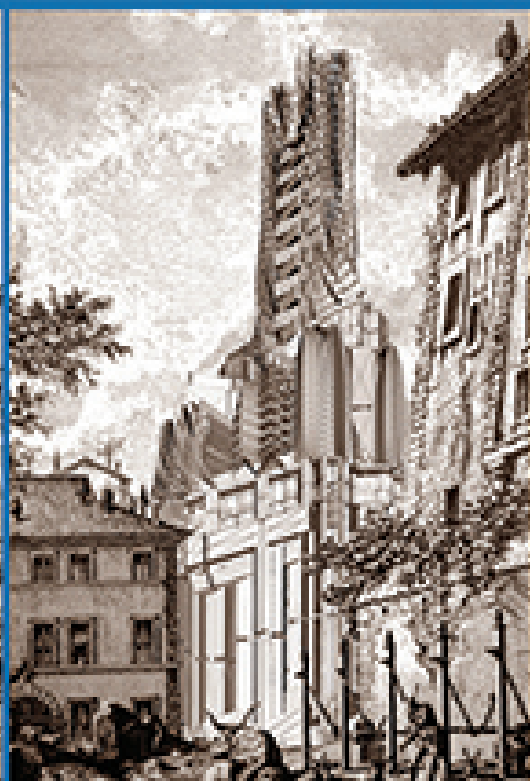




# Generative Art *FUTURING PAST*

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Michele Leigh, Nicola Baroni, Nicolas Reeves, Robert Spahr, Michele Leigh, Roger  
Alsop, Yiannis I Papadopoulos

edited by Celestino Soddu and Enrica Colabella



*dedicated to all young people  
for crossings the time from Past toward the Future  
with the aim to preserve the human heritage with passion and care*

*In the cover a sequence of Generative Design variations of "Baroque Species of Architectures", as an homage to Francesco Borromini and Piranesi and In the back cover three 3D prints of Generated Baroque Cathedrals. All these architectures were generated by Celestino Soddu using his Baroque Algorithms,*

*Inside the book a sequence of drawings by Leonardo da Vinci, Atlantic codex, about mathematics and geometry codes, as the most important reference for generative geometry.*

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*Proceedings of the "Generative Art, Futuring Past" performed in Rome the 7th of June 2019 at the "Casa delle Letterature" inside their cultural program "Il Domani del Classici. Letterature Festival Internazionale di Roma, 2019"*

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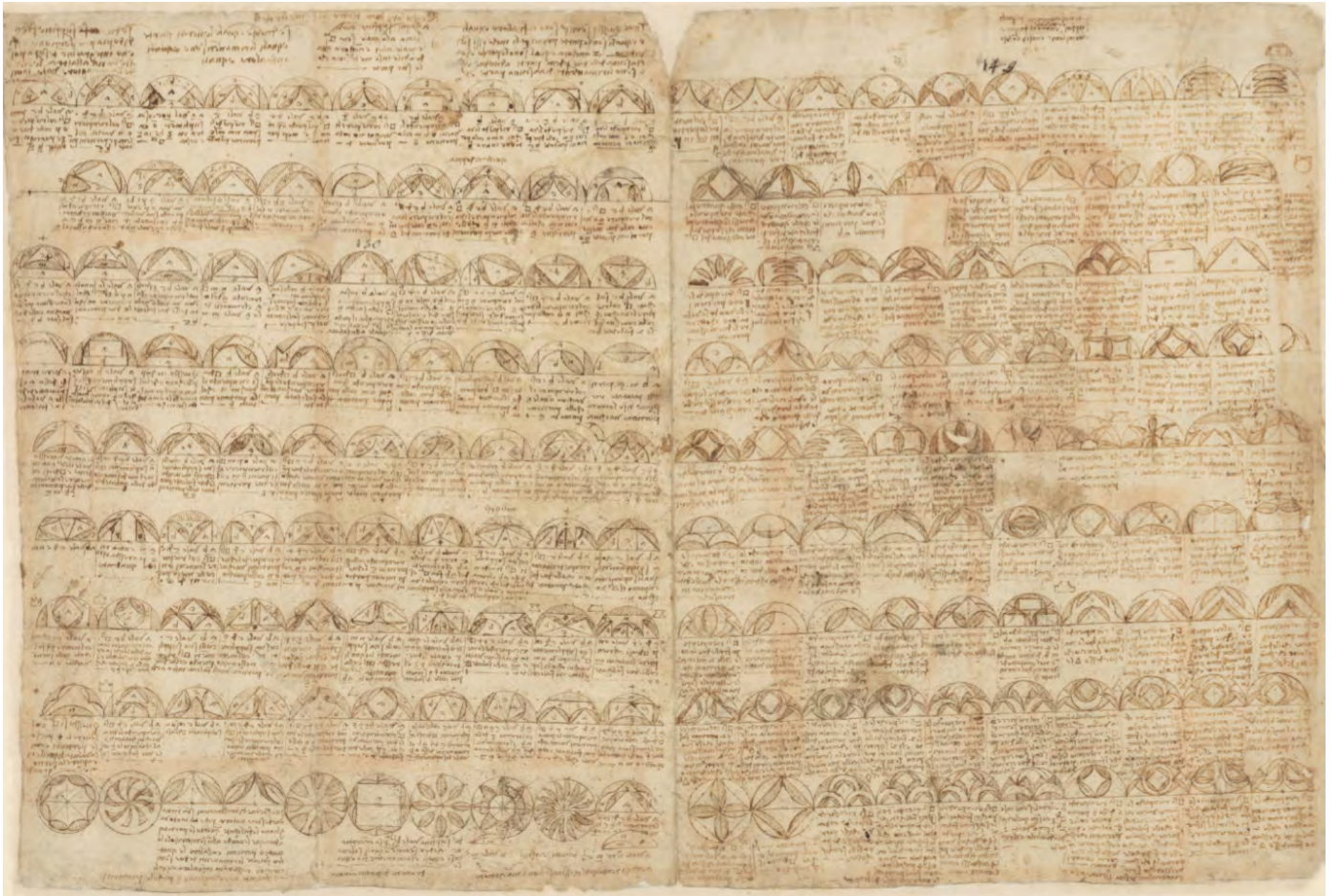


*Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations*

# Generative Art *FUTURING* PAST

Edited by  
Celestino Soddu and Enrica Colabella

*Domus Argenia Publisher*  
*Roma 2019*



*Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations*

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*Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations*

**LETTERATURE FESTIVAL INTERNAZIONALE DI ROMA**  
**XVIII EDIZIONE 4 GIUGNO / 3 LUGLIO 2019**  
**BASILICA DI MASSENZIO – FORO ROMANO**  
**CASA DELLE LETTERATURE – piazza dell’Orologio n.3**

**IL DOMANI DEI CLASSICI**

**Quand’è che un testo contemporaneo si dà come classico?**

**LETTERATURE**, il Festival Internazionale di Roma, è lo storico festival della Capitale che ho l’onore e l’onere di aver ideato e di dirigere sin dall’anno della sua prima edizione, il 2002. Giunge quindi quest’anno alla sua XVIII edizione, avendo ospitato complessivamente in tutte le edizioni precedenti più di **500.000 spettatori** e oltre **300 tra i più celebri autori stranieri e italiani** che, di anno in anno, sono stati invitati a scrivere e a leggere un proprio **testo inedito** sul tema che ogni anno il Festival propone. Accompagnati da grandi attori e musicisti, artisti e video maker, gli scrittori vivono l’emozione di leggere dal vivo, e il pubblico di ascoltarli, in uno dei luoghi più suggestivi di Roma e del mondo: la **Basilica di Massenzio al Foro Romano**.

La domanda a cui quest’anno il Festival chiede agli autori ospiti di rispondere attraverso l’inedito che leggeranno nel corso delle serate, è: **quand’è che un testo e quindi il suo autore viene riconosciuto come classico?** Le risposte saranno diverse e le ascolteremo da autori che avranno inevitabilmente differenti prospettive di analisi e differenti rapporti con la tradizione. E se, come ha scritto Italo Calvino, *un classico è un libro che non ha mai finito di dire quel che ha da dire o i classici sono quei libri che ci arrivano portando su di sé la traccia delle letture che hanno preceduto la nostra e dietro di sé la traccia che hanno lasciato nella cultura o nelle culture che hanno attraversato (o più semplicemente nel linguaggio o nel costume)*, ecco che queste indagini contemporanee potranno offrirci una ricchezza tale da farci riflettere sull’attualità con grande libertà critica.

Tutti gli appuntamenti della manifestazione sono ideati, secondo una ispirazione che da sempre accompagna il Festival, guardando alla letteratura come a un evento concreto e come a un atto di fede rispetto al proprio tempo. Guardando a un testo, a un libro di letteratura, con la sua grana filologica, come una sorpresa seria, radicale, una macchina di pensieri e un cardine attorno a cui verificare la realtà.

**Il Convegno GENERATIVE ART – FUTURING PAST** organizzato da Celestino Soddu e Enrica Colabella nella sede della Casa delle Letterature di Roma, appuntamento annuale della associazione Argenia, si inserisce in modo virtuoso nel programma del Festival fornendo un contributo importante alla riflessione sul rapporto tra passato, presente e futuro nelle arti. Nella giornata di studio, infatti, tutti i relatori, provenienti da differenti luoghi e contesti culturali, sono invitati a pronunciarsi, proprio come gli scrittori ospiti di *Letterature*, provenienti anche loro da paesi e contesti differenti, sul rapporto tra classicità e

contemporaneità, tra tradizione e innovazione, cercando di indicarne connessioni e/o fratture, continuità o interruzioni.

In qualche modo il tema che fa da filo conduttore a questa edizione di *Letterature*, alla serie di incontri con alcuni dei maestri della prosa e della poesia contemporanea, è lo stesso che unisce i relatori del Convegno. Nel Festival scrittori che sono chiamati nell'arco di un mese a confrontarsi tutti con lo stesso argomento, ma che si esprimono ciascuno adottando un passo diverso, quando non addirittura un genere letterario differente (dal saggio al racconto breve, dal pamphlet etico-politico alla riflessione di poetica); e nel Convegno studiosi di varie discipline, anche performers, chiamati a parlare e a esibirsi tutti nello stesso giorno a Roma. Un insieme di voci che si esprimono sullo stesso tema in date differenti e con diversi linguaggi ma fino a confluire, in dissonante accordo, nello stesso Festival.

Maria Ida Gaeta

Direttrice Casa delle Letterature e Festival Letterature di Roma

#### THE TOMORROW OF CLASSICS

When does a contemporary text look like a classic?

LITERATURE, the International Festival of Rome, is the historic festival of the Capital that I have the honor and the burden of having conceived and directed since the year of its first edition, 2002. Then comes this year to its XVIII edition, having hosted a total of more than 500,000 spectators and more than 300 of the most famous foreign and Italian authors who have been invited to write and read their own unpublished text on the theme that the Festival focuses each year. Accompanied by great actors and musicians, artists and video makers, writers experience the thrill of reading live, and the public listening to them, in one of the most evocative places in Rome and the world: the Massenzio Basilica at the Roman Forum.

The question that the Festival asks the guest authors to answer this year and that they will read during the evenings is: when a text and therefore the author is recognized as a classic? The answers will be different and we will hear them from each author who will inevitably have different perspectives of analysis and different relationships with tradition. If, as Italo Calvino wrote, a classic is a book that has never finished saying what it has to say or the classics are those books that come to us bringing with them the trace of the readings that preceded ours and behind itself the trace they have left in the culture or in the cultures they have been through (or more simply in language or custom), these contemporary investigations will be able to offer us such richness as to make us reflect on current events with great critical freedom.

All the events of the event are designed according to an inspiration that has always accompanied the Festival, looking at literature as a concrete event and as an act of believing in our time. Looking at a text, a book of literature, with its philological grain, as a serious, radical surprise, a machine of thoughts and a cornerstone around which to verify reality.

The GENERATIVE ART - FUTURING PAST Convention organized by Celestino Soddu and Enrica Colabella at the headquarters of the Casa delle Letterature in Rome, the annual meeting of the Argenia association, fits in with the Festival program in a virtuous way, providing an important contribution to the reflection on the relationship between past, present and future in the arts. On the day of study, in fact, all the speakers, coming from different places and cultural contexts, are invited to pronounce themselves, just like the writers guests of Literature, who also come from different countries and contexts, on the relationship between classicism and modernity, between tradition and innovation, trying to indicate connections and/or fractures, continuity or interruptions.

In some ways, the theme that is the theme of this edition of Literature, of the series of meetings with some of the masters of prose and contemporary poetry, is the same that unites the speakers of the Conference. In the Festival, writers who are called within a month to confront each other with the same subject, but who express themselves each by adopting a different step, if not even a different literary genre (from the essay to the short story, from the ethical-political pamphlet to the poetic reflection); and in the Conference scholars of various disciplines, including performers, called to speak and perform all on the same day in Rome. A set of voices that express themselves on the same theme on different dates and with different languages but up to the same Festival, in dissonant agreement.

Maria Ida Gaeta

Director of the Casa delle letterature and of Letterature Festival di Roma

## **Preface**

Particular thanks to Maria Ida Gaeta, director of the Casa delle Letterature who hosts the Generative Art, Futuring Past event inside the program "Il Domani dei Classici", Literature International Festival of Rome 2019.

Generative Art is the Art of creating generative codes as the DNA of artificial events. *The tomorrow of classics* is a very hot topic from those who deal with Generative Art because the generative approach always requires attention to the Past in order to design the transforming algorithms for generating events for the Future.

Generative Art, as a term, was identified and coined in 1998 for the first international Generative Art conference that we organized at the Politecnico di Milano and which is still continuing annually in different Italian cities, arriving this year at the XXII edition. The collected material, over a thousand scientific texts, is available to all. Referring to these scientific contributions, we tried to identify some people for focusing, in this first book, some various disciplinary fields involved in the generative approach.

Particular attention has also focused on the Baroque past also because the location of our meeting is a Baroque architecture by Francesco Borromini, "Il giardino degli aranci".

The aim of this event is to discuss our teaching experience, focusing on the strong relationship between past culture and our generative approach. Interpreting the Past and the environment for discovering the potentialities for generating the Future is the basis of this scientific approach.

This book contains various experiences of Generative Art and its advanced teaching experiences and methodologies. But also various experiences of live performances as experimentation of the potentialities of the generative approach to Art, Science, Architecture, Design, Music, Poetry and Communication. A range of different experiences showing, in the various possible facets, we hope that can grow the interest towards a generative approach in many disciplines and all over the world.

The story of our personal experience in teaching on Generative Art/Design that we have developed mainly at the Politecnico di Milano University, in the US, and in China in the last 35 years is identified in the first part of this book. These didactic experiences were based on the creation, theoretical development and operational experimentation of the generative art and design approach implemented by us starting from the eighties.

All the contributions focus on several experimental experiences on Generative Art, as it is currently called the generative approach to "mathematical" creation of artworks.

Many are the disciplinary contexts presented in the articles, from the generative approach in advanced dance teaching and choreography experimented in Japan by Asako Soga, to the generative approach in reading climate change and the transformation of the oceans, with the reading of these as events of art, developed by Andrea Vollensak in the USA with his research group.

The generative and emotional teaching on the philosophy developed by Yiannis Papadopoulos of the University of Hull shows the potentialities of space involvement of words.

Many contributions refer to the didactics and the advanced generative experiences on music as they have been experienced by Jonatas Manzolini and his group from Brazil in reliving the artworks of the past for generating operas. More, there are the experiences of interpreting the past and the environment by constructing algorithms to generate music such as Arne Eigenfeldt from Canada, Gabriel Maldonado from Italy, Roger Alsop from Australia, Gregoire Davy from France, as well as Nicola Baroni, Italian, who interprets the past, and in particular the Baroque in harmony with the poetic words by Enrica Colabella and the images of architectures generated by the contemporary interpretation of Borromini by Celestino Soddu. Generative multimedia experiences are also the basis of the generative expression in live performances by Malgorzata Dancewicz and Krzysztof Pawlik from Poland as well as those of the multimedia generations by Robert Spahr and his teaching experience on Generative Art in the US.

The relationship between science and art remains at the center of all these experiments. Even disciplines that can be considered far from the generative approach, such as medicine, are involved in these experiments, as indicated in the performances of Alejandro Rincon from The Netherlands.

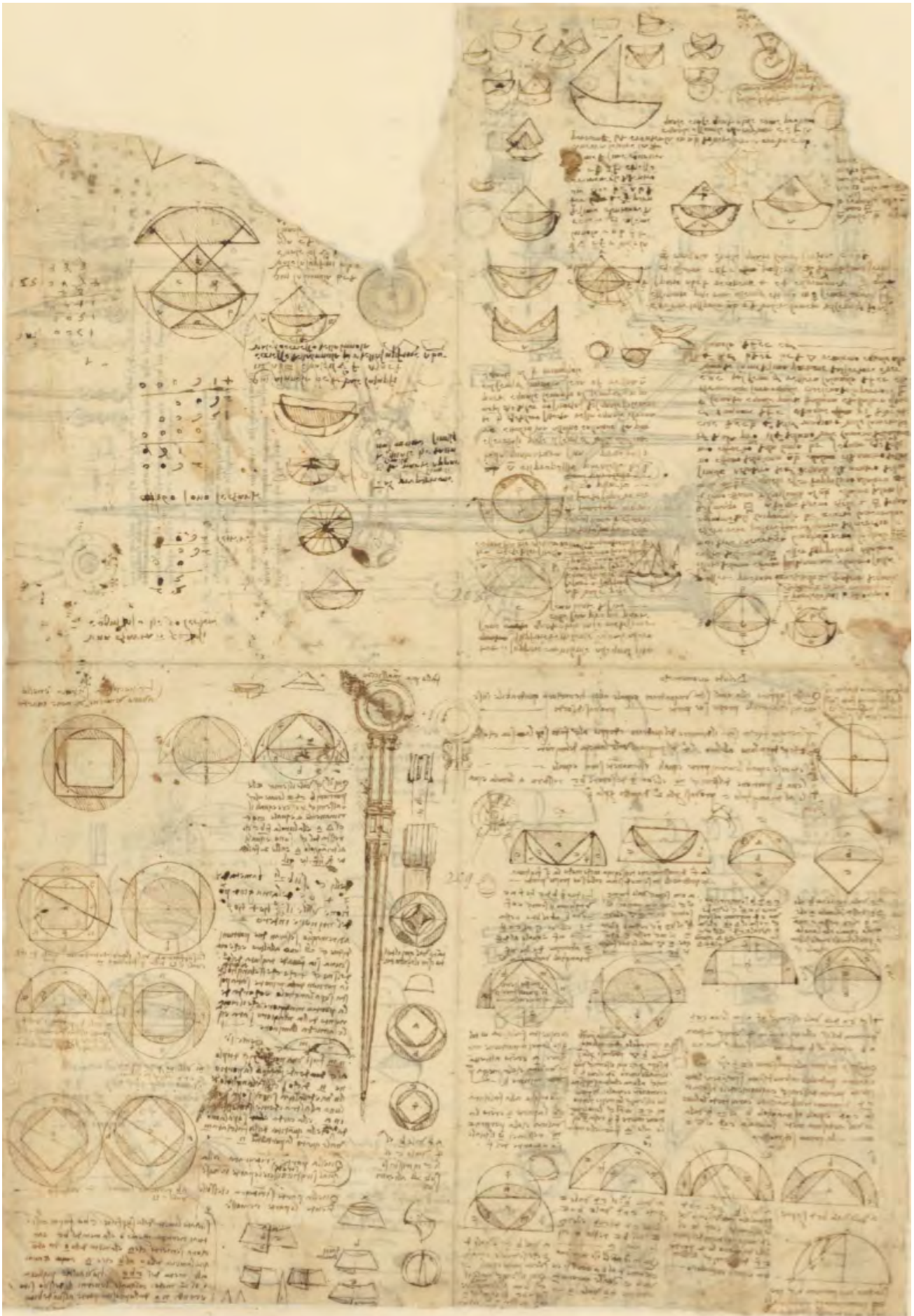
Nicolas Reeves from Canada links music and architecture with his approach to cathedrals able to generate musical interpretations of these wonderful architectures.

The purpose of this book, and of the related event at the Casa delle Letterature, is to see in our past the poetic key of our future by reading not only the references to our cultural identity but the possible indications for finding them as active interpretations in our tomorrow.

Rome, 7<sup>th</sup> of June 2019

Celestino Soddu, Enrica Colabella





*Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations*

# Baroque algorithms, a Vision toward the Future Generative Art in Advanced Teaching

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## ***Introduction***

The purpose of this text is to identify how my experimental research on Generative Design was used in the teaching I mainly did, together with Enrica Colabella, at the Politecnico di Milano University in the classes of Architectural Composition, Architectural Design, Environmental Design, Industrial Design and, most recently in Generative Design classes at the School of Engineering-Architecture and then, in English language, at the Master School of Industrial Design of the Politecnico di Milan University. More, through the Asia-link program supported by the European Commission, in Hong Kong, in China, and in Europe.

The results were appreciated by the students who attended the courses without stopping at the first conceptual difficulties. Then they expressed the usefulness of this approach both for what concerns the acquisition of ease of creative activities and also for the ability to build their own recognizable style.

My original research carried out since the end of the 1970s on morphogenetic design (ref. The non-Euclidean image, 1986 (note 1), Città Aleatorie, 1989 (note 2)).

Enrica Colabella and I established the term “Generative Design” when we founded the Generative Design Lab, of the Politecnico di Milano University in 1992 (note 3). Then, in 1998”, for the first annual Generative Art conference which identified the multidisciplinary approach to Generative Art, [www.generativeart.com](http://www.generativeart.com) (note 4), we defined the use of the term Generative Art, Art as “ability to operate following a scientific approach”.

In the same years Enrica Colabella and I developed, also theoretically, our didactics at the Politecnico di Milano (ref. The environmental project of Morphogenesis (note 5)) orienting it towards a generative approach based on supporting each student in the development of his own *poetics*, able to orientate the increasing complexity of the project towards results that might be recognizable as belonging to a specific design vision, designing an Artificial Species.

## **Generative Art**

Generative Art is the Art of creating generative codes, the DNA of artificial events.

The results of Generative Art are the species, as in nature. Artificial species are formed by unique and unrepeatable individuals that together represent the idea in its fullness. The artificial species is strongly representative of a subjective vision as the expression of a poetic in its developing path.

The tools used to create these artificial DNA are algorithms, especially those associated with Artificial Intelligence and Artificial Life.

Generative Art is a way of performing one's creative activity. The language is that of the numbers of mathematics and geometry. The fields involved can be multiple, from Science to Art, from Music to Poetry, from Architecture to Object Design.

In fact, the creative approach involves science and art at the same measure. Generative Art arises from possible interpretations of the existent, of nature, of the Past aimed at identifying a possible Future. This happens in the formulation of new scientific theories that identify a new point of view and a new interpretation of the existing. But in the same way, it happens in art where a possible interpretation of the past creates the premises for future scenarios.

In this art and science have always been linked by a common approach. This parallelism has been clarified in an incredible way, especially in the Renaissance.

In the drawings of Leonardo da Vinci, shown in this book, the strong relationship between art and science, and the relationship between art, nature, and geometry is clearly identifiable. The drawings are from the Atlantic Codex and are chosen to focus the dynamic structure of geometrical possibilities as an interpretation of nature and past toward the construction of the future.

Attention to the Past in contemporary existence is a constant in the generative approach. In creative people, artists, architects, poets, and musicians are usual to surround themselves with events that recall the past and nature so as to have them available for the moment of formulation of a possible logical interpretation that transforms them by generating possible scenarios into the future.

Generative Art and my generative approach were born with the Past as a reference. What strongly identifies each generative approach is how the interpretation of the past takes place.

While this approach to Past normally occurs by identifying a specific point of view, and also identifying an interpretative logic linked to one's own vision and applying it to the creation of a new work, in Generative Art the identification of an interpretative logic leads to the explicit creation of an executable process capable to transform the past into a future by answering to the vision of the Artist.

This process, formalized by algorithms, contains in itself the logical interpretation that has been implemented. The

peculiarity of Generative Art is due to the fact that this algorithmic process is, by its nature, available to be used a multiplicity of times, starting from different past events to transform them into futuristic events. Obviously, the events that can be considered the implementation of the process must have the characteristics that we are looking for and must be in tune with the point of view that we identified as based on own vision. Through the definition of the process in its non-linearity, future events will express the sought characters.

The fundamental element of this approach is that the results will never be copies of the Past, not having activated a process of copying, but of logical interpretation. Instead, they will have the possibility of being characterized by those aesthetic and symbolic values that the artist has identified in the past event and that he liked to insert into his own work. This means that it will not be possible to find in the results the forms of the references. Such an approach would represent a copy and not a generation. Instead, in the generated event you will find only the characters that you are looking for and that you already identified as belonging to your discovering vision.

This process is able to construct a poetic elaboration for the simple fact that the artist moves, in his art production, following his own peculiar point of view turned to the past to generate it in the future, following in this the biological systems.

In the subsequent figures a presentation at Tel Aviv and at the Biennial of Lima of my first experiments of Generative Design focusing on the interpretation of the Past as a way of shaping the Future.

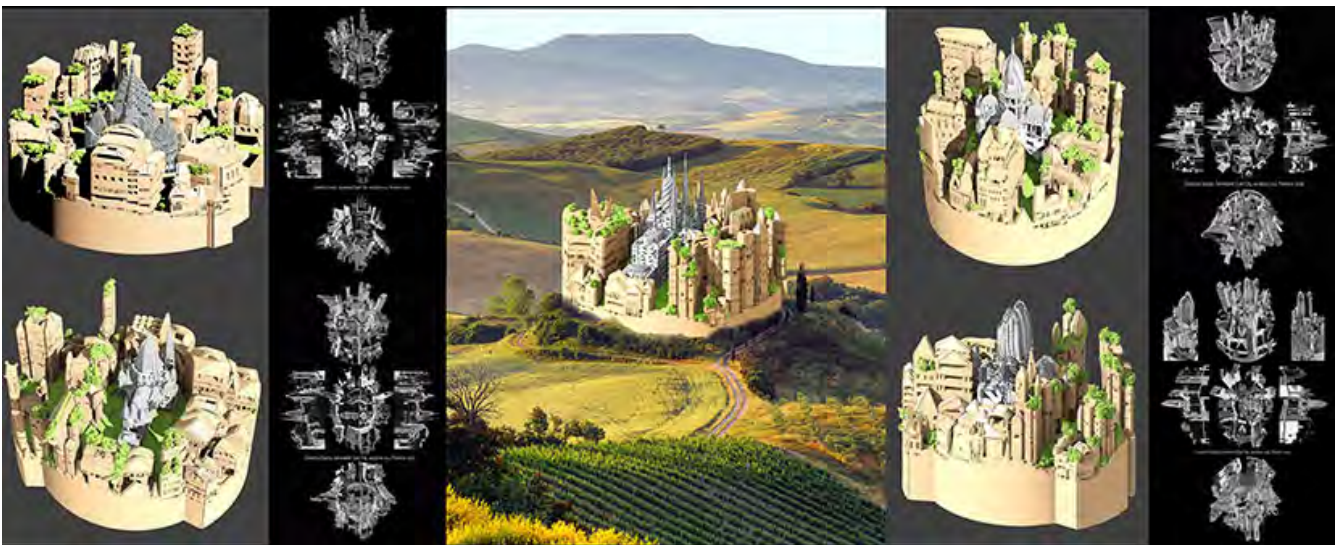
Medieval Identity. Generated cities by interpreting with algorithms the artworks of Giotto, Simone Marini, and Piero della Francesca. 1988



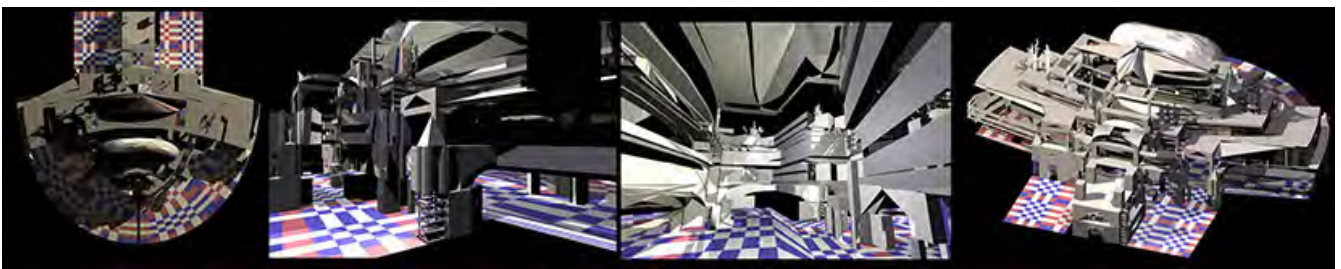
Medieval castles and Chairs. The variations 2001



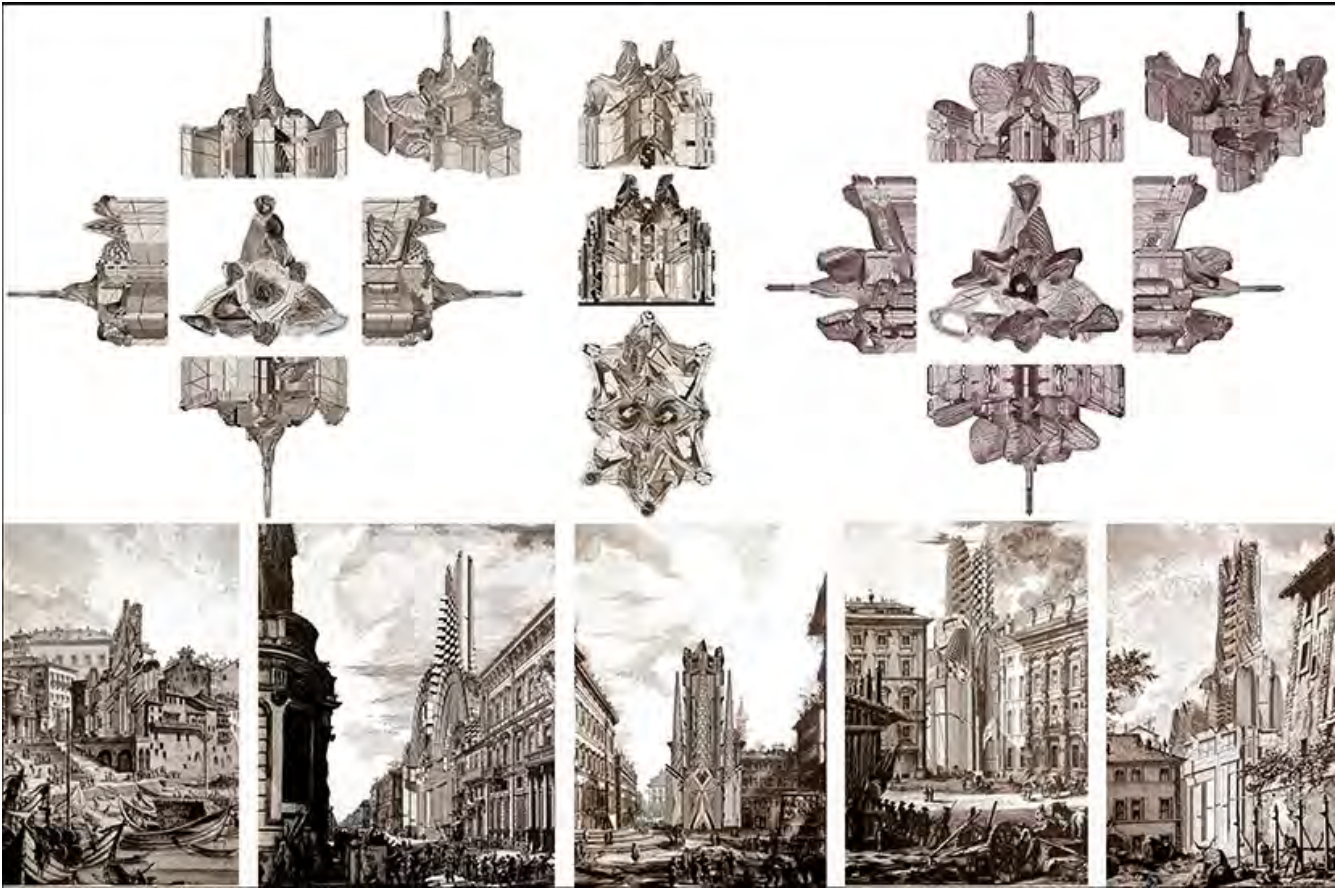
Tuscanian cities identity codes. Duets, the medieval environment, and the Renaissance core. 2016



Milano Identity, 1999



Baroc Identity codes, interpreting with algorithms the geometry transforming processes by Borromini. 2011



Venice Identity, interpreting Canaletto, 2015



Jerusalem Identity, 2011



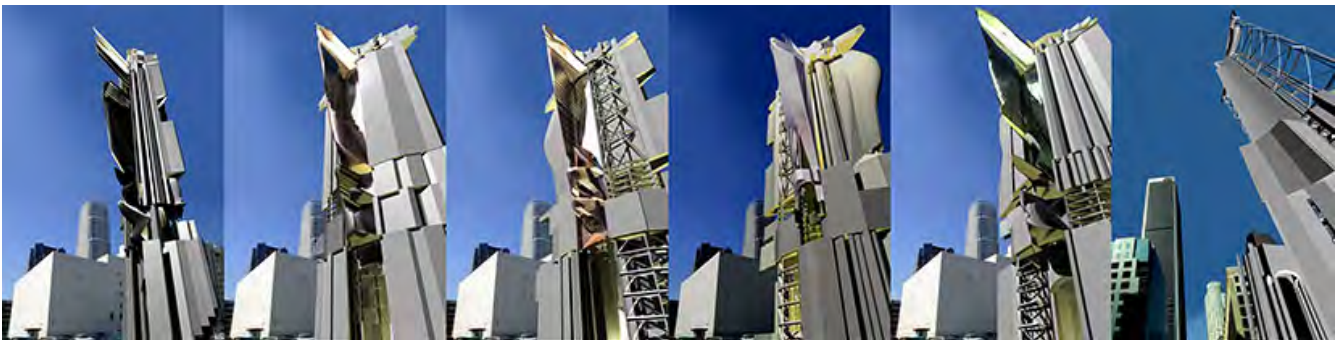
Chicago, one century ago, 2003, Nagoya 2003, Italian Commercial center 2000



Barcelona Identity, Homage to Gaudi', 2003; Hong Kong Identity, Kowloon and Central SeaFront, 2009; Sardinian Identity, Cagliari Poetto, 2009



Los Angeles Identity, the variations of the broadcasting tower, 2002



Ravenna Identity in generated architecture mosaic 2017



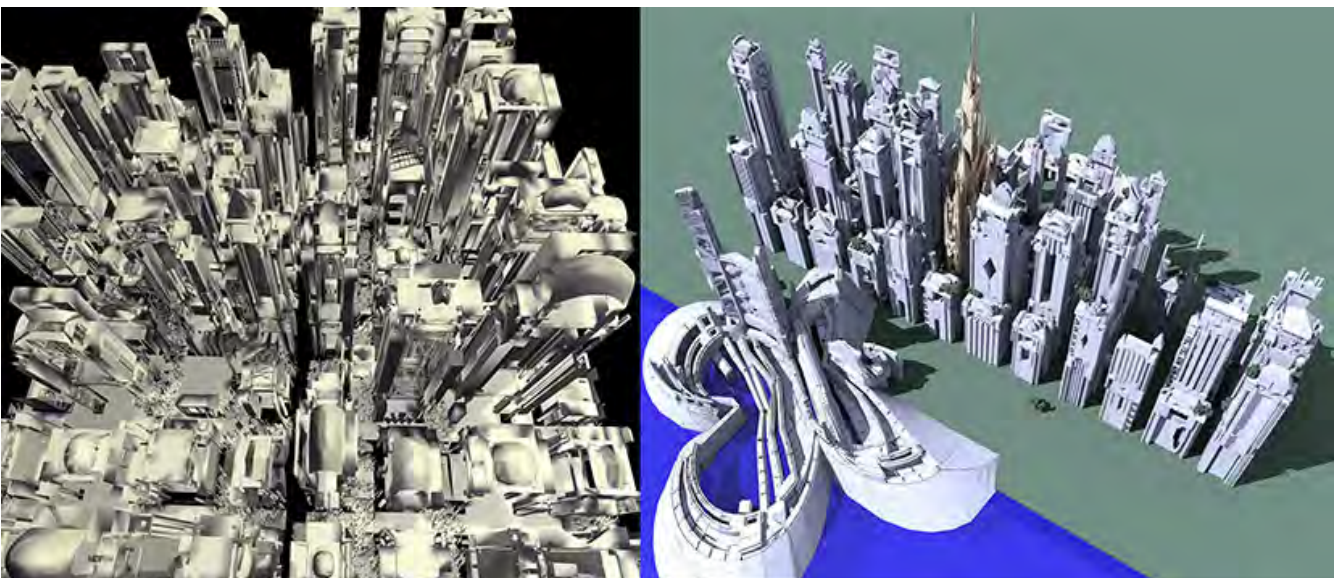
Milano Identity, Variation of Futurism Museum, 2004



Lake of Como, Lecco Identity, 2009



New York City Identity, 2016





### ***Teaching approach***

Going back to teaching, in the past there were school-workshops. Every artist or architect had a school-workshop where young talents worked to complete the artworks that could be very large and complex. Every young artist learned the art and did his work following the interpretation, logic, and vision of the Master and learning to use the same tools.

This is still possible and is still practiced in many studios today, but it is completely different for Generative Art. The primary objective of students in learning Generative Art is to construct its own interpretative logics and tools. Quoting H. Focillon, every "visionary", that is every artist, who has his own vision and pursues it, must build his own tools. These tools, especially if processed as algorithms, define, through a specific subjective viewpoint, the processes to be implemented to transform the past into the future. They constitute the result of Generative Art. Teaching Generative Art is not teaching how to use existing tools but teaching students how to create their own tools.

In these decades of teaching the generative approach to architecture and design, but also to all the disciplines that require a creative approach to Art and Science, the greatest difficulty has been to fine-tune the logic behind the invention for a possible construction starting from the identification of an idea. As an alternative to the usual design approaches based on data analysis and optimization,

the major difficulty of Generative Design is to have answers from students that arise from their specificity as creative people in progress. They work from their subjective vision of the environment, for fine-tuning their specific interpretative logic.

Teaching Generative Art is teaching how to interpret one's own cultural references by building one's transformation logics and, when possible, by writing one's own original algorithms. Algorithms are the expression of subjective tools, as rules for the implementation of possible transformations. They are created according to one's own vision, capable of generating species of artificial objects whose individuals are unique and unpredictable. Many are the fields of application, from architecture to objects, musical compositions, robots, visual art, poems, literature. (note 6-7, the structure of the Generative Design course)

### ***The approach with interpretative logics versus the objective analytical approach***

Unfortunately, the ideology, philosophy, and epistemology prevailing in the last century, based on deconstructivism and analytical logic as the guarantor of the objectivity of supposed optimizations, has been destructive. The result has been the poor quality of a lot of contemporary cities. We discover it in the ever more anonymous suburbs with the impossibility of recognizing architectures as a contemporary mirror of different cultural and historical identities. Most of our

contemporary cities have lost the ability to belong to a specific poetic vision based on the interpretation of what they represented. In the last century, the impossibility of identifying the author (R. Barthes, "*The death of the author*", 1967) was the result of international homologations. This also happens, and above all in visual art and music where the use of commercial technologies has led to recognizing the used instrument more than the author.

The analytical operation of deconstructing and reconstructing a system does not, in fact, lead to any step forward in the definition of an idea but re-proposes homologation models based on the presumed search for optimization. This is done by setting aside, if not denying, the character and quality of an artwork that could instead be built by using a subjective interpretation of our cultural heritage to which we refer for improving our identity.

Not only that, deconstructing and reconstructing is also based on the assumption that what matters is the form and not the organicity. The deconstructing approach puts in the second level and sometimes even negates the basic importance of the paradigm that identifies the topological structure of the event. The topological paradigm, on the other hand, contains the very structure of the idea, as, for example, we can read in the Palladian paradigms that summarize Palladio's architectural vision, as indicated by Wittkover. The topological paradigm of a historical architecture reflects the structure of relations among the architectural parts and the dynamics

of reading them, privileging, for example, the character of the external-internal, public-private path, the temporality of perspective perception and anything else it makes a fundamental contribution to the identity of a work and of its progressive perception structure.

Entering in an architecture conceived following the deconstructivist approach it is not possible to immediately perceive its organic structure. What it is easy, for example in cathedrals and palaces of the Past The same happens also in gardens and in anything else based on a topological idea.

Furthermore, we have learned from cathedrals that shapes are interchangeable. They are realized as subjective variations, due to the identity of each stonemason, also being structured as multiple representations of an idea, of a topological vision that represents its code.

Deconstructing and reconstructing a work analytically based on formal or functional optimizations could remove, and in some cases intentionally, some fundamental architectural features from the project. The results can appear as without history and, indeed, as designed by starting from zero, without referring to the cultural identity of the environment and of the architects.

In the didactic experiences focused on the search for optimization that has been mainly used in the last century, the pre-project systematic analysis, followed by the primary attention on the form of the events, is in contrast with what should be an interpretative operation on the context.

This should be based precisely on the consideration of the peculiar characters related to the topological sense of space.

In my opinion, the two parallel processes involving project design and teaching are:

1. Identify a topological paradigm and use it as a matrix of project development.
2. Identify, following own architectural vision, the progressive formal transformations based on the multiple and dynamic logical interpretation of the geometric matrices of own cultural referents

Two completely different approaches to design are:

- A. The form-finding and the repeating forms acting through possible deconstruction
- B. Interpreting topological paradigms together with using the interchange of possible forms.

The first, based on the deconstructivist approach, produced the homologation of the cities of the last century, the second based on the interpretation of a vision, of an idea of architecture or of an ideal city is at the base of the generative approach.

The ideal city is, in fact, an abstract and subjective concept of urban identity in progress. (note 8). Each person has its own peculiar interpretation of the ideal city. Every resident or visitor of NYCity has in mind his ideal New York, every Venetian has in mind his ideal Venice and all design acts are focused to improve this concept. When an architect finds himself designing in one of these cities, he

designs following his interpretation of the abstract concept of that ideal city and proposes an event that, in its peculiarity, could amplify, and carry forward the uniqueness of the environment. This is because the project shows a further facet, a further point of view of the ideal concept of that city. The designed vision, added to the other projects made with another subjective vision of the same ideal city, reinforces and develops the very idea and uniqueness of that city. The identity, ever in progress, is identified by these multiple variations of subjective visions.

The "generative" approach is found precisely when the architectural vision is based on an abstract concept. Results are not a generative idea but only the possible variations able to express this abstract concept *in fieri*. Each architecture, in NYCity, is different but explicates different points of view of a shared Ideal City. This way of conceiving the idea has produced the progressive increase in the architectural and urban identity of some cities where an ideal concept exists. This made these peculiar cities increasingly recognizable. The ideal city, however, cannot be reached as an optimization because this concept is only an abstract pre-vision of how the process could run towards the future. The optimization cannot exist because all cities are different and all ideal concept follows the unicity of a city and the subjective concept of each inhabitant.

In the teaching activity, I have done over the last 40 years (note 9), and since the end of the 1980s in tandem with Enrica Colabella, we have proposed, as a starting point for a project, a subjective and

interpretative approach connected to the cultural references of each student. In proposing this, we found the greatest difficulty in asking students to get involved subjectively, abandoning the security, but also the limits due to the previous experience of courses based on an analytical approach.

Leading students to consider their own subjectivity as a necessary condition for proposing their own poetics has always clashed with considerations that questioned the usefulness of subjective approaches in front of the objectivity of analytical considerations. This happens because the analytical approach, the identification of objective aspects and the aim of optimizing the results, certainly appears to be more easily practicable and is considered easy and safe by the student. Following that, they don't need to discover themselves, to consider and explain the uniqueness of own subjective vision. This type of analytical results are strongly homologous and lacking the recognisability and identity of an author's imprinting.

The author's death was, in fact, the philosophical banner at the base of this analytical approach.

### ***The interpretative logics and the Past.***

One of my first generative experiments carried out in 1986, the generative code of medieval cities, is not based on an analytical collection of data on medieval cities but, on the contrary, on my subjective interpretation of the tables by Simone Martini, Piero della Francesca,

and Giotto. With this approach I tried to retrace what has always been the path of the great artists, reinterpreting the works of previous artists, as Picasso did with Velasquez or Francis Bacon with Van Gogh. This approach does not consider analytically or copy the past but reinterprets it. The work that I carried out fully reflects my subjective vision as an artist and, at the same time, fully identifies the character that I had appreciated in these references. It happens because the identity of a work of the Past becomes dynamic through the multiplicity of interpretative readings stratified in the time and done by different people. Referring to Giotto's medieval urban representations, these artworks give back the possibility of communicating the multiplicity of facets of the idea of medieval cities shared, at that time, also with other artists but with different subjective points of view. Not only, looking at the different interpretations of these artworks during the time, but we can also discover the complexity and the richness of these cultural references.

### ***Subjectivity as Interpretative Logic***

A fundamental contribution, in this difficult phase, for the students in approaching a logical explanation of their own subjective vision, was the invention of Enrica Colabella to identify with three words, three adjectives, the basic component of their subjectivity when efforting the design approach.

These three words, which we asked, not without difficulty, to each student to

declare at the beginning of the course, were subsequently used by them as an interpretative key to their referents and as future characters of the project they intended to carry out. These words were also the same words that, at the end of the generative experience made with performing a whole series of variations, were at the base of the final considerations of quality and interest of the design experience they carried out. The student was asked to verify if those adjectives, identified at the beginning of the design process, had been reached, and how. If they considered having not reached all the aims, they were asked to make some considerations about why.

These three adjectives transformed, in practice, an approach considered uncontrollable because subjective in a verifiable approach because the explicit terms of the evaluation were available and, with these, the possibility of acting controls by the students themselves.

The choice of three adjectives, and not one, two or more than three was due to the fact that a single adjective was too categorical and it was difficult to manage because it could not cover the range of subjective interests during the process of interpreting the referents of the past. Two adjectives could create problems because they appeared as one the antithesis of the other and more than three began to be too many, losing their importance.

Three adjectives, on the other hand, in their intrinsic ambiguity, were able to help the student in two ways. First by subjectively classify the interest of the student towards the characters to be achieved through his design. Second by

operatively focusing the interest towards the legible matrices that appeared more relevant and interesting to them in the past and in the contemporary world. This approach based on three adjectives made clear, in a communicable mutual way, their subjective vision and the characters they like to develop in their projects as a subjective forecast of a possible future. But not only that, this early definition of characters traced their possible and recognizable identity as designers in progress.

Through these three adjectives, each student can read his cultural matrices using a logical interpretation and not through the assumption of static forms.

The request to the students was explicit: you have to interpret the past that interests you by looking for and defining the possible transformation processes that, following your consideration, have contributed to performing the character (chosen adjectives) of these references.

This search for possible processes of progressive transformations is not, and did not want to be, a historical reconstruction. No importance that the identified processes could really be the same ones used by the authors for performing their results. Rather, the challenge was to interpret those results that appeared full of the sought qualities through "new" transformation processes that were able to generate the performing character that each student was looking for.

Each student was asked to verify if the hypothesis is good applying the identified transformation to simple geometric

figures. The result of each transformation had to appear to each student closer to the searched.

The didactic proposal was to operate referring, for example, to the way in which Francesco Borromini worked. He defined a geometric logical structure of transformation from the classic to the baroque following his unique vision. This worked on the consideration that possible generative results were more baroque events than before, but also more belonging to Borrominian unique vision.

The construction of transformation codes is expressed not only in the interpretative logics adopted but also in the structure of the possible points of view. These highlight specific characters able to focus on one's own subjective vision. Going from a perspective structure to another, or from two to three dimensions and vice-versa, or reading the images as if they were geometrically constructed in a non-Euclidean system, or moving the forms performed with a classical perspective as if they were done through an anamorphic perspective, could be of great help. This approach activates firstly mental processes, then geometric processes of progressive transformation that are able of constructing unpredictable generative engines for transforming and, in the same moment, maintaining the original topological structure. (note 10)

The results of this logical interpretation of their referents led the students to collect and catalog a whole series of "transformation processes", which structure refers to algorithms. They were then nothing more than their personal

design tools, specific to the identity of each student-designer.

### ***The double track of the Topological Paradigm and the definition of Transformation Processes.***

The collection of "transformation processes" is a project development track that every single student carried on. Indeed it is the operational structure, the toolbox that each student build to tackle the design processes. A toolbox that not only is able to support the current project but would have been useful for all future projects. With further projects, indeed, this personal toolbox would grow, while also increasing the identity and recognizability and the professionalism of every student architect or designer.

The contingency of a project, the peculiarity of the "theme" is instead tackled by drawing the Topological Paradigm.

The topological structure and the indication of the characteristics proper to each relationship between events are, in fact, a fundamental element for identifying one's own idea before its formalization. This structure is the paradigm, first circumstantial and then organizational paradigm. I used both in my generative software when I had to build a new project. Following that, I used it as a teaching tool for students. The paradigm, in fact, memorizes the idea as an organizational structure of the event to be designed. No problem if the event to design will be a chair or an architecture. The paradigm indicates the structure of

relations between the parts, the characteristics of these relationships and the main character (adjective) of each part and obviously, its functions too.

The use of paradigms makes possible to activate different generations of events with the same software. It also makes possible to switch from one project to another with a completely different theme without losing the job of defining the characters and creating previous transformation logics. This is also true for students who can verify, on a subsequent project occasion, the same characteristics that they had structured in previous projects and appreciated in the generated variations. Changing the paradigm but maintaining the logical structure of the transformations is, therefore, a highly innovative tool to fully appreciate the utility of the generative design approach.

In my generative design courses, but also in those of design and architectural composition, I had always asked each student to perform, individually, at least three projects in sequence. The result was to bypass the initial impact of the design process and then enjoy the ease and speed of carrying out other projects, even very different ones. Doing that by maintaining, indeed increasing in progress, the own identity as a designer and the recognizability of own vision as a further goal by these experiences.

### ***Catalyst and Paradigm***

An important educational tool to move students from passive reception of analytical data was to make easier the

starting of the project process by constructing the first control paradigm of their design evolution. Normally, the student takes a very long time to draw the first sign on the blank sheet. He does it a thousand times and the student is not easily able to take off towards the fundamental part of the design process: the progressive transformations. Generative design is not, by its nature, an approach based on forms but on transformations and the projects will start when it will be communicated also with algorithms. Using too much time by drawing shapes and then erasing and remaking them is not only useless but the risk is to deteriorate the same initial idea. The idea is not, and must not be, a form but an organization, the organic nature of a topology.

The teaching operative idea was to ask the students to use a catalyst, chosen by themselves. Better if this catalyst is not directly related to the theme of the project and, even to the field of work. A piece of music, a poem, a pictorial image, a natural organic, vegetable or animal image, etc. could be of great help. This because the catalyst is really useful when it contains no form to follow or copy but only organic structures to interpret. A catalyst, indeed, must not be an already operational choice linked to the form, also if it could seem easier and more immediate to use. If the form is the reason for this choice, this initial option could be really dangerous, shutting possible doors, for the further design process.

The catalyst, on the contrary, should be chosen by the students as their abstract referent for the organic nature of the

event. An elephant, an olive tree, an interpretation of a sonnet or of a piece of music were chosen by the student because in tune with their vision for gaining a possible organization, organicity, and topology structure. The step from this catalyst to an initial circumstantial paradigm of the event appeared easily possible. The progressive transformation towards an organizational paradigm was feasible. The subsequent transition from the abstract to possible first formalizations could be done considering that, in any case, every form is considered ephemeral, always being as interchangeable with another possible one.

### ***Transforming sequences***

The fundamental element was to have a first form to transform. This form is useful only for activating the already prepared transformation processes in order to progressively shift towards the adjectives identified in the reading process of own referents. The character, the adjective associated with each event was the fundamental element of the development of the design process and was pursued by applying, in progress, all the already identified transformation processes.

The initial event, and above all the first formalizations, like the catalysts in chemical processes, does not enter in the process but only helps the starting up. The forms used as a catalyst disappear and the design path finds its own autonomy in harmony with the student's subjective vision. The project, step by step, transformation after transformation,

grows in complexity and autonomy from any predefined form.

A fundamental element is having opted to work not with forms but with transformations. It is useful because, when the forms are not stratifiable but only changeable, the transformations can be used in sequence. Each transformation can operate on the result of the previous one without taking away the character already reached.

### ***Discovering to have already done the project***

At this point, the student suddenly realizes that he is not starting his own project but everything has already been designed by himself. In fact, he has implemented a generative project, he constructed a generative engine able to run producing results performed as possible variations of his idea. Going ahead from this point, the generation process could also be automated. For the student, it is a disconcerting and exciting discovery.

Naturally, he continues to work, on the one hand expanding his personal toolbox and, on the other, going ahead on the topological paradigm, nesting successive paradigms within every single event. The student discovers the possibility to easily manage the progressive process of increasing complexity and the ability of his project to reach the possibility to answer to the unpredictable requests of users and to increasingly advanced functional needs, just as it is normally requested in a professional design.



The quality of his project is not linked to the first drawing. It will disappear soon. It is not useful to work a lot by continuing to changing the first drawing. The goal is in the quality of the generative engine that he succeeds in constructing.

The generative design process is a progression based on own interpretative logics and on an idea as an organic structure in which the subsequent passages are implemented by following the fundamental and structured support of their uniqueness as authors, artists, designers, architects. Thus, each student discovers that, in the process of generative design, nothing is wrong, nothing is to be canceled but all that appears wrong is only at the first step of increasing transformation. Going ahead each student can implement a good generative project by increasing, in progress, the complexity. He is only running a path, sometimes hard, to perform his own peculiar generative code, his own identity in progress as designers.

The further discovery of the students is the knowledge to have acquired, in progress, great ease of producing further projects, even very different from the first. They discover to do not have the need to retrace the process of constructing their own instruments, their own transformation codes, but they only need to build a new paradigm suitable for the new theme.

The constant of my teaching was to propose, in each design class, a series of different projects. Each subsequent project becomes increasingly faster, with results of better quality than the previous ones and, at the same time, able to arrive

to manage the increasing complexity and the growing of the design identity of each student.

### ***Jumping to another paradigm***

Sometimes happens that the possibility to manage the increasing complexity appear too hard even if the student gradually adapts the used paradigm. He must not erase his work. The possibility is to easily improve the project by operating what we could identify as a paradigm jump. He can radically change the paradigm, resorting to a new catalyst, more organically relevant to his design vision. Doing that, the student does not start again from zero, he doesn't lose his previous work but he will continue to use all the transformations already positively tested in the previous project development.

This is a didactic result that is unthinkable to achieve without a generative approach.

### ***Random versus Subjectivity***

I must also remember that, in some courses, however, currently called Generative Art, sometimes it's used a different approach. Stochastic variations based on analytical data and the reconstruction of possible events using randomness are used.

This way of teaching Generative Art had, and has, a strong difference from mine owing to the role of randomness. Despite the unpredictability but also, very often, the fascination of the possible results, the results seems not to have any identity, so

much so that they are often referred to as made by machines: the "artist" robot.

In fact, this reconstruction of analytical data is performed by replacing the subjectivity and uniqueness of the author with the unpredictability of randomness. What is missing, however, is precisely the identity of the author and the non-interpretation of the data that are chosen not based on the vision of the author but randomly. The results can also be unpredictable and surprising but they are not recognizable in a particular vision of the future. They are in any case homologated because they follow only the used technologies identity.

In fact, technology had and has, in these experiments, a primary role. It defines the type of expression and puts aside the possible expression of the cultural and subjective identity of the author. Artist or architect, designer or musician is pushed in a second line. The direct relationship between student and artwork disappear and the students cannot find a feeling with their artwork because they are not the expression of their identity and their vision.

### ***Recognizability***

Starting from the first generative experiences, in fact, I have always identified the recognizability of the results as the founder of the generative approach, able to gain multiple expressions of a subjective vision. (note 11)

Making a parallel with nature, the results, the variations generated are like

individuals of the same species. The generative project is a project of species whose character and vision are identifiable as belonging to an artificial DNA.

The diversity among individuals of the same species, the plurality of variations, is, in nature, due to variations in the genetic code and to the unpredictability of the surrounding environment. Re-proposing this using the random is possible, indeed it is useful if we limit ourselves to simulate what happens in Nature: the unpredictability of the context and the variations of the DNA that, however, is able to keep alive and strong the identity of a species. As happens in nature: the olive trees are more olive trees than before is the wind is strong and push the tree to express all its identity in growing and keeping alive the complex and peculiar form of these trees.

On the contrary, using the random to simulate subjectivity, the author's imprinting and to generate forms through random variations of parameters is exactly the opposite. Instead of reinforcing the character, as in nature, the unpredictability of the context could do, this type of use of the random cancels the recognizability of species, the identity of the author and of his works.

### ***AI and Generative Art***

It is not a coincidence that, in the last decades of the last century, research related to artificial intelligence was stopped after the first initial fires. AI in fact, as it has finally been clarified in

recent years, is based on an interpretative structure of reality and not only on an analytical data collection structure. From the first attempts and experiments, the concept of abduction, that is the concept of interpreting events through the construction of an interpretative paradigm, has been identified as essential for the concrete development of AI systems.

Finally abandoning the desire to analytically condense human mind as an analytical deconstruction of knowledge, in recent years we have opted to construct artificial subjects capable of interpreting what happens around them based on a character, on a vision that focuses the way of each AI system in adducting the context and managing their own activities. Based on this specific point of view that is identified and structured by the software designer, each AI system learns about the environment and increases its own singularity, that is its specific uniqueness, its artificial subjectivity.

An evolved AI system must gain, in progress, its unique and highly identifiable identity precisely because the experience acquired will depend on the environment in which it has been in contact and from the point of view that has been defined by the software designer as the basis of its construction.

### ***ARGENIA, a subjective AI system***

Argenia, my generative software, not only generates variations of 3D models all different and recognizable as belonging to my vision and to one of my generative

projects but, also, is the system able to record my design activity.

Doing that it works not following an analytical approach in recording my generative projects, that is building a database of results, but following the advanced AI systems approach to singularity. Argenia is, however, a software that collects and systematizes, after each new project, the algorithms I have designed. (AI organic complexity in Generative Art, note 12)

In the 40 years since my first version, Argenia has become a software that has inside all the transformation rules that I designed for each of my projects. It seems to be like an artificial intelligence software structured as a complex labyrinth of multiple generative paths, intersected between them and able to manage unexpected contaminations. The long sequence of my projects, from cities to architectures, from objects to artworks, and the multiple and different interpretations of the past, Roman, Medieval, Renaissance, Baroque (fig. 4,5,6) and Contemporary Art that I have built over time, summed to the different feeling of the different moments of my work, increased its singularity. Now, this software is capable of generating unique and unrepeatable events, complex and highly recognizable but all identifiable in my vision of space, in my poetic.

The singularity acquired by Argenia continues to grow with each new experimentation and it is and will be able to independently reproduce, even in incoming and further different projects, my particular vision of the space. It is my operative memory.

NOTE

(note 1)

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Ambientale di Morfogenesi", 1092

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[www.artscience-ebookshop.com](http://www.artscience-ebookshop.com)

(note 6)

C.Soddu, A swimmer in a natural sea  
frame

A paper on Generative Design Teaching.  
Presented at generative Art conference,  
2006

<https://www.generativeart.com/on/cic/papersGA2006/21.htm>

(note 7)

GDDM

Generative Design Digital Manual  
Celestino Soddu and Enrica Colabella

This Digital Manual was built for the first  
time for supporting the managing, step by  
step, of the Generative Design process in  
the teaching.

It was implemented during the teaching  
process with different material: examples,  
theoretical and practical references,  
dedicated papers, lesson movies, etc.  
used in each lesson and in each teaching  
exercise.

<https://www.generativism.com/tiki-index.php?page=GDDM>

(nota 8)

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Cities Asia Summit, Singapore, Nov 2002  
and Generative Art conference 2002,

[http://www.generativedesign.com/papers/soddu\\_GA2002.htm](http://www.generativedesign.com/papers/soddu_GA2002.htm)

(nota 9)

All the teaching activities starting since  
1995 (the internet beginning) by  
Celestino Soddu and Enrica Colabella is  
in the website  
<https://www.generativism.com>, as well as  
one hundred of master thesis, the course  
programs, and the student's works.

(nota 10)

AI organic complexity in Generative Art,  
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[http://www.generativeart.com/GA2018\\_papers/GA2018\\_Celestino%20Soddu.pdf](http://www.generativeart.com/GA2018_papers/GA2018_Celestino%20Soddu.pdf)

(note 11)

C.Soddu, "Recognisability of the idea: the  
evolutionary process of Argenia" in  
P.Bentley & D. Corne (edited by),  
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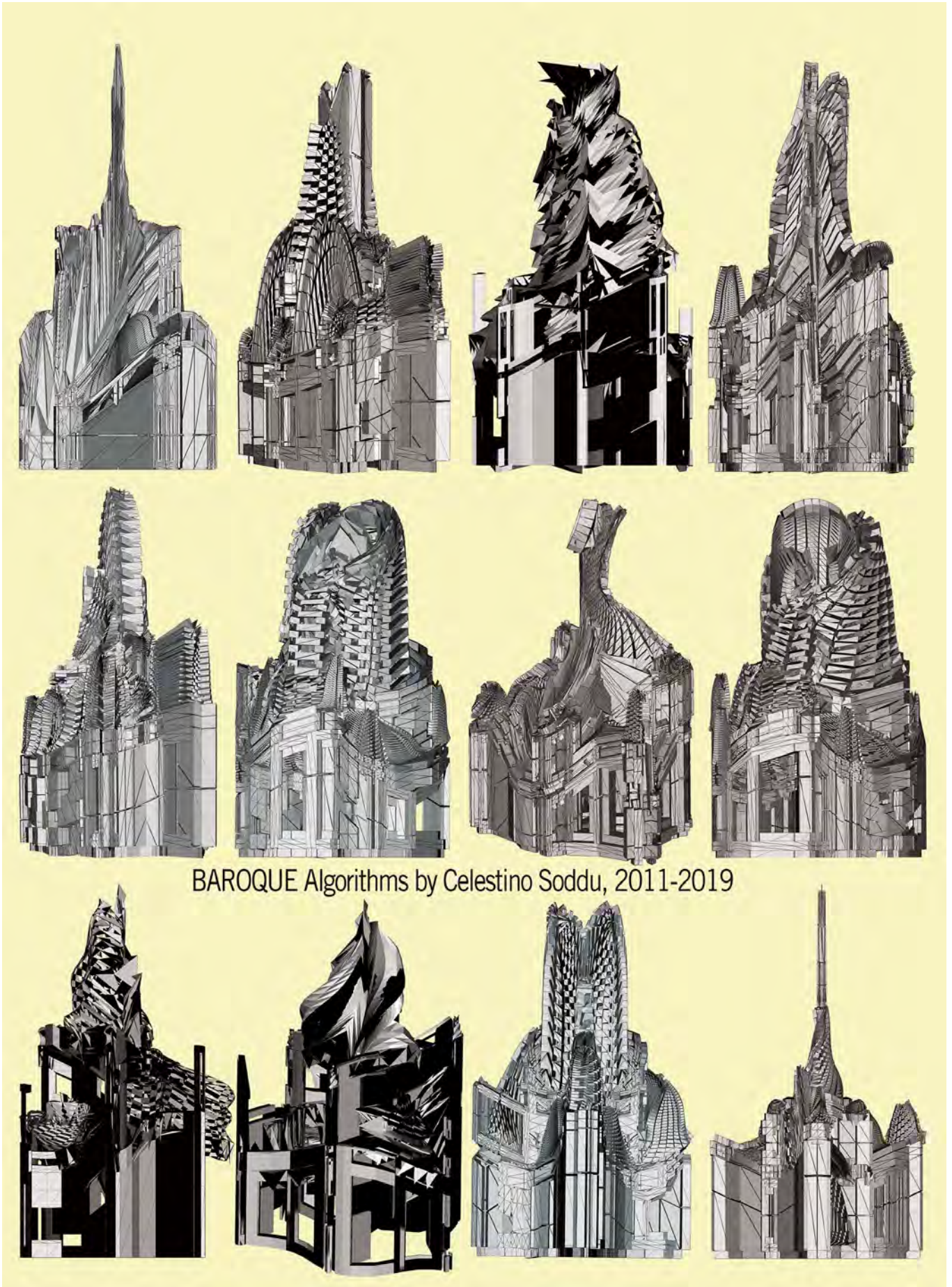
C. Soddu, AI organic complexity in  
Generative Art, paper at XXI Generative  
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Fig 4,5,6

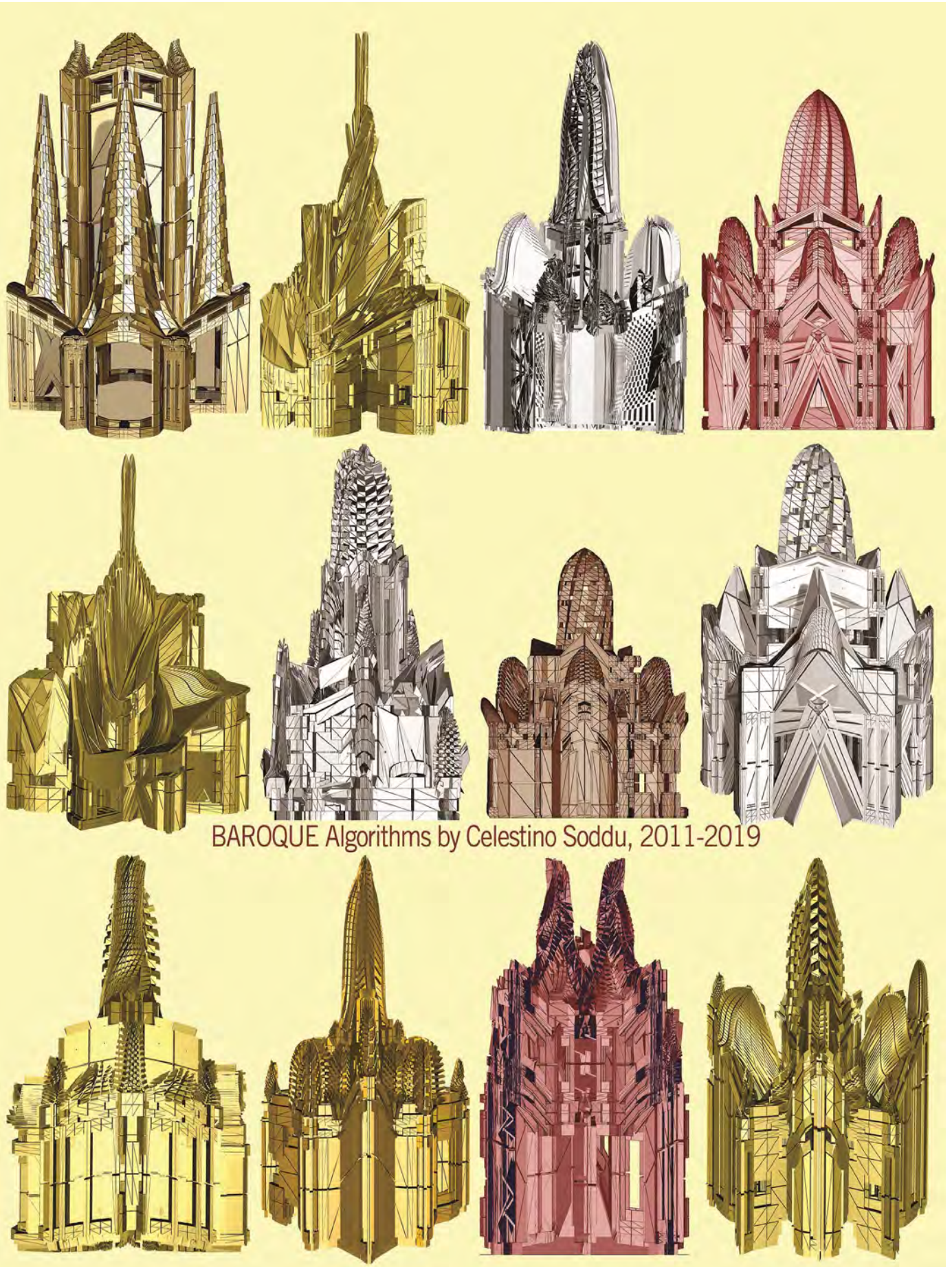
The baroque algorithms I developed in my  
software are, for example, interpretations  
of Francesco Borromini's architectural

logic, not an analytical reading of his works or a deconstruction of them. Each algorithm is a progressive identification of a transformation of the classical past towards the future born of the interpretation of the works of Borromini. In the generated variations, the original forms of the Borrominian baroque disappear, being only catalysts of the construction of the transformation codes. Instead, the characters of the subjective interpretation of these dynamics remain. With the occasion of the event at the Casa delle Letterature I present a generation of chairs based on my interpretation of the Borrominian Baroque. Moving from architecture to design, the topological paradigm obviously changes but I kept the same transformation codes used to generate Baroque cathedrals. The result is clearly recognizable as baroque even if the forms of the variations are not directly attributable to Borromini. The contemporary nature of the generated chairs reflects not only the transformation processes adopted but also my particular vision of space and its complexity.



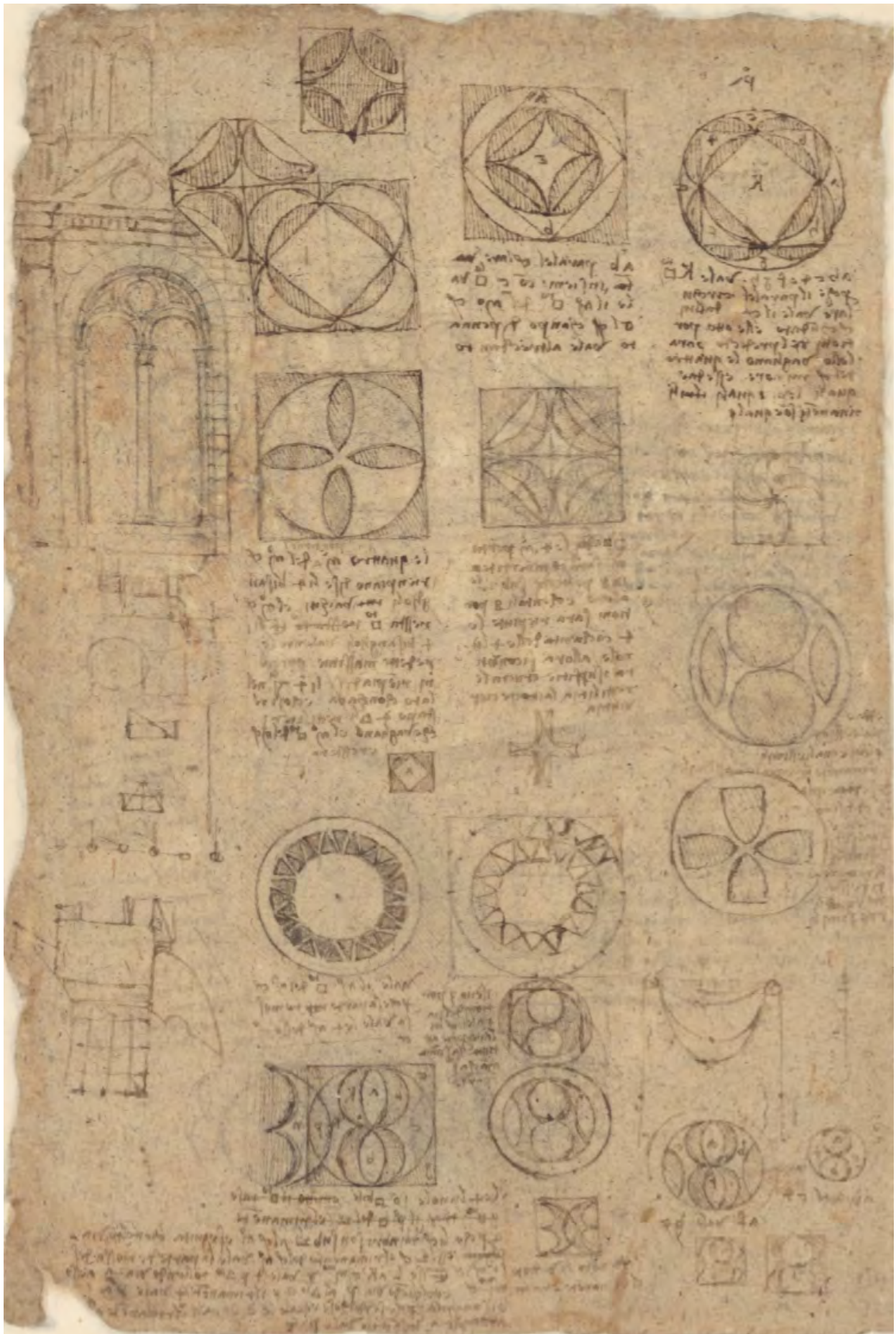


BAROQUE Algorithms by Celestino Soddu, 2011-2019



BAROQUE Algorithms by Celestino Soddu, 2011-2019





*Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations*

# Generative Art, a *poetic* vision

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**OVIDIO. CRONACA DI HEIDELBERG 1493**

*Tertia post Nonas remove Lycaona  
Phoebe*

*Fertur, et a tergo non habet Ursa metum.  
Tunc ego me memini ludos in gramine  
Campi*

*Aspicere et dici, lubryce Thybri, tuos..  
Festa dies illis qui lina madentia ducunt,  
quique tegunt parvis aera recurva cibis.*

**Book Vi – June 7, Ovid FASTI**

*On the third dawn after the Nones, it's  
said that Phoebe  
Chases away Arcturus, and the Bear's free  
of fear of her ward.*

*Then I recall, too, I've seen games,  
named for you  
Smooth-flowing Tiber, held on the turf in  
the Field of Mars.*

*The day's a festival for those who tug at  
dripping lines,  
And hide their bronze hooks under little  
strands of bait. [1]*

*Still today, the Tiber flows its dirty waters  
between the grey walls of time,*

*Following its sound still performed in our  
new silent war, everywhere for everyone.  
On its skin, it welcomes hungry seagulls  
dreaming of their lost solitude.*

*Smooth-flowing Tiber, you say today  
welcome to the Featuring Past Art  
participants*

*At today's Literature Festival open for  
those who visionary lines tug  
Hiding the noise all around with the  
eternal song of life*

This paper tries to collect some fragments of my past investigations about the possible relationship between poetry and the generative art process, starting from the past toward our new digital time.

The bridge between art and science and poetry worked full of steps especially in *Renaissance* with Michelangelo, 302 *Rime*, and with Leonardo, *Fabulae*.

After a long time of discovering experience about this connection, now, the word poetic seems to be the winner in the competition of the most used word in art processes. Having lost its classic complex significance, it gains a rule of a *nudge* for urging a "slow thinking" [2] that is the system of reflective thought, *intentional and logical*, characters of poetry. The second system is the rhythm. Last but not least.

## **GENERATIVE ART [3]**

*"Generative Art is the Art of process and not only of the result. GA works using the rules of the alive world, as a mirror of Nature.*

*This is in line with the motto by Jean Mignot, 1392, **Ars sine scientia nihil est.***

*The process works as a chaotic not linear system, in order of a methodological procedure structured following Kuhn, Ilya*

*Prigogine, and Renè Thom. This structure, defined as a math problem, individualizes a hypothesis, able to define a code that performs generative results, running in AI sites.*

*The results are all unique **ad continuum**. These are variations of the same hidden codeness, as a transforming vision of an interpreted "reality".*

*GA marks the passage of the last 30 years from homo faber to homo creator.*

*Overcoming the artifacts characters of the last century, industrial, serial, component, standardized, quantified, optimized, anonymous, obsolete, etc., synonymous of generative are unique, digital, organic, complex, meta-poetical, recognizable, endless, experimental, morphogenetic, variable, mirroring, imaginary, etc.*

*Precedents of GA are Michelangelo Leonardo, Piero Della Francesca, Pacioli, Mantegna, Borromini, Piranesi, Gaudi, Caldano, Mozart, Schubert, Wordsworth, Coleridge, Rembrandt, Bruguel, Swift, Bach, Goethe, Leopardi, Flaubert, Florenskij, Van Gogh. Melville, Baudelaire, Poe, Seurat, Cézanne., Matisse, I Futuristi, Picasso, Klee, Kandinskij, Eisenstein, Pollock, Mondrian, Pound, Auden, Bacon, Borges, etc.*

*The list is long and open."*

*This writing so distinctly of the kite my destiny seems to be, because in the first remembering of my childhood and it seemed to me that, being in a cradle, a kite came to me and it opened my mouth with its tail and many times it moved with such a tail inside my lips.*

*Leonardo, Atlantic Code, sheet 186v*

#### **"The codes of Harmony [4]**

*A tale from the past time:" The child, father of man"*

*"L'eau claire:comme le sel des larmes  
d'enfance"*

*Rimbaud, Memoire*

*At the entrance of two Maestri, the rustling of their dresses generated a murmur on the child's face, fast ended on his astonished eyes. For an instant the pars triangularis resounded with the opercularis part in the area of Broca on the brain of the child: mirror neurons activated themselves.*

*Empathy became perfect, just at the beginning of the lesson.*

*After a fast but so deep discussion, they agreed to use their own room in which they died as mental memory image for their lesson. Leonardo, proud walking toward the room in which the child was waiting, reminded the softness of his bed, the color of the candle, that he asked always on for lighting the corners darkness and the mirror just covered with a pitying veil. He saw also the books, on the wall, very closed to his bed: Dante, La Divina Commedia, Ficino, Lucrezio, Pico, De hominis dignitate, Pacioli, De Divina Proporzione and his last drawings too on "The end of the world".*

*There was also his casket with the secret opened from a week, on the table with his last will and with his love letters, that he asked in his will to put into the fire after his death. Finally, the unique great grace comfort of his life: La Gioconda. At once, he decided to start his lesson from her.*

*Michelangelo, in the meantime, was singing in his mind his preferred Madrigale, the same that was singing in his heart when he died. His closed eyes,*

*in his last room in veiled dim light, were able to figure the smell of Roma, in that evening.*

*Leonardo, sitting fast as an eagle just back to his nest:” I will start from my last thoughts in my death room”.*

*An immediate blush went down the child's eyes as for a pitying act of love. “For many years I take with me, in my bedroom wherever I went, my painting “La Gioconda”. I was not able to dream without given to her my last looking at the night. After my death, she was pilgrim until she resides now in the dark, submerged in an unrelated vacuum odorless and without any radiation of the sunlight. However, how did raise the idea of this so wonderful painting? I was depressed after my big mistake of too much water in material color for the fresco for the battle of Anghiari. My mind became as fixed at that night spent with fire trying to preserve paintings that inexorably disappeared. More I felt myself nothing after also seeing Michelangelo David walking and in a pause at the same time! He was able to put the infinite inside the space of the statue feet. I worked in silence for a long time, walking in the woods of the mountains, hearing the mute sound of Nature and crying for discovering the right street of my life. I took conscience that tools are precarious; the main real alchemic process is to transform alive nature music in a mirrored sound of the heart. So I designed in my heart La Gioconda. I gained the infinite in her smiling. This reminds to me my mother tenderness. The code idea rises as mute music, kindly full of significance that suddenly performs a “sgomento”, able to leave you without any breath. With ostinato rigore you must pass through the*

*darkness if you want to see the splendor of Beauty. La Gioconda is the smiling side of my melancholy. She is the lightness on my darkness. With her veiled color light, she is the maternal code of my heart”.*

*Expert in variations, Michelangelo started: “Dear child, you represent a double terrific vection of my time and of my eternal hope. Image a blind man, until he moves inside his home, he feels free inside his space, but if he moves outside in an unknown space, he needs a helping tool. This can be a dog, a stick, a friend. These tools can leave him free to recognize with his other senses, touch, smell and most of all hearing, the discovering space. The same happens in our creative process. We need a tool. Each one of us chooses his more peculiar tool, belonging to his own attitude. How can we be sure that is the right one for us? There is only a way, by trying, more and more in an experimental process. Until it happens that, we recognize a familiarity with this tool, like an artificial hand of our mind. The most complex simple one is the pencil for the writer. If you are a good writer, you need a pencil as a part alive of your hand. Life is not a game. Moreover, if it is, we all are a loser, for the simple reason that we all die. I got it in my soul three times, surrendering for rising again with indelible signs. Then I tried to remember each day of my last alive time the imperfection of our human condition. I worked every day until I died, but I lived not finished with strong intention and pain “La Pietà Rondanini”, et aliae operae, but this only one I take in my bedroom until my death.*

*As in most of all my works, I looked for discover a mirror of my screaming vision hidden inside the stone. I tried to perform*

harmonic proportions, structured in dynamic relations, following an anthropomorphic concept that was the main center of my poetic. In this work, I tried to perform a mirror of my own condition. There is evidence in the code ready for generating endless variations. The act of the reader becomes being born, an alive embryo, which represents itself inside the dying action. The inseparable figures of Maria that embraces her dead son Christ seem to rise from a water mirror. They tell a soul condition, a tension of mind that is possible to understand only with emotions. This my maternal code is the representation of my humble mood and of my melancholy as an artist.

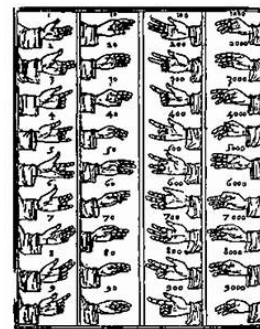
*“Per fido esempio alla mia vocazione/  
As a trusted example to my vocation  
Nel parto mi fu data la bellezza /  
In my birth to me was given beauty  
Che d’ambo l’arti né lucerna e specchio”/*  
What both arts it is lamp and mirror  
Michelangelo, Madrigale, 164 [5]

You, child, must walk hearing your own music that indicates your street of life. If you want to discover your identity, silence and attention are the basic tools for focusing clearness in your emotions. Don't trust yourself to people that give you fast explained solutions, especially if they look so much sophisticated”.

” Any questions?” asked Leonardo, knowing very well that the child had spoken all the time with his eyes, also with a kind tear, and with his mouth, with his hands, also with his feet, emulating a walking passage.

The child said:” I am really very curious, Maestro Leonardo, to know the reason why you wrote every script of yours in a reverted way”.

“Oh, a good question. You give me the opportunity to talk about the veiled mirror in my deathbed room. Therefore, if you see in a mirror my written words you can discover the good side of their deep significance. They are the results of the same generative process of La Gioconda. She is the other side, the good one, of my soul. My reverted scripts represent the process that the reader must active for reading them. After the process, the raider of a noble investigation street can follow the enchanted, discovering the words sound. I can give you a very simple example. You learn to number on the fingers of your hands. You can use the right or the left one, naturaliter. But if you start in numbering until ten starting for example from the left hand and you restart for twenty starting by the right hand, in your mind you will see the numbering until twenty as a mirror of the precedent ten. Following nature, that is figurative and also abstract, you wrote also in a reverted way, indigitatio in the illusion of time”.



“Oh, it is so deeply wandering!” exclaimed the child in a fast murmur. “Good lesson,” Leonardo thought in his heart. Michelangelo added, finishing: “So, sweet child, now you are the only skipper of our visionary ship. Take care of us, child forever.....Please, where is my hat?” “Siss Be silent!” said Leonardo, speaking with a low voice” I

*hid it into the coat pocket of the child; I knew that you would just appoint him the only skipper". While a suddenly amused astonishment was designing on the face of Michelangelo, a strong wind opened wide the door, banged back with a terrible noise. A moment later a nice girl, with a kind of cheeks red for the mountain cold, entered into the room, slight as flying with the wings of a white butterfly. Smiling she asked: "Are you the skipper of the ship of dreams?".....  
....ad continuum"*

### **Verba, scripta et alea generatim [6]**

*"Poetry has always been the natural home of multiplicity. Metrics, significance, sense, words, and sound. In only one line, it is possible to define and to allude at the same time. Rational, logical approach and irrationality, sensibility, passion, horror, fear, etc. are all together, in just a little space, for a long time, until eternity. We just find a natural similitude between the world of poetry and Generative Art, as a new tool for artificial life. First, the connection is in the same objective: to define a possible sense of our vision of the world. A new idea of the world that is closer to reality than the reality itself. This artificial life represents the potential of reality. A virtual history is born from our idea, during uninterrupted, constant evolution, in infinite scenarios. This generative work defines a possible sense, over the dialectic, a dynamic sense in evolution.*

*Man is free from all restrictions of mistaken truth: the same image of beauty and of a new infinite reality.*

*Order of the generative process:*

*1. Poetic Texts*

*2. Adduction and definition of a possible sense*

*3. The selection of categories*

*4. The indication of a paradigm*

*5. Matrix*

*6. Scenarios*

*We try with Generative Art to organize the transformation of senses. A new sense of sense. We connect praxis and poiesis, action and opera. Generatim*

*"But from where does our sensibility to beauty come from? The opera is not only arbitrary but it has been directed by a large organizing center very far from common structures of ordinary thought, but in resonance with the great emotional and genetic structures that are inside all our conscious thinking. The work of Art is as an embryo in a virtual catastrophe in the spirit of the observer. When poetry meets the world of image, freaks come up".*

### **Generative Art Language [7]**

*"In 1992, Celestino Soddu and I published "The Habitat Morphogenetic Design, artificial codes of the environment" where we delineated all our GA process also in our teaching experiences.*

*My peculiar effort was to choose for every chapter of this book a proto-text from the words of famous poets, philosophers, artists, as a poetic synthesis of each chapter significance. This for enlarging the contest of each part of the generative theory inside a poetry and prose reference of a past time. For the reason that does not exist generation in the art without references to the past, as in organic life. The generative line is an evolutionary passage from the past toward a future.*

*Following this methodology, I started in experimenting in teaching in 1994 as an homage to Leopardi in an Architecture Design course at Politecnico di Milano. The didactic main aim was to generate spaces starting from an abduction process from the Leopardi texts in poetry and in prose too. The abductive action chooses three adjectives also in significant contrast as aims of the incoming generative process. We can generate nothing if we do not fix in advance the characters of our aim. This was the first bridge between the world of poetry and AI processes*

*The discovering aim of this type of investigation is in trying to outline possible organic structures inside the art experience of the past. This with the main aim of performing an **organicity** as a connector by delineating a progressive process looking for also inside the past, as in the lighting of the previous scientific results.*

### **G A MetaLanguage [8]**

*GA MetaLanguage is a generative process for gaining a language where the starting point is in the preposition **meta**. This expresses a passage from a time before to a time after as a translation able of crossing words toward figurative results. Figurative means that the results are recognizable in our cultural history, where all human artifacts belong.*

#### **Organicity in GA MetaLanguage**

*The discovering aim of this investigation is in trying to outline possible organic structures inside the GA experience of the past, for more than 30 years. Organicity works as a connector by delineating a*

*progressive process looking for also inside the past, in the lighting of the previous scientific results. GA innovation works in art tradition. This should be the main condition for defining generative this kind of art. Firstly, the choice of the title "GA MetaLanguage. This expression identifies two parts that stay together working in an autonomous way. The main reference is In Douglas R. Hofstadter that identified possible connections ad continuum in his book "Godel, Esher, Bach. An Eternal Golden Braid", as a metaphorical escape between minds and machines in the spirit of Lewis Carroll", published in 1979.*

#### **Crossing the river in electric resonance**

*The peace of all things is the achieved order". S. Agostino*

*Two different systems perform the GA MetaLanguage. The first is not linear and it builds by algorithms open processes. The second system delineates a crossing interaction with the first one by a linear system that is time. This process is like the crossing of a river that is running toward the sea, connecting its two different sides with all the memory of its own running. In the swimmer crossing time, the running of the double systems generates an electric resonance between the timed crossing and the river flowing with the running swimmer. This crossing in electric resonance performs a unique result of perhaps infinite variations of the same generative process. The best paradigm of the process control is in crossing the river from one side to the other side, by following a past time toward a future with a singular point of view in one direction. This is able to*

*connect the real site into our imaginary vision by performing experience of our idea/ code. This works as a paradigm of control inside our incoming generative experience.*

*The GA artist is alone as a swimmer in the organic sound of nature, preserving in his heart the imaginary vision of his infancy with its sounds, smells, and orders. This is the main condition for gaining an art result.*

### **GENERATIVE CHAINS [9]**

*In art, a creative process works performing imaginative constraints able to generate chain. However, how constraints can generate a chain? With imagination, crossing times and spaces and connecting extraneous distant elements in a new generative vision. The main tool is the performing of an interpretation on the significance, able to delineate a new double resonant measure as a generative chain. As soon as a rhythm in our mind structures the core of a new poem, so we are able to follow the sound of our mother tongue generating a new poem in resonance with the precedent poem. This becomes a catalyst able to generate a new imaginative chain. Following the concept of comprehensiveness delineated by Eliot, we can discover imaginary constraints as a connection from different times generating chain.*

*A dual/double sound delineates the structure of this research, following the concept of Polarität, performed by Goethe. The dual conjugation was in the structure of Greek grammar.*

*The dualism works in imitation of a natural code, performed in a double helical.*

*Image to have a tetrahedron at whose basis we connect to each vertex the words: imagination, thinking, memory and on the top intuition.*

*In a generative process, we can cross from the significance from one word to another performing a helical double direction, one toward up, the other toward down.*

*So the intuition/perception can manage these two structures that we can schematize in:*

#### **1- Imaginative constraints**

*- In his talk for the Nobel Prize in 1995 "Crediting Poetry", Heaney said:*

*"As poet, I am inclined toward the search of a rhythm, in the sense that my effort is to submit me to the stability conferred by an order of musically satisfying sounds".*

*Imaginative constraints are able to delineate a process by discovering our own codeness as a paradigm of organization of our own ability in giving answers in art procedures. This is an open endless system. More we discover connections and distances, more we are able to delineate the complexity to gain. Sound after sounds.*

#### **2 - "Comprehensiveness"**

*Following the concept of comprehensiveness delineated by Eliot, we can discover imaginary constraints as a connection from different times generating chain.*

*"Every author that embodies such characteristics and is able to maintain a sort of equilibrium between tradition and personal expression. And, above all, each work that expresses in a complex way the thematic and the feelings of each own epoch (that possesses, that is, "comprehensiveness") and that is remarkable in the same way in all the*



literature, .these could be defined **classical**". Words by Seamus Heaney in "The meeting with the classical Greek and Latin".

Moreover, in 'Alphabets' Heaney is found again as a child, reserved to associate the form of the letters of the Greek alphabet to the familiar objects of his rural world.

**A chain tale:** A voice from past

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

"A song with art in jubilation" So far from the global broken song of our wasteland.

However, you can smile and look to the sky, still today. That's all.

## **POETRY** [9]

*"The first function of poetry, as of all the arts, is to make us more aware of ourselves and the world around us "*

*W. H. Auden, The voice of the poet*

### **The Angel looking**



Tischbein, *Goethe in via del Corso, Rome*-  
G.D.Friedrich, *Woman at the window*

*Poetry is not only a sound, defined in a random way, in which every sense is dead.*

*Poetry is a strong guide for performing a complex system, always it remains: "The absurd pretension to fix what time leaves behind".*

La festa del sole / The feast of the sun

Non c'è ombra nel solitario paradiso  
interiore ,/ There is no shadow in the  
solitary internal paradise,  
Ma solo il ricordo d'ascolto della prima  
voce, / But only the memory of my first  
voice listening,  
Generatrice di parola sin nel tenero ventre  
materno. / Word generator just in the  
tenderness of the mother's womb.  
Il maestrale si è assopito, accarezzato  
dalla sera / The mistral fades out,  
caressed by the evening

Noi volgiamo lo sguardo nel silenzio dei nostri cuori, / We look in the silence of our hearts,  
 Per scoprire il profumo del giardino perduto. / For discovering the scent of the lost garden.  
 Un canto risuona tra le rime di versi che la memoria evoca: / A song resounds among the rhymes of verses that memory evokes:  
 Segno di infante meraviglia risvegliata nella piega del tempo. / A sign of infant wonder awakened in the fold of time.  
 Madre, accarezzami il viso di bambina, che ha perso / Mother, caress my child face, that lost  
 Per un'ombra improvvisa il primo raggio di sole, / For an unexpected shadow the first ray of sunshine,  
 Che illuminava nel mio spazio tempo le prime vocali tratteggiate. / Illuminating on my time-space my first traced vowels  
 Spavento trasformato da Te in tenera dolcezza. / Fear transformed suddenly by You into tender sweetness  
 A Te affido le lagrime della mia paura di vivere / To You I entrust the tears of my fear of living  
 Certa che le tramuterai in piccoli bianchi fiori sui monti, / Sure that You will transform them into small white flowers on the mountains,  
 Dal colore irradiato dal sole su sassi cangianti / With the color radiated by the sun rays between iridescent stones  
 Nel profumo assopito tra l'oscuro delle foglie. / In the scent dormant between the shadows around the leaves  
 E tu Aurora risveglia in me la dolce luce dell'infanzia. / And you, Aurora, reawakens in me the sweet lightness of my childhood.

**Math + Poetry = Bivocal Art** [10]

*This is an investigation around the adjective popular, as a cosmic constant of which number and mathematics is a universal formula.*

*Variations, combinatorics, and permutations.*

*There is an hour, at night, of cosmic silence.  
 F.I. Tiutchev*

**1. Aim: Math + Poetry = Bivocal Art**

*Discovering double non-linear segments in the continuum of significance.*

**1.1. Hypothesis:** *through the investigation of a particular field as poetry in prose the concept of the universal singular poet is performed as a mirror of the popular voice.*

**2. Lecture key: Bivocal.**

*Poetry is a complex system defined by the vision of a poet in which structure is metrics and text is a variation of a structure able to perform the popular voice in the language connected to its specific time. The metric structure is a mathematical procedure using length, capacity, weight, value, etc. Basic site of poetry is Mathematics especially if the writer is using also prose. Like everyday life, patterns and rhythm surround poetry. Numbering is a musical structure. Rhythm is able to raise the writing art in a regular layout using clear punctuation. These are empty signs of rhythms and abstract elements of writing. The musical structure is the metric articulation of the text.*

*Gian Battista Vico calls poetry the first operation of the human mind. "Every writer action is a system". "Every writer text needs an irregular line, this is in a*

*certain way the organic condition of written appearing”.*

*The linguistic thesis is that:” The written code is secondary in relation to oral code that is a language configuration”.*

*Michail Bachtin discovered **bivocal** ability in making transparent from the text what belongs to not written.*

**This is a form of popular evocation.** So we can define the relationship between written code and oral code as a transforming process of a bivocal art.

*”Style is a man. Or better style is two men.”*

**The familiar evocative sound** is the material voice of the writer. He transcribes oral codes. This works as a performing process that uses algorithms as transforming rules. These are in the text frames like bridges, able to work as hidden structures that give with words a deep expression of a collective wandering. The implied is inside every language, the word never is a transparent tool, but there are always inside all extra-verbal elements, all evaluated touches. “The active understanding, accumulating what is understood with the new horizon of people that works in understanding, establishes a series of complex connections, assonances and dissonances with what is understood and this improves it on new moments”.

*“The care that you take is poetry for the hearts of simple men”.*

*Poetry is also a remembering art. We memorize in our child wood the poems of the most important poets of our language. For this reason, we learn in a deep fast way the sound of our culture. However, poetry is not only a local language. There are inside also elements of a universal language. The constructive vision of*

*Bachtin works on the constant and silent listening of the Russian complex voices inside the unlimited others of a cultural contest that englobe also Goethe, Rabelais, Socrates, Dante. The result of this original dialogic relation is the new liberating elaboration able to break what is static, dogmatic, tragically finished and to project it into a plural voice and unlimited universe, of which rules as in microbiology and physics are **interaction** and **performing**.*

*“The thinking can grow only with the help of other voices that enrich, recurs and put it again in discussion”. The reasonable unit of word focused the action of “pushing always more on, in a boundless way, toward infinite”. Bachtin defined a dialogic line from ancient Greek romance until Dostoevskij.*

**2.1. A definition of poetry in prose. A polymorphic vection.** (In Mathematics, a symbol of quantity having magnitude and direction)

*Possible montage: we can imagine in the topic of poetry in prose two dissociated vections together. One of the writer and the second one of the reader. A double body. One is reverted to the other in not Euclidean geometry. Poetry curves itself towards prose. The result is a matched song in two voices of different tonality.*

*In this way works a polyphonic shape by Hermannus Contractus.*

*Poetry nests as syntax inside explanatory prose. Poetic sentences disclose themselves as a meditated pause.*

*So we have:*

*A concise fluid syntax*

*Allusion / Referring / Performing to another system*

*A deep delimited text in prose*

*A double text*

*The two systems, structures + text, become **discontinuous** adding in not linear way a poetry unit.*

**Math and Poetry have the same ability to put bridges from the human mind and reality.**

### **3. Variations, combinatorics, permutations**

*It is impossible to be a mathematician without being a poet in soul.*

*Sophia Kovalevskaya*

#### **Variations**

*Variations are a result of performing a vision that uses metrics as structure. From *coblas esparsas*, to Dante, Petrarca, Tasso, Leopardi, Pound, Auden, Ungaretti. Endless variations represent a performed style delineated with a universal singular thinking.*

*Singular code + mother tongue = Style*

*Universal code + Style = Variations*

*The process from singular to universal needs a popular passage in performing style*

#### **Combinatorics**

*“Man is deprived of his recognisability...he is got into a forced solitude” Bachtin*

*From *Cent mille milliards de poèmes* by Raymond Queneau, to *Oulipo*, *Perec*, *Less* by Beckett is an incredible example of poetry using combinatorics. Human vision is reducing in the replying of just assumed forms.*

#### **Permutations**

*The use of a double language, alphabetic and numeric as an open system. A great example is “*Lo Zibaldone*” by Leopardi. Poetic annotations using index-linked to categories as tools of a generative system.*

*A possible open result. As for Fellini’s movies is not possible to use the word end as a conclusion of a process. The only fable end that belongs naturally to us is:*

*“... And they lived happy and glad forever”*

*Like *Filemone and Bauci*, Math and Poetry have the same ability to put bridges from the human mind and reality.*

#### **Poetry in prose in teaching experiences**

#### **A teaching exercise -Praxis from “Elected Affinities” [11]**

*“Infancy is the site where the difference between dream and reality has borders open and not close” Goethe*

**Aim:** *To perform a Universal Code as a collective identity*

*“The ultimate result of Pythagoreans was friendship”*

*This is one of my teaching experiments. I carried out it in my academic experience. I have connected two very different and remote identities.*

*One is the reality of underage boys and girls that stay in prison at Beccaria’s remand center in Milan.*

*The other reality is my 3rd-year students at the Faculty of Industrial Design.*

*I have worked for one week at Beccaria. Young imprisoned girls and boys have collected drawings of their reality and recordings of their spaces with a digital camera.*

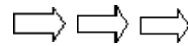
*I have put all these materials in my teaching web site*

*Another tool that I defined is an ancient scheme of the universal system.*



*This Universal Code works as a catalyst able to connect different young souls*  
*The Universal code, that is the Systema Magicum Universalis, taken from Opus Mago-cabbalisticum by Georg von Wellings, is a collective diagram for every student. It organizes a circular linear sequence, in which the center is the individual subjectivity. A possible evolution starts from each singularity*  
*A very important step in this generative project is the poetic test.*  
*I started in generating this idea from Elected Affinities.*  
*This is a very complex text. Benjamin tells that it represents Goethe's research of a code of eternal development. If we compare the System with the seven characters of the Goethe test, we find a tightly connected structure in which the center is Nature.*  
*It shapes "The eternal return of the identical"*  
*It offers each student a possible way of connecting in a sense different elements of material's pluralities.*  
*Text is like a nonstop source from which it is possible to feed an emerging aggregate field.*  
*I chose categories and orders from the text as an open system:*

<i>Beccaria's young boys' drawings</i>	<i>Text is as a connected material,</i>	<i>Students' processing</i>
<i>Are like voices indicator</i>	<i>and represents an axis parameter</i>	<i>First choices</i>



*Several cells*  
**NEOTENIA**  
*Natural selection*  
*n*  
**GENOMA**

**EVOLUTIONARY FILTER**

*Symbiosis*  
*( Also Random in its performing )*  
**FENOMA**  
*(open system)*

**Subsequently new objectives**

*This is a sequence acting from a dynamic center, performed by two different persons.*

*Together, in a union of minds, they carry out an overview of evolution as a possible generative process of collective consciousness.*

*After doing their work, my students went to shake their hands with Beccaria's young boys with friendship.*

*Il vuoto è oltre/The void is beyond.*  
*Il comune senso del luogo./The common sense of place.*

*Appare nella mente/Appears in mind*  
*Inedibile come unzione*  
*rappresa/Undamaged as coagulated unction*

**Teaching exercise about: "The sound of infancy "**

Maxims and proverbs in the mother tongue as **a familiar evocative sound**

"... (use) finally the words with a vague shadow of music, words that suggest music, measured words or words in a rhythm that considers some precise characteristic of the emotional impression, or of the precise character of the nourishing and maternal emotion. When this rhythm, when the melody or vocalic and consonant sequence seems to really bear the imprint of the feeling that poetry is intended to communicate, this part of the work is good. "  
Ezra Pound, "The serious artist", III, 1913

This exercise performs as a starting point of a GA process a focus based on the sound evocations of the popular maternal voice of infancy. The main aim is to perform a **clear character** connected to the first infancy vernacular sounds like the main aim of the generative process. This works from the first impressions toward generative expressions.

Exempla:

PROVERBIO BERGAMASCO: o sol l' ulia o sol of, al piof  
(o alle palme o a pasqua, piove)

LINGUA MADRE (BERGAMASCO), parola---  
tronsonosa (motosega)

-----  
Proverbio Salentino: "l'oiu de ulia lu male porta via" (l'olio d'oliva toglie tutti i mali)  
Parola Salentina: Sirama: mio padre

-----  
: "L'Ã mej un usell in man che cent che vula "

PROVERBIO IN TRIESTINO: "movemose che el sol magna le ore"

LINGUA MADRE), mularia (ragazzi/bambibni)

( NAPOLETANO): Chi vo' mettere 'o pede 'ncopp 'a ttutt' e pprete, nun arriva maje

Quand el corn al ga l'capel, ol pivv ol fa bell  
(img src=show\_image.php?id=1042)

Proverbio pugliese (Bitonto): Ci nge n'am'a scÃ¬, sciamaninne, cÃª non nge n'am'a scÃ¬, non nge ne sime scenne!

Parola: Rezz = Tenda

Sal piof ol dÃ" de la sciensa per quaranta dÃ" an se piÃ² senza

PAROLA (BERGAMASCO): Che botepl!!

PROVERBIO (BERGAMASCO): SÃ¶che e melÃ¹ a la sÃ² stagiÃ¹.

PAROLA (BERGAMASCO): S'cÃ"tÃ¬  
(bambino)

PROVERBIO(MANFREDONIANO): A cÃ"cere a cÃ"cere ce jÃ"gne â€"a pegnÃ"te(A cece a cece si riempie la pentola di terracotta)

LINGUA MADRE(TRICARICESE):Picnenn  
(modo affettuoso per dire bambina piccola)

PROVERBIO: (il caffÃ" sculent, sedent e par nient. (bollente, seduti e per niente)

LINGUA MADRE: magiostra (fragola)

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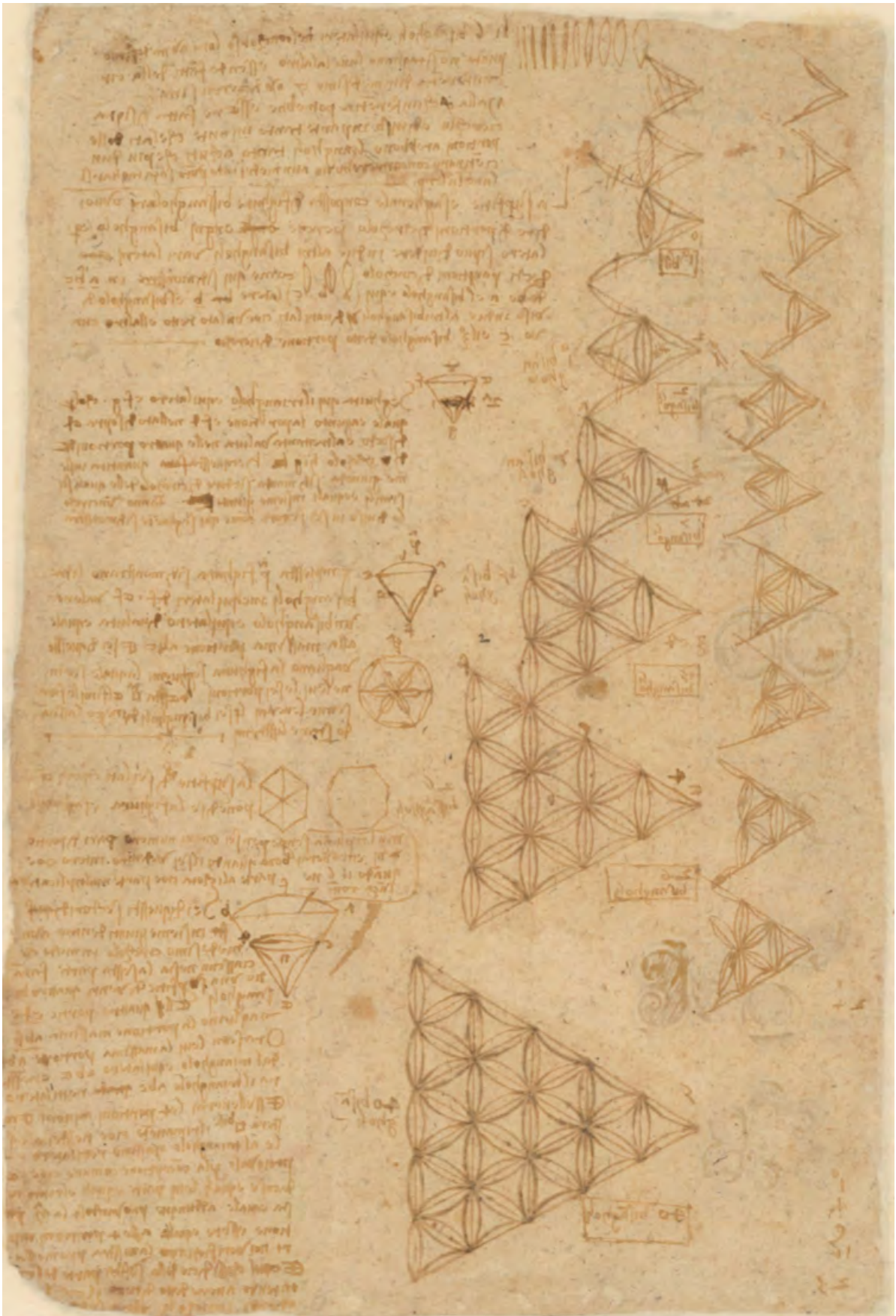
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*Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations*



# **Body-part Motion Synthesis System for Discovery Learning of Dance: Dance Creation Experiments with Students in Three Countries**

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## **Abstract**

This paper reports an assessment of the feasibility and the practicality of a creation support system for contemporary dance e-learning. We developed a Body-part Motion Synthesis System (BMSS) that allows users to create choreographies by synthesizing body-part motions to increase the effect of learning contemporary dance choreography. Short created choreographies can be displayed as animation using 3DCG characters. We conducted evaluation experiments for

creating contemporary dance choreographies to verify the learning effect of BMSS as a support system for discovery learning. The 48 examinees who are majoring in dance at three different universities in Japan, the UK, and the USA created their own dance pieces by selecting and connecting short movements composed by BMSS. We verified that BMSS is a helpful creation training tool to discover new choreographic methods, new dance movements, and new awareness of their bodies.

## **1. Introduction**

Our goal is to develop useful tools for the education, creation, and appreciation for dance using 3D motion data captured from performances by professional dancers. We have been developing interactive simulation systems for dance using dance-motion archives. Automatic composition for ballet and contemporary dance using the motion clips of the whole body have already been developed in our project [1, 2].

We developed a Body-part Motion Synthesis System (BMSS), which allows users to create choreographies by synthesizing body-part motions to increase the effect of learning contemporary dance choreography [3, 4]. The system targets students who are studying contemporary dance and is designed to promote the discovery learning of contemporary dance. Discovery learning is a concept that argues that learning is more effective when learners discover something for themselves rather than being spoon-fed by a teacher. This paper assesses the feasibility and practicality of a creation support system for contemporary dance e-learning.

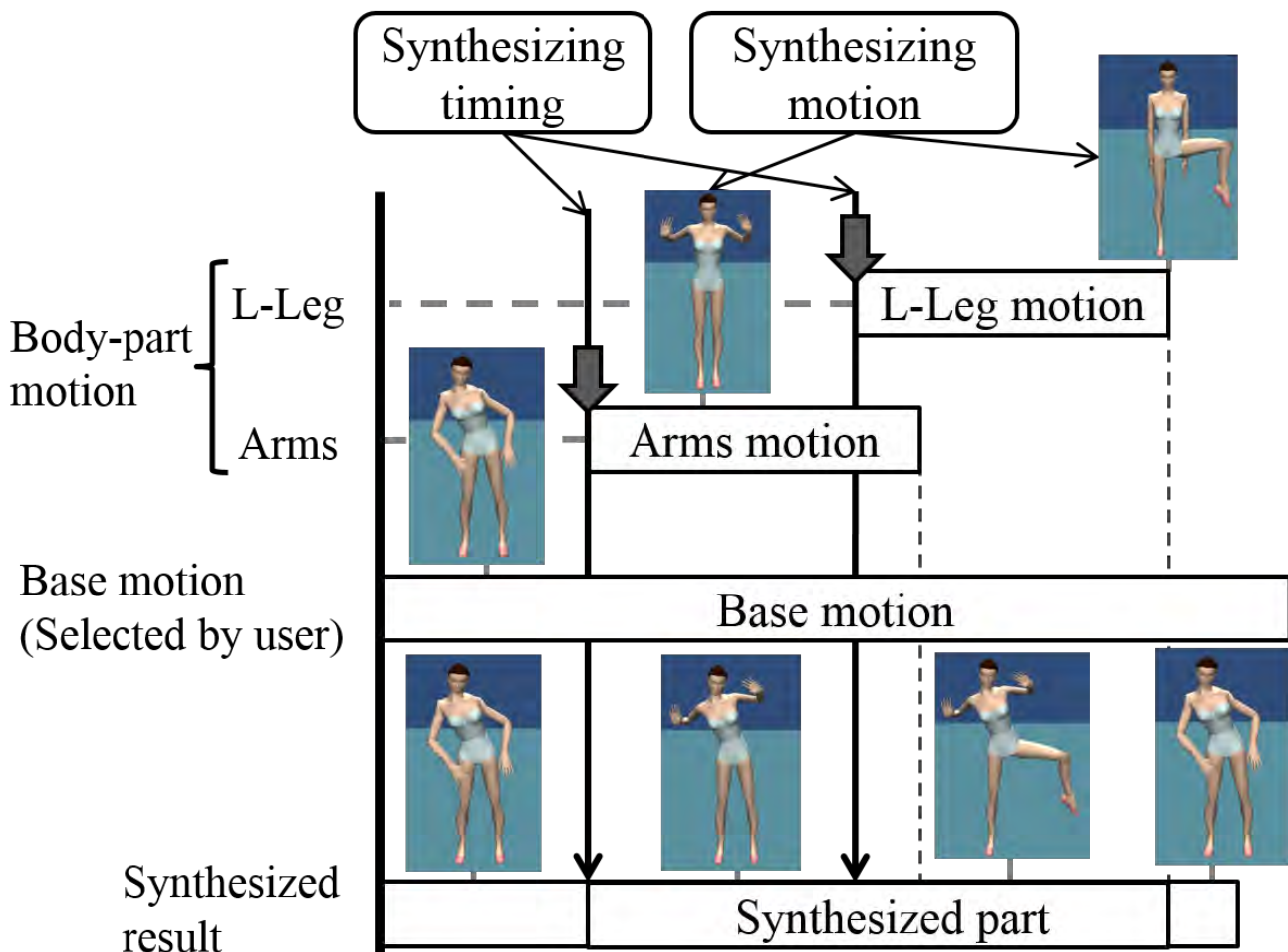
There have been some researches using dance notations and application software [5, 6, 7]. By using these software, one can simulate already captured or strictly described dance animation. However, it is difficult to compose original dances by describing the movement of each body part. Our approach easily creates new dance motions by selecting the already provided motion clips.

Other studies addressed motion synthesis, such as synthesizing dance motions based on emotions [8] and the contents of a piece of music [9]. These studies generated natural motions by connecting or synthesizing multiple motions automatically based on rules. However, we support creation that targets contemporary dance without style or traditional manner restrictions. Rather than natural motions, our proposed system generates unexpected motions that are helpful for dancers and

choreographers.

Our proposed system allows users to select each motion clip of specific body parts and synthesize them in real time. Therefore, different varieties of dance movements can be created based on the selected timing and the combination of body-part motions. Our approach does not create a complete connection and the physical reality of dance, instead of creates unexpected motions and conceptual sequences. We generate rough but unique dance motions so that users can refine and create their own choreographies.

We conducted a series of experiments with 48 students who are majoring in dance at three universities in Japan (JP), the United States of America (US), and the United Kingdom (UK) to verify the effectiveness of our software as a discovery learning tool. The students



created short dance pieces using BMSS and explained their creative process. This paper describes the concept of BMSS and the results of our experiments.

## 2. Concept

### 2.1 Analytic-synthetic choreography

The basic concept of our approach segments dance movements into elemental motions and synthesizes these segments to create novel movements. We call this method analytic-synthetic choreography.

From the standpoint of dance education, university students tend to be taught more expressive than structural methods. It is easier for students to make dances based on their own feelings or some kind of stories than from original movements or unique concepts. Especially in Japan, structural methods are seldom taught in choreographic learning courses. However, structural methods are also required to achieve creative works in recent contemporary dance trends. This is the reason we employed analytic-synthetic

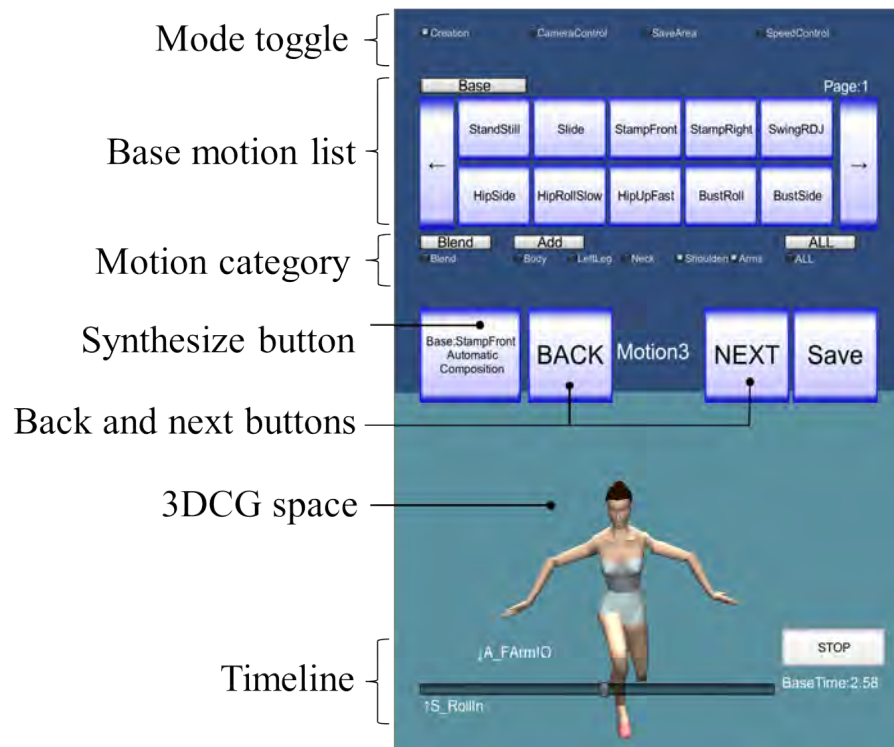
choreography as a structural method. We target choreographers and dancers who are specializing in contemporary dance.

Figure 1 shows our concept of body-part motion synthesis. Short choreographies about five seconds long are created by synthesizing body-part motion clips. After selecting a base motion, body-part motions and their synthesis timings are interactively or automatically selected.

Figure 1. Concept of body-part motion synthesis.

### 2.2 BMSS

Figure 2 shows the Graphical User Interface (GUI) of BMSS version 3 (BMSS3). This system automatically provides various short choreographic motions called a 'Unit'. First, users select a base motion and body-part categories. Then the system automatically selects and synthesizes body-part motions to the base motion. The system randomly determined the synthesis timings of the selected motions. This feature allows countless variations of Units to be



generated each time. The generated Units can be displayed as animation using 3DCG characters. Users can control the camera view or the playback speed of the animation. BMSS has been improved from version 1 to 4. In the second version, BMSS2, body-part motions and their synthesis timings are interactively selected by the user. Our third version, BMSS3, supports automatic synthesis.

Users can generate short choreographies with BMSS and combine and use them as references for dance creation, learning, and training. Occasionally, impossible and unnatural motions as human motion are created, but users do not have to completely reproduce real movements in 3DCG characters. Users can incorporate various arrangements and ideas in their created motions without using our application by adopting such techniques as horizontal inversion and devising motions of the hands and feet to simplify balance.

## Figure 2. Body-part Motion Synthesis System

### 2.3 Discovery learning

BMSS is designed to promote the discovery learning of students of contemporary dance. Regarding the process of learning, it refers to the unique individual experiences by which concepts evolve in the mind of learners rather than being transmitted ready-made [10].

Discovery learning is quite controversial because its educational effects depend on the fields of learning, the learning purpose, and the personality of the learners. The method enhances motivation, interest, satisfaction, and the development of both intellectual capacities and problem-solving skills [11].

Contemporary dance can be described as an artistic endeavor without any shared or standard choreographic vocabulary. Since no traditional or canonical manner of contemporary dance choreography exists and students are required to discover their own path, the educational method of discovery learning is absolutely appropriate with which to study it.

### 3. Experiments

#### 3.1 Hypotheses and participants

We conducted a series of experiments with 48 students who are majoring in dance at universities in three countries to verify the following two hypotheses:

1. BMSS is useful for students to discover new movements of contemporary dance.
2. BMSS is helpful for students to learn a new choreographic method of contemporary dance by themselves.

The first hypothesis addresses the usefulness of the analytic-synthetic choreography method, which BMSS applies. The second hypothesis suggests that the analytic-synthetic choreography is worthwhile per se for discovery learning.

The 48 examinees consisted of 18 students of University of Tsukuba in Japan, 16 students of the University of California, Irvine in the USA, and 16 students of Middlesex University in the UK. They consisted of 44 females and four males. We conducted the experiments twice and changed the participants in each time. 23 students used BMSS2 in the first experiment for each country in 2012, and 25 used BMSS3 in the second experiment in 2014.

#### 3.2 Method

Our experiments were conducted by one set of four or five participants in a gymnastic or dance studio, and the experiment time per set was 90 minutes.

First, the participants were briefly taught how to operate the software, but its two concepts were not explained to them in order not to give the preconceptions. The analytic-synthetic choreography and discovery learning concepts were intentionally concealed, because we wanted to test how much contemporary dance choreography the students would learn by themselves.

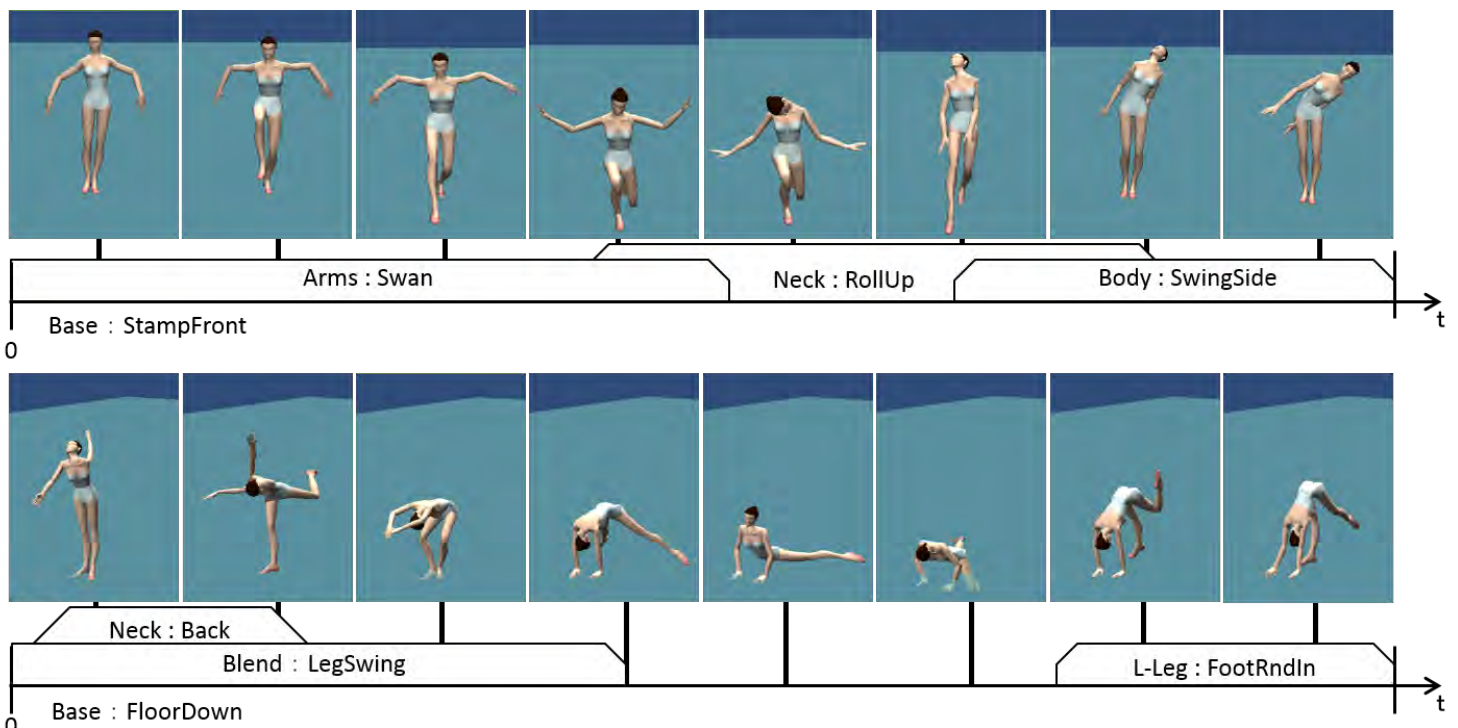
Then they created their own short dances (about 30 to 60 seconds) by connecting and refining the Units simulated by the software in 3DCG. Figure 3 shows the scenes of an experiment. They were also requested not to copy the movements simply but to refine them as their original choreographic works. They were allowed to freely add such techniques as iteration, inversion, or speed changes. After brief rehearsal they performed their choreographic works in front of a video camera. The duration of the performances by the students, which varied from 16 to

77 seconds, averaged 41 seconds. The number of Units they used were 5 to 10, with average of 7.



At the end of the experiment they filled out questionnaires about the two hypotheses at four levels and explained the reasons of their answers.

Figure 4 illustrates examples of short choreographic motions created by a student using BMSS3. The base motion of the first one is 'StampFront' (stamping frontward) and arm motions 'Swan' are replaced at the early point, and then a neck motion 'RollUp' and a body motion



'SwingSide' are replaced to the base motion from the halfway point. In the second one, the base motion is 'FloorDown' (getting down on the floor), and a whole-body motion 'LegSwing' is blended and a neck motion 'Back' is replaced to the base motion at the early point, then a left-leg motion 'FootRndIn' is replaced at the last phase.



Figure 3. Scenes of an experiment.

Figure 4. Example of created sequence by a student.

dance, understanding of movements, and training of dance techniques. They selected the level of usefulness from four levels, as illustrated in Table 1. Table 2 shows the results by country. In Table 2, each average point is calculated based on the level in Table 1. The years of dance experience and the number of times he participants had previously created contemporary dance choreography are also listed in Table 2. The years of dance experience varied from three to 22 with an average of 13.6 years. The number of times of choreographing dance ranged from zero to 50 with an average of 12.

All 48 students chose “Effective enough” or “Effective if reformed” for “Creation of dance”. The numerical analysis suggests that the software is useful as an e-learning tool to create contemporary dance. Several typical reasons for “effective enough” are excerpted as follows: “Very effective for dance creation. Gives great ideas for choreography.”(US); “Very good! I found a lot new movements from the software.”(UK); “I got inspiration and new ideas from the animation displayed when I combined several movements randomly.”(JP); “I think this could be a very useful tool for some students and/or professional choreographers. It's always helpful to have many tools for the creative process.”(US) The country of each student is shown in brackets.

## 4. Results and Discussion

### 4.1 Results of four levels questionnaires

The students answered questionnaires about the usefulness of the system for three purposes: creating contemporary

*Table 1. Evaluation by students.*

	Creation of dance	Understanding of movements	Training of dance techniques
effective enough (2 pt)	41	25	10
effective if reformed (1 pt)	7	18	22
not so effective (0 pt)	0	0	10
don't know (0 pt)	0	5	6

*Table 2. Difference among countries.*

	JP (18)	US (16)	UK (14)	Total (48)
Creation of dance	1.94	1.75	1.86	1.85
Understanding of movements	1.11	1.56	1.64	1.42
Training of dance techniques	1.33	0.56	0.64	0.88
Total	1.46	1.29	1.38	1.38
Experience of dance (years)	13.9	16.0	11.0	13.6
Experience of choreographing dance (times)	2.4	8.7	27.4	12.0

In terms of understanding the movements, 43 of 48 students (90%) chose “effective enough” or “effective if reformed.” The numerical analysis suggests that the software is basically useful as an e-learning tool for understanding dance movements. We received the following positive comments: “The pictures are clear and offer different angles for viewing.”(UK); “If you don’t know much about contemporary dance, seeing the movements provides a big hint.”(JP) On the other hand, we received the following comments to point out the problem: “I believe it is effective for an intermediate to advanced level dancer, but feel it would be challenging for a beginner to assess which body half, which direction, and which pathway.”(US); “Some movements were hard to specify from software.”(UK) We found that the synthesized motions became more complex and difficult to recognize, when the number of synthesizing body-parts increased.

In terms of training of dance techniques, 10 of 48 students (21%) chose “effective enough”, 22 (46%) chose “effective if reformed,” 10 (21%) chose “not so effective”, and six (12%) chose “don’t know”. This result was expected because this system has not designed to support training of dance techniques. Several typical reasons for “effective if reformed,” or “not so effective” are excerpted as follows: “Training in dance, to improve a technique is a guided experience.”(US); “I believe most dancers benefit from feedback in training – with this tool, they can see and practice but can't be critiqued.”(UK); “For beginning or intermediate, it might be too difficult to only use visual cues to learn movement.”(US) We recognized that learning from teachers directly and getting feedback in studio were essential for dance training.

As shown in Table 2, we compared the average of evaluation points by students among the three countries. In terms of creation of dance, there is no significant

difference among countries. In terms of understanding of movements, JP group is different from US and UK groups. This was probably caused by the experience of choreographing dance, because the average times of JP group is appreciably smaller than US and UK groups. Another same difference came from training of dance techniques. One reason might be based on the teaching methods of each country. Analyzing the responses in detail and finding out the reasons are our future considerations.

Judging by the analysis of the responses, the first hypothesis, “BMSS is useful for students to discover new movements of contemporary dance,” was verified by our experiments.

#### 4.2 Discovery learning

The student ratings already suggest that the software is useful to create contemporary dance. However, to verify the effect of discovery learning, we scrutinized student responses to the following open question: “What did you learn about creating contemporary dance choreography through this experiment?”

All 48 students described something they learnt through the experiments. Most of students believed that they learned a new choreographic method of contemporary dance, although their expressions varied. Several typical responses are excerpted as follows: “I usually do not combine multiple elements together simultaneously but was delighted to experience them.”(US); “I realized that the combination and permutation of movements gave me an infinite number of original choreographies.”(JP); “I learned that there are many possibilities for movement that I wouldn't naturally come up with because they feel unnatural or uncomfortable.”(US); “I learned that creating movements by layering different

elements or body parts can be very effective.”(US)

Some students described what they found by observing created movements of the other students through the experiment. Two typical responses are extracted here: “I noticed how you can take basic movements but each person who takes the movement to their body moves differently, thus it looks different on different people creating an interesting sequence.”(UK); “Contemporary dance is individual to everyone as the software gives you set movements but they can be changed and modified through individual creativity and style.”(UK)

These responses show that the students learned the concept of analytic-synthetic choreography by themselves, even though it was not explained explicitly during the experiments. Judging by the responses, BMSS worked as a discovery learning tool of contemporary dance choreography. Our second hypothesis, “BMSS is helpful for students to learn a new choreographic method of contemporary dance by themselves,” was verified.

#### 5. Conclusion

In this study, we developed a system that creates short choreographies by synthesizing many body-part motions to support choreography creation. We conducted evaluation experiments for creating contemporary dance choreographies to verify the learning effect of BMSS as a support system for discovery learning.

As a consequence of experiments with 48 students at three different universities who created contemporary dances, we verified that BMSS is a helpful creation training tool to discover new choreographic methods, new dance



movements, and new awareness of their bodies.

In the future, we will give this system to professional choreographers to create longer dance sequences and perform them by professional dancers on stage. Collaborative performances such as creating a dance performance using a sequence created by the other choreographer, or improvisation of dance and music using BMSS to promote the discovery learning will be another challenges in the next step of our study. We will also archive additional motion clips and adapt our system to such dance genres as hip-hop dance, classical ballet, or ethnic dances.

### Acknowledgements

We thank Kanagawa Institute of Technology for permission to use a studio and a motion capture system. We wish to thank Sakiko Matsumoto and Yuho Yazaki for their support in developing the systems. We also wish to thank the dancers, teachers, and students to cooperate with our experiments. This work was partly supported by JSPS KAKENHI Grant Number 19H04424.

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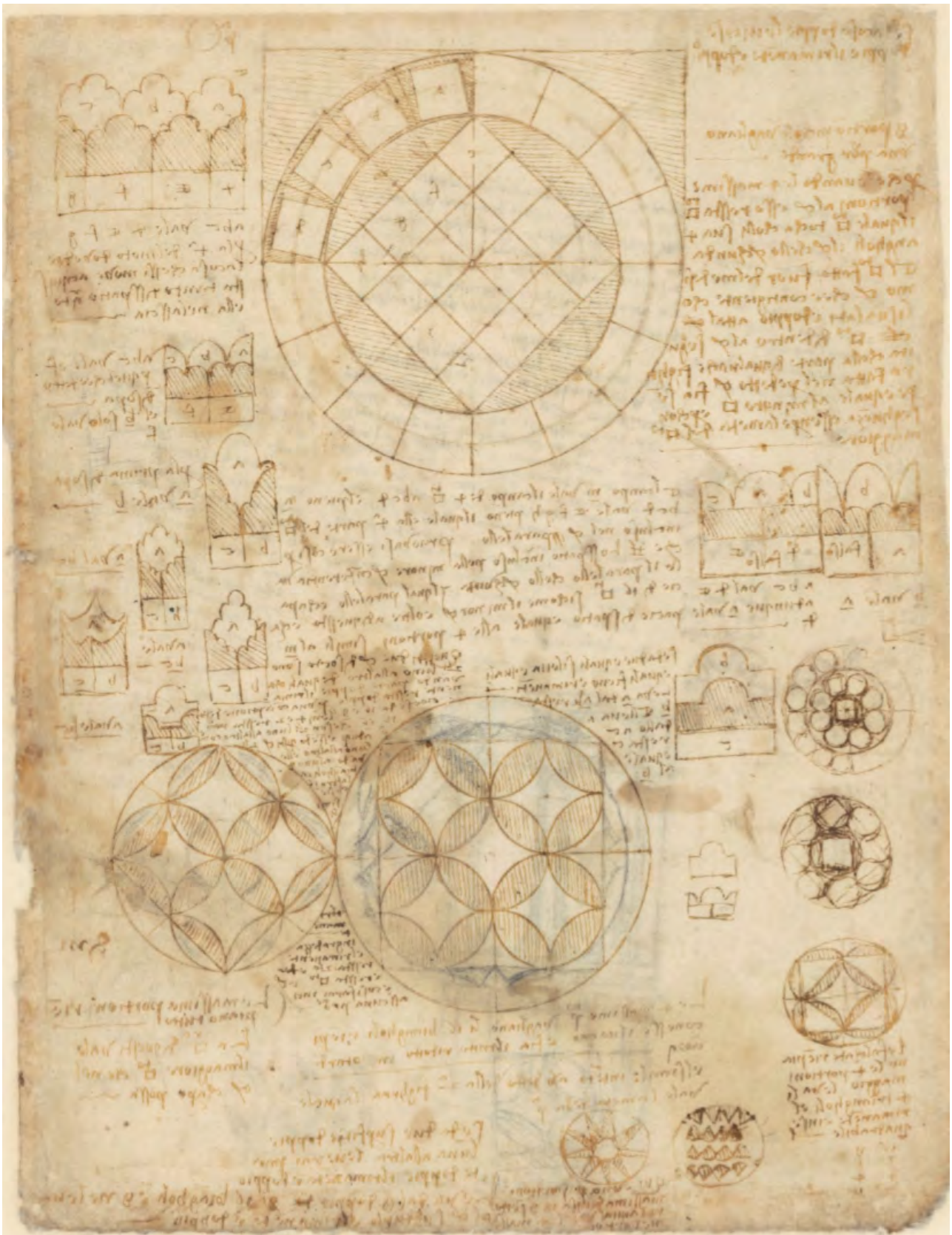
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*Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations*

# Audio-visuals in shared space as a metaphor for mindscapes: generative creation in a network performance

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## Abstract

This article presents ongoing research focusing on the development of a platform for generative networked creation. That is, a process of creation in which several collaborators act on different parts during the artistic creation while a computer network integrates communication between these agents and processes generative transformations. Therefore, we established a working methodology with a group of thirteen researchers of the Interdisciplinary Nucleus for Sound Studies (NICS), Ph.D. students, postdoctoral researchers and

senior researchers. Our proposal was to distribute the stages of the collaborative process in separated generative modules, to develop a network architecture to enable interaction between the elements and, finally, perform a multimodal work as a result of the information flow circulating in the network.

**Keywords:** generative art, audio-visual composition, networked performance, collaborative creation.

## 1. Introduction

Studies on the possibility of using a network architecture and connectionism as a paradigm for musical creation are already described in [3]. The authors argued that "neural networks cooperate to produce a heuristic value that represents the worth of each of musical fragments". Others developed the NEUROGEN with the idea of using genetic algorithm and cooperating neural networks as architecture for a generative musical composition [6].

Brown [2] explores computers as a vehicle for collaborative music making through improvisation using computers on a network. They also point out that: "*Networked improvisation suggests the 'contemporary musicianship' which embraces the computer as an instrument and the network as an ensemble and cyberspace as a venue*". The authors comment on the last two aspects as follows: 1) The network as an ensemble: "*This allows ensemble activity to occur to separate sites for musicians who share the network and the software, this means they can play together in a collaboration where each can see and hear the result of their gestures have, facilitating real musical communication between them*" (idem, p. 3); 2) The Cyberspace as a

venue: "*With algorithmic musical instruments that do not depend upon continuous gestural input, the user can be both listener and performer, both producer and consumer*" (ibidem, p. 3).

The main concern in our article is the conceptual viewpoint and interactive perspectives that motivate our study. Next section presents a brief retrospect of previous participation in the Generative Art Conferences which follows the conceptual perspective that anchors our approach concerning collaborative practice in contemporary art. After we shortly introduce the implementation of the network, visualization and sonification, and finally, we discuss our understanding of generative performing art as an open platform for collaboration and networking.

## **2. Retrospective: Generative Art**

The study presented here dialogues with other presentations at the Generative Art Conference. We presented a generative networked performance at the 17th Generative Art Conference in Rome, 2014. The work MinDSounDS was a performance involving a dancer, a flautist, a BCI performer, and electronic music [10]. Similar to the work presented in this article, MinDSounDS was a performance in which a group of musicians and computers in a network produced a continuous exchange of information among themselves<sup>1</sup>. The emerging audio-visuals were shaped by physical actions, movements, music, and improvisation with interfaces and music instruments. Therefore, the performance created meaningful relationships between agents

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<sup>1</sup> minDSounDS – 17<sup>th</sup> GenArt, Rome, <https://youtu.be/cHJ1fRza9Ig>

while they explored interactions with the visualization and sonification [10].

We have also studied how generative installations and interactive narratives can be understood as an interdisciplinary research methodology to investigate new paradigms on human cognition mediated by technology in the 18<sup>th</sup> Conference [11]; we presented how a multimodal opera was created and performed<sup>2</sup> in the 19<sup>th</sup> Conference [12]. In the 20<sup>th</sup> Conference, we presented the Selfhood Installation<sup>3</sup> [13]. Finally, a multimodal performance entitled as an Ode to Salvador Dalí's Christus Hypercubus<sup>4</sup> was discussed in the 21<sup>st</sup> Conference [14].

## **3. Conceptual Perspective**

A tendency towards collaborative, participatory practice is undeniably one of the main characteristics of contemporary art. Admittedly, these attempts are not new; one may contend that this genealogy dates as far back as modern art itself. In the early Romantic era, at the end of the eighteenth and beginning of the nineteenth centuries, poets and artists started to form groups that bemoaned the separation of art from its audience.

By the middle of the nineteenth century, the strategy Richard Wagner set forth in his seminal essay "The Art-work of the Future" [3] is still central to any discourse in Participatory Art. In order to reach the artwork of the future, the artists should overcome the distinctions between various artistic genres or, as we call

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<sup>2</sup> Descobertas – 19<sup>th</sup> GenArt, Florence, <https://youtu.be/zCRq9zVPLew>

<sup>3</sup> Selfhood – 20<sup>th</sup> GenArt, Ravenna, <https://youtu.be/B2Ryo6Y9Rz0>

<sup>4</sup> Ode to Christus Hypercubus – 21<sup>st</sup> GenArt, Verona, <https://youtu.be/Ks3X80TZkMs>

today, different artistic media. The synthesis of artistic genres is for Wagner more a means to an end: the unity of artists among themselves and the unity of artists and the people. In this way, participatory art can be understood not only as a reduction, since the author forgoes his subjective authorial power by reducing his own creative role, but also as an extension, of authorial power, whereby the viewer forfeits his secure external position, his aesthetics distance from the artwork, and thus becomes not just a participant but also an integral part of the artwork.

During the sixties, artists collectives, as well as happenings, performances, and similar events, were famously reborn on a worldwide scale. Among them, to name but a few examples, were Fluxus, Guy Debord's Situationist International, and Andy Warhol's Factory. In all of these cases, the twofold aim was both the collaboration of different artists and the synthesis of all artistic media. However, central to these activities was the readiness of artists to forego their isolated, elevated, privileged position in relation to the audience [7].

By the same time, in another context, an analysis methodology based on generative theory emerged, focusing mainly on the field of language theory. Noam Chomsky proposed "generative and transformative" models that analyzed the different sentence structures. Those were deductive models whose objective was to describe the process of producing abstract chains and to determine a set of "generative" rules that included syntax, interpretive semantics, and phonology.

The works of computer art, in its early beginnings, were based on rules or basic parameters, from which it was established repetitions and variations. The roots of this practice lied in the current Neo-

constructivist in the plastic arts. Nevertheless, while Constructivism focused on the application of mathematical and/or geometric models to art, neo-constructivism, as well as Generative or Processual Art, worked with the visualization of algorithms that enlarged their formal field by introducing new processes. The difference is that the "manual" work of most neo-constructivists compelled them, for practical reasons, to restrict themselves to structures of relative simplicity, while computer-generated works allowed the creation of complex structures.

The purpose of several computer art artists to generate the work from the development of a certain process of repertoire selection and statistical distribution certainly retained the proposal of the generative grammar of considering generative mechanisms of construction, related to the specific characteristics of art based on procedural creation. For Nake [15], the essentially new one in Computational Aesthetics is the concept of algorithm. The works based on this generative aesthetic allow the creation of aesthetic situations specified by several different but limited steps. For Georg Nees [16], the computer is a generator of creative processes, whose products are models of work of art. The essence of computer-aided work is, according to him, the selection and distribution of signals in a given field, which he calls Composition.

Still in the sixties, while the generative approaches emphasize the procedural resolution of the work, other computational approaches look at the role of the observer. Artists of the time analyzed both in their work and in their discourse the possibility of reaching a work of "dialog" art, in which the point of reference is not the mere circulation of information, but a true "aesthetic

communication." Subsequently, there is the telematics, or the art of telecommunication and network art. The art that transits through the telecommunication network is based on a type of open interpersonal communication and, therefore, is an art without a certain public. The fundamental element is communication, art as traffic. Together with the communication process is the idea of participation, which happens to the extent that the artist offers the public a field of action, not a definite and finished work. In this chain, all artistic activity is related to information. In the creative act, the information is generated, processed when received by the public, and transmitted through a medium, which is known as communication.

In order to enable communication between humans and machines, Turing [20] had emphasized the need to generate an intermediary element that would function as a translator of information transmitted in symbolic language to the computer language (binary code). The idea of Turing predates the conception of the interface between people and computational systems since, unlike direct communication between machines, the direct coupling between minds and machines until today is still not completely possible. Man-machine interfaces play a role similar to the means humans need to communicate and enable coupling between different systems.

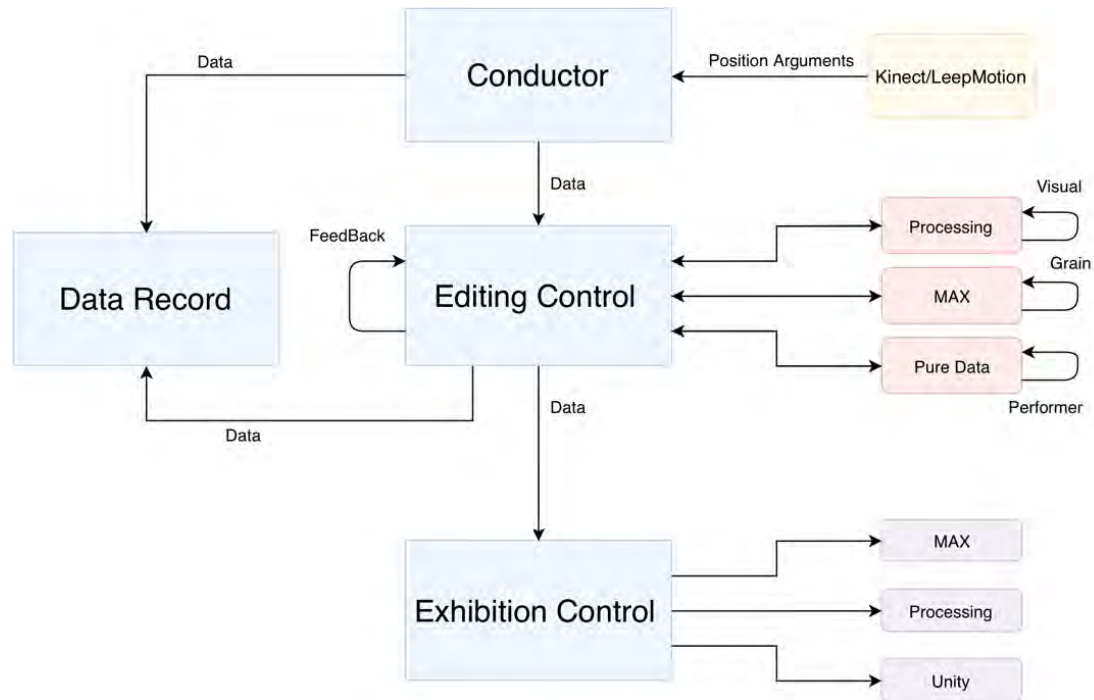
At first, the information processed by the computer was not visible to the user. This obstacle began to be overcome around the year 1949 the development of a first monitor with an interactive, dynamic and visual display under the direction of Jay Forrester at MIT, which allowed manipulating the information directly in the window with the optical pens of the time. And from that time we arrive in today's interactive systems, with the

immersive technologies, intelligent devices and the increasingly complete discourses from the fields of cognitive sciences and neuroscience on the notions of reality and observer that are placed at the core of the interactivity field. The, which virtual spaces and interactions that progressively determine and enable cultural practice, particularly in our time?

Perhaps as a remake of the happenings in the sixties, but with the possibilities of the environments available now, this project was conceived and presented to an interdisciplinary group of thirteen researchers, with musicians, artists, developers, physiotherapists, and gymnasts. The proposal was: Do it! The available environments were presented: Processing, Pure Data, Max MSP and the communication protocol, OSC. Like in Fluxus, the twofold aim was both the collaboration of different artists and the synthesis of all artistic media. However, central to these activities was the readiness of artists to forego their isolated position in relation to the creative process towards an engaged, collaborative, participatory approach. Simple as that.

#### ***4. Development: Network, Visualization and Sonification***

We introduce in this section the three main elements of the study presented here. Firstly, we describe the initial network architecture which is based on a data flow that starts in the gesture captured by two interfaces (Kinect and Leap Motion) and then is sent via OSC protocol to other computers in the network that controls the visualization and sonification. The subsection introduces the visualization that was



**Figure 1: network architecture**

developed in two aspects: 1) geometric transformations and 2) video clips of silent movies. Finally, we describe how the sound generation was developed from granular sounds and sound textures.

#### 4.1 Network

The first network architecture developed for the study is based on the principle that the information flow has its origin in the gesture of a conductor that represents the interpreting action of the whole system (see figure 1). The first tested performance metaphor is that of a networked audio-visual generative instrument. Therefore, each of the elements of the network is represented by computers that perform different tasks and are connected to each other by the OSC protocol, all in the same using an ad hoc network. In addition to the sound and image processing units, each entity of the network has an editing and display

controls. Finally, the data flow is stored so that one can make future analyses of the interaction between the different mechanisms of interaction between each agent after performances.

When in operation, the network architecture obliges a circular causality, which is generated with data of cinematic quality, derived from a movement interpretation that is tracking from the Kinect or Leap Motion interfaces. Cognitively, acceleration carries information of intention. An abrupt change of acceleration creates an expectation breach and, in this system, corresponds to the start point. These two aspects of the movement of the conductor are further explored in the sonification.

#### 4.2 Sonification

The sonification developed for this study was based on principles already

implemented to compose the multimodal work “Ode to Christus Hypercubus”, which was discussed during the 21<sup>th</sup> Generative Art Conference [14]. The main sound devices explored in the sonification are: 1) long duration low-frequency sound with a dense texture that remains during the whole work as a mechanism of connection between the two distinct visual elements, the geometric transformations and the video clips; 2) granular sounds with a variety of grain density and attack mechanisms that depend on the recognition of the gesture captured by the two control interfaces (Kinect and Leap Motion); 3) a set of incidental sounds to signal the insertion of new visual elements, parameter changes, and video clip changes.

As a compositional process aided by the computer that connects sounds and visual the main task was to fulfil the space with many sound alliterations. We already discussed that a multimodal performance can be seen as a way to create a unified experience where sound, image, and audience are merged in space and evolve coherently in time [11]. Therefore, a constant musical drone accentuates resonances in which listeners’ memory is expanded. Our approach was to study the relation between granular sounds and sound diffusion by controlling digitally the generated sounds and correlating granular synthesis spatialization with the Ambisonics technique.

### **4.3 Visualization**

Using the Processing environment, the visualization process was based on the construction of two distinct elements: 1) geometric images generated by parametric transformations in real time, 2) silent movies clips in black and white. These two visual contents with their different natures were woven into the work. The objective was to create contact surfaces between two different representations and seek to explore their similarities and differences.

#### **4.3.1 Geometric Transformations**

The images, generated by a rather spartan program implemented in Processing (p5.js), reproduce frames of a spiral in perpetual motion (figure 2 and figure 3). More than the adoption of a certain mathematical objectivism, as it could mislead the ellipsis in rotation regulated by trigonometric functions that the code implements, the spiral refers in particular to a visual analogy of obsession, of “*idée fixée*”, as used in cinema. The “Fraser spiral illusion” that the video, confined to dark shades exclusively, aims to accomplish, refers to the spirals that Fritz Lang uses as metaphor for his protagonist's psychopathy in *M – Eine Stadt sucht einen Mörder* (1931) or those that Alfred Hitchcock and Saul Bass use in *Vertigo* (1958), one of the most renowned cinematographic studies on human obsession.

#### **4.3.2 Video Clips**

Originally, these video clips were cut to fit their related musical themes. These relationships follow a logic of cataloging



the moods used in the silent movies and distributed in dedicated publications called photoplay music, mood music, motion picture music and so on. The most comprehensive of these publications is Erdmann & Becce's huge manual, called *Allgemeines Handbuch der Film-Musik* of 1927. The macro-scheme is based on a taxonomy indexed by the following 2 parameters: '*Incidenz*', or themes for general, incidental music, and '*Inhalt*', or themes specified by dramatic and narrative contents. There are more than three thousand small thematic fragments organized like this on the *Handbuch*. The music suggested by the publications, in particular by Erdmann & Becce [1], were used here as a starting point, but the resultant sonification will be generated by the network interaction. However, the cataloging of emotions and meanings was a way of producing insights into the generative process

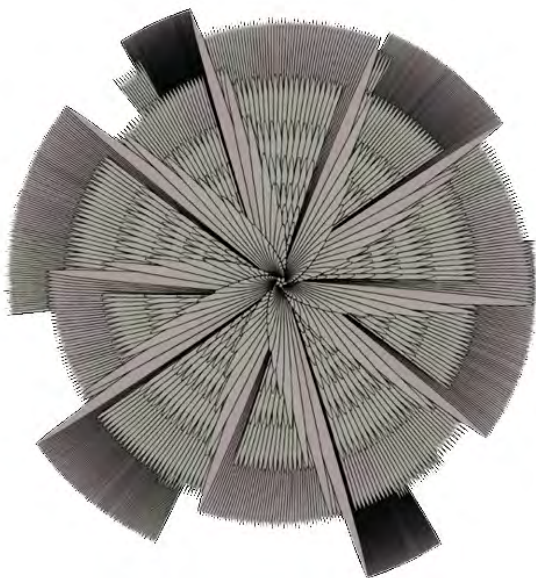


Figure 2: spiral perpetual

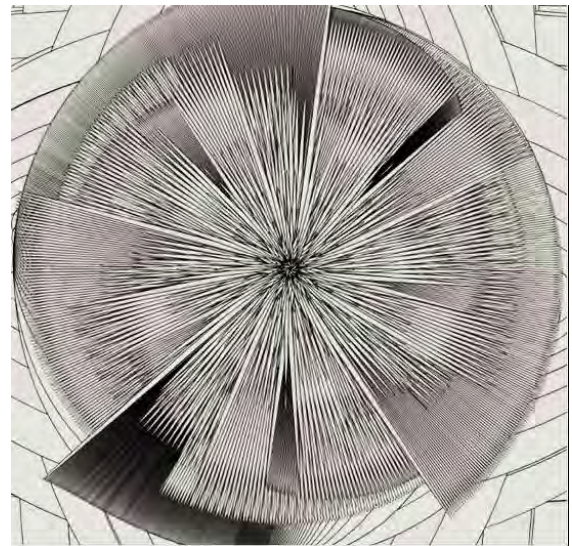


Figure 3: converging frames

Video Clip 1: The meeting between Eva (Hedy Kiesler, then Hedy Lamarr), and Adam (Aribert Mog). While Eva was swimming her horse runs away, and is captured - and returned - by young Adam. The mismatch of the escape of the horse generates the encounter between the couple, in causality that triggers the passion and ecstasy that will follow its irrepressible path.



**Videoclip 1: Ecstasy, 1933,**  
**dir. Gustav Machatý**

Video Clip 2: This meeting creates a communication between the two sides of

the city Metropolis: the apparent side of wealth, prosperity and unconcern, and the underground side of poverty, the enjoyment of the proletariat, and the insalubrity.



**Videoclip 2: Metropolis, 1927**  
**, dir. Fritz Lang**

**5. Discussion**

As we understand in the article, Generative performing art is an open platform, where the agents can be at the same time the subject, the main character of the poetic lyrics, and the public who enjoys the performance [8,16]. As usually happens, the construction of a creative process is not built by linear actions and interactions, either by the artist who creates a message or by the observer who receives it. This process, in fact, of any art, remains an open work, an open art form that offers different interpretations, always according to the subjective experience of the viewer.

In the digital age, technological devices could be seen as extensions of the body [9], it is the experience and interaction between the work of art and the human body that determines the subjective understanding of the artistic message, as

mentioned by Kozel [7]. In this context, in fact, when we talk about the artistic process, therefore, we are not referring only to the 'at source' process anymore, that of the artist himself. We are, in fact, referring to the same process carried out by the observer, who through his exploration and his Sensorimotor Contingencies can understand, interact and therefore directly modify the entire creative process of the work of art.

For this reason, the work presented by our research group 'NICS' is an open work, an ongoing process to remote and in-person interactions, to demonstrate how the artistic process can be modified non-linearly and can determine a cyclic co-determination (concrete) and a constant (abstract) perturbation, thus increasing the creative potential that emerges from the interaction between the parts.

Therefore, a non-linear communication takes place with the other agents, which transform the information they receive and then return this stream of data so changed to the network. This is possible through the design of various associations, both concrete and abstract, through the technological piece that we propose, and bearing in mind what the paradigm of Embodied Cognition underlines; in particular the Sensorimotor Contingency Theory in which the sensorimotor contingencies governing perceptual exploration in the different modalities [17].

**6. Conclusion**

The study discussed here focuses on network architecture as a means of providing a framework of collaboration between different researchers so that everyone can contribute to the accomplishment of creative work. In this

sense, project members shared the same physical space during the performance or may be in remote locations. During the creation, the network architecture was mainly used to enable prototyping of structures and development of ideas. In a second moment, the actions were integrated and the performance itself is the process of adjustment between the parties of the work.

In a previous article, we have argued that a theory of mind, including one of creativity and aesthetics, will be critically dependent on its realization as a real-world artifact because only in this way can such a theory of an open and interactive system as the mind can be fully validated [21]. In this way, we understand that, while we develop a platform that allows creative interaction among researchers, this same methodology is a way of studying creativity using computational models that by extension will reflect models of the mind.

Considering the broad Embodied Cognition paradigm, perception is connected to embodied experience, and within an interactive landscape “this perception is augmented and can be directly tied to our emotional experience” [19]. That means that through this artistic and experiential process, we can represent the subjective self-perception that the user experiences.

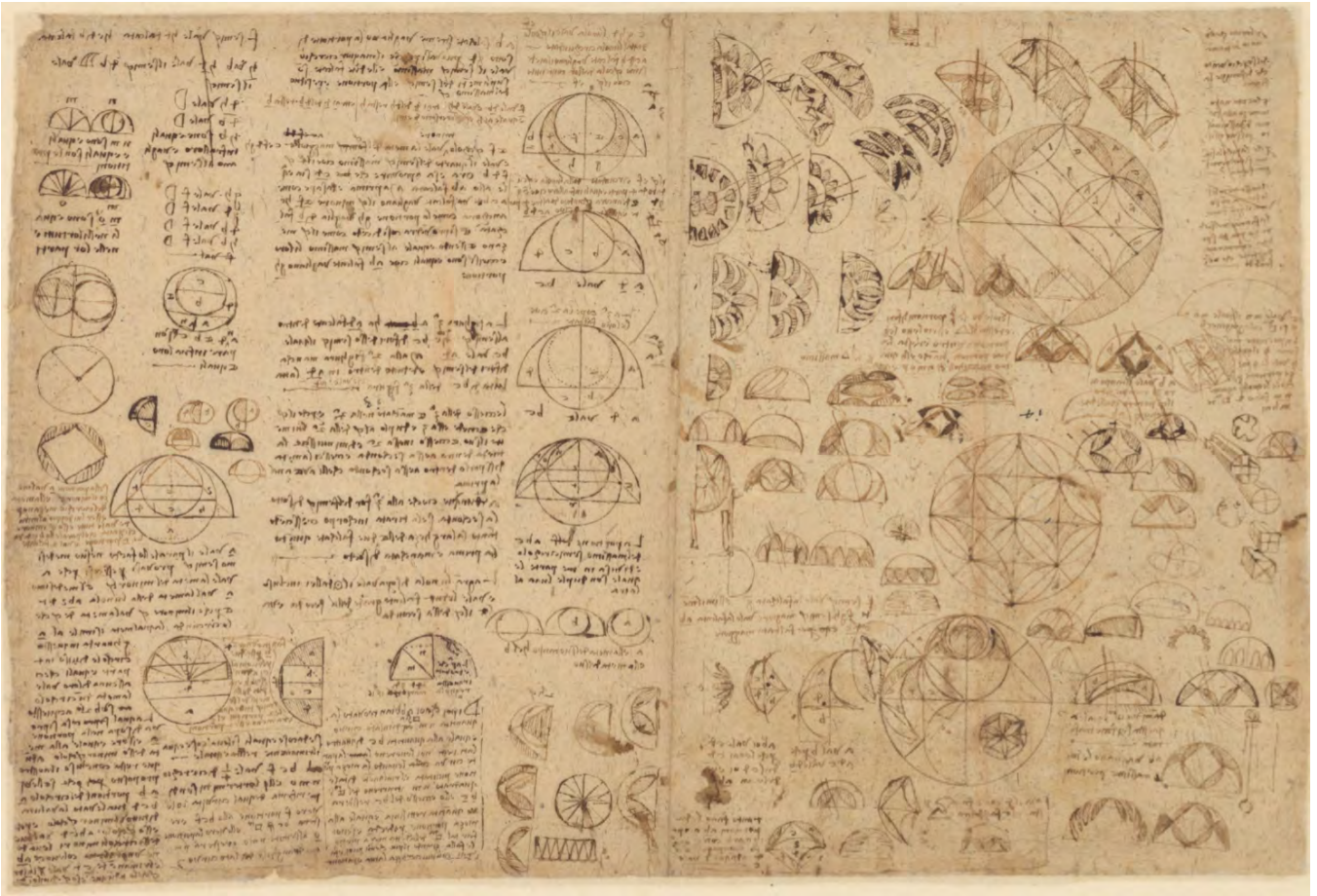
### **Acknowledgments**

The research described here, developed at the Interdisciplinary Nucleus for Sound Studies (NICS), UNICAMP, is supported by the Brazilian agencies São Paulo Research Foundation (FAPESP) and the National Council for Scientific and Technological Development (CNPq).

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*Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations*

# Open Waters [Northwest Passage & Polar Sea]

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## Abstract

Open Waters [Northwest Passage & Polar Sea] is an interdisciplinary, interactive multimedia artwork inspired by a five-hundred-year history of expeditions that sought to find the Arctic Northwest Passage and Open Polar Sea. The work blends together this rich history with twenty-first century realities of environmental and geopolitical change at the top of the Northern hemisphere.

Through a constellation of interconnected pieces including an interactive book and interactive wall projection, the Open Waters exhibit seeks to echo aesthetically the ecological and other change affecting the Arctic cryosphere and to offer creative, analytic lenses through which to understand what is occurring there and how we got to this conjuncture. The installation scrutinizes and reworks a number of discursive and visual genres across disciplines, to expose both how they have represented the Arctic's realities and potentialities and how they have consequentially intervened in their unfolding.

An interactive artist book features a suite of archival poems on Arctic exploration, politics, and ecological change. Across the double-page spread, containing printed poems, appears projected digital generative art consisting of fading poetic text and animated phrases that coalesce and then fade away (or melt). As the viewer/reader turns the pages of this unique, print-digital hybrid book, RFID tags embedded in each page signal a sensor that in turn signals a computer to "turn" the projected digital page. The interactive back wall of the gallery (Figure 1) combines video and audio generative works that, using a Kinect motion sensor, respond to the activity present in the room, evoking the effects of human disruption of the Arctic environment.

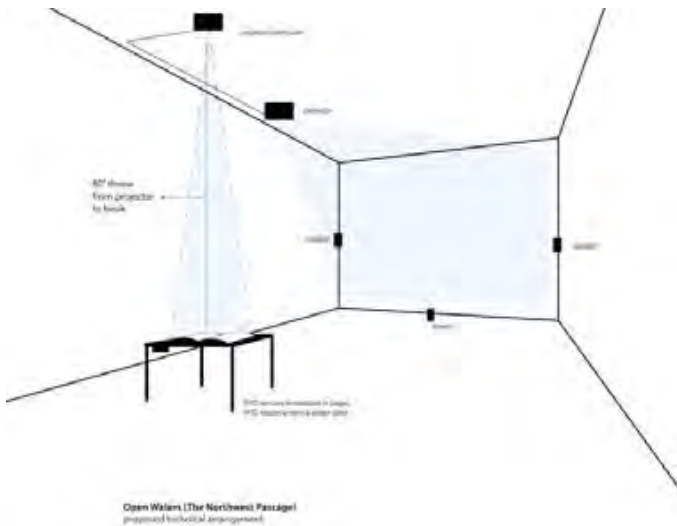


Figure 1 Open Waters Gallery Layout

Open Waters was created for and organized in association with the Brown University Arts Initiative symposium titled Polar Opposites: Creative Interventions in the Arctic and Antarctica, April 2018. Open Waters transforms the gallery into an ambient environment, produced in large part through generative artworks. Visitor interactions, both intentional and involuntary, with these generative ensembles triggers audio-visual events that shape the gallery space and happen differently each time they occur.

### 1. Background Collaboration

Open Waters [Northwest Passage & Polar Sea] is the most recent artistic collaboration between the authors, and is part of a series of works focused on the Arctic and Antarctic. A previous collaboration, Ice Core Modulations: Performative Digital Poetics was featured at the 2015 Generative Art Conference (among other venues) and included imagery and poetic fragments inspired, generated and controlled via historical Antarctic CO2 data taken from ice core samples made available from the National

Snow and Ice Data Center (NSIDC). These collaborations build on a series of prior works involving several of the authors that have focused on creative approaches to visualizing and sonifying data, generative and interactive audio-visual works involving place and personal narratives, and the synergistic rendering of a creative idea in multiple digital and physical media.

As a collaborative goal, Open Waters seeks to create a body of artistic work that is a semantically rich landscape containing simultaneity of disparate yet complementary disciplinary perspectives connected to the historical and evolving conceptions of the Northwest Passage and Open Polar Sea. To create a common source vocabulary for the collaboration, the creation of the work began with conduct in-depth historical research and gathering of archival and audio-visual source material. From this primary matter, poet Judith Goldman wrote a set of poems and poetic text fragments that other collaborators used in their respective media, rendering the phrases typographically, programming their behavior in generated audio-visual projections, and subjecting spoken recording of the phrases to dynamic audio processing.

### 2. Historical Inspiration, Current Climate Data and Source Material

Our title Open Waters is meant to capture multiple, productive contradictions on which our project reflects:

- The historical irony that the Northwest Passage, once so ice-impacted it was

thought to be mythical, is now traversable by commercial transport vessels and cruise ships alike

- The longstanding, Western, tragic-Romantic fantasy of a polar paradise and “Open Polar Sea” that was held tenaciously, against all evidence of the frozen, impassable state of the high north
- The contemporary conflict between, on one hand, scientific and indigenous perspectives focused on understanding, assessing, and halting ecological damage and, on the other, forces that see the rapidly melting Arctic as an opportunity for resource extraction, economic growth, and alterations of the parameters of political sovereignty.



Figure 2 Northwest Passage Routes



Figure 3 Gallery Wall Rendering of Northwest Passage Routes

In sixteenth-century Britain, the spatial technology of a Northwest Passage (Figure 2) was central to the inception of globalization and imperialism, while the Arctic, as a region where climate change is amplified and accelerated, is emerging as a focal point of the Anthropocene era. The interconnected pieces of the Open Waters installation (Figure 3) thematically and formally echo, in a number of modes, the process of ecological and other change affecting the Arctic cryosphere.

The gallery’s media ecology also reflects the collaborative structure and process of researching and creating Open Waters. Our primary sources include archival documents, travel narratives, ship’s manifests, personal letters and memoir, contemporary science articles, historical maps, government policy statements, trade journals, newspaper headlines, data sets, recorded environmental sound, and stock and drone video footage. Some of our primary materials have been created, rather than sourced, such as the visual vocabulary of aesthetic ice-forms and the Processing language programs for the digital media. From this primary matter,



we have made poems, book components, processed and mixed audio tracks, data visualizations as digital graphics, processed video segments.

### 3. Poetic Elements and Processes

The twelve poetic texts written for *Open Waters* are original, research-based poems composed by Judith Goldman, through scholarly-aesthetic exploration of the historical archive of works of literacy, documentary, scientific, and political on the Northwest Passage and the Arctic realm. The poems are informed by contemporary scientific literatures on climate change and ice loss in the Arctic; engineering and economic literatures on the feasibility of new routes of transport/shipping; and legal literatures on contemporary questions of sovereignty among nations and indigenous claims.

Major themes of the poems include:

- The long history of extractive capitalism in the polar north, told through the exploits of Martin Frobisher and James Knight,
- Changes in the global ocean current system, due to desalinization through glacial melt,
- New plans around global transport of commodities using various polar routes, Arctic cruise tourism, and the effects of pollution on wildlife,
- The expeditions of John Franklin and the search for his lost expedition,
- Emily Dickinson's abiding interest in polar travel and imagery, and

- Contemporary Arctic geopolitics.

Written specifically for the print-digital hybrid structure of the interactive book (Figure 5), the poems are organized in thematic or topical “vignettes,” with each vignette taking up a verso-recto page (double-page) spread, with some of the text appearing in print and some digitally projected. Phrases from the poems appear in the gallery as vinyl printed forms on the walls and are incorporated into the digital projection on the gallery's back wall.

After the poems were written, the collaborators selected textual fragments to feature in their work. Specifically:

- Each two-page spread of the book featured one of the poems and used ‘fixed’ poetic fragments with typographic layout and formats designed by the visual artist,
- For each spread, ‘dynamic’ poetic texts were programmed in Processing with generative spawning and behaviour logic as to when and where they would appear and how they would evolve over time, and
- Texts were recorded by the poet and then subjected to sound processing for use in the audio-visual wall projection.

Figure 4 presents an excerpt from the poem “Open Water Fetch”.

open water fetch in the Arctic sea & swell depend  
 on open water **fetch** air-water-ice interface ocean surface  
 waves {sea & swell} generated by winds blowing over distance {**fetch**}  
 waves develop beyond pure wind seas, evolve  
 into (swells)  
 long waves resulting  
 from nonlocal winds  
 remain tied to available **fetch**

swell waves accumulate energy  
 in the wind sea wave energy scales w/**fetch**  
 {space required to build a swell}  
 ice can suppress waves distance available for wave  
 evolution  
**wave energy scatters**

**Beaufort Sea:** ice-covered in summer: no waves to measure  
 reduction in seasonal ice cover results in larger waves **waves break**  
 up sea ice accelerate  
 ice retreat  
 results in larger  
 waves break  
 up sea ice  
 accelerate  
 ice retreat results in larger  
 ~ waves

Figure 4 Excerpt from "Open Water Fetch" poem

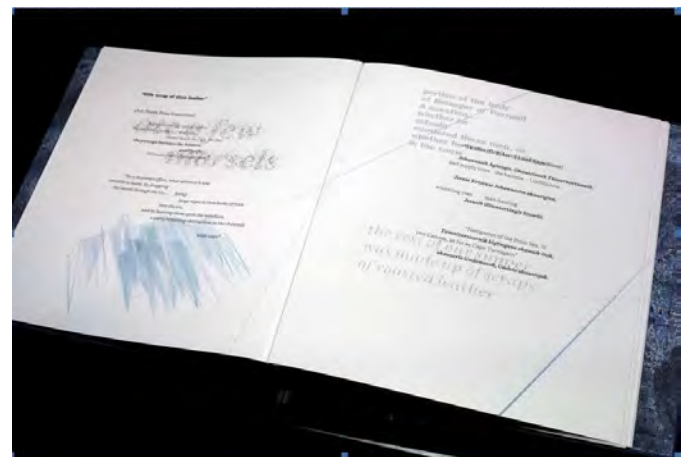
#### 4. Interactive Book of Poetry

The main component of the gallery installation is a large format (65x65cm) hardbound interactive thirty-page artist book featuring a suite of twelve poems. The book is bound with a screw-post binding allowing for flexibility in adding/changing pages for future iterations. The book cover is inlaid with hand-marbled endpapers made from facsimile historical maps of the Northwest Passage. Embedded in each left side page of each double-page spread is an Radio Frequency Identification (RFID) tag that is recognized by a RFID reader positioned within the left side of the table. As the reader turns the page, the tag is recognized by the RFID reader and sends data to the computer (positioned inside the table), which then generates corresponding graphics, and poetic texts

that are projected onto the open pages of the book.

The components of the projected information, generated by Processing software, include various sized text phrases, and ice graphical imagery blue triangular clusters, and perspectival line art (Figure 5). These dynamic visual elements are designed to interact and move around in relation to the fixed text on the page. Different behaviours are assigned to each element; certain text passages are formed from coalescing granular particles before dissolving and fading out. The non-textual imagery evokes qualities of ice, from the translucent blue and surface cracks of frozen lakes to the drifting of icebergs retreating from a glacier.

Figure 5 Interactive Book showing fixed printed and dynamic projected elements



Similar to erasure poetry forms, the projected generative typographic elements intentionally obscure and “overprint” the printed text on the page changing the meaning and emphasis of the poem. The projected text and graphics are designed to enter and exit the pages slowly allowing the reader to engage in complex readings. The poetic text and animated granulated

phrases slowly appear, coalesce, and then fade away (or melt). Ice cluster forms appear across the pages, briefly obscuring the text. Because the digital text complementing a particular print page changes with every reading, generated by algorithmic selection from materials matched to that page, the book is different each time it is read. By combining physical interfaces with typographical information in a hybrid environment, this piece explores new ways of receiving and reading information.

#### 5. Interactive Visual/Sonic Wall Projection

The interactive back wall of the gallery combines video and audio works that, using a Kinect motion sensor, respond to the activity present in the room, evoking the effects of human disruption of the Arctic environment. The video projection (Figure 6) introduces drone footage segments of Alaskan and Greenland glacial and meltwater, as well as footage from a United States Coast Guard icebreaker. This footage is combined with animated, digital graphic vignettes that combine mesh-structures based on climate data with visual poetic language that is generatively processed/alterd through a program whose algorithm is based on ice loss and other data from the National Snow and Ice Data Center.



Figure 6 Back Wall Projection

Movement in the room is detected by a Kinect sensor and granulates the video, amplifies the movements of the mesh-structures (Figure 7.)

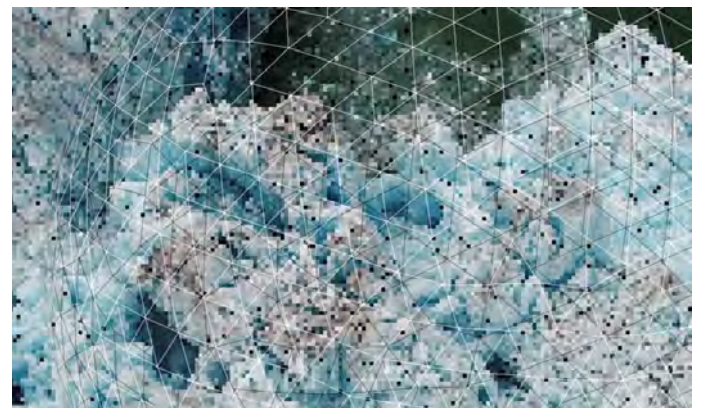


Figure 7 Video Processing based on Kinect Gesture Sensing

The audio embodies a long, multi-layered loop made of processed sonic material from the Arctic landscape (flowing water, glacial calving, whales, sonar, and industrial sonic pollution) and spoken language that includes poetic excerpts and interview responses about Arctic Policy taken from a faculty member of the US Coast Guard Academy. Against this sonic backdrop, audience motion triggers audio events of ice cracking that intensify with increased visitor presence and activity.

The generative behaviours triggered by the Kinect motion sensing are based on an estimation of the number of people in the room and gestural detection of left and right oriented gestures. New visitors and gestures lead to sequences of video granulation (in proportion to the number of people in the room) and activity over short periods of time, returning to a recognizable video background as activity subsides.

## 6. Summary and Future Directions

The collaborative intent of Open Waters [Northwest Passage & Polar Sea] project allowed for interdisciplinary synergy between a creative team spanning poetry, computer science, electronic sound composition, and visual art, expanding the technological and creative means by which the historical information about the arctic could be conveyed and expressed. Our collaborative team plans on an ongoing series of installations that bring art and science together immersively and interactively to educate the public about the Northwest Passage: its status as an important strand in the history of globalization; its potential to reconfigure contemporary networks of global relations; its function as a bellwether of the transformation of Earth systems. We are confirmed to exhibit a version of this work in 2019 at the Burchfield Penny Museum in Buffalo, New York. We plan to travel this research to other exhibition spaces and will transform its components both to continue to explore dimensions of the Northwest Passage/Arctic and to make each installation site- and public-specific.

## References

The complete booklet containing all references for this work can be found at:

<https://www.conncoll.edu/andrea/openwatersnorthwest-passage--polar-sea/>

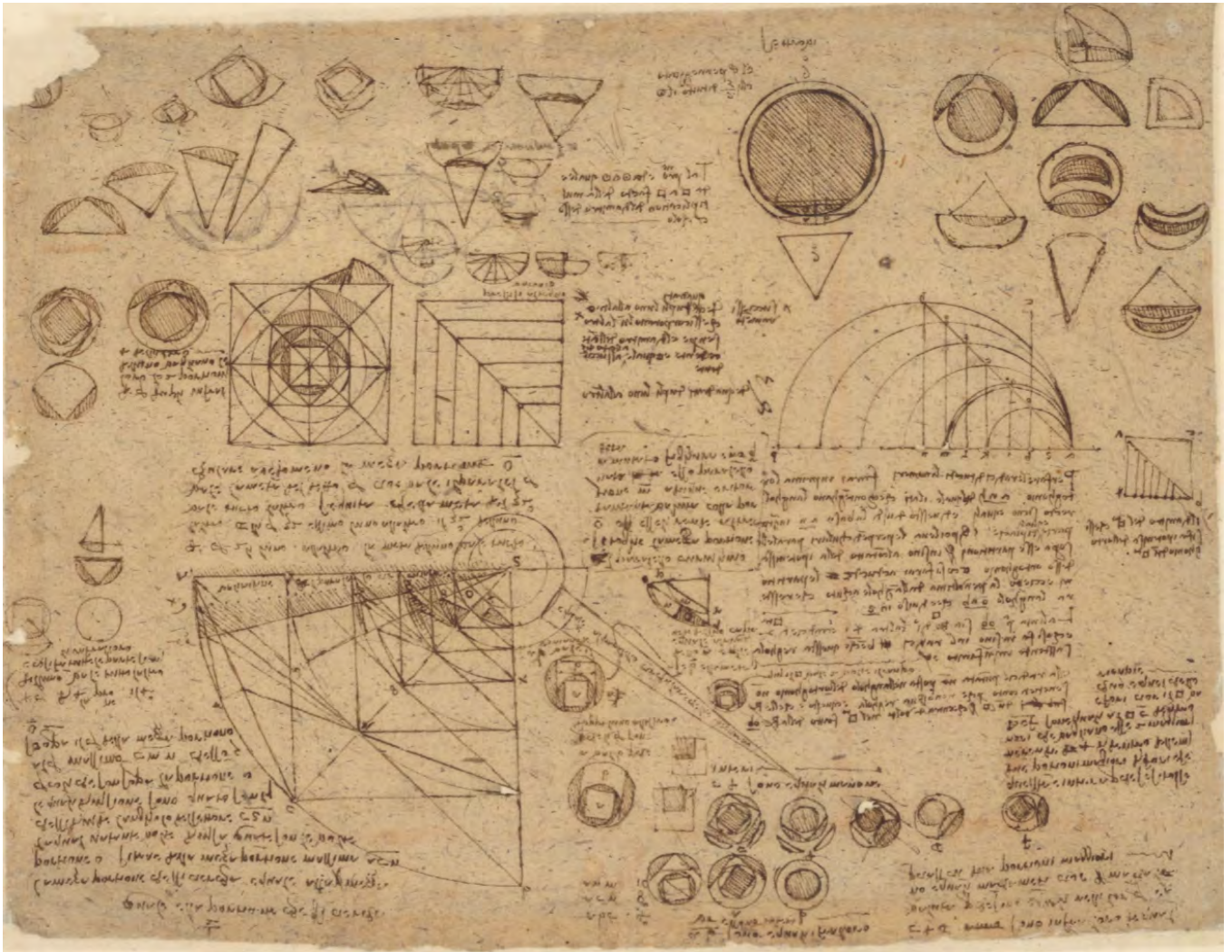
Open Waters project links:

<https://www.conncoll.edu/andrea/openwatersnorthwest-passage--polar-sea/>

Brown University Arts Initiative Promotional Brochure (page 8)

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Brown University POLAR OPPOSITES: CREATIVE INTERVENTIONS IN THE ARCTIC AND ANTARCTICA (conference and exhibition April 5-6, 2018)  
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*Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations*

# tinySounds: for voice and musebot ensemble

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## ABSTRACT

*tinySounds* is a collaborative work for live performer and musebot ensemble. Musebots are autonomous musical agents that interact, via messaging, to create a musical performance with or without human interaction.

## INTRODUCTION

Generative and interactive systems have a long history within music [1, 2, 3]; more recently, aspects of artificial intelligence have been applied to such systems, creating a contemporary approach known as metacreation [4]. One useful model borrowed from artificial intelligence is that of *agents*, specifically multi-agent systems. Agents have been defined as autonomous, social, reactive and proactive [5], similar attributes required of performers in improvisation ensembles. Musebots [6] offer a structure for the design of *musical agents*, allowing for a communal compositional approach [7] as well as a unified model. An overview of

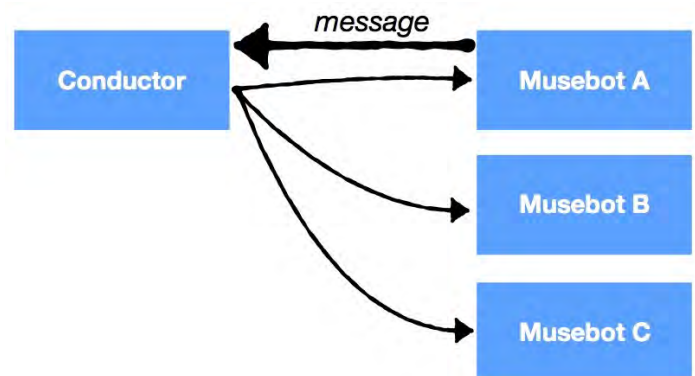
recent musebot ensembles is given elsewhere [8].

## MUSEBOTS

Musebots are pieces of software that autonomously create music collaboratively with other musebots. They decide how to respond to their environment – and each other – on their own, based upon their internal beliefs, desires, and intentions.

The musebot protocol<sup>5</sup> is, at its heart, a method of communicating *states* and *intentions*, sending networked messages established through a collaborative document via OSC [9]. A *Conductor* serves as a running time generator, as well as a hub through which all messages pass (see Fig.1).

Individual musebots broadcast to the ensemble aspects of their performance; the details of *what* they communicate is left to the designer of the ensemble.



*Figure 1. Diagram of messages between musebots and the Conductor. In this case, Musebot A sends a broadcast message to the Conductor, who rebroadcasts it to the ensemble.*

<sup>5</sup> <http://tinyurl.com/gngmews>

## **TINY SOUNDS: FOR VOICE AND MUSEBOT ENSEMBLE**

The musebot ensemble in *tinySounds* is a redeployment of an earlier metacreative system, *The Indifference Engine*, which is partially described elsewhere [10]. Live audio is analyzed for features: spectral centroid; spectral flux; loudness; activity level (onset detection); and Bark band spectrum. This information is messaged to the audio musebots and an effectsBot (see Fig.2). This latter musebot adds effects – delay, pitch shift, time stretch, ring modulation, and distortion – autonomously, based upon its interpretation of the analysis messages. For example, it will switch effects when activity is low, and add more processing when flux is high.

The audio musebots – in this case, four instances of *tinySoundBot* – have access to a large corpus of pre-analyzed soundfiles; given a Bark band spectral analysis via the *Conductor*, the audioBots will attempt to find the closest matching recordings from their available database. The audioBots autonomously begin and end playing based upon incoming messages, including activity and flux, as well as reacting to whether other audioBots are active or not.

Audio is generated using a modified version of *CataRT*[11].

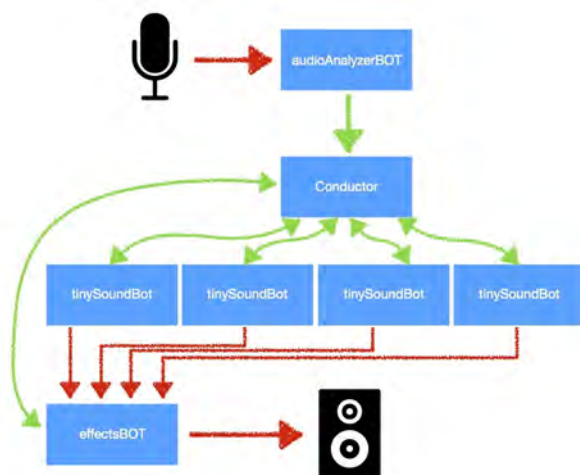


Figure 2. Diagram of musebots in *tinySounds*. Audio paths are in red; musebot messages are in green.

## **PERFORMANCE NOTE**

Machine learning algorithms are wonderful for sifting through data and discovering relationships; more challenging is how these algorithms can be used for generation. It isn't that difficult, for example, to train a system to provide similar sounds for a database, given a live sound. But what's the artistic interest in that? Similarly, it isn't that difficult to extract live performance information from an improvising musician – activity level, general frequency range, timbre – so that the system responds likewise. But, again, reactive systems lose interest fairly quickly.

I find it much more interesting when my musebots go off on their own, exploring their own ideas through beliefs they may have formed incorrectly and unintentionally. For that reason, I usually build a lot of ambiguity into my analysis or provide conflicting information. What happens when one musebot is sure of something, while another is absolutely sure of something else? And what if a third musebot just doesn't care?

In *tinySounds*, musebots are trained using a neural net on a corpus that has been hand-tagged for valence and arousal measures, as well as pre-analyzed for spectral information. However, the correlation between audio features (what the musebots are listening for) and affect (valence and arousal) isn't direct; in assigning the latter, I may decide that a sound from the corpus is complex and active, but my reasons for doing so may not use the same information as the musebots are provided with. Thus, a musebot may decide that, based upon what it has learned, a live sound is high valence / high arousal, but the listener may perceive it otherwise. This isn't a flaw in the system; it's a feature!

Lastly, my role as overseer in the musebot ensemble allows me to further disrupt how the musebots apply their knowledge. The corpus is organized semantically (i.e. voice sounds, kitchen sounds, transportation sounds, etc.); once a musebot is using a certain subdirectory, it can't easily switch to another. As a result, its choice of related sound, whether affective or timbral, is limited to what is immediately available to it. If the musebots are frustrated, they haven't mentioned it to me (yet).

Musebots are not straightforward reactive processes; instead, they have their own beliefs (in this case, the incoming analysis data), desires, and intentions. They will happily play on their own, or they may react very closely to the live performance; more often than not, they will offer their own "reinterpretation" of the live performance, with individual reactions to the analysis data.

### **Acknowledgments**

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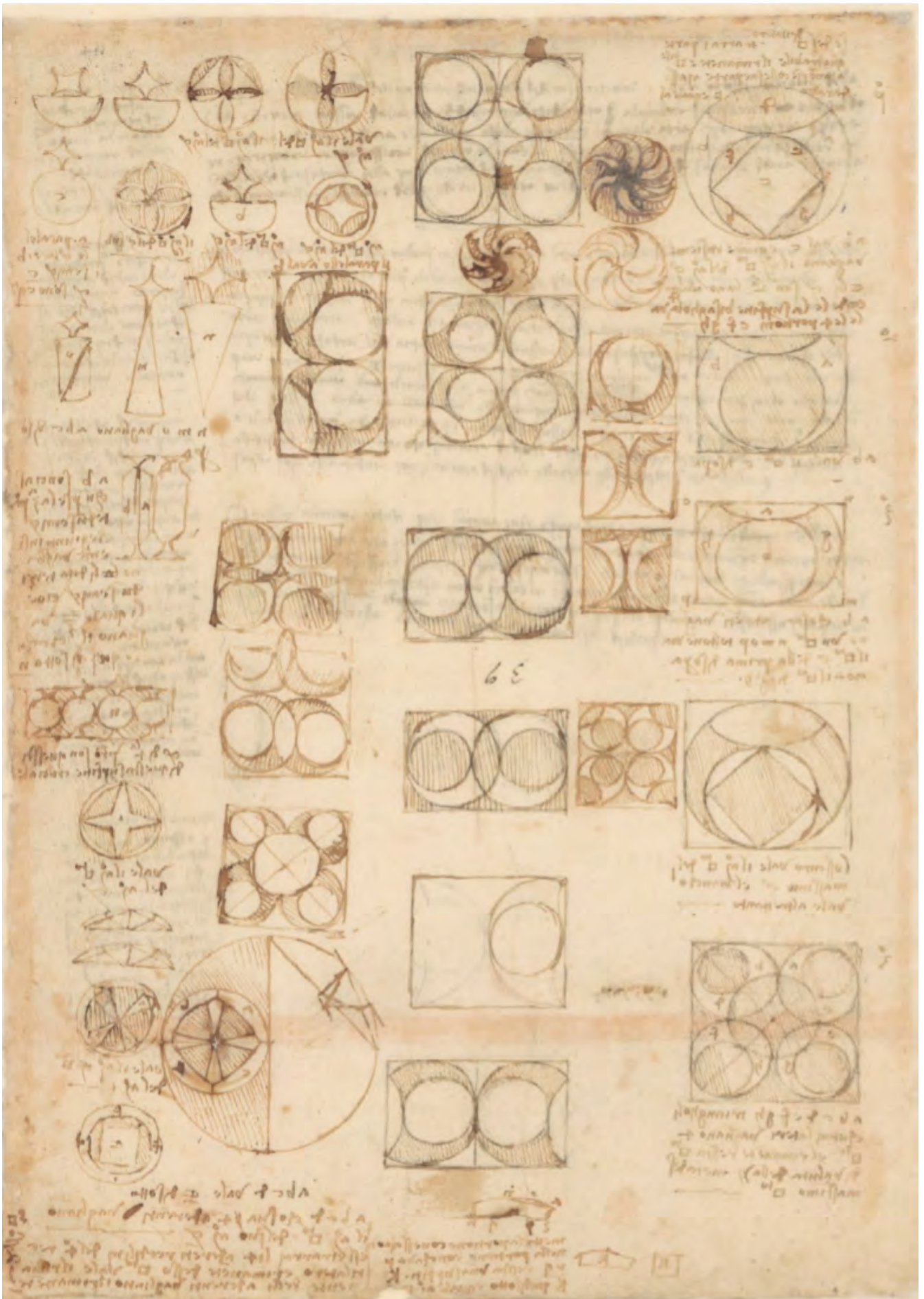
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# Meeting Epictetus and Seneca in an Infinite Virtual Stoa

## Classical Wisdom as Emotional Education of the Future

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### **1. Introduction**

Socrates thought that the most important question one can ask is 'what is'. The philosopher spent a lot of time in the Athenian market place (agora) asking the great and the good of Athens questions such as: 'what is courage', what is virtue' and 'what is truth'. The 'what is' question was in the centre of his dialectical method of investigating and clarifying concepts that are widely evoked to steer emotion and action in public life; his hypothesis was that concepts behind words may seem self-explanatory, but the use of words often conceals vague, poor or conflicting moral meanings and interpretations; he was right. Many of the questions posed by Socrates are still

fiercely debated and one of them is 'what is education'.

Contemporary societies have normalised education as an organised process of teaching and learning which is supported by institutions, schools, technical colleges and universities. This education is typically instrumented towards acquisition of skills that make people useful in the economy and its regulation. Training is focused on linguistic and mathematical skills, sciences and history, the running of business and to a smaller extent culture. In this educational system, little attention is paid on helping people to grow emotionally so that they can cope with the complexities and challenges of life. Much of education is indeed geared towards facilitating business and is not at all focused on the needs of individuals. However this conception of education is becoming increasingly inadequate as it lacks the capacity to address the increasing number of psychological challenges that people face in a fiercely competitive world. Let us briefly examine these challenges

#### **1.1 A clash between economy and psychology**

A key problem today is that the market economy is not driven by the needs, desires, and aspirations of the people who form the labour force. The system is simply driven by economic competition and not designed to deliver many of the things that humanity longs for: job security, better community and family life, more free time, less stressful and more meaningful work. On the contrary, the process of competition, and the acceleration in technology it causes, destroy much of the qualities that we appreciate in life. Take email as an example. This innovation has increased productivity. A company which rejects email and communicates with

handwritten notes and letters is likely to go bust. But what is the effect of email on the lives and mental health of individuals who constantly feel the pressure to check and respond to their email outside office hours?

In this economy, our longing for stability, calm and peace clashes with a system that by necessity creates perpetual change. Our economy is indeed an anarchic system where multiple agents compete for survival. Agents who invent new products that meet new demands, or fulfil existing demands better or at lower price, survive this competition. In this system, labour is just another factor of production: a commodity bought at a price and incorporated into the price of the product sold. There is always an incentive to reduce the contribution of labour costs within the price of the product. This can be done by keeping wages low or increasing the productivity of labour. The latter is done by better management systems and by introducing automation so that each worker can produce more economic value per unit of time and therefore their wage contributes less to the price of each unit of production. All this creates perpetual innovation and change in society; economic entities go bust and are replaced by other entities; society changes and forces change in the life of individuals at an increasing, often impossible, pace. Let us not forget that humanity has evolved in a very slow pace and therefore such accelerated pace of change may be challenging the very core of our biological nature.

There are many problems arising out of these mechanics of a fiercely competitive economy. If competition forces the productivity of each individual to increase annually through use of machines and technology, then fewer and fewer individuals are required to produce a

certain amount of global economic output. Hence, economic output must perpetually grow to maintain employment, and this threatens to deplete resources and destroy the environment. A second problem is that labour is the ultimate source of demand in this system. However, as people are replaced by technology, there are no guarantees that lost demand will be replaced. The economy is indeed today largely sustained not by demand created by real wages but by an increasing amount of unsustainable debt incurred by individuals and governments. This is in fact accumulated capital which cannot be invested productively in the absence of effective demand and which, through the banking system, is recycled into the economy as unsustainable loans. This debt and the instruments with which it was managed caused the 2008 crisis, and will cause similar crises in the future. Finally, there are also severe economic consequences for nations that don't compete well in this system, but also for individuals and groups within wealthy societies that bear failures and systemic pressures personally.

Now, there are possibly three individual and collective responses to the above situation: first, an individual may blame themselves for the failures or stresses that they experience, e.g. unemployment or a failure to adapt to change, which is opening the road to mental illness. Second, groups especially disadvantaged ones may be encouraged by demagogues to start blaming smaller groups, the Jews, black people, immigrants, Islam, the 'crusaders', which of course opens the road to fascism. Finally, a more appropriate and reasoned response would be to look for systemic problems and failures that need to be fixed. The first two responses underpin many of the societal and political problems that we observe today: the rise of the far right, the

prevalence of conspiracy theories, e.g. antisemitic ones, the increase of mental illness among the young, and perhaps the prevalence of divorce and alcoholism in older generations.

There are no easy solutions to these problems, but at least a diagnosis of the real systemic causes will help to identify remedies. Changes in the economic system and effective social policies will certainly be required to address these serious problems. However, how the citizens of this world, individually and collectively, cope with problems does not only depend on external circumstances and policies. It also depends on the way they personally feel and think about external events; this brings us to Stoicism and the view presented in this paper that an expanded view of education that supports emotional development is needed, and can play a part in addressing the psychological challenges arising in the modern world. Education can be delivered in many ways formally and informally, using conventional means and digital technology through instruction and games. Too much of contemporary education but also computing, our own discipline, is focused on enhancing productivity and innovation and overlooks the real psychological needs of people. There is potential to pursue work that fills this gap, so in this paper we describe a system that could help to educate new generations on the ancient but still useful for emotional growth and resilience philosophy of Stoicism.

### ***1.2 Stoicism and the goals of the Infinite Virtual Stoa***

Stoicism is a philosophy that considers the object of life to be ataraxia (αταραξία), a state of psychological stability which is undisturbed by exposure to phenomena and circumstances that lie outside one's control. Such

circumstances may include ill health, poverty, natural disasters, corrupt social orders and unrequited love, and may cause loss of composure and mental balance through feelings of pain, humiliation, insufficiency, envy or greed. Stoicism is a coherent system of powerful ideas about how to pursue a life of equanimity in the face of adversity which has nurtured philosophy and psychology to this day. The founders of Cognitive Behavioural Therapy have cited Stoicism as their main inspiration [1]. Stoicism flourished in ancient Athens and Rome at a time when ancient democracy was dying and people experienced loss of control over their lives under authoritarian and imperial regimes. In an age of serious global economic, environmental and psychological uncertainty and crisis, Stoicism has still pressing and valuable lessons to teach us about calm, composure, resilience and emotional stability, and we are working towards facilitating these goals using digital technologies.

Stoicism owes its name to Stoa Poikile ('painted porch' in Greek), a colonnaded building in the Athenian agora where Zeno of Citium founded his school in the 4th century BCE. In this project we develop an 'Infinite Virtual Stoa' to host an expandable online repository of resources about Stoicism. Our repository exists in the space defined by the Stoa, which is a colonnaded building that takes the form of the ancient, and sacred to many cultures, geometrical motif known as 'the flower of life'.



*Aerial view of the infinite Stoa*

The building is composed of multiple evenly-spaced, overlapping circles arranged in a flower-like pattern with six-fold symmetry that is potentially expandable to infinity. Our Stoa is immersed in water, with pools regularly forming in the space between the colonnaded walks that delineate the space and becomes an art gallery-library for the exhibition of online stoic resources: quotes, stories, books, paintings and videos.

Stoicism explored patterns of psychological fallacy on one hand, and patterns of thought and behaviour for the pursuit of ataraxia on the other. Our Stoa is built on a geometrical pattern that is expandable to infinity. Thus, the concept of pattern is central to this paper. Firstly, we focus on patterns as they occur in Mathematics, Science, the Arts and the mind. Then we discuss patterns within Stoicism and the design of the infinite Stoa. Finally, we highlight the long term educational goals of this project and its further evolution.

## **2. *Téchn* and 'Arthematics'**

We start from a vision where Mathematics, Geometry, and Computer Science may be embraced in a sense of the unified arts and technology suggested

by the ancient meaning of the Greek word *téchnē* (τέχνη) [2]. Stefanie Mandelbaum interestingly coins 'Arthematics' as a crossing field between the Arts and Mathematics [3]. This goes also in line with another neologism, that of 'Artification' [4], which gives name and meaning to the fusion of the artistic and the - apparently - non-artistic, that then sublimates to a new Art. In this context, we are specifically interested in the dynamics between Artification of Games and Gamification of Arts.

### **2.1 *Mathematics, patterns and the Arts***

The appearance of perspective in Renaissance painting is intimately related to the influence of 'the science of sight' [5] and the mathematical notion of infinity. It is an example of mathematical thinking that proved to be instrumental in the making of artistic masterpieces. This advance in the Arts was driven by the Renaissance artists' brave geometrical thinking including the contemplation of insightful but counterintuitive ideas, such as equating the existence of parallel lines that do end up meeting [6].

Deeper in history, humanity has left us with an ancient panoply of beautiful patterns still exposed in old walls, windows, floors and ceilings, or visible in other kinds of artefacts - such as ceramics - of antique cultures like the Assyrian, Greek, Roman, Byzantine, Iranian and Arabic [7]. This heritage has inspired artists through times. Technically, the motifs and regularities can be classified by periods and styles or even in more systematic ways and they too have an intimate connection with mathematical knowledge. These ancient arrangements are still present in contemporary works of the decorative arts of ornament and in prints. Yet their influence is not limited to those fields of creativity. Escher, for instance, has used

them - and has also developed his own ideas over them - in his engravings and drawings introducing the visual senses into new heights of thinking geometrically.

Perhaps the harmonies of symmetry, isometry and geometry are desirable and explain that the order present in the universe is also present in cultural artefacts such as Art, Music, and Architecture [8]. Such thoughts led Ackerman to state that ‘the modern argument of form versus structure is as meaningless as the mediaeval argument of *ars* versus *scientia*, for it likewise disrupts a partnership which can function only in happy union’ [9].

In Music, as in the visual Arts, Geometry and Techne also coexist. In musical composition, geometric transformations and symmetry are known to have played a role in the works of Bach and of Bela Bartok [10]. There are also known composition symmetries such as the ‘Friezes patterns’ [10] and tonal and rhythmic patterns, such as dissonance, two-voice vs. coloration, and ostinato patterns [11]. These are resourceful tools for the composer because patterns in music can also be derived from one into another by variation [12].

## **2.2 Historic technologies in the service to the Arts**

The history of the synthesis of Mathematics and the Arts is also exemplified by several engineering artefacts such as the tools that have helped artists to achieve extraordinary paintings and sculptures. From the chisel to calligraphy pens, the compasses and the proportional dividers, to more complex tools for achieving a correct perspective in painting, such as the perspective machine depicted in Leonardo’s ‘Draftsman drawing an armillary sphere’ [13] or the

pantograph, a linkage device invented in 1630 by Christoph Scheiner that makes it possible to draw a scaled copy of a smaller depiction [14]. The automation that nowadays is the focus of interest of the Generative Art is also rooted in history, from the legendary Antikythera mechanism to the pervasive echoes of the music of the automatic carillons of Mafra [15] and the writing, drawing and musical automata of Jaquet-Droz [16].

## **3. Patterns and Computer Science**

Patterns are also prevalent in Computer Science, and that indeed is the case in the fields of pattern recognition and machine learning [17]. Pattern recognition searches for regularities in data and deals with their automatic classification [17]. In Computer Science, a pattern is an abstraction of an object that can be understood as a class described by certain attributes and that can be searched for in the data [18]. Patterns can usually be recognized statistically or syntactically [18]. It is, for instance, possible to run pattern matching algorithms in a musical piece to study its ‘motifs and their variants’ [12].

### **3.1 Repetition, tilings and tessellations in Computer Graphics**

Going back to the works of Leonardo da Vinci and the Renaissance, it is remarkable to see that his description of dealing with perspective essentially matches the contemporary approach for rendering a 3D scene to a computer screen. Long before the Renaissance, the Romans had also used small tiles – tesserae - to build mosaics that could fill the plane with depictions. This regular tiling of the plane or even space is hence called Tessellation. Still today, the ‘tessellation stage’ is one of the steps of current graphics 3D rendering pipelines. Other kinds of regularities are also

thought fundamental in Computer Graphics. The symmetrical divisions of the plane and of higher dimensions are crucial for rendering pictures, movies and geometries as they can be reduced to structural repetitions of bidimensional pixels and three-dimensional voxels.

### ***3.2 Pattern generation***

Efforts are also directed towards understanding pattern formation and to ‘describe universal classes of pattern’ in a ‘precise formalism which serves as the conceptual basis for synthesizing and analysing patterns’ [19].

### ***3.3 Proceduralism, and digital games***

Proceduralism in the realm of digital games allows the automatic creation of infinite and randomised worlds. These can be populated with procedural models and game objects, geometries, textures, levels, AI behaviours, and with impact on the dynamics of narratives, story, and in music generation where, for instance, musical piece sections are repeated according to dynamic patterns [20]. Dynamic music can be parametrised by variations of tonality, rhythm, harmony, ‘andamento’, pitch, and themes and can have an impact both in immersion and inclusively play with the narrative and player interaction, as in the use of the ‘leitmotiv’ in dynamic game music [21].

### ***4. Patterns and the mind***

There are two noticeable connections between the realm of patterns and the human mind. The first is that the mind has the tendency to be attuned and attracted to regularity as in symmetric patterns, in which it finds beauty [22] [23]. The second is that patterns have an influence in processes and flows within the human mind. For instance, temporal patterns have the power to induce an

‘inner clock’ that influences the perception of music [24]. One recognises and remembers different birds by the melodies they sing. Studies in psychology have also investigated intrinsic and extrinsic structures of stimuli and their relationship with discrimination, classification, judgement of similarity [25] and, particularly in music, in long-term memorisation of melodies [26]. Additionally, the repetition of static images and sculptures are also interpreted as ‘visual rhythm, or an impression of coherence and movement’ [27]. The ‘same measure’ of patterns is also mentioned in some mental pathologies, as it is the case of the obsession with symmetry in Obsessive Compulsive Disorders [22].

### ***5. Stoic patterns and areas of emotional educations***

Stoicism is an ancient philosophy that encompasses logic, physics and ethics in a comprehensive philosophical system from which much can still be learned about tranquillity, resilience, mental balance as well as tolerance and openness in society. Stoic philosophers used the analogy of a ‘garden’ to describe their system [28]. In this analogy, philosophy is seen as a garden that it is fenced by logic protecting it from erroneous reasoning often motivated by imperfections in human nature. Within the garden, physics is the soil where we cultivate our understanding of the world including that of our human nature. The fertile soil of physics in turn yields the fruits of philosophy which for Stoicism is the ‘ethics’, or living a ‘good life’ characterised by serenity and justice that can be experienced individually and collectively.

Stoics have made contributions in many areas of intellectual enquiry. Chrysippus, for example, is known to have founded

propositional logic, an early form of the formal reasoning system employed in contemporary analytical philosophy and Computer Science [29]. However, one of their most significant and lasting contributions is in the area of psychology. Stoicism is indeed the first systematic attempt to understand patterns of fallacious reasoning that cause disturbances in human psychology and behaviour; and stoics proposed remedies which still inspire modern cognitive therapy [1]. For the purposes of this paper, and its discussion of patterns, we focus on three areas of human behaviour where stoics identified dysfunctions caused by fallacious thinking and where they proposed interesting remedies: anxiety, agitation and tribalism.

### **5.1 Anxiety**

Many of us tend to live in constant anxious anticipation of stressful events, e.g. fearing loss of status, wealth, health, or reputation. According to the stoics such anxieties are largely caused by mental confusion and inability to consider a basic dichotomy between those things that we can control and those that we cannot. Status, wealth, and health are largely defined by external events which can be random and outside one's control. Realising this can lead to a fundamental shift in how one then responds to unfortunate events. It is not the event itself that matters - argue the stoics - but our responses to it, and these can be adjusted. Once one understands, for example, that a job promotion is not entirely in one's control, but depends on circumstances and personalities of others, then failure to obtain the promotion becomes less personal and hurtful and therefore one can be less anxious about the outcome and rather focus on the effort. Stoics instead propose that life should prioritise the pursuit of four cardinal virtues: wisdom, courage, justice

and temperance, and all these are entirely in our control. A good life is defined as acting with wisdom, be courageous and doing the right thing, treating others justly and responding to events with moderation. Status, wealth, health and reputation, on the other hand, are simply defined as 'preferred indifferents' i.e. things that may be nice to have but one should easily part with [30]. Stoics developed some excellent advice around this theme. Epictetus, one of the eminent stoics, for example, advised us to think of our loved ones not as possessions but as borrowed from the universe [31]. When the time comes to return them, we should not be devastated but be grateful for the time we had with them as we would be grateful when we have returned a good book lent by a friend.

### **3.2 Agitation and anger**

Stoicism attributes agitation and anger to overt optimism and unrealistic expectations. In his *Enchiridion*, Epictetus gives a lucid illustration of this using the example of a citizen visiting the Roman baths for cleansing, relaxation and recuperation.

"If you are going to bathe, picture to yourself the things which usually happen in the bath: some people splash the water, some push, some use abusive language, and others steal. Thus, you will more safely go about this action if you say to yourself, "I will now go bathe, and keep my own mind in a state conformable to nature. For thus, if any hindrance arises in bathing, you will have it ready to say, 'It was not only to bathe that I desired, but to keep my mind in a state conformable to nature; and I will not keep it if I am bothered at things that happen' " [32].

For the stoics, 'nature' in the above effectively means 'reason' (logos),



because nature is both logical in its regularities and has gifted humanity with the capacity to reason. Epictetus makes a very apt point: overt optimism disappoints and agitates. Indeed, many of us regularly get upset about traffic jams and aggressive drivers as if we lived in a world where these things were extinct. We use computers for online banking but hope never to suffer malware, and when we do we get angry. However, Stoics had a very clear view of anger as temporary suspension of mental faculties. In his famous essay, Seneca described anger as temporary madness [33]. The stoic message is that unrealistic expectations lead to disappointment, agitation and anger. Thus, it is preferable to be realistic, and when we encounter potential triggers of anger, create mental space between external events and our responses to allow reasoning and calm reflection to take place.

### **3.3 Tribalism**

Tribalism assumes that a strong cultural or ethnic identity, often based on proximity or kinship, separates one member of a group from the members of another group. Various forms of tribalism, including nationalism, have historically exploited false and simplistic conceptions of history which glorify the tribe or the nation, and exclude other groups.

The stoics developed an antithesis to tribalism based on a cosmopolitan view of human nature and society. According to the cosmopolitan view, we are social animals who participate not in one but many groups which are increasingly larger. In each of those groups we may assume different roles which, if performed well, lead to collective benefit. The word cosmopolitan derives from the Greek *κοσμοπολίτης* meaning being 'citizen of the world'. Hierocles, an eminent Stoic, developed a brilliant

illustration of the concept by placing the individual in the centre of a series of expanding circles of concern: the smallest circle is the individual itself, next comes the close family, the extended family, the city, the neighbouring cities, the country, and finally the larger circle is humanity. Our task - stated Hierocles - is to compress those circles so as to bring humanity closer to the core of our concerns [34]. Cosmopolitanism thus becomes the idea that all humans belong to one community based on our shared nature and capacity for logic and morality.

## **6. The infinite Stoa**

Stoicism has lasted millennia and still carries valuable lessons for humanity. There are contemporary communities of practising stoics, hence there is no reason to believe that Stoicism will cease to exist and develop in the future. To facilitate this, we propose an infinite virtual Stoa that will enable hosting an expandable online repository of resources about Stoicism. The internet is already potentially infinite, but we propose to create a more interesting virtual space that offers artistic possibilities and sensibilities for the presentation and exploration of stoic ideas. Thus, we configure our gallery as a virtual colonnaded Stoa that is reminiscent of the original Stoa Poikile. Our Stoa has no boundaries, being allowed to grow *ad infinitum*. Below we explain how this is achieved.

### **6.1 The geometry of the circle**

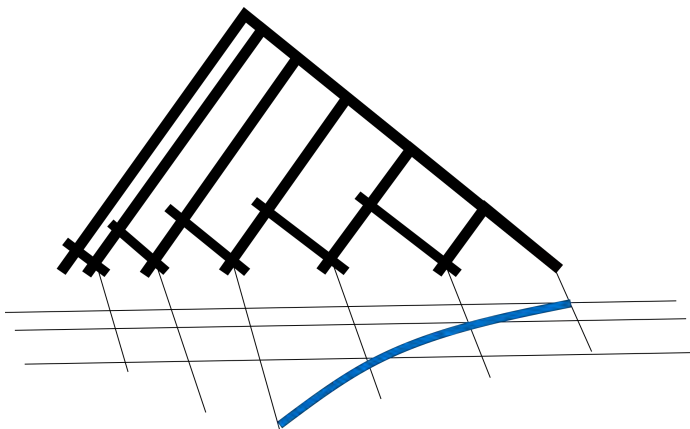
Computationally, an infinite virtual Stoa can be built procedurally. This requires some form of structural arrangement that can be repeated in the Stoa's architecture. We could have created a linear Stoa but have chosen a more interesting motif of seven overlapping

circles known as the ‘flower of life’. This arrangement has the particularity that by the connection of all points another pattern can be found, one that combines the projections of all platonic solids, known as the ‘Metatron Cube’, that is a figure that shows ‘perfect proportions and relations between its geometric components’ [35]. This hidden pattern is also known since antiquity and archaeologists account finding it in the architecture of a defensive structure of the Copper Age in the Iberian Peninsula [35].

### 6.2 Pantographs and Splines

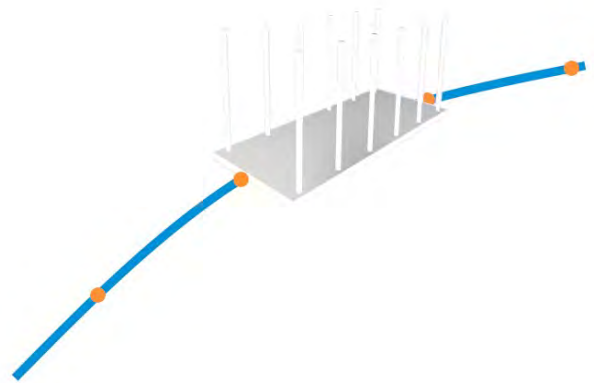
The prominent technical device necessary for building the pattern is the spline, a computational resource with roots in the ancient art of making tools [36], specifically the pantographs that have been conceived and used for drawing elliptical arches in the 17<sup>th</sup> century [37].

In the 1950s, automotive design required novel ways for the representation of volumes’ and shapes’ which led to the invention of computational splines [38]. The invention of splines moved from the elliptic pantograph to defining curves algorithmically, an innovation that also moved on from defining the arch inside a sectioned 2D rectangle, to a 3D parallelepiped [38].



Drawing ellipses before algorithms, with a pantograph (diagram based on [38])

Splines are nowadays present in all kinds of drawing and modelling software, and also present in digital game engines, along with multitudinous other technical advances in the service to the Arts, that mostly have all had their roots in historical engineering. Among the contemporary applications, splines can, for instance, be used for extracting the geometrical features on digitally reconstructed parametric model representations of objects [39].

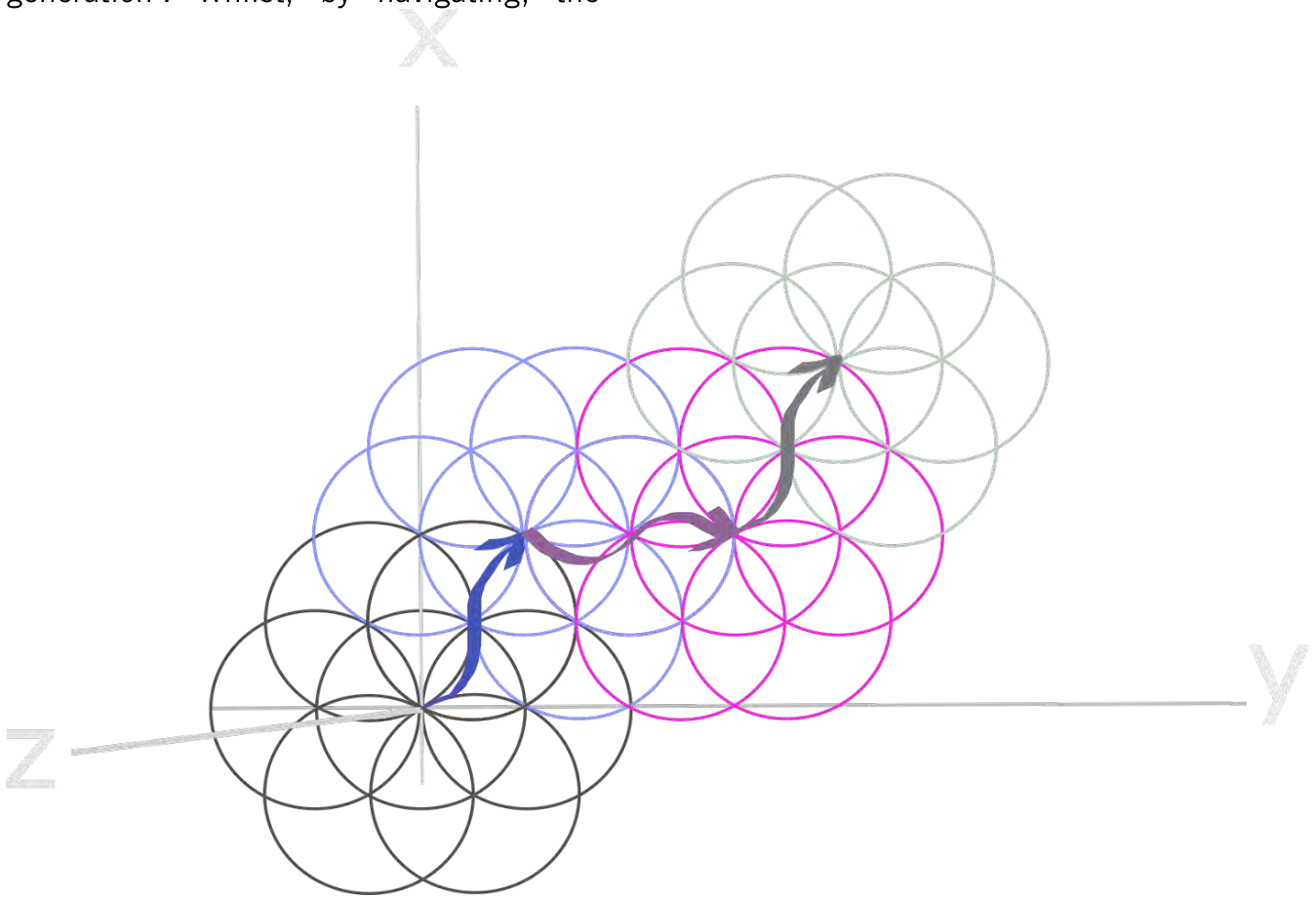


*The Stoa’s modelled section is reproduced along a spline*

By resourcing to splines, it is possible to section them equally and populate their parts with 3D models. In the Stoa, the spline sections are associated with a reduced 3D model of a small motif of a segment of a Stoa, that can be repeated, and then sections are harmoniously collated. Every spline instantiates a circle of the flowered pattern and infinity is achieved by making the rendering of the Stoa dependent on the player’s navigational directions. The circles also have anchor points that can work as the origins for further splines/circles. So, by being generated on the fly, in conformity with the navigation of the viewer, the Stoa becomes virtually infinite in any direction

of browsing. The result is that moving towards the horizon creates new space. This is a characteristic of what is known in game development as ‘procedural world generation’. Whilst, by navigating, the

world is created instantly, it is also possible to recreate previous paths towards where the audio-visual sculptures have been situated.



*Process of the splines being generated during navigation, viewed from above*

### **6.3 A procedural art gallery for viewing artworks**

Navigating the Stoa resembles walking on an infinite unbounded labyrinth. Along the continuous paths, the player can find the audio-visual sculptures that can be

designed with the resources provided by TIMAEUS. TIMAEUS is a virtual art studio, which has been inspired by Plato’s homonymous work, especially in its narrative about the Platonic realm of geometrical thinking. The sculptures contain audios, films, pictures and texts that are continuously being displayed and that can be visited from inside by the wanderer. An example sculpture inspired by Hierocles’ circles of concern is shown below.



Hierocles-themed sculpture viewed from the Stoa

The sculpture viewed from the inside

## 7. Conclusion and future

Much of education and computing is geared towards business and productivity and does not address psychological needs. In this project, we explore the space for computing applications that could improve the welfare of individuals, in this case through a system that can help people get to know about the philosophy of Stoicism.

Stoicism is a philosophy that explored patterns of psychological fallacy on one hand, and patterns of thought and behaviour for the pursuit of ataraxia on the other. We observed that the world is abundant with recurring patterns that repeat themselves in completely different areas. The branching of the trees is similar to that of veins, the delta of rivers, the wrinkles of a palm and cracks in dry soil. In this paper, we discussed the concept of pattern as it occurs in Mathematics, Science, the Arts, the mind, but also in the philosophy of Stoicism.

Building on the themes of patterns and Stoicism, we designed an infinite virtual Stoa using a classical geometrical pattern that is expandable to infinity. The Stoa could be used to host and present in an artistic manner an infinitude of past and future resources about Stoicism. It can potentially host areas of study devoted to great philosophers, like Epictetus, Seneca and Marcus Aurelius, or thematic areas where stoic ideas are explained with quotes, text, animations and videos. Specific ideas or themes can be presented in a creative fashion to the viewer as multimedia illuminated sculptures using TIMAEUS.

The gallery is designed to be accessible online. It can be seen as a serious game for education and learning or a development towards Gamification of the

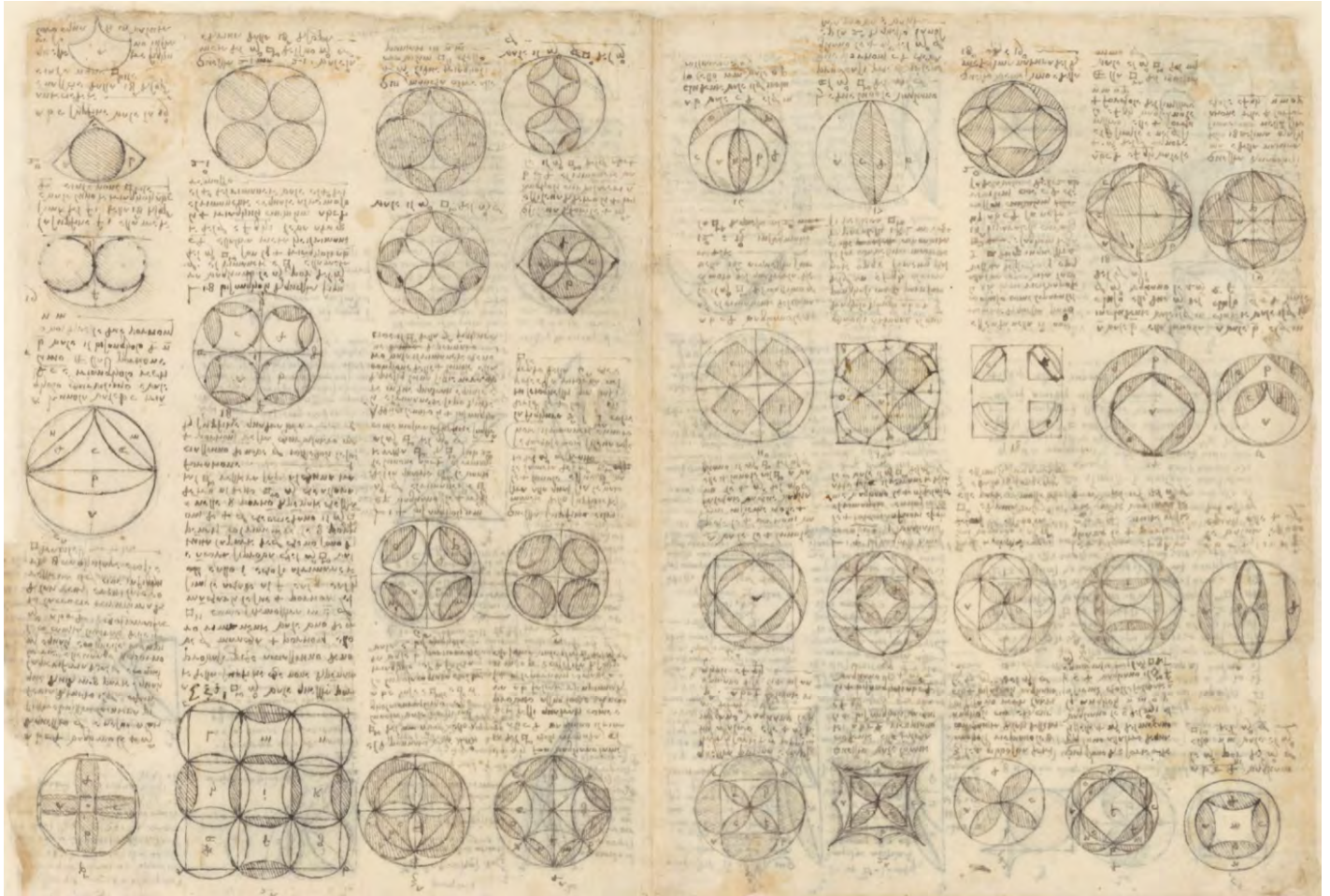
Arts. The longer-term project where it belongs also includes the TIMEAUS digital art studio, and its applications for art therapy, and aims at creating technologies through which the emotional education of people could be hopefully be enhanced.

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*Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations*



# Weaving the world with waves

## Layers of knowledge in research-creation processes

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### **1 – Introduction: the specific nature of artistic knowledge**

There is little consensus about the precise and definitive role of arts and artists in contemporary societies, and the questions revolving around these thematics have been fuelling for decades a series of problematics that show no sign of resolution. We will not enter this debate here, except for proposing a statement about artists that, more than several others, is likely to generate a certain level of agreement: if artists have a role in our societies, it is to escape every role that these societies try to impose on them.

Apart from this, arts and artists seem to be much better defined by what they are not rather than by what they are. Here again, several points of view can be brought to the discussion. The present communication must be seen as an essay, illustrated by an example, about the following statement: art is neither a pedagogical field, nor an educational discipline. It is not meant to explain anything, or to demonstrate through various metaphors and similes the proper way to conduct an ethical or moral life. I am well aware that several major artists have been indulging in such ventures, be it from their own will or under the influence of a political or religious instance; and that important works of arts have been created by following these slippery paths. We can legitimately admire the results because of the artists' skills, the mastering of his own technique, the way he manages to convey emotions through the different characters on his works – all components of the artwork that will move, touch or impress us much more than the general theme of the piece. But more than often, in front of works created during very religious time or propagandist eras, are we aware that our emotions, as intense as they can be, are felt despite the theme of the piece rather than thanks to it.

That by no way means that we cannot learn anything by contemplating a work of art. Quite the contrary: through the experience of art, something is learned. Each time we read a major novel, contemplate a painting or a sculpture, listen to a piece of music, walk through and around an architectural masterpiece,

a new knowledge is acquired. This immediately opens two sets of questions: the first one is to define which kind of knowledge is thus transmitted; the other is to find out the channels by which it is transmitted. These two problematics are at the very origin of the emergence of research-creation, a now bursting field whose birth can be traced back to the 90's, and that strives since its birth to establish itself as a legitimate mode of knowledge production, just like the two older and more familiar fields of pure and applied research.

Thing is, since Greek Antiquity, the proper way to transmit knowledge developed along a path oriented towards the form of reasoning called “demonstration”, in which the notion of irrefutable affirmations plays a major role, and that is based on the production of valid (or true) statements constructed by a deductive methods from a set of axioms or experimental results. It is hard to overestimate the current impact of that method, the only one that is considered scientifically valid, on all spheres of knowledge. Even in the most daily situations, like in discussions with our closest relatives, it is generally considered as the only proper way to rationally discuss a problem and to find ways to resolve it.

Problem is, precisely, that out of science, very few situations in the real world can be solved that way. Like it can be shown through many examples, trying to map directly the scientific rhetoric to

humanities or research-creation is a very risky venture – not to say a highway to failure. Though definitive conclusions still have to be reached, in research-creation, the question to *demonstrate* something to someone can adequately be replaced by the question to know how to make someone *share* a specific emerging meaning, *join* a position, *adhere* to conclusions, or simply *subscribe*, even temporarily, on some point of view. For all forms of arts, knowledge transmission has very little to do with explaining or describing. It relies on analogies, intuition, relations, emotions. It calls for the effect of immediate and/or sensorial experience, and it may well escape any attempt at verbal descriptions.

## **2 - An example: the Point [d'] Origine project**

The work I will present here has been developed by my lab during the last years. I am not in an independent position to evaluate its artistic value, so I will leave this to the reader (though I strongly suggest experiencing it real life before doing so). I selected it because after implementing it, I realized that it was based on a set of interrelated analogies, transpositions and transcoding processes that propose several levels of reading, and therefore of interpretation, that deeply anchor in very different disciplines; and because it illustrates that every work of art actually deploys itself on several scales, each of which contributing to its own extent to the emergence of the art phenomenon; and because for the viewer,

digging into the different scales and levels on which it rests actually modifies his appreciation of it, allowing him to benefit from the various kinds of knowledge it may transmit, and even to learn something about the different ways through which this knowledge is transmitted.

The work in question is called *Point [d'] Origine*, which in English translates by “Point of Origin”. The translation actually fails to grasp the double meaning of the French expression, which can indifferently mean “Point of Origin” and “No Origin”: this detail is important for the following. It has been presented for the first time in the French Gothic cathedral of Mende during the summer-fall of 2017, and will be presented in the Château de Chambord, also in France, this coming fall.

The experience as such is as simple as it can be: the visitor entering the building is given a headset and a small translucent egg-shaped module, a “harmonic lantern”, to which the headset is connected. Inside the lantern glow small coloured, oscillating lights. When the visitor walks the alleys and spaces of the building, he hears tones and timbres that are very rich in harmonics, and that creates musical sequences when he walks, or when he moves the lantern at the end of his arm. The only setting at his disposal is a volume knob.

The visitor quickly realizes that the music is generated by his own movements and displacements, and that different musical orchestrations are associated with different zones. The installation is very simple to use, so anyone can experience it without any kind of training, from toddlers to elderlies. There is one detail though: as the visitor enters the building, the person in charge of lending the devices explains him that the sounds he will hear are generated from the architecture of building. Not that they have been played and recorded inside its spaces; they are actually computed and synthesized *from the architecture itself*, and then assembled through additive synthesis to generate the rich timbres and tones heard by the visitor. In other words, the sounds are a direct transposition of the architecture into music. Moreover, the transposition is computed at every instant from the very position of the visitor. Any displacement generates a new transposition, and thus a different sound, which is why he hears a melodic sequence: his movements and displacements create a music of which he is simultaneously the composer, the interpreter and the auditor. Everything happens as if the space was filled of myriads of small music droplets hovering still in space, each one concentrating the whole architectural information of the building in a very tiny volume, waiting to be crossed by the harmonic lantern to be sounded.



Fig. 1 – Visitors experiencing the Point [d'] Origine installation in the Cathedral of Mende with their harmonic lanterns and headsets, July 2017.

### **3 - The intimate link between music and architecture : an intriguing story**

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From the two previous paragraphs, the experience of the visitor is fully described. But, as the informed reader can guess, under the simplicity of this description lie several layers of scientific, mathematical and computer science development, as well as a dense theoretical and historical substrate structured by the deep, intimate and age-old relation that music and architecture have been maintaining in the Western world from Greek Antiquity. We will not enter here in a full description of all these considerations, which have already been published on different instances [1] [2], but we will briefly sum them up in order to illustrate our opening statements.

The idea of a privileged relationship between architecture and music can be traced back to time immemorial. It is found at all times, and in many great civilizations. In the Western world, it was an important component of the cosmological model of the Harmony of the Spheres, which at the time of Classical Greece governed most human activities, establishing a system of proportions that determined a set of formal, numerical, and geometric relationships relating celestial bodies, musical scales, human body measurements, and architectural scales. Although it is not corroborated by any archaeological survey, and although no written text of the time explicitly mentions it, the treaty of Vitruvius, written five centuries later, implicitly refers to it when establishing as a prescription the necessity of designing

buildings according to proportions that must in every respect conform to musical scales, and to those of the canonical human body. The resurgence of the Vitruvian precepts following the publication of Alberti's treatises in 1452, about 1500 years later, gave this theory a vigour it seems never to have known in Antiquity, and which lasted throughout the Renaissance. It faded out only with the well-known episode of the Quarrel of the Ancients and the Moderns, itself concomitant with the birth of contemporary science.

The relentless battering by philosophers, scientists and thinkers of the early modern times has fully defeated the Harmony of the Spheres, which by the end of the 18<sup>e</sup> century has lost all legitimacy for providing a valid description of the cosmos, and more specifically to talk about any human activity or behaviour. Yet in each of us persists the deep conviction that music and architecture still maintain a privileged connection, and that makes the former, if not the twin, at least a close kin of the latter. Many artists and authors have tried to grasp this feeling through literary or poetic attempts (Novalis, Goethe, Franz Liszt, Frank Lloyd Wright, Hassan Fathy, Yannis Xenakis, Paul Valery, to name a few); many terms remain common to both domains (rhythm, cadence, mode, range, scale ...). Despite having eliminated the Harmony of the Spheres from its models, contemporary science still often uses obvious musical references: on all scales, it regularly describes a cosmos that sings in a quite harmonic way. Some of the most

established laws of physics are born of direct musical analogies : Kepler's laws, which describe the behaviour of objects in orbit, were born from the ancient idea that planets were singing. Fourier's theorem, one of the most striking achievement of classical physics, matched only by Einstein's theories or Maxwell's equations in terms of scope and importance, offers nothing less than the possibility to describe any event or object by a wave vocabulary, thus opening the possibility to look for harmonic correspondences between any elements of reality. The arrangement of electronic orbitals around atomic nuclei was discovered by Louis de Broglie, by a direct analogy with the vibrating strings of a musical instrument. Despite its complexity, string theory, the latest and most sophisticated attempt at unifying the four fundamental forces of the Universe, replaces the point particles of atomic physics by incredibly tiny strings (about  $10^{-35}$ m) whose modes of vibration generate all elementary particles. It seems that music can not be easily eliminated from contemporary descriptions of the world; that the harmonic connection between architecture and music could well be resting on the deep feeling that both are, in fine, kind of cosmological models with a strong degree of equivalence; and that, less objectively but no less important, we all have the unconscious desire to live in a Universe that is structured and evolves like a harmonious and coherent musical piece.

#### 4 – The harsh constraints of a formal transposition

Despite the historical and theoretical importance of the connections between architecture-music, from which we will refer from here as the “harmonic connection”, since the end of the Renaissance, very few direct attempts have been made to explicitly design an architectural project from a musical work, or vice versa. The most famous example remains the Phillips Pavilion at the Brussels 1958 World Fair, said to have been designed jointly by Le Corbusier and Iannis Xenakis, with a musical composition by Edgar Varèse<sup>6</sup>. This work is seminal for the genealogy of the Point d'Origine project: Xenakis, a mathematician and engineer of Greek origin, used several principles of the Harmony of the Spheres in his compositions, including the simultaneous production of forms and sounds from sets of integer numbers, and the concept of architecture and music as reflections of the cosmos. At Xenakis' time, the cosmos at a large scale was, and remains today, structured by the relativistic notion of space-time. The shape of the Pavilion has been explicitly described as representing



the movement of straight lines in space-time, in a process not dissimilar to the one used by Duchamp in his series *Nu descendant un escalier*, analogically transposed into music by operations such as glissandi, using modalities unknown to classical music.

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Fig. 2 – The Philips Pavilion at the 1958 Brussels World Fair, by Yannis Xenakis, is one of the few examples of attempts at representing directly musical concepts through architecture. Using spatial glissandi as evocations of space-time transformations, it is also rooted in the ancient cosmological model of the Harmony of the Spheres, which considered music and architecture as representations of the cosmos.

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It is from these considerations that the Point [d'] Origine project was born. Resulting from an exploration that lasted several years, it has as its main objective the generation of an architecture-music transposition corresponding to a contemporary and poeticized version of the Harmony of the Spheres, revisited from the current scientific models of the cosmos, and from the descriptions that physics give of music, sound, auditory perception, harmony and wave theory in general. From the beginning, it was decided that the model should have

precise characteristics, leading to a well-defined set of constraints :

1 • Formal transposition – All efforts are made to keep transposition strictly formal. Although it is followed by a phase of musical composition, the transcoding itself should not be opened to interpretation. In other words, the sound representation of the architecture through a wave vocabulary must be as precise and abstract as a formal description through geometric forms.

2 • Full theoretical precision - The transposition must be able to reach the degree of precision needed by the composer, the theoretical resolution limit being only determined by the performance of the technological equipment available at the time of the work.

3 • Complete reversibility - The transposition must be reversible: the musical and architectural pieces should be indefinitely transposable into each other without any loss of information. This also means that any musical piece can eventually be converted into architecture, although we have not yet tried this reverse transposition.

4 • Minimal arbitrariness – Since the process must be fully formal by virtue of constraint one, all decisions related to the transposition process should be derived from the process itself, and not determined by human interpretations. A

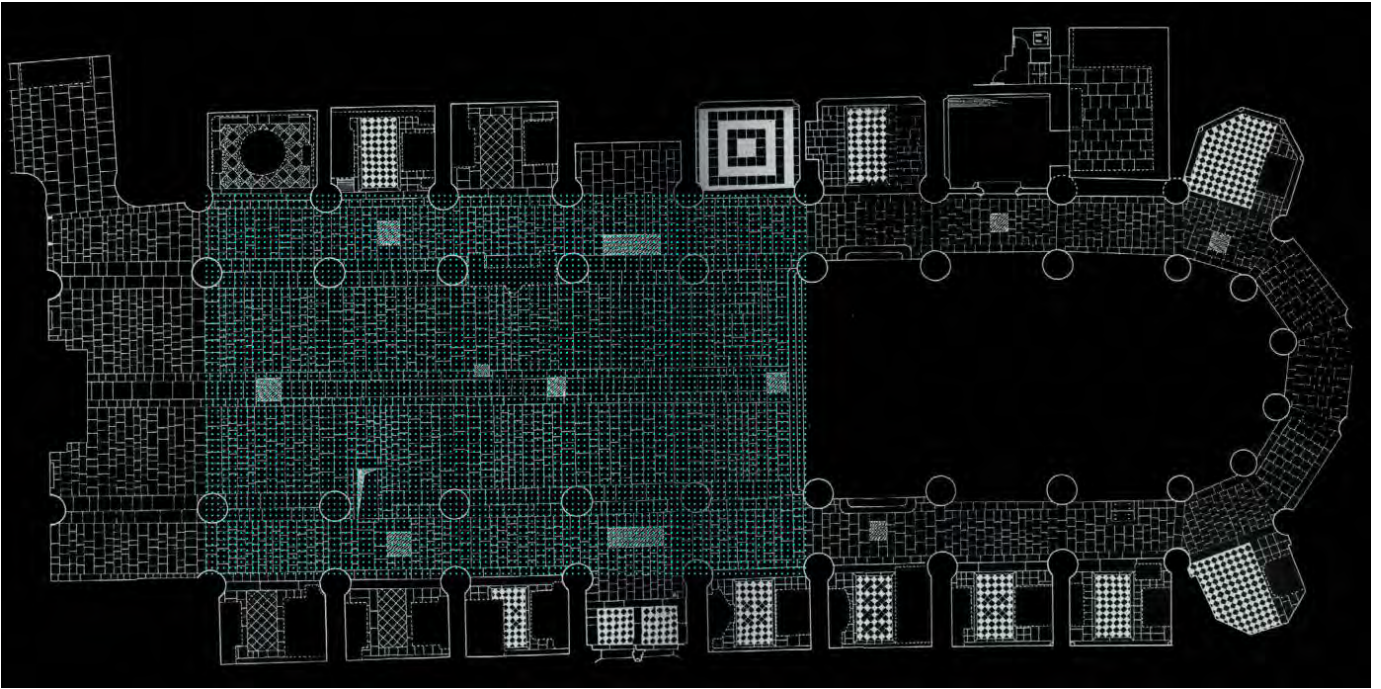
fully formal process is impossible to reach, but the arbitrariness can be confined to specific areas that does not betray or contradict the essential principles of the project.

5 • Music before and above everything - Once the formal transposition has been completed, it yields a series of sound harmonics that theoretically describe the building with great precision. However, nothing in the process guarantees the musicality of the resulting sounds, especially since it yields a lot of harmonics - typically several billions. There takes place the actual composition process, which consists in sculpting this harmonic jungle with digital tools in order to produce identifiable sounds, and without which the whole project would be a bare, bijective and dumb translation of a set of data into another.

For anyone having tried to transpose anything from one field to another (music, picture, text, videos, 3D models) through digital descriptions, these constraints will look very strong – and they actually are. After several attempts and a lot of experimentations, they led to a transposition sequence in six steps, which is the object of the next section.

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Fig. 3 – A map of the French Cathedral of Mende, showing in green the 30cm-grid of harmonic points that covers the space of the nave. More than 60 000 of these



points have been defined. For each of them, a different transposition is computed, resulting in a different timbre. Walking through the points, the visitor creates his own harmonic trajectories by his movements and displacements.

### **5 – The steps of the transposition**

The transposition involves the following steps:

- 1 – Implementing a high resolution 3D model of the building;
- 2 – Decomposing the model in spherical shells;
- 3 - Describing each spherical shell in terms of spherical harmonics;
- 4 - Mapping the spherical harmonics thus obtained on sound harmonics;
- 5 - Generating the musical timbres and tones by selectively adding the sound harmonics;

6 – Composing the harmonic map of the building.

### **1 – Implementing a high-resolution 3D model of the building.**

A surprising as it may seem, a lot of historical building are not properly documented on the digital level. For several of them, the existing paper documents are difficult to obtain and often incomplete to a large degree. The transposition process thus begins by gathering all existing historical and official documents and data sets to create a preliminary model, which is then completed and refined through an on-site residency that may last up to two weeks. In the most critical cases, the use of drones or photogrammetric devices may be required. This step can be the longest of the whole sequence, since it cannot be automatized, and since some parts of the building might be very difficult to reach.

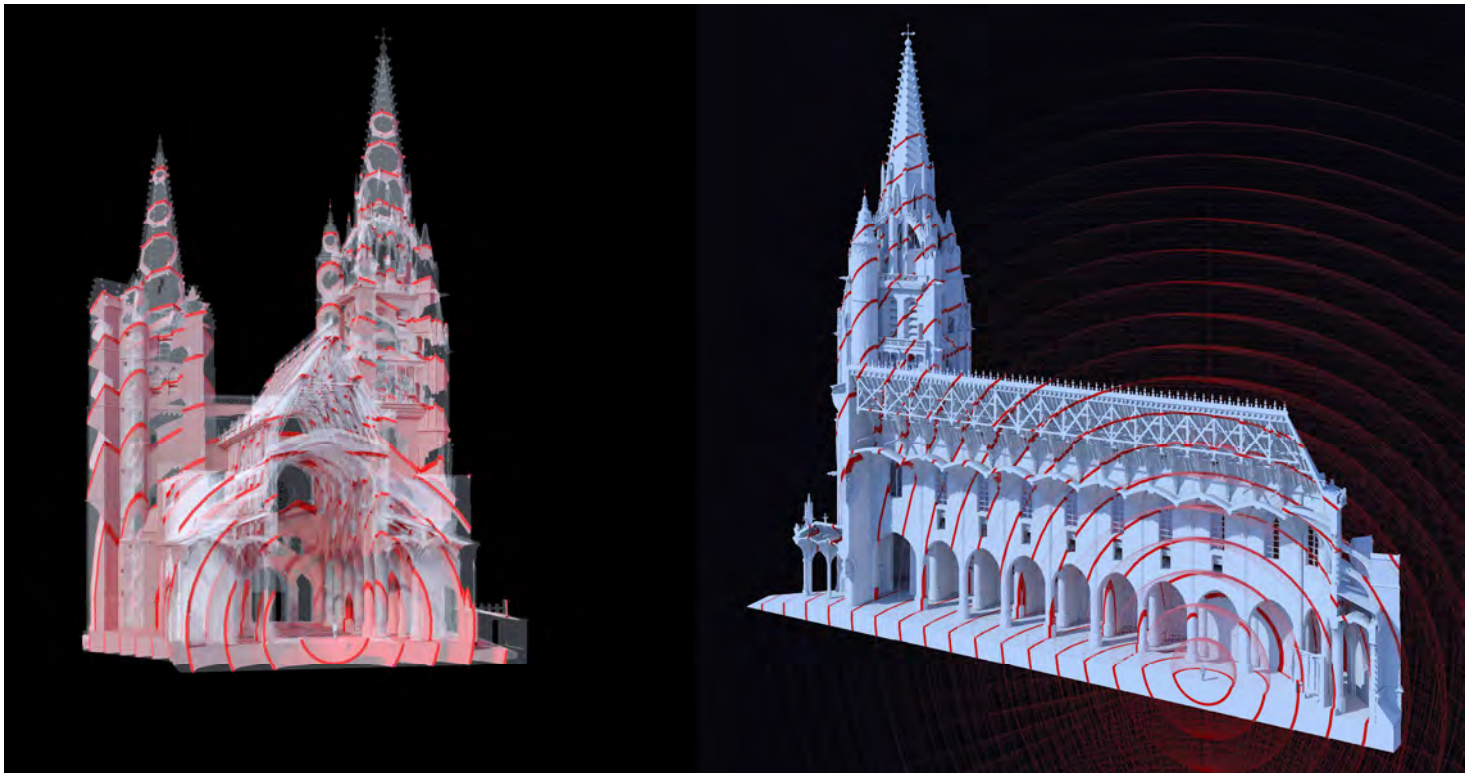


## 2 - Slicing the building in spherical shells

A set of potential positions for the visitors is defined. Each position is represented by a dot in the internal space of the building. All the dots form a 3D orthogonal grid that fills the entire space. In our first studies, the dots were separated by 30 cm intervals, which gave about 60 000 points that were christened “harmonic points”.

From each harmonic point, a series of concentric spherical shells of progressively increasing radius is

following ones intersect the different elements of the building while they progressively increase; the largest encompasses the whole building, which by this process is cut into a series of spherical slices. On each of them sphere appears a pattern determined by its intersection with the different elements of the architecture. If the composer decides to center fifty shells on each harmonic point, the final number of spheres is over three millions.



generated. The number of shells, as well as the interval between them, can be specified through the computer interface. One can for example determine about fifty shells separated by one-meter radii increases. The smallest shells surround the visitor's head; their surface is completely located in space. The

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Fig. 4 – Each position of the visitor defines a specific set of spherical shells, centered on the harmonic points he crosses at a given moment. The picture shows the set of shells emanating from a visitor positioned close to the entrance

(left) or entering the choir (right). The timbres that can be heard at each point theoretically correspond to a full wave-based description of the cathedral, as precise as a geometric one.

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### 3 - Describing each spherical shell in terms of spherical harmonics

This step is undoubtedly the most abstract, and requires some introductory notes. It is based on the Fourier's theorem, one of the most important of contemporary physics, already mentioned in section 3. It states that any periodic complex signal can be decomposed into a sum of elementary signals. In music for instance, it means that the timbre of an instrument such as a clarinet or an oboe can be decomposed into a sum of elementary sound signals called « harmonics »; each harmonic is described by a simple sinusoidal wave.

Fourier's theorem is fairly known in contemporary music, especially in the realm of spectral music. Less known are its extensions to other domains, such as cosmology, picture processing, shape analysis or computer-aided design. Its application in picture processing consider an image as the representation of stationary waves, just like if the picture corresponded to an interference pattern created by water waves running in a rectangular water pool: this pattern can then be decomposed into two sets of

elementary waves, one running through the length of the image, the other one through its width. The decomposition yields a list of elementary waves, the spectrum of the image, and specifies the wavelength, the amplitude and the phase for each of them. It can be demonstrated that any pattern can be drawn on a pool by using these principles.

We consider that the patterns that appear on the spherical shells are equivalent to patterns drawn by orthogonal waves on a spherical pool. This concept is rather unfamiliar to us (spherical pools are not that common in contemporary times), but it that can be grasped through an analogy with a planet completely covered by water, in which two sets of tsunamis perpetually run in mutually perpendicular directions, one running parallel to the equator, the other one from pole to pole. By properly adjusting the wavelength, the amplitude and the phase of each tsunami, it is possible to adjust the interferences between the waves so that they draw any pattern at the surface of the sphere. Conversely, any complex spherical pattern, such as those that appear on our spherical shells, can be decomposed into elementary spherical waves called « spherical harmonics ». Here again, the decomposition yields a list of spherical harmonics (« spherharmonics »), each of them being uniquely associated to a wavelength, an amplitude and a phase. The first and largest spherharmonic consists in a single wave whose wavelength is equivalent to the length of the equator of the sphere; the wavelength of the second one is equal to half that length; and so on, each

following spharmonic corresponding to progressively shorter wavelengths, with the constraint that the successive wavelengths must correspond to integer subdivisions of the equator.

The shortest spharmonic that will be considered determines the resolution of the analysis: a detail of characteristic dimension  $L$  will be detected by a wave of minimal length  $L/2$ . The composer must then decide what level of resolution he

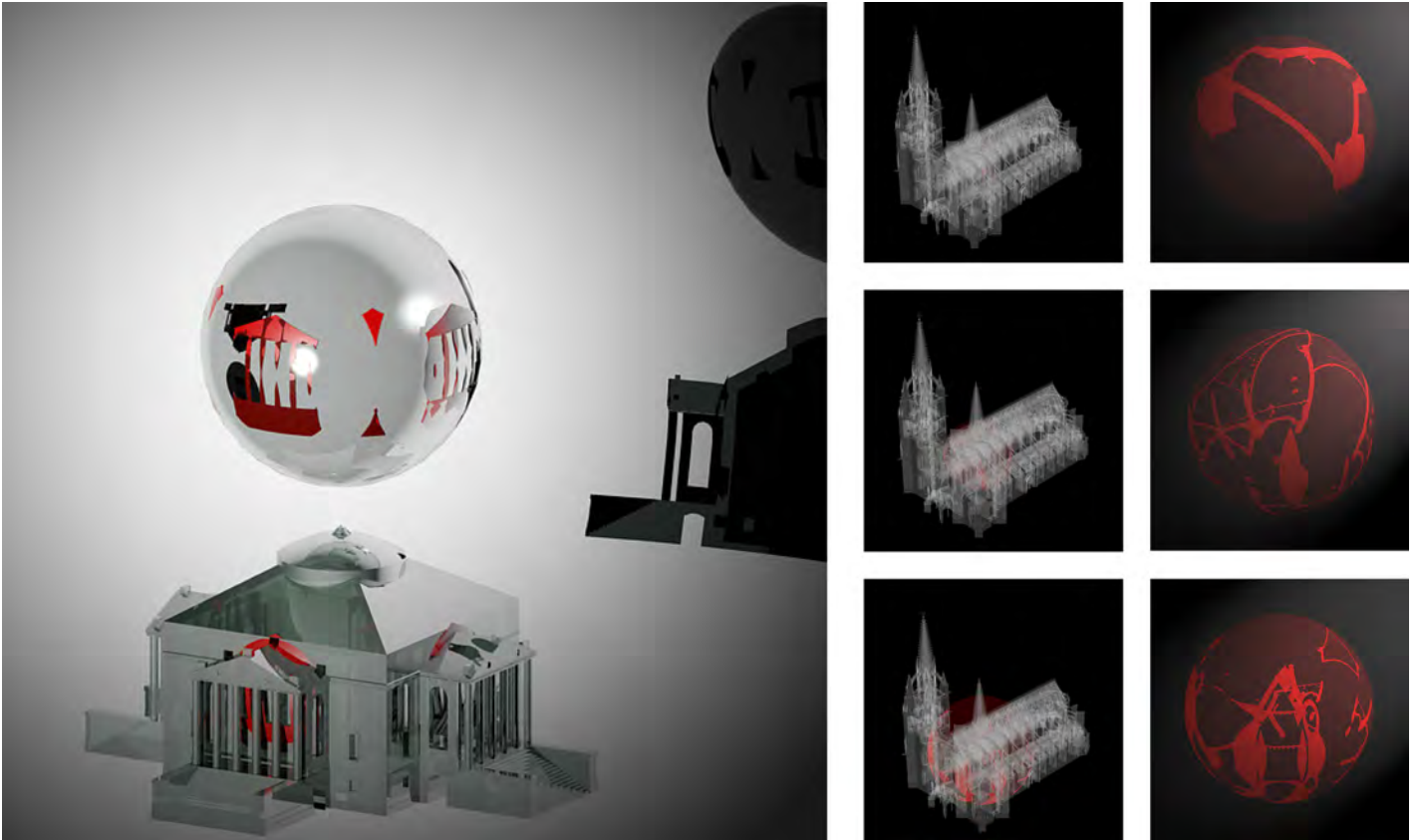


Fig. 4 (left) and 5 (right) – Intersection spheres, two examples. On the left, a spherical slice extracted from Palladio's Villa Rotonda hangs over it, revealing the pattern generated by its intersection with the building. On the right, three spherical shells of increasing radii intersect the Cathedral of Mende, generating the three intersecting patterns on their surfaces. In both cases, these complex patterns can be decomposed in series of simple, elementary spherical harmonics, which are then converted into sound harmonics.

wishes to reach, by carefully determining what are the relevant architectural features for his composition, simultaneously considering that any increase in resolution results in a much larger increase in the number of spharmonics - and thus in the required computing power. For a monument like a cathedral, a 30 cm resolution will require several billion spharmonics for all spherical shells, a number that reaches several trillions if the resolution is increased by a 10 factor.

4 - Mapping the spherical harmonics to sound harmonics

Once the spharmonic spectrum is obtained, their mapping to sound harmonics is almost straightforward: each spharmonic is transposed into a sound harmonic that maintains its amplitude, its wavelength and its phase. There are however two important points. The first one is that spharmonics are 3-dimensional mathematical objects (they are described by 3 coordinates), while sound harmonics are 2-dimensional. A reduction must then be applied, in a process that must preserve the entirety of the information from the 3D-space. This process is fully described in [2]. The second one is that a high-resolution spharmonic analysis yields a lot of waves of high to very high frequencies, which, when converted to sound waves, result in ultrasounds that the ear cannot perceive. However, these short waves may have a perceptible impact on what is heard through two phenomena. First, through their phase, they can modify the phase of audible sounds, thus potentially shifting the audible waves in a way that modifies the interferences between them, resulting in amplitude modulations. Second, the interferences between ultrasonic waves may create, through beats, frequencies that are easily detectable : a 40 KHz sound associated with a 41 KHz one generates a 1 kHz beat, which is in the audible range. Through these two phenomena, the smallest architectural features, even the ones that are out of sight, manifest themselves through perceptible sound events.

#### 5 - Generating the musical timbres and tones by selectively adding the sound harmonics

The harmonic jungle that is obtained after mapping the spharmonics is impenetrable, and produces no recognizable sound: the number of harmonics is so important, and the sound spectra so dense, that playing them would produce an almost perfect white noise. The next step therefore consists in selectively pruning this harmonic jungle in order to produce sounds whose timbre and tone can be individually identified, while preserving the global harmonic structure of each sound. This is the first step of the composition process. The digital tools that are used are typical from the realm of spectral music. As opposed to classical music, where the composer places its notes in a space that is originally silent, the process here consists in starting from a space saturated with sound, and to sculpt it so as to obtain families of identifiable timbres. As the reader can guess, there are infinitely many ways to do this, and this part of the process is not anymore formal: it is almost entirely determined by the composer.

#### 6 – Composing the harmonic map

The final step corresponds to the preparation of the harmonic trajectories. The composer now has at his or her disposal a large number of timbres and tones, like the different sounds that can be produced by a synthesizer, the oscillators corresponding to the architectural elements, and the modulators to the different sound processing tools used for setting the timbres. The architectural space is then separated into zones corresponding to

different timbres, and the challenge for the composer is to try to associate, for each zone, the ambiance produced by the music to the atmosphere of the corresponding place in the building. In the Mende cathedral, the timbre were classified into sets of categories, ranging for instance from «familiar» to «unusual», or from «percussive» to «sustained». The more familiar timbres, sounding somewhat like bells or organs, were used close to the access areas of the installation, which were close to the entrance portals. The most unusual ones, made by associating the harmonics in more contemporary ways, were heard close to the most sacred places of the church, like the chair or the altar. Short percussive sounds were associated with the alleys where people were walking. Longer ones were used in the areas with church benches where the visitor could sit for a while, trying to catch the sounds suspended in space by moving the lantern with his arm, creating time-spread, contemplative pieces. Moreover, the sounds being polyphonic and spatialized, the timbre that could be heard in a particular harmonic point depended on the direction by which that point was reached : this made almost impossible to create twice the same composition. Finally, small islands of silence were positioned at certain specific places, so that the visitor could rest his ears for a while, allowing him to regenerate his desire for architectural musicality. By walking the cathedral, he could then compose the successive movements of his harmonic trajectories, which became nothing less than the spatial scores of his own compositions.

### **6 - Spherical harmonics : messengers, organizers, descriptors**

Spherical harmonics are conceptually simple – elementary waves running on spherical surfaces – but they are mathematically complex, and present important challenges in terms of computer processing. One could legitimately ask why they have been chosen over linear harmonics, which are conceptually equivalent but much simpler to use. Several reasons led us to privilege them. The first one is that they greatly facilitate the enforcement of several of the constraints exposed in section four above. As a fundamental principle, describing any element of reality in terms of waves imply first to find a periodic description of it. In that respect, the use of linear harmonics would have required to artificially «periodize» the cathedral, for instance by repeating its shape a large number of times along the three axis of coordinates, in order to transform it into a sound signal shaped like of endless, aligned cathedral representations. Even so, this modification would have implied to maintain the continuity of the waves at the ends of the cathedral-shaped signals, which, in sound processing, is usually made by convoluting the signal with a function that smooth it at both ends. This method, which typically uses a smoothing signal delimited by a temporal window (the most famous one, the Hanning window, uses one cycle of a cosine wave) actually transforms the wave by modifying its harmonic content. This problem is completely eliminated by the use of

spherical harmonics, since the repetition of the signal is inherent to the sphere : constantly running around the spherical shells, the wave naturally and automatically repeats itself without any need for an artificial completion. Through this, an important step towards non-arbitrariness is achieved.

Moreover, the use of spherical harmonics naturally locates the visitor at the centre of the transposition. That would not be the case with linear harmonics, which implies no privileged point, and where this location would have to be decided in an essentially arbitrary way in relation with the wave signals.

Besides these formal considerations, spherical harmonics are also used because of their deep symbolical content, and of their historical rooting. It can be demonstrated that the transition from the Harmony of the Spheres to contemporary cosmology went along with the substitution of the notion of harmonics, a mathematical/physical object, to that of harmony, an all-encompassing concept that was used to describe, arrange and control the affairs of the world and the Universe, and that transmitted, through the notion of proportions, the messages and wills of the gods to the human beings. Harmony also allowed these same humans to understand the way the whole cosmos was structured. It is not uninteresting to notice that harmonics, and especially spherical harmonics, play today a somewhat similar role. To give but one example, they allow us to explore the

cosmos at all scales : on the microcosm, they reveal the behaviour of electronic orbitals; on the macrocosm, they tell us how the Universe is structured at the most gigantic scales, and even allow us to propose some hypothesis about that structure [4]. In both cases, they act as describers and messengers of regions of the world that will forever be unreachable to us, in the same way that harmony was transmitting to human beings the ways to organize their life and their environment as prescribed by the gods, who were living in the also unreachable celestial spheres.

It is actually no wonder that these objects prove optimal for describing our physical Universe, whose configuration at several scales is determined by forces such as gravity or electromagnetism whose elementary field of action adopts a spherical topology. They are also particularly fit to represent our perceptual Universe, since our perception of the world is uniquely based from our current position in the cosmos. In this respect, it is worth remembering that the history of cosmologies, which is the history of the histories of the cosmos, closely matches the progressive displacements of the center of the world since the Greek Antiquity. As a matter of fact, this privileged point spent almost twenty centuries oscillating from the center of the Earth to points located very near to the planet, before jumping towards the Sun, then to the center of the Milky Way, to end up being pulverized on every point of the Universe with Einstein and Hubble. From the first half of the XXth century, we know that no point can pretend to a

privileged central status : everything moves, and everything can be considered as moving around any point taken as the center of every movement. Therefore, the only singular position that remains definable is the very point where I stand, and from which I contemplate the Universe.

### **7 - Perceptual spheres, spheres of eventual interaction**

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From that very point, two sets of spheres can be defined. The first is made of my own perceptual spheres. These are the spherical shells on which I project all the objects, being and phenomena that stand, move and unroll around me. The farthest one is the celestial vault, whose spherical appearance is obvious by any clear day or night : though every element of it is a three-dimensional object lying in a three-dimensional space, everything happens like if all these objects were projected against a spherical 2-D screen. A good illustration of this phenomenon is provided by the constellations, whose 3D-configuration is not perceptible from the Earth to the naked eye. In the same way, all earthly objects located to a certain distance from me are perceived as 2-D projections of these objects on a spherical shell whose radius correspond to that distance, just like constellations made from figures of objects. All the positions, proportions and deformations of these projections change with my displacements, which confirm the fact that I am actually at the center of all of my perceptual spheres.

The second set of spheres is called « spheres of eventual interaction ». It is based on the level of action or energy that is required to act on the objects or beings situated around me. The closest objects can be reached with minimal actions, just by stretching an arm, for instance. The next ones require a displacement of the body; then there are those that require a few steps; those that imply another kind of physical effort, such as opening a door, or climbing a wall; up to those on which any direct action is impossible, such as the Moon, the stars and the galaxies. The important point here is to consider the notion of « distance » as metaphoric : objects or beings that are physically close to us can imply a disproportionate effort to interact with, because of the symbolic or imaginary load that we put on them. An example is provided by a situation where a man wants to interact with a woman that impresses him a lot for a reason: though the woman is physically very close, interacting with her will require a lot of energy. All the objects and beings that require the same level of energy to interact with define a sphere of eventual interaction. It is easy to see that, just like the perceptual spheres, all such spheres are concentric and centered at the very location where I stand; and that they constantly transform and evolve with my own movements and displacements.

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***8 – Layers of knowledge : the Point [d']  
Origine project***



Fig. 7 (left) – Perceptual spheres. All objects and beings around me appear like constellations projected on successive spherical screens. Fig. 8 (right) – Spheres of eventual interaction. The radii of each of these concentric spheres depends of the level of action and energy I need to interact with each of the objects, events, beings and phenomena that surround me.

I hope that these considerations will help the reader to understand the main layers on which rests the Point [d'] Origine project, in particular for what concerns its name : from an antique universe where everything was measured from an origin point (*un point d'origine*, the center of the world), the evolution of cosmology progressively led to the concept of a universe where there is no origin (*il n'y a point d'origine*). To fulfil the intentions of the present paper though, a step is missing : if every architecture is a small cosmology, then, according to the current models of the world, the visitor wandering among its space should be constantly located at the center of the architectural cosmos, carrying this center with him along his displacements. And if the music is also a reflection or a transposition of the same cosmos, or vice-versa, then the whole installation becomes an extensively immersive representation of the contemporary universe, using all the resources of visual and auditive perception in a sensorial and perceptual synergy.



As the reader can see, the *Point [d'] Origine* rests on layers of knowledge pertaining to fields that can seem very remote from each others. From the description of the installation itself, it appears clearly that it is not necessary to know them all in order to fully appreciate the live experience. However, since the work triggered a lot of questions from its



very beginning, it is also presented along with a parent exhibition in a near gallery in which the origin and mechanisms behind it are fully described, and illustrated through architectural plates, sculptures and video animations. In this way, all these layers of objective knowledge, be they historical, theoretical, scientific or technological, are made available for all interested audiences. But as stated in introduction, they does not constitute, nor sum up, the essence or aim of the work, whose intention is to provide the visitor with an experience that will increase in his mind the consciousness of his central position in the universe, simultaneously inducing the notion that the same is true for all human beings. It is also to magnify and concretize the importance of the connection between architecture and music by providing an environment where the relation between these two arts is made as obvious as possible, and to show the depth of their anchoring into primordial cosmological notions, thus revealing that both, each in its own way, evoke our very position and situation in the Universe.

If this result is achieved, which can be verified by experimenting the installation or by speaking with the people that experimented it, then the whole experience could become an illustration of the specific kind of knowledge that art can produce and transmit, and of the

singular ways by which this transmission occurs. And if the visitor, after having composed his own harmonic trajectories, reaches the parent exhibition in order to better understand the origin of the music he just created, then the work will also have played an often neglected, but nonetheless major role, that of a vector of knowledge, a curiosity trigger that which will induce in the visitor's mind, through the emotions and impressions he went through, the desire to learn more about the underlying mechanisms of the Universe he lives in.

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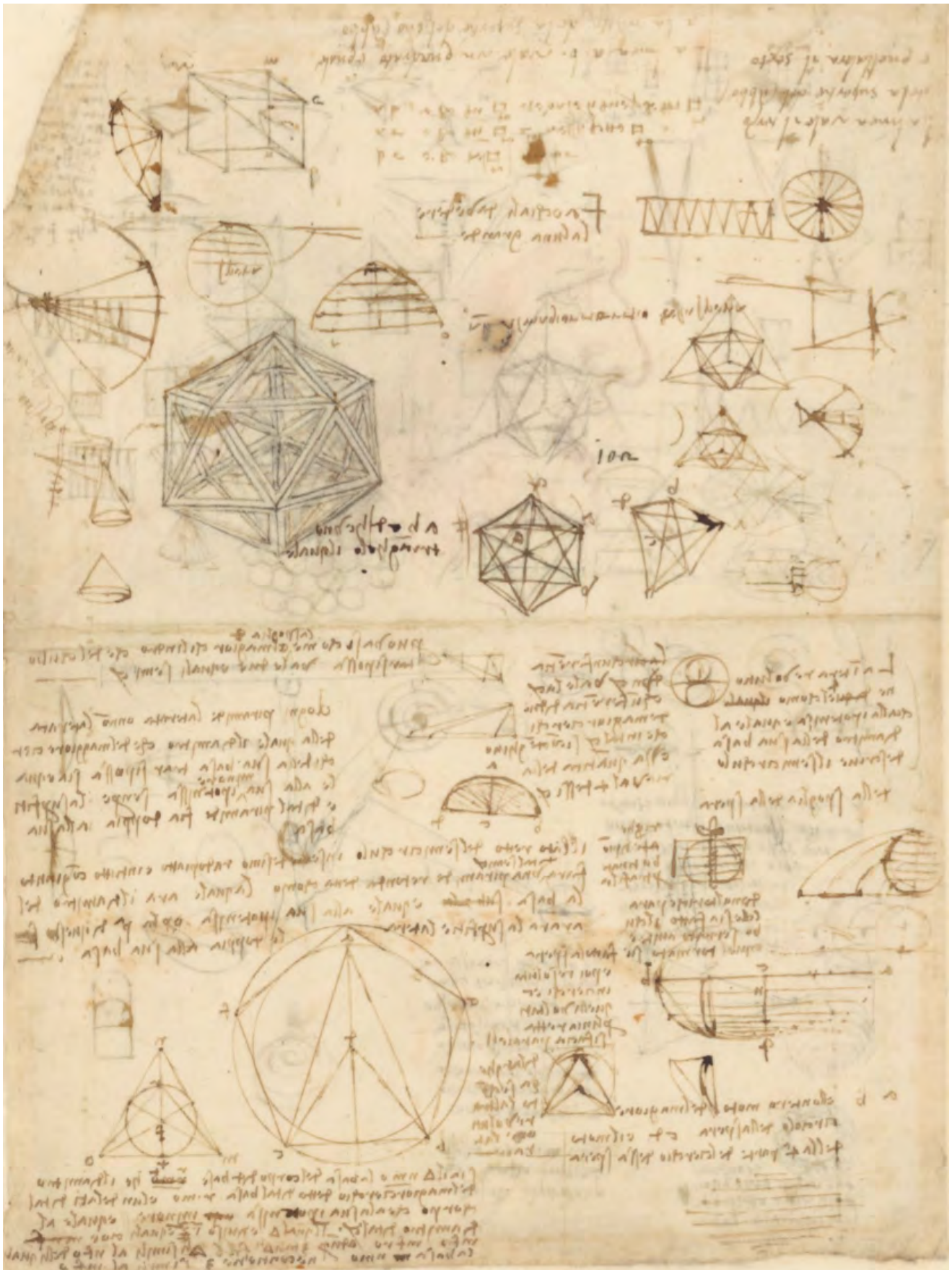
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Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations

# Generative Processes in Art and Science

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## 1. Abstract

This paper will address my recent work as a visual artist and my exploration of generative art processes. I will also address some of the pedagogical strategies I have used in the classroom at Southern Illinois University Carbondale, where I am an Associate Professor of Digital Media Arts in the Department of Cinema and Photography. In the Fall of 2018, I co-developed and taught with my colleague Dr. Scott Hamilton-Brehm, an Assistant Professor in the Department of Microbiology, a University Honors course entitled *Creative Critical Thinking: Between Art and Science*. In this course we had the students explore the generative possibilities of an iterative process, while working collaborative on projects that involve both science and engineering as well as the aesthetic issues of art and design. Through creating generative art, students began to question previous assumptions about originality, creativity, and craft, as well as the role of creativity within the process of art and science.

For me teaching and research exists in a symbiotic relationship and my generative arts practice is a personal inquiry into fundamental questions about our values, ideas, fears and dreams. I am interested in how the humanities and technology shape our

individuality and communities, and how the arts and humanities can inspire us to ask who we are and what our lives might mean.

## 2. Technological Reproduction Leading to Generative Art Processes

### **Let Art Flourish---and the World Pass Away**

“‘Fiat ars---pereat mundus,’ says fascism, expecting from the war, as Marinetti admits, the artistic gratification of a sense of perception altered by technology. This is evidently the consummation of *l’art pour l’art*. Humankind, which once, in Homer, was an object of contemplation for the Olympian gods, has now become one for itself. Its self-alienation has reached the point where it can experience its own annihilation as a supreme aesthetic pleasure. *Such is the aestheticizing of politics, as practiced by fascism. Communism replies by politicizing art.*”  
(Benjamin 42)

In the early 20<sup>th</sup> Century, Walter Benjamin witnessed the attempt of fascism to render politics aesthetic, seen in propaganda such as Hitler’s mass rallies and ultimately in war, as expressed by the Italian futurist F. T. Marinetti. In the early 21<sup>st</sup> Century, we bear witness to the self-destructive aesthetic pleasure one feels watching 24 hour cable news, structured like reality television, presenting a world where what is truth

and what is falsehood is nothing more than a difference of opinion. Our own self-alienation has reached the point that we are watching a system that profits from telling us news stories of freak weather anomalies while so many deny climate change. We witness the dehumanization of immigrant children held in cages, and the perverse sense that our systems of government are no longer working, while so many believe government is no longer necessary. All these narratives are presented to us in an electronic hallucination on screens supported by technologies that once promised free expression, and yet ironically seem to only produce the tightening of already existing corporate and governmental control.

As a visual artist working in the early 21<sup>st</sup> Century, I would like to present some examples of my generative art while addressing a few ideas of Walter Benjamin. My art practice produces code-based automated art, live art performance, drawing, painting and sculpture, all of which examines the relentless flow of information on the Internet that quickly becomes digital leftovers, to reveal a relationship in which we don't simply consume media, but are also consumed by it. I explore the Internet as source material to be appropriated, taken apart, juxtaposed, and recycled, by writing computer code that is automated and runs on a 24/7 schedule producing a form of collage I call *Cruft*. The resulting digital artwork allows me to investigate broader issues of traditional concepts---such as originality, creativity, authorship and eternal value.

The Internet has the ability to provide freedom by connecting us at great distances, democratizing the world's knowledge, and facilitating disruption and resistance to systems of power. It can also simultaneously provide control by restricting and regulating our thoughts

and actions while propagating fear, divisiveness, surveillance and repression. My artwork delves into this very nature of the Internet, pulling at it's strengths and exposing the flaws, producing what has been coined Post-Internet art, that by definition references the "network" that we all inhabit, and ultimately, it's effects on our society and culture.

In his 1936 essay entitled "The Work of Art in the Age of its Technological Reproducibility," Walter Benjamin discusses a shift in perception and its effects after the advent of film and photography.<sup>7</sup> He writes of the loss of aura through the reproduction of art. For Benjamin the aura represents originality and authenticity. A painting has an aura while a photograph does not. He states, "In even the most perfect reproduction, *one* thing is lacking: the here and now of the work of art---its unique existence in a particular place. It is this unique existence---and nothing else---that bears the mark of the history to which the work has been subject. This history includes changes to the physical structure of the work over time, together with any changes in ownership" (21). Digital information does not have an aura, as it usually never enters the world of atoms, and will always remain nothing more than computer bits existing nowhere and everywhere, displayed upon screens and stored on hard drives separated by large geographic distances. In the age of digital information which can be manipulated algorithmically, the separation between the here and now live event and its immediate documentation has completely blurred. Our social media habits reflect this compressed sense of time. While at some distant vacation destination, our

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<sup>7</sup> I am using a recent translation of this essay which has changed the usual 'mechanical reproduction' to 'technological reproducibility' which is more useful for discussing Benjamin in the digital age.

family and friends will be able to immediately experience our documentation just moments after the live event. The Internet helps make these digital media objects ephemeral, ubiquitous, easily copied and freely available.

### ***An Aestheticizing of Political Life***

*All efforts to aestheticize politics culminate in one point. That one point is war. War, and only war, makes it possible to set a goal for mass movements on the grandest scale while preserving traditional property relations. That is how the situation presents itself in political terms. In technological terms it can be formulated as follows: only war makes it possible to mobilize all of today's technological resources while maintaining property relations. It goes without saying that the fascist glorification of war does not make use of these arguments. (41)*

In my lifetime, it was the attack on September 11, 2001 that created a mass movement of fear and anger, as technology, warfare and the visual collided. I was in lower Manhattan, as I saw a small cloud of smoke rising above the towers. I was oblivious to the two passenger planes that were being subverted into missiles. I was experiencing warfare and terrorism, though at the time, not fully aware, I simply wondered if I would be late for work. The media showed images of the planes, the impact, and the buildings collapse, over and over, in a repetitive loop. Our screens had become weapons of terror. The system of representation was hacked, much like the planes and through this spectacle we were forced to relive the moment in a never ending present. The main stream media controlled the message and the United States was going to war. I became frustrated with the way

the media was presenting ideas and images that affected our world view. The ever present cable news cycle pushes a daily message of fear filled with political polarization. It was at this time that I began to think about how these digital images and text operated, one day influencing our daily discourse, the next day vanishing without a trace. Digital leftovers reminded me of redundant computer programming. Code that was once useful, but later forgotten and obsolete. It was these events, and my questioning of what happened to the images once they became digital leftovers, that lead me to making the auto-generated digital collages I call *Cruft*. To create this work, I write simple algorithms that an automated computer system follows. The instructions outline what websites to target, and the system then downloads selected images and text which are then used as source material, and remixed to create new artwork on a schedule that imitates the 24 hour cable news cycle.

The resulting endless war since September 11, 2001 has mobilized our technological resources as devices of fear and surveillance, that not only maintained property relations, but actually increased the speed of the wealth redistribution, which reached a fever pitch with the financial crash of 2008 and still continues to expand. The divisive rhetoric and the polarization of our current politics is the logical extension of Walter Benjamin's thoughts on the aestheticizing of political life. We live in a time of global anger, expressed in 2016 with the British vote to leave the European Union, known as Brexit, and the election of Donald J. Trump as the 45th president of the United States. *The aestheticizing of our political life is now complete.* The tools used to aestheticize our political life are the Internet, social media, computers, mobile phones and main stream media all of which have been weaponized to

produce fearmongering, surveillance capitalism, and mind control. As an artist I use these very same tools subverting the fear, surveillance and mind control, to create art that is an act of resistance in an age of technological reproducibility.

### 3. Recent Generative Art



#### ***Darkling (an eye on dangerous) Craft***

<http://www.robertspahr.com/work/darkling/>  
Created April 25, 2019 @ 04:47 AM,  
Started in 2017 with daily updates at 47 minutes past every hour  
Source: CCTV Cameras in the City of New York.

This craft program creates an auto-generated image which updates every hour, capturing images from surveillance cameras watching the streets of New York City.



#### ***Compost Craft (Pop! Goes the Weasel)***

<http://www.robertspahr.com/work/compost/>  
Created February 17, 2019 @ 08:53 PM  
Updated at 17 minutes and 47 minutes past each hour.  
Source: CNN.com, FOXNEWS.com, MSNBC.com

This craft program started running every 30 minutes beginning on May 1st, 2018. Each new craft becomes a layer on top of the old images, with the most recent news on top.



#### ***Value Meal Craft***

YouTube: <https://youtu.be/7DjHxxvsQHU>  
Updates daily at 9:12 AM EST  
Source: Donald J Trump, KABL960.com radio, WBUX-AM1670.com radio, & fast food images.  
Auto-generated video from computational processes.



### ***Ecce Homo: Trace Evidence #6***

<http://www.robertspahr.com/work/traceevidence/>

Electrostatic print, charcoal, ink and acrylic, 48" x 36"

2018, Signed and dated on the back.

The source images of *Ecce Homo: Trace Evidence* were created by the Deservings Cruft.

In response to the intense pace and constant change happening online, my art practice includes a slower and thoughtful method of applying traditional media such as charcoal, paint, wax and ink, to prints of selected *Cruft* images creating an analog iteration of the original digital image. These mixed-media images are created over longer periods of time resulting in a meditative process that subverts the goals of speed, spectacle and distraction, offering an opportunity for slower looking and deeper thinking compared to the crushing overload of an endless stream of automated *Cruft*.

### ***4. Generative Processes and an Iterative Methodology***

As an educator I try to inspire learning and curiosity by creating a classroom environment where students can develop their imagination, creativity and

innovation. I work to stimulate their imaginations and to help them understand that creativity is a process that strives to create original ideas of value, while innovation is simply putting creativity into practice. When I give generative art assignments, I use the following definition:

***“Generative Art can be defined as any analog or digital art practice, that incorporates instruction-based, mechanical, organic, computer-controlled, and/or other external, random, or semi-random processes and/or apparatuses directly into the creative process, which is then set to motion with some degree of autonomy contributing to or resulting in a work of art.”***

Students are exposed to the history and current practice of generative art, and to consider the use of chance and automation, which brings into question assumptions about originality, creativity and craft, as well as the role of the artist within the creative process.

### ***4.1 Selected Student Work of Generative Art***



Net Art, CP470D

Kate Collins

Net.Art, HTML/CSS/Javascript, 2019

<http://www.robertspahr.com/teaching/studentwork2/kcollins/>



Media Arts Performance, CP300D

Hannah Friedman & Thomas Bickel

The Fabric of Time - Performance Art with Clothing, 2018

YouTube: [https://youtu.be/vPM7W3VXq\\_s](https://youtu.be/vPM7W3VXq_s)



Media Arts Performance, CP300D

Generative Art Walk, 2018

A mindful walk exploring the generative possibilities of nature, architecture, sound, space and color.

In these generative art assignments students might explore the use of chance and randomness, as well as computational art using Javascript, Processing and/or Raspberry Pi computers. We also explore historical precedents and contemporary artists using generative processes. The students explore issues of modularity, automation,

and variability, as well as the creative possibilities of the computer interface, computer operations, and the database, as well as analog processes of live art performance.

The work ranges from a web based work of Net.Art that embraces the interactivity and agency of the viewer, as well as random processes that produce a work of art that is very different each time it is viewed.

In the Media Arts Performance class, students explore the role of the artist and the work, while thinking about what they control, and what they do not control. They write simple performance scores as the algorithm of the live event, developing methods that produce varying amount of artistic control over the details. One of the goals is for the students to become more receptive to happy accidents, looking for them in places they might not expect to find them.

In the Generative Art Walk, the students take a mindful walk across the campus, slowing down and looking at life with the same mindfulness that one looks at a work of art. Students think about the language of art, and the principles of organization, making connections between the design of nature and architecture, listening, looking, and feeling. This walk is then used as a generative process to develop an awareness and mindfulness that will then lead to new works of art through discussion and an associative method of connecting ideas.

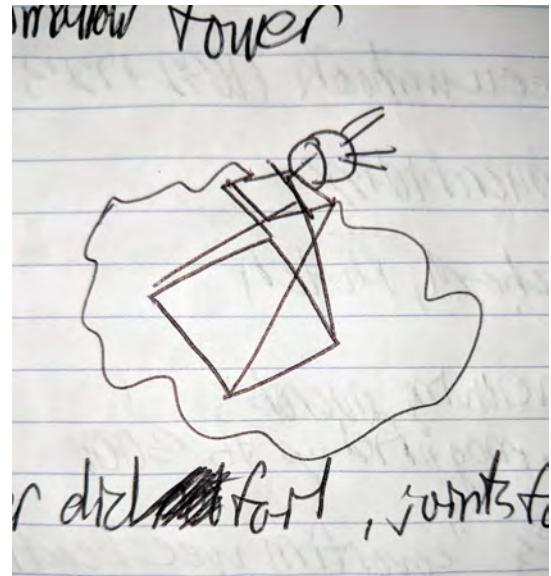
#### ***4.2 Generative Processes Between Art and Science***

In the Fall of 2018, I co-developed and taught with my colleague Dr. Scott Hamilton-Brehm, and Assistant Professor in the Department of Microbiology, a University Honors course entitled Creative Critical Thinking: Between Art and Science. Although many view Art and

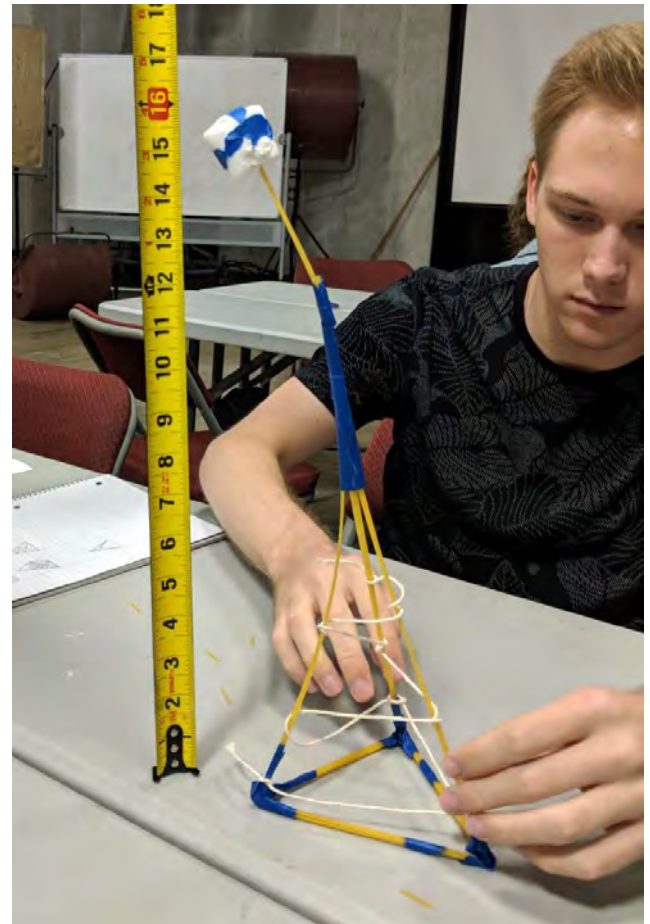


Science as opposites with different practices and artifacts, our course explored the common creative processes that are the starting point of both endeavors. We looked closely at the ways the arts help give us insight into the human condition and how science can help explain the workings of the natural world. The students addressed a variety of problems from both a science and arts perspective. We developed a creative iterative approach to critical thinking to achieve an empirically driven solution to fitness problems as it applied to both art and science.

In the *Creative Critical Thinking* course, we had the students explore the generative possibilities of an iterative process, while working collaborative on a project that involves both science and engineering as well as aesthetic issues of art and design. For this course we adapted a team building exercise called *The Marshmallow Challenge*. Students work in small groups using 20 sticks of dry spaghetti, three feet of string, three feet of tape, and one marshmallow. In 18 minutes each group attempts to build the tallest structure that will support a marshmallow. We did three iterations of this challenge, the first attempt very few groups even can build a structure that does not collapse. This exercise set the stage for discussing creativity and design based on nature.



*Creative Critical Thinking, UHON 351  
Observations of the Iterative Process,  
2018*



*Creative Critical Thinking, UHON 351  
Marshmallow Challenge, 2018  
Alex Menke*

### **5. Conclusion: The Role of Generative Processes**

Generative Processes are an important component of creativity. In my recent classes, both art and science students have explored their creative practice and have developed the tools to allow them to work in an iterative way, stress testing their solutions and then further developing their prototypes. This process also included consciously embracing chance, allowing the process itself to present solutions that the students would not have easily discovered, either due to preconceived solutions, or self imposed constraints. The generative exercises developed for my students have allowed them to explore solutions with a freedom and a sense of experimentation, as well as forcing them to work quickly with very little self-consciousness; to consider their role as either artist or scientist within their creative process.

For me teaching and research exists in a symbiotic relationship and my generative arts practice is a personal inquiry into fundamental questions about our values, ideas, fears and dreams. I am interested

in how the humanities and technology shape our individuality and communities, and how the arts and humanities can inspire us to ask who we are and what our lives might mean.

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Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations

# SMBH

*Music Live Performance*

*Gabriel Maldonado  
Musician and Composer, Rome  
Italy*

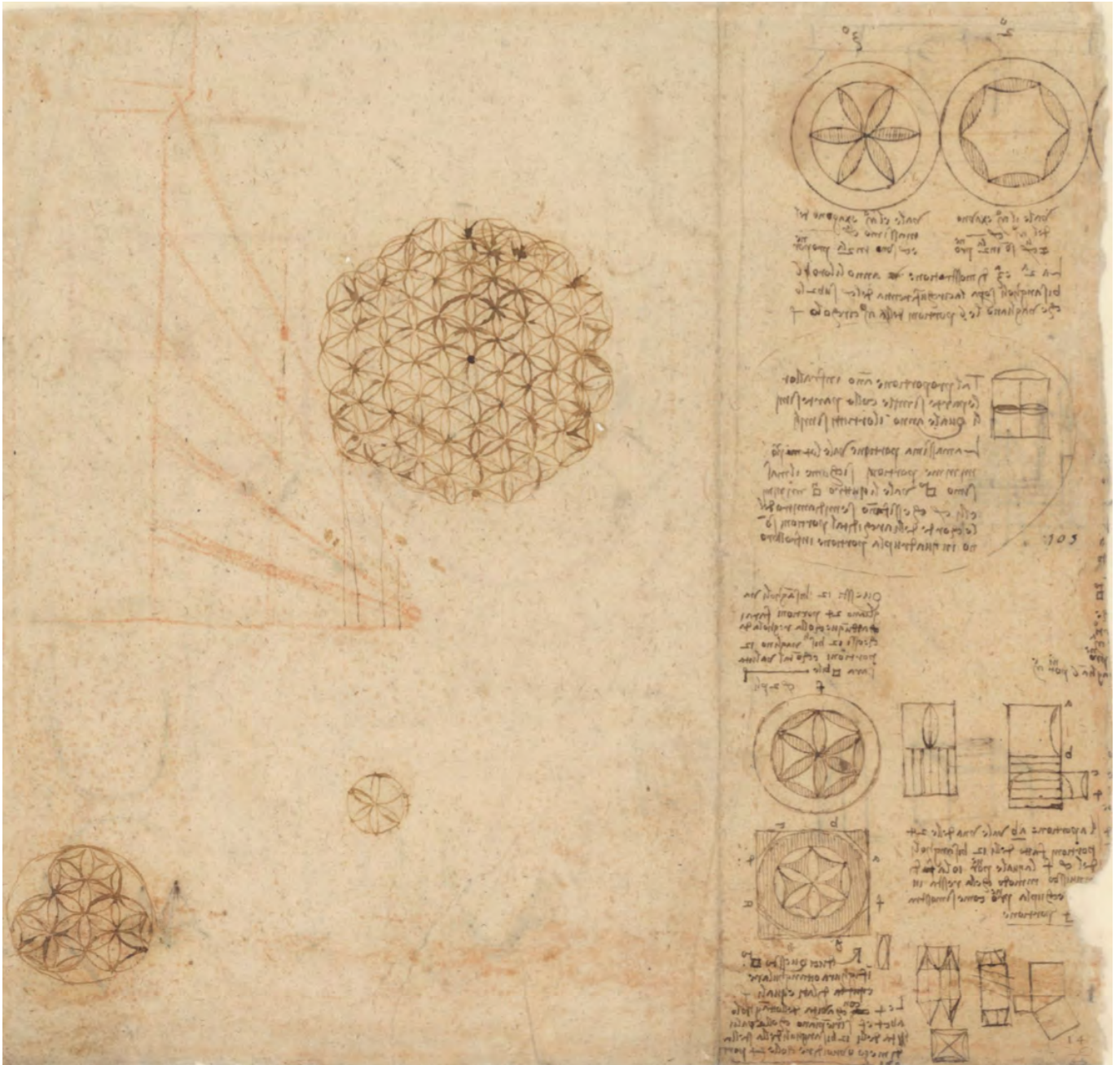
The M87 black hole (recently photographed thanks to an array of telescopes located around the globe), together with TON 618, S5 0014 + 81 and SDSS J0100 + 2802 are four of the largest black holes discovered to date.

Black holes show incredible properties not only in terms of their spatial size, but also in terms of time. The time, when one is in the event horizon of a black hole, is literally stopped, frozen, with respect to the events outside the horizon itself, due to the enormous intensity of the gravitational force. As a consequence of the theory of relativity, for every second spent into an object (for example a clock counting the seconds) located at the event horizon of a black hole, in the rest of the universe it will literally spend eternity (!)

I found that the idea of eternity links black holes to the concept of "hypertime". Hypertime, or multidimensional time, is a musical concept linked to the principle of identity between a single moment and eternity. It is a non-linear, non-homogeneous entity, without a beginning and without an end, in which virtual events can materialize in the act of performance following a non-predetermined order in the structure previously "frozen".

So the final musical result is influenced by two factors: by the structure or "sculpture" frozen in the "event horizon" of a computer's memory, and by the instantaneous dynamics that take place in the exploration of this structure at the time of the performance.

Even in the physical world, every passing and fleeting moment influences and conditions, and is in turn conditioned by, all past and present events in the universe. In other words, every single moment of our existence influences and is at the same time influenced by all the other possible conditions, probable or actual, in a sort of "ipertemporal" network of relations (as it is not limited by classical Newtonian



*Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations*

## Generative Algorithms, a *flexing* mood in space/time numbering

Alive *generative* performance by

*Celestino Soddu, Generative Algorithms  
for 3D Borromini spaces and chairs*

*Nicola Baroni, Cello and Generative  
Electroacoustic Music*

*Enrica Colabella, Generative poetic text in  
II Quadri:*

*La notte dell'Angelo / The Angel night  
"The sea dingle" / Il suono della foresta  
del mare*

*L'ordine non si costruisce con la  
ripetizione dell'identico / The order is not  
built with the repetition of the identical  
L'ordine nasce nella variazione / The order  
is born in the variation*

The main aim is **to connect poetic words sound** as a bridge with a generative *space* numbering performed by Celestino Soddu and with a time numbering performed by the cello sound, played by Nicola Baroni on his electronic music.

These multi-structures connections work for gaining **a flexing mood**

This connection between the generations of *numbering* in spaces and in music performs a *flexing* mood following these *prefixed characters* for the II Quadri:

*1 furioso suadente*

*2 profondo sospeso*

These ways of playing are one of the most ancient tools used in performing a musical text. For doing that, since, from ancient times, it is often used *the Italian language*, for the reason that it is the most adaptive for expressing the words sound.

The starting point of this performance is 3D *numbering* spaces generated through codes interpretations *abducted* from Borromini by C. Soddu. His generated Baroque cathedrals are performed by using algorithms, designed interpreting the transforming rules of Francesco Borromini. Borromini did not clarify his own transforming rules from Classic to Baroque because, like all great visionary people, these rules were hidden inside his opera. It is possible to discover them with algorithms, following the interpreting process defined in the Renaissance. In the generated variations, the original Borromini forms disappear. What remains is the character and complexity of Baroque vision filtered by C. Soddu as his own particular approach to space art. The set of Baroque algorithms works also for different events at the microscale.

With the occasion of the event at the *Casa delle Letterature*, C. Soddu presents a generation of chairs built with his Baroque algorithms. Moving from architecture to design, the topological paradigm obviously changes, but Soddu kept the same transformation codes used to generate Baroque cathedrals. The result is clearly recognizable as Baroque even if the forms are not directly attributable to the Past Baroque. They are similar, not a copy, as in organic life. The contemporary nature of these generated chairs reflects not only the transformation processes adopted but also Soddu subjective vision of space in its modern complexity.



Celestino Soddu, 3D prints of Baroque Cathedrals, 2019

Nicola Baroni's musical performance integrates with the spoken texts as a cello commentary developed by electroacoustic algorithms generating sound shapes in real time.

QUADRO I The cellist engages with baroque sonic archetypes ornamented by contemporary musical styles and gestures  
 QUADRO II offers an electroacoustic extension of the previous sonorities, developed as memories and transfigurations interactively reliant on the accents of the recited words

Between *sound and space numbering*, there are Enrica Colabella two original poetic texts:

**Quadro I:** a fragment of the Borromini last night in "*The Angel night*"

The poetic text follows an interpretation of data regarding the Borromini last night: an official report of his suicide attempt

and some imaginary hypothesis on a possible kill action.

The revocation from past in our time of this tragic event tries to resound the pathos of a great artist in his last days, full of solitary darkness.

La notte dell'Angelo / The Angel night

*"Non mi sarei posto a questa professione per essere solo copista"*

*"I would not have put myself in this profession to be just a copyist"*

*Francesco Borromini*

Era un tempo troppo elevato. / It was too long a time.

Il tempo dell'oscurità che copre ogni dove / The time of darkness that covers everywhere

I disegni, gli scritti: parole e figure oscurate. / Drawings, writings: *words and figures obscured.*

Ogni lume non trasfigurava il buio statico  
fisso / Each lamp did not transfigure the  
fixed static darkness

Una notte perenne indelebile sulle sudate  
carte. / An indelible perennial night on his  
sweaty papers.

Leonardo aveva descritto a fondo il male  
oscuro del non vedere / Leonardo had  
described in depth the dark evil of not  
seeing

Dopo il racconto dell'esperienza terribile  
di Piero della Francesca: / After the story  
on Piero della Francesca's terrible  
experience:

*“Qual è colui che non voglia prima  
perdere l'udito, l'odorato ed il tatto, che il  
vedere? / “Who is the one who does not  
want to lose hearing, smell and touch  
before seeing?*

*Perché chi perde il vedere è come uno  
che è cacciato dal mondo, / Because  
whoever loses sight is like one who is  
driven out of the world,*

*Perché egli più nol vede, né nessuna sua  
cosa, / Because he no longer sees, nor  
any of his things,*

*E questa vita è sorella della morte. / And  
this life is the sister of death.*

*Infine, aveva deciso, determinato ad  
incontrare la morte. / Finally, he had  
decided, determined to meet his death.*

*L'ora migliore quella della sera dove il  
buio avrebbe oscurato / The best time is  
the evening, where darkness would have  
darkened*

*Le ombre del sangue sul letto per il suo  
assistente Massari / The shadows of blood  
on the bed for his assistant Massari*

*Che ignaro al mattino lo avrebbe scoperto  
/ Who unaware in the morning he would  
discover him.*

*Il suo buio si spegneva nel buio infinito  
della morte. / His darkness blew out in  
the infinite darkness of death.*

*Tutto pronto: la richiesta di silenzio, /  
Everything is ready: the request of  
silence,*

*L'inizio di un testamento, non finito / The  
beginning of his last will, unfinished*

*L'ordine di ogni suo scritto, come ultima  
carezza, / The order of each of his  
writings, as his last caress,*

*Prima di gettarli nel fuoco, secondo la  
tradizione / Before throwing them into the  
fire, according to tradition*

*Degli Antichi Maestri, che l'avevano  
custodito da sempre. / Of the Ancient  
Masters, that had always embraced him.*

*Fissò la spada affilata sulla testata del  
letto / He fixed his sharp sword on the  
head of his bed*

*Pronta ad infliggere l'ultimo perenne  
taglio della vita / Ready to inflict its last  
eternal cut of life*

*Verso il buio irreversibile perenne della  
morte. / Towards the perennial irreversible  
darkness of death.*

*Si lanciò forte come un soldato dal cuore  
traboccante onore. / He threw himself as  
hard as a soldier with an honor  
overflowing heart.*

*La fine dell'oscurità viva era lì, pronta ad  
estinguersi: sul filo di lama. / The end of  
his alive darkness was there; ready to die  
out itself on the cutting edge.*

*L'Angelo pietoso deviò la direzione. / The  
compassionate Angel diverted the  
direction.*

*La lama colpì, ma non in immediata  
profondità di morte. / The blade struck,  
but not in instant depth of death.*

*“Splende la luce al cieco...la morte  
dona la vita”. / “The light shines on the  
blind ... death gives life”.*

*Un urlo straziato come di bambino senza  
madre/ A howled cry like a motherless  
child*

*Echeggì nella casa. L'assistente si destò  
dal suo sonno fiducioso. / Echoed in the  
house. His assistant awoke from his  
confident sleep.*

*In un attimo gli fu accanto, Lo strinse in  
fasce di sangue, / In a moment he stood  
beside him, squeezing him in strips of  
blood,*

*Cercando di frenare la sua vita, che tanto  
aveva donato di bellezza. / Trying to hold*



*back his life that gave so deep homage to beauty.*

*Corse a chiedere aiuto, che trovò immediata sulla strada dell'Angelo. / He ran to ask for help, which he found immediately on the Angel road.*

*Borromini trovò aiuto, cura nel corpo e nell'animo. / Borromini found help and care in body and in the soul.*

*In più scoprì nel pentimento della sua disperata azione di morte/ In addition he discovered in the repentance of his desperate action of death*

*La tenerezza infinita dell'amore che lo custodiva / The infinite tenderness of the love that surrounded him*

*E che aveva dimenticato nel buio della mente. / And that he had forgotten in his mind darkness.*

*Questo nuovo ultimo giorno che l'Angelo pietoso gli pose accanto / This new last day that the pitiful Angel set beside him*

*E' vivo per sempre tra le pieghe delle sue cupole a Roma / It is alive forever in the folds of his domes in Rome*

*In spazi di perfezione armonica, atti di un canto puro / In spaces of harmonious perfection, as acts of a pure song*

*Solitario e laborioso dove può risuonare la Divina Bellezza. / Solitary and hardworking where Divine Beauty can resound.*

*Spazi dove ancora oggi gli Angeli amano cantare le lodi a Dio. / Spaces where still today the Angels love to sing the praises to God.*

**Quadro II:** "Il suono della foresta del mare" / "The sound of the sea-wood"

*To read is to translate, for no two persons' experiences are the same.*

*W. H. Auden*

"Sea dingle" a W. H. Auden poem fragment from "The Wanderer" works as a catalyst for a *figurate* words sound.

In his young time, about the wanderer, Auden wrote a poem following an ancient

oral tradition with so many contributions for the final written version. This became **a classic** poem in evolution that inspired so many poets: Jonathan Swift's in *Gulliver's Travels*, Samuel Taylor Coleridge's in *The Rime of the Ancient Mariner*, William Golding's in *Rites of Passage* and in music in the Shubert *sonata*. The historical contexts of the 'corpus' given have very little in common with each other, but they hold a common *meta-language* able to discover each uniqueness in the same character during centuries.

This is a passage in open transformations as a generative art process works.

C'è una linea invisibile sul mare / There is an invisible line on the sea

Che I pesci tratteggiano di note / That fishes trace with notes

Al lume di luna, seguendo un canto antico / At moonlight, following an ancient song

Che solo l'onda conosce da sempre / That only the wave has always known

Un canto d'amore per I bambini non nati. / A love song for unborn children.

Un cespuglio rigoglioso nella profondità del mare / A luxuriant bush in the depth of the sea

Accoglie i loro suoni senza note /

Receives their sounds without notes

Come solo la tenerezza materna opera. / As only maternal tenderness operates.

L'onda li deposita ritmando l'invisibile / The wave deposits them, given rhythm to the invisible

Per correre ad infrangersi sulla riva, / For running to break itself on the edge,

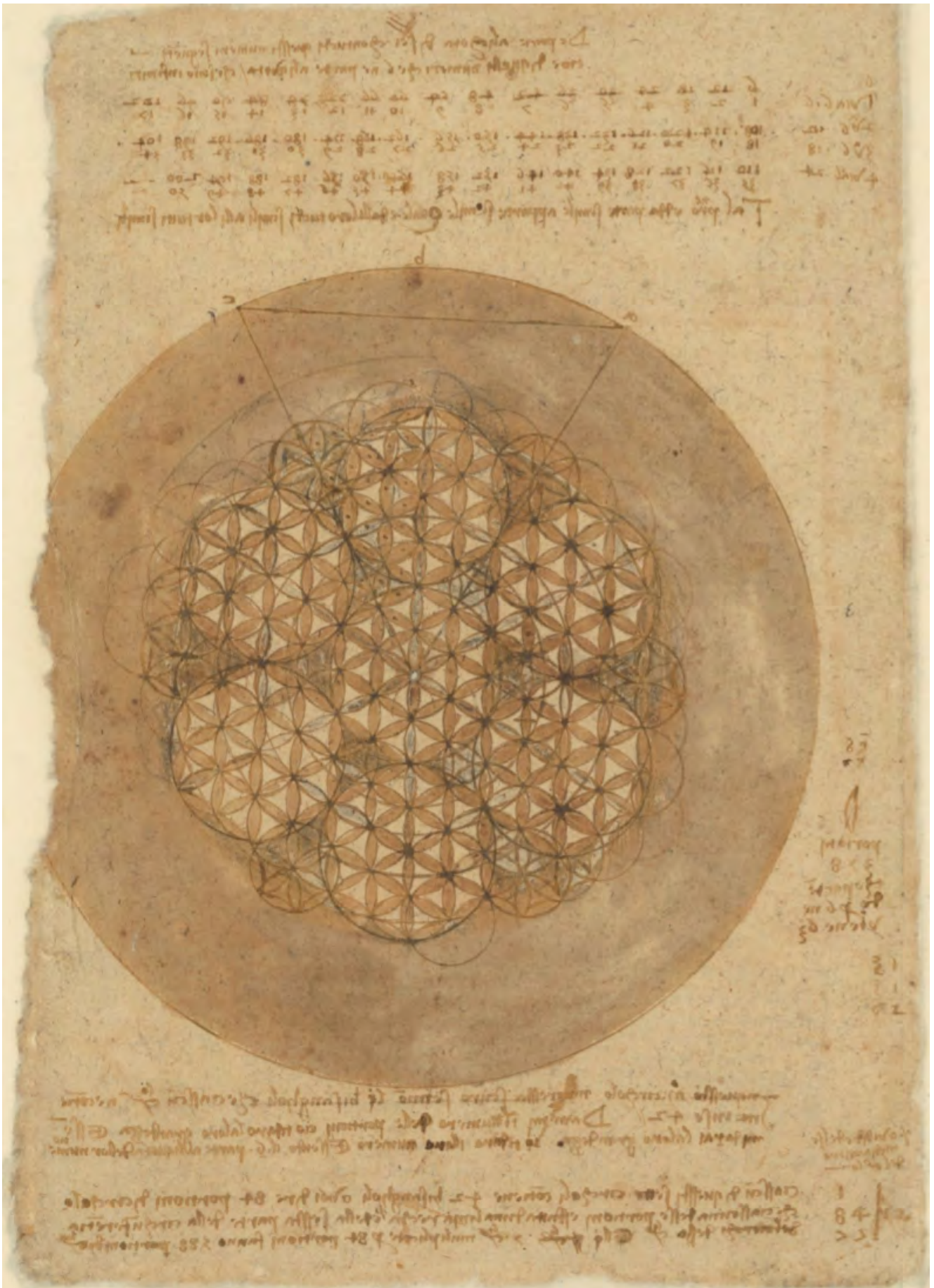
Amata ed odiata, ma senza timore. / Beloved and hated, but without fear.

E' il suo destino: si alza rigogliosa / It is its doom: it stands up luxuriantly

Per sparire in breve schiuma sulla riva. / For disappearing in short lather on the edge.

*Ad continuum*

Ed il cespuglio cresce, diventa una foresta / *And the bush grows, becomes a forest*  
Dove i poeti attingono la forza del canto / *Where poets draw the strength of song*  
"Doom is dark and deeper than any sea dingle"  
*Verso l'aurora. E' l'ora più profonda delle trasformazioni. /Towards the dawn. It is the deepest hour of transformations.*  
*Il buio si frantuma lentamente /The darkness shatters slowly*  
*Mentre la luce irrorà ogni singola piega / While the light floods every single fold*  
*Con la stessa forza con cui i fiori si aprono / With the same force with which the flowers open*  
*Pronti ad accogliere il lume segreto / Ready to welcome the secret light*  
*Per un inno collegiale alla bellezza. / For a collegial hymn to beauty.*  
*Abbiamo dimenticato di osservare /We have forgotten to observe*  
*Ciò che da sempre il giardino dell'Eden / What from always the garden of Eden*  
*Continua a manifestare ai nostri sensi. / Continues to manifest to our senses.*  
*La vista si è spenta. /The vision has turned off.*  
*Siamo orientati altrove, in falsa induzione / We are oriented elsewhere, in false induction*  
*La parola rimane ancora un ponte tra spazio e tempo. / The word still remains a bridge between space and time*  
*Un traduttore che unisce entrambi / A translator that unites both*  
*Per raggiungere la profondità del cuore: / To reach the deepness of the heart:*  
*Una corsa infantile sulla riva del mare. / A child running on the sea edge.*



*Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations*

# Trace time to Measure Space

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This paper discusses my personal trajectory and development in the act of generating art.

The desire to create art works through a generative process came about through a need to extend my personal creative, aesthetic, philosophical, and knowledge boundaries. Through doing so a sense and experience of interconnectedness arose that may seem incongruous with the idea of computer-generated art as being in some way soulless and lacking in 'human' sensibilities. This possibly came about through the understanding that computer-based systems perceive the world with absolutely equality, every object is considered through numbers and through relationships of and between numbers. With this in mind, based systems and procedures, when set in motion, offered a unique perspective for the creative artist. One in which a colour, a movement, an articulated idea, the motion of air and its interpretation (sound), the physiological responses, the behaviour of flora and fauna, and so on, can be integrated, adjusted, influenced by and influential on, the creation of something that while

generated from the sum of its parts far exceeds the sum of those parts.

***Beginnings: Imagine something you don't know.***

I was asked to teach courses in computer music and harmony at La Trobe University in the late 1990s, and the discussions became quite free ranging and vigorous. In one lecture we began discussing the value of a systems-based approach, serial music composition in this case, and why this may be a valid approach to anthropocentric expression. I personally found, and still find, the works of Anton Webern, particularly Symphony, Op.21 and the Three Pieces for Cello and Piano, Op 11. While these are so clearly the result of a systems-based approach they are artworks which most incisively exposed and resonated with my anthropocentric core on first hearing; perhaps it was Webern's acute attention to the immanent relationships within his systems that caused this.

The discussion, after listening to these works, continued on to the point that we considered the often-typical approach to music making – the expression of something extra-musical by the creator – has its creative potential confined within the knowledge of the composer. It was accepted that, if the creative act springs from the imagination of the creator, it represented only a small section of creative possibility and creative experience, it is impossible to imagine something unknown.

Generative processes can ameliorate this problem. While the process(es) that generate will begin in the creator's imagination, the outcome may well exceed their imagination.

***Initial discussion***

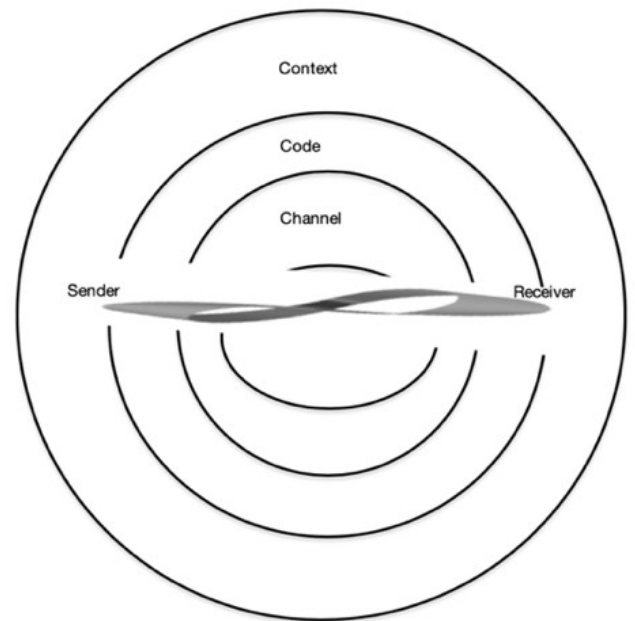
I first discussed this in the paper [Exploring the self through algorithmic](#)

composition, where I discussed approaches to algorithmic composition as providing insights to the composer's self. I wrote, "The trap of over-protectiveness is especially dangerous when creating with algorithmic processes. There is an endless, almost overwhelming desire to adjust the algorithm in the hope that a better composition will result. This desire must be restrained in order for truer and more frank self-expression to take place." [1], and this sentiment still informs my practice. The concept of a *better composition* is rooted in the concept of the artist, and/or the perceiver, as authoritative diviner and arbiter of what is *better*. This is a potentially flawed position and paradigm, particularly when the arbitration is made through the current and immediate knowledge and opinions of the artist – within what they know. But by staying true to the output of the algorithm(s) the composer creates works based on their larger goals, and less on the shifting notions of taste or immediate expression.

Philip Galanter says that to the neophyte generative art "often seems like a fuzzy notion" [2], and this is quite understandable. He then provides an elegant definition:

*"Generative art refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art."*

which is broad and embracing enough to fit all rules-based or rules-interpreted art making.



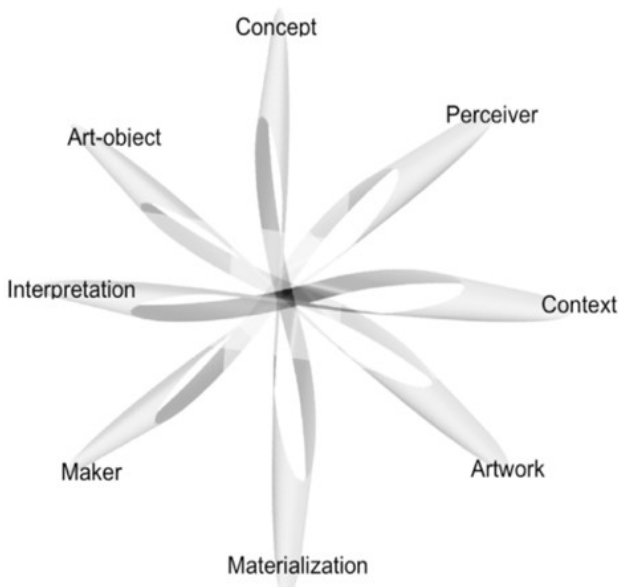
**Figure 4: The perceiver/maker environment**

The rules of counterpoint and fugue could be considered generative in that they reduce options and prescribe rules to create a known-to-be effective aesthetically pleasing outcome. However these may not be ones in which, as Galanter describes, "the artist cedes partial or total subsequent control" [3]. This ceding of control is a normal part of the music composition (and other mutable artforms) and the performance of the composition, in which the performer, in collaboration with the instrument, has the ultimate role in the rendering of the composition, which is in fact creating the art. Examples of this may be heard in the very different performances of Bach's Well Tempered Clavier by Andreas Schiff, Sviatoslav Richter, and Glenn Gould; here the same sets of sounds are prescribed in the score, but the outcome of each rendering is markedly different.

#### ***The role(s) of the maker and perceiver***

"To express [herself/]himself the artist must both receive and transmit." [4]

In my PhD Mapping Gestures in the Creation of Intangible Art Objects [5] I explored the relationship of the perceiver to the artworks and creator, the works created in this study are discussed in MOTION, SPEECH, and sotto . After the typical soul-searching, confusion, elation, depression, and clear and murky insights invoked by the creative PhD, it became clear that this is best described as an continuously reciprocal engagement. This is indicated in Fig 1, which draws from the typically tripartite and unidirectional descriptions of communication models outlined by Doty [6].



**Figure 5: Maker/perceiver interactions**

Here the communication strand is presented as a Möbius strip, where there are intuitively two distinct sides, but where through experience and experimentation only one can be traced. In this case the sender (maker) and receiver (perceiver) are constantly engaged in the reception and transmission process, simultaneously in the role of maker and perceive Here the context, code, and channel provide an environment that is constantly mutating and reinventing itself in ways that maybe

unexpected and unpredictable, with the centres of this environment: the sender, receiver, and artwork itself, being the most stable. Of course the context of code may change dramatically according to many different things; these can range from the social political contexts, the context inherent to the iteration of the work itself. For example: Picasso’s Guernica [7]–[9] can be seen as a political statement and as a “essentially a flat surface covered with colours assembled in a certain order” [10]. Both are accurate descriptions of the work. The first one in which the perceiver is making the work by applying an interpretation, the second where the perceiver is describing what is perceived.

Figure 2 indicates the central point where influences meet to create the making of the artwork, keeping in mind that the artwork is simultaneously and continuously made and experienced, therefore the act of making is always being generated, reified and experienced. Here the art object becomes an artwork (and vice versa); the context creates the interpretation (and vice versa); the concept is materialized and the material forms the concept, and so on.

**Works**

Here I give a brief, mostly chronological, history of some works I have taken a role in generating (partnering with a bespoke generative system). I will outline the philosophies that informed the cause of the works, the process of iterating these philosophies through generative processes, and then give examples, where possible, of the works.

**Aural works**

**Ambit Improvisations One**

My first real foray into computer-based generative music making is heard in “Ambit Improvisations One” [11]. This

came about through wanting to find, develop, and then use an approach to music making, one that transferred and translated forms of sonic communication from one modality, in this case ‘speech’, to another, ‘music’. My aim was to experiment with processes that could test the aesthetic legitimacy of this transference. I translated the phoneme string of the poem *Ambit* [12] into a string of numbers where each number related to a specific phoneme, for example the phoneme sound “A” (as in spade) was assigned the number 12 [13]. The selection of assigned numbers was arbitrary, with no intention of any extra-musical meaning. When this number was encountered it would trigger a set of four numbers to be produced, these related to: the note number, the loudness number, and the duration of the note number, and the period of time before another note could occur number. These four numbers were randomly generated, in order to ensure that I had no influence on the sounds attached to the phonemes of the poem, and therefore could divorce the meaning of text to the attribute meanings of the sound is created.

This process formed a melody not invented, and therefore removing any ‘interpretative’ action by me, in order to explore the potential outcomes of this process. This melody was then fed through another algorithm, based on the tropes of traditional Western harmony, that provided an accompaniment to the initial or altered melody.

### ***St Dymphna’s Bells***

*St Dymphna’s Bells* [14] was created at the same time as ‘*Ambit Improvisations*’. It too is based in creating some kind of interpretation of the spoken word. Here the reading of the poem by its author, Barry Dickins, is played through a set of filters that change the pitch and create harmonies based on the undulations of

the reader’s voice. Here, instead of being based on the well-tempered scales and pitch/frequency structures of Western harmony, the harmonic system was based on Pythagorean tuning, one that is not inherently capable of forming harmonic outcomes that fit the traditional sensibilities, paradigms and predilections of the western ear when played simultaneously or when modulations occur. But what does happen when used to provide harmonic outcomes is that unexpected and unintended pitches/frequencies are generated and heard as these frequencies collided with and influence each other and therefore the perception of a harmonic outcome.

Here “procedural invention[s], were] set into motion with some degree of autonomy contributing to or resulting in a completed work of art”, following Galanter’s paradigms, to confront and subvert the traditional sensibilities, paradigms and predilections of the western ear by creating a static set of procedures that significantly influence the heard outcome. First the sound of the voice is almost completely obscured, removing any possibility of understanding the text, but potentially enhancing/influencing the emotional content of the reading. Second the harmonic outcomes do not fit the traditions of the western ear, nor does the flow of sounds fit within the traditions of Western melodic and harmonic development.

By colliding and then blending two static and immutable objects, the recorded voice and the algorithm through which it was fed, procedural inventions, or codes, extra to the poem, algorithm, and heard work are confronted. These include that: when listening to text reading the communication of the semantic intentions of the author are important or even paramount; that, in the context of the western listener, specific harmonic and

developmental procedures are adhered to; and that computer-based musical works in some way lack the gestural and anthropocentric nature assumed in human-based creation of musical works. (When this work was created in 1999 there was an abiding sense that music in which computer/algorithmic generated systems played a significant part in the creative output lacked the nuance(s) of more anthropocentric creative outputs.)

### ***Hush! Caution! Echoland!***

The creation and reification of an art work requires a careful integration of all aspects involved, including the procedures of inspiration, devising, communicating, inspiring, testing, and broadcasting/performing/presentation. Each of these is vital in the invention and transmission of the work, and not paying any attention to the nuances of each diminishes the work.

Hush! Caution! Echoland! takes its name from a fragment of text in James Joyce's *Finnegans Wake*. It was created using the text of Chapter 1 of that book and this performance, by Brigid Burke on clarinet, and Roger Alsop on computer-based effects, was recorded at Elder Hall, Adelaide University, as part of the 2017 Australasian Computer Music Conference. [15]

The compositional process had three stages. The first was to generate a score from a computer reading of the text, and to then ensure that the score could be rendered by the musician(s). This process relied on the algorithms within the program Logic Pro 10 that's could translate actual pitches to a MIDI score, then there was the consideration of the instruments that maybe performing the work. I was initially invited to compose this work for a Chamber Orchestra, but unfortunately they became unavailable for the concert season. This required a

significant re-devising, as the procedures, context, and codes inherent to the instrumentation were now no longer relevant or appropriate; this channel of communication no longer was available. Fortunately clarinettist Brigid Burke was available to perform Hush! Caution! Echoland!, and this consequently required a significant rewriting of it. This rewriting not only required an adjustment in orchestration but also in the attitudes taken to the rendering of the work.

In the final version of Hush! Caution! Echoland! the approach taken to creating the performance of the work was to consider all elements: the score, the discussions of the score, the performer, and the environment in which the piece was performed as you equally generative in the final rendition of it. Together they become the system through which the work is generated.

Here the performer was fundamental in process of developing the piece. Burke is a well-known performer, composer and visual artist in Australia in the areas of contemporary new music and improvisation. Combining the skills in the creation of the work was significant part in its generation. I knew that Burke would it take and interpretive and improvisatory approach to the performance of the work, and that she would be responsive too its developments during composition and while performing. For this reason I staggered my discussion and presentation of the work to her.





*Figure 6: Example extract from the score to Hush! Caution! Echoland!*

I first gave her the score two weeks prior to performance, and with as little traditional scoring information as possible, there were no bar lines, and colour was used to indicate dynamics, an example can be seen in Figure 6.

The piece is quite long and tiring to play as it's continuous with little space for breath indicated in the score. I knew Burke would approach this score as an indication for the performance rather than a strict set of instructions. I did not give her any information regarding the way in which the score had been created, instead requesting her to interpret as she pleased. Three days before performance I told her how the score was developed and that she should consider it similarly to the way an actor made interpret a text, with the expectation that she would infuse it to a large extent, with her own personality. This would result in an interpretation unique to her, just as when an actor performs a script that interpretation is unique to them.

Two days before performance I outlined the electronic accompaniment for her performance, and while we were able to rehearse with this, we understood that the rehearsal experience would not be replicated in the performance experience. This accompaniment was made up of long reverberations and delays, with the sound being broadcast through the eight speakers made available the performance. This resulted in harmonies being created from the interactions of Burke's performance with the room, and the

subsequent feedback into the microphone from the sounds broadcast into it.

While Burke's performance was intended to be an interpretation of the score, one which may vary from performance to performance, the electronic

accompaniment was unchanging, it followed its own trajectory, with the only adjustments I could make relating to the speed of that trajectory.

This approach is unusual in traditional scoring for music, where the composer tries to illicit a performance that accurately represents their intentions. Instead considering the score to be similar to a script for a play, where each individual actor, the director, and the design team are required to interpret the script through their own abilities and intentions. In this way they become an intrinsic and essential part of the generative process. This process was chosen because I knew that Burke would adjust to her particular playing style, and that this would then result in an authentic performance in situ, one in which the score, performer, and actual and virtual environments integrated to make a unique holistic experience.

The development of this work is discussed in greater detail in the paper [Using the text of Finnegans Wake to create the electro-acoustic work Hush! Caution! Echoland!](#) [16] and in the accompanying presentation [17]

**FLOW2000**

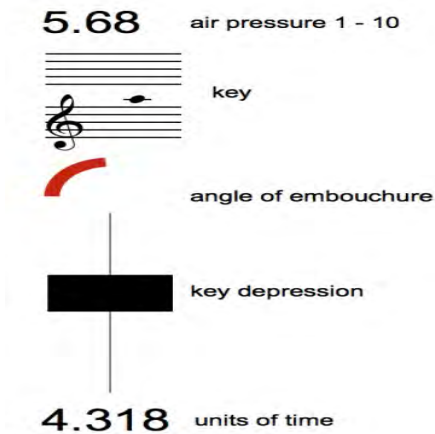


Figure 7; Example of the performer's score for FLOW2000

This piece [18] was created prior to Hush! Caution! Echoland! and is discussed in more detail in the paper Interpreting Data: Re-contextualizing data to develop approaches to musical composition [19], co-written with Vincent Giles.

It too uses the acoustics of the performance space, the interpretive and responsive abilities of the performer and an extra-musical cause, in this case the Reynolds Number. Its difference to Hush! Caution! Echoland! is that the score itself is generated during performance. An example of the performer's score is seen in Figure 4.

In this composition the first action is the performer playing one sound to excite the room. This begins the process of generating the score. As can be seen in Figure 4 five instructions are generated, these are the amount of air pressure the performer should exert in creating the next sound, the pitch of next sound, the angle of embouchure (or the articulation process), the depths to which the key should be depressed, and the comparative duration of the note played. Each of these aspects is open to interpretation by the

performer in the act of you performing, and can be decided on with the composer if desired.

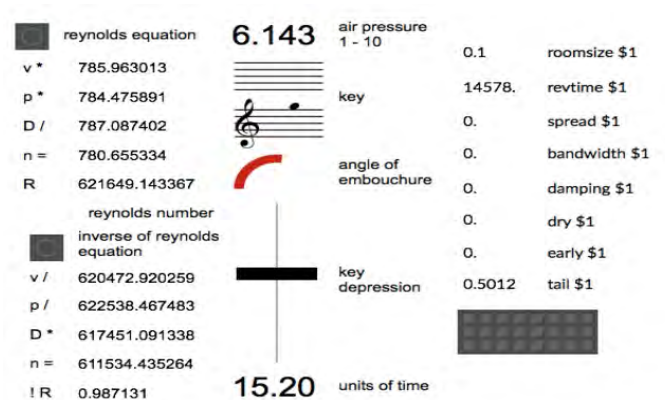


Figure 8: Example of the composition interface for FLOW2000

Figure 7 **Errore. L'origine riferimento non è stata trovata.** shows the composition interface, which includes the numbers that are generated when a sound is heard on the left, the performance interface in the centre, and the aspects of the reverberation algorithm that are affected by the sound created by the musician. This heard outcome is completely dependent on the performer, the performance space, and the instrument(s) being used. Each of the five aspects listed above can be adjusted and interpreted to suit the instrument been played. For example if a violin is used: air pressure may refer to the relative dynamics, key to the pitch or note class, angle of embouchure to the position of the bow against the strings, key depression to the position on the strings, and units of time to the duration of the sound, or period between sounds.

**Blended works**

I initially considered this section to be titled 'Visual works' but that would be an untrue description. Instead the works are

a hybrid, complementary blend of concurrent sound and vision making.

### ***MOTION, SPEECH, and VISION***

These three works were created as part of my PhD studies. They explore the relationship between maker, artwork, and perceiver as exemplified in Figure 1 above. Each work came into existence only when being viewed, and each perceiver, in the act of perceiving, created a unique iteration of the work. This iteration would change as it was being perceived, affected by the act of perceiving. Each work was presented using an iMac computer and attached headphones set on a table. This allowed only one person to experience the work at a time and made for a singular and intimate experience.

MOTION had two interfaces, the first was a black screen that came to life when first encountered, the other a complex set of controllers that the perceiver could use to adjust their experience of the work to suit.

The first interface encountered shows as a blank screen, but as soon as the work is interacted with by viewing an image such as that shown in Figure 9. This is because the computer camera tracks the movement of the perceiver according to the 20 quadrants shown in

Figure 10. For example: movement in quadrant 9 will affect how much green is seen and motion in quadrant 12 will affect how much blue seen, and movement in quadrant 19 will change the shape of the primitive presented on screen

The second interface, seen in Figure 8, shows the various aspects of the output that can be affected by the perceiver when movement happens in any of those 20 quadrants in order to make the work fit their tastes and predilections.

MOTION had an sonic element that fused together the sound of Ronald Reagan's speech discussing the Challenger Space shuttle tragedy of January 26, 1986 and a solo voice sourced from the Rex Box™ sound library titled Religious Voice. This was heard it through a set of headphones, and it treated through a binaural algorithm created by Tom Erbe [20]. As the perceiver viewed the work the pitches heard and virtual position of the sound were effected in the listener's headphones.

SPEECH and VISION also have two interfaces, and use the same motion recognition approach, and have similar processes of influencing the relevant outcomes.

SPEECH expanded on the processes discussed in Ambit Improvisations One above. The text of the poem Ambit, was used as causation for the generation of images, and the controls in the second interface are appropriately adjusted to allow the perceiver to taste. The images seen in the first interface of SPEECH are of the perceiver while perceiving, filtered through the responsive, generative algorithms of the work. Again sound was a fundamental part of the work, in this case sine waves were generated that blended the choice of frequencies as selected by the processes discussed under Ambit Improvisations and in response to the actions of the perceiver.

VISION used as its causation the saccadic Motion of the eye. It too has a sonic aspect based on a subtractive synthesis system where pink noise is sent through eight filters, which have their parameters set by the RGB values detected by the camera. The image uses a similar approach, focusing on a minute section of the perceiver's image, which is used in the system. This section is moved in a quasi-random way, reflecting the quasi-random behaviour of the saccadic motion

of the eye. Again, the second interface allowed the perceiver to adjust the outcome to taste.

#### Quite/Moments/Geometries/Circle

This is an ongoing set of works based on the same generative algorithm. In many ways it is an ongoing exploration of temporal and spatial interactions. This particular approach to making generative systems whose primary purpose is to make artworks has become an intriguing enquiry into how a system may be expressive of, represent, and illuminate a creative approach, its fountainhead, and potentially a causative essence. It is a return to the ideas first declared in the paper Exploring the self through alg

orithmic composition.

Here numbers that relate to distances and time are used to simultaneously create the visual and sonic output. I chose these two measurements as they are fundamental to our understanding of the world. Images created by the system are seen in Figure 14 to Figure 16.

The first work, Circles, was generated from the number sequence 13, 12, 7, 5, 3, and 2, which was passed on to me as representing an ancient way of understanding the motion of stars. (Whether or not this number sequence has any astronomical accuracy is not relevant as it is simply a starting point to the creation of artworks). The other influence in making the work was the drawings of Eiichi Tosaki [21], [22], which I used as an aesthetic/geometric model in assessing the output.

The second work, Inhabited Geometries, was created for an exhibition exploring Einstein's theories on the interconnectedness of space and time. This work used as the seed numbers: the closest and farthest distances of the moon to earth, 405696 and 363104

kilometres respectively, and the first 12 prime numbers. Here the process was to send out numbers from 405696 to 363104 over a period of 42.592 seconds and divide the output by the 12 prime numbers, using the result then being used to create coordinates for the generation of shapes presented on screen. The same sets of numbers were used in generating the pitches heard (in this case a piano sound).

The third, Some Quiet Moments, takes a more speculative and creator-centred approach. Here the numbers used were selected by me, and the output was allowed to develop without any intention, such as representing the distance of the moon to the earth. Here I was able to see what relationships I found interesting – keeping in mind that whatever relationship I presented regarding time and distance would be expressed in the perceived outcome, and that my tastes would not be influencing that outcome as it was developing. This process also allowed me to explore the responses I had to the outcome, and in doing so provided insights to the nexus of my creativity - as an act, and my taste – as an intuitive response to the outcome.

When making generative artworks the unexpected and unpredictable are, or at very least can be, incorporated into the process of making. The approaches outlined above demonstrate processes in which the generation of the artwork is a blend of the computer-based systems used, the performer, the environment (when involved), and in the audience. The audio/musical works range through being generative based interpreters of non-musical causations (speech/text) and physical properties (the flow of gasses in tubes).

MOTION, SPEECH, and VISION are amalgams of the systems and the perceiver, creating works that are totally

dependent on the interactions between them. While there are many works that have audience interactivity as primary in their creation, few require the perceiver in order to exist, or have outcomes that are totally unique to the perceiver-while-perceiving. Quite/Moments ... diverges from this approach in that it is completely self-contained, requiring no input from anything external to itself, and as a result is completely self-generating.

These approaches form two ends of my work in generative sound and visual art making, and the development along the way has created many insights to my practice.



Figure 9: Possible image generated when perceiving MOTION

1. Rotation on the x axis	2. Light position 1	3. Perturbation 1	4. Light position 2	5. Rotation 2 on the y axis
6. Rotation 3 on the z axis	7. Red value	8. Perturbation 2	9. Green value	10. Camera Angle 1 on the x axis
11. Camera Angle 2 on the x axis	12. Blue value	13. Perturbation 3	14. Light position 3	15. Camera Angle 3 on the z axis
16. Dimension value, the number of x and y dimensions of the primitive shape	17. Image type (alternating between outline or solid)	18. Radius minor (the size of the hole in the centre of the torus)	19. Shape primitive	20. Trace amount, influencing the roughness of the image edges.

Figure 10: Quadrants in which motion of the perceiver influences the heard and seen outcome.

**MOTION RELIES ON YOU TO BE CREATED**

PRESSING THE SPACE BAR WILL START AND STOP MOTION  
PRESSING THE esc KEY WILL SHOW OR HIDE THE VISUALS

**INTERPRETATIONS**

PLEASE ADJUST THE NUMBERS/OBJECTS IN THE OBLONG SHAPES TO APPLY YOUR INTERPRETATION OF MOTION. (click on a number to change it)

YOU CAN STORE YOUR INTERPRETATIONS BY HOLDING DOWN THE SHIFT KEY AND CLICKING ON A LIGHT COLOURED CIRCLE UNDER INTERPRETATIONS

EXPERIMENTING IS REQUIRED (It is not necessary that you know the effect of your actions before you do them)

YOU CAN RECALL YOUR INTERPRETATIONS BY CLICKING ON A DARK CIRCLE UNDER INTERPRETATIONS (Some interpretations are already stored)

WHEN INTERACTING WITH THE SYSTEM, CHANGING NUMBERS OR OBJECTS TO THE LEFT OF THE TEXT INFLUENCES THAT ASPECT OF THE SYSTEM

Figure 11: Second interface for MOTION. Similar second interfaces are used for SPEECH and VISION



Figure 12: Image created when perceiving *SPEECH*

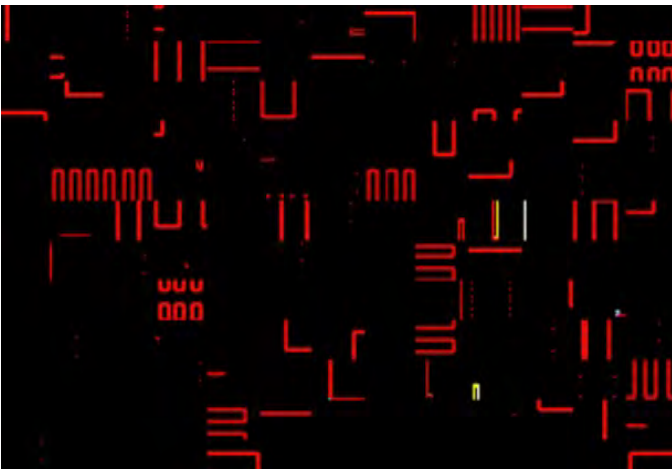


Figure 13: Image created when perceiving *VISION*

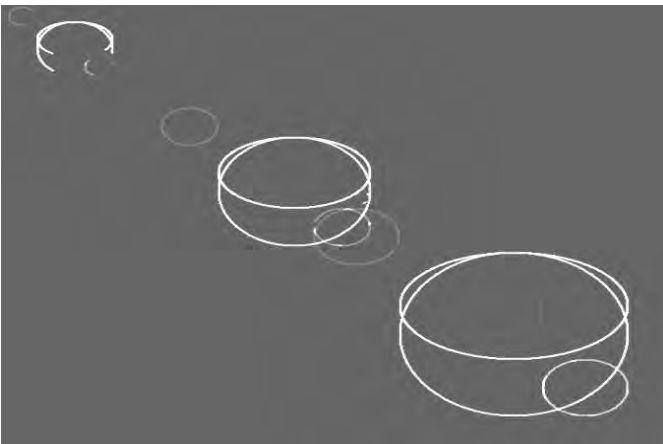


Figure 14: *Circles*

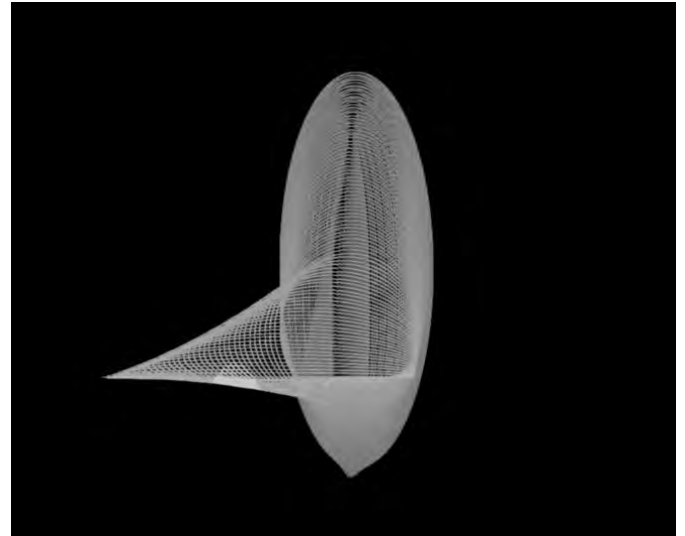


Figure 15: *Inhabited Geometries*, created for the *SPACETIME* exhibition

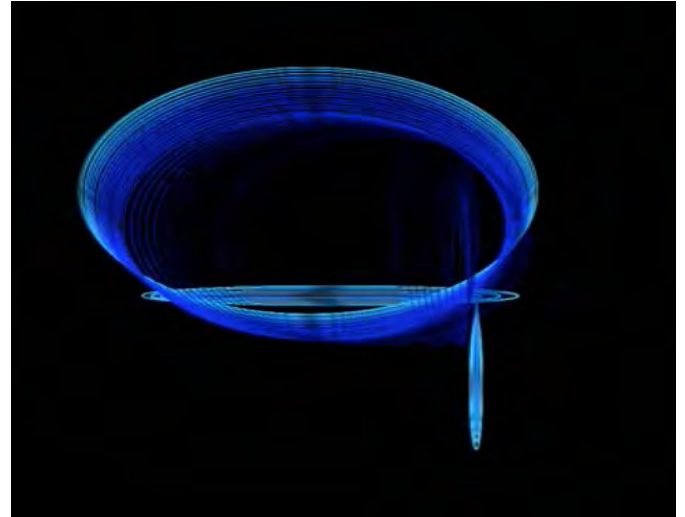


Figure 16: *Some Quiet Moments*, from the *Quiet Moments* collection

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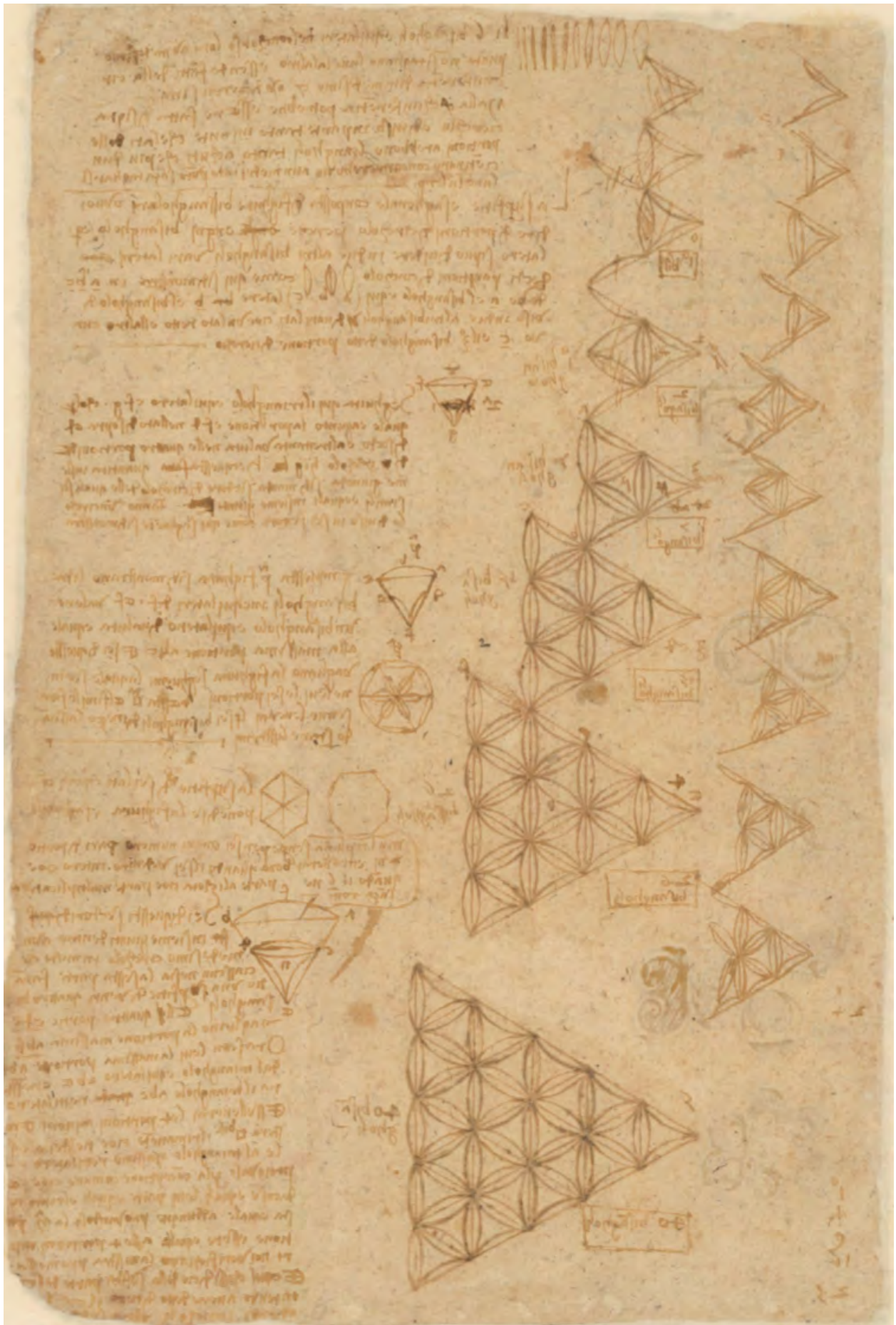
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Drawing by Leonardo da Vinci, *Atlantic Codex, Geometric codes and Variations*

# Hyper-instruments. Interactive systems for real-time composition, and post-classic pedagogy

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Hyper-instruments have, for a quarter of a century, been developed to enhance the interactive potentials of acoustic performers through sensing systems describing their gestures and mapping them to electroacoustic outputs. Radical approaches to similar technologies explored boundaries of real-time composition as a multi-agent cooperation between musicians, automatic generators and music digital processes.

The author develops original means of interactive composition for soloists and ensembles, who integrally drive digital music systems fed by the performer music, as interpreted by the computer through a complex audio-analysis feature extraction sometimes combined with a minimal inertial motion tracking setup. The integration of digital mappings allows performance sound-gestures to be treated as intentional semiotic objects able to drive networks of virtual instruments, shape scores and influence music macroforms, producing visual messages animating the laptop screens. Performance choices are suggested by specific interactive narratives. In this way navigation and gesture substitute fixed scores and controllers, allowing a timbre-emergent contemporary music mediation.

The project is the result of the PhD in Music Composition accomplished by the author in the 2016 at the University of Edinburgh (*Gesture and Listening: towards a social and eco-systemic hyperinstrument composition*) reinforced by artistic activity and international lecturing. These works, usually performed in concerts, are also part since 2016 of pedagogy strategies at universities and conservatoires for advanced students involved in performance and/or composition classes. A few successful experiences were also realised with kids. A relevant aspect of these systems regards a special mesh of performance and composition actions, harmonising improvisation with off-line musical choices which the performer has to arrange in order to achieve the interaction. The performance doesn't necessarily require a competence in digital music, and integrates traditional approaches with electroacoustic sounds.

## ***K\_messages for lpercello***

This presentation shows a selection of the *K\_messages*, performed by the author. *The K\_messages* are a cycle of interactive systems designed for a cellist motivated to animate a sequence of electroacoustic compositions evolving in real-time as a dialogue with his/her mediating music choices. The Messages implement an extended approach to the concept of hyperinstruments, sensing agencies allowing acoustic performers to interact with the electronics through gestural (sound and motion) detection and analysis. The complex behaviour and non-linear mutuality of these digital systems compels the cellist to immerse inside an environment of gestural algorithmic composition in real-time, rather than to perform a straight augmented instrument.

The *K\_messages* are interactive compositions, each of them shaped as a

specific unified MAX/Msp environment. Every Message integrates physical computing (upon the performance gestures happening on stage), modules of sound and gestural analysis, codes evolving as music processes, sound synthesis, and visual feedback operating as an animated score (graphic or in common notation). The animated scores, as well as the resulting musical configurations are programmed as variables highly dependent on the performance sound/gestures of the cellist.

Gestures are considered as non-verbal rhetoric transfers of information negotiating with Music Information Retrieval objects. In this way classic instrumental practices become interfaces of self regulating generative electroacoustic music forms consistently relying on the sound and the gestures of the cellist. The composition itself advances through a network of mappings grounded on the complexity of timbre, musical phrasings and sound producing gestures.

Every single interaction has a predefined duration exhausting different sections, which embody peculiar inspections to be solved by the cellist through self-analysis, interaction and performance. The soloist is suggested to navigate the system by making music choices which follow a specific dramaturgy according to the encoded affordances given by the system and some off-line verbal instructions. The performer engages a symbolic trade with music processes without the help of any disembodied controllers. The



*Ipercello performance at the Soundscape Festival, Maccagno, 2014*

*K\_messages* represent Short Stories by Kafka for the purposes of giving a conceptual identity to the electroacoustic interaction related to the choice of the cello input sound materials.

### **CONCEPT**

We take into account that Kafka's anti-heroes, tangibly alienated by machines and laws, concur to raise the issues of communication and mis/understanding at a higher level. Kafka's narratives unfold through fragmentary information which infringe stable labelling and metaphors, evading common models of interpretation. The typical coexistence of mythological and technological contexts is often empowered by a descriptive strategy which is technological as if the narration where a kind of machine detection of body-languages and interactive strategies. The resulting apparent losses of awareness inside the narration, the absurd dimension, causes an increase of agency of the main character as well as the reader (Baumer, 2011). This non-linear communication, a strategy of deconstruction of the machinery of power, allows for a multi-entrance access to meaning (Deleuze, 1975).

The *K\_messages* include the idea of a controversial approach to technology. We

take for granted that an interactive description of performance features returns fragmentary notions and decontextualised correlations, looking at music as a creative search for transparency and meaning, mutually embodying algorithms and performer.

The success of the interaction is closely dependent on the extraction of high level descriptors from the performance features of the cellist, who needs to think musically. A proper extraction of musical patterns from physical low-level vectors calls into question music theories, orienting my research towards frameworks unifying micro-sounds and note-oriented methods (Xenakis, 1992) and modelling *Expressiveness* ontologies extracted from instrumental practice (Canazza, 2003).

#### BACKGROUND

The original implementation of Hyperstruments dates back to 1992 with Machover's impulse to develop sensing technologies for musical productions at the MIT (Machover, 1994). Among others the IRCAM *Augmented Violin Project* (Bevilacqua, 2012) applied sensing technologies to enhance consistency between performance gestures and electroacoustic procedures related to score-based compositions. A more face to face approach is shown by Lewis's *Voyager*, coupling a listening engine to a generative musical system, able therefore to answer and improvise with a human performer (Lewis, 2000). The exhaustive concept of *Performance Ecosystem* shifts interactivity towards a hybrid world of real-time composition, interfacing sound-analysis modules with AI agencies undertaking autonomous music decisions on-stage (Eigenfeldt, 2011).

The *K\_messages* consider digital augmentation as a means to mesh in a new dimension the traditionally split categories of instrument, performance

and composition. The cellist navigates different virtual instruments, driving gesturally evolutionary strategies. Hyperinstruments are treated as real-time algorithmic composers absorbed in a semiotic circuitry of a mutual listening process merging the actions of performance, analysis and composition (Baroni, 2014).

#### DESCRIPTION

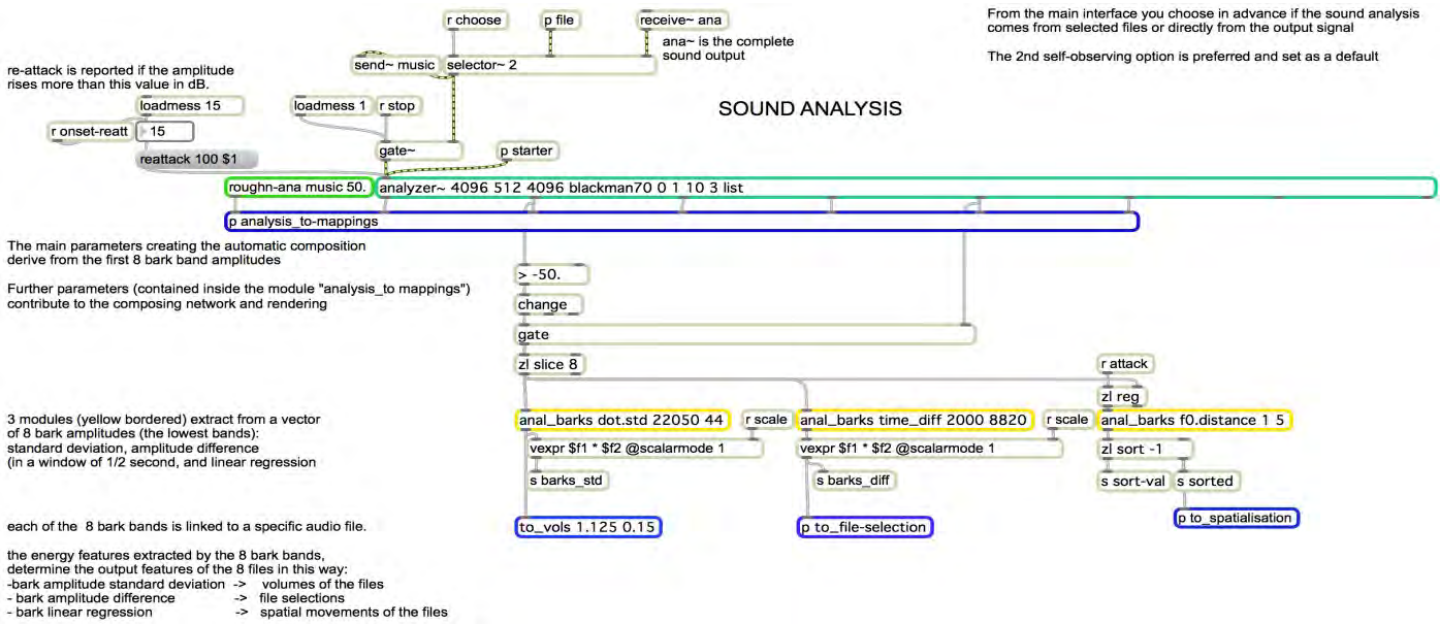
The performance presents three *K\_messages* for Ipercello: *The Wish to be a Red Indian*, *Odradek*, *Metamorphose*. The cellist interacts with the digital system and drives it by means of sound gestures consisting in timbres, articulations and phrasings. The software extracts these kinds of features and distributes their evolution in order to offer the performer the chance to gain an influence upon the overall composition in terms of electronic sounds, macroform and spatialisation.

*The Wish to be a Red Indian* allows the cellist to drive chains of granulators processing cycles of live recordings of the performance itself. A system of note and "expressivity" detection is implemented. Sound grains are output with lengths, transpositions, overlapping textures and rarefactions comparable to classic notes, controllable by the cellist through the notes, articulations, rhythmic groupings and frequency ranges as live detected by the system.

[Fig. 2 Sound-analysis module](#)

[Fig. 3 Bow-tracking schema](#)

From the main interface you choose in advance if the sound analysis comes from selected files or directly from the output signal  
The 2nd self-observing option is preferred and set as a default



## BOW Motion Tracking

The overall sound shapes are driven by the bow movements

### Impulsive bow movements (triggers)

- A bow action turns OFF an instrument -> White Toggle
- A bow action turns ON an instrument -> Crossed Toggle
- A special action sends a message or enables a function -> Coloured blink

GYROSCOPES detect quick bow rotations (in degrees per second)

Very quick-impulsive rotations allow triggerings in 4 directions:  
Up-Down-External-Internal



OFF ON



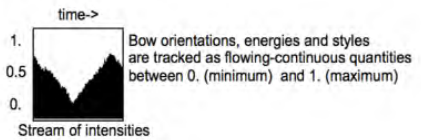
The 4 triggers behave as ON/OFF functions controlling discrete actions upon the sound system such as:

- Open/Close 4 different virtual instruments
- Rec/Play 4 numbered buffers
- Send specific messages to the other players



Cello\_1: a very quick downbow causes a bang (seen as a coloured blink): the result is a freezing sound effect

The bow movements can be impulsive or flowing  
-impulsive movements allow triggerings  
-continuous movements shape many sound details: they are called Orientations, Energies and Styles



#### A) BOW ORIENTATIONS

1)-TILT (angle between bow and string)

full-bow-hairs = 1.



hairs + wood = 0.

2)-ROLL (bow position: low vs. high strings)

low string -> towards 0.

high string-> towards 1.

Roll = 0. -tip of the bow pointing the ceiling  
Roll = 1. -tip of the bow pointing the floor

In case of violins this values are reversed!

2bis) CELLO\_2 and CELLO\_3 detect the precise string upon which the bow is playing



Cello\_2 and Cello\_3 don't activate bangs (coloured blinks) with the bow, but with a sharp sound attack instead. At the moment of the bang the system detects the string upon which the bow is playing

#### B) BOW ENERGIES

- 3)-Overall energy of the bow QUICKNESS
- 4)-Intensity of Bow crossing-strings ROTATION

The bow energies are changes in acceleration and orientation as functions of time

#### C) BOWING-STYLES

- Relative intensities of
- 5)-TREMLOLO
- 6)-BALZATO
- 7)-STACCATO

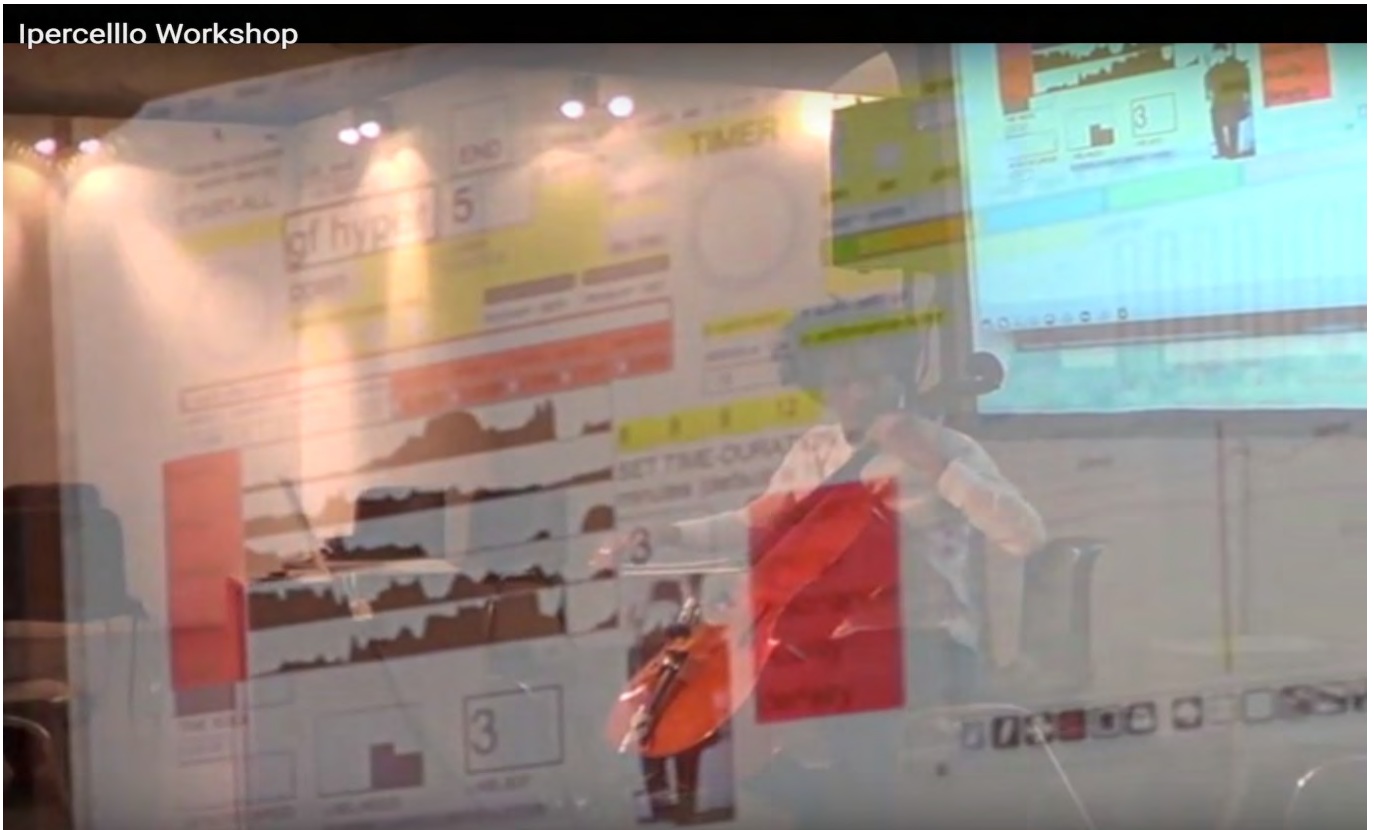
The bowing-styles are computed as rates of change of directions, accelerations and energy-deviations

The triggering movements are more effective and precise when played off the string. The continuous movements are instead calibrated to be performed in the the string, since they are conceived to keep a deep connection between the normal cello playing and its electronic performative extensions (Augmented-instruments technique). The streaming values and their effects are anyway working also when the cellist is playing with the bow in the air, and it allows for unexpected and gestural music solutions



Through their bows the cellists directly shape and mix the electronic sounds, exchange messages and scores, process the video, influence the macro-form

No additional hardware is required



*Odradek* requires a disembodied cello sound searching for overtones and sweeping noises which are expanded via Fast Fourier Transform to resonators, extreme filters, synthetic sounds driven and mixed by the coordinated method of performance of the cellist, who also determines the macro-evolution of the piece through synchronised sound signals.

*Metamorphose*, originally conceived as an interactive choreography for two dancers and a cellist, is here elaborated for a ipercello soloist who wears an inertial sensor fastened to the frog of the bow. The electronic sounds, recalling insects, fights and dreams follow a “storytelling” timeline supported by the interactive sound and bow actions of the performer.

#### TECHNIQUES

The interaction works through the mediation of real-time gestural analysis. Sound analysis can involve timbral aspects (such as spectrum partials, periodicity, spectral gaussian derivatives), psychoacoustic features relating to

Roughness or Mel-Cepstral and Bark bands means and standard deviations, as like rhythmic patterns, expressive articulations, pitch contours and note-oriented stylistic detections. Motion tracking deals with the *Orients Motion Tracking System*<sup>8</sup> (which data are processed in order to describe bowing styles). The gestural feature extraction in real-time is performed in order to gain a maximum of transparency with regard to the intentionality of the performers and the description of shared music styles.

#### PEDAGOGY EXPERIENCES

<https://www.youtube.com/watch?v=cjDSfGqCirs&t=194s>

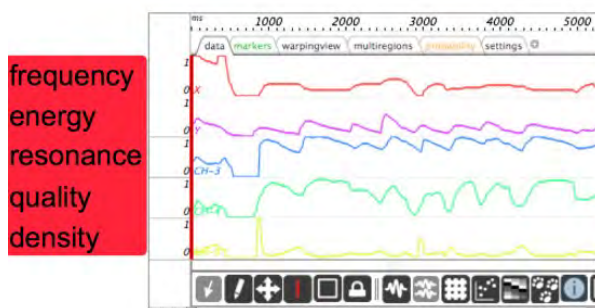
*K\_Messages* for Ipercello. Workshop and Live performance at the 100cellos Festival in Genoa. The interactive screen

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8

<https://sites.google.com/site/speckledcomputing/cello2>

live-describes five cello timbre features through which the performer shapes the macro-form of the electronic composition in dialogue with a machine listening system, acting as a memory module which interrelates current and past cello music inventions.



Five tracked cello timbre features and their “history” feeding the machine listening system *Gesture Follower*, through which the performer intentionally shapes in real-time the sound narrative and the time-segmentation of the electronic sounds.

<https://drive.google.com/open?id=12Dq2ZQ00z1szzms86mKoyR6ZbXDf46M->

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## TITLE Performance

*K-messages* nr. 2, 3, 5 for Ipercello  
*The Wish to be a Red Indian*, Odradek,  
*Metamorphose*  
 Nicola Baroni, Sound Design and Performance

# Maybe Arrive

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*Jay Hardesty*  
*jayhardesty@gmail.com*

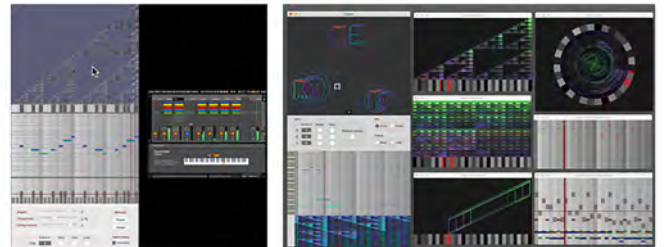
This interactive musical composition was performed at the 2018 Musical Metacreation concert in Salamanca. The piece integrates computer-assisted melodic improvisation into the electro genre, where solo live performance typically does not permit improvisation at the note-by-note level because of the attention required for other aspects of the production, such form, orchestration, and signal processing.

## Conceptual aim

The goal was to link subjective musical content to concrete musical surfaces by detecting and manipulating structures that underpin low-level rhythmic coherence. The software plays the role of a musical coprocessor that complements human actions and judgements, using a map of nested musical anticipation to parse melodic patterns into rhythmic building blocks that encapsulate to some degree the intuition of a listener and/or practiced musician. User actions are further complemented by selective use of genetic algorithms that impose organizational constraints on the building blocks.

The note pattern analysis and regeneration occur in real time; there is no preceding statistical analysis. The software does not model compositional strategies or to evaluate musical results; those aspects are left in the hands and ears of the composer/performer/producer/user. The performance is successful to the degree that the overall result does not sound algorithmic or experimental.

Details on the supporting theory and algorithms are in papers linked at [coord.fm/](http://coord.fm/) papers. Examples of the software in use are at [coord.fm/videos](http://coord.fm/videos).



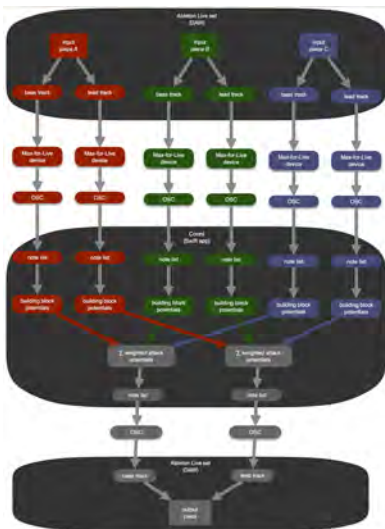
Two modes of live interaction/performance

Two custom music apps provide different interaction with the same algorithmic note pattern analysis and generation. In both cases, any elements of the composition not under the control of the algorithmic apps are left undisturbed so that they play back as they normally would.

1. Coord-map varies a selected looping part by manipulating the building blocks into which the rhythm for that part has been parsed.
2. Coord-morph interpolates melodically between two or three parts by applying relative weights to the rhythmic building blocks for each.



During the performance different combinations of Ableton Live scenes (sub-mixes) are triggered, and selected tracks from each scene are routed through the Coord apps. The apps analyze the looping input note patterns, provide interactive manipulation of those patterns, and stream the resulting variations back to the original tracks in Live.



**Personnel**

The composer and performer of the piece is Harun Gezici. He has been producing different styles of electronic music for more than 15 years as LowNoiz, and he is founder of netlabel Rauscharm Recordings at [www.rauscharm.com](http://www.rauscharm.com). His music can be found at [lownoiz.bandcamp.com](http://lownoiz.bandcamp.com) and [soundcloud.com/ultratech](http://soundcloud.com/ultratech). He resides in Ennetbaden, Switzerland.

The author of the software is Jay Hardesty, He has created music software since studying music composition at Columbia University. He designed and built intelligent music software during eight years at NYC-based music production company tomandandy. Recent projects, including the software used for this performance, are detailed at [coord.fm](http://coord.fm). He resides in Zurich, Switzerland.

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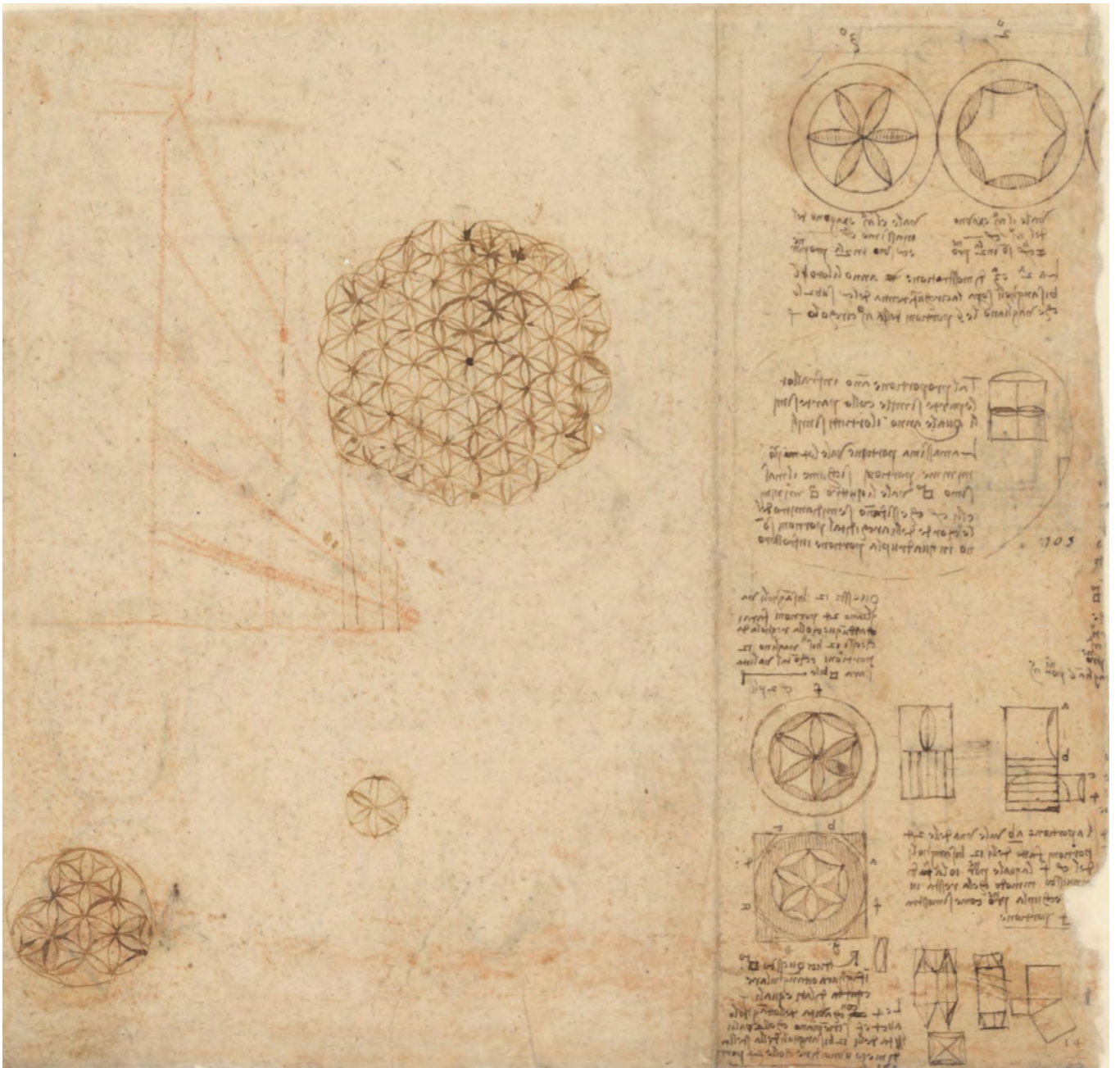
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*Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations*

## Drifting down and up the meaning

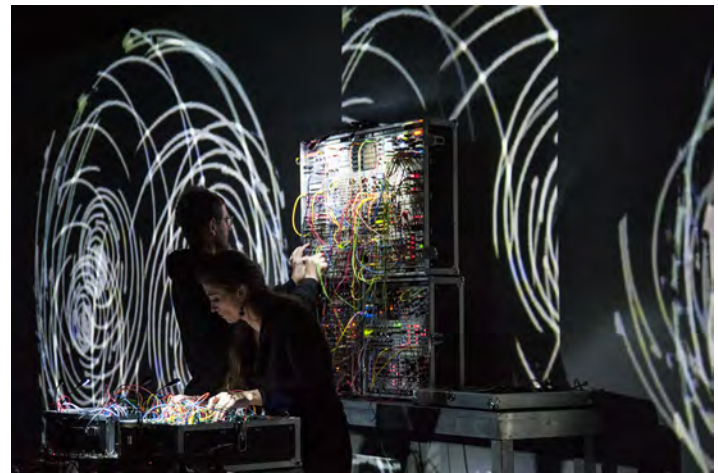
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Institute of Cultural Studies at  
the University of Wrocław  
*Krzysztof Pawlik*  
INIRE  
Poland

"The participation in the review has been completed in the frame of the research project No. 2014/15/N/HS2/03858 „Postmedial performance. The contemporary technological context of performative actions.”, funded by the National Science Centre, Poland.

INIRE is a duo formed by Krzysztof Pawlik and Małgorzata Danciewicz, delivering audiovisual performances, installations and projects based on dynamic sound and image mutual intermediations.

Their explorations act between sound art, field recording, noise and references to contemporary music. They blend traditional composing with reproducing, improvisation, recording and mastering. INIRE productions are created using multiple sensory channels by electronic and electroacoustic instruments, samplers, analogue synthesizers, modular systems, both audio and video. The main focus of INIRE's activity is perception, interaction and convergence of sound and image. Their work encompasses a range

of activities in the audiovisual art, most of all formed as live performances.



The audiovisual performance *Shipwreck Score* (2012) was a project inseparably linked to space, as a kind of a deconstruction of found sounds. The recordings that served as an audio and visual base were made during the group's stay in Iceland. The duo's idea was inspired by the specific atmosphere of the Djúpálónssandur bay, where an English fishing ship sank in 1948. At that time sixty boats worked in this bay. Today all that remains is what's left of the wreck that was cast ashore by the sea. The remains of the shipwreck organize the empty space abandoned by men, a territory in which there is no division between nature and culture.

The line between nature and culture ceases to exist because no one is determining this line. Fragments of the metal parts of the ship which were cast ashore were used in the recording of

sounds and images. Because of this, the duo's field recordings from the Djúpalónssandur bay have the feel of industrial music. The audio and visual materials recorded at the Icelandic bay were deconstructed by analog modular systems in both the aural and visual spheres.



Certain prefabricated images and sounds created by the duo in the framework of the Shipwreck Score project later served as a basis for on-stage improvisation. Shipwreck Score was made complete by Icelandic songs and lullabies – from their completely natural, live forms, to alterations making it impossible to qualify these pieces of music as vocal compositions.

INIRE's activity can be described as a kind of audiovisual archaeology referring

to archives and the widely discussed issue of documentation in performance. In 2016 group realized an audiovisual performance inspired by the films of Walerian Borowczyk and Jan Lenica. The Labyrinth project, a variation on the Boro-Lenica duo animations, was created as music for electronic instruments and prepared piano, on which Fabrizio Casti played a guest role. The recording of the performance was issued on Labirynt CD (CD, Artcetera 2017).

Audiovisual performance *Transcape Disturbances* (2017) was built entirely from the sounds and images generated by voltage-controlled audio and video modular systems. Live composing created here structures in which music and pictures were subjected to mutual deconstruction. The range of what was visible affected what was audible, and vice versa. Intense structures, interacting and permeating each other explored here human and non-human acting in terms of music and video. Interchanges of analogue audio and video harmonies brought human recipient aware of the constant immersion in the network of electromagnetic dependencies.

Audiovisual performance „Drifting down and up the meaning” explores complementary areas for all entirely previous work. It raises the subject of human and non-human structuring of narration. It tells us that there is no good reason to forget about storytelling.

<http://www.inire.net>  
<http://trendbook.digitalcultures.pl/en/inire/>  
<http://culture.pl/en/artist/inire>  
<https://vimeo.com/inirevideo/videoshttps://www.facebook.com/inire.net>

# Towards using Generative Art in Therapy

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## **Introduction**

### **Why Art Therapy?**

According to the WHO Worldwide, cerebrovascular accidents (stroke) are the second leading cause of death and the third leading cause of disability [1]. In a stroke, blood flow can't reach the region that controls a particular body function, as a consequence producing a disability. The effects of a stroke depend on several factors, including the location of the obstruction, and how much brain tissue has been affected [3].

To recover the function of the brain (depending of the position of the stroke) therapy will be necessary. Most of the therapies focus on the recovery of motion of the patients, e.g. Timmermans, Annick AA et al [4] makes an analysis of types of therapy from which the most effective is the repetition task therapy to recover limb mobility. This therapy consists in the repetition of a series of key movements which altogether form tasks, and

increases the brain function to try to restore the loss of movement.

Therapy for the patient has been proven to be tiring and difficult; hinski, Vladimir, et al. [7] concluded: “**Joy of participation in the training should compensate its hardship**”. In repetition task-therapy the patient will have to repeat several times the same movement, if we optimize which movements will be used, we can reduce the recovery time. Although this approach is proving to be very efficient **studies suggest that a combination therapy targeting several processes may prove superior to any monotherapy** (standard therapy alone) [8]. Standard therapy alone is not enough for rehabilitation.

There is a high percentage of patients that need rehabilitation and in 30% of the cases of stroke patients show Post-Stroke depression (PSD) that influences recovery in activities of daily living (ADL). Non-depressed stroke patients were found to show either a slight improvement or no change in functional status from the acute post-strokes to 1-month follow-up, while depressed patients showed a decline in ADL during the first month.

**Post-Stroke depression (PSD)** delays the effects of therapy and slows down the recovery process due to the patient's resignation from rehabilitation and the lack of willingness and motivation to regain physical fitness. The depressed patients had significantly less improvement at the 2-year follow up than the non-depressed patients. This was independent of the amount of in-hospital rehabilitation therapy.

There are several examples of these applications and devices. For example, Unitherapy[16] is a computer-assisted neurorehabilitation tool for teleassessment and telerehabilitation of the upper extremity function in stroke patients. It makes use of a joystick as therapy platform. Another example is Rutgers Master Glove II [17] where patients use a therapeutic glove connected to a virtual reality setting to continue their therapy in form of videogames. Another option is the use of art therapy to engage patients.

### **Art Therapy**

Art therapy can be defined as the therapeutic use of art making, within a professional relationship, by people who experience illness, trauma, or challenges in living. Art therapy helps to overcome physiological disabilities through non-verbal methods. Physical therapy alone would not be sufficient to address the struggles in patients [9]. Art therapy has helped patients with diverse disorders that include developmental or acquire, medical and/or psychiatric conditions [10].

Benefits of art participation after stroke are becoming increasingly recognized. Qualitative studies suggest that participation in visual arts creative engagement interventions (CEI) during rehabilitation after stroke may improve mood, self-esteem, hope and some aspects of physical recovery. ***Survivors (of stroke) suggested that recovery of upper limb function and communication occurred because art allows them to recover function in ways regular therapy***

***cannot.*** The art itself provided ways in which survivors could use their upper limbs and try out activities for themselves. Interactions with the artists and within the group provided an environment in which survivors could practices and regain control over their communication [11].

There are several examples of use of art therapy; in Altenmüller, Eckart, et al. [12] results showed that music-supported therapy yielded significant improvement in fine as well as gross motor skills with respect to speed, precision, and smoothness of movements. Music-supported therapy leads to marked improvements of motor function after stroke and that these are accompanied by electrophysiological changes indicative of a better cortical connectivity and improved activation of the motor cortex.

Using creative engagement intervention ***(CEI) protocol similar to ACES*** [13].



We develop an application of interactive video that measures the movement and requires control and precision from the patients using an interactive video, to make the rehabilitation more engaging. The planned application is similar to the one created by artist Petros Vrellis [14] using ***motion particles decomposition***

helping peoples with mobility disabilities to engage in repetitive movements. In addition, we create a system capable of creating a particle system by itself and automatically.

**Methods**

A video is composed by frames  $f_i$  that change over time, thus giving the illusion of motion. Instead of considering a video as a set of frames  $V = \{f_0, f_1, f_2, \dots, f_n\}$ , we will consider a video as a set of particles  $p_i$  that vary over time.  $V = \{p_0, p_1, p_2, \dots, p_n\}$ , the difference is that the particles are set of lines with a length, color and a position, and these lines change in color and position over time, but always present. Making an analysis of video and considering it as flow of particles has been approached in other works, e.g. [18,19]. This new representation of a video allows a user to interact with the video, as we are not able to modify frames, but we can change the position length and color of the particles. This is clearer in the following figure:

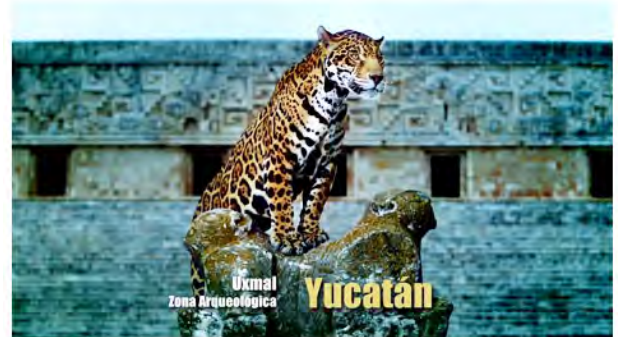
For example, 7 particles of the 150,000 in each frame are:

- 643 522 643 524 42 42 42
- 643 524 642 526 69 69 69
- 642 526 642 528 82 82 82
- 642 528 642 530 88 88 88

642 530 642 532 86 86 86

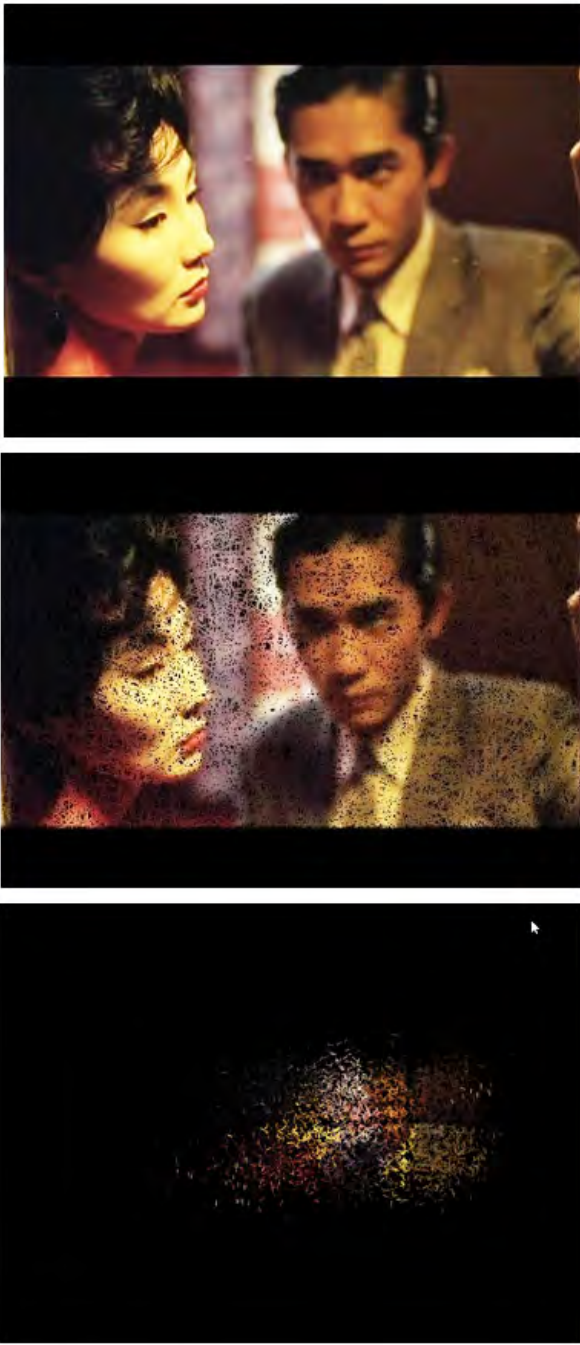
642 532 641 534 98 98 98

641 534 641 536 109 109 109



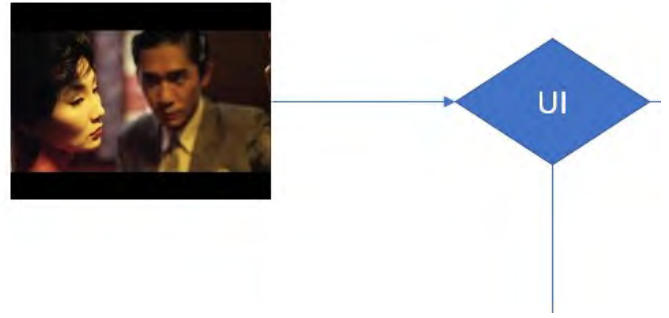
where the first two values are equal to  $x_0, y_0$  (initial point of the line), then the next two  $x_n, y_n$  (end point of the line, followed by 3 integer values equal to the color in RGB code. Both, end and initial points are the pixel in the image. The lines are generated using turtle graphics [22] with a random generator.

In the case of a video, let us consider the following example from the trailer of the movie, “In the Mood for Love” [20]. We take the original frame and decompose it into 150,000 particles (lines). With this decomposition we lose quality as reflected in the image, but then when we press in the frame the particles gather as in the following figure.



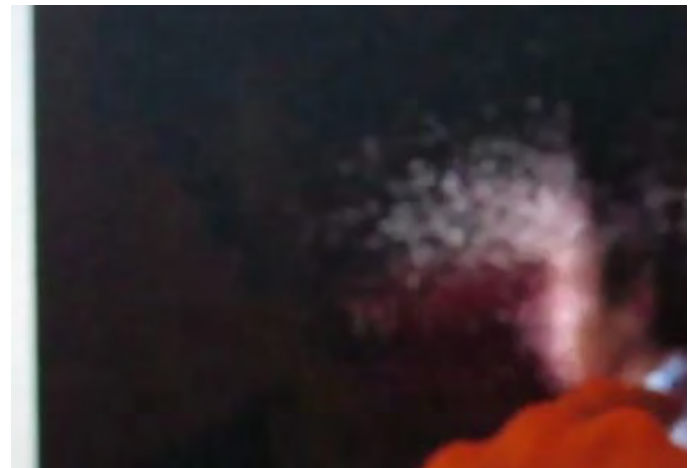
**Figure 17 Change from Original Frame to Particles.**

We will use two buffers, the first one for the original video, and when pressed change to the background buffer and the particles. Once that we are working with the particles state, we can interact with the particles through any user input interface.



**Figure 18 Video Interaction Options, continue with the regular video or change buffers into the user interaction mode.**

For example, as User Interfaces UI, we can use either a touchscreen or something more complex as the Microsoft Kinect [21].



**Figure 19 Touchscreen Interaction with the Particles system.**

To test the system interactions, we make a control of the particles movement using the Kinect. In this case the particles will compress when closing a hand, and then the particles will follow the movement of the arms.





**Figure 20 Control of the particle motion with the Kinect.**

### **Conclusion**

In this project we want to create an application that automatically changes a video, and images into user-controlled particles. The objective is that through this automation, generate several systems of videos, where a user can interact and play with them. The final goal is to develop a therapy for patients with a motion disability to engage them into making several repetitive movements necessary for improvement.

This work is currently under development, and as already mention this is the design of the user interface. The next step will be to start working with patients in a controlled environment and following medical protocols.

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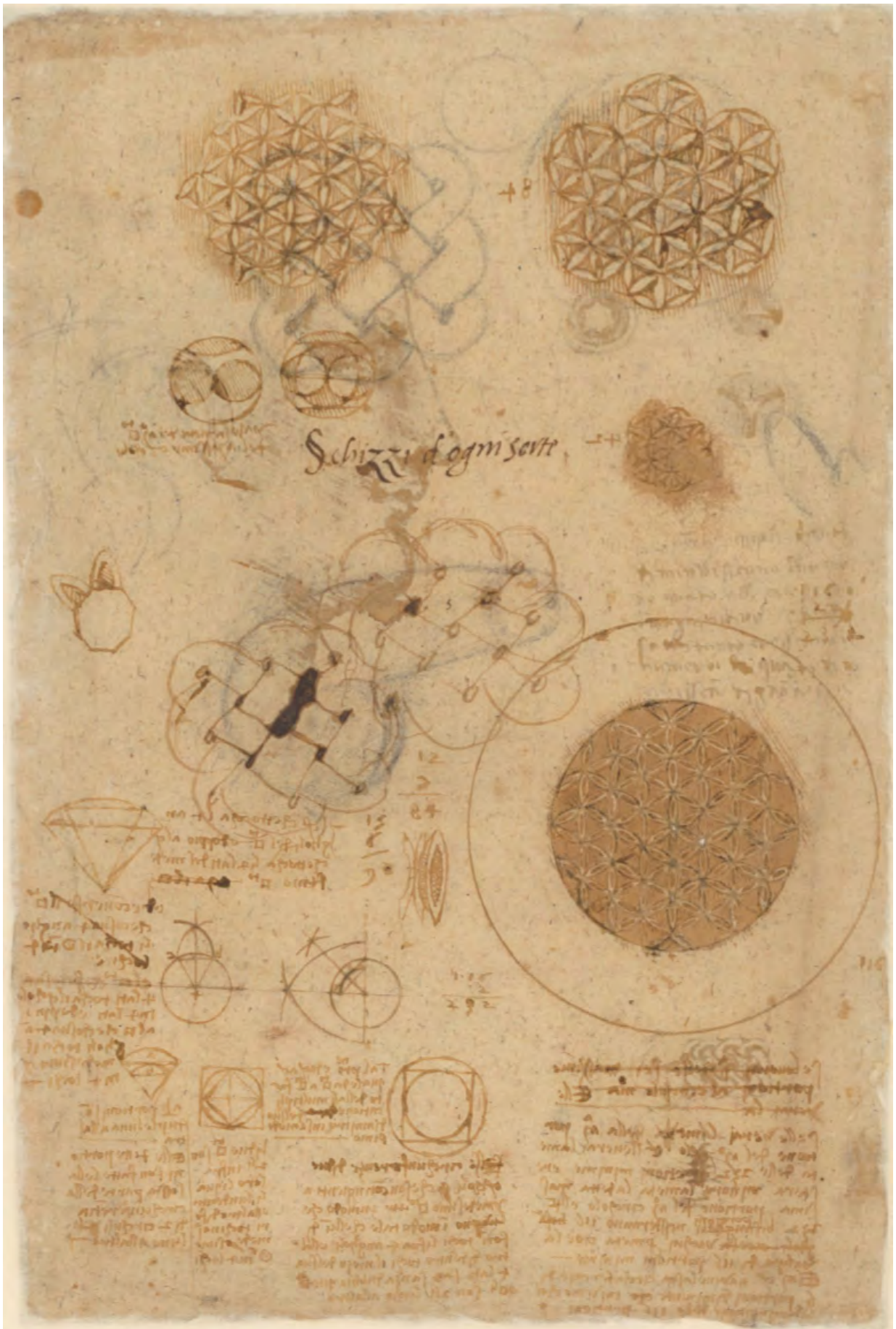
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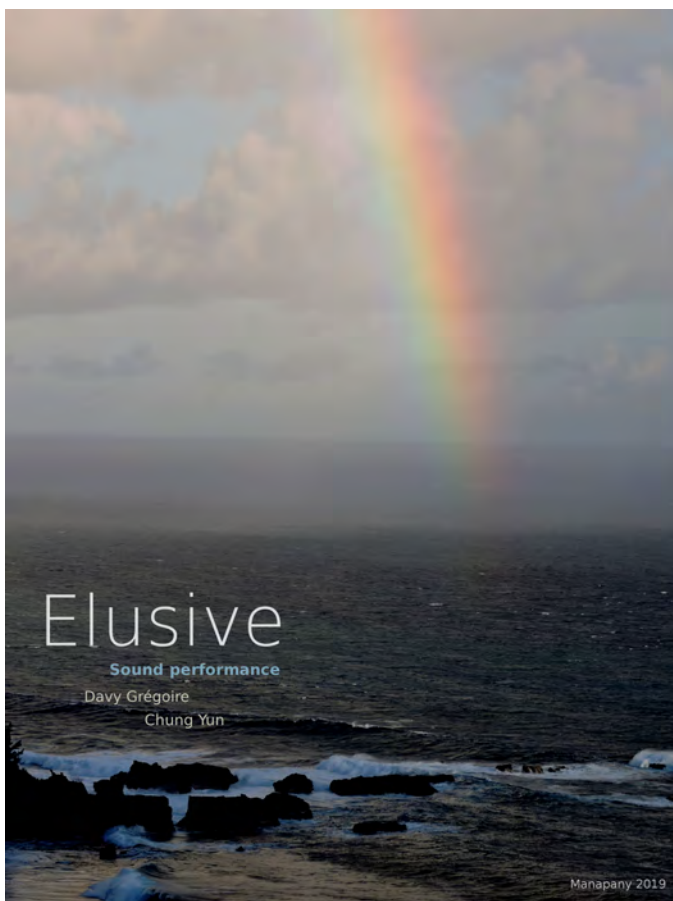


*Drawing by Leonardo da Vinci, Atlantic Codex, Geometric codes and Variations*

# *Elusives*

performers:           Davy           Grégoire  
(aagregaas@yahoo.fr),   Chung   Yun  
(vena19861203@gmail.com)

"Elusives" is a dialogue between concrete and digital sound, where two players, one using singing bowl and voice, the other one using a tactile app to generate sounds, are developing an imaginary landscape.



Proceedings of the event "Generative Art, *Futuring Past*" performed in Rome  
the 7th of June 2019 at the Casa delle Letterature for  
the Letterature Festival Internazionale di Roma, 2019 -  
"Il Domani del Classici"

The event is organized by Argenia Association, Generative Art & Design Lab

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