evident approach to the evolution of consciousness. Always different in action, individual by individual, the process carries a predictable, universally true, default system. It is the hope of the author, the artist and scientist, whose work I have cited for their inspiration, that we as artists and educators directly answer the broad and complex challenges that Integral educators around the globe seek to transform via educational practices. As Jennifer Gidley, *President of the World Futures Studies Federation* (UNESCO and UN Partner) questions in her book Postformal Education: A Philosophy for

Complex Futures (2016) we all might ask: *"If higher-order, more complex forms of cognition do exist, how can we better educate children and young people so that more mature forms of reasoning appear at the appropriate life stages?"*[16] Since instinctual aspirations of science, art and living sacred traditions are presently transitioning through parasympathetic dynamics (from the predominance of our primitive instincts to civilizing "return" dynamics), humans, must develop bio-psycho-physiological skills so that autonomic nervous system functioning may locate the source of finer vibrational energies that would evolve coherent conscience from emotional associative patterns and cogent reason from desultory thought (Porges,1994; Lindahl, 2017).

To serve humanity and t he cosmos this guidance prepares our way.



SUSANNAH HAYS MFA, Ph.D. is a fine art photographer and educator whose philosophical approach to image-making contributes to her understanding of the human predicament. By way of Nature's Discourse: A Co-Evolutionary Systems Approach to Art and Environmental Design (U. C. BERKELEY, 2016) and Nature's Discourse: Transdisciplinarity and Vagus Nerve Function (ATLAS, 2018), she joined Dr. Porges at Cape Cod Institute in August 2019 to discuss the biological and moral imperative for Humanity programs to instill the necessary curricula to responsibly transform our somatically pressured autonomic nervous system so that our higher, more recently evolved neo-cortical psychic energies may refine and adapt our latent (largely dormant) human potential.



HAROLD TERRY LINDAHL now in his late eighties, was in his day, a modernist Architect, in the Frank Lloyd Wright tradition of Organic Architecture. Having studied the geometric base of art and architecture at the University of Oklahoma in the 1950s with Bruce Goff, he pursued his "Light-Color-Space-Form" watercolor studies in 2008 and developed ***The Gestation, History, and Potential of Humanity*** as recently as 2018. Fascinated with geometric order and metamorphic form-generation through systematic variations and modulations, his black and white studies became color-filled triptychs influenced by the cosmology of George Ivanovitch Gurdjieff, the Greek-Armenian philosopher and esoteric teacher and his teacher Lord Pentland, in New York and San Francisco from the late 1960s to the 1980s.

STEPHEN W. PORGES Ph.D. is Distinguished University Scientist at the Kinsey Institute, Indiana University and Professor of Psychiatry at the University of North Carolina. He is a neuroscientist working at the intersection of behavioral, clinical and bioengineering strategies. His investigations of the evolution and expression of human autonomic psychophysiology has become a wellspring advancing the theories and practices of multiple disciplines and human service fields of practice. Since 1994, when Dr. Porges announced the basic concepts, POLYVAGAL THEORY has been adopted and used productively in a wide array of psychological and somatic clinical practices. The theory is bringing alive the profound significance of our evolutionary neural organization in daily psychological and relational processes.

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[2] See Basarab Nicolescu, et. al., for transdisciplinary moral charter http://ciret-transdisciplinarity.org/moral_projet.php

[3] To heal the split between theory of knowledge and embodied phenomenological experience an individual pursues the engagement of physical sensori-motor experiences where mind-body cognition emerges from a phylogenetic/ontological matrix, such as the cognitive and functional effects of meditation on body-brain circuits or vagal exercises such as vocalization and breathing exercises.

[4] See Hays, Susannah: “Nature’s Discourse: Transdisciplinarity and Vagus Nerve Functioning” (ATLAS journal, 2018).

[5] George Ivanovich Gurdjieff (1866-1949), was an influential early 20th century Russian philosopher, and composer of Armenian/Greek descent. John Pentland, appointed by Gurdjieff to lead ‘the work’ in North America, was Lindahl’s teacher.

[6] Hays, Susannah (2016) “Nature as Discourse: A Co-Evolutionary Systems Approach to Art and Environmental Design” © U.C. Berkeley.

[7] See H.T. Lindahl, (2017) The Harmonics of Unity: Endogenous Semiotics of the Vagus Pineal Gyre, Trioctave Editions.

[8] Gidley, Jennifer (2016), Postformal Education: A Philosophy for Complex Futures, p.2.

[9] Diagram from H.T. Lindahl’s *Program Initiative* published by The Intropy=Entropy Institute San Francisco, CA 2019; page 5, which has gone through a number of reiterations since 2011.

[10] Porges, Stephen W., *The Polyvagal Theory: New insights into adaptive reactions of the autonomic nervous system;* 2009. Online Link:

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3108032/

[11] In Lindahl’s Harmonics of Unity expository treatise, he integrates the alchemical knowledge of ancient gnostic wisdom traditions with contemporary science.

[12] See Porges, Stephen W., July 1995 “Orienting in a defensive world: Mammalian modifications of our evolutionary heritage. A Polyvagal Theory” https://doi.org/10.1111/j.1469-8986.1995.tb01213.x

[13] Porges, Stephen W. (August 7, 2019) unpublished recorded conversation at Cape Cod Institute in Massachusetts, page 3.

[14] Porges, Stephen W. (2017) Chapter 15: *Vagal Pathways: Portals to Compassion*, The Oxford Handbook of Compassion Science. Oxford University Press p.189-202.

[15] See Selz, Dr. Peter and H.T. Lindahl in conversation with Susannah Hays, Berkeley California, April 12 & 25, 2011, page 16. Chemistry diagrams are hand-drawn by Lindahl, after Gurdjieff (see Ouspensky, P.D. In Search of the Miraculous, Fragments

of an Unknown Teaching, Chapter 9).

[16]Gidley, Jennifer (2016), Postformal Education: A Philosophy for Complex Futures, p.2.



LATHER RINSE REPEAT:
THE ITERATIVE PRACTICE AND PEDAGOGY OF HAIR CLUB
(Paper)

Topic: Art & Pedagogy

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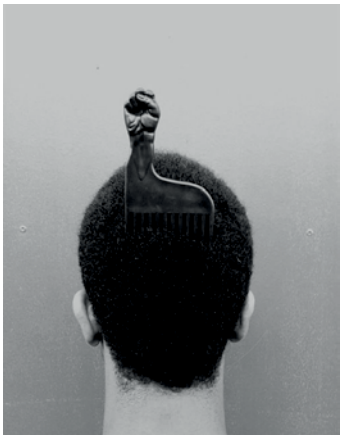
Abstract
HAIR CLUB is an interdisciplinary research-based art collective whose work is centered around the multivalent topic of HAIR in culture. Co-founded in Chicago in 2014 by Suzanne Gold, Kelly Lloyd, and Michal Lynn Shumate, HAIR CLUB operates as a platform for discussion, dialogue, research, exhibition, and publication. The founders of HAIR CLUB are artists, scholars, and educators, committed to rigorous academic inquiry in concert with the indelible mark of the anecdotal.

HAIR CLUB's ongoing collaborative work stems from a study of hair as a vehicle for meaning in contemporary art, art history, and culture. Through the development of Hair-based curricula for community workshops and internationally accredited university courses, we have developed systematic ways of cataloguing and harnessing personal narratives related to hair. By stewarding narratives that touch upon issues of identity, ethnicity, spirituality, and culture, we have formed a socially-engaged methodology which we use as the foundation for an emerging discipline.

With the singular, continually generative subject of Hair at its root, HAIR CLUB practices a pedagogy and mode of inquiry that is both expansive and iterative. Considerations of the issues that Hair raises – of care and cruelty and symbolic meaning and identity – are carried out across fine art and popular culture, across material, visual, and literary texts, across wide geographical and chronological strata: yielding new images, perspectives, and juxtapositions with each inquiry.













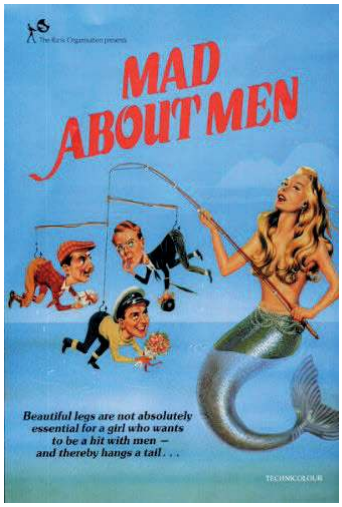

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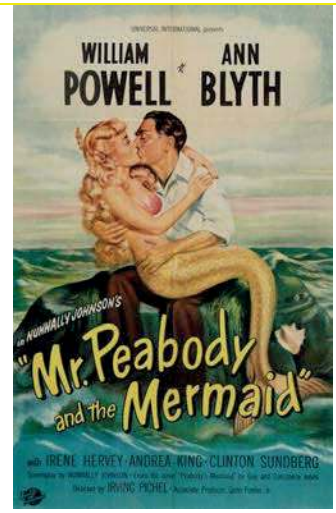





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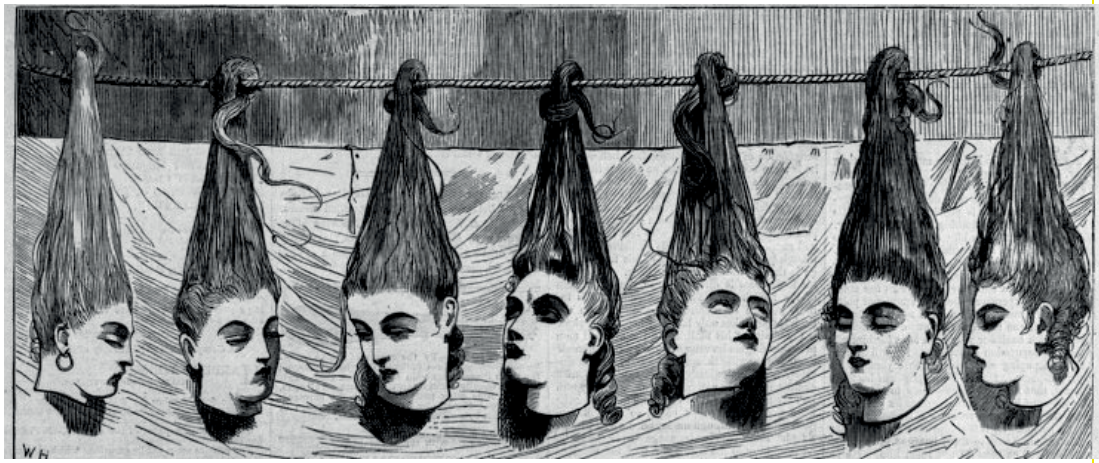

MAD ABOUT MEN
Beautiful legs are not absolutely essential for a girl who wants to be a hit with men — and thereby hangs a tail. . .
TECHNICOLOR




WILLIAM POWELL
ANN BLYTH
"Mr. Peabody and the Mermaid"
with IRENE HERVEY · ANDREA KING · CLINTON SUNDBERG




Il copricapo degli eroi omerici
Da G. Ferrario, Il costume antico e moderno, Firenze 1828



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Key words: hair, pedagogy, art, design, literature

Main References:

[1] “HAIR CLUB: Towards a Hair Studies Discipline,” *Socially Engaged Art History and Beyond: Alternative Approaches to the Theory and Practice of Art History*. Edited by Cynthia Persinger and Azar Rejaie. London: Palgrave Macmillan, forthcoming 2020.

LATHER RINSE REPEAT: THE ITERATIVE PRACTICE AND PEDAGOGY OF HAIR CLUB

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Abstract

HAIR CLUB is an interdisciplinary research-based art collective whose work is centered around the multivalent topic of HAIR in wider culture. Co-founded in Chicago in 2014 by Suzanne Gold, Kelly Lloyd, and Michal Lynn Shumate, HAIR CLUB operates as a platform for discussion, dialogue, research, exhibition, and publication. The founders of HAIR CLUB are artists, scholars, and educators, committed to rigorous academic inquiry in concert with the indelible mark of the anecdotal.

HAIR CLUB's ongoing collaborative work stems from a study of hair as a vehicle for meaning in contemporary art, art history, and visual culture. Through the development of Hair-based curricula for community workshops and internationally accredited university courses, we have developed systematic ways of cataloguing and harnessing personal narratives related to hair. By stewarding narratives that touch upon issues of identity, ethnicity, spirituality, and culture, we have formed a socially-engaged methodology which we use as the foundation for an emerging discipline.

With the singular, continually generative subject of Hair at its root, HAIR CLUB practices a pedagogy and mode of inquiry that is both expansive and iterative. Considerations of the issues that Hair raises – of care and c ruelty and symbolic meaning and identity – are carried out across fine art and popular culture, across material, visual, and literary texts, across wide geographical and chronological strata:

yielding new images, perspectives, and juxtapositions with each inquiry.

Key words: hair, pedagogy, art, design, literature

Introduction

HAIR CLUB practices a pedagogy and mode of inquiry that is both expansive and iterative. [Figure 1] In this chapter we would like to elaborate on one topic that has blossomed specifically due to our iterative and social treatment of it: The Mermaid. This topic is discussed briefly in a case study on the emerging discipline of Hair Studies for *Socially Engaged Art History and Beyond: Alternative Approaches to the Theory and Practice of Art History* (2020) and was developed in part for a conference paper, “Wet Hair: Visual Culture of the Mermaid” for Liverpool’s Centre for Port and Maritime History Conference: Art and the Sea (September 2019) and we are pleased to expanded on its findings here. [1] What was initiated in a HAIR SALON conversation about wet hair became a lecture, a syllabus module, and a multivalent research vector into the nineteenth-century origins of our contemporary understanding of the mermaid as equal parts aspirational magic creature, anti-feminist trope, and queer allegory.

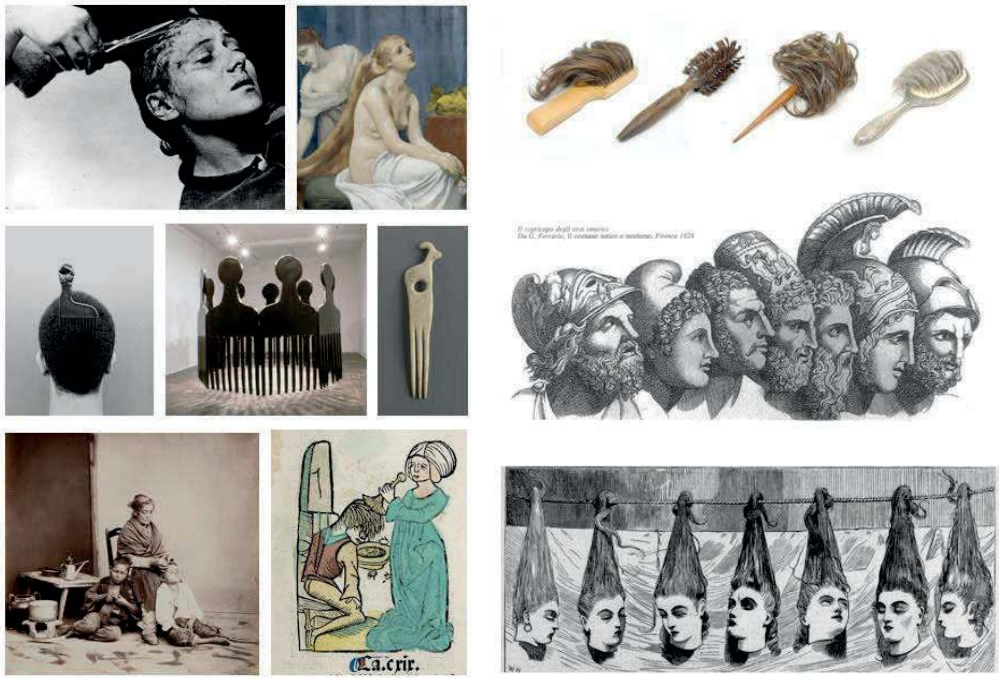


Figure 1. Collage of iterative research vectors as represented in various HAIR CLUB lectures and syllabus modules. Left: still from The Passion of Joan of Arc, 1928; Pierre Puvis de Chavannes, Woman at Her Toilet, 1883, Musée d'Orsay; Black Panther afro pick, photo credit @SonofBaldwin, 2018; Kori Newkirk, Legacy, 1999, polyurethane foam, pigmented resin and brackets, 74” x 100”; ivory Egyptian comb of the Predynastic Period, Boston Museum of Fine Art; photograph of de-lousing scene from nineteenth-century Naples; de-lousing scene from medieval woodcut. Right: Agustina Woodgate, Brush Series,

2007; "Il copricapo degli eroi omerici, Da G. Ferrario, Il costume antico e moderno, Firenze 1828"; nineteenth-century Bluebeard story illustration.

Wet Hair: Mermaids

We happened upon mermaids almost by accident in a 2014 conversation about wet hair, about how hair's wet state is central to hair care logistics as the way that many of us wash and cut our hair. But just as central is the need to then dry your hair because wet hair is inappropriate (very disrespectful to go out like that!) and dangerous (you'll catch pneumonia!). Wet hair is inappropriate because it's so intimate, because it implies bathing and all other connotations of the private, bodily realm. And it was in this discussion that an attendee pointed out that mermaids' hair is always wet.



Figure 2. Collage of siren/mermaid evolution as described in Milliken's 2012 book and collected to facilitate student participation and discussion. Left to Right: Besançon, BM MS 69, Rouen, before 1498; Luttrell Psalter, c. 1325-1340, British; British Bestiary, 15th century; Diego Gutierrez, Map of the Americas (detail), 1562; Greek Attic Red Figure Stamnos, c.480-470 BCE, British Museum; Ashmole Bestiary, c.1170; Noah's Ark, Anton Koberger, Nuremberg Bible, 1483, German; Bodleian Library, MS. Bodley, 602, folio 10r.

Around the same time, we had picked up Roberta Milliken's *Ambiguous Locks: An Iconography of Hair in Medieval Art and Literature* as part of research into the hirsute depictions of Mary Magdalene, and came across a short chapter on "Sirens and Mermaids." [2] Milliken traces the development of the siren into the mermaid during the medieval period: from sky-creatures carrying musical instruments to feminized water-dwellers equipped instead with combs and mirrors. This transformation was due in large part to the adaptation of the siren figure by the church:

> Early on, church authorities identified the siren – both the image of her as well as the stories that surrounded her – as having a significant metaphorical value that was therefore didactically useful. They therefore recycled the mermaid to serve their own purposes, namely to teach basic important Christian morals. In the church's hands, the siren came to represent the lure of sin. And since the siren was female, that temptation to sin naturally involved lust… Whereas the siren was considered a knowledgeable demigod, the mermaid was then flattened into the image of yet another remarkably lustful feminine creature to be avoided because she was sinful and may tempt men to sin. [3]

Hair features prominently in this shifting iconography, with the mermaid's long, prominent locks remaining a visual trope today. The topic of wet hair and mermaids as understood in Milliken's genealogy was presented in a conversational lecture and further developed in the discussion following.

Not long after, we began teaching the interdisciplinary studio/seminar *HAIR! HAIR! HAIR!* at Oxbow School of Art in Saugatuck, MI and later Humboldt University in Berlin, in which we consistently assigned Milliken's chapter on mermaids. Because the publication itself only includes a couple images, we began to compile files of Greek vases, medieval manuscript marginalia, and early modern maps to be able to illustrate the pieces of her argument and open up discussion once we were all together in class. [Figure 2] In an affective, rather than strictly art historical way, we worked with students to consider these different iterations in the visual transition in bodies and in accessories, from bird women with musical instruments to fish women with a comb and mirror.

Among other avenues, the mermaid helped students think through how tropes and accessories and hybrid forms might be employed to visual effect in their own work. Students took to the mermaid quickly and incorporated its themes and visual culture in their work; their enthusiasm was infectious and the mermaid became an ongoing research vector.

Filmic depictions of the mermaid have dominated the twentieth-century's visual culture, with Ariel from Disney's *The Little Mermaid* (1989) becoming an iconic representation for American audiences. There was of course also *Splash* (1984), part rom-com, part buddy comedy from the same decade that in turn has its own precedents in a series of romantic comedies such as *Miranda* and *Mr. Peabody and the Mermaid*, both from 1948, and *Mad About Men* from 1954. In all of these iterations, the approach is by no means feminist but the mermaid is at least an actual distinguishable character. But the protagonist or co-protagonist mermaid with a heart of gold is more the exception than the rule. As exemplified in Disney's 1953 animated *Peter Pan* and it's 1924 silent, live-action precursor, mermaids are not portrayed as individuals but rather as one of many in an exotic species. In later iterations of Peter Pan, including *Hook* (1991) and by extension the similarly-themed series *Pirates of the Caribbean* (*On Stranger Tides*, 2011), the mermaid is part of an anonymous side show that is above all things overly sexual, while managing to be both completely silly and quite dangerous. From 1924 to 1953 to 1991, this silliness or vapidness manifests in tropes that we are now all familiar with: the gestures of waving, especially enthusiastic waving at men; in primping generally and combing their long hair in particular. It is only in *Pirates of the Caribbean* and in an earlier Odyssey adaptation, *O Brother, Where Art Thou?* (2000) that the siren song is featured, and in both instances it is used to emphasize the mermaid as an essentially dangerous set-dressing or plot interlude.

In these first iterations of the mermaid syllabus module, we tended to gloss over the nineteenth-century in the visual culture timeline, treating it as a kind of bridge between the medieval solidification of the dangerous lusty fish-lady with her comb and mirror and the more familiar twentieth-century mermaid. The Pre-Raphaelite painters were always featured due to their industrious production of dead-eyed naked water-women, but we had presented the period as a continuation of Milliken's thesis, rather than a break from it. What we were missing in skipping across the nineteenth-century was the deep ambiguity that is inherent to understanding the mermaid in

contemporary culture, which driven in large part by the importance of hair in Victorian culture.

In recent years, it was current events that brought the mermaid and specifically the nineteenth-century back into focus: The end of 2017 saw the publication of Emily Wilson's translation of Homer's *The Odyssey*. [4] Her uniquely lucid style (the first translation into English by a woman) shed light on ho w twentieth-century translators have embellished and gendered the siren, and in turn, how this kind of creative license can be seen starting only in the mid-nineteenth-century, once the water woman craze is in full swing and the language becomes more gendered, with word choice emphasizing *lips* over *mouths*, for instance. Wilson herself posits that the Victorian preoccupation with mermaids could be the result of this, but there's still much more detailed work to be done.

Just last year, John William Waterhouse's *Hylas and the Nymphs* was removed from Manchester Art Gallery as part of a feminist museology project by artist Sonia Boyce, and then promptly returned following public outrage. [5] Later that summer, Waterhouse's *The Siren* was auctioned off at Sotheby's for more than £3.8 million. The auction catalogue discussed the removal and re-installation of *Hylas and the Nymphs*, using it as a launch pad to argue that "rather than subrogating women or casting them as dangerous and untrustworthy, these pictures are enigmatic" :

> The subtle eroticism in *Hylas and the Nymphs* inspired Waterhouse to paint a s eries of depictions of female water deities, including *A Mermaid* of 1900 (now in the collection of the Royal Academy of Art) and finding its most powerful resolution in *The Siren* of 1901 which will be offered in the sale of Victorian, Pre-Raphaelite & British Impressionist Art on 12 July. Rather than subrogating women or casting them as dangerous and untrustworthy, these pictures are enigmatic and we are unsure what the intentions of these women are. In *The Siren* the pale maiden looking down at the drowning sailor has an expression of curiosity rather than murderous appetite and it is just as likely that she may at any moment hold out her hand to help him from the surging torrents, as push him under to a watery grave. [6]

Enigmatic woman certainly sells better than 'dead-eyed non-human' but in considering scholarship on women's hair in Victorian art and l iterature, this more fluid nature of the mermaid gains some credence:

> More intensely and self-consciously than any other generation of artists, [Victorian painters and writers] explored the symbolic complexities and contradictions of women's hair, at the same time developing and deepening its multiplicity of meaning. For them, Arachne, whether she spun a web of flax or hair, was an intriguingly ambiguous figure: victim and predator, trapped and trapper, Penelope and Circe, angel and mermaid. [7]

However, the most prominent re-emergence of the mermaid in popular culture came with the hashtag #NotMyAriel trending on Twitter in July of 2019 in response to Disney's selection of African American actress Halle Bailey to play Ariel in their live-action remake of the 1989 animated classic. [8] Just as immediate was an outpouring of fantastic fan art celebrating Bailey, and it only took

a couple days for queer and literary focused platforms to inform (or remind) the rest of the internet that: my friends, if you're bent out of shape about a woman of color playing the little mermaid, just wait till you hear about Hans Christian Anderson. As discussed in a 2016 article by Maddy Myers,

> "The short story, which was published in 1836, lines up with a series of love letters that Andersen wrote in the mid-1830s to a young Duke named Edvard Collin. Many historians have concluded that the two men were engaged in a romance, rather than just a platonic friendship; their adoring correspondence in letters lends credence to this interpretation. Much like the Prince with whom the Little Mermaid falls in love, Edvard Collin also faced pressure from his family to marry a princess. Anyone who has read Andersen's original short story remembers the heart-wrenching conclusion, in which the Prince chooses to marry a princess rather than the mermaid." [9]

And so not only was the original author likely a queer person, but the entire story speaks to the queer experience (or at least *a* queer experience) – of being silenced and of existing between worlds. Sacha Coward, the Community Participation Producer for the National Maritime Museum in Greenwich and self proclaimed 'mermaid hunter,' has produced various media and events in the past couple years to bring these stories to the forefront. Of particular interest to this perspective are his writings that point to queer literature and artistic production from later in the nineteenth-century, including Oscar Wilde's short story *The Fisherman and His Soul* (1891), a mirror narrative of sorts to *The Little Mermaid* which Wilde stated was directly inspired by Anderson's original story.

Without these important elements, i.e., without a research practice that involves exhaustively examining through multidisciplinary means every iteration of the mermaid in history, art history, and culture, HAIR CLUB's formulation of the mermaid might have remained interesting but somewhat simplified, seen only through the anti-feminist tropes of hand-waving and hair-combing. With these iterative, social investigations the mermaid blossoms also into queer allegory and vehicle for projection of identity, in addition to protagonist with a heart of gold or overly-sexual anonymous side show.

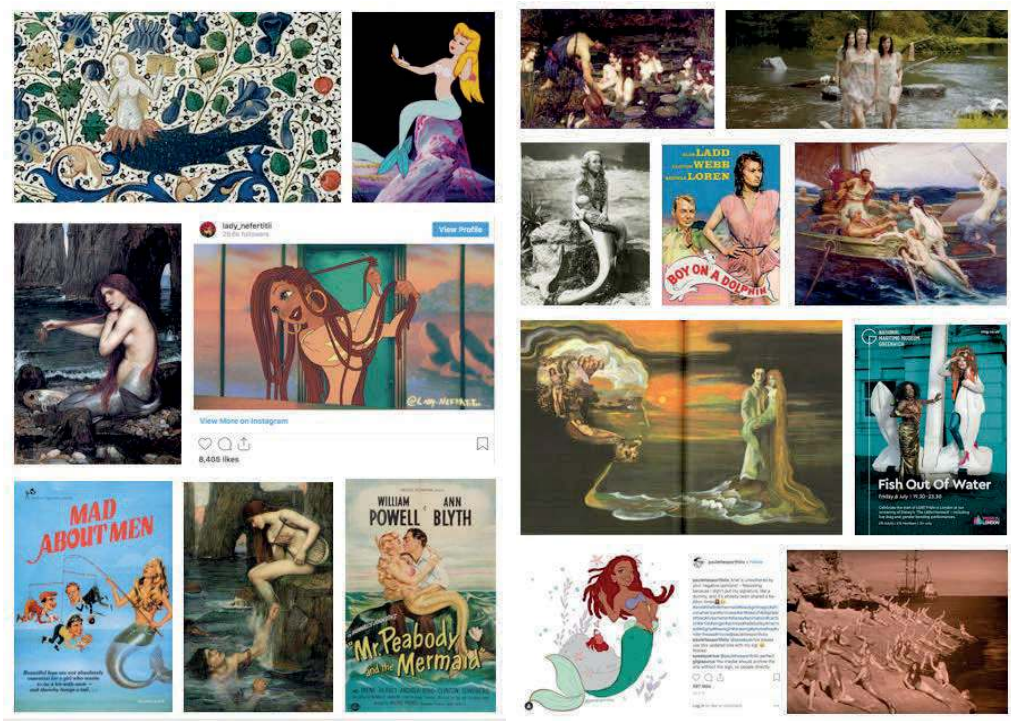


Figure 3. Selection of thumbnail images that speak to the iterative nature of HAIR CLUB's research into contemporary mermaid visual culture.

Conclusion

The mermaid and its meandering, ever expanding path through the last couple millennia of western visual culture (one canon among many) has much to teach us. But the approach to the subject is as important as the subject itself. [Figure 3] We close here with HAIR CLUB's statement on the development of a Hair Studies discipline:

> HAIR CLUB's expansive, associative, and iterative methodology for examining how Hair is performed and how it achieves metaphorical meaning in art, history, and wider culture, has led to the development of an academic discipline that defies genre, category, and discrete definition. Hair Studies relies at its root on a process of socially-engaged, socially-driven, and socially-minded inquiry, where the anecdotal is processed with the same power of place as more traditional, disciplinary research practices. The historically significant, the ritualized, daily, inhabited, and pre-determined conditions for having hair in society broadens our understanding of what it means to be ba sically, meaningfully human. [10]



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Using the inka's calculator for generative art (Paper)

Topic:
Generative art, etnomatemathics, music

Author(s):
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Abstract
The yupana is the ancient abacus used by inkas to make calculations. It was first described by Juan Poma de Ayala in 1615 and r ecently by Radicati di Primeglio, Fiorentino and Florio. They agree that the yupana computes numbers using decimal notation and t he Fibonacci's sequence. But I will follow the interpretation of peruvian researcher Davhit Prem (yupanainka.org), that explains how to use the yupana with more simplicity and speed. In this paper I will first present a br ief explanation of the theory, supported by a digital model I developed during this research. Then I will present some ideas and suggestions about the creative possibilities of the yupana for generative musical creation.
The characteristics of the yupana is the algorithm that allows sums, subtractions, multiplications and divisions using a simple set of movements, like in a chess game. The yupana can also be compared to Turing Machines and finite state automata.
The blend of topology and movements is of the greatest interest for generative art and music. The yupana can be modified to represent scales of different types, movements can be used to compute intervals and chords and movement rules can generate structures of great complexity. All these assets offer new formal solutions that improve generative techniques usually grounded on generative grammars, fractals or Cellular Automata.

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Key words: etnomatemathics, music, generative grammars, yupana

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Using the Inka's Calculator for Generative Art
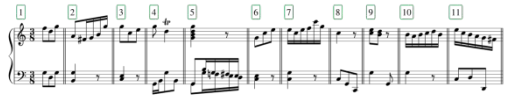
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Abstract
The yupana is the Inca's abacus. It was first described by Juan Poma de Ayala in 1615 and recently by Radicati di Primeglio, Florio and Urton. So far, nobody is absolutely sure about how worked the yupana's computational system. In this paper I will present the theory of Peruvian researcher Davhit Prem, because it is the most efficient method to use the yupana with simple rules and movements similar to chess games or Turing Machines. I will suggest some ideas concerning the creative possibilities of the yupana for generative musical creation. The yupana's design and rules can be m odified to represent musical information and to generate rhythms, melodies and structures of interesting complexity. All these possibilities add new formal solutions that expand what generative techniques such as Generative Grammars, Fractals or Cellular Automata usually provide. As a conclusion, I will add some insights about computation, generative art and c ultural identity.

Introduction
The architecture of any technological artifact, such as analog or digital machines, has a deep impact over the generative process and the formal characteristics of its audiovisual outputs. Talking about the algorithms designed for music composition, Mozart wrote a process to compose random music using dice to choose harmonic and m elodic rules[1]. Also the interaction with natural processes to foster imagination is an old and well-known practice with a deep impact over artistic production. I can mention here Leonardo's notes about the growing of humidity spots that can be used as inspiration to paint landscapes or skies [2]. The point is that every method produces results that reflect its information structure and the design of its architecture.
In this article I will try to explain the creative and generative possibilities of the yupana, the ancient Inca's calculator[2]. This can be of some importance not only for generative artists (always in search of new creative algorithms), but also for the definition of some concepts of generative art. But my goal is not just to produce new music; instead, I want to suggest new creative solutions that could develop creativity through cultural identity, a v ery important task for generative artists and educators.

[1] "*The basis of the musical dice game consists of 272 musical measures and a table of rules used to select specific measures given a certain dice roll. The result is a randomly selected 16 bar minuet and 1 6 bar trio*". http://www.amaranthpublishing.com/MozartDiceGame.htm. Also Haydn developed something similar known as "philharmonic game".
[2] This continues the topics of my paper on Quipus that I presented at the XXI GA Conference (Roncoroni, 2018).

	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°
2	96	22	141	41	105	122	11	30	70	121	26	9	112	49	109	14
3	32	6	128	63	146	46	134	81	117	39	126	56	174	18	116	83
4	69	95	158	13	153	55	110	24	66	139	15	132	73	58	145	79
5	40	17	113	85	161	2	159	100	90	176	7	34	67	160	52	170
6	148	74	163	45	80	97	36	107	25	143	64	125	76	136	1	93
7	104	157	27	167	154	68	118	91	138	71	150	29	101	162	23	151
8	152	60	171	53	99	133	21	127	16	155	57	175	43	168	89	172
9	119	84	114	50	140	86	169	94	120	88	48	166	51	115	72	111
10	98	142	42	156	75	129	62	123	65	77	19	82	137	38	149	8
11	3	87	165	61	135	47	147	33	102	4	31	164	144	59	173	78
12	54	130	10	103	28	37	106	5	35	20	108	92	12	124	44	131

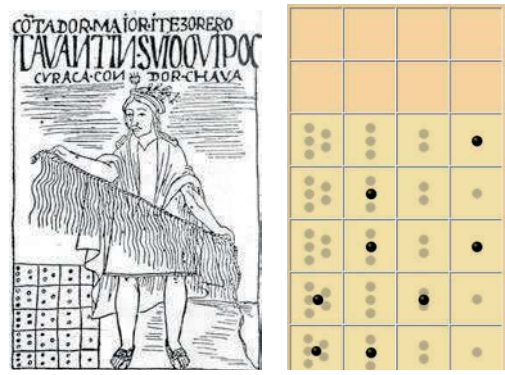


Mozart: Musikalisches Würfelspiel *(Berlín,1792). https://musescore.com.*

I will start with a brief description of the yupana, following the system of Dhavit Prem [10], a Peruvian engineer that developed a fast and efficient method (in my opinion, the best) to use this artifact.
Then I will describe how the yupana could be used for generative art. As a reference for cultural identity, I choose the case of *icaros*, the Shipibo's[3] shamanic songs performed during ayawaska's sessions. The reason of this choice is because Shipibo's music is often based on the tetratonic scale that matches, as we will see, the yupana's design and topology [9].

The yupana

The yupana was first described by Juan Poma de Ayala in 1615. It is uncertain when it was invented; probably Incas inherited this technology from older empires conquered during their expansion.
Actually, there are many studies trying to explain how the yupana was used [4, 5, 7], but nobody can demonstrate which the right one is. I follow the theory of Prem because it is simple, efficient and powerful. Now, it could be safe to affirm that the simplest solution was the best choice for practical people like the Incas. In any case, it is the best method to implement the yupana computationally[4] that also opens a lot of generative possibilities.
The yupana is a matrix of 4 columns and n rows. The columns, from right to left, represent numbers 1, 2, 3, and 5 (note the Fibonacci's series). The rows represent, starting from the bottom line, units, tens, hundreds, thousands, and so on (theoretically, there are no upward limits).
To form a number, the *yupanki* (the yupana master) put little stones or seeds in the appropiate cells of the board, as shown below.



Quipucamayoc
https://www.arqueologiadelperu.com.
Number 13478

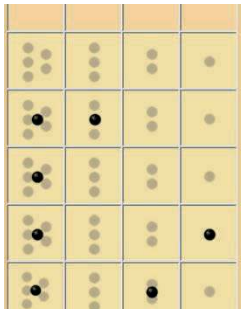
It's easy to see how a number, like 13478, is represented: with 1 seed in the first cell of row 10000 (the first row starting from the top), so we have 10000, 1 seed in the third cell of row 1000, so now we have 13000, then 1 seed in the first and third cells of the hundreds row, so we have now 13400, 1 seed in the second cell and 1 seed in the fifth cell of the tens row, so we have 13470, and finally, 1 seed in the fifth and another seed in the third column of the units row (the first from the bottom), so the number represented is 13478.

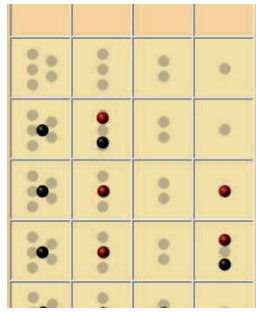
[3] One of the most Important tribes of Peru's Amazon rainforest.

[4] If interested, send me an email to receive a copy of the Windows application.

With the yupana you can perform sums, subtractions, multiplications and divisions. I will explain Prem's method to show the procedures and functionality of the yupana. First some general rules:

- You can put any number of seeds in any cell of the matrix
- To compute, you must clear the yupana, that means to leave just 1 seed for cell and the fewer seeds that is possible
- This is done following simple rules that define how to move seeds in empty cells
- Every column has its own rules (the row's level doesn't matter)
-





Number 8567

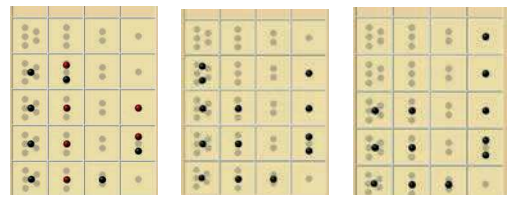
Number 8567 and 3443 (red)

It's not important here to expound all the rules, suffice to say that they are very simple and easy to remember. The yupana seems to be a concoct of chess games, Turing Machines and Generative Grammars[5].

To explain how to use the rules to obtain a correct computation I will perform the sum of 8567 and 3443. Remember: every cells of the yupana must contain only 1 seed per cell and the less number of seeds that is possible. When you accomplish this pattern, you have the result! Now, these are some of the rules, (enough to perform our sum):

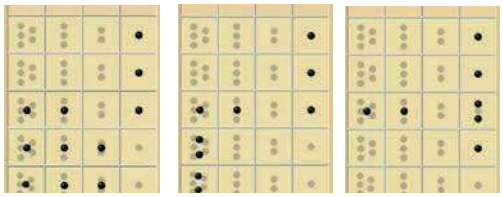
- Rule 1) Begin the process in any cell with 2 or more seeds
- Rule 2) With 2 seeds in the 3 column, you move 1 seed to the left and 1 to the right (actually the first column of the same row).
- Rule 3) With 2 seeds in the 1 column, you move 1 seed to the 2 column and discard the other; that makes sense, since 2 seeds in column 1 have the same value of 1 seed in column 2 (obviously in the same row!).
- Rule 4) If you have 2 seeds in the 5 column, you move 1 to the 1 column of the upper row and discard the other. 2 seeds in the fifth column (5x2) of row 1 have the same value of 1 seed in the first column of the upper row (1x10). By the way, this movement is called "pisqa".
- Rule 5) If you have a row of three cells with 1 or more seed for each, you do a jump: move the right seed two cells to the left, jumping 1 cell and discarding its seed. Like a piece of chess eating another.

So to make the computation we have the following sequence of moves (the color of the seeds is just to better visualize the numbers, it affects computation only in the subtraction's case):

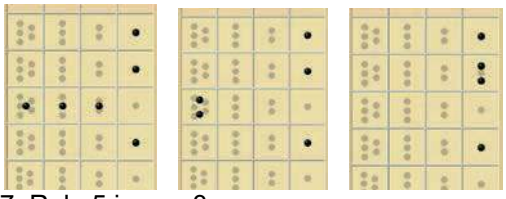


1. Rule 2 in row 4
2. Rule 4 in row 4
3. Rule 3 in row 2

[5] And also with Cellular Automata. CA concepts such as rules, values and neighborhood can be easily adapted for the yupana.

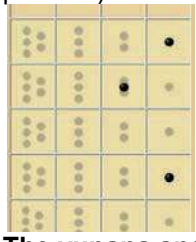


4. Rule 5 in 1-2 rows
5. Rule 4 in 1-2 rows
6. Rule 3 in row 3



7. Rule 5 in row 3
8. Rule 4 in row 3
9. Rule 3 in 4

With this last move we have the final result, as shown in the image below. We used a total of 9 moves, that (with some practice) can be done i n a few seconds.



12010

The yupana and generative art

All this explains well enough some of the yupana's basics concepts. But why and how the yupana could be relevant for generative art?

In the first place, it is safe to say that generative artists are always seeking for new algorithms, data structures and production rules to improve their art. These elements are relevant for the creative capabilities that a generative process can provide and for the aesthetic characteristics of its musical or visual outputs. For instance, the data order in a Turing Machine's strip determines its computational behavior. In Cellular Automata, rules govern the evolution of its audio/visual pattern[6]. In fact, the rule's behavior generates in time a specific effect, even if you can't figure out the result from the beginning.



Turing (right) and colleagues working on the Ferranti Mark I Computer in 1951. This is how the first piece of computer music was created. https://www.bbc.com/news/magazine-37507707

On the other hand, taking into consideration that many (if not all) generative processes are recursive, it is correct to assume the existence of some sort of repetition. As Shannon demonstrated [14], repetition is a measure of the predictability of information, since it gives a rhythmic order that allows to forecast the information's flow. In other words, as Moles explained very well in *Aesthetics and Information Theory* [6], rules and data structures make the difference between noise and aesthetic order (at the cost of less information, since predictability and information capacity are inversely proportional). As Dobrian pointed out:

[6] A Turing Machine Music project: https://www.codechef.com/problems/TMBOX. Turing Machine Music: http://www.amancalledadam.com/?page_id=1753.

> "*In a totally random distribution of possibilities within a given range, all possibilities have an equal likelihood of occurring. In that case, over a large sampling they will tend to occur in equal amounts. This equal distribution is the musical equivalent of white noise. The random numbers can be shaped by control of their range, but the content of that range is neutral. To create a distribution in which some things are more likely to occur than others, we can ascribe different 'weightings' of probability to each possibility*" [3]

The yupana's pattern and rule set do just that: weightings control. The recursive application of rules, patterns and weightings spread an order that affects the form of the generative audiovisuals that the yupana produces. In fact, the yupana's cells' structure is like a Cellular Automata neighborhood: for any cell, we can check the data of every neighbors and act in consequence. For instance, you can dispose the cells in different ways (see the next paragraph), to represent different musical scales, processing flows or balances between randomness and determinism.
In any case, we can add complexity mimicking the strategies applied in Turing Machines, such as:

- Playing with different set of symbols (binary, number, letter, words…)
- Using various read/write rules for multiple tape heads
- Trying different initialing patterns
- Connecting tape heads with outside sources
- Connecting many Turing Machines in parallel

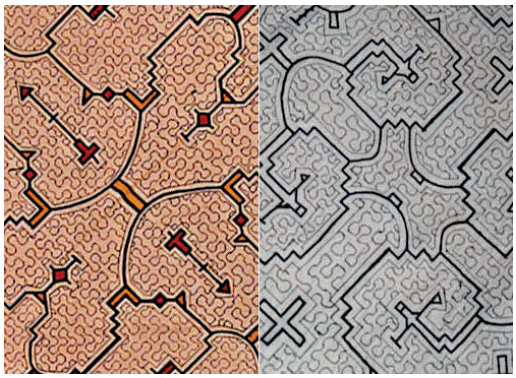
Another interesting property of the yupana is its design and computational logic. Both work like an interface to connect precise cultural contexts (the traditional and the digital), giving to the computational process cultural identity and originality. From the educational point of view, this makes the computational system significant to users of some specific cultural context, as suggested by Belaunde (translation is mine): "*It could be interesting to invert the roles and, instead to decipher kenes* (shipibo's textile drawings) *with occidental criteria, it will be more useful to analyze occidental writing with amazon eyes*"[1]. This concept could be generalized for ancient artifacts of every culture.

The yupana and Shipibo's *icaros*

To make a practical example of a generative production with the yupana, I will develop the case of Shipibo *icaros*. Shipibo is an important tribe of the Peruvian Amazon basin, and *icaros* are their shamanic songs or ayahuasca[7] ceremonies. Icaros are created using tetratonic or pentatonic scales with simple rhythm repetitions of dotted quaver and semiquaver sequences, mimicking the heartbeat pulse [7]. *Icaros* are linked with *kenes*:

[7] A hallucinogenic plant used by shamans to induce trance and improve consciousness.





Shamanes Shipibo. https://andina.pe
Diseños Shipibo https://www.dataisnature.com

> "*The intricate linear geometric and symmetrical artworks of the Shipibo Indians, a l arge tribe of the Peruvian Amazon, act as visual music maps – scores notating the chants and songs (Icaros) associated with Ayahuasca healing ceremonies.*
> *The textiles and embroidery, all crafted by women, contain recursive and self-reflective motifs, including geometric configurations common to those generated computationally by iterative functions*". [9]

Speaking about music, Belaunde adds (translation is mine):

> "*In some way it is possible to compare designs with musical scores. Nevertheless, this is a very generic comparison, because more than a writing form or music formally codified, the kene is a visual notation to aid memorization to inspire and r emember and perform a s ong starting from some property or event included in a painted or embroidered, such as a curve or a straight line, or a l ine which change angle and direction*". [1]

But Shipibo's *kenes* and *icaros* are not just audio-visual patterns sharing recursive and fractal structures. In fact, both are more of a sort of shamanic languages to map land, rivers and trees, as Belaunde pointed out (translation is mine):
"*In the geographic scale, designs are linked to the rivers of the forest. From the botanic point of view, the designs represent the leaves, the veins and the midrib that transport the* savia *and the* rao *the plant's power. The veins of the leaf are actually named* ca*, radical of the word* cano*, path*". [1]

The computational function and the fractal pattern of *kenes* and *icaros* are, so far, evident. In the following paragraph I will experiment, using the properties of these cultural artifacts and the yupana, the possibility of a musical algorithmic solution.

The musical yupana: a hypothesis
The relationship between *icaros*, generative art and the yupana is a work of imagination and anthropologically

arbitrary[8], but I'm looking at its creative and generative potential. Thus, this is the starting point of a research on ethno mathematics and generative music that certainly demands more studies and experimentation [13]. As a starting point, I used the tetratonic scale because it fits the design of the yupana's board: the upper rows hold the higher frequencies and the lower rows the low frequencies. The order of the notes, from left to right, follows the tetratonic scale of A major [9].

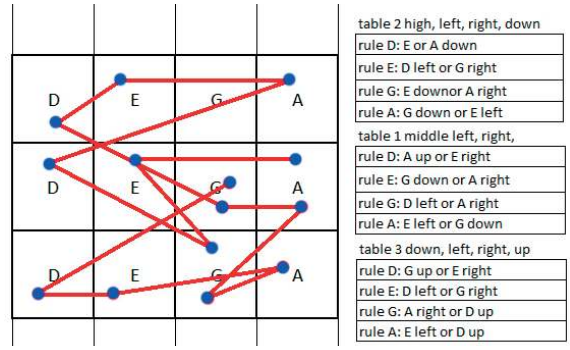
A	C	D	E	A
huk	iskay	kimsa	piska	
D	E	G	A	D

D	E	G	A	Higher pitches
D Re	E Mi	G Sol	A La	A 440 MHz above n
D	E	G	A	Lower pitches

Anhemitonic (no half steps) tetratonic scale in A and C and positions in the yupana

In the second step, I used two yupanas, the first to determine pitches and the second to set durations, using only dotted quaver and semiquavers. Following Moles' musical information hierarchy, these are sonic objects, or the basic sonic elements, that put together, form the sonic cell [6].

Anyway, as in the traditional usage of the yupana, we need to design rules for every cell, considering that *icaros* have a limited frequency range, just 1 octave up or down, with a tendency to stay in the middle pitches. The musical yupana's rules behave in the same way of Turing Machines programs [16], context Generative Grammars[9] and it is also similar to the Markov Chains' mechanism that is widely used to make computer music [3]. If rules share a common logic when working with sonic objetcs and sonic cells, we can generate self-similarity and fractal patterns, like we can appreciate in *kenes*.



Turing Machine table. http://ocw.mit.edu. Rule pattern with musical yupana

Look at the similarity between the graphic pattern of *kenes* and Brownian Motion, but with an important difference: yupana's moves are not completely random, since rules generate an implicit order through repetition of information.

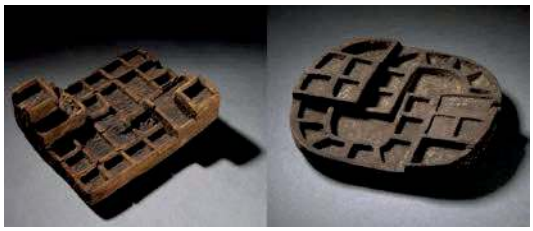
The yupana's generative potential

Concerning the generative domain, it is safe to say that a t ool is really creative

[8] The *icaros* and the yupana belong to completely different cultural contexts, even if Incas had contact with many Amazon tribes, Shipibo included.

[9] Context grammars are grammars which rules consider the neighborhood of the symbol (or cell in the case of the musical yupana). In this sense can be u sed like shape grammars and L-Systems.

when its architecture offers the widest range of possible combinations. This is the case of the yupana. I will mention here some of its possibilities.
Imagine to change the topology and use different designs to process sonic objects (pitches), bars (cells, or group of pitches) or higher level structures. Changing the geometry of the yupana obviously multiply its generative possibilities.
As you can see in the picture below, Incas made many yupana's designs, probably to serve not only as abacus, but as calendars or data bases. The yupana of the right shows a clear intention to control the flow of information and maybe to materialize an algorithm to process data. So far, each model could be used like a computer program to solve specific musical tasks with surprising results.



Two different yupana conserved in the Castello Sforzesco Museum of Milan, probably collected by A. Raimondi, a famous explorer of Peru born a century ago in Milan. http://elieducacion.blogspot.com.

On the second hand, we could use a set of parallel yupanas, adding a second one to process beats and a third to process measures. Like in Turing Machines, additional layers increase complexity and the creative potential.
And finally, the yupana physical model could be combined with natural elements (for instance, water). Clearly a similarity between the design of the yupana, Inca's architecture and landscape exists, as shown in the image below.





Tipón, Perú. Incas hydraulic facility and terraces. www.fotoaleph.com. It is unmistakable the similarity with the yupanas of the previous images.

Now, the flow of water is similar to the flow of information and can be combined with physical computing (sensors, actuators) and algorithms. As future computational yupana's applications, Prem pointed out (translation is mine): "*its specific ability to solve parallel computing problems allows the design of new algorithms and also of new architectures for math coprocessors*". [10]

Conclusions

The first goal of this paper is to discuss the yupana as a generative computational machine. I have explained how its features offer new possibilities to generate audiovisual artworks. The benefit of such an artifact is to insert the performer and

even the programmer in a different cultural dimension that opens new creative spaces, like African art did for Picasso and Braque. But the use of the yupana should not be limited to art production as such. We already have enough generative art made with Machine Learning, Artificial Life or Fractal systems. The addition of one more, even if exotic, is not the main priority. Besides, it seems to me that art in general is over saturated. Then, is more art (generative or not) really necessary?

What really interested me are some theoretical problems about art, computation and education that the study of the yupana clearly exposed. To mention one, to correct the generative art technocentric bias, in other words, to relocate its discourse in a broader dimension, connected to postmodern aesthetics and cultural production in general, seems to me more important.

Thus, the yupana's generative value is educational: the connection between different computational cultures and the inclusion of native knowledge that help artists today to face multiculturalism and globalization with better awareness. But how can we benefit native cultures without paternalism or neocolonialism [17]?

In fact, another important issue is to develop inclusive and sustainable education technology, a big problem for all native communities, especially in the Amazon basin. The digitalization of traditional computational devices, like quipus [8] and yupana, linking digital technology with cultural identity, makes the digital world significant for everybody.

Generative Art, from this point of view, is all about the design and development of intercultural, creative and interactive tools and procedures. In this sense, free Software and Open Source are politically strategic. But how students and teachers of native communities without refined digital literacy can read and understand algorithms and code?

My conclusion is that the generative art is wider than the domain constituted by algorithms and audiovisual objects: it includes code writing, interface design, semiotics and cultural studies. And when the users' creativity is empowered, the true meaning of the noun "generative" comes up.

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Interactive Architecture: The Case Studies on Designing Media Façades
Paper

Topic: Architecture

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Abstract
Today, the façade of a building is considered to be more than a envelope that separates the interior and exterior and component that protects the building. The facade is more than a statically existing envelope outside the building; it is the building element that determines the cultural role of the building and how it is perceived by the community through its communication with them. This role of the façade has enabled it to be used as an interactive communication tool through technology. Art, communication, advertising or transmission of a message is possible with the media front. The media facade demonstrates the idea of transforming the facade into a public display with the aim of interacting with the community through the use of technology, movement, color and light on the surface of the building. It is defining a new relationship between media and architecture, where digital media becomes a contemporary interface in architectural design. It differs from advertising architecture in its multidisciplinary aspect, giving a broad perspective to urban design. Text, graphics, or video animations are controllable light layers added to or embedded on the outer surface of the building as a tool for transmitting. It can be summarized as a type of urban computation that integrates digital indicators into buildings. Integrated into the building concept and planning process, it is guided by narrative content, which provides an identity for the structure and the environment in which it resides. At the same time, it can interact with the environment in which it is integrated not only to the building façade but also to the street furniture. Media façade is associated with interactive architecture, influenced by the fields of technology, art, advertising and marketing, as well as architectural design and urban design. Media surfaces are classified according to how they display their content, or how they are technically created, due to a variety of attributes and features. Front projection façades, reflects media content to the front using at least one video projector. Back projection façades, reflects media content from the back of the facade and into translucent areas coordinated to the building. Display facades transmit content to the surface of a building through the coordination of screen video screens. Window animations benefit from existing windows in a building by illuminating vision targets in pixels. Illuminantor façades, coordinate light-emitting components onto their surfaces. Finally, mechanical façades use mechanically moving components to change the appearance of facades. In the design phase of the façade; urban space, society, the message to be given, the stability of the system and the facade, weather conditions, light conditions, visual pollution and psychological effects are some of the issues to be considered. This study will focus on the purpose and scope of the media façade and to clarify the differences between the concepts of advertising architecture and media surface. The relations of the media façade with the society and its environment will be examined

through case studies in relation to many different fields and disciplines. At the same time, the challenges such as integration, content, robustness, image pollution, advantages and disadvantages of the media surface will be ex amined through examples. The design, application and experience of urban interaction will be examined in three phases. Thus, the facade will be studied to the stage where it is designed, implemented and experienced. In this study, it is aimed to shed light on the challenges facing the media surface for future studies by examining the applied and experienced media fronts through examples. It is thought that the facade, which is a permanent part of the urban space, will help expand the scope of design by using it as a media facade, increasing the interaction with the community, providing an identity to the place where it exists, and creating a basis for artistic works. In this way, it is aimed to expand the application area of interactive architecture.

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Key words: Media façades, urban, interaction design, mediatecture, interactive architecture

Interactive Architecture: The Case Studies on Designing Media Façades

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Abstract

Today, the façade of a building is considered to be more than an envelope that separates the interior and exterior and component that protects the building. The facade is more than a statically existing envelope outside the building; it is the building element that determines the cultural role of the building and how it is perceived by the community through its communication with them. This role of the façade has enabled it to be used as an interactive communication tool through technology. Art, communication, advertising or transmission of a message is possible with the media front. The media facade demonstrates the idea of transforming the facade into a public display with the aim of interacting with the community through the use of technology, movement, color, and light on the surface of the building. It is defining a new relationship between media and architecture, where digital media becomes a contemporary interface in architectural design. It differs from advertising architecture in its multidisciplinary aspect, giving a broad perspective to urban design. Text, graphics, or video animations are controllable light layers added to or embedded on the outer surface of the building as a tool for transmitting. It can be summarized as a type of urban computation that integrates digital indicators into buildings. Integrated into the building concept and planning process, it is guided by narrative content, which provides an identity for the structure and the environment in which it resides. At the same time, it can interact with the environment in which it is integrated not only to the building façade but also to the street furniture. Media façade is associated with interactive architecture, influenced by the fields of technology, art, advertising, and marketing, as well as architectural and urban design. Media surfaces are classified according to how they display their content, or how they are technically created, due to a variety of attributes and features. In the design phase of the façade; urban space, society, the message to be given, the stability of the system and the facade, weather conditions, light conditions, visual pollution, and psychological effects are some of the issues to be considered. This

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1. Introduction

The architecture was created to meet the need for housing and was in an order that was inward-looking, in which society was in limited communication with the environment and ea ch other. Today, however, it has become a discipline that is shaped according to the demands and needs of society and aims to interact with it.

Architecture, as we know, must combine two uncompromising easy tasks, inside and out. On the one hand, it has to provide a shelter that protects its inhabitants against unwanted influences; on the other, it must be a place that is physically adapted to their function and visually expressive, inviting or deterring, informative, interacting. [1]

With the inclusion of technology in design, the physical and di gital environments have been blurred and become an evolving and changing spaces. Computer and architectural elements began to identify and r espond to each other. Thus, approaches were formed in which architecture became more prominent, responsive, and actively interacted with its surroundings. Interactive architecture is one of these approaches. It provides the basis for the design of spaces and buildings that respond, adapt and manipulate the physical and di gital environment at the same time, based on the interaction between the environment and people. The method of architectural design has become not to create the one that exists statically, but to design the one that interacts with its environment and gives it an identity.

The façade is beyond being a statically existing shell outside the building; it is where the city first communicated with people. Emotional and rational communication with society is first established through it. It plays an important role in interacting with the public through dynamics such as its size, visibility, the urban environment in which it is located. This communication from the past to the present has been in different ways. However, this role of the façade has been neglected in this process.

Before the digital age, within the framework of advertising architecture, the facade's communication with the environment was provided with signs, signboards, and bi llboards attached to it. This way of communication is a functionality-oriented approach that does not relate to the city and its surroundings. It only engages in visual communication with the user and doe s not include it in design because of its dominant way. Urban design has progressed parallel to the development of building technologies by focusing on i nteractivity rather than

functionality since the process in which technology is incorporated into the design. With the inclusion of media in architectural design, a media architecture approach has been formed and a new form of urban design has been defined in which information flows. This approach represented means of communication such as the internet, computers, and mobile phones. Thus, the shapes and dynamics of cities have changed through the effects of digital technologies. McLuhan said, *"Since ancient times, architecture has been used as a means of adapting ourselves to nature. In contemporary architecture, we now need to adapt to function and context as well as to the information environment. Architecture should be a layer of both nature and knowledge at the same time. So today's architecture should be a media suite."* [2].

Thus, beyond the media dimension of architecture, the media façade approach has emerged where context is not ignored, added on or improved. Today, with the integration of digital technologies into design, communication has started to exist where the media façade has been designed, the interaction and building become stronger and dynamic. With media façade, while communication with the society was established only through advertising, it has started to established through disciplines such as art, urban design, architectural design, marketing, technology or communicating the messages determined to the society. For instance, lighting is no longer just functional; It is designed to make a city interactive and invite even after dark [3]. Therefore, exterior façade lighting has a vital role in urban spaces and predominantly influences the environment and memories of a city at night. The possibility of programming the new lighting technology would consider the potential for architecture to go beyond the stasis of a frozen process or repetitive script [4]. In this way, architecture is not invariant and static, but dynamic and shaped according to change. Interaction design can be done in a way that maintains and emphasizes function and identity; It can also change the perception of urban space by defining a new function and identity to the building and its environment. In this context, designs have begun to emerge in which new functions are added to the existing functionality within the framework of interaction. Media façade illustrates the idea of turning buildings into large-scale interactive surfaces. It is aimed to improve the urban experience by providing interdisciplinary information flow, bringing society from the role of spectator to the role of interactor.

In this study, within the framework of interaction, the use of architecture as a communication tool in the historical process will be examined through advertising & media architecture and media façade approaches. Specifications of media façades will be examined with current buildings under the headings of; the role of media façades in urban space, digital appearance, technical, social and technological content, communicative and technological roles. In this way, in the context of interactive architecture, the transformation of the user from the audience to the participant will be observed.

Thus, the future aspects of the media façade approach will be examined. Interactive media façades will be examined and classified under the titles of feature, technical installation, interaction, communication tool, light source, display time, sustainability, image integration, function and transparency/opacity in terms of the use of digital technologies. The study aims to examine and classify the characteristics, urban value and technical structure of facade designs with new media technologies. At the same time, by examining different approaches and interaction designs; to identify deficiencies or possible potentials in the development of architecture and media architecture. By determining these potentials, it is thought that the urban and spatial experiences will

improve and interactions will increase.

2. Architecture as a Communication Tool: Advertising and Media Architecture

"The urban environment has long been used as a multifaceted communication tool" [5].

For a long time, streets, facades, squares, public spaces have been converted for communication purposes. The building facade has been a communication tool that reflects the identity, culture, and message of the environment in which it is located, although information, methods, and tools have changed throughout history when we consider the process from the Middle Ages to the present. First, with Gothic and Baroque architecture, this communication was authority-oriented and symbolically established.

In the renaissance, this communication has shown examples mainly in civic architecture. It represented institutional or individual power by showing a dominant feature in the urban environment with structural ornamentation. With the Industrial Revolution, factors such as mechanization, mass production, rapid construction caused machine-inspired designs. This caused the information to become temporary, accelerating and simplifying the building's method of communicating. So, the period of communicating the message through graphic design has begun. In the Postmodern period, the first steps of advertising architecture were taken and information became even more temporary. Paintings, sculptures, and graphics have been replaced by temporary billboards. As Larson said, the only thing that didn't change in the historical process was that words and drawings came before buildings and the urban environment. [6].

In all periods, architecture was used symbolically. But the information is still not used and has not been interacted with the community. Ranaulo says: When we think of a cathedral as one of the mass media; information is transmitted through stained glass windows, sculptures, tapestries, mosaics. However, this information is constant and static. Today, space is considered as where information is active and interactive. In other words, it is no longer just frescoes, sculptures, niches or stained glass windows on t he walls; it is concerned with the design of the space which is the place of movement and interaction. Therefore, the architect must apply himself to this third dimension [7].

In the continuation of the process in which the façade is a m eans of communication as a s ymbol that expresses authority and individual power; it has become a means of communication with advertising-oriented symbols through traditional methods. Then, digital technologies started to be used on facades. The change in the needs and wishes of the postmodern society has prepared the ground for this situation. Thus, the first steps of advertising architecture were taken. In advertising architecture, advertisements, messages or graphics are added to the building with a screen or signboard. This causes it to ignore the added building, the urban environment, and the community.

One of the first examples of advertising architecture is Adolf Behne's Schocken Department Store and Warehouse 1927. In this building, to direct the people to shop, the lights in the store are integrated into the building. It was the first example of advertising architecture, with street-level storefronts, movable staircases, and illuminated signs. This building has an important place in advertising architecture because of creating a corporate identity for the brand [Fig.1].



Figure 1: *Shocken Department Store* [8].

While the media used architecture to manifest itself, architecture used media to acquire character. So media tools have become more important than society, the building and its urban area. This has caused people to be separated from the environment and each other within the context of consumption. As Venturi said, the advertisements establish verbal and symbolic relationships in the space. They convey complex meanings and messages in a matter of seconds. The symbol, therefore, governs the space and the architecture remains inadequate. Because spatial relationships are made not by form but by symbols. As a result, it becomes a symbol, not an architectural space in its surrounding area [9]. With the advancement of advertising architecture, billboards, signs and digital screens along with the digital age have found their place in every part of the city. Digital screens have been added to the buildings, identifying the façades as electronic screens and making them a means of information on the building. Consequently, the transformation of advertising architecture into media architecture began. Urban space has become a place of interdisciplinary interaction. Apart from the purpose of advertising, it has enabled events, shows or exhibitions to be held in public spaces. The term *Media Architecture* was first used for Oscar Nitzchke's Maison de la publicité *1936. "Although this project did not build, it is one of the first statements of the twentieth century that New Media Architecture was associated with culture, advertising and media. Eighteen feet wide, a steel cage was fitted. A facade capable of bearing images, icons and neon writings was produced in one-tenth of the building. In the Modern city of Paris, the ever-changing facade surface is leased by advertising agencies."* [10]. This approach was started to call *"mediatecture",* a combination of media and architecture. The use of a digital display of media architecture is divided into led billboards and interactive billboards. The interactive billboard, conversely to led billboard, invites people to exchange information. It receives information from the environment, not from the computer. Due to this, for the first time, an approach that interacts more with the environment and society is formed.

From another perspective, screens have become a dominant character in public spaces, ignoring the building and the environment. Media is not adapted to the urban area; it makes it a complex and image-polluting environment. In this way, the building no longer represents its own identity or a new identity, but only to showcase the billboard.

In the media facade approach, situations that are intended to be conveyed to the environment by façade, such as advertising, art, messages, are applied to the building, environment and society in a way that adapts them. In other words, disciplines are not added to the building and the city, they are integrated into them. In media architecture, advertising architecture and media façade approaches have the same purpose as each other under the media title but differ in their application methods. At the Media Architecture Conference, David Cunningham said: *"All architectures involving media and media issues are Media Architecture."* [11]. Tim Edler also says: *"The screens added to the facade are not architectural because they reject*

architecture." [12].

The biggest difference between advertising architecture and media facade is that media facade incorporates the relationship between media and architecture into the building planning and design process. In contrast to advertising architecture, advertising or other disciplines ignore architecture; in the media facade approach, the facade is designed by integrating disciplines into architecture. As Edler says, there is spatial, structural and environmental integration of digital tools into the building's concept, as opposed to the addition of a screen above the facade. The screens added to the architecture completely or partially close the facade and attract all attention by acting individually. But the integrated media becomes part of the facade, having spatial influence in architecture and public space [12].

The individual who experiences the media façade perceives the building as a whole with the media, context, function, and form integrated into it. This media integration can change the whole meaning and character of the building. Integration is the most important point that determines whether a surface is a media façade. Without integration, the added element becomes that has its own meaning and no relation to the building. If it is well integrated into the facade, these two elements define something new in what we call *"Media Architecture"*. [13]. When such integration is possible, it finds its place in the city as *"media façade"*.

3. Media Façade

Urban spaces offer extensive possibilities for information systems. Therefore, in the context of interactive architecture, the environment provides the basis for interactive designs. Media facade is an interface between the physical and digital spaces, a method of contemporary facade design that aims to establish connections with urban space and collective users through technology. By interacting with the surroundings, building skin acts as an interface or media façade [14]. Joachim Sauter describes the facade as interactive as a *"fourth format"*. The facade is the membrane between architecture and public space. Integrating media into a built-in form allows the facade to transform into the building's digital display skin by defining a new urban language. It moves the programmed content of the building into the environment while making its prominence more visible [15].

It aims to combine digital media tools and electronic indicators with the body and content of the building. It signifies the connection between technology, architectural design, innovation and substance, both aesthetically and functionally, and communication with new media introductions of modern art [16].

In this study, in the context of interactive architecture, digital imaging technologies were examined as integral parts of a building.

Lev Manovich calls for a vision of *"augmented space"* rather than filling the city with new techno-objects. According to him, thinking of the surface as an electronic display paradigm allows architects to consider both material and intangible architecture (streams of information) as a physical whole. He suggests that the design of electronically augmented space can be approached as an architectural problem. In other words, Architects along with artists may have the next logical step to accept the *"invisible"* space of electronic data streams as matter rather than as space. To him, this is something that requires structure, politics, and poetry [17].

3.1 Image Integration on Media Façades

Digital Media tools are included in the process from the design phase of the building. It gives identity to the building and the environment for the way and purpose of its application. Their goal is to transform the outer surface into an

architectural communication element with flexibility and depth, differentiating spatial perception. Combined with light and image indicators, it creates depth and spatial meaning that differs from a billboard. It also manipulates the planar space restricted by a panel with different methods, giving it volume. Screen integration is the most important point of whether a façade is a media façade [13].

On media façades, the image is integrated into the facade in three ways. These can be summarized as light, image, and water as the current method. Facades with light integration are formed by two light sources, direct and indirect. Direct light sources include lighting devices such as simple, halogen, fluorescent lamps and high-tech LEDs. Indirect sources use natural factors using the reflection of sunlight. Image displays are created by these light sources. Size, resolution, pixelation give depth to the image.

3.1.1 Direct Light Sources

Halogen lamps are the simplest lamps used to illuminate interiors. It is produced by different chemical methods to ensure that the bulb does not burn even when operating at full voltage. The bulbs are small and are made of quartz. Its small size is advantageous for the creation of light and graphic displays on the surface [Fig 2.,a].

Figure 2:*Direct light sources*



a.*Halogen* [18] **b.***Fluorescent* [19] **c**.*Led* [20] Fluorescent lamps contribute RGB and white colors with low energy costs. Because it creates large pixels, the resolution and sharpness of the image are reduced. It uses less power for the same amount of light than halogen lamps. It usually lasts longer but is more complex and more expensive [Fig 2.,b].

LED systems are emerging as light-emitting diodes in the category of small light sources. LEDs provide new possibilities for displaying large media content on the façade. The new LED-based setup is used to enhance the visual effect and reduces energy based on its multiple advantages, such as dynamic color switching. It also provides flexibility in effects, lighting, image and video impressions by improving resolution and clarity, as well as long-term use. Therefore, it is the type of lighting most commonly used on media façades [Fig 2.,c].

3.1.2 Image Sources

Resolution is the number of pixels that make up the image. As the number of pixels increases, the sharpness and detail of the image improve. The size of the pixels and their distance from the observer is an important factor. At the same time, the brightness of the painting supports long distances.

Color depth allows the lighting element to create spaces with color and spatial depth. LED light sources are the type of lighting that allows maximum color depth.

3.2 Media Façade Design Elements

Integration defines the function, identity, and environment of the building by transferring information to the façade. The relationship between the content, form, structure, and environment of the media and the building, or the new content and identity is related to integration. Thus, while depth is given to space through disciplines, interaction is designed.

Location is an important element in interaction. Conditions such as distance, movement, perception, visibility of the observer/participant play an important role in building-environment-society interaction. Therefore, for interaction to be achieved, the participant's experience must be designed to be perceived from every distance. This affects pixel counts and the brightness of the light. The larger the number of pixels, the greater the perceived value. Media because the content of the facade is not temporary in some cases, is an issue that is one-to-one related to the function, environment, identity, and culture of the building

through integration. It can relate to these features of the building and the environment, as well as add new features to them.

The way the media façade communicates makes people from the audience to participate by integrating media technologies into the façade. In advertising architecture, signs, advertisements or art establish a relationship with people only while the media façade approach interacts with disciplines. It creates a local culture by interacting with the identity of the environment in which it is located or with the identity that it has just defined. Thus, the city becomes a place where society is interactive.

The dynamism of the facade makes it a dynamic surface that can be changed from a static facade to its context. At the same time, the facade can be summarized as allowing the same material or lighting to be used for multiple activities during day and night use.

The size of the media front is the most important point after image integration. This is effective in differentiating the media façade from flat, rectangular and 2D advertising boards. It provides spatial differentiation and depth of the façade. According to Tscherteu, *"2,5D projections mean that media façades are not limited to a single surface, flow around the boundaries of the building or extend to spherical surfaces. In this way, it is possible to create striking spatial effects with projection."* [5].

Because of the façade is a surface separating the interior and exterior of the building, the transparency, translucency, and opacity of the facade become important. In this context, the media façade also affects the interior space. Beyond the outside and the environment, it plays a role in the experience and perception of the interior.

Sustainability is the most challenging point in media façade design. Energy consumption control is required because of the large number of lighting or digital elements. Therefore, the use of energy-saving materials when designing the media facade is important for sustainability. Another issue that relates to sustainability is the display time of the display screen. Lighting creates a perception of space especially at night and it allows transmit the content. The lights used to transmit the daytime image are too bright and negatively affect energy consumption. Consequently, the transmission of the image by taking advantage of the natural environment during the day and night transitions can help to contribute to sustainability.

3.3 Classification of Media Façades

In this section, media façades will be classified with integration, communication tool, experience, interaction, sustainability, function, location, dynamism, dimensionality, transparency, display time and algorithm characteristics. Examples are to examine the range of use of the media façade and its relationship with disciplines; it will be selected from temporary and permanent projects where different approaches are applied for the first time, technical setup and communication tools are differentiated [Table 1,2].

Table 1: *The Case studies*

Feature	Haus des Lehrers	Kunsthaus Graz	Iluma Shopping Center	Galleria Centercity
Software	Interfaces program-med by Blinkelights: Playpong, Blinkenpaint, Loveletters.	BIX	1,900 special software	DMX control system. Animations on the front with individual programming of LED spots.
Technical installation	A low resolution screen of 144 pixels was created with each window defining 1 pixel.	Digital creation with fluorescent lamps behind the facade. Each lamp acts as an independent pixel.	Crystal Mesh	High resolution is used in the corners of the building, low resolutions are used on the flat surfaces of the building.
Interaction	It is an interactive download and the content was created by users.	Invitation to artistic events.	Referring the user to entertainment / shopping.	The interaction of the current behavioral rends with the ob-servation of light ar-rays that act as waves.
Communication tool	Message, art	Art	Art	Marketing, fashion, art
Source of light	Halogen lamp	930 ring-shaped, black and be-summer fluorescent lamps	Fluorescent Lamp	LED
Display time	Connected to the user.	Used both day and night.	Night illumination when using daylight reflection	During the day the building is reflective and indeterminate. It turns into a variable urban sign with illumination at night.
Sustainability	Temporary	Fluorescent lamps for technological sustain-ability, low cost, less energy.	Energy-saving fluorescent	Energy-saving with high-efficiency lighting.
Integration	It is a temporary presentation and installation	Conceptual phase and content matches the function and form of the museum technically successfully	The irregular arrangement of the crystal lattices divides the façade into areas with different resolutions, becomes the main component of media architecture.	The LED spots are invisibly integrated into the façade.
Function	Integrated on the traditional façade.	Membrane panels providing water protection behind fluorescent lamps.	It is aimed to change the character of the building's skin and to obtain a dynamic expression of the whole architecture.	A dynamic double-layered façade aimed at reviving the experience of use.
Transparency	Opaque	Opaque-translucent	Opaque, translucent	Translucent-opaque

Feature	Flare	Daisy World	Pixel Cloud	Digital Water Pavillion
Software	Pneumatic piston with computer control. The system is controlled by a computer to generate any surface abrasion.	Illuminating pneumatic actuator system. Size + shape control with air pressure, color + light control with DMX data network	Each world can be controlled individually with specially developed software.	Motion Sensor Technology (camera, radar or laser)
Technical installation	The Flare system consists of a series of tiltable metal washer bodies supported by individually controllable pneumatic cylinders.	An artificial self-defining ecosis-supply simulation built on the structure. The size and shape of the colored illuminating flower heads can be controlled by air pressure.	The formation of a three-dimensional network of 624 white polycarbonate spheres. Eight parallel polished stainless steel sections each support three arms carrying 26 spheres.	LED lighting wires cover the plastic pipes of the water curtain. The wall consists of a close-range solenoid array. In computer control, valves can be opened and closed. This forms the water curtain that falls with the cavities in certain places.
Interaction	Reflecting environmental factors	Kinetic, spatial perception-altering, in-therapeutic performance	Office workers and the environment	Sensor technology
Communication tool	Open to different disciplines.	Artistic performance	Information flow	Information and technology
Source of light	Sunlight, natural environment	Colorful, bright, moving flowers, 3D pixels,	LED	LED
Display time	Every hour	Every hour	Every hour	Night
Sustainability	It takes completely from the environment and transmits it to the environment. In this way, sustainability is ensured.	Next-generation visible environments with 3-D pixels, compatibility with changing external conditions	Energy-saving with LED light.	Most of the energy required for recycling
Integration	The flake is integrated into the building to be controlled by the pneumatic piston. Reflects and shines using sunlight.	Large actuator network covering the building facade, integrated façade system, visibility effect from a distance	The interior glass façade is transformed by changes in color and light	It is collected by photovoltaic cells from sunlight with a movable roof.
Function	Acting as a live skin, the building expresses itself, communicates with its environment and interacts with it.	Large actuator network covering the building facade, integrated façade system, visibility effect from a distance	To transfer the data flow in the environment to be observed inside and outside the building.	Integration of digital technology over water.
Transparency	Opaque openable membranes.	Opaque	Opaque, translucent	Texts and patterns appearing on the water. The dynamism of water.

Table 2: *The case studies*

3.3.1 Haus des Lehrers

The temporary installation at Berlin's Alexanderplatz was done by Blinkenlights. This study is one of the first examples of the media façade; is considered one of its pioneers. The most important point is that

it succeeds in interacting through the facade. It made the society turn into a participant. It is an interactive download and the content was created by users. The entire community was controlled remotely with the help of a computer. In the installations realized within the framework of 3 interfaces (Playpong, Blinkenpaint, Loveletters), the messages sent by the users from the games were found on the front. The windows are painted white to achieve an illuminated effect. Interaction (control, ringing, telephone interaction) occurs through development and operation network protocols[Fig 3.].

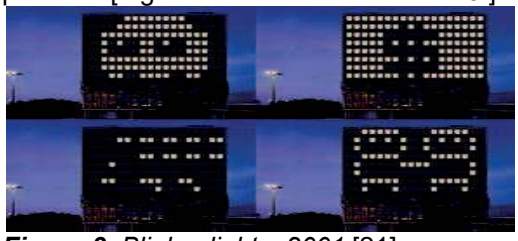


***Figure 3**: Blinkenlights, 2001* [21]

3.3.2 Kunsthaus Art Museum

The building was built by Peter Cook, Colin Fournier, Niels Jonkhaus, Mathis Osterhagen, and Marco Cruz in Graz, Austria. The media façade was incorporated into the existing building, designed by Jan & Tim Edler. The building is located in the city, overlooking the river and the city. These factors played a role in the idea of transforming the facade into an urban screen. The importance of this structure among the media façades is the use of BIX for the first time. BIX is a communicative organic facade that creates a new type of language and allows different artworks. The aim of BIX is that the façade acts as the *"information face"* of the building on the street and the other side of the river. It does not give the impression of a digital display, however, it transforms the entire building into a communicative device. While creating low-resolution graphics by creating double walls on the frontage, large pixels allow reading and viewing of images over long distances. By using fluorescent lamps, it promotes affordability and sustainability. It provides both a cheap modular structure and a large installation [Fig 4].



***Figure 4:**Kunsthaus Graz - BIX Façade* [22]

3.3.3 Iluma Shopping Center

Iluma is an entertainment and retail building designed by WOHA in the art, education and entertainment district of Bugis Street in Singapore. The main idea of the design is not a monitor, but a facade with a changeable expression. It is a digital facade made with the mosaic pattern of 3,000 polycarbonate modules. It combines the aspects of a traditional curtain facade with a light installation or monitor facade. 1,900 illuminated abstract digital patterns are generated, controlled by special software.

The crystal lattice forms the visual body of the building; The physical functions are performed by a deeper outer wall. In digital staging, it is aimed to change the facade character of the building, not an individual motif, and thus to obtain a dynamic expression of the whole architecture [Fig 5].



***Figure 5:**Iluma Shopping Center* [23]

3.3.4 Galleria Centercity

The project was designed by UNStudio in

Seoul Korea. The project demonstrates the functional aspect of the commercial store and emphasizes the sense of public space for social and cultural aspects. Establishing “social and semi-cultural meeting places” tries to redefine the traditional typology of the place. The strategy for building preservation consists of creating an optical illusion. It is aimed to shape the urban landscape and u rban spaces with light. Illusions were made on the façade with dynamic light shows and fluctuations that emphasized the transience of the image and were intended to be accessible/visible from a distance. The asymmetrically constructed double-sided façade overlaps and vertically arranged aluminum sections, creating a moire effect. The light is mounted invisibly is reflected on it. Glass discs contain special dichroic foils that produce pearlescent effects throughout the day, while during the night each glass disc is lit with programmable LED lights to create a m ultitude of effects. Computer-based animations developed by UNStudio are also included in the lighting design. The installed DMX control system has individual programming of individual LED spots and animations on the building surface. All led spotlights interact to produce dynamic images and transmit messages on the surface. [Fig 6].

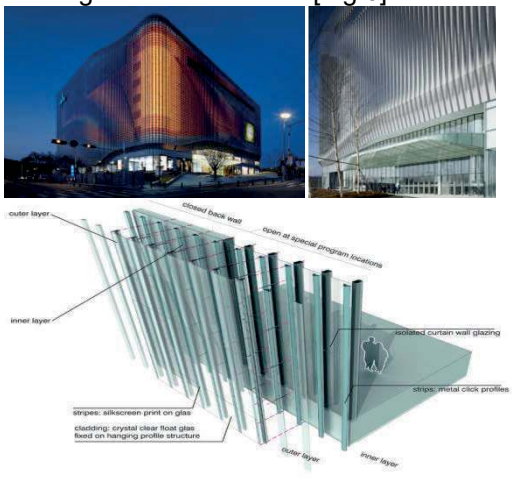


Figure 6: *Galleria Centercity* [24]

3.3.5 Flare-Kinetic Membrane Façade

The facade is a modular system to create a dynamic body for the wall surface of the facade designed by WHITEvoid. Acting like a l iving skin, it allows the building to communicate and interact with its surroundings. T he Flare breaks as a static skin that transforms the building facade into a p ermeable kinetic membrane. The system consists of a series of tiltable metal flake bodies supported by individually controllable pneumatic cylinders. Because of the pattern developed, an i nfinite series of stamps can be m ounted on any building or wall surface in a m odular system of multiplied flare units. Each metal flake reflects bright sky or sunlight. When the Flake is tilted downwards by a computer-controlled pneumatic piston, its face is shaded by Sky Light and thus appears as a dark Pixel. B y reflecting ambient or direct sunlight, the individual flakes of the flare system act as pixels formed by natural light. T he system is controlled by a computer to create any kind of surface animation. Sensor systems inside and outside the building transmit the activities of buildings directly to the flare system, which acts as a l ateral line of buildings [Fig 7].





Figure 7: *Flare* [25]

3.3.6 Daisy World

Daisy World, by Thomas Nicolai, is a simulation of an artificial self-policing ecosystem built on a n urban structure. The concept of an ar tistic performance front concerns the scientific experiment, a computer simulation made by James Lovelock, creator of the GAIA theory. Compared to the rules in nature, computer simulation calculates the dynamic growth behavior of two artificial flower populations. Undulating through the branching of organic structures, corals, anemones, mosses create new architecture algae, creating micro-cosmic life forms. The 2-dimensional illusion is replaced by 3-dimensional elements that can be t ouched. The size and s hape of the colorful illuminating flower heads can be controlled by air pressure upon request. Robustness of building reliability by making changes in outdoor weather and altitude sustainability conditions a network of actuators is installed covering the facade of the building with a v isibility effect from a distance. Subsequently, a kinetic media system was formed. [Fig 8.].

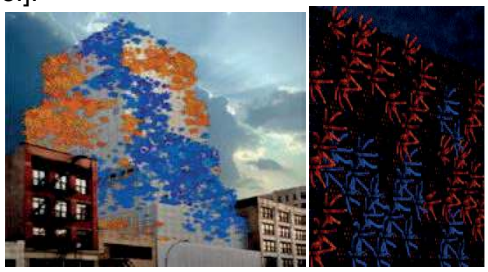


Figure 8:*Daisy.World* [25]

3.3.7 Pixel Cloud

The project is a l ighting scenario in the atrium of Allen & Overy's office building in Bishops Square, designed by Foster and Partners in London. *"Pixel Cloud"* concept and design was developed and p roduced by Jason Bruges Studio in London in association with Zumtobel, Ledon Lighting, which provided the LED fixtures. The LED light sculpture is hung f rom the ceiling of the 10-story atrium, like an oversized chandelier; it undergoes dynamic changes in color and light-controlled at intervals. The sphere is equipped with 24 LEDs and can be controlled separately. Inside the sphere, a dodecahedron (12-sided solid) shaped flexible circuit board allows each sphere to be illuminated in the same way. The system provides an 8-bit resolution in the main colors red, green and blue. Real-time color and Light updates constantly change the appearance of the three-dimensional LED lighting installation. The server creates a wide variety of modes. A sky tracking camera installed on t he roof is used to transfer images of passing clouds to the Pixel cloud. This ever-changing LED app i ncludes films or sequences of prepared individual images, and even supports the interactive engagement of web communities. Colorful animations and playback of local weather events provide ever-evolving simulations in the atrium space. The designers adjusted the range of the Ledon matrix to fit the grille of the facade. The interior glass facade is transformed by changes in color and light. One bar burns at a time, bringing the outdoor lighting air inside, from top to bottom, so that it shares it with employees in offices [Fig 9].

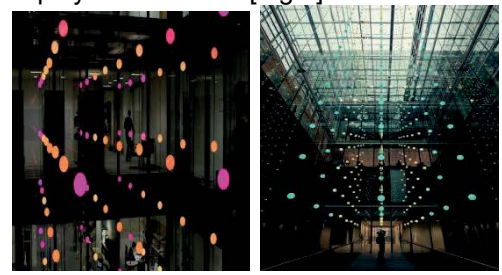


Figure 9: *Pixel Cloud* [25]

3.3.8 Digital Water Pavillion

The pavilion was designed in Zaragoza by Walter Nicolino, Carlo Ratti and Claudio Bonico. The interaction design was done by the MIT Media Lab. The pavilion

reflected digital media using the dynamism of water. Visitors can perceive the content as visual, aural and tactile [Fig 10]. Thus, the contents of both the pavilion and the expo were combined under Architecture, Science, Water, and technology. The wall of water has been the “information face” of texts, letters, and Expo. Sensor technology allows oncoming visitors to interact by changing the facade. Thus, technology can adapt the building itself to the visitor (flow, time of day, weather conditions and s chedule needs). The contents of the structure represent the function of the texts and patterns revealed in the water curtain. Mitchell says: *“With the search for different fluidities from other projects; in the case of the DWP, the building itself becomes fluid. Water is dynamic and t his dynamism is used with the help of digital technology.”* [26].



Figure 10: *Digital Water Pavillion* [25]

4.Conclusion

In the relationship between media and architecture; communication has been established in many different ways in history. Although the tools changed from the early ages to the information age, the aim remained the same. In the communicative role of the façade; The process of evolution from symbolic representations to advertising architecture, from advertising architecture to media architecture was examined. Accordingly, it was concluded that the main purpose of the media façade approach is the effort to interact with the environment in which the building is located. Subsequently, with the digital age, these signboards and signs are represented by digital technologies. However, the main problem with these approaches is that advertising, representation, building and ur ban environment are prevented and interaction remains secondary. Digital technologies and interdisciplinary information flow were integrated into the surface with the media facade. Thus, the integrated discipline is no longer considered independent of the architectural environment and society. Along with the media front approach, the concept of interaction has been incorporated into the design. With this concept, it is aimed to create an interaction between society and front. Technology has been a qualified tool for creating interaction. Yet, these interactions cannot be used as effectively as intended.

According to the content of a media façade, it is the layer that shows the various contents of the disciplines such as art, advertising, marketing and messaging. Moreover, an inward-looking building structure is included in information flow to interact with the environment. These situations can be done temporarily or permanently, although the media façade's relationship with technology and its flexible structure, changing conditions and a ctivities can be realized. Thus, the content of the facade is in a d ynamic structure which can be reconstructed

according to the disciplines and conditions in which the activities are related. These facades can produce different spatial constructions and contents, even in a day and night differences. According to the interaction to be e stablished, it can be perceived at distant points to the building. Interactive façades aim to attract the community and involve them in the building and urban space experience.

With its variable nature, it bears resemblance to the ever-changing billboards and rented building surfaces in

advertising architecture. Despite this, it continues to adapt to its environment.
Besides, the interaction of the front with its environment and society should be increased. This requires treating the building, not as its facade. The building must interact with its surroundings in its entirety. The building must interact with its surroundings altogether; it should not only interact with the façade. Interaction, movement, and flexibility are not only in the design of the façade and lighting; they must be handled throughout the building. In this respect, Digital Media Pavillion has been a s uccessful example. The facade renews itself from its data as it interacts with the user. At the same time, it can be reconstructed flexibly according to user needs and desires.

In addition to this, while the media represents the features such as advertising, propaganda and branding while designing the facade, it is another challenge for the building to protect its own identity. Even though the integrated features will transform the identity of the building, it must still look after its environment and society before it becomes the element itself.
On the other hand, avoiding image pollution when using Lighting is a challenging condition for the designer. The design should also benefit from its natural environment without departing from its nature. It is thought that this will help to optimize image pollution and sustainability conditions in future media façade designs.

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Title: **An Alternative Virtual Odyssey**

Topic: ***Art***

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Abstract
Stefanos Zannis is an Athenian painter who has been painting for over 20 years Homer's Odyssey but with a twist: delving into verses of the original poem who many would find obscure. This ancient poem has always been a quintessential symbol of the journey of life that we all go through, complete with the monsters we face and the longing for a spiritual home, or end goal, symbolised by Odysseus island home, Ithaka. We take inspiration from Stefanos's work on this epic poem to create an "alternative virtual Odyssey" in multimedia form, an artistic reinterpretation of the poem that throws light on unheroic but important and emotionally loaded aspects of this journey.
This virtual Odyssey takes place in a navigable virtual gallery of Stefanos's works which are projected on multimedia sculptures created with the Timaeus art studio. Sculptures are customized with media including images, videos, music, and narration, can be hollow and translucent, illuminated, and navigated either externally or internally. These become curved spaces or 'worlds' where projected episodes of the Odyssey can be experienced in three dimensions. Timaeus is thus a medium for creating spaces appropriate for experiencing the elements of this alternative Odyssey. Apart from Stefanos's paintings, we integrate relevant poetry by Greek poets Constantinos Cavafy and Alexandros Vanargiotis.

In the picture, one can see a virtual sculpture illustrating how Stefanos imagined Circe in one of his paintings. In Greek mythology, Circe is a bad and dangerous woman, goddess of magic, an enchantress and s orceress. When Odysseus shipwrecks on her island of Aeaea, she transforms his crew into swine and forces him to live with her. In the world's literary tradition, Circe is mostly depicted as the archetype of the predatory female who is a big threat to men and masculinity. However, in his much quieter Odyssey, Stefanos shows a charming view of the



sorceress weaving a fine red fabric in her loom.
There is something really endearing and attractive in observing a person work with calm, devotion and fine skill on something that they really love doing. The painting shows another side of Circe which might explain better why Odysseus stayed with her. Perhaps he was rather charmed by her talent, her elegance, and her devotion to her artful work. Perhaps human relations are much more subtle than a desire for control.

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Key words: ***Timaeus, Virtual Sculpture, Odyssey, Circe***

‘Ithaka gave you the marvellous journey. Without her you would not have set out’ – Cavafy

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1. Introduction

For over 25 years, Athenian painter Stefanos Zannis has been painting Homer's Odyssey but with a twist: delving into verses of the original poem who many would find obscure. This ancient poem has always been a quintessential symbol of the journey of life that we all go through, complete with the monsters we face and the longing for a spiritual home, or end-goal, symbolised by Odysseus island home, Ithaka.

We take inspiration from Stefanos's work on this epic poem to create an 'alternative virtual Odyssey' in multimedia form, an artistic reinterpretation of the poem that throws light on unheroic but important and emotionally loaded aspects of this journey. This virtual Odyssey takes place in a navigable virtual gallery of Stefanos's works which are projected on multimedia sculptures created with the Timaeus art studio [1]. Sculptures are customized with media including images, videos, music, and narration, can be hollow and translucent, illuminated, and navigated either externally or internally. These become curved spaces or 'worlds' where projected episodes of the Odyssey can be experienced in three dimensions. Timaeus is thus a medium for creating spaces appropriate for experiencing the elements of this alternative Odyssey. Apart from Stefanos's paintings, we integrate relevant poetry by Greek poets Konstantinos Cavafy and Alexandros Vanargiotis.

In section 2, we give some background on the original epic. In section 3 we discuss the inspiration for this work in the art of Zannis and the poetry of Cavafy and Vanargiotis. In section 4, we present the architecture and progress of this alternative virtual Odyssey and finally, in section 5 we draw conclusions and outline future work.

2. Odyssey

Composed around 800 BC, Homer's Odyssey is a corner stone of Western literature. It takes the form of an epic poem telling the story of Odysseus in his quest to return home, the island of Ithaca,

after the Trojan War. The poem describes a ten-year long trip, in which Odysseus encounters the fury of Gods while he battles with mythical creatures and monsters. It also narrates events back home in Ithaca where a group of suitors are competing for the affections of Penelope, Odysseus's wife, and the throne of Ithaca. The Odyssey is an epic, a long narrative poem written in an elevated style dealing with the feats and struggles of a great hero. The poem was most likely written to be recited with musical accompaniment [2], and it has wonderful musicality in its expression. Odysseus is brave, strong but most importantly rational and intelligent. The epic celebrates these virtues in the context of heroic action but also throws plenty of light on human weaknesses and failings addressing a range of universal themes related to human nature which are still relevant.

There is a groundbreaking narrative structure beginning *in medias res*, i.e. in the middle. The poem does not start in Troy but 10 years after the beginning of Odysseus's trip, focusing first on Telemachus's attempts to stave off the suitors who plot to assassinate him. Odysseus first appears in the fifth rhapsody (book) in the middle of his trip in the island of Calypso, a beautiful nymph who wants to make Odysseus immortal and keep him with her [3]. Odysseus has spent seven years with Calypso but at this point the Gods have decided to free him. Reluctantly, Calypso sends Odysseus on his way on a small raft which god Poseidon shipwrecks on Phaeacia, a place of hospitable people who welcome Odysseus and encourage him to tell his adventures. His narrative contains the most intriguing part of the epic. Among other fascinating episodes, Odysseus talks about his encounter with people who lack memory as a result of eating lotus fruits; the Cyclops, a race of uncivilized, brutal, one-eyed giants; the cannibalistic Laestrygonians, the beautiful and cruel sorceress Circe, the Sirens, and an attack by a six-headed monster named Scylla. Odysseus leaves Phaeacia, and ultimately lands in Ithaca where he proves his identity to his compatriots, then slaughters the suitors, and is finally reunited with his family and throne.

3. Interpretations and Inspiration

The influence of this poem in art and literature has been immense: over time people have created their own interpretations or stories that have references to the epic. A prominent example is James Joyce's Ulysses [4] (Latin for Odysseus), a novel about an anti-hero in Dublin written in stream of consciousness and widely accepted as a masterpiece of modern literature. In this paper, we are concerned with reflections by Greek painter Stefanos Zannis and poets Konstantinos Cavafy and Alexandros Vanargiotis.

3.1 Ithaca by Konstantinos Cavafy

In the early 20th century, Greek poet Konstantinos Cavafy wrote a great poem called 'Ithaca'. The poem is inspired by the literary trip of Odysseus, but is a metaphor about the journey of life. A fine translation by Edmund Keeley and Philip Sherrard [5] follows.

> As you set out for Ithaca
> hope the voyage is a long one,
> full of adventure, full of discovery.
> Laestrygonians and Cyclops,
> angry Poseidon — don't be afraid of them:
> you'll never find things like that on your way
> as long as you keep your thoughts raised high,

as long as a rare excitement
stirs your spirit and your body.
Laestrygonians and Cyclops,
wild Poseidon — you won't encounter them
unless you bring them along inside your soul,
unless your soul sets them up in front of you.
Hope the voyage is a long one.
May there be many a summer morning when,
with what pleasure, what joy,
you come into harbours seen for the first time;
may you stop at Phoenician trading stations
to buy fine things,
mother of pearl and coral, amber and ebony,
sensual perfume of every kind —
as many sensual perfumes as you can;
and may you visit many Egyptian cities
to gather stores of knowledge from their scholars.
Keep Ithaka always in your mind.
Arriving there is what you are destined for.
But do not hurry the journey at all.
Better if it lasts for years,
so you are old by the time you reach the island,
wealthy with all you have gained on the way,
not expecting Ithaka to make you rich.
Ithaka gave you the marvellous journey.
Without her you would not have set out.
She has nothing left to give you now.
And if you find her poor, Ithaca won't have fooled you.
Wise as you will have become, so full of experience,
you will have understood by then what these Ithacas mean.

In wonderful language and with seductive metaphors, the poem talks about life as a personal journey through a world of discovery. This journey is not only physical through space; it takes place in our home and hometown where our relationships with people and our roles in the family and society are formed, and evolve with time. The poem suggests that this metaphorical journey is more important than the destination. Indeed, there will be little to know about the self without exploring the world. How else do we enrich our memories, experiences and improve our judgement if not by escaping the prison of what we have been taught in order to understand other lives, cultures and history? Cavafy writes that the wild dangers that Odysseus encountered, the "Laestrygonians and Cyclops, the wild Poseidon — you won't encounter them, unless you bring them along inside your soul, unless your soul sets them up in front of you". In similar spirit about the journey of life, Montaigne [6] wrote that "Travelling through the world produces a marvellous clarity in our judgment. This great world is a mirror where we must see ourselves in order to know ourselves". This journey does not happen only when we take a plane, it also happens in books, in the vast resources of the internet, in our mind and in our ordinary life. Cavafy takes inspiration from the ancient epic to give us a great personal, but also political, poem in an age when ideas of nationalism, isolationism, and religious fundamentalism are on the rise.

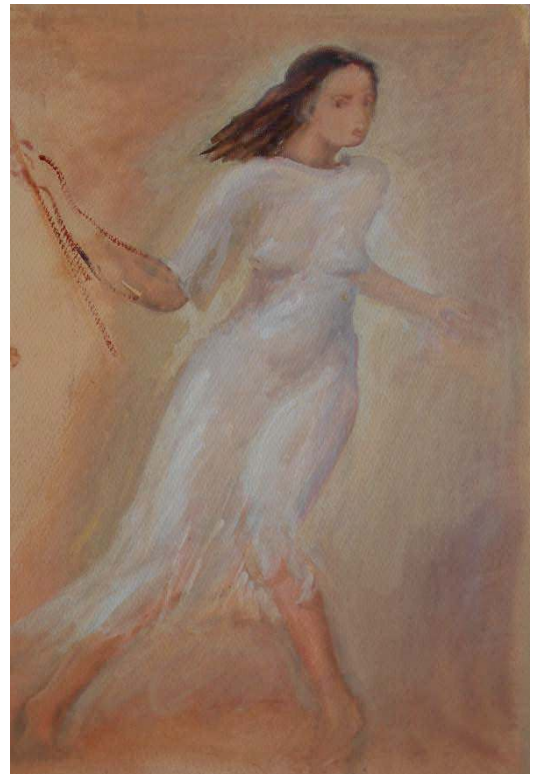
3.2 Circe by Stefanos Zannis

In Greek mythology, Circe is a bad and dangerous woman, goddess of magic, an enchantress and sorceress [7]. When Odysseus visits her island of Aeaea, she transforms his crew into pigs and she forces Odysseus to live with her. In Western literary tradition, Circe is mostly

depicted as the archetype of the predatory female who is a bi g threat to men and masculinity. Stefanos Zannis who has been painting a m uch quieter alternative gives us a different and less neurotic view of Circe. In the painting below, Stefanos shows a charming view of the sorceress weaving a f ine red fabric in her loom. There is something endearing and attractive in observing a person work with calm, devotion and fine skill on something that they love doing. The painting shows another side of Circe which might explain better why Odysseus stayed and fathered two of her children. Perhaps the hero was not coerced by the sorceress; perhaps he was rather charmed by her character, her talent, her elegance, and her devotion to her artful work. Perhaps human relations are much more subtle than a desire for control. Stefanos takes an unheroic view of the Odyssey, one which makes it much closer to a j ourney of life that we all experience. His paintings are charming and emotional, mastering colour and shape with a fine impressionist touch. In his painting of Circe, he employs a wonderful palette of complementary colours and his atmosphere is stunning and reminiscent of the Lace maker by Caspar Netscher [8].



Like all of us, Circe has many aspects in her personality. In the next page, another painting by Stefanos shows a beautiful, elegant and dynamic Circe in motion.



3.3 Circe by Alexandros Vanargiotis

Alexandros Vanargiotis is a contemporary Greek poet who produces verses of unique sensitivity and bea uty. His poetry is often inspired by themes of classical Greece and is reminiscent of Cavafy: poems unfold softly with a s implicity and harmony in expression but moving towards a m eaning/concept that has motivated them and which they sharply embody and convey. Alexandros is a gentle poet of the everyday and or dinary; below, an example of how he writes about the inevitable disappointments and disillusionments of life.

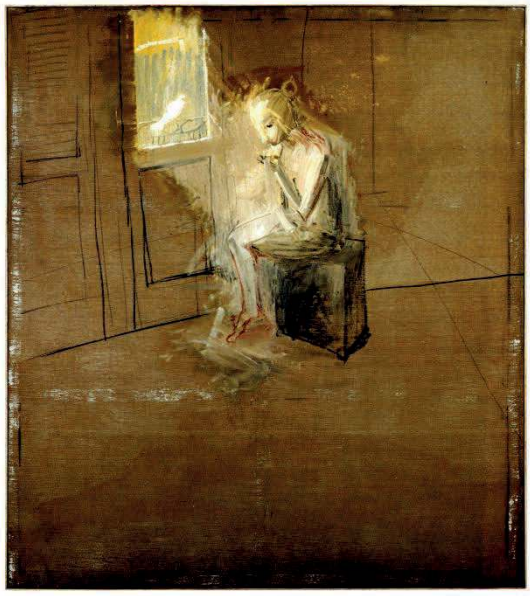
As a young man I tackled the big issues
trying to interpret the world.
Now, naked and empty,
in order to understand the sea
I look at water paddles.
For the rocks,
I stroke pebbles.
For meadows,
I converse with flowers.
For the forest,
I listen through the night
to the sound of the lonely trees in a fertile field
Before dawn,
I hear the forgotten stars on the horizon speaking of heaven.
And for people ...
Ah, for people,
it is a long time now that I wander,
In my own wilderness.

Like others, I met her too.
She had the reputation of a witch.
If you approached her,
you would lose your mind.
She was naked and beautiful,
her eyes were enormous,
two shiny mirrors.
When you woke up next to her,
they would reflect your face.
Don't ask me; I won't say
whether I saw a pig in them or a rabbit.
I'm still shaking, though.
I heard she married
someone who, they say,
drunk the potion of Love
before meeting her.
And instead of being reflected in her eyes,
he saw behind them
a soul, tormented.

Such poetic thoughts could belong to a modern Odysseus. The poem suggests that, in our youth, the world seems full of prospects and hope, and susceptible to positive change in which our potential agency is overestimated. As we grow up, disappointments pile up, hopes are dashed, and it dawns on us that humanity is fundamentally flawed. Some people like Alexandros learn to sublimate this feeling of disappointment into an appreciation of the joy of small things: pebbles, flowers, trees, dim stars in the skies. Instead of blaming others for their failures, they look into themselves, into these unexamined internal spaces for an insight to the human psyche and the condition of humanity as a whole. Like Stefanos with his paintings, Alexandros has written poems with an alternative take on themes from the Odyssey. A translation of ‘’I met Circe once” follows. There is no sorceress in Alexandros’s poem but a tormented soul that if someone could see, they would love:

3.4 The Corpus of Stefanos Zannis on the Odyssey

Stefanos Zannis started working on the Odyssey in 1992 as a student of the School of Fine Arts in the University of Athens. In 2007 he conceived of a grand visualisation of the 24 rhapsodies of the Odyssey in an equal number of large-scale bound books, where each book would include paintings, drawings and original text in calligraphy. Since then, this project has become a constantly evolving work in progress. Stefanos has been focusing on subtle 'unheroic' episodes and verses of the original poem who many would find secondary or obscure. One such episode depicts Goddess Athena appearing in a dream of the Phaeacian princess Nausica (1998) [9].



People familiar with the Dutch Grandmaster Johannes Vermeer may find this painting reminiscent of the Letter Reader (1663) [10]. There are conceptual similarities in the scene, the treatment of light and the overall dignified and serene ambience. Stefanos's painting is less representational and more impressionistic in style. However, it is also charming and emotional, providing a unique and original interpretation of the relevant Homeric verses in the spirit of Vermeer. The latter was not only a master of light and atmosphere, but made a radical departure from religious, military and mythological themes and started painting ordinary life showing beauty and elegance in it [11]. His famous paintings depict a maid pouring a glass of milk, a young woman thoughtfully reading a letter under the light of a window and a mysterious and anonymous girl with a pearl earring. Like Vermeer who gave value, prestige and dignity to ordinary life, Stefanos is showing the beauty of ordinary and often bypassed moments within the great epic.

In another episode of his journey, Odysseus travelled through the Ocean river to the land of the Cimmerians, where, according to Homer, people are covered by clouds and fog, the sun never casts her rays on them, never travels towards the starry skies and never returns to earth; this is a land where the unfortunate mortals live perpetually under gloomy grey skies. Stefanos imagined a strange and wonderful Cimmerian land in a painting entitled "There is always a passageway through the land of fog".



The Cimmerian land is shown in a stunning composition of a dreamy, fantasy landscape emerging from the surfaces of a room, perhaps the bedroom of an imaginative child. This work is reminiscent of landscapes by Turner in its atmosphere with vague forms of people, trees and buildings gently emerging out of a hazy background. The painting includes masterfully crafted elements of surrealism in the wonderful use of colour in texturing and creating the complex elevation of the landscape, the fine perspective of this strange room and land, the weird and elegant figures and details, the window with its light grey clouds, the beautiful diffusion of light, the slice of water melon that looks like a boat, and the toy plane hovering above the landscape. This is a wonderful composition and would deserve a place next to one of the Turners in the British National Gallery or between a

Manet and a Dali in a museum of modern art.

Another painting of Stefanos depicts a key dramatic moment in Odyssey just before a major disaster unfolds. At a certain point in the trip, the God of winds, Aeolos, gives Odysseus a bag that safely contains storm winds, leaving only a g entle west wind to take him home to Ithaca. Odysseus doesn't tell his crew and steers the ship by himself for days. In the crucial moment, though, he falls asleep, and his men who see Ithaca on the horizon decide to open t he sack. They expect to find a hidden treasure, but as they open the bag, the storm winds rage out and bl ow the ship away, undoing all their efforts.

Stefanos paints this in a gentle but dramatic manner the moment before the bag is opened. Dark and ominous clouds gather from the four points of the horizon and cover the Mediterranean sky leaving only a s mall patch of turquoise blue from which rays of sun enter the picture. They illuminate the clouds from above and create gentle light effects on the land and seascape below. A few of the clouds are similar in colour and texture to the rocky island below, looking like “rocks of the sky”, and cast their dark shadows on Ithaca.



The marble temples and civic buildings of Odysseus`s hometown appear graciously on a hill by the port, vague but glimmering with silver light from above. The sea is just about to become stormy, and one can almost feel the energy gathering in the waters.

In Greek, “opening the sack of Aeolus” means “opening a can of worms” and the episode speaks volumes about humanity. Like Odysseus's crew, humanity sets big collective goals, which we manage to undermine because of greed or lack of trust in each other. We also suffer from inadequate communication. Odysseus did not communicate well, so his crew were unaware of the risks. We could imagine how many troubles could be av oided if people just communicated better their knowledge, feelings and thoughts, instead of waiting to be mind-read.

It would be impossible to discuss all Stefanos’s work on the Odyssey here as it includes over 100 pa intings and d rawings and it goes beyond this medium. The picture below depicts a sand sculpture of beautiful Helen of Troy.



The sculpture is accompanied by the following evocative text.

> Telemachus now knew about Helen,
> for the sake of whom his dad, Odysseus, went to war.
> They had harsh words for her in his town.
> But Telemachus had finished high school now;
> he had grown up.
> He spent time on the beach sculpting Helen in the sand;
> creating and destroying her feminine form,
> creating and destroying her again.
> She was an elusive form this Helen, so hard-to-reach.

What a beautiful and original thought on a story that has been told thousands of times! The sculpture was done one summer, and the waves took it like time takes everything else. In a recent trip to Athens, we had the pleasure to see one of the rhapsodies that Stefanos captured in an art book. It is not often that someone so talented, passionate and persistent reinterprets so beautifully and originally one of the classics of Greek literature. Stefanos's work became the main inspiration for this alternative virtual Odyssey.

4. The Virtual Odyssey

The goal of the project was to realise a virtual environment where the creative presentation and synthesis of various alternative artistic and literary projects, in this case those inspired by the Odyssey, could be achieved. To facilitate this, we have created a virtual art gallery that currently hosts works that combine the paintings of Zannis, and the poems of Cavafy and Vanargiotis. This gallery is an interesting space that offers artistic possibilities and sensibilities for the presentation and exploration of these works. It is configured as an open and potentially infinite seascape that is dotted with "islands'" of three-dimensional sculptures inspired by these art works. We gave this virtual gallery a symbolic haiku [12] in Greek.

> Έτσι είναι, Οδυσσέα,
> ήταν πάντα εσύ και η Πηνελόπη,
> μόνο.
>
> (So it is, Odysseus, it was always you and Penelope, solely)

The haiku is dedicated to Odysseus and Penelope and others like them with disconnected lives; people who have memories together and apart, experiences of arguments and play, hesitations and decisions, virtues and failings, hopes and disillusionments. Such lives, even when they are lived in parallel and in isolation, can be deeply connected and subconsciously projected onto each other.

The virtual navigation of the gallery resembles a poetic, spiritual trip where the visitor can experience the feelings left by the sea in the soul of someone who discovers that, through a journey, they can achieve a richer understanding of life. The audio-visual sculptures were designed with the resources provided by Timaeus, a virtual art studio that has been inspired by Plato's homonymous work, especially the Platonic geometrical cosmogony. The sculptures can contain audios, films, pictures and texts and be continuously displayed and played; sculptures can be hollow and translucent, illuminated, or navigated either externally or internally by the visitors. We have populated the sculptures with displays of paintings by Stefanos and readings of poems by the two Greek poets we discussed. The pictures below show

instances of sculptures within this virtual space:





The software that implements Timaeus and renders the gallery draws heavily from tools provided by the Unreal game engine, over which a layer of software has been added to enable custom use by artists that wish to make creative digital compositions of their works. In this particular case, we have also incorporated a path-finding algorithm that can forge a path through the virtual seascape of Odyssey. The algorithm exploits weights assigned to sculptures which form a graph upon which the symbolic distance between Odysseus and Penelope can be continually established and minimised by the algorithm.

Conclusions

Zannis's monumental work on the Odyssey and poems by Cavafy and Vanargiotis have inspired the creation of a virtual gallery where poetic journeys through compositions of these artworks can be experienced. We hope that such journeys will provoke sensual feelings akin to those experienced when minds are meandering through verses, music, paintings, sounds, landscapes, and t he sea. The computing infrastructure that we have developed to achieve this virtual Odyssey is reusable and gi ves the possibility of more general design of spaces. It could, in the future, be used for creative exhibition of other works of literature and art in synthetic, multimedia, and immersive new forms.

Acknowledgements

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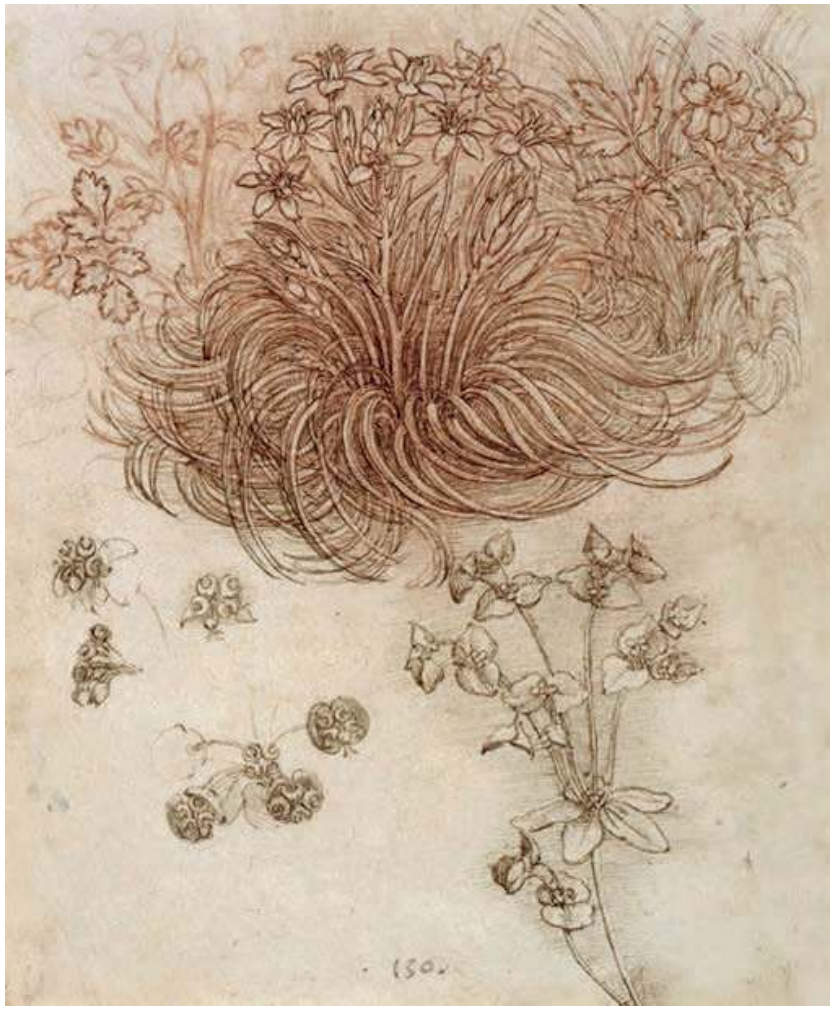
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POSTERS
ARTWORKS
INSTALLATIONS



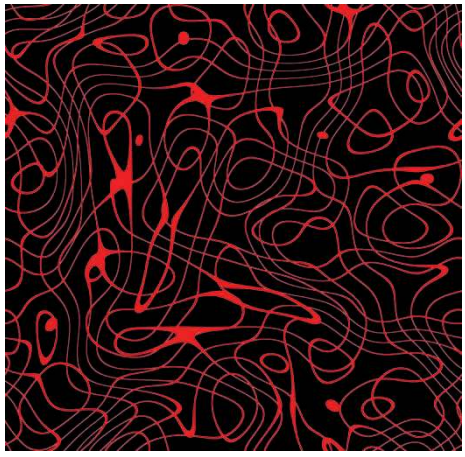
Design for textile prints
(Poster, Installation)

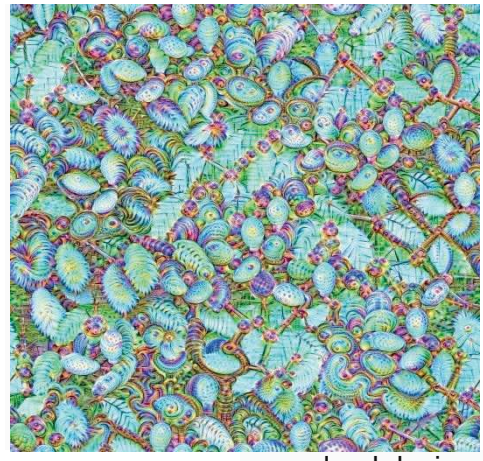
Topic: (Art, Design)

Author:
Alessandro Violi
Independent artist and researcher at
negativewall.com

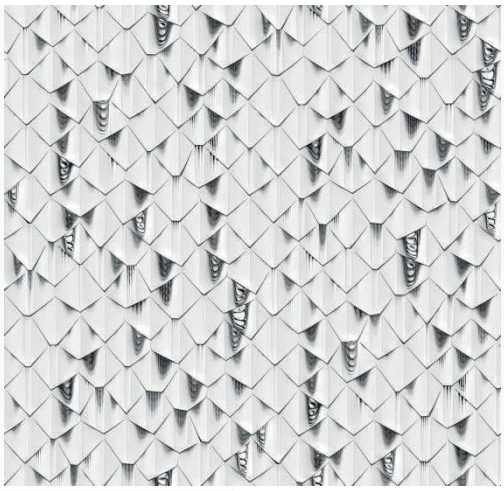
Abstract
A practical use of procedural graphics in the real world: the design of textile printable or weavable patterns for fashion design. Connections between the words of fashion design and computers are difficult these days. Difficult also because digital is now deep and essential in fashion as it is in most other fields of human practice. So indeed there are many connections. Algorithmics design are often modular, repeating as tiles. Changing both deterministic parameters and or applying controlled variations of the seed values generates different designs. Being math based they have all the graphic depth of the infinite: a look that can be deceiving as hyperreal. They have a scary mechanical quality that is their limit, but also their fascination. They can be tools or layers or whole systems. Neural convolutional network and generative pareidolia are the extreme edge of this research.

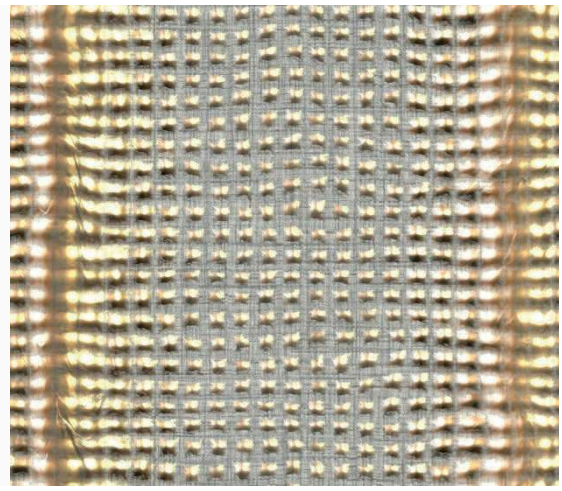
All the designs presented here have been then printed on fabric for commercial use in fashion.





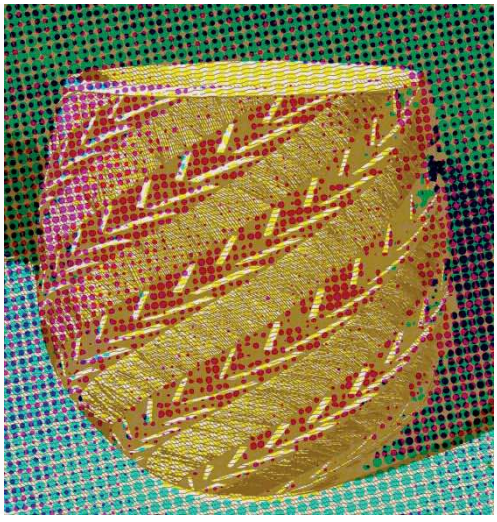
procedural design - 2015
Two vertical lines panels distorted through some noise and overlapped
AI dream - 2015
Neural convolutional network - generative pareidolia





Procedural - 2015
Noise based modifications of a grid

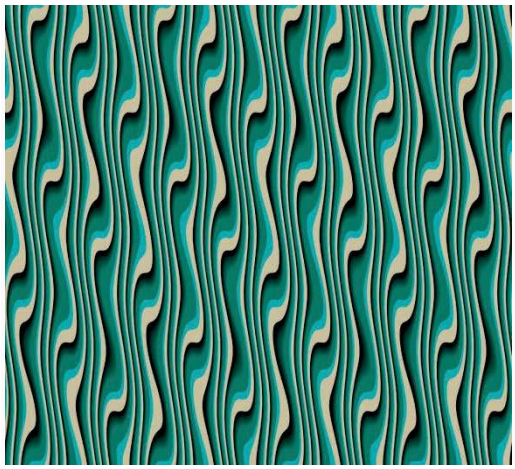
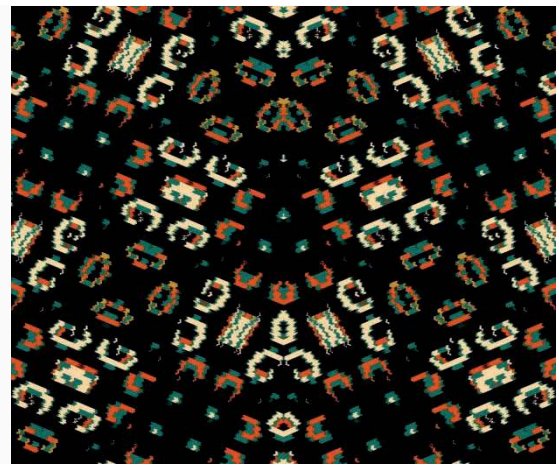
Procedural: materic effect - 2015
Reflection environment applied to a grid overlapping a generated cloth pattern





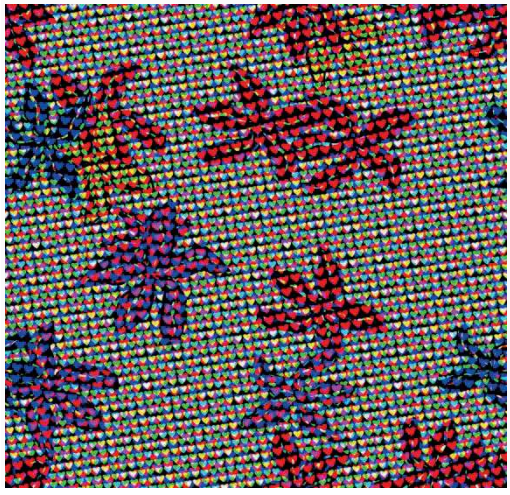
Procedural + tribal - folk image - 2015
Folk object color separated by rotating inclined graphic pattern

Ai dream - 2017
Neural convolutional network

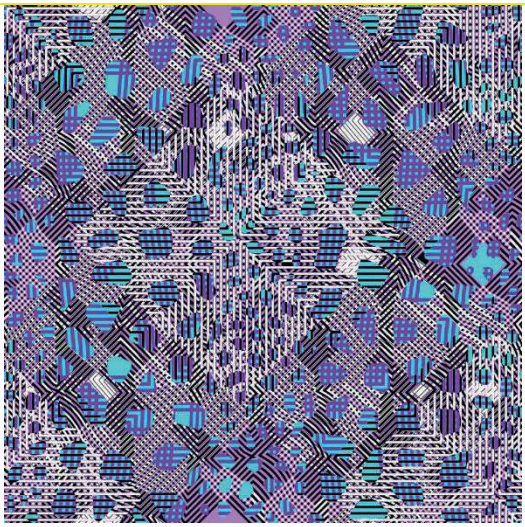
Procedural - 2017
Colorized wave noise

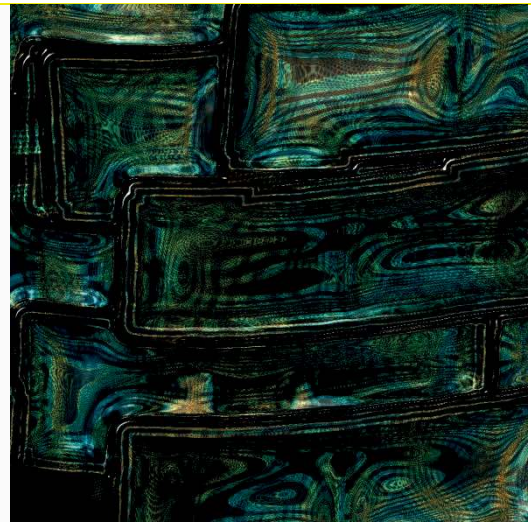
Procedural
Algorithmic generated icat weaving




Procedural - 2019
Folk object color separated by rotating inclined graphic pattern

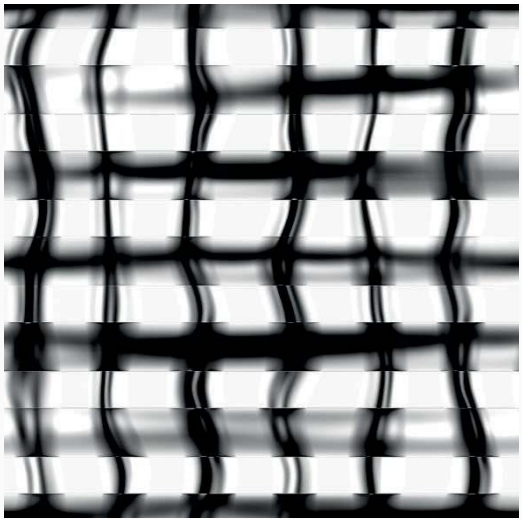
Procedural - 2014
Generated 3d spiral ribbons

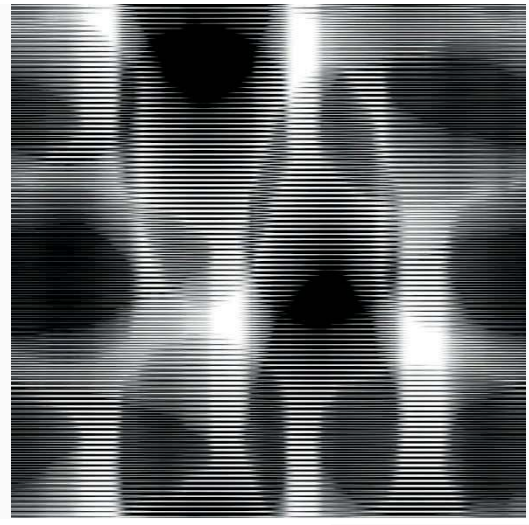




Procedural - 2018

Procedural - 2018
Glasses refraction over imaginary rug - detail





Procedural -2018
Overlapping noise distorted lines

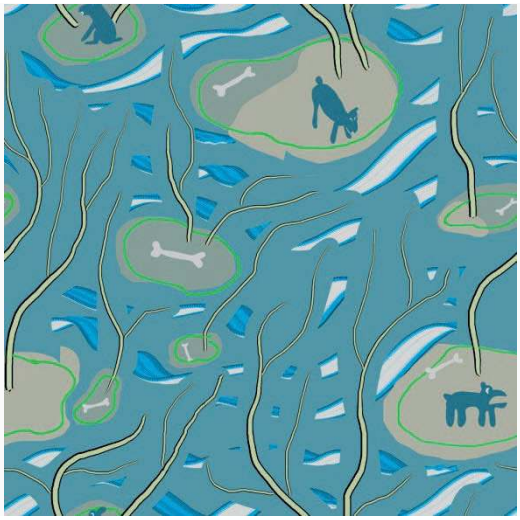
Procedural - 2019
One more procedural icat

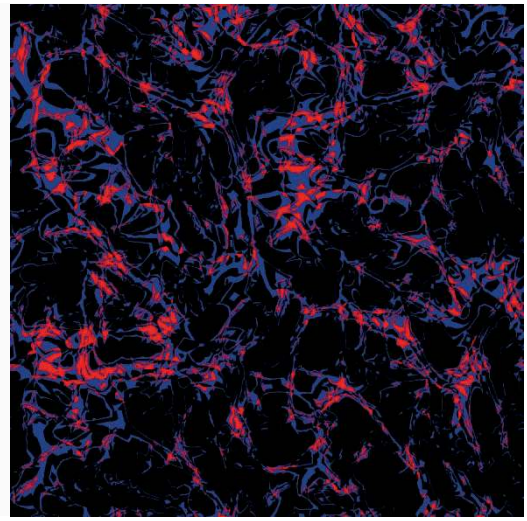




Procedural - 2019
Gradient driven distortions
Generated 3d spiral ribbons

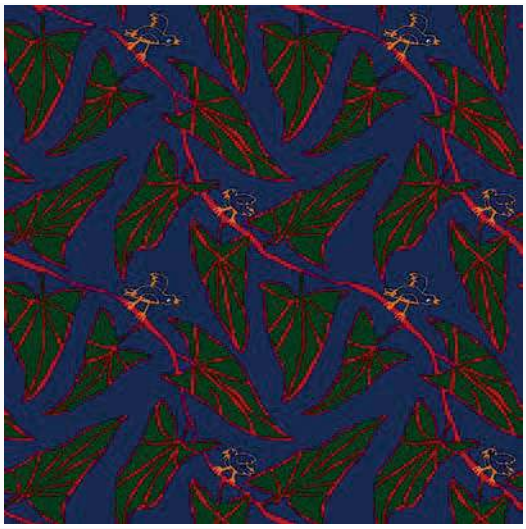
Traditional - 2017
Digital painting - tiled

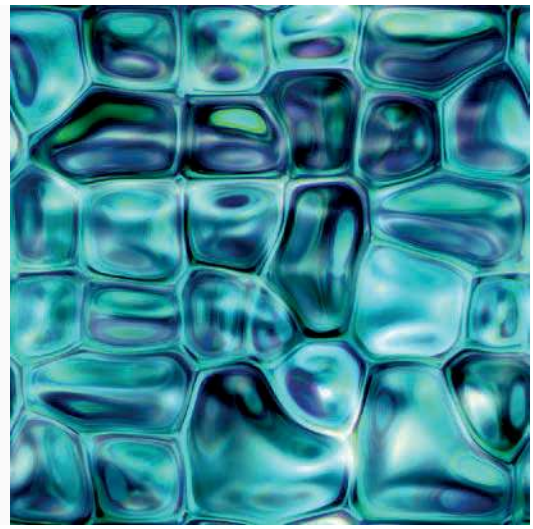




Traditional - 2017
Digital painting - procedurally fragmented

Procedural - 2018
Gradient on complex stratified noise





Traditional -2018
Birds repeat - procedural brush

Traditional -2018
Glass bubbles effect



virtual 3d webgl showroom at negativewall.com

sandrovioli@gmail.com

Key words: **#**cgi #designer #wallpaper #prints
Thanks to:
Anna: "*Stilista*", Manfredi" "*Programmer*"



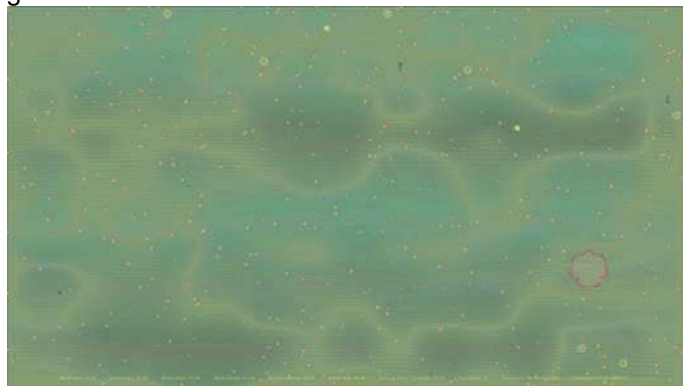
TITLE

Artwork: The Regeneration of the Earth After Its Destruction by the Capitalist Powers

Topic: Synthetic Ecology, HGT Simulation

Author(s):
Angela Ferraiolo, Sarah Lawrence College, Visual & Studio Art, New Genres
http://littleumbrellas.net/

Abstract
The Regeneration of the Earth is an artwork that simulates the re-mergence of life on our planet after the sixth extinction. The system begins after life on planet Earth has ended. The world lies in darkness, engulfed by a toxic, acidic sludge. This hostile environment seeded with a small number of digital entities that exist as a random collection of energy profiles and genomic instructions. Members of this 'generation 0' are not guaranteed survival but, through horozontal gene transfer (conjugation, transformation, and transduction), are able to evolve and over time and may gain the ability to sense, move, mutate, replicate, compete, or co-operate. In *Regeneration*, entities that can evolve their instruction codes to develop multi-faceted genomes will gain greater sensitivity to co-habitants and to the world around them. A heightened sensitivity to their environment acts as a survival strategy. Ultimately, the more sensitive an entity is to its environment and its co-habitants, the greater its chances for survival.



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Keywords: synthetic ecology, origins of life, gene transfer

Main References:

[1] Ray, Thomas S. *Evolution, ecology and optimization of digital organisms.* Technical Report 92-08-042, Santa Fe Institute, Santa Fe, NM, 1992.
[2] Skippington, Elizabeth, and Mark A. Ragan. *"Lateral genetic transfer and the construction ofgenetic exchange communities."* FEMS microbiology reviews 35, no. 5 (2011): 707-735



Title: Automata I & II: Generative art as a language of the socio-political

Artwork

Topic: Art

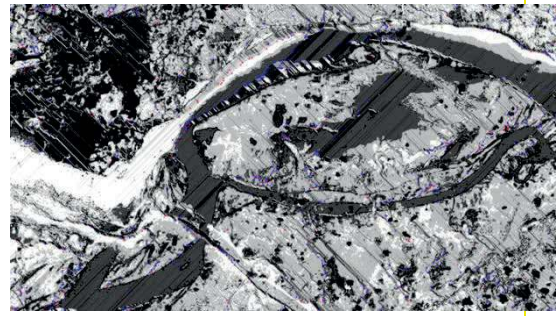
Author:
Catherine Griffiths
USA, University of Southern California, School of Cinematic Arts
https://cinema.usc.edu/
https://isohale.com/

Abstract
Automata I and Automata II are two parts of an arts research piece that attempt to connect socio-political ideas to computation using the aesthetic expression of generative art. The artwork explores the idea of reverse engineering a social issue – in this case the gaze of a street surveillance camera – back through a particular algorithmic logic – in this case cellular automata.

The piece presents different perspectives on a scene: the algorithm's view and the human's view, whilst creating a generative redesign of its landscape. It is an opportunity to think through the difference between the simplified data and rules that an algorithm operates with, and the higher-level image that we see, and which might hold cultural or social meaning.

This generative visual thinking is applied to computer vision processes and the image of a surveillance camera: breaking down an image, making it algorithm readable, isolating state changes. The resulting animations are generative expressions of movement and stillness, revealing and concealing oneself in relation to an algorithm. This work is conducted in the context of ideas of algocracy [1], which is a form of power that takes place through the design of algorithms and the way they tacitly shape behaviours and assert authority without our conscious awareness. Jentery Sayers proposes a reframing of the essentializing binary modes of technologies of vision by using strategies that promote ironic or ambiguous vision [2], to which I would like to look to the generative arts for those strategies.

The work is about using generative art techniques to think through computational ideas, to consider seemingly foundational and neutral systems like cellular automata in the context of more complex social issues. Can such an aesthetic expressive process-based work enable access to these computational issues? What is the scope for using the visual language of generative art for critical argument?



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Key words: cellular automata, computer vision, critical code, creative code, algocracy

Main References:

[1] A. Aneesh, "*Virtual Migration*", Duke University Press, 2006

[2] Jentery Sayers, "*Computer Vision as a Public Act: On Digital Humanities and Algocracy,* in Disrupting The Digital Humanities", Punctum Books, 2016



Drift Mirror
Artwork

Topic: Art

Author:
Chad M. Eby
U.S.A., University of Kentucky, School of Art & Visual Studies
https://finearts.uky.edu/savs

Abstract
The liminal infrastructure supporting the digital world creates complex but imperceptible electromagnetic fields of oscillation in the physical world; the inner workings of the ubiquitous devices that collect, store and transmit data emit a Byzantine array of inaudible drones, clicks, howls and buzzes all around us. Cruder devices, such as motors, lamps and even the electrical grid itself contribute to this spectral chorus. And though we do not perceive this EMF cacophony directly, our very bodies also emit, absorb, reflect and refract varying kinds of electromagnetic radiation.



Figure 1 Left view

The sound sculpture *Drift Mirror* (currently in development) employs environmental sensors in combination with generative strategies to create an evolving multi-channel soundscape from both live and pre-recorded EMF events. Three microcontrollers monitor electrical field distortions around the sculpture caused by bodies moving in real space—and uses those readings to steer a notional "sound probe" through a cubic volume of virtual space seeded with EMF recordings. When the virtual probe encounters a pocket of sounds, those sounds are collected and played back through an 8-channel speaker array. In parallel, live EMF

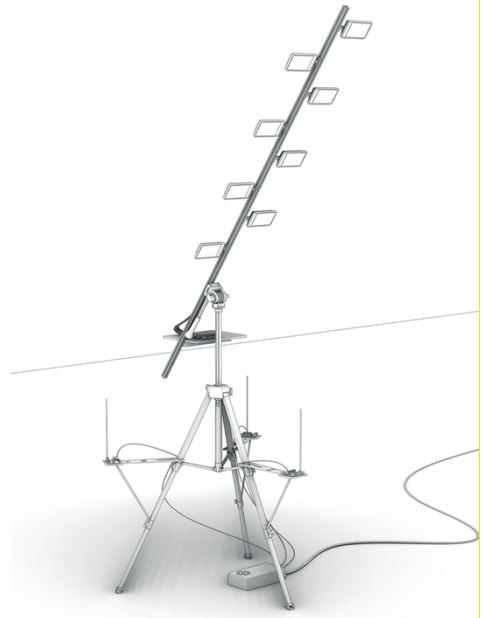


Figure 2 Perspective view

events captured in real space are also added. As the sounds overlap in time, they mix, generating an ev er-changing soundscape as many as 32 l ayers deep. *Installed dimensions: 2.3 x 1 x 1 meters*

chad.eby@uky.edu
hello@chadeby.studio

Key words: Sound, EMF, autonomous art systems, environmental sensing

Main Reference:

[1] Chad Eby, "*The Machines Wave Back*", Media-N, Urbana, Illinois, 2019: https://doi.org/10.21900/j.median.v15i1.48



TITLE : *: Art and Design: The Unique and the Uniform*
Topic

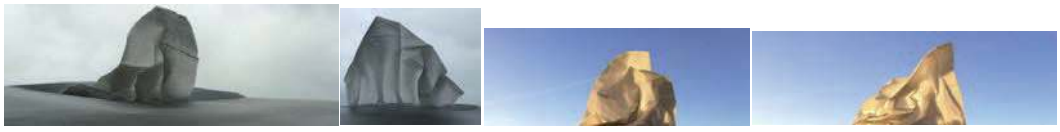
Author(s):
Name Gavin O'Brien
New Zealand
Otago PolytechnicOtago Polytechnic,
Te Kura Matatini ki Otago

Abstract
Design and Art: The Uniform and the Unique

This project is derived from a satori-like moment triggered by an everyday product of global culture, yet a product that exhibits fleeting qualities of both the uniform and the unique, and whose raison d'etre is it's disposability: the personal tissue. A chance encounter of strong winter sunlight seen through an emerging tissue (see images below), from a box left on a window sill provoked subsequent ruminations which resulted in a mind map of thoughts and words triggered by associated values and/or characteristics, embedded, in or implied by, this startling image.

While my proposal remains a work in progress, it suggests multiple stimulating possibilities for delivery at the Generative Art Conference.

My current concept is to display a bank of nine of nine boxes of tissues on a square white plinth approximately 400mm x 400mm x 1200mm. A mash of the associated mind map of key words provoked by the original observation will be pasted around the top of the plinth and will appear in several languages emphasizing the theme of *weaving* that is based on the etymology of the word 'tissue'. (please note that this text is not yet definitive).
This will be an interactive exhibit where attendees at the conference are encouraged to participate in the work by drawing a tissue from any of the boxes.
With each of these interactions, the unique nature of the composition is continually refreshed with a fleeting new, unpredictable, and unrepeatable iteration.
It is hoped that a small light fitting can be added to each plinth to further enhance the display.
Perhaps conference delegates could each bring a box of domestic tissues from their homeland to add to the mix.



evanescence transience inference fragility rationality multiplicity provisionality durability longevity plasticity tentativity permeability uniformity commonality connectivity variety authenticity ambiguity agility opacity individuality identity anonymity conformity replication duplication association provocation insinuation implication variability utility erasure recycleablity globalization connectivity evanescenza transitorienza inferenza fragilità razionalità molteplicità provvisori durabilità longevità plasticità tentatività permeabilità uniformità comunanza connettività varietà autenticità ambiguità agilità opacità identità identità anonimato conformità replicazione duplicazione associazione provocazione insinuazione implicazione variabilità utilità cancellazione riciclabilità globalizzazione connettività Yì shì xìng yì dù tuīduàn cuìruò xìng hélǐ xìng duōyàng xìng yǒngjiǔ xìng nàijiǔ xìng chángshòu xìng kěsùxìng shèntòu xìng tǒngyī xìng liántōng xìng liántōng xìng liántōng xìng duōyàng xìng móhú xìng mǐnjié xìng bùtòumíng gèxìng shēnfèn yīzhì xìng fùzhì guānxì fùzhì xìng fēibàngévanescence inférence fragilité rationalité multiplicité provisionnalité durabilité longévité plasticité tentativité perméabilité uniformité communalité connectivité variété authenticité ambiguïté agilité opacité individualité identité anonymité conformité réplication duplication association provocation insinuation implication variabilité utilité effacement recycleablité mondialisation connectivitéエバネッセンス一過性推論脆弱性合理性多重性プロビジョリティ耐久性寿命塑性触覚浸透性均一性共通性接続性多様性真正性あいまいさ敏捷性不透明性個体性同一性匿名性適合性複製重複結合挑発含意可変性ユーティリティ消失再循環性グローバリゼーション接続性エバネッセンス一過性推論脆弱性合理性多重性プロビジョリティ耐久性寿命塑性触覚浸透性均一性共通性接続性多様性真正性あいまいさ敏捷性不透明性個体性同一性匿名性適合性複製重複結合挑発含意可変性ユーティリティ消失再循環性グローバリゼーション接続性Vergänglichkeit Vergänglichkeit Inferenz Fragilität Rationalität Vielfalt Provisionalität Haltbarkeit Langlebigkeit Plastizität Tentativität Durchlässigkeit Gleichförmigkeit Gemeinsamkeit Konnektivität Vielfalt Authentizität Ambiguität Beweglichkeit Opazität Individualität Identität Anonymität Konformität Replikation Duplikation Assoziation Provokation Unterstellung Implikation Variabilität Nützlichkeit Löschen Recyclingfähigkeit Globalität Konnektivität evanescencia fugacidad inferencia fragilidad racionalidad multiplicidad provisionalidad durabilidad longevidad plasticidad tentatividad permeabilidad uniformidad comunalidad conectividad variedad autenticidad ambigüedad agilidad opacidad individualidad identidad anonimato conformidad replicación duplicación asociación provocación insinuación implicación variabilidad utilidad borrado reciclabilidad globalización conectividad ευαισθησία παροδικότητα συνάφεια εύθραυστη ορθότητα πολλαπλότητα προσωρινότητα αντοχή μακροζωία πλαστικότητα δοκιμασία διαπερατότητα ομοιομορφία κοινότητα συνδεσιμότητα ποικιλία αυθεντικότητα αμφισημία ευκινησία αδιαφάνεια ατομικότητα ταυτότητα ανωνυμία συμμόρφωση αντιγραφή επικάλυψη αλληλεπίδραση πρόκληση υπαινιγμός εμπλοκή μεταβλητότητα χρησιμότητα διαγραφή ανακυκλωσιμότητα παγκοσμιοποίηση συνδεσιμότηταευαισθησία παροδικότητα συνάφεια εύθραυστη ορθότητα πολλαπλότητα προσωρινότητα αντοχή μακροζωία πλαστικότητα δοκιμασία διαπερατότητα ομοιομορφία κοινότητα συνδεσιμότητα ποικιλία αυθεντικότητα αμφισημία ευκινησία αδιαφάνεια ατομικότητα ταυτότητα ανωνυμία συμμόρφωση αντιγραφή επικάλυψη αλληλεπίδραση πρόκληση υπαινιγμός εμπλοκή μεταβλητότητα χρησιμότητα διαγραφή ανακυκλωσιμότητα παγκοσμιοποίηση συνδεσιμότητα

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Key words: Uniform, unique, tissue, generative

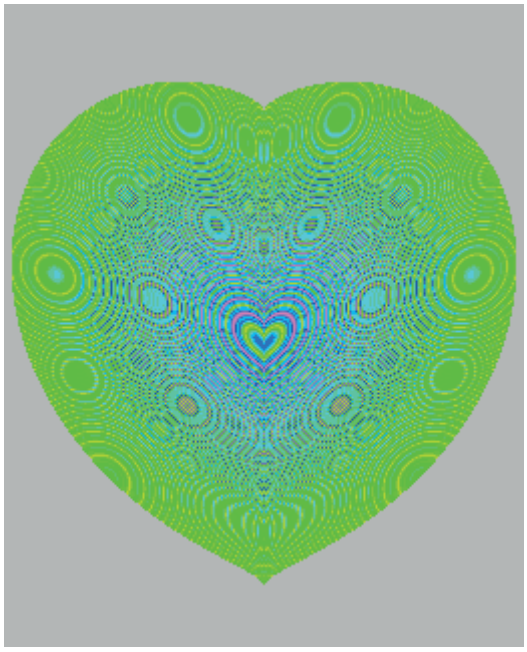


TITLE: Art and equations
(Artworks)

Topic: Art, Mathematics

Author:
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Latvia, University of Latvia, Department of Mathematics
www.lu.lv

Abstract
Author of this work sometimes use programming in Free Pascal to create pictures that can be considered as an “art”, for example, see pictures below. To construct such works, for any point of picture with coordinates x and y, author uses procedure PutPixel(x, y, c). Here c is a number, denoting some color. Number c often is computed from coordinates x and y cleverly combining equations of plane curves and trigonometric functions.





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Key words: Free Pascal, programming, equations

Main References:
[1] https://en.wikipedia.org/wiki/Algorithmic_art
[2] http://mathworld.wolfram.com/HeartCurve.html



FilmGrain

Installation, Art

Topic: Design, Visualisation

Author(s):
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University of Waikato, New Zealand
Mark Apperley
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University of Waikato, New Zealand
https://www.cms.waikato.ac.nz/people/mapperle
Chin-En kEiTH Soo
Senior Lecturer (Visual Design)
Faculty of Computing and Mathematical Sciences
University of Waikato, New Zealand
http://www.cms.waikato.ac.nz/people/ceks

Abstract
Films are an integral part of our cultural zeitgeist, as time goes on they have become more than entertainment, they have become a mirror that we point at ourselves in order to explore issues and our position in the world. To do this they use a myriad of tools to communicate with us quickly and effectively and from a design perspective this communication is at the very heart of what we do. FilmGrain is designed to visualise the colours of a film in order to explore whether the visual language of colours developed by the director and directory of photography stands up when removed from the context of the visuals. This concept of visualising film colours is not new by any means, in fact it can be traced back almost to the 1980s in the current form known colloquially as “movie barcodes” [1][2]. These barcodes take a small sample of frames from the film and visualises the average colour as strips either vertically or horizontally to great effect, however this inadvertently changes the experience of the film as not every frame is represented and those that are can be quite some distance from one another chronologically. This can be seen in Figure 1; one frame is captured every ten seconds meaning that the visual only represents 852 of 204,224 possible frames.



Figure 1 2001: A Space Odyssey as visualisaed by The Colours Of Motion.com

This is where FilmGrain differs, FilmGrain takes every frame from a film and captures pixels from three locations in the frame (top left, centre, bottom right) and presents the pixels sequentially, left to right, top to bottom in order to maintain sequence of the frames and also to present the film in one screen, with no need for scrolling to see all of the data. The three locations are visualised in their own "panel" to allow comparison of the variations of the colours across the frame. This presentation has the effect of creating a "grain" as the sequences of pixels change, hence the name.



Figure 2: Disney Pixar's Coco (2017) as visualised by FimGrain

Figure 2 shows the typical three panel visualisation of a film by FilmGrain showing top left pixels on the right, centre pixels in the centre and bottom right pixels on the right. We have found that if people are familiar with the film on display, they can actually "read" the image and identify moments in the film based solely on the colours in the context of the visual narrative. We believe FilmGrain also has utility as a tool for people to use in order to delve into films and start considering the colours as a deliberate choice. This is not just limited to cinephiles, this can be of use to anyone as colour is an integral part of our daily lives and so by really considering colours in the media we consume, we can become more sensitive to visual languages at work. FilmGrain is interactive and we hope people gain something interesting from their experience in using it.

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Key words: generative, visualisation, interactive, film

Main References:

[1] https://moviebarcode.tumblr.com/, 2011
[2] https://www.thecolorsofmotion.com/. 2015

FilmGrain

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Premise

Films are an integral part of our cultural zeitgeist, as time goes on, they have become more than entertainment, they have become a m irror that we point at ourselves in order to explore issues and our position in the world. To do this they use a myriad of tools to communicate with us quickly and effectively and from a design perspective this communication is at the very heart of what we do. FilmGrain is designed to visualise the colours of a film in order to explore whether the visual language of colours developed by the director and directory of photography stands up when removed from the context of the visuals. This paper will explain the process by which FilmGrain captures and visualises film colour data.

1. Introduction

Colour has been an i nescapable part of the cinematic experience since it was first introduced in the early 20th Century with such films as *With Our King and Queen Through India* [1] and *Cupid Angling* [2]. Colour brings with it all types of connotations and relationships and filmmakers have been using it to help tell their stories ever since those early days. The concept of visualising film colours is not new by any means, in the current form, known colloquially as “movie barcodes”, the most prominent practitioners online are moviebarcode.tumblr.com [3] which started in 2011 and thecoloursofmotion.com [4] which appears to have started in 2014. These barcodes take a small sample of frames from the film, calculates the average colour of the frame (earlier versions of this process

were a m odified form of slit-scan photography as they simply take a slice of each frame and display them sequentially others compress the frame horizontally until 1 pi xel wide which creates an approximate average colour of the frame) and visualises that colour as strips either vertically or horizontally to great effect, however this inadvertently changes the experience of the film as not every frame is represented and those that are can be quite some distance from one an other chronologically. As shown in Figure 1, one frame is captured every ten seconds meaning that for 2001: A Space Odyssey, the visual can only display a total of 894 of 204,224 possible frames.

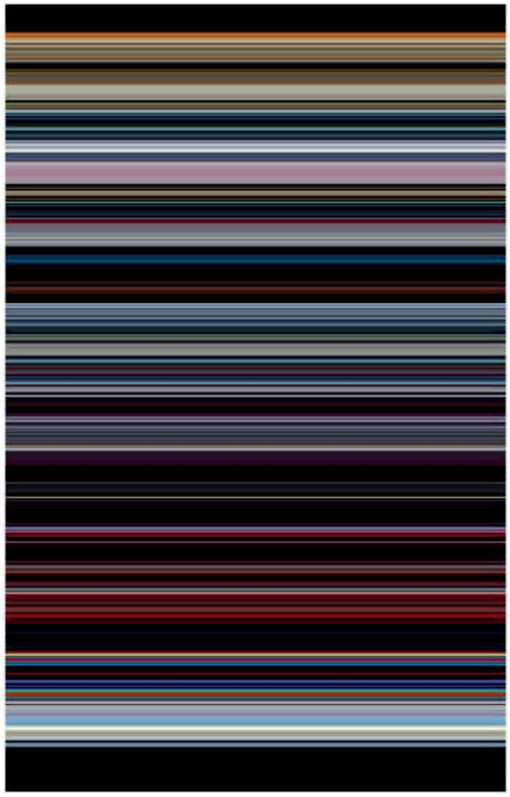


Figure 1 - 2001: A Space Odyssey by Stanley Kubrick as visualised by thecolorsofmotion.com

2. FilmGrain process

2.1 Capture

This is where FilmGrain differs, FilmGrain captures every frame from a film using the ffmpeg software [5] as this software is more efficient than anything we have so far come up with and then captures pixels from three locations in each frame (Top Left, Centre, Bottom Right) as shown in Figure 2. Twenty pixels are captured from each location within the frame in order to create a pool of colours that can be drawn from to fit the visualisation to different display resolutions. This results in 60 pixels being captured for every frame, which for a 90-minute film running at 24 frames per second saves 7,776,000 total pixels or 2,592,000 pixels for each screen location. These pools of pixels are saved into text files and loaded only when required.



Figure 2 - Pixel capture locations in each frame. For certain films with differing aspect ratios or framing, the position of the right and left capture locations had to be modified to capture the desired data. In future we will seek to do this position calculation work programmatically to avoid accidentally missing the data.

2.2 Calculation

To fit the visualisation to the display resolution FilmGrain uses the following calculation to determine how many pixels to take from each pool:

$$\frac{\text{Width x Height}}{\text{Number Of Film Frames}} = \text{Number of pixels to display per frame}$$

Figure 2 - Pixel calculation to fit visualisation to screen

This calculation has a drawback in that due to the inability to display partial pixels, the calculation rounds to whole integers and due to the variability of the lengths of films and display resolutions, film often do not fit completely on the screen and will appear too short. We have considered stretching the visualisation image to fit but that is an undesirable solution as it would distort the scale of the colours from film to film.

2.3 Construction

FilmGrain then presents the pixels for each location sequentially, left to right, top to bottom on the screen in order to maintain sequence of the frames and to present the film in one screen as shown in Figure 3, with no need for scrolling to see all the data which we feel is an improvement over other approaches.

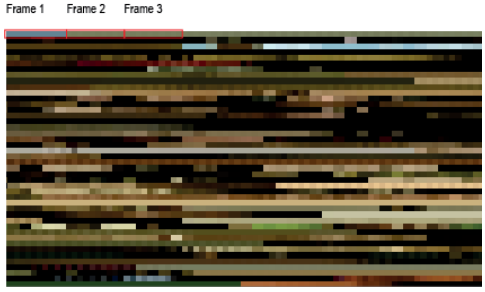


Figure 3- Single panel of visualisation construction, Frame 1 > Frame 2 > Frame 3> etc...

2.4 Output

The three locations are visualised in their own “panel” to allow comparison of the variations of the colours across the frame. This presentation has the effect of creating a “grain” as the sequences of pixels change, hence the name of the project. Figure 4 shows the typical three panel visualisation of a film by FilmGrain showing top left pixels on the left, centre pixels in the centre and bottom right pixels on the right. These panels are also able to be clicked in order to fill the screen, pixels are reloaded, amounts are recalculated, and the visualisation is redrawn as a single panel over the entire screen.



Figure 4 - The Fall by Tarsem Singh as visualised by FilmGrain

We have found that if people are familiar with the film on display, they can actually “read” the image and identify moments in the film based solely on the colours in the context of the visual narrative. We believe FilmGrain also has utility as a tool for people to use in order to delve into films and start considering the colours of a film as a deliberate choice. This is not just limited to cinephiles, this can be of use to anyone as colour is an integral part of our daily lives and so by really considering colours in the media we consume, we can become more sensitive to visual languages at work in our daily lives.

3. Conclusion

"Movie Barcodes" have become an increasingly interesting medium for visual and data exploration. At the time of writing this paper, the authors have become aware of the work of Jason Salavon, most notably his piece from 2001 titled *MTV's 10 Greatest Music Videos of All Time* [6]. It is a jarring similarity purely because of the identical approach to the presentation of the colours. This clearly indicates that this is an engaging way to approach the visualisation of movie colour and will not be the last time it is discovered.

Full Diagram included on the next page to illustrate entire FilmGrain process.



Figure 2 - FilmGrain pixel capture locations in each frame

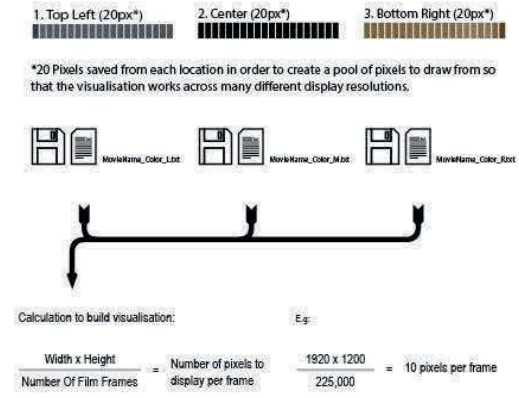




Figure 3 - FilmGrain single panel of visualisation construction, Frame 1 > Frame 2 > Frame 3> etc...



Figure 4 - The Fall by FilmGrain

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[1] https://www.imdb.com/title/tt0008984/

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[5] https://ffmpeg.org/

[6] http://www.salavon.com/work/MtvsTop10/image/205/



Love of Evolutionary Shrimp
(Installation)

Topic: (A-Life Art, Evo-eco simulation, 3D visualization)

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Abstract
This is a simulation of evolution wherein hundreds of shrimp are born, encounter each other, breed, and die; visualized with 3D Computer Graphics. The visitors can observe the partial details when they put their hands over the screen. The author created it as a part of the exhibition entitled “Volcana Brainstorm” organized by Elena Knox in Koganecho Bazaar 2019 in Yokohama, Japan. The concept of the exhibition is on Ecosphere, a commercial product of a small ecological system packed in a closed glass sphere filled with seawater and containing algae, bacteria, Hawaiian volcano shrimp. It was thought to be sustainable, but it usually ends with death of shrimp by unknown reason, though the designer assumed shrimp could reproduce their offspring inside of the sphere. From a view point of artists, one idea to save this ecosystem is to make a porn for shrimp that could excite them. The organizer expected the discussion on the issue might also be suggestive for people in a country whose population is shrinking, such as Japan.

The author was inspired through the discussion and workshops an idea to make a simulator as an extension of author’s last work [1] that simulates evolution of humans and generates a series of biographies. The system was extended from 2D to 3D, and added an interactive feature by camera control in a virtual space so as to focus on the scene of lovers. As same as the case of the previous one, each individual has genetic information on physical appearance and cognitive preference that inherits to the offspring with mutation and crossover, and the action is determined as a reaction against the internal and environmental situation. Because the calculation is done independently for each individual in parallel, it is not easy to predict what will happen next.



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Key words: A-Life, evo-eco simulation, 3D visualization, shrimp

Main References:

[1] T. Unemi and D. Bisig: Rapid Biography In A Society Of Evolutionary Lovers, GA 2017, Ravenna, Italy, 2017.

Love of Evolutionary Shrimp

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Premise

The author developed a software that simulates an evolutionary ecological system of a shrimp colony equipped with 3D visualization. Each individual owns genetic codes of both appearance and preference to help effective mating inherited from parents to children with crossover and mutation. Some hundreds of individual shrimps are roaming, eating, swimming, and sometimes making intercourse in a virtual 3D space. By controlling the pose of camera as it tracks a sampled individual, it shows a closeup of what they are doing.

1. Why Shrimp?

This software was developed by the author as one of the artworks exhibited in "Volcana Brainstorm [1]" organized by Elena Knox in an art festival of Koganecho Bazaar 2019 [2] in Yokohama, Japan, from September 20 to November 4. Knox organized discussion meetings to pursue an artistic solution to help shrimp in "ecosphere" for their reproduction that would be realized the true sustainable micro ecosystem. The exhibition was by a collection of artworks inspired through the discussion by totally 42 artists of a variety of forms. The ecosphere is a commercial product that packs shrimp, algae, bacteria, and sea water together in a closed acrylic sphere [3]. It was inspired from a challenge of a NASA's project to develop a method of travel by the space ship for a long time around the planets in the solar system and beyond [4]. Although this micro ecosystem would also be expected sustainable through a type of biochemical cycle, it ends with the shrimp's death as they do not reproduce their offspring. One of the ideas by Knox was to produce a pornography for shrimp that makes them feel sexy to promote their mating. Her idea was also inspired by the history of Koganecho that used to be a dangerous area in the downtown occupied by a number of illegal underground businesses during the chaotic era after the end of World War II. The exhibition place is also a house where a number of girls were working in sexual services. The piece introduced here is an author's answer that shows scenes of reproduction in the lives of shrimp in a virtual world.

2. Shrimp's Life Cycle

From the view point of biological taxonomy, shrimp is a subgroup of Decapoda together with crab and lobster. The shrimp employed as heroes in ecosphere is "Halocaridina rubra" whose other name is Hawaiian Volcano Shrimp or ʻōpaeʻula. They are tough enough to survive in a severe environmental condition and easy to feed in a normal tank. The wild colonies are found in brackish water pools near the sea shore in Hawaiian Islands.



Fig 1. A photo of a colony of shrimp in an anchialine pool in Hawaii Island, excerpted from youtu.be/Sa9sA-UMLPg in Opae Ula Related.

They are getting nutrition by eating algae and detritus. The female of this species lays 20 - 30 eggs, and holds them until the incubation. As similarly as the other arthropods, they grow through metamorphosis from larvae to adults. Some details of the life cycle of the species can be found in the page of Wikipedia [5].

3. Model of Behavior

Instead of modeling sensors, actuators and neural circuits that controls the individual behavior, a simpler computational model is employed so that individual behavior takes one of eight modes, floating, roaming, swimming, hungry, eating, sex, dazed, and dead. This is an extension of the author's previous work under a collaboration with Daniel Bisig [6].

A larva is usually floating under water, as it spends a planktonic life, then roaming on the bottom surface of the pond after grown up to adult. The adult individual seeks a partner during it is roaming, according to the observation of the neighbors' figures. When it finds a target as a new partner whose appearance matches with its own preference, it start approaching to the target. If two individuals of different sexes approached each other, they may have intercourse when the distance between them became short enough. After the intercourse for a constant time, their behaviors transit to the dazed mode to slowly move apart from each other, then start roaming again. The fertilized eggs incubate after some duration. The number of new born larvae is maximally 20 or less depending on the population density around the mother and the total population size in the current virtual world. The limitation of the number of individuals is to avoid a population explosion and to guarantee the smooth movement in the simulation.

Each individual has a numerical status value of energy that constantly decreases depending on the mode. When the energy level became low, it stops the current behavior to transit to the eating mode. After it ate enough, it returns back to the mode it was doing before eating. It would be more realistic if the growth and consumption of algae could also be modeled and simulated, but the current implementation assumes that algae is always available in enough amount to save shrimp from starvation. When an adult individual is roaming and it has no target of the partner, it may leave from the bottom and start swimming to move straight toward another place in a given probability. The transition from swimming to roaming is also determined in a given probability. The death is also determined in the same manner.

For the motion in any mode, each individual is affected by repulsion forces from the others surrounding it in order to avoid mutual collision, except the partner target as similar manner with classic

BOIDS model for collective behavior [7], though it employs forces of neither cohesion nor alignment with neighbors except the target partner. The male shrimp tends to approach the position on the target's back and to align the orientation. The female stays on the bottom and is not applied an alignment force to.

4. Model of Shapes

For the visualization in 3D space, the author designed the contour of bottom surface of the pool as shown in Figure 2, and the shapes of larva and adult shrimp in Figure 3.

In order to reduce the computation cost, the author also designed simplified shapes of both larva and adult. Because the load for scene rendering depends on the number of vectors necessary to be processed, such omission of some details is effective. The shape is drawn by the simplified version when it is small enough in the rendered image on the screen.

It could be better to make each individual move its legs, fins, and antennas, though these body parts are fixed in the current version.

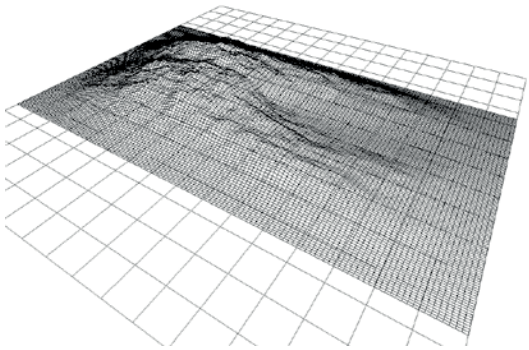


Fig 2. 3D model of contour for the bottom of the pool in the wireframe, made by a fractal random generation of natural landscape.

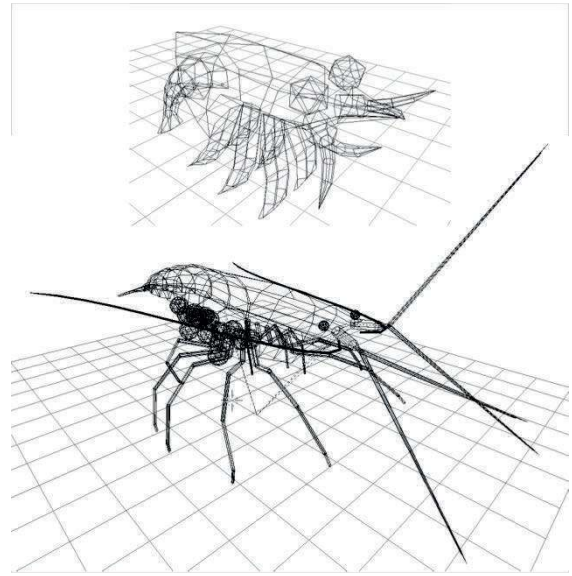


Fig 3. 3D model of larva and adult shrimp.

5. Viewpoint Control

Conceptually, this piece should display a scene to focus on the behavior of shrimp for reproduction to satisfy the motivation as described in section 1. It is also effective for visitors if they can observe not only the perspective view of the virtual pond but also the detail of individual behaviors and relations. To achieve this requirement, the author implemented a functionality to make the virtual camera move to explore in the pond. The home position of the camera is above water surface to provide a view of whole area of the pond. It moves smoothly toward the position and

orientation where a sampled individual can be observed from upper position to look it down in 45 degree. The individual is randomly chosen from the list of lovers who has a partner target. After tracing the sample for 15 seconds, the camera moves again to a newly selected sample.

This motion of the virtual camera starts when the visitor covers the screen by their hands. It was easy to detect such visitors action by ceiling camera as the exhibition space is dark enough to measure how much portion of the screen is hidden behind obstacles above it. When the obstacles left, the virtual camera moves back to the home position slowly.

Figure 4 is an example of the snapshot captured when a sampled lover is closed up by the virtual camera. As shown in this image, a sign is attached to the monitored individual to show what it is doing.

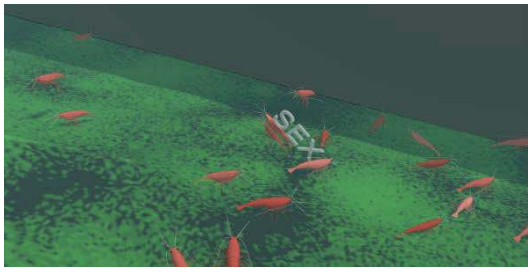


Fig 4. A snapshot during the virtual camera is tracing a sampled individual.

6. Implementation and Installation

The software was written in Objective-C and developed using Xcode on macOS 10.14 utilizing 3D graphics framework named SceneKit provided by Apple [8]. This framework includes easy APIs to import 3D shapes from a file of a standard format. The author used Blender [9], an open source 3D modeler, to draw the necessary models described in section 4. The software runs on Mac mini 2018 equipped with Core i7 CPU under a supervised control by AppleScript that starts and stops the system to follow the exhibition schedule. The states of the population are saved into a file before it stops, and it is loaded just after the system starts in the morning of the next day, so that the evolutionary process continues throughout whole of 40 days of the exhibition. For both simulation and rendering under the condition that the maximum population size is limited to 500, the processing speed is faster than 30 frames per second, enough to be recognized as smooth motion.

Figure 5 is a photograph taken at the exhibition site of Volcana Brainstorm. A 55-inch Full HD monitor laid on the floor facing upward with ornaments made of some pieces of real volcano rocks, artificial grass, and cloths. This ornamentation was designed by Elena Knox. Sound effects were also attached in the software that bring an atmosphere under the water with a mixture of sampled sounds of bubbles and click noises.

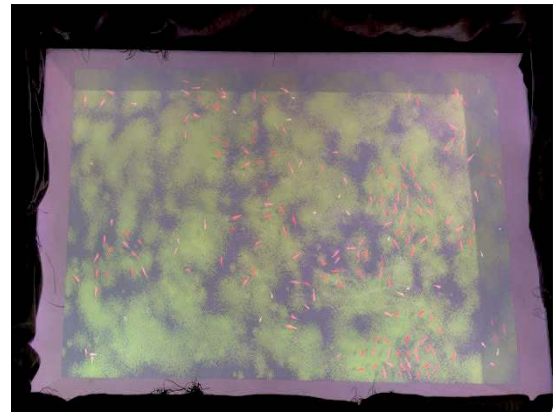


Fig 5. A photo of installation at the exhibition.

7. Concluding Remarks

A computer simulation of evolutionary ecosystem is one of the possible sources for a type of generative art. From a view point of artistic production, it is important not only how the mechanism behind the generative system works, but also how to visualize the complex phenomena produced through the generative process. It should have an explainable connection with the concept of the artwork. As described in section 5, this system uses a motion control of the virtual camera so as to provide the viewers a natural transition of scenes and closeups to show what the individuals are doing. The author designed the motion through several times of trials and error. He wishes to expect a raise of more scientific researches concerning the effective camera control for filming in the 3D space in both real and virtual world.

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[9] Blender, https://www.blender.org



LIVE PERFORMANCES

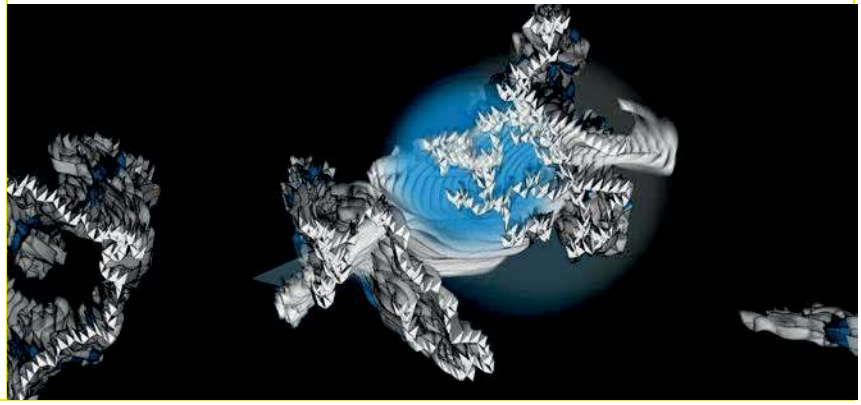


Namba AV

Music and Visuals in realtime with Processing & Sonic pi

Alba G. Corral (b. 1977 – Madrid) based in Barcelona is a Visual Artist and creative coder based in Barcelona. With a background in computer engineering, Corral has been creating generative art using software and coding for the past decade. Her practice spans across live performance, video, digital media and installation, exploring abstract narratives and expressing sensitivity and taste for colour. By combining generative systems with improvised drawing techniques, her digital language becomes organic, creating mesmerising digital landscapes. Corral is known for her stunning live audio-visual performances where she integrates real-time coding and drawing in collaboration with musicians. . Her works has been exhibited at festivals and events in Europe, México, Japan & EEUU .
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http://blog.albagcorral.com

See videos
https://vimeo.com/315268036
https://vimeo.com/288610642







email/address

Key words: one, two three, four five

Main References:

[1] Name FamilyName, "*Title*", Publisher, Where, Year
[2] Name FamilyName, "*Title*", Publisher, Where, Year





Unauthorised
(Live Performance)

Topic: (Music and Theatre/Dance performance)

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Abstract
Unauthorised is a collaboration between dance/theatre artist Kathryn Ricketts, composer Arne Eigenfeldt, and an ensemble of intelligent musical agents.

Kathryn inhabits a character names Rufus, a tired clown that struggles to find humour in dissonance. In *Unauthorized*, we draw a parallel to the work of Samuel Beckett, which echoes the principles of improvisation found in clowning: it denies a linearity and instead constructs its own logic, an ecosystem of creative impulses, shared and collectively developed.

We explore new ways to approach narrative, character, setting, and props; Rufus becomes a catalyst for storytelling. In the telling, we trigger more stories, which fosters a sense of collective belonging by the nature of their commonalities and subsequent empathy.

Musebots – intelligent musical agents designed by Arne Eigenfeldt – respond to Kathryn's voice and movement through realtime analysis, creating a synergistic play between sound,

text, and video, adding a richness of the creative choices and subsequent provocations. Aware of each movement's text, the musebots respond, provoke, and influence Kathryn's movement and speech choices, as well as determining certain structural choices in the work itself.

Unauthorised is 33 minute work in 6 movements; we propose to perform 2-3 movements.

Work in Progress examples: https://aeigenfeldt.wordpress.com/unauthorised/

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Key words: generative music, musebots, dance, theatre, Beckett



SOLILOQUIUM
Live Performance
Topic: Art, Music, Movement performance

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Abstract

Generative art constitutes a dynamically developing area of experiences representative for the modern digital culture and builds up space for creative explorations. This form of art requires interdisciplinary competences, deepens artistic awareness and steers the imagination towards new, digital domains. This encourages experimenting, bringing together the activities undertaken by artists of various backgrounds in order to form a multi-dimensional area for cooperation. *Soliloquium* project is the result of the joint efforts of the composer – music choreographer – graphic designer, scenographer and animator.
Soliloquium, composed by Katarzyna Kwiecień-Długosz, is a music miniature which became an inspiration for creative activities in the fields of:
- creating movement to music
- interactive visualisation
- generative design, capturing human body movements

The outcome is a movement interpretation assuming parallel co-existence of physical body and interactive visualisation, related to the body in a specific manner within the frame of the sounds of music. According to the definition in "Dictionary of literary terms", the title *Soliloquium* means a monologue, a sort of inner dialogue of an individual, in which the speaking subject becomes the main object of observation, tries to define, specify, describe his/her own mental attitude.
In music such a subject is a cello in a solo part, played by Anna Szmatoła. This performance is accompanied by sounds recorded on tape, such as: processed sounds of traditional Vietnamese instruments (lithophone, hegaro) along with zither and double bass string harmonic, as well as the sounds of thrown stones, water and processed sounds of a washing machine.
In music choreography the sounds of the cello are interpreted with expressive movements of a dancer, attempting to convey the sounds of the instrument, its melody, rhythm, articulation, dynamics and tempo through the body's plasticity. Movements refer directly to the sound of the cello and are its vivid visualisation in the form of gestures and body movement sequences in space. Other recorded and processed sounds on tape are

interpreted by interactive visualisation, creating movable scenography (displaying animated images on spatial objects, thanks to which they gain entirely new dimensions and/or are vivified).
The second dimension of the spectacle is created by means of movable visualisation. Dancer interacts with the light, either pursuing it or giving it a new direction.
Dancer's movements, in terms of stage design and dynamics, are complemented by animation-related activity in two ways:
1. Dancer's movements (cello) are interpreted directly by means of software and processed, resulting in simultaneous animation of the previously designed multi-layered graphic object. This part of scenography is of interactive nature, brought about by choreography. 2. The layer of complementing digital "sounds on t ape" will be also interpreted with previously made synchronised animated images, creating the environment based on gr aphic and l ight elements for dancer's main choreographic activities and for the choreography of the graphic outline made by her movements.
Video projectors will be us ed to display the activities connected with scenography and animated images.

The aim of this project is to take a look at music and movement from the virtual world perspective and to search for the means of expression attempting to create an aesthetic piece of art.

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Key words: generative art, virtual reality, generative music, contemporary Polish music, body movement, music choreography

Main References:

Beata Oryl, choreography: „Francesca da Rimini" by Sergiej
Rachmaninow, venue: Baltic Opera, Gdańsk, 2014

Beata Oryl, preparation of stage movement for the theatrical performance " Śmierć Byron'a" ["Death of Byron"] venue: Gdańsk Shakespeare Theatre, 2015

Beata Oryl, director and choreographer of the concert „ Z miłości do niepodległej” ["For the love of independence"] venue: Forest Opera, Sopot, 2018

Beata Oryl, preparation of music choreography for the concert ”Język muzyczny wybranych utworów wiolonczelowych polskich kompozytorów XX i XXI wieku w interpretacji ruchowej”["Musical language of selected cello compositions of Polish 20th and 21st century composers in movement interpretation"] (2019) venue: Stanisław Moniuszko Academy of Music in Gdańsk

Robert Turło, ”O królewnie zaklętej w żabę” [" Princess turned into a frog"], film (awards: New York 2015, OFAFA

	Cracow 2005, Cairo 2006, Houston 2007 Robert Turło, „Miś fantazy” ["Fantazy the bear"], film, director of the series and episodes Niebieski miś [Blue bear], Tajemnica kryształu [Mystery of crystal], Imieniny Fantazego [Fantazy's nameday] (awarded in Tarnów 2008) Robert Turło, Gdzie jest Nowy Rok? [Where is New Year?] (film, 2006) Robert Turło, Czarne licho [Black evil spirit] (film, 2009) Robert Turło, Dar skarbnika [Treasurer's gift] (film, 2010)



Numbering, where trees move

Live Performance

Topics: Generative Poetry, Design, Music and Dance,

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Abstract

"Our life away from public haunt finds tongue in trees…"
Shakespeare

Numbering is the site where trees move for generating *tongue,* full of all human impressions from the trans-dreamed real Nature world.

With this main aim, Enrica Colabella wrote "*Numbering,* where trees move", a poem for connecting points of view of different disciplines in a collective discovering generative process of art.

The main aim is an actual transfiguration in our digital time of the ancient process of discovering a *similarity* between the natural world and the art process.

Loneliness seems to be the eternal main condition, but as often happens it is always possible to open also *just a little crossing* between different disciplines and points of view for gaining collective interactions for impressive possible results. The scenic space will be performed by a braid expression of connection between the digital architecture spaces the sounds of words and music with the body of the dancer.

In these ways, the poetic texts becomes a catalyst for generating connections between digital spaces, dance and music.

Numbering, where trees move / *Numerando*,dove si muovono gli alberi

When trees move, sounds deeply static brighten. /Quando gli alberi si muovono, i suoni profondamente statici si illuminano.

The movement of trees from their more hidden roots/Il movimento degli alberi dalle loro radici più nascoste

Until their highest leaf toward the sky lightness/Fino alla loro foglia più alta verso la luminosità del cielo

Becomes like the first step of an unstable child/ Diventa come il primo passo di un bambino instabile

Left for the first time alone from tender helping hands, / Lasciato per la prima volta solo dall'aiuto di tenere mani

For discovering the wonderful human ability in crossing space.time;/ Per scoprire la

meravigliosa abilità umana nell'attraversare lo spazio-tempo…..
The performance images are generated 3D models of Italian Gardens.
The peculiarity of Italian Gardens is the presence of architecture, trees and vegetation in a complex and constantly evolving mix. In the interactive video, which responds in real time to sound, the 3D models of Italian Gardens move, varying size and posture, but maintaining their specific characters. Interaction with music and w ords dynamically amplifies the interpretative structure of trees and architecture and their visionary character.
Within *Numbering* project digital processes are used to increase listening strategies among performers and to animate logical connections and semiotic implications between image, poetry, music and dance.
On one hand the video images are programmed to respond and expand interactively the sound events happening inside the room; at the same time the overall sound design allows digital connections between the performers, making it possible to unify poetry music and gesture through a system of digital real-time analysis. In this way cello sounds and narrative voice accents and timbres feed an algorithmic mapping system modulating and mixing prerecorded sounds of nature and classic repertoire, in parallel with the data coming from the movements of the dancer on stage. In this way the performers' gestures, accents and intentions flow together to transfigure electronic sound materials fragmenting the sound of sap and leaves of trees intertwined with piano pieces (quoting Debussy, Ravel, Messiaen) symbolically linked to natural themes and musics taken from sound actions of natives of the Amazon in dialogue with the rhythms of nature. The electroacoustic sounds thus become an interregnum where different sound actions mix up to lose individuality and generate new forms, thanks to digital hybridation.
The accelerometers guided by the hands of the dancer trace orientations, energies and impulses, which combined with the vocal accents and cello textures drive a complex flow of data mediating the artistic intentions of the performers with the recorded sounds mixing symbolic, magic and actual nature..

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Keywords: Generative Art,Giardino all'italiana**,**Numbering, Music Dance
Main References:
Shakespeare, Piero della Francesca, Leonardo, Palladio, Debussy, Ravel, Messiaen



The Persistence of Elusion: Hard and Soft Dances — Machine Learning Glitch Version
Live Performance

Topic: Music

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Abstract
In pursuit of exploring the underlying nature of a 1980s-style drum machine, this work uses basic and even banal approaches to synthesise bass and snare drums, cymbals, etc. and exploits their creative potential by using them in unintended ways. Every voice is driven by and derived from a single clock signal. This clock signal is intended to increment by 1 with each processing cycle, and the resulting music sounds commonplace when it does. However, a rich variety of surprising material results when the direction and speed of this clock signal are manipulated.

In this improvised performance, an indeterminate process steers the clock signal in unpredictable ways, and the performer is given only the mundane and limiting controls of a drum machine interface to roll with these rash changes and to shape the performance aesthetically. This wild and awkward predicament serves as a crucible or creative performance that allows native features of the interface, the sound-production model, and human creativity emerge in ways that would not have happened in a calm environment with unlimited control. As such, it is a reflection on the relationship between constraints and creativity and how our tools may unintentionally shape them, for better and for worse.

The video content is structured to intensify immersion in this situation. It shows glimpses of the performer's gaze and his computer screen, although fleeting and glitchy ones, as well as text from an essay on the aesthetics of this work, presented in a randomly meandering way, driven by the audio. This allows viewers to form multiple and tenuous connections among words as they appear in proximity, with speed and obtuseness that might allow the audience to perceive deeper, more poetic meanings across the words than any standard, formal writing might express. The title is a reference to Salvador Dalí's work including his *The Persistence of Memory* and related paintings as well as his theoretical reflection on the 'hardness' and 'softness' of things, which those paintings explore.

This version of the performance uses errors made by a k-nearest neighbour machine learning system in place of a standard (pseudo-)random number generator as a way to give voice to the natural patterns of wavering and unconfidence when it occurs in such a system, thereby reflecting on the inherent nature of such a process.

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Key words: Dalí, drum machine, glitch, improvisation, live video



Divining Rod
Live Performance

Topic: Music

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Abstract
Although my creative work covers many genres, styles, and techniques, the majority of my creations are unified under the concept of *native composition*—that is, devising new composition methods for each project that leverage the situation of the artwork to generate or shape the artistic content as much as possible. This may include site-specific works, data sonification or visualisation, various sensors, feedback systems, exploiting glitches, and other techniques, in order to create new works and discover new ways of creating work by making the venue, the parameters, the goals of the performance resonate maximally and in their most natural ways. When invited to pursue the underexplored potential of machine learning through a gr ant program of the Texas A&M University President's Excellence Fund, I did not seek ways to make machine learning techniques more fool-proof but rather to better understand such systems by studying the ways in which they fail.

Divining Rod is the first project in this inquiry. In pursuing this approach, I needed a physical interface that could simultaneously give me (a) reliable, deterministic input reflecting how the performer is interacting with the interface and (b) a way for a machine learning model to attempt to determine the same information. A computer keyboard provides this kind of *crib sheet* most naturally (comparing questionable results to reliable answers): software easily and reliably determines what keys are being pressed via the HID input protocol, and a camera suspended above the keyboard lets a neural network attempt to determine the same information, so I can give voice to the difference between the two results. At the time of writing this abstract, the system uses a 16 x 16 pixel video, i.e., 256 inputs (the maximum allowed by the tools used at this time), with a k-nearest neighbour classification algorithm, trained with approximately 7000 frames, averaging 134 frames per key.

To give voice to the errors in the machine learning (ML) system, the HID input is mapped to the frequency of a sine wave oscillator, and the ML input is mapped to the centre frequency of a bands top filter, such that it will silence the sine oscillator if both inputs match. Any difference between the inputs results in audible sound, and a ny audible sound is a sonification of errors made by the ML system. Erroneous values are mapped to the parameters of a frequency modulation synthesizer driven by the sine oscillator described above, so the intensity and distribution of the sidebands (i.e., the fullness and complexity of the sound spectrum) portray the degree of error. Since this is an artistic portrait of the this system's tendencies rather than an empirical and quantified data analysis, this audio output

is sent into a network of delay lines that build the sound into a rich contrapuntal tapestry, reflecting aesthetically on the natural character of this system, or as Roland Barthes might have put it, focusing on the *grain* of this voice rather than any intended message. The video accompaniment is derived from the computer's glitchy live view of the keyboard, shaped by changes in the sound, to build an intermedia counterpoint between the sonic and visual content.

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Key words: error, glitch, improvisation, intermedia, machine learning



The making of Land(ing), a provocation towards place and space

Topic: (Art, Performance)

Author(s): Kathryn Ricketts
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Abstract

How is making understood across all dimensions of art education in the 21st century?

→ *Place* | How can place consciousness impact art education particularly in an era when migration, immigration and refugee status change our sense of location?
→ *Identity* | How might we describe hybrid identities and rethink our practices as a result?

The making of Land(ing), a provocation towards place and space

> *…pure relationality, the interval of change, the in-itself of transformation. It is a time that does not pass, it only comes to pass.*
> *Massumi (2002, p.58)*

We are visitors on a profoundly beautiful land which is Treaty 4. The troubling history and the promising future of this land meet in a powerful landscape and is the source of this collaboration involving very long drives, long walks and endlessly curious captures from prairie fields to abandoned farm houses. This proposed performance is called Land(ing) and is a collaborative multimedia dance performance created by three artists Kathryn Ricketts, Dancer – (Regina) , Ian Campbell – Video Artist/Filmmaker (Regina), and Scott Morgan - Composer and Audio Artist (Vancouver).

I would be presenting the excerpt of our resulting 4 years of research both in the field and in various theatres and studios. We have created an interdisciplinary work around Remington: an anthropomorphized bird inhabiting an austere prairie soaked landscape of sound and video. This research is a co-mingling of our 3 practices, integrating sound movement and visuals within an evocative and poetic performance, which is always emerging and shifting through refined living improvisational frameworks.

This research allowed us to experiment and construct new interdisciplinary languages

within our distinct interpretations of these rich and complex landscapes of Treaty 4 land. Collaborative work in the arts entails a process of, leaning™ into each other and creating new languages and practices through this syntax. We are questing a true integration of the dialects of our practice as opposed to augmentations, juxtapositions or even complimentary simultaneities.
Land(ing) celebrates and troubles rural Saskatchewan landscapes through rich poetic renderings as we honor the land we work and learn on provoking important conversations around identity, land, place, migration and belonging.

I will present a 15 excerpt from Land(ing) as a catalyst to dialogue centered on place/space and identity.

Massumi, B. (2002). Parables for the Virtual: Movement, affect, sensation. Durham, NC: Duke University Press

Key words: Place, Space, Identity, Post-Humanism, Dance, Improvisation

Main References:

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Love YOU … niverse

(Live Performance, but only for video/audio playback)

Topics: Visual Art and Music

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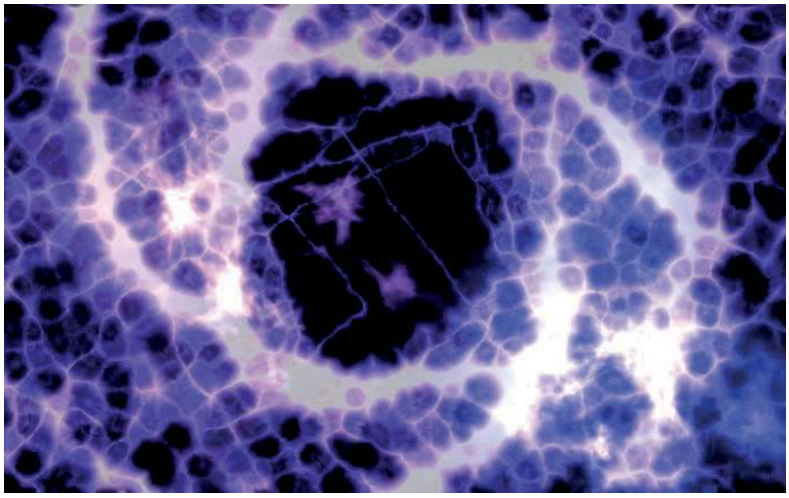
Abstract

The piece, Love YOU ... niverse written for the University of Austin CAET Launch attempts to describe a hidden love story from one of my dreams. https://vimeo.com/156101786

“I see my entire body as a brilliant and luminous object, which is radiating with love and gratitude. The energy of this love is filling all cells of my physical body, and lighting up every corner of my mind. I feel the undeniably strong connection towards to you, and then, this shinning connection destroyed my world. My world collapses with yours. Born into the nova in the Love You … niverse.”

In the piece, atmosphere ambient music combines with astronomic video to reveal the love universe, which is sentimental, unreal, and full of adventures, creativities and conflicts.





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Key words: fixed visual generative art and electroacoutic music

*This performance requires a PA system, prefer quadraphonic setup. If quad is not available, stereo could work too. A projector and a projection screen/surface are also required for the performance.



KOBANE
Live Performance
Music

Nicola Baroni
Italy, Music Conservatory of Bologna

Kobane for Ipercello

Kobane is an interactive composition originally created by Nicola Baroni for an Augmented Bass Flute and premiered by Roberto Fabbriciani in Bologna in November 2015 in the context of a large festival celebrating Luigi Nono. On the occasion of the *22nd Generative Art Conference* we now present a new version of the work performed with the cello by the author Nicola Baroni. Kurdistan and Syrian tragedies inspired the work dedicated to Luigi Nono, taking into account a conflictual condition of the performer with respect to the interactive electroacoustic environment strictly responding to the sounds proposed by the soloist engaged in a contrasting match with the digital system.

The interaction is based on a detailed timbre feature extraction monitoring the live sound of the soloist in comparison with 10 sound models scheduled in advance by the performer. In addition the sound evolution of the electronics is highly influenced by the rhythmic qualities and densities of the performance, and by the activity of the cello bow monitored through an accelerometer.
The central part of the work is ruled by an interactive score (microtonal and in common notation) which has to be sight read by the soloist, but which is at the same time produced by the soloist through the mediation of the digital sound analysis in real-time. The ending part spectrally elaborates, partially quoting, 2 sound files containing fragments by important works of Luigi Nono.

The characters of the sound treatments are integrally dependent on music as improvised and/or sight read by the soloist, who is engaged in a multilayered action integrating the acoustic sound with the complexities of the electroacoustic responses. The system offers the soloist the opportunity to deliberately orient multiple electronic sound qualities at the same time, adding a challenging complexity to the performance.

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FREE IMPROVISATION ON A GIOVANNI PIERLUIGI DA PALESTRINA'S THEMES
(Live Performance)

Music

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Abstract
Contemporary organ improvisation requires from the performer the skilful use of mutli-vocal texture. Practice shows that many factors have impact on the performer. The type of instrument and its original sound quality as well as acoustic space are the main variables determining the final shape of musical work.

The aim of the presentation is to perform improvised, organ improvisation on the theme of selected pieces of the representative of Renaissance Roman School, Giovanni Pierluigi da Palestrina, who was famous for his polyphonic perfection. The choice of the musical theme for improvisation is not coincidental – the musical pieces date back to the times when Villa Giulia, the venue of this year's session, was built.

The improvised *live performance* will take place in one of the churches in Rome. Organ disposition, the times when the instrument was built and the venue itself will be the inspiration for the creation of author's own composition generated in real time.

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Key words: live performance, contemporary organ improvisation, Giovanni Pierluigi da Palestrina, Roman School

Main References:

Piotr Rojek, "Wielkie Toccaty Organowe" (CD), DUX, Poland, 2005
Piotr Rojek, Igor Cecocho, "*Bach: Transcriptions for Trumpet and Organ*" (CD), DUX, Poland, 2018
Piotr Rojek, *Improvisation*, St. Anne's Church, Warszawa, 2018
Piotr Rojek, *Improvisation, Fantasia romantica*, International Organ Festival, Nieblum, 2018
Piotr Rojek, *Improvisation,* International Organ Festival, Marijampole, 2018
Piotr Rojek, *Improvisation,* International Organ Festival, Bezdekove, 2018



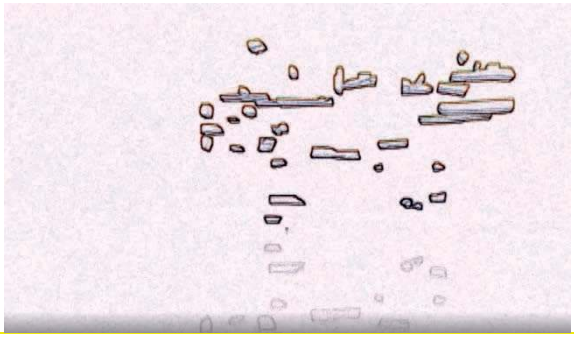
TITLE: "Inside". *(Live Performance)*

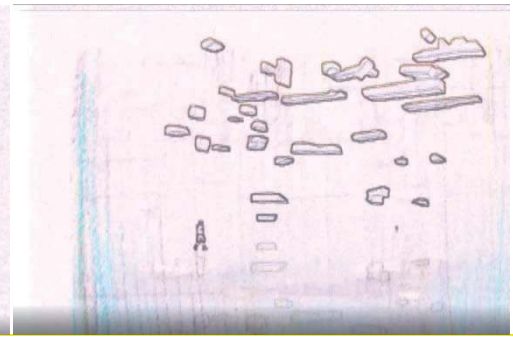
Topic: Art

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Abstract
Art and science in the 21st century are no longer two separate cultures. In the tradition derived from romanticism, art was supposed to be a manifestation of resistance to soulless technology that deprived people of sensitivity to intuitive and supernatural factors at the price of progress. Today, not only digital technology and virtual reality define areas of interest for Visual arts. In their Works, artists combine scientific aspects with interactivity, virtuality, and hybridity, they challenge established aesthetic conventions. We are looking at the intriguing weave that determines the condition of contemporary visual culture. Visual arts greatly benefit from the achievements of technology and science. Today's art both uses new opportunities, such as photography and cinema and also explores their intellectual, practical and cultural potential [1].

Following the above-mentioned definition, I used several media to combine them to create an intriguing film performance referring to the place where I live. The film etude using generative tools and traditional means of artistic expression reproducer the specificity of the lowland landscape of the village, somewhere in north-eastern Poland – a place where the present, past, and future meet each other. As an architect and artist, I have always been interested in observing the space in which I live. This observation is interesting because it concerns the unique culture of the borderland of east and west civilization and its natural landscape. Semi-abstract forms in my animation refer to a man who lives in a specific cultural environment and expresses himself through the prism of place. The film etude is complemented by a gesture and sound created directly in front of the audience. This part of the performance is a certain extense directly improvised to strengthens the artistic statement. The performance is a development of the previously presented movie „The Seed" (2018) and „Manor House" (2017). The film etude with live sound is an example of combining electronic, generative and traditional media in search of the language of artistic expression. The presentation is inspired by the possibilities of generative art.





email/address s.wojtkiewcz@pb.edu.pl	***Key words:*** art, graphic, painting, architecture, generative design, ***Main References:*** [1] Marek Wasilewski, "*Czas Kultury 2/2019*", Copyright by Czas Kultury, Poznań, 2019

GA2019
XXII GENERATIVE ART
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