FROM XENAKIS'S UPIC TO GRAPHIC NOTATION TODAY

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HATJE CANTZ

CENTRE IANNIS XENAKIS

zkm karlsruhe

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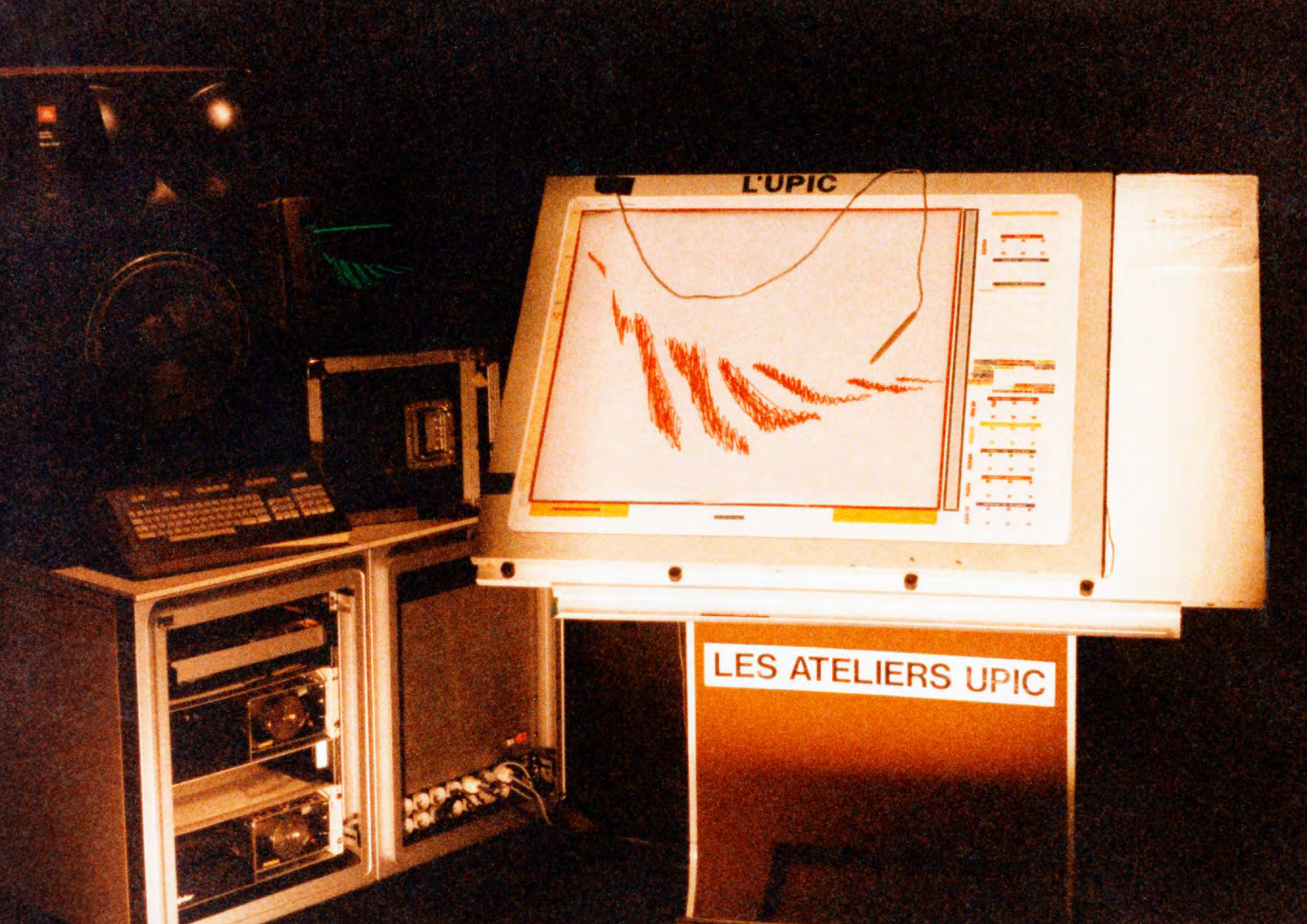

L'UPIC
LES ATELIERS UPIC

PREFACES

PETER WEIBEL
LUDGER BRÜMMER
SHARON KANACH

INTRODUCTION

Viewed from certain perspectives, Iannis Xenakis is not only a singular figure in twentieth-century music history, he is probably the most revolutionary, for he was not only a composer of grandiose works of a "strangeness in the proportion",[1] which is how Francis Bacon defined beauty. But like Arnold Schoenberg, Karlheinz Stockhausen, Pierre Boulez, and John Cage, he was also the author of theoretical music writings of the highest order. He was an independent architect for many years and worked for Le Corbusier from 1947 to 1959. He created an extensive architectural oeuvre, also manifested in many texts on architecture. In addition, Xenakis was a mathematician, inventor, and engineer. G.W. Leibniz defined music in 1712 as "an unconscious exercise in arithmetic in which the mind does not know it is counting,"[2] and there is probably no other composer as close to this understanding of music as Xenakis.[3]

1.
Francis Bacon, "There is no excellent beauty that hath not some strangeness in the proportion," F. Bacon, "Of Beauty," in *Essays* (1625).

2.
G.W. Leibniz in a letter to Christian Goldbach, April 27 1712: "Musica est exercitium arithmeticae occultum nescientis se numerare animi," in Oliver Sacks, *The Man Who Mistook His Wife for a Hat* (New York: Summit Books, 1985).

3.
See Xenakis's collection of essays "Musiques formelles," in *La Revue musicale* 253, 254 (1963); Formalized Music (Bloomington, IN: Indiana University Press, 1971).

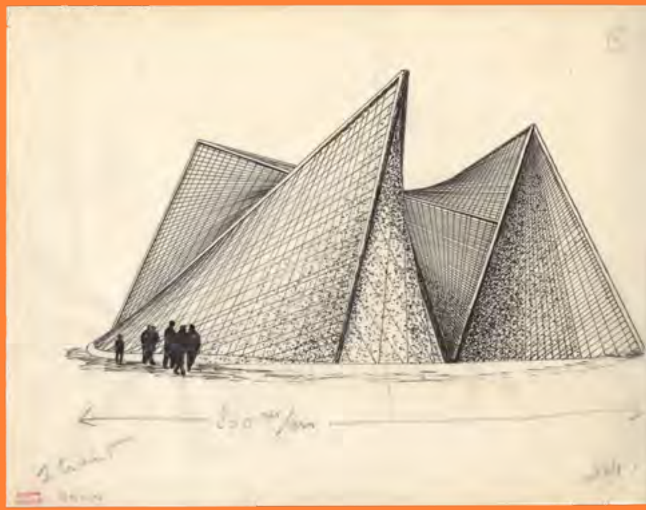


FIG. 1 Iannis Xenakis, Philips Pavilion, 1958, drawing
© Iannis Xenakis Family

PETER WEIBEL
CHAIRMAN AND CEO
ZKM | KARLSRUHE

Let us consider, for example, his critique of serial music in 1955 "La crise de la musique serielle" (The Crisis of Serial Music),[4] his text "Theory of Probability and Music" (Wahrscheinlichkeitstheorie und Musik)[5] of 1956, his work on stochastic music from 1958, and his compositions from 1957 to 1962 in the electroacoustic music studio of the GRM (Groupe de Recherches Musicales) directed by Pierre Schaeffer from 1960–1974 as part of the French broadcasting agency ORTF (Office de Radiodiffusion-Télévision Française).

The development of New Music made the search for a new kind of notation necessary in the 1950s—from Darmstadt to Donaueschingen, from New York to Gravesano.[6] A well-known example of this is Xenakis's sketch for *Metastasis* of 1954.[7] It is typical of Xenakis that he varies these musical figures and uses them as the basis for the hyperbolic forms of his architecture of the Philips Pavilion for Expo 1958 in Brussels, in which Edgard Varèse's *Poème électronique* for tape, Le Corbusier's multimedia projections, and Xenakis's own tape piece *Concret PH* could be heard and seen.

The glissando curves of the strings become bold architectural curves that anticipate deconstructivist architectural forms à la Zaha Hadid. Sound curves transform into building curves.

With his novel compositional ideas Xenakis paved the way for computer music. He began to research the relationship between music and computers already in 1956 at the laboratory of IBM France. From 1956 to 1962, Xenakis wrote compositions whose score data had been calculated using IBM computers. In the beginning, it was computer programs whose results the composer transcribed for traditional instruments. Later, Xenakis produced synthetic sounds with the computer. His passion for mathematics eventually led him to the UPIC. In 1966, Xenakis founded EMAMu, better known since 1972 as CEMAMu (Centre d'Etudes de Mathématique et Automatique Musicales).

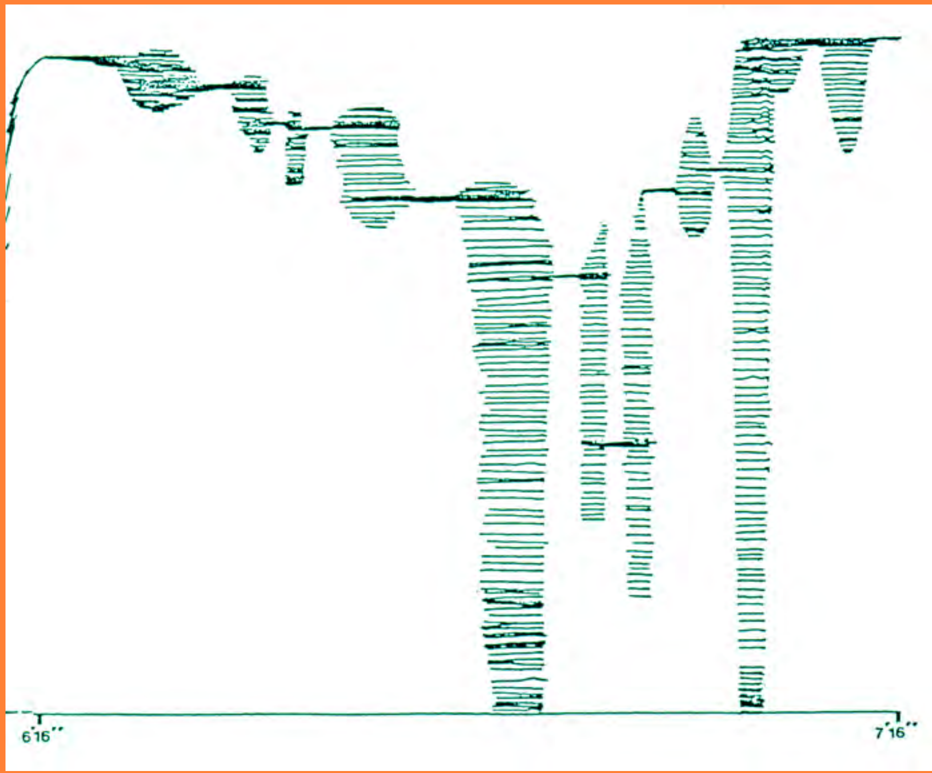
4.
Iannis Xenakis, "La crise de la musique serielle," in Hermann Scherchen's *Gravesaner Blätter. Musikalische, elektroakustische und schallwissenschaftliche Grenzprobleme*, 1, 1 (1955): 2–4.

5.
Iannis Xenakis, "Wahrscheinlichkeitstheorie und Musik," in Hermann Scherchen's *Gravesaner Blätter. Musikalische, elektroakustische und schallwissenschaftliche Grenzprobleme,* 2, 6 (1956): 28–34.

6.
See Earle Brown, Morton Feldman, Mauricio Kagel, Anestis Logothetis, Roman Haubenstock-Ramati, and others.

7.
See Fig. 1 in Robindoré, this volume: Iannis Xenakis, *Metastasis*, 1954, graphic sketch.

FIG. 2 Iannis Xenakis, *Mycènes Alpha*, 1978, UPIC score page



With the UPIC, he combined two important revolutions of twentieth-century music, namely, a revolutionary notation with a revolutionary instrument: graphic notation produced with the computer. The composer no longer needed to write complicated programs, but was able to fix the sounds graphically and render the graphics audible with the help of the computer. The UPIC is a revolutionary composition device; a music machine that enables sounds to be generated directly via self-designed graphic structures.

The idea of a graphic input mode, "drawn" music, after the end of the conventional notation system, had already been developed technically by many pioneers—from Rudolf Pfenninger to Daphne Oram. With the UPIC, musical ideas are drawn on paper with pencils, and then redrawn on a graphics tablet with an electromagnetic pen-like stylus. The drawn music is stored page by page. These drawings and the graphic input are played back simultaneously on two screens. One screen is used for graphic (analog) representation, the other for alphanumeric (digital) representation. This information is sent to a 16-bit minicomputer, analog-to-digital sound converter (ADC), and RAM storage devices. The digitally captured information of the graphic coordinate system is read at high speed by a computer via ADC on the drawing tablet, converted into numerical information, and processed into sound material by the computer. The sound leaves the computer via digital-to-analog sound converter (DAC) and is made audible via amplifier and loudspeaker.[8]

The ZKM | Center for Art and Media is a museum with the usual remit of collecting works of art and presenting them in exhibitions. It is a museum of all genres and media, both spatial and time-based arts. It is therefore interactive, participative, and performative. However, the ZKM is more than just a museum. It is also a research center. It develops and produces its own works of art together with guest

8.
See Fig. 1 in Mâche, this volume: setup of the UPIC (Unité Polyagogique Informatique du CEMAMu), an invention by Iannis Xenakis, schematic drawing.

artists and staff. With its symposia and publications, ZKM conducts scientific research and contributes to a multidisciplinary discourse on art, science, and technology.

Music is the mother of all time-based arts and therefore plays a special role at the ZKM. Music provides an excellent example for recognizing and understanding the transformations of art through technological innovations. Music is the scene of perhaps the most daring artistic and technical revolution of the twentieth century. Xenakis is a master of twentieth-century music. Hardly any other composer has worked as universally and ahead of his time as Xenakis: as a theorist, musician, and architect. With his pavilions for music, from the Philips Pavilion in Brussels (1958) to *Diatope* (1978) in front of the Centre Pompidou in Paris, he paved the way to spatial music, sound spaces, and spatial sounds. With his computer-based music, Xenakis has thought beyond the boundaries of music, beyond traditions and schools. He has revolutionized the traditional tonal orders. He is one of the most radical musical innovators as a thinker, composer, architect, engineer, and inventor. With the UPIC, his reflections and visions culminated in an incunabulum. For this reason Xenakis and the UPIC are of seminal interest to the ZKM.

To all participants of the symposium, authors of this publication, and my two coeditors Ludger Brümmer and Sharon Kanach, as well as the graphic designer Uta Kopp and the editor Lisa Bensel, I would like to express my deepest thanks for the fact that a long cherished desideratum, the scientific processing of the UPIC project, could, at the highest level, finally be realized.

PETER WEIBEL

DIGITAL AVANTGARDIST XENAKIS— THE UPIC'S IMPULSES FOR THE FUTURE

LUDGER BRÜMMER
HEAD OF DEPARTMENT
ZKM | HERTZ-LAB

This publication tracks the development of the sound synthesis and composition instrument UPIC developed by Iannis Xenakis, describing not only its beginnings from the planning phase to the present day, but also the traces it has left behind. And the publication itself has a long history behind it. In various ways—in exhibitions, concerts, and installations—the ZKM | Karlsruhe and the former Institute for Music and Acoustics of the ZKM, today the Hertz-Lab,[1] has engaged with the oeuvre of Iannis Xenakis for many years—whether through the performance of his compositions, the presentation of installations and documentation materials by Xenakis, or through new works by other artists that refer to Xenakis.

In 2006, the ZKM presented for the first time the architectural context of Iannis Xenakis's work with reference to the Philips Pavilion for Expo '58 as part of the exhibition *The Museum of Time-Based Art,* a collaboration with the Bavarian Chamber of Architecture.

The UPIC itself, with its hardware and artifacts, was exhibited in 2013 and 2018 in the ZKM exhibitions *Soundart* and *Art in Motion: 100 Masterpieces with and through Media.* Most recently, the idea of Xenakis's *Polytopes* was elaborated in

1.
The ZKM | Hertz-Lab operates as a transdisciplinary research and development platform at the interface of media arts, science, and society. It was formed in 2017 from the ZKM's existing institutes for visual media (Bildmedien) and for music and acoustics (Musik und Akustik).

Chris Salter's work *N-Polytope* and presented in 2018 in the subspace of the ZKM_Cube, the blue architectural landmark of the ZKM. Peter Weibel was the curator of these presentations.

The Institute for Music and Acoustics, of which I was artistic director, supplemented these exhibition projects with concerts or defined its own focuses in the context of several festival series. The concerts given in the series *Quantum Leaps*, later renamed *Con:temporaries,* which have been fantastically interpreted by musicians from the International Ensemble Modern Academy Frankfurt (IEMA), should be mentioned here, as well as the concert series *Piano+,* curated by Catherine Vickers, in which many compositions by Xenakis were interpreted in a first-class manner. These included compositions that demand enormous skill from the performers, such as the duet *Dikhthas* for piano (Catherine Vickers) and violin (Jacek Klimkiewicz) Xenakis composed in 1979. Symposia framed and enhanced some of those performances. A complete overview of all events on Iannis Xenakis organized by the ZKM to date concludes this foreword.

The idea of reflecting more profoundly on Xenakis's work was first articulated by Peter Weibel during the exhibition *Iannis Xenakis: Music and Architecture* in 2006. The idea began to take shape later in exchanges with musicologists Makis Solomos and Sharon Kanach, especially in discussions after the symposium *Paranoia: Limit Experiences of Electronic Music in the Context of Iannis Xenakis's Work* in 2012. However, it only took on a concrete form when I held planning discussions with the project manager Christos Carras for *Interfaces*, a Creative Europe project supported by the European Union. The project deals with new models and practices for Audience Development in Contemporary Music, and for the first time this created the framework for a longer-term discussion with the UPIC. In further conversations with Sharon Kanach, it became clear that the publication needed to revolve around the historical experiences and testimony of contemporary witnesses, and at the same time take a look at the traces left by the UPIC, which have undergone further development in connection with technological advances.

In the autumn of 2018, artists, scholars, and scientists were invited to follow these traces and reflect on them in musical and textual contributions during a two-day conference entitled *UPIC: Graphic Interfaces for Notation* at the ZKM in order to identify the most important thematic areas. The conference was organized in collaboration with the Centre Iannis Xenakis (CIX), of which Sharon Kanach is the vice-president. In addition, the ZKM | Hertz-Lab invited artists Julia Jasmin Rommel, Marcin Pietruszewski, Lukas Nowok, and Kosmas Giannoutakis for a residency to develop new electroacoustic compositions resulting from the digital, real-time interpretation of graphics. All artists, contemporary witnesses, and lecturers were invited to present their material as a collection of ideas for the planned publication. The editors hoped not only to get an overview of the existing narrative strands and the wealth of subject areas, but also to develop a strategy, to review the content of the concept, and to adjust it, which in the course of numerous additions also led to the necessary scope of the present publication. The narrative strands resulted in a historical section for this publication, for which Sharon Kanach is mainly responsible. The archives of the Centre Iannis Xenakis enabled her to connect with numerous witnesses contemporaneous with the birth of the UPIC. This section is discussed in the first three chapters of the publication and explained separately in her preface. Further, there is a contemporary section of the publication that I compiled. It is also divided into three chapters which I will go into below.

The aforementioned symposium *Paranoia. Limit Experiences of Electronic Music in the Context of Iannis Xenakis's Work*, from which the decisive impulse to realize this publication emanated, was held at the end of May 2012. In this context, Xenakis's Polytope *Persepolis* was performed in the Schlossgarten Karlsruhe, the park of Karlsruhe Castle, as a reconstruction of the original performance by Daniel Teige. One of the topics discussed at the symposium were the unsettling, impressive, and extreme aspects of Xenakis's work. What does "unsettling" mean in this context? Well, for example, there are descriptions of the first performance of *Bohor,* where Xenakis presented the composition at a very high volume. This is something that Xenakis has in common with the performances of electroacoustic music conducted by Karlheinz Stockhausen. However, *Bohor* differs from Stockhausen's compositions: the work has no dramatic fluctuations in volume, and its texture remains dense and complex over a period of 22 minutes. This means that a high volume is disturbing to the listener, straining their hearing to the limit and beyond. The term "paranoia" was intended to express these overexcited sensory impressions, which Xenakis provokes in other works and musical parameters.

In his works, Xenakis always distanced himself very far from the mainstream taste of a given period, and it is interesting to see how he was able to induce rejection and a strong fascination simultaneously. His transgression of aesthetic boundaries may have its roots in biographical aspects that have been sufficiently discussed, such as his war experiences. Of decisive importance, however, was the fact that his tonal and compositional thinking made use of new concepts and new tonal ideas, with which he radically set himself apart from his colleagues within serial music and developed alternative methods. It is noteworthy in this context that Xenakis had joined

the Groupe de Recherche de Musique Concrète (later GRM) in 1954, from which, in the course of time, incredibly heterogeneous aesthetic models such as those of Pierre Henry or Eliane Radigue developed, and which in turn influenced composers such as Karlheinz Stockhausen. The contrast between the aesthetics of all these composers could not be greater.

Also noteworthy is the fact that Xenakis, in addition to his thematic fields of sound pavilions, sound installations, compositions, and composition theory, also used mathematical methods to develop digital tools for composition and sound generation. After all, he had already started composing with computers in 1956. He brought together the financial and human resources for a composition center and then for an entire composition system. This is not possible without the political context, the openness to the visions of society. But we need people like Xenakis who recognize and implement opportunities and necessities. In addition, Xenakis succeeded not only in enabling composers to use the system right after the completion of the first UPIC prototype in 1977, but also in creating understanding among young people for technological composition.

To explain the context in which the UPIC was created, one should bear in mind that the electronic studio of the Technical University of Berlin, one of the most advanced studios in Germany for example, would only invest in computer music years later, from 1984 onwards. But of course Xenakis's idea for the UPIC was not formed in isolation. Rather, it evolved from concepts and technical modules that already existed. For example, Max Mathews had already developed a usable version of the sound programming languages, MUSIC V, at the Bell Labs in 1966. A few years later, Fernando von Reichenbach completed his *Convertidor Gráfico Analógico*[2] in Buenos Aires, a machine that could be used to convert drawings done on paper

2.
R. Dal Farra, *Historical aspects of Electroacoustic Music in Latin America: From the Pioneering to the Present Days* (France: Digi-Arts UNESCO Knowledge Portal, UNESCO, 2003).

into sound. Compositions have been created with this system since 1970; but this was a purely analog system based on the existing sound synthesis methods. In 1972, John Chowning had already produced his work *Turenas* with a digital system (the DEC PDP-10), but if one considers these contemporary technological developments, it becomes clear how ambitious Xenakis was to combine these individual inventions or to develop them from scratch in order to create a completely digital composition tool with elaborated digital sound synthesis and a graphical user interface. Without a doubt, Paris was the hot spot of digital music in Europe and Xenakis a pioneer with his ideas. When the IRCAM opened, Boulez hired a group of American composers and software developers, including Max Mathews, John Chowning, and Jean Claude Risset, a US-based researcher, to start digital music production. But the UPIC was already working a couple of months after IRCAM opened in 1977!

The fourth chapter of this publication begins with a comprehensive contextualization of the UPIC. The text by Peter Weibel has its own section titled **THE ROAD TO THE UPIC**, as Peter Weibel goes into considerable detail in his text to establish the interconnections between technological, artistic, visual, and scientific thinking in Xenakis's work. As the list of exhibitions and presentations accompanying this foreword shows, since 2006 Peter Weibel has repeatedly initiated exhibitions which, among other things, have dealt intensively with the work of Iannis Xenakis and he has thus placed Xenakis at the center of the ZKM's music-centered activities.

Once the UPIC existed, its effect was able to unfold. Many composers were able to work with the system and the radically new concept significantly influenced their thinking. For Gerard Pape, contact with the UPIC opened new spheres of thought such that he was the only private individual to purchase his own UPIC system. For Curtis Roads, the handling of sound composition learned with the UPIC triggered the development of granular synthesis. The UPIC concepts also left a number of traces in many future developments; they were a model for a number of compositional technique ideas, which later, as technology became more affordable and easier to master, led to new software and hardware. This aspect is discussed in the chapter **THE UPIC AND UTOPIA**, in texts that are oriented on the ideas of the UPIC and develop them further with regard to current software or hardware. The title is borrowed from the text by Kiyoshi Furukawa.

The book's concluding chapter is titled **REFLECTIONS**. It brings together authors who discuss compositional, cultural, and creative aspects of the UPIC on an abstract level.

THE ROAD TO THE UPIC. FROM GRAPHIC NOTATION TO GRAPHIC USER INTERFACE

PETER WEIBEL presents in his text the development of musical instruments in the twentieth century which led to the UPIC. At the beginning, around 1900, there were the synaesthetic dreams of color pianos, of the connection between sound and color, of music and painting. In the 1920s, interest shifted to research on the interdependence of light and sound, to synthetics, to the synthetic generation of sounds and images. It was at this historic moment that cinematography came into play, which used music drawn on film strips as optical sound in abstract or absolute film. The graphic notation of sound, which began in music in the 1950s, had already been sketched out 20 years earlier in abstract film. With this optophonetic turn, numerous composers began to overcome the boundaries of traditional music notation and expand the cosmos of sound. A variety of electrical, electromagnetic, electro-optical, electromechanical, and electronic instruments

CONCERTS WITH WORKS BY IANNIS XENAKIS PRESENTED AT ZKM

31.10.2003
Listen and Watch, Orient Occident for tape, 1960, by Iannis Xenakis

04.10.2006
Accompanying programme for the exhibition *Iannis Xenakis: Music and Architecture*:
Audio and video simulation of the TU Berlin for the Philips Pavilion at the Brussels World Exhibition, 1958
DVD launch *Iannis Xenakis: Mythos und Technik* by Peider Defilla, WERGO

14.02.2008
Quantum Leaps VI: *Plektò (Flechte)* for 6 instruments, 1993, by Iannis Xenakis

06.11.2008
László Hudacsek: Looping on the Ghost Train of Time: *OKHO pour trois djembés et une peau africaine de grande taille*, 1989, by Iannis Xenakis

20.05.2010
LUX VOCAT. Through the Night to Light:
Aroura for strings ensemble, 1971, by Iannis Xenakis
Nuits for 12 voices, 1967, by Iannis Xenakis

24.11.2011
Piano+/IMATRONIC "Xenakis today":
Concret PH for two-channel tape, 1958, by Iannis Xenakis
À.r.(Hommage à Ravel) for piano, 1987, by Iannis Xenakis
Herma for piano, 1960/61, by Iannis Xenakis
Bohor for multi-channel tape, 1962, by Iannis Xenakis
Dikhthas for piano and violin, 1979, by Iannis Xenakis
Six Chansons for piano, 1951, by Iannis Xenakis
Orient-Occident for four-channel tape, 1960, by Iannis Xenakis
Evryali for piano, 1973, by Iannis Xenakis
Mists for piano, 1981, by Iannis Xenakis
Diamorphosis for tape, 1957, by Iannis Xenakis

11.03.2012
Quantum Leaps XIV: *Diamorphosis* for tape, 1957, by Iannis Xenakis

were developed, until finally the computer arrived. These replaced paper as the medium of notation with screens, whether oscilloscopes or monitors. They replaced the composer's hand with pens or keyboards, musical notation with programs and graphic notation with graphical user interfaces. Music, which had always been a temporal code, now became a code programmed by machines and algorithms. Traditional music notation was instructions for people to operate instruments. The digital code is at once instructions for music machines and the execution of the same.

THE UPIC AND UTOPIA

In his text, **KIYOSHI FURUKAWA** refers to the experiences made with his interactive composition software *Small Fish* with regard to a system between composition, score, instrument, and performance. Although the UPIC was not able to completely eliminate these categories, for the first time they were combined in one tool. Relics from the previously necessary division into necessary steps of the creation process of a composition could now only be recognized to some extent in the course of working with the UPIC. Furukawa goes further in his comments on these categories and asks to what extent it is necessary to fix a composition at all, and whether the implementation and configuration of information in an interactive system is not already sufficient.

CHIKASHI MIYAMA'S chapter places the UPIC in the context of the current developments that have resulted. He works as an actor with live electronics and visuals with audiovisual particle systems. In his text "UPIC 2019," he gives a systematic overview of the currently available programs related to the UPIC system, and shows to what extent these systems could possibly be extended with the help of the latest hardware and software. Based on the fact that nowadays a UPIC system with camera, sound input, sound output, and a mouse is already included in every laptop, he designs ideas that go beyond these possibilities by composing with head tracking and 3D systems. With the programs *Rotating Scores* and *Rhythm of Shapes*, he has already developed possibilities in the past—in collaboration with Anton Himstedt and myself—to generate sound with rotating signs or to translate live generated photographic contents.

VICTORIA SIMON focuses on tactile interaction with the UPIC, which she describes as a tool. From Xenakis's thinking, she develops the suggestion that tactile interaction with the sound should be as direct as possible. Every device, even the mouse, or any programming language is an obstacle to direct communication between a listener or composer and the sound. Therefore, a way of interacting directly with the sound via graphical notation would bring progress in this direction. It presents the touch screen as a further step that, unlike the pen, as is the case with the UPIC system, enables a more direct and intuitive interaction with the sound via fingers and palms. She demonstrates its advantages by means of the Borderlands notation software and the UPISketch app as examples.

JULIAN SCORDATO examines the software IanniX for the further development of the ideas created in UPIC. In particular, he describes the possibilities of IanniX with regard to the manifold possibilities of a "score" called data representation, and interprets, as an expert and codeveloper of IanniX, the potentials created therein as well as the role of the user. He sees this not only as a composer, but also as a programmer who is capable of extending the functionality of the software. IanniX was developed as an open environment that invites extensions. This aspect develops the implementation of UPIC further in essential points and brings it up to date.

31.05.–02.06.2012
Symposium: *Paranoia. Limit Experiences of Electronic Music in the Context of Iannis Xenakis's Work*:
Persepolis, 1971, by Iannis Xenakis at Schlossgarten Karlsruhe
Voyage absolu des Unari vers Andromède, 1989, by Iannis Xenakis

22.02.2013
Portrait concert Arturo Fuentes:
Charisma for clarinet and cello, 1971, by Iannis Xenakis

04.03.2016
ZKM presents *4DSOUND: Points on the Curve*:
Orient-Occident for four-channel tape, 1960, by Iannis Xenakis

19.03.2016
con:temporaries
Phlegra for 11 instruments, 1975, by Iannis Xenakis

22.09.2017
con:temporaries:
Plektò (Lichen) for 6 instruments, 1993, by Iannis Xenakis

01.09.–23.10.2018
Installation *N-Polytope: Behaviors in Light and Sound After Iannis Xenakis* by Chris Salter

06.04.2019
Sculptural Aspects in Loudspeaker Music in the framework of the exhibition *Negative Space*:
Diamorphosis for tape, 1957, by Iannis Xenakis

LECTURES AND SYMPOSIA ADDRESSING WORKS BY IANNIS XENAKIS HELD AT ZKM

24.06.2011
Symposium: *Art. Archives. architectures*:
Cyrille Delhaye: The Archives of the Centre Iannis Xenakis, or the Sources Heterogeneity such as Documentary Richness

24.11.2011
Symposium: *Xenakis, Algorithms, Electronics*:
Makis Solomos: The Notion of Space in Xenakis's Music

Daniel Teige: Performing the music of Xenakis's *Polytopes*

Reinhold Friedl: The Multiple Being of Xenakis's "la legende d'eer": The Necessity of Critical Editions of Electroacoustic Music

KOSMAS GIANOUTAKIS describes an interesting experiment in his text: An algorithm used compositionally is visualized and in the next step its sound result is influenced by manipulations of the visual object. Through rotation, stretching, and compression in three-dimensional space, the parameters of the algorithm—and thus the resulting sound—are changed. He adds a kind of feedback loop to Xenakis's idea of sonifying graphical elements, but their manipulation, in accordance with the UPIC, is carried out on the graphical level.

REFLECTIONS

MARCIN PIETRUSZEWSKI highlights the relationships between the synthesis possibilities of the UPIC system and the pulsar synthesis developed from it giving concrete examples. Pulsar synthesis is also used by the pioneer of granular synthesis, Curtis Roads, who owes his main impulse for this to his work with the UPIC. Pietruszewski adds another option to pulsar synthesis with its proprietary granular synthesis software New Pulsar Generator. But he also points out that the tools used influence both the composers and the compositions.

LUKAS NOWOK's essay is devoted to the role of notation, which he develops as a reduction or quantization of the concrete. He endeavors to break up the rigid relationship between idea, translation into notation, and transformation into sound, which is functionally encoded in the notation.

In her text, **JULIA JASMIN ROMMEL** presents an artistic project that deals with acoustic space measurement in close relation to graphic notation and cartography. An observation that Xenakis realized in a similar way by using architectural drawings as sketches for musical ideas, as in *Metastasis.* In this context she touches on the specifics of the application of graphic notation by Dieter Schnebel, Cornelius Cardew, and György Ligeti by the graphic artist Rainer Wehinger. She emphasizes the necessity of drawing for notation in general as a subset of information, touches on the aesthetics of the sign, and refers to the neurological connection of hearing, sight, and the sense of balance that per se is responsible for spatial orientation.

I would like to express my thanks to everyone who has contributed to this very extensive project. My special thanks go to Lisa Bensel, who brought and held together the incredible puzzle of numerous texts, images, and information for the realization of this publication, to Sharon Kanach, who managed to win over so many contemporary witnesses for the publication and to Peter Weibel for his continuous soft pressure leading to this work.

As a special feature, this publication is published simultaneously in printed form by Hatje Cantz and in a digital version, which can be downloaded free of charge from **WWW.ZKM.DE/UPIC**.

Since this publication was financed by the *Creative Europe* programme of the European Union and by ZKM | Karlsruhe donors, it is of great concern to us to make the knowledge about the work of Xenakis, which has been collected here for the first time in this breadth, contains previously unpublished archive material, and can establish itself as a standard work on graphic notation and the UPIC, unrestrictedly accessible to the public. We follow the contemporary credo "Public Money, Public Book." While the book form fulfills the necessary and sustainable role of presence in a public or private library and stands alone as a physical object, the digital version is aimed primarily at students, scholars, scientists and a digitally networked worldwide readership.

LUDGER BRÜMMER

31.05.–02.06.2012
Symposium: *Paranoia. Boundary Experiences of Electronic Music in the Context of Iannis Xenakis's Work*:

Bill Dietz: Interactions with *Listening Mind* – Maryanne Amacher's Glial Instrumentations

Werner Dafeldecker, Valerio Tricoli: Williams Mix Extended

Rudolf Frisius: Musik als Formverlauf? Form und Struktur in der instrumentalen und elektroakustischen Musik von Iannis Xenakis

Daniel Teige: Dead or alive: Performance and interpretation aspects on Xenakis *Polytopes*

Leopoldo Siano, Tobias Hünermann, Christoph von Blumröder and Matthias Nowakowski: Iannis Xenakis Künstlerische Physiognomie und kompositorisches Umfeld

Rodolphe Bourotte: Limits and perspectives of the computer-assisted sound drawing experience

Makis Solomos: *Pour la Paix*

Sharon Kanach: Iannis Xenakis: Construction and Sensation

Thomas Troge: Genie oder Paranoia – Musikdenken bei Xenakis unter dem Aspekt der Kognitions- und Gehirnforschung

Daniel Teruggi: Did Iannis Xenakis ever compose "Musique concrète"?

28.–29.09.2018
Conference *UPIC—Graphic Interfaces for Notation* with lectures by Cyrille Delhaye, Alain Després, Guy Médigue, Julian Scordato, Julio Estrada, Marcin Pietruszewski, François-Bernard Mâche, Mark Pilkington, Chikashi Miyama, Rudolphe Bourotte, Sharon Kanach

EXHIBITIONS WITH WORKS BY IANNIS XENAKIS PRESENTED AT ZKM

09.09.–04.10.2006
Iannis Xenakis: Music and Architecture, part of the exhibition *The Museum of Time-Based Arts* in collaboration with the Bavarian Chamber of Architecture

01.03.–26.07.2009
Notation: Calculation and Form in the Arts with drawings by Xenakis

17.03.2012–06.01.2013
Soundart with the original UPIC hardware and visual documentation

14.07.2018 AND 20.01.2019
Art in motion: 100 Masterpieces with and through Media with the original UPIC hardware and visual documentation

THE UBIQUITOUS UPIC

For LAF, whose patience, support, and understanding never cease to astound and inspire … reciprocation. And beyond… There.

SHARON KANACH
VICE-PRESIDENT,
CENTRE IANNIS XENAKIS

If you ask people "What one word does the name Xenakis evoke?" you get answers such as "*Metastasis,*" or "stochastics," or "polytope," or "*Formalized Music,*" or even "Le Corbusier"; but rarely does "UPIC" spring first to anyone's mind. However, if the question is posed the other way round, "What one word does the UPIC evoke?" a vast majority will reply "Xenakis." This machine, this tool, its very idea, is inextricably linked to the creator who conceived it. Over forty years have passed since its first prototype was publicly introduced in 1977—which we discover in this volume was initially called simply *Polyagogia,*[1] *(*poly, meaning many, an indefinite number; *agogics,* referring both to the expressive qualities of musical time and to the concept of education).[2] This publication is the opportunity to both retrace its history (verifying it with its primary actors, for the first time), and to project its possible future iterations as a compositional tool with today's (and tomorrow's) technology, as well as in terms of the future of graphic notation at large. The twenty-seven essays in this volume, penned by distinguished authors/artists from eleven different countries, are living testimony to the UPIC's history, scope, influence, and, ultimately, potential.

We have chosen to divide this volume's contents into six sections, and this preface serves mainly as an introduction to the first three: *The UPIC: Its History, Institutions, and Implications*; *Composers Experiencing the UPIC*; and *Xenakis and the UPIC*. My esteemed colleague **LUDGER BRÜMMER**'s preface addresses both the genesis of this volume and recounts ZKM's own history with Xenakis as well with as the UPIC over the past fourteen years. Furthermore, he specifically

1.
See Dimitris Kamarotos's chapter, this volume.

2.
However, in an interview with the journalist Georges Charbonnier broadcast on France Musique on August 26, 1982, Xenakis states "*Polyagogic* is a neologism I introduced that means a sort of multiple pedagogy." (Source: INAthèque, PHD99256553; 3'28"–3'36")

addresses the contributions under the three final chapters, covering the prospective future of the UPIC and its implications in the broader realm of graphic notation. ZKM's scientific and artistic director, **PETER WEIBEL**'s contribution contextualizes Iannis Xenakis in the context of the history of 20th century music. Of course, each individual text can be read independently and in any given order indeed, as a book, from beginning to end.

BACK TO THE DRAWING BOARD
THE UPIC: ITS HISTORY, INSTITUTIONS, AND IMPLICATIONS

What was ultimately called the UPIC (*unité polyagogique informatique du cEMAMu*, the CEMAMu being Xenakis's research lab where the system was originally developed: *centre d'Etudes de Mathématique et Automatique Musicales*), maintaining the concept of polyagogics is, in a word, a musical drawing board. Xenakis often reverted to making sketches as part of his poietic process of composition for a multitude of reasons,[3] and this volume offers some handsome examples; in particular, excerpts of previously unpublished preliminary sketches for the first work composed solely on the UPIC: Xenakis's *Mycènes Alpha* (1978).[4] But the UPIC was not the first nor the only attempt by composers/creators to imagine audio computing devices, as revealed by **ANDREY SMIRNOV**'s valuable contextualization "UPIC's Precursors". However, unlike most if not all of its predecessors, the UPIC not only thrived for decades, its influence and potential continue to inspire. This is manifest in the graphic notation softwares developed, in particular UPISketch, developed by **RODOLPHE BOUROTTE** for the Centre Iannis Xenakis in partnership with the European University Cyprus in the context of *Interfaces*, a project in the framework of the Creative Europe Programme of the EU.

3.
See, for example: Sharon Kanach, [...] "Xenakis's Hand, or The Visualization of the Creative Process," *Perspectives of New Music* 40, 1 (2002): 190–97; Sharon Kanach, "Music to be seen: Tracing Xenakis's Creative Process," in *Iannis Xenakis: Composer, Architect, Visionary* (exhib. cat. (New York: The Drawing Center (Drawing Papers 88, 2010), 95–127, available online: https://issuu.com/drawingcenter/docs/drawingpapers88_xenakis

4.
See François-Bernard Mâche's chapter (Fig. 3), Brigitte Robindoré's chapter (Fig. 3), and the preface by Peter Weibel (Fig. 2), this volume for score sketches of *Mycènes Alpha*.

It is generally considered, and Xenakis himself has stated, that the then future UPIC germinated in the composer's mind while working on his breakout orchestral work *Metastasis* (1953–54) and led to his founding first of MYAM in 1961, an informal group (with strong GRM connections: Abraham Moles, Pierre Barbaud, Roger Blanchard, and Michel Philippot);[5] then, more formally, to the creation of the EMAMu, in 1967 (with mathematicians Marc Barbut, François Genuys, Georges-Théodule Guilbaud), later renamed the CEMAMu in the early 1970s, designating it as a center for research. It is interesting to note that the founding of the EMAMu in Paris corresponds precisely with the start of Xenakis's part-time tenure at the University of Indiana at Bloomington, where he was promised the means to create a "Center for Mathematical and Automated Music" (CMAM).[6] Between 1967 and 1972, when he resigned from that position due to lack of real support in developing the CMAM, Xenakis must have been expending

5.
See Olga Touloumi, "The Politics of Totality: Iannis Xenakis's *Polytope de Mycènes*," in, *Xenakis Matters: Contexts, Processes, Applications*, ed. Sharon Kanach (Hillsdale, NY: Pendragon Press, 2012). MYAM, sometimes spelled MIAM seems to be an acronym of the main protagonists' initials: **M**ichel Philippot, **Y**annis (or **I**annis) Xenakis, **A**braham **M**oles.

6.
See Charles Turner, *Xenakis in America* (Tappan, NY: One Block Avenue, 2014), 75–101. Available as a free download here: https://monoskop.org/log/?p=12791

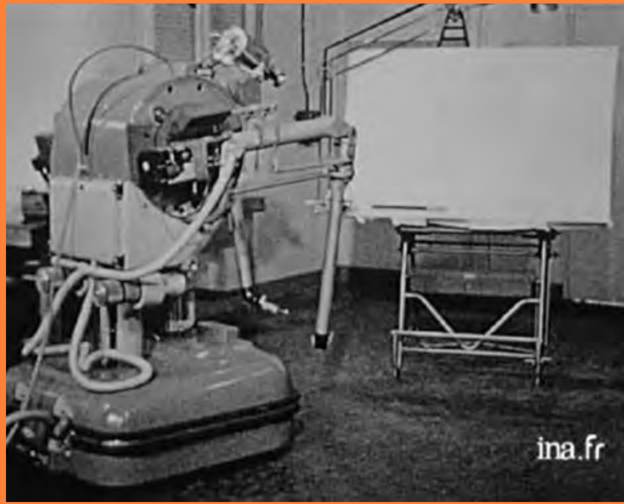


FIG. 1 A precursor of Xenakis's UPIC, 1963. In "Des machines à penser?", screenshot from video taken at 56:37. Courtesy of Edition Point de vues © INA

considerable energy in Paris during the several months he was not on campus in the mid-West USA, gearing up to launch the CEMAMu officially in early 1972.

However, our own research on a seemingly unrelated topic, "Xenakis and film,"[7] reveals that already in the early 1960s, Xenakis knew the UPIC would include a "musical drawing board." In Xenakis's personal archives, we find a trace of a letter dated December 12, 1961, when the composer was active at the GRM, from the studio's director Pierre Schaeffer, inviting Xenakis to a meeting about "Thinking machines."[8] Indeed, two years later, a film was produced for a French public television series *Visa pour l'avenir* (Visa for the future) on the subject of "Des machines à penser?"[9] (thinking machines), which not only includes excerpts of Xenakis's music in the soundtrack, but also shows a precursor to the UPIC drawing board being approached by a robot with a writing instrument in its "hand" during the last minutes of this one-hour documentary (see Fig. 1). Perhaps it is therefore not a simple coincidence that some twenty-five years later, Xenakis revisits this combination of robots and the UPIC in his previously unknown (because alas unrealized) visionary project, *Ballet for Emancipated Robots*, revealed here by **HENNING LOHNER**, who attempted to produce it in Germany, at Xenakis's request, in the late 1980s.

However, even well before that, we know Xenakis had reverted to making graphic transcriptions of works from the repertoire, as Bálint András Varga recounts in a comment during his interview in 1980 with the composer:

> *Xenakis rose and produced some thick folders from a bookshelf. Suddenly, unexpectedly, he came face to face with himself of thirty years before. […]*

7.
See Sharon Kanach, "Xenakis et le film: la face cachée du compositeur," in *Xenakis et les Arts*, ed. P.A. Castanet, S. Kanach (Rouen: Editions Point de vues, 2014), 128–145.

8.
Source: Iannis Xenakis Archives, catalogued under OM 16/4 while on deposit at the Bibliothèque national de France. At the end of 2014, Xenakis's heirs withdrew this collection from the BnF (cf. Reinhold Friedl's interview with Mâkhi Xenakis-Klatzmann on WDR on May 13, 2015: Archivnummer 5189 962).

9.
See: https://www.ina.fr/video/CPF86656441

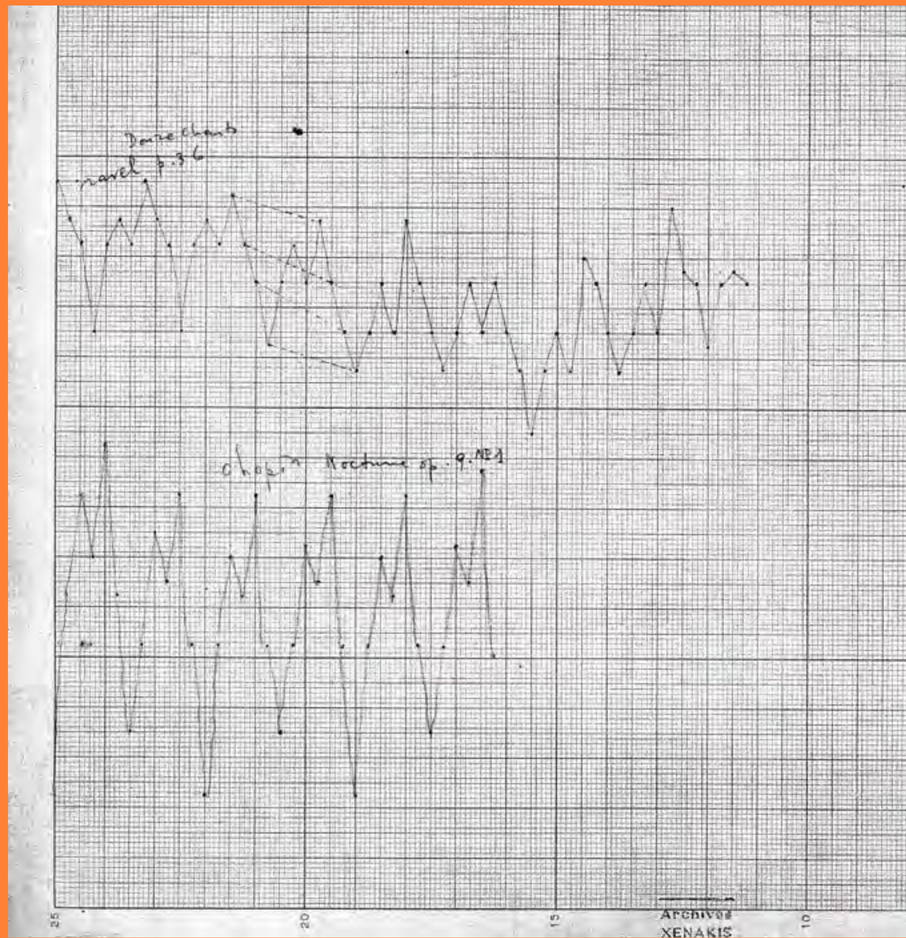


FIG. 2 Iannis Xenakis, graphic transcriptions of excerpts from Ravel's *Douze Chants* (p. 36) and *Chopin's Nocturne, op. 9 no. 1*, undated © Iannis Xenakis Family

Another piece of paper showed a Bach fugue with the structure shown in different colours on squared graph paper. This was also a product of the student years. (*Manuscripts from 1955 and then from December 1949*).[10]

While compiling the general inventory of Xenakis's personal archives for the Bibliothèque de France soon after they were deposited there, with Benoît Gibson and Makis Solomos, we never came across this colored graph of Bach; however, we did discover a similar document, also a graphical treatment of passages from Chopin and Ravel (see **FIG. 2**).

10.
Bálint András Varga, *Conversations with Iannis Xenakis* (London: Faber & Faber, 1996), 27–28.

FIG. 3 Le Corbusier (left) and Xenakis (right) in the former's studio in Paris © Lucien Hervé

Finally, Xenakis permanently adopted the "occupational deformation" of working while standing that he had acquired during the twelve years in Le Corbusier's studio (1947–1959),[11] a habit he never lost, even when composing instrumental music in traditional notation.

For the first time ever, in this book, we get to relive "The Early Days of the UPIC," the actual conception of the UPIC, from the pen of the engineer who personally worked side by side with Xenakis to create the first official prototype, both inside and out, **GUY MÉDIGUE**. We not only discover what choices were made and why, but also gain an insight of their race against the clock that perhaps caused some of the limitations of this first realization and which subsequently became inherent in its future iterations.[12]

ALAIN DESPRÉS was the first director of Les Ateliers UPIC, the entity created by Xenakis in 1985 specifically to promote the system beyond the confines of his research lab CEMAMu to the broadest public possible. In his article "UPIC: Towards a Pedagogy of Creativity," we learn of the UPIC's odysseys throughout Europe, twice to Japan, and a grand tour spanning from Mexico to Quebec. Little by little, we witness UPIC's profile being defined independently yet simultaneously as a pedagogic tool for initiating music training and as a tool for professional composers.

RUDOLF FRISIUS specifically addresses Xenakis's UPIC as a tool for Experimental Music Pedagogy and appraises it within the tradition of European post-WWII music education at large and also within the approach of "notation reform" that was happening concurrently. In the context of such societal transformations, he addresses Xenakis's own work directly involving the UPIC, originally conceived as a radio play (but later adapted for several distinct concert versions), *Pour la Paix* (1981).

11.
See Iannis Xenakis and Sharon Kanach, *Music and Architecture*, Book 1 (Hillsdale, NY: Pendragon Press, 2008), 3–124.

12.
Specifically, so far there have been eight distinct versions derived from the UPIC:
1977 = UPIC A
1983 = UPIC B (Intel 8086 version)
1986 = UPIC C (real time version)
1991 = UPIC (Windows version)
2001 = UPIX (software version)
2014 = UPIX2014 (experimental UPIX update)
2018 = UPISketch 1.0 (for mobile iOS devices)
2019 = UPISketch 2.0 (for mobile iOS devices, OS, and Windows)

The person who succeeded Després at Les Ateliers UPIC for the following sixteen years (1991–2007) was also the only private individual to ever own an original, first-generation UPIC (which still functions!). In his interview "Composing with Sound…", the American composer **GERARD PAPE** divulges to us his reasons for enlarging Les Ateliers UPIC's focus to embrace other compositional tools alongside the UPIC. In 2000, it was Pape, with Xenakis's consent, who renamed Les Ateliers UPIC the Centre de Création Musicale Iannis Xenakis (CCMIX) to honor its founder.

In 2007, a new team was appointed by the French Ministry of Culture to run the CCMIX, which was rapidly and simply renamed Centre Iannis Xenakis (CIX), as it is still called today, with a stated mission to refocus, very specifically, on the "artistic and intellectual legacy of Xenakis and the UPIC."[13] One of the first tasks we accomplished at CIX was to create a general inventory and begin cataloguing our unique collection of archival items accumulated over a long time span and by so many (sometimes confusingly) articulated institutions. **CYRILLE DELHAYE**, responsible for the CIX's archives and their dissemination, recounts in his essay "Milestones and Challenges" in this volume what we have accomplished so far, some of the challenges we still confront, and offers a casestudy of what research in our archives can yield. It is also thanks to Delhaye's preliminary work in the CIX archives that we were able to identify and contact key figures in our history, such as Guy Médigue and Alain Després, amongst others, as well as several composers included in this volume such as Richard Barrett, Takehito Shimazu, Dimitris Kamarotos, and so on. **VICTORIA SIMON**'s chapter "Unflattering Sounds…" also originates in part from a three-month research residence in 2016 in the CIX Archives in Rouen that she did while a PhD candidate at McGill University, Montreal.

13.
See: Fernand Vandenbogaerde, *Rapport d'inspection du CCMIX*, unpublished, December 2006 (CIX Archives, uncatalogued)

During the important stages of UPIC's development, **HUGUES GENEVOIS** was at the French Ministry of Culture overseeing research activities, and he offers a behind-the-scenes and personal perspective on how and why certain decisions were made that impacted life both at the CEMAMu and Les Ateliers UPIC. He also offers an enlightening contextualization in relation to other institutions in France at the time; let us not forget that IRCAM opened in 1977, the same year the first UPIC was launched. Finally, to end this historical part of our book, one of the best-kept secrets of the Xenakian community is finally revealed: the same year Les Ateliers UPIC was founded, Xenakis also opened the KSYME (Contemporary Music Research Center) in Athens, Greece, with local colleagues, which was the only public music center and studio outside France to possess and utilize a UPIC both for educational purposes and as a tool of creation. **KATERINA TSIOUKRA** meticulously explains the genesis of this project, and even how Xenakis proposed to the then Greek President Karamanlis that he could return permanently to Athens to head this center. Then follows the rich and unique testimony of **DIMITRIS KAMAROTOS**, who was intensely involved with all of KSYME's UPIC-related activities, offering us detailed accounts and appreciation of the creative life of and within this institution. After being dormant for several years, the KSYME has recently integrated the Athens Conservatoire, and its invaluable archives are now entrusted to that library. The CIX and KSYME have already begun a close cooperation and our goal is to mutualize our archives to streamline future Xenakian and UPICian research, without borders.[14]

THE BLANK PAGE: COMPOSERS EXPERIENCING THE UPIC

Xenakis always intended the UPIC to be a neutral space, where either the uninitiated or experienced

14.
This aspect of our cooperation is also addressed in Cyrille Delhaye's chapter, this volume.

composers could have free rein to express themselves without any aesthetic impositions made by the system itself. Of course, this was rather utopian, especially given the technological limitations at the time, but it was his goal.

The entries comprising the second section can be seen as "user reports" about some of the most original individual approaches made with the UPIC. We start with **JULIO ESTRADA**, who was initially invited to take over the CEMAMu after Xenakis's death in 2001, before the French Ministry of Culture decided simply to close it down in 2002. His prior experience with the UPIC, both as a composer and as an instructor, notably with groups of blind children, provided him with the hands-on knowledge necessary for outlining future directions for the system, which he publicly shares here for the first time. Furthermore, he develops his fascinating transformation of his important, yet only work on the UPIC, *eua'on* (1980), into a work for large orchestra, *eua'on'om* (1995).[15] Finally, his compositional experience with the UPIC was fundamental to the development of his theory of continuum–discontinuum which he discusses here as well.

RICHARD BARRETT composed his stunning *The Unthinkable* in 1989 at Les Ateliers UPIC. We discovered a poignant "user's report" written by him at the time in the CIX archives which I dared to ask him to revisit for this volume. His acceptance of the challenge and reflections on a work from thirty years ago is moving, telling, and informative. In his original report, he included eight suggestions for improvements to the system, several of which were indeed implemented in subsequent versions of the UPIC. But especially today he describes what working on this piece taught him as a composer, when those "miraculous accidents" occur, which led him to seek out spontaneity rather than obsessive control. He invites us to do a comparative listening between *The Unthinkable* and a very recent electronic work, *disquiet* (2019) to discover for ourselves any similarities, and it is certainly revealing.

15.
Interestingly, Xenakis also noted in an unpublished recorded interview with Alain Després (undated) how his *Mycènes Alpha* (1978), composed on the UPIC, influenced his work for large orchestra and chorus, *Anemoessa* (1979) (See: CIX Archives, item 0477–01, at ca. 5'.) Due to copyright restrictions, only the first three minutes of this informative interview (in French) can be consulted online here: http://www.centre-iannis-xenakis.org/items/show/105 See also Benoît Gibson, *The Instrumental Music of Iannis Xenakis: Theory, Practice, Self-Borrowing* (Hillsdale, NY: Pendragon Press 2011), 208. Gibson, in his impressive "Genealogy of Xenakis's Works" at the end of his book, indicates that there Xenakis "borrows" from *Mycènes Alpha* in *Anemoessa*, without specifying any instances.

One of Xenakis's closest and oldest friends, **FRANÇOIS-BERNARD MÂCHE**, was probably the first other composer to use the UPIC as a tool for composition. His pioneering approach ended by turning it "upside down," generating several remarkable works such as *Tithon* (1980) and *Hypérion* (1981). He was also one of the first, if not the very first, to combine acoustic instruments with UPIC-generated tape in compositions such as *Nocturne* (1981) for piano and tape. Furthermore, as director of the Primus sound lab at the Université de Strasbourg, Mâche purchased a UPIC in 1987, and fully integrated its mastery in the first ever (in France) specific training program for sound engineers.

In all, Les Ateliers UPIC made two tours of Japan under the direction of Alain Després, the first one taking place in 1984. In early 1990, the Japanese composer **TAKEHITO SHIMAZU** was first introduced to the UPIC in Paris. Immediately upon his return to Japan, Shimazu began organizing a second UPIC tour of his country, which took place in October of the same year, managed by Després and Les Ateliers UPIC. Later Shimazu invited Les Ateliers UPIC (then under Gerard Pape's directorship) to participate in the ICMC (International Computer Music Conference) conference hosted in Tokyo in 1993. Shimazu's unique approach of integrating traditional Japanese ideas in his UPIC compositions, whether for tape (*Monodie IV,* 1990), mixed (*Monodie IVa,* 1990) for tape and percussion, or *Illusion in Desolated Fields* (1994) for tape and the traditional Japanese string instrument sangen, are distinctly personal and refreshing.

As the author of the internal "User's Guide" for the real time version of the UPIC in the early 1990s,[16] **BRIGITTE ROBINDORÉ** certainly knows—inside out—what

16.
Brigitte Robindoré, *The UPIC User's Guide and Tutorial*, 1992, Université de Rouen, CIX Archive 4/224.

that last hardware iteration of the UPIC was capable of producing, as well as its inherent limitations. Despite the hundreds of composers' forays into the UPICian universe, the subtitle alone of her chapter—"The Undiscovered Terrains of the UPIC" is extremely intriguing, and we at CIX are now in close contact with Jean-Michel Raczinski, the main architect of that version, to attempt to restore to full working order at least one of our UPIC mainframes. It is rather encouraging to think that the historic UPIC has still not said its final word!

XENAKIS AT THE UPIC

Although Xenakis wrote only five works on the UPIC (and ultimately pulled the last one, *Erod* (1997) from his catalogue), they are part of his opus of electroacoustic works, which itself is proportionately small in relation to his entire musical output, around ten percent, yet among his most influential and pioneering works. His UPIC works represent roughly one-third of that category and, aside from the very first work ever to be created using only the UPIC, *Mycènes Alpha* in 1978, the remaining three works were all composed in the 1980s. Like the UPIC itself, these works can be approached and analyzed in an infinite number of ways. **RUDOLF FRISIUS**'s sociological approach to *Pour la Paix* (1981) has already been mentioned. **RONALD SQUIBBS** offers a "Listener's guide" to the very first work ever to be created using only the UPIC, and which is perhaps the most iconic UPIC work to date, *Mycènes Alpha* (1978). Unlike his other UPIC works, Xenakis provided his publisher, Salabert, with the UPIC score for publication. Therefore, it is readily available online for consultation while listening to this work and, after reading Squibbs's analysis, identifying repetitions and various structural and temporal perspectives, we are surely able to better comprehend Xenakis's focus on the actual listening experience of this masterpiece.

The attraction of the relatively new realm of digital musicology becomes apparent in **PIERRE COUPRIE**'s analysis which covers the two remaining UPIC works by Xenakis: *Taurhiphanie* (1987) and *Voyage absolu des Unari vers Andromède* (1989). Couprie's proprietary software iAnalyse offers stunning and insightful new perceptions that complement the meticulous archival research of both the drawings and the audiotapes that the composer has left us. Unprecedented visualizations, in vivid colors, enable us to see what, in fact, the composer was doing, either intuitively or consciously, and therefore increase our appreciation of his work.

Occasionally, unearthing or rediscovering unrealized projects can shed enormous light on a creator's most profound intentions. Often, they reveal wildest dreams, an utopian vision, a drive to surpass one's own limits, and this is indeed the case with Xenakis's unrealized "Ballet for Emancipated Robots." **HENNING LOHNER**, who as mentioned above,

FIG. 4 Group photo taken in a Greek restaurant in Karlsruhe, September 28, 2018, from left to right: Guy Médigue, Cyrille Delhaye, Rodolphe Bourotte, Alain Després, François-Bernard Mâche, Marie-Luce Staib-Mâche
© Marie-Luce Staib-Mâche, photo: Sharon Kanach

was solicited by Xenakis to try to get this project off the ground in Germany after his own failures in France and in Italy, recounts with passion his adventure and why it ultimately had to be shelved. His comparative chronology between the advent of robots and Xenakis's own life resounds eerily like it is more than a simple coincidence.

STATE OF THE ART

Innumerable lives have been transformed by either brief or extended encounters with the revolutionary UPIC system, and hundreds of works have been composed using it. This volume, a first scholarly approach to the subject under many of its historical, current and future aspects, hopefully also renders palpable the creative, human, and even emotional impact it has made—not only on those of us who knew and worked closely with Xenakis over the years. Even our own recent meeting—for the first time—with the actual people behind the myths that their auras have generated in the UPICian universe, such as Guy Médigue and Alain Després, in Karlsruhe during the conference *Graphic Interfaces for Notation* which the Hertz-Lab at ZKM | Karlsruhe organized cooperatively with the CIX as a prelude to this book in late 2018,[17] felt like a "welcome home" celebration.

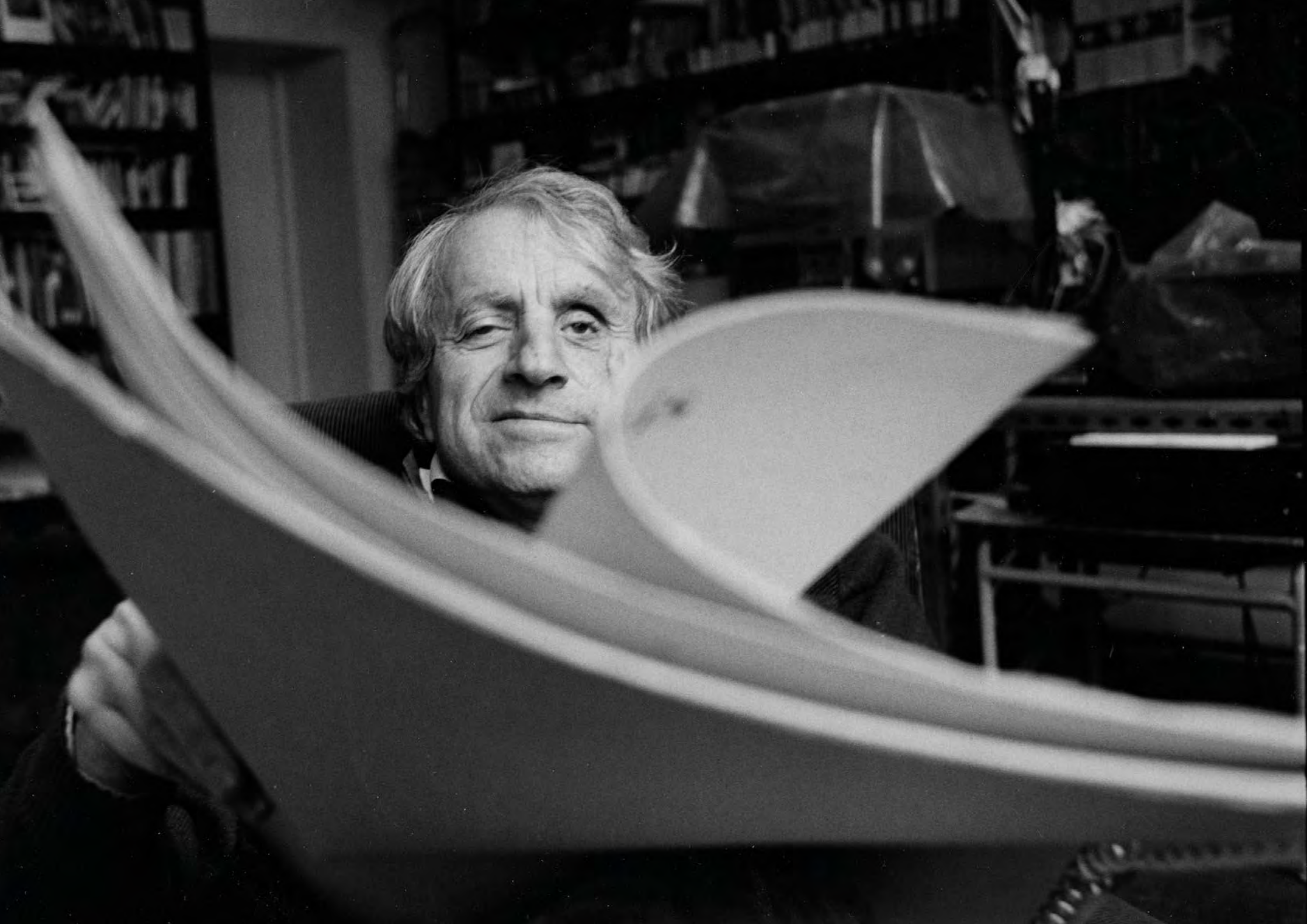
My sincere gratitude to all our authors who willingly accepted the challenge to commit to paper their experience which will now enter the annals of verified history. Profound thanks, too, to Marie-Emmanuèle Verrier, secretary of the CIX, who knew how and when to save the day by transcribing some of the oral testimony gathered while compiling this volume. Also, we at CIX welcome this opportunity for our modest association, that runs on extremely limited financial resources, but is a treasure trove of memories, experience, and commitment, to cooperate with the important institution ZKM | Karlsruhe.

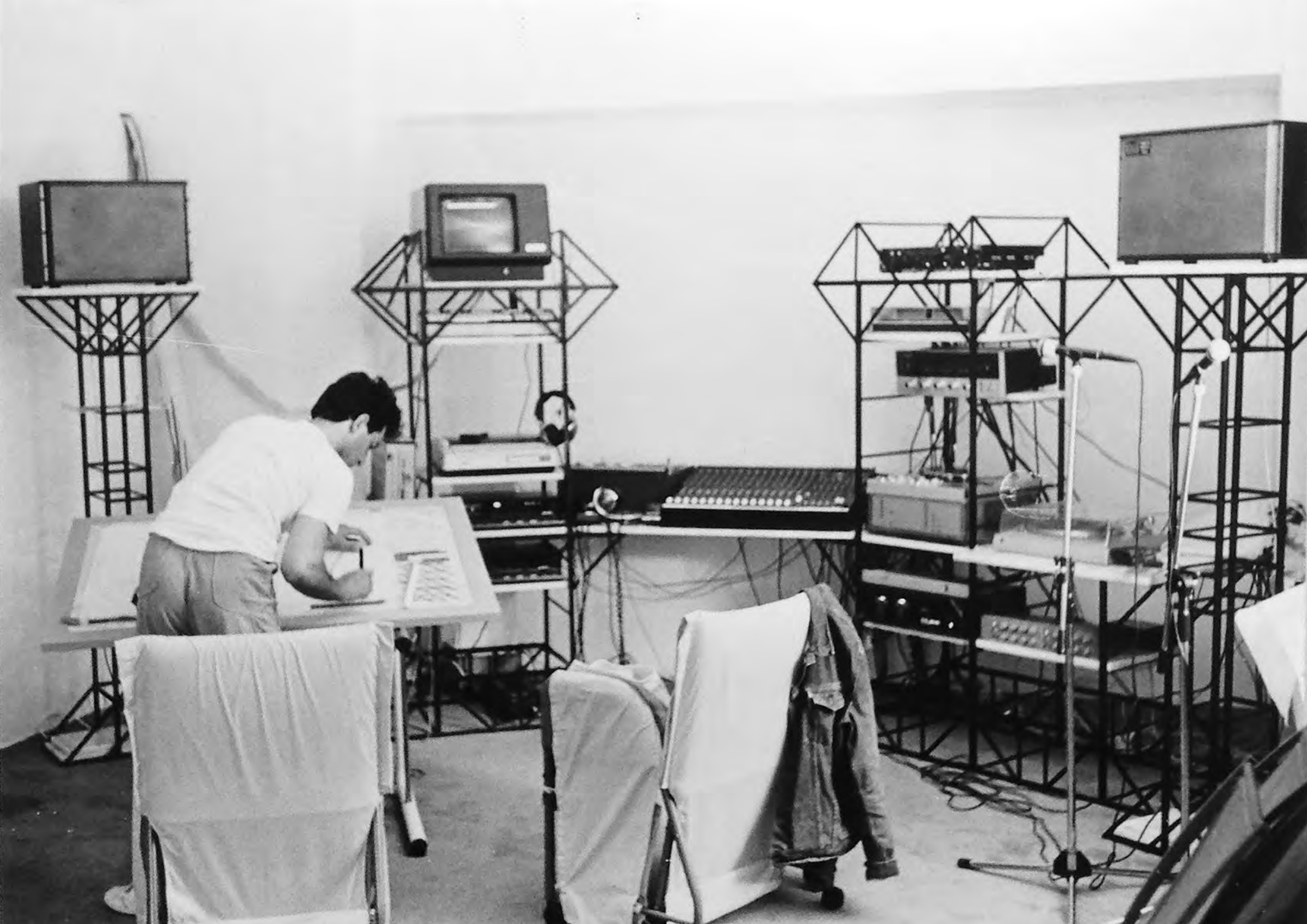
17. https://zkm.de/en/event/2018/09/upic-graphic-interfaces-for-notation-conference

Cocurating this book has been a journey on which I learned many new things, although I've been on the "inside" for decades. I truly hope our readers, too, will be enlightened through the discovery of little or previously unknown facts about the UPIC. Like all major breakthroughs, Xenakis's initial intuition required incredible teamwork, institutional cooperation and support, plus dedicated users to enable it to become a reality, thrive, dwindle, and then thrive again over nearly half a century. Although authoritative, this book was never intended to be exhaustive; it is rather an invitation for future research showing that different perspectives can yield multiple and unforeseeable horizons. May this publication, too, be a prelaunch of centenary celebrations of the life and work of this great yet humble man, Iannis Xenakis.

SHARON KANACH

FIG. 5 Iannis Xenakis at the CCMIX, 1995 © Curtis Roads





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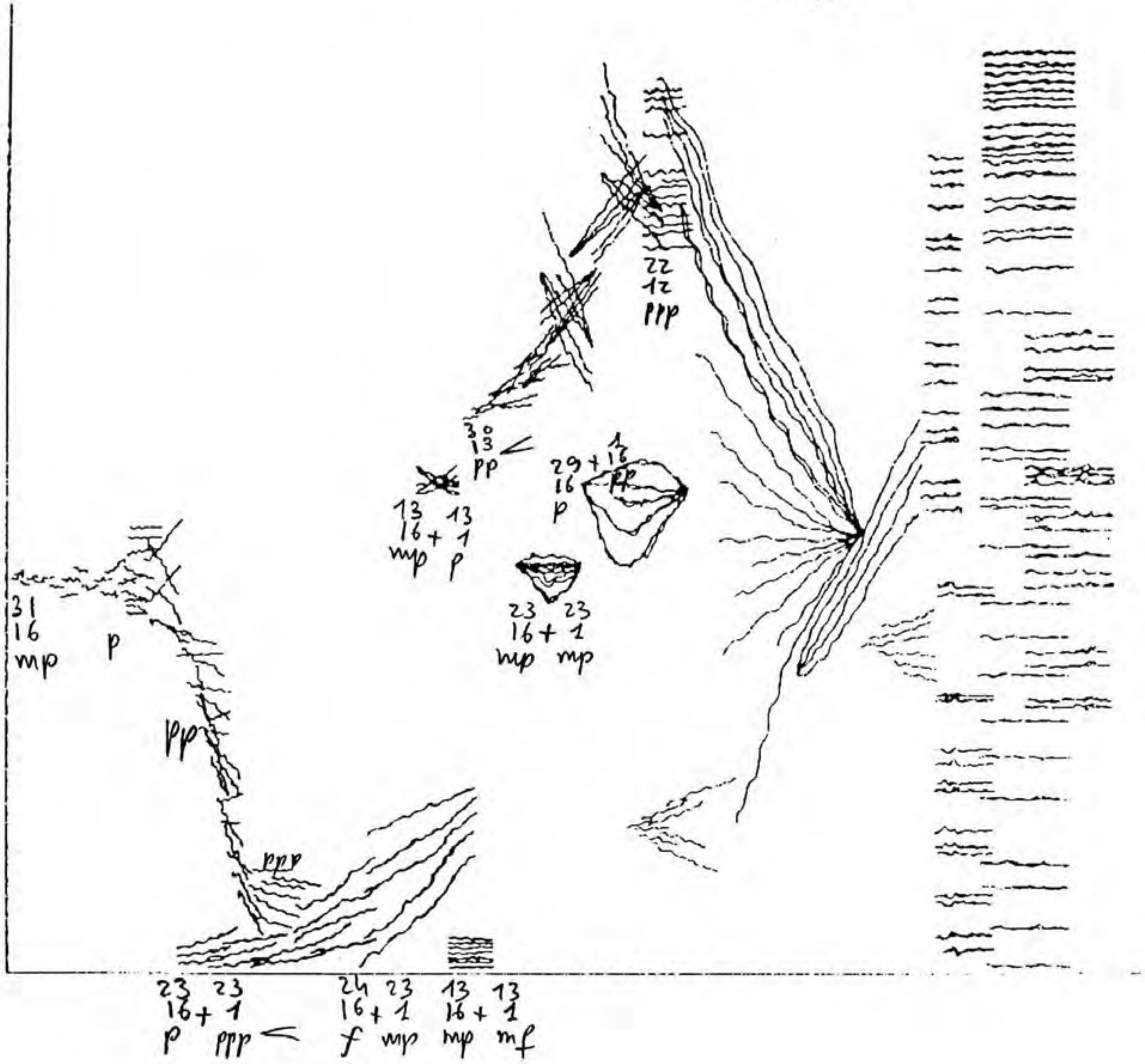

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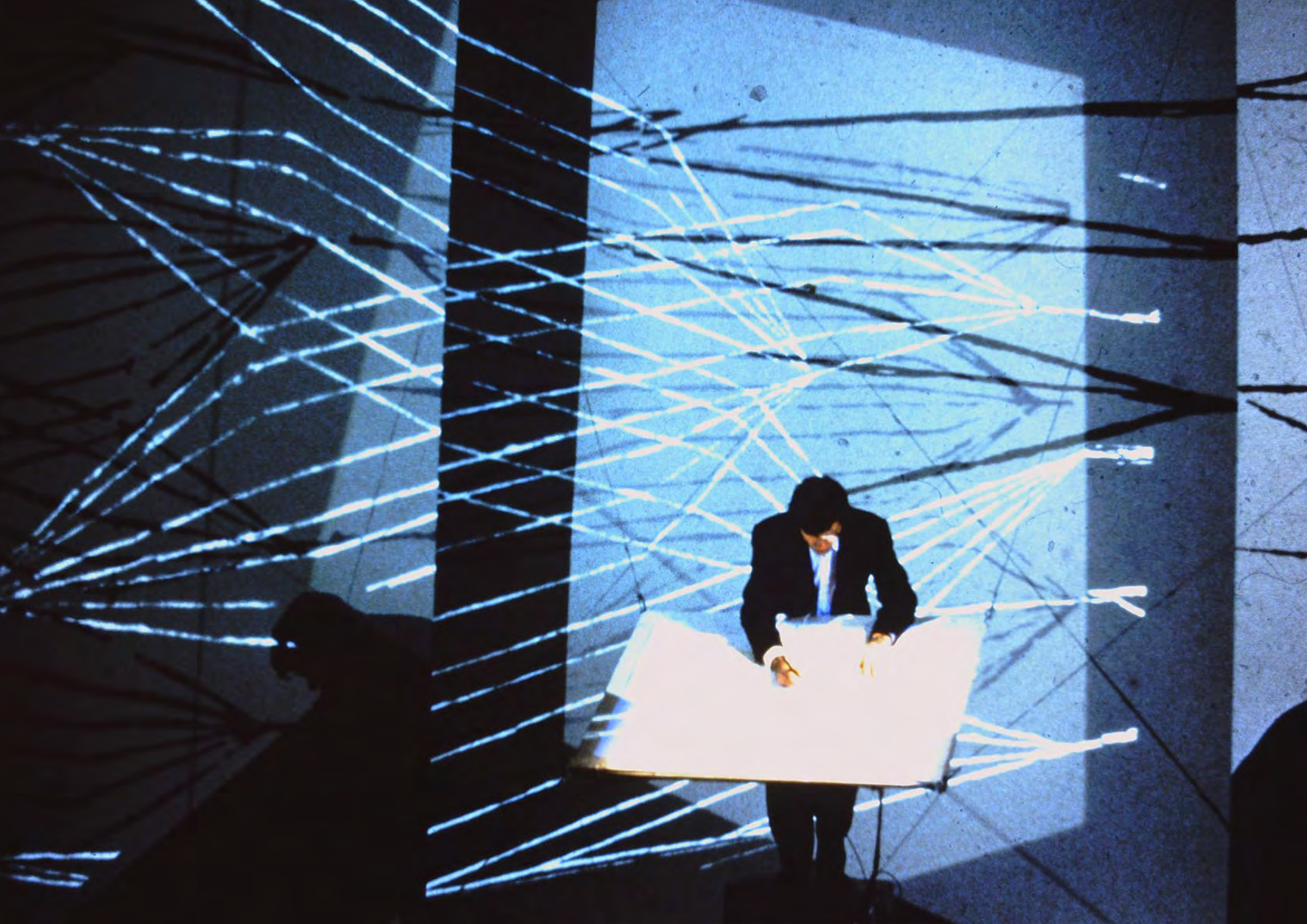

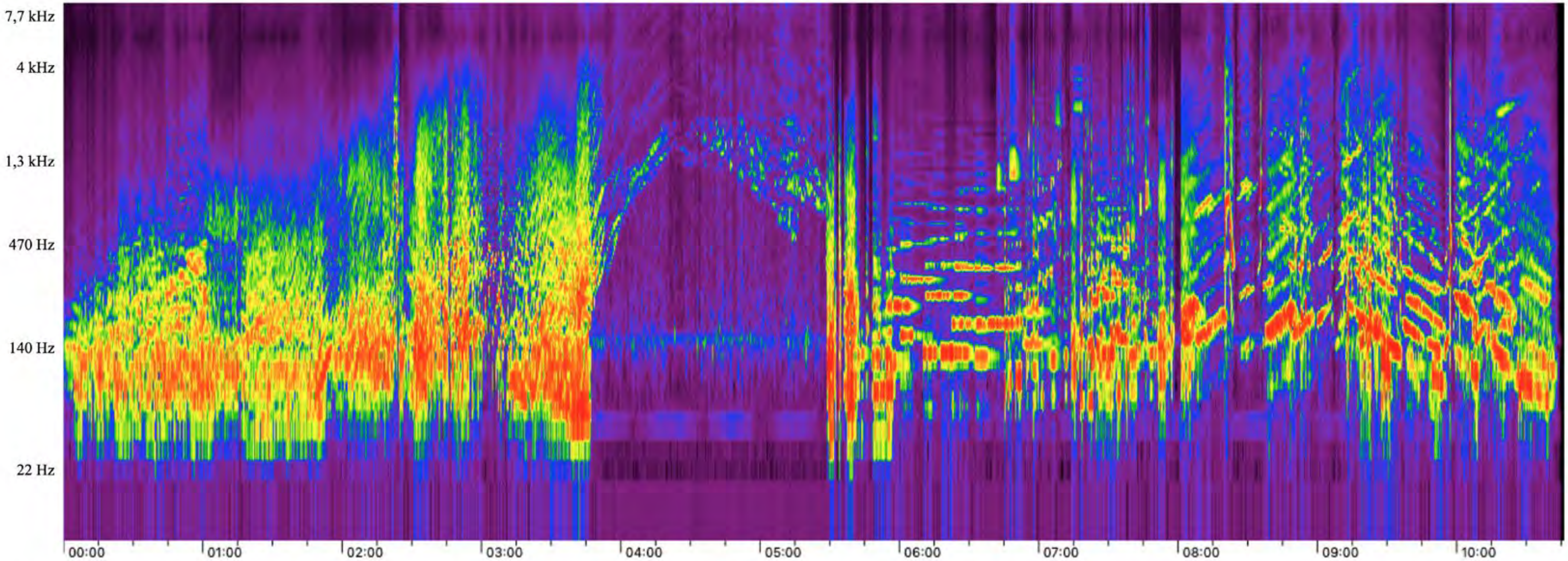
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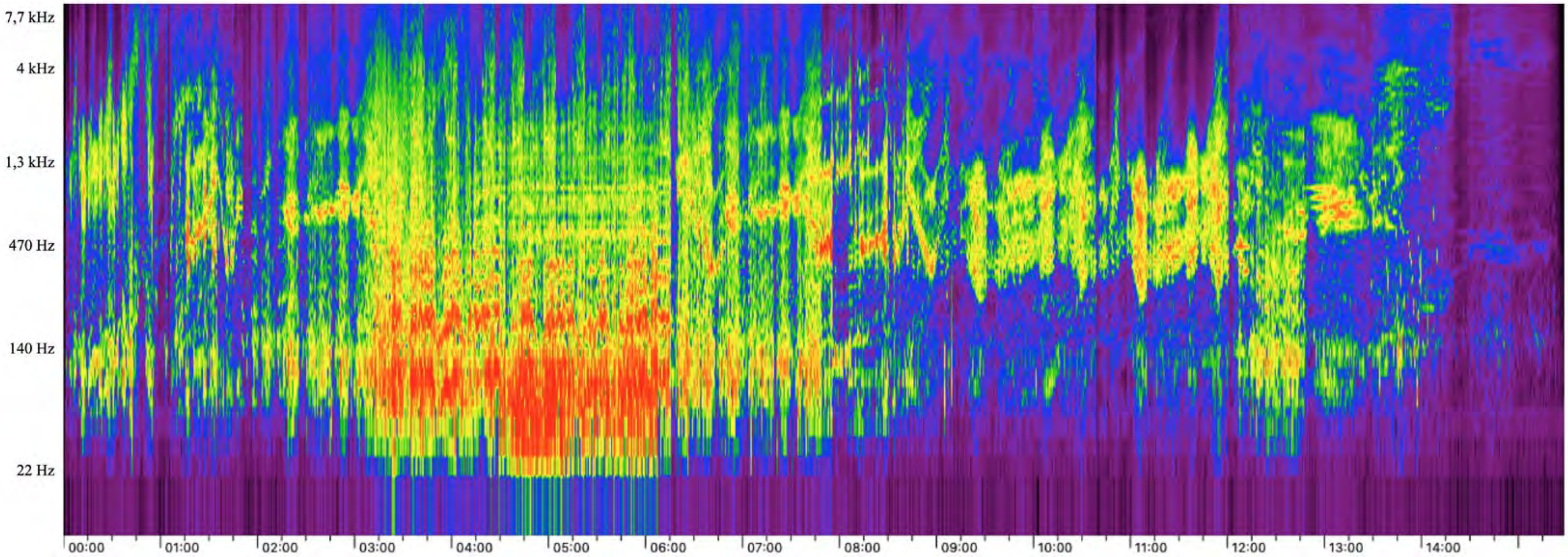
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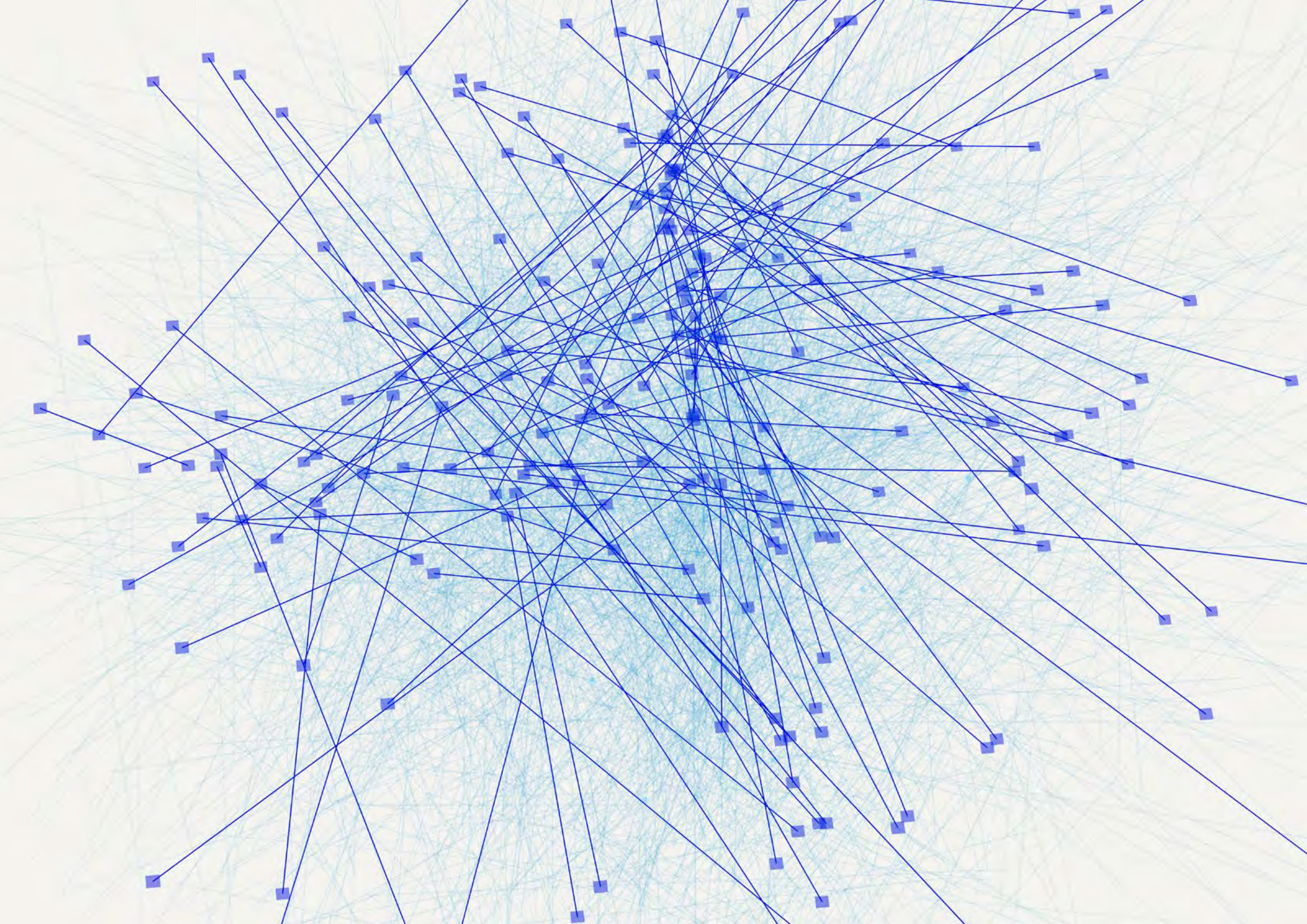


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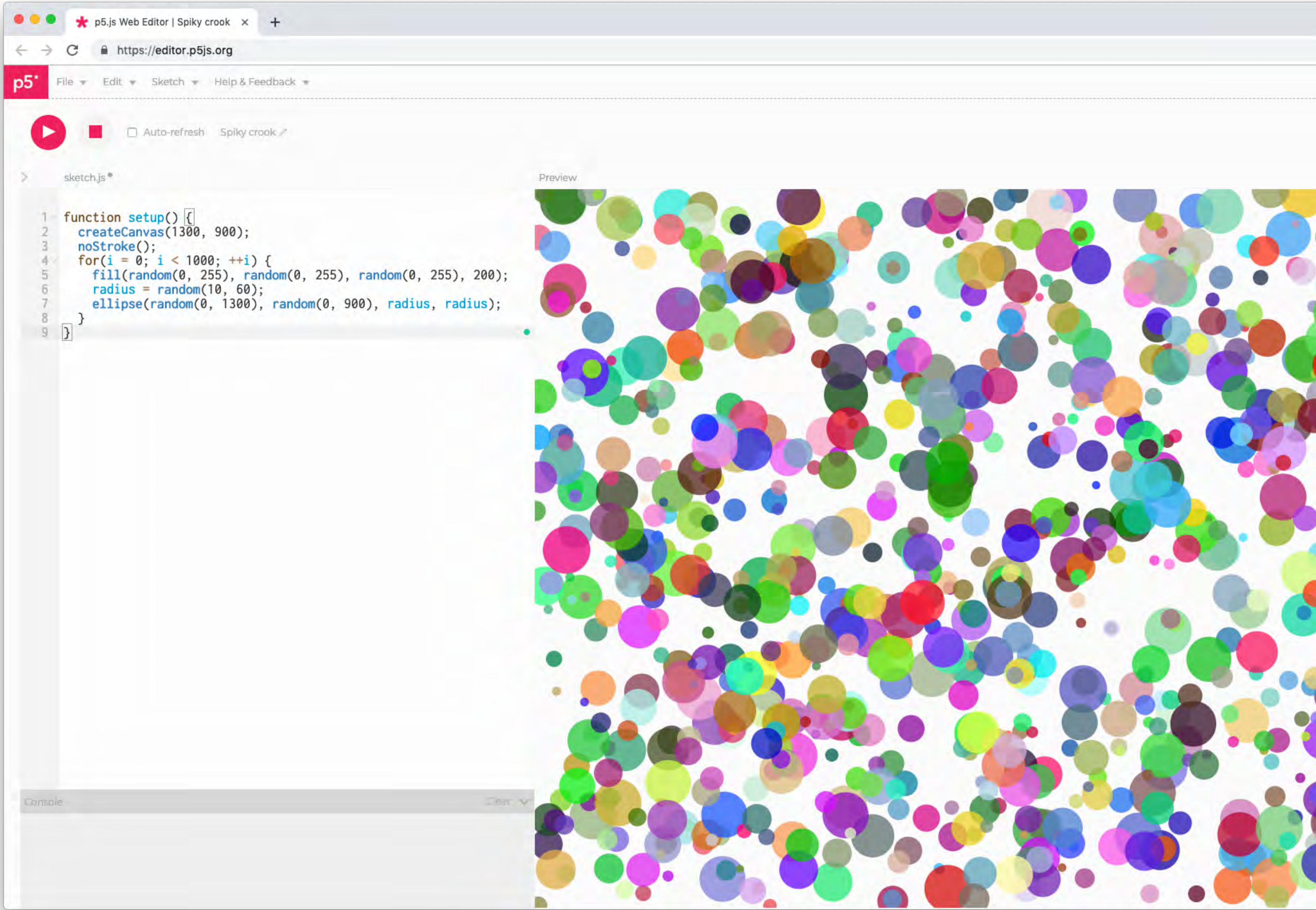
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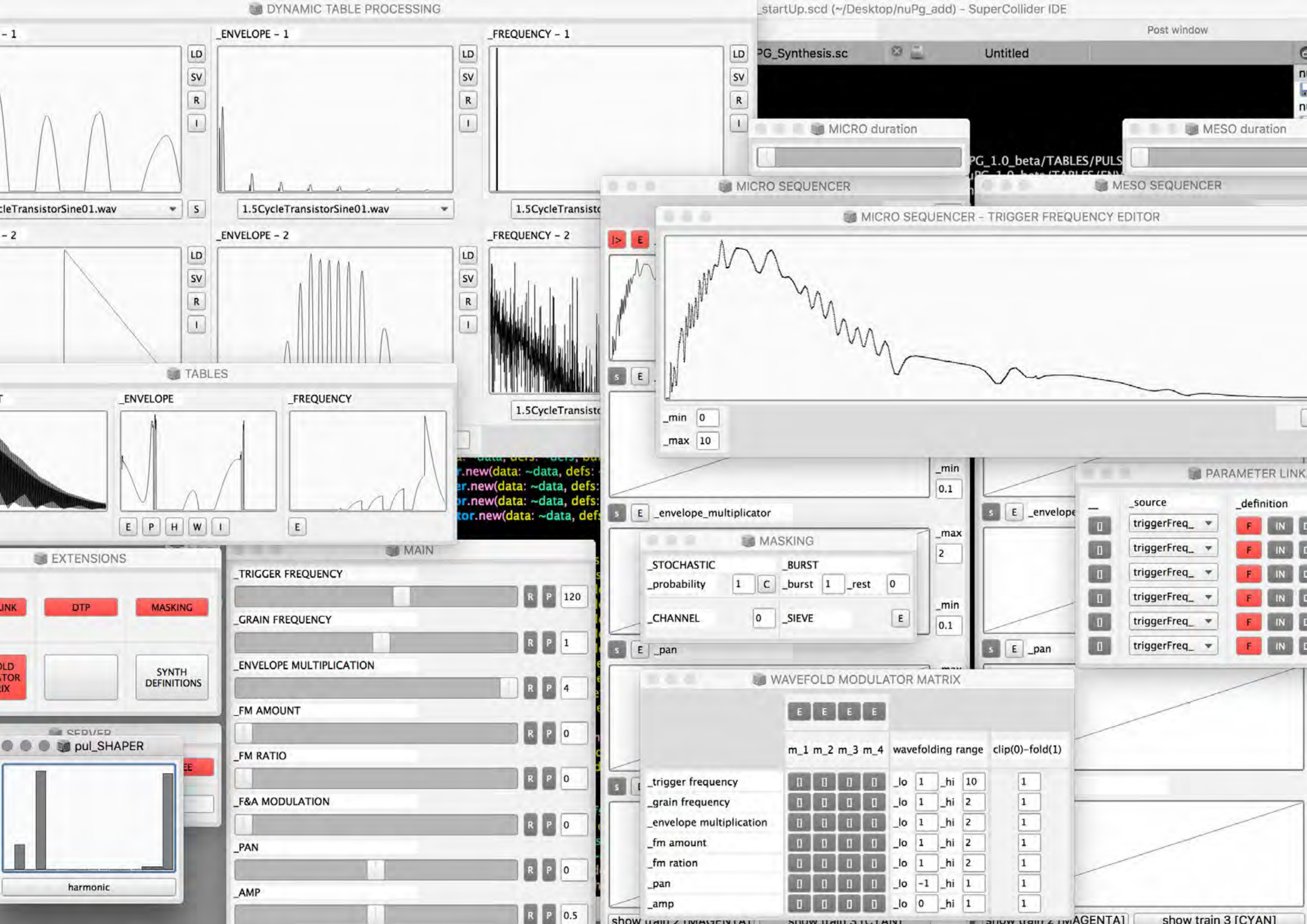
    fill(random(0, 255), random(0, 255), random(0, 255), 200);
    radius = random(10, 60);
    ellipse(random(0, 1300), random(0, 900), radius, radius);
  }
}
Console
Clear


DYNAMIC TABLE PROCESSING
_ENVELOPE – 1
_FREQUENCY – 1
LD
SV
R
I
1.5CycleTransistorSine01.wav
_ENVELOPE – 2
_FREQUENCY – 2
startUp.scd (~/Desktop/nuPg_add) - SuperCollider IDE
Post window
Untitled
MICRO duration
MESO duration
MICRO SEQUENCER
MESO SEQUENCER
MICRO SEQUENCER – TRIGGER FREQUENCY EDITOR
_min
_max
TABLES
_ENVELOPE
_FREQUENCY
_envelope_multiplicator
_pan
MASKING
_STOCHASTIC
_BURST
_probability
_burst
_rest
_CHANNEL
_SIEVE
PARAMETER LINK
_source
_definition
triggerFreq_
EXTENSIONS
DTP
MASKING
SYNTH DEFINITIONS
MAIN
_TRIGGER FREQUENCY
_GRAIN FREQUENCY
_ENVELOPE MULTIPLICATION
_FM AMOUNT
_FM RATIO
_F&A MODULATION
_PAN
_AMP
pul_SHAPER
harmonic
WAVEFOLD MODULATOR MATRIX
m_1 m_2 m_3 m_4
wavefolding range
clip(0)–fold(1)
_trigger frequency
_grain frequency
_envelope multiplication
_fm amount
_fm ration
_pan
_amp
_lo
_hi
show train 3 [CYAN]


Factory Sounds
Animals
cock.wav
ELEPHANT.wav
growl.wav
Instruments
Banjo-B.wav
Banjo-D.wav
Guit.wav
Guit2.wav
PrepPiano.wav
Sax.wav
SlideFlDown.wav
User Recorded Sounds

→ method:
documentation of all tunnels and bridges on a train trip

→ location / means of transport:
train trip between [illegible] and [illegible] / switzerland

→ structure:
time box / from [illegible] / duration of train trip
every line stands for 5 minutes / measurement in seconds

→ visualization:
half black circles stand for tunnels / arches stand for bridges
the size of the elements refer to the length of the bridge
or the tunnel

→ linear map

link / transition

→ tunnels and bridges are spatial elements that connect [illegible]
→ [illegible]

space directions:

basic:
sequences of separated places that are linked to each other by spatial elements (spaces)

character:
fragmentary

bridge:
a overview / giddiness / balance
b wide / free / light / soft
c possible development: topography / height differentiation / e.g. from low to high / e.g. reversal point / different grounds
d transition from bridge to regular landscape can be abrupt or smooth

tunnel:
a lose orientation: where am I? / claustrophobic
b compressional wave - tight / table / reflection of the interior / swoosh / dull / noise / thunder / vibrating
c almost no development / preparation for the [illegible] of the tunnel (lightly increasing brightness)
d transition from tunnel to regular landscape is always abrupt

dramaturgy:
intervals between the elements within a single minute can be arranged as favoured (no overlapping) /
tunnel: surprise / different landscape element before and behind the tunnel / bridge: same landscape element on both sides of the bridge /
in general: descent / heights of bridges descend towards the end of the map /
minute 19: highest bridge

stage direction:

→ **demonstration of the transition from one position to the next**
example: one p is crossing the stage from one side to the other carrying a chair / according to the rhythm of the map the p stops and climbs over the chair (bridge) or crawls [illegible] (tunnel) /
focus: body

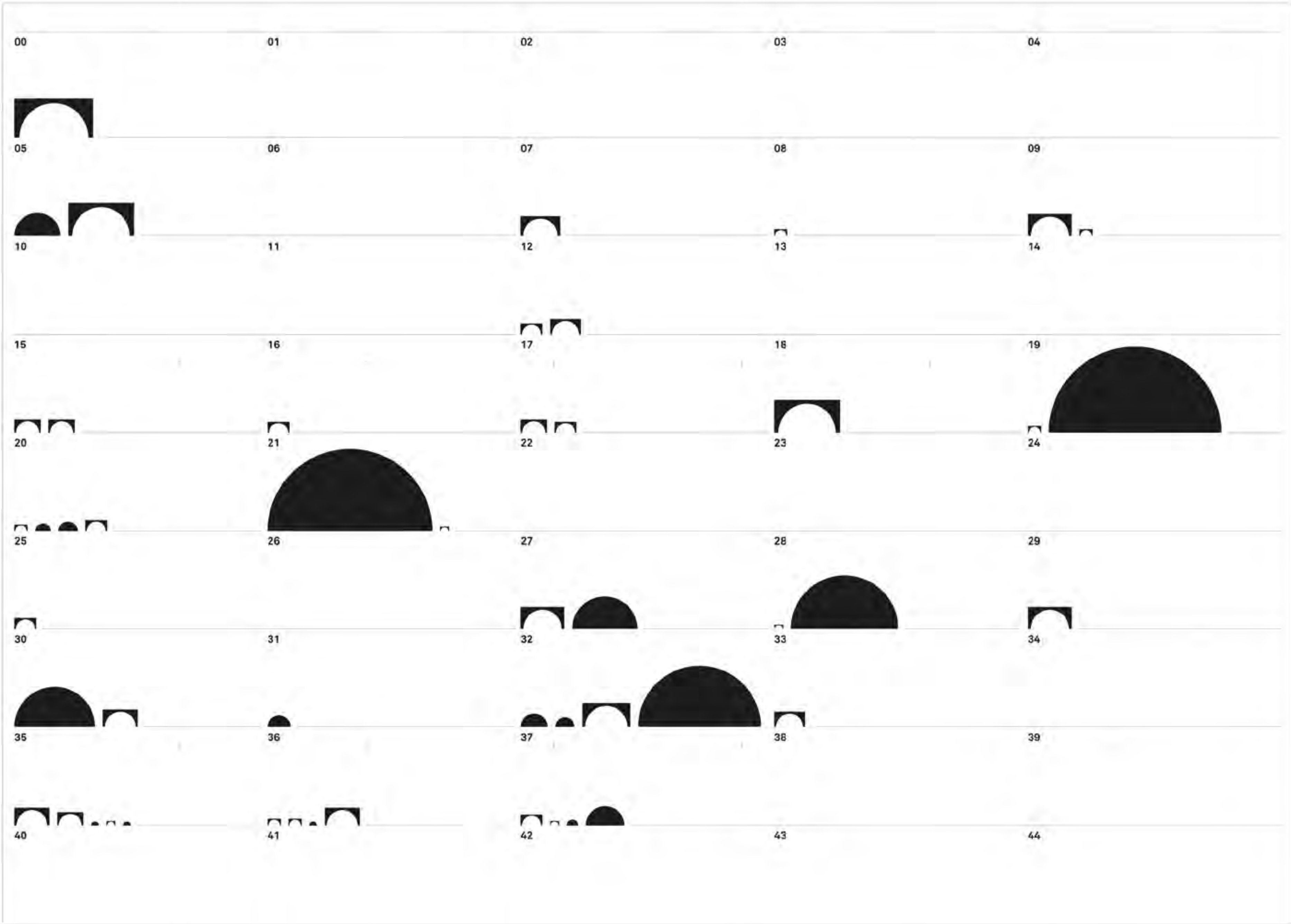
→ **demonstration of the link between different ps / both the tunnels and the bridges are represented by actions that create an interaction between people / the rhythm of the action refers to the rhythm of the map.**
example: an object is given by one p to another /
tunnel: a hands out ticket to the ticket controller / ticket controller gives it back
tunnel: flight attendant hands out [illegible] to the ps
[illegible] text map
focus: body and speech

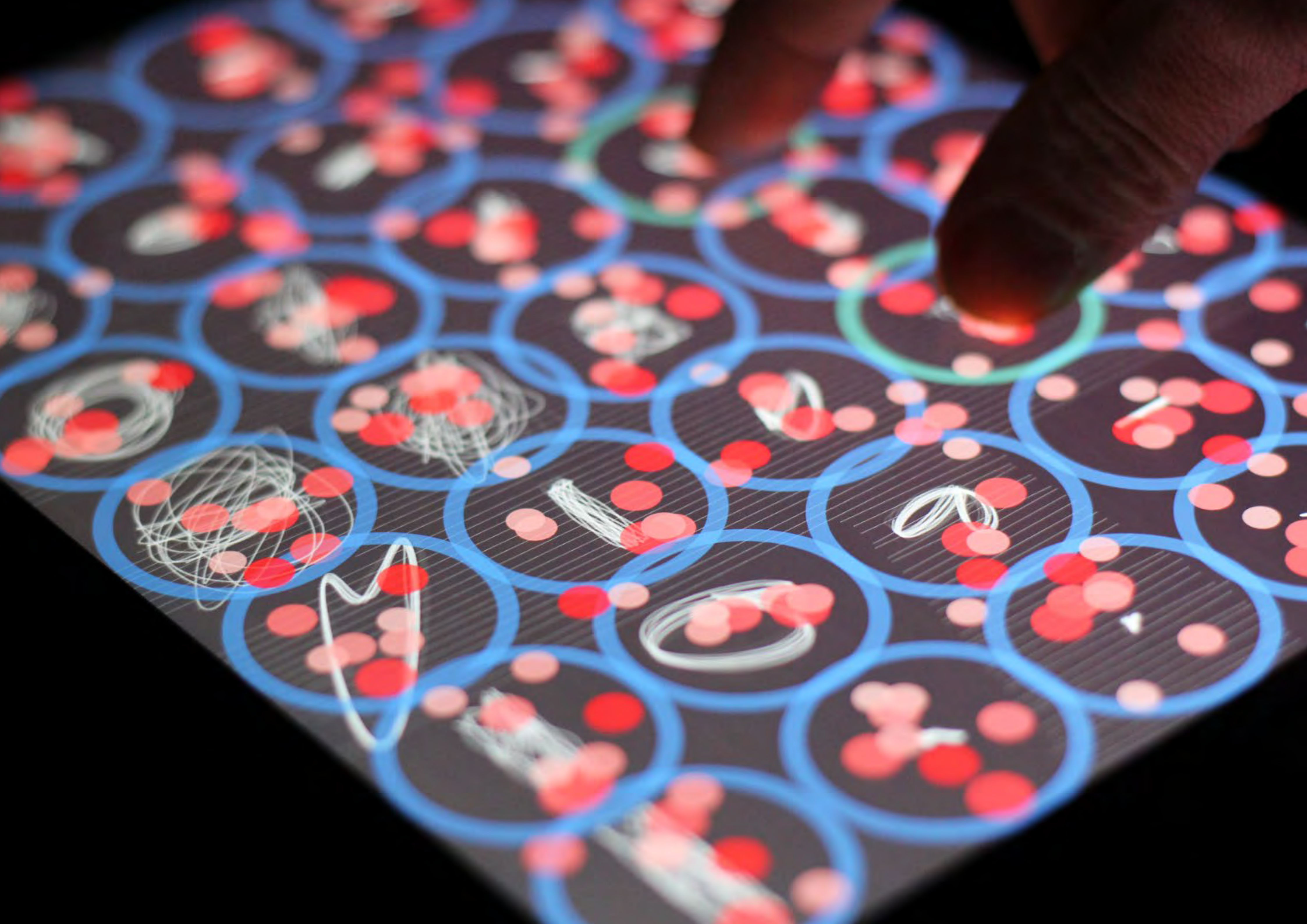
→ **demonstration of the transformation from one situation to the following**
example: reorganisation of the stage setting
focus: body

→ **demonstration of the transition by a break through**
example: paper walls
focus: body

→ **demonstration of the discontinuity of the landscape / disruption of a circulation system**
example: electric circuit that connects various light sources / tunnel: black, shade / bridge: bright light
length of the tunnel / bridge refers to the amount of light sources (bridge) and the burning time
focus: body

bridge and tunnel map





THE UPIC: HISTORY, INSTITUTIONS, AND IMPLICATIONS

ANDREY SMIRNOV
GUY MÉDIGUE
ALAIN DESPRÉS
RUDOLF FRISIUS
GERARD PAPE
HUGUES GENEVOIS
CYRILLE DELHAYE
KATERINA TSIOUKRA
DIMITRIS KAMAROTOS
RODOLPHE BOUROTTE

UPIC'S PRECURSORS

ANDREY SMIRNOV

ANDREY SMIRNOV

UPIC'S PRECURSORS

The UPIC (Unité Polygogique Informatique du CEMAMu) is a computerized system designed and implemented in 1977 by Iannis Xenakis and the engineers at CEMAMu, and made for a Solar computer mainframe.[1] It consists of a digitizing tablet connected to a computer, which has a vector display. It is not an instrument to sonorize drawings, but rather a tool for composition which allows one to translate drawings into a musical piece by means of a graphical approach that replaces traditional music notation. The UPIC was also a digital synthesizer, capable of working mainly with additive synthesis and frequency modulation. The system allows for real-time performance by moving the stylus across the tablet, and it enabled not only the definition of the score but also its execution. As Xenakis put it: "Anybody, even myself, or you, or children, can draw lines or graphics with an electromagnetic ballpoint, and they are transformed by computer directly into sound."[2] It was an "interactive composing environment based on drawing and manipulation of images of waveforms, envelopes, and sonographic spectra,"[3] revealing new musical possibilities as harmonic or temporal events are shaped over time and woven into a musical narrative. Which, in its turn, opens up a way to explore the conceptual and perceptual boundaries between timbre and harmony, frequency and pitch, rhythm, duration, form, and the evolution of processes implied by the physical properties of sound. The UPIC is therefore closely allied with technological developments in the field of audio analysis and synthesis, psychoacoustics and the perception of music, engaging these phenomena as a fundamental aspect of new musical discourse.

The first known attempts to realize this idea were undertaken as early as the first half of the twentieth century by various mechanical, optical, and, later, electronic means when researchers involved in sound synthesis faced growing mountains of controls and related parameters or, in the case of audio computing techniques, tedious, repetitive calculations. Arithmometers and abacuses were widespread, but too slow and outdated. Artists and inventors around the world—often unaware of each other yet following parallel paths—tackled the challenge.

In 1938 Percy Grainger, an Australian-born polymath—a pianist, composer, conductor, ethnomusicologist, inventor, artist, and polyglot—decided to create his first technical device to compose "free music:" music that was free from scales, fixed intervals, rhythmic constraints, and other conventions. As he put it: "It seems to me absurd to live in an age of flying, and yet not be able to execute tonal glides and curves."[4] In 1944

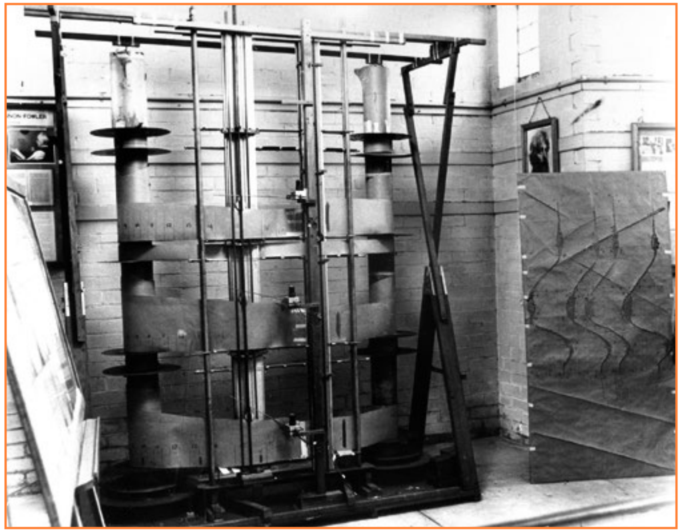


FIG. 1 Percy Grainger and Burnett Cross working on a Free Music tone-tool experiment at White Plains, ca. 1950. Courtesy and © Grainger Museum Collection, University of Melbourne

FIG. 2 Kangaroo-pouch Tone-tool Free Music experiment created by Percy Grainger and Burnett Cross, created after 1955. Courtesy and © Grainger Museum Collection, University of Melbourne

Grainger met a scientist, Burnett Cross, and they began a collaboration to build the Free Music Machine. Cross describes the project:

> *Granger wanted a composer's machine, not one for the concert hall. As he said, he wanted to hear in actuality the sound he had heard in his mind for many years [...] The Free Music Machine had to be able to play any pitch within its range. It was to be free of the limitations of speaking in half tones, or quarter tones, or eigth tones for that matter [...] The machine had to be able to go from pitch to pitch by way of a controlled glide as well as by a leap [...] The machine had to be able to perform complex irregular rhythms accurately, rhythms much too difficult for human beings to execute [...] The machine had to be workable by the composer. It was not to require a staff of resident engineers.*[5]

Perhaps the most famous of Grainger's and Cross's machines was the "Hills and Dale" or "Kangaroo Pouch method of synchronizing and playing eight oscillators," which had rolls of paper, with the edges cut in a wavy pattern, made to turn on a roller. The final version of the Free Music Machine, called "Electric Eye Tone Tool," was, however, purely electronic. It was completed in the mid 1950s and in its last version, the cut paper outlines were replaced by patterns painted on rolls of clear plastic. A row of spotlights shone through the plastic projected light beams onto an array of photocells, which in turn controlled the oscillators. The inventors were working on this device at the time of Grainger's death (1961).[6]

While Grainger considered his concept of "Free Music," as well as the experimental machines to create it, to be "his only truly valuable and original contribution to music,"[7] his attempts produced no follow-up; they were quickly overtaken and nullified by new technological advances.

At the end of World War II, when planes were being decommissioned, a Canadian physicist, composer, and instrument builder, Hugh Le Caine, began collecting parts from these planes, especially the oscillators used in wing de-icers, which produced sine tones. In 1957, Le Caine took up this idea again and produced the "sine bank." Between 1957 and 1959 Le Caine created a bank of 108 oscillators, which he designed to work with his tool called the Spectrogram, which used 100 photocells to read a graphic score (although only 24 were functional in the McGill Electronic Music Studio).

A composer with an idea, using 10"-wide graph paper, would use India ink to completely blacken a track (2,5 mm wide) or part of a track on the paper. When the paper passed under the light emitted from the 300-watt bulb, no signal would pass lightened sections, but when darkened sections of the score passed the photocells, the specified oscillators would sound.

In 1961 Le Caine created two smaller Oscillator Banks with variable waveforms, operated by touch-sensitive keyboards. The final version of the Spectrogram controlled 25 separate output lines, each of which could be fed to an oscillator or to another device. It was used with the smaller oscillator banks, but the size of the graph paper makes it clear that the Spectrogram had originally been designed for a larger number of generators.

It was a tiresome process to do anything that was going to be controlled in any detailed way. The paper roll could be moved at various speeds, with a 12" (30,5 cm) drawing passing under the light in one to four seconds. Thirty cm of "score" could easily take several hours to draw with the result often being poor and frustrating. Few people had the time to devote to getting more than a few seconds of the sequenced sine tones.[8]

During her BBC training in 1947, the British composer and electronic musician Daphne Oram encountered a cathode ray oscilloscope which shows a visual image of sound waves. Her intention was to reverse the process so that if you paint the shape of the sound wave you want to hear on 35 mm film, determining the pitch, vibrato, timbre, and so on, scanners could read and convert that into layered sound. This idea led to the development in 1957 of a drawn sound technique called Oramics. The machine was further developed in 1962 after receiving a grant from the Gulbenkian Foundation.

Oramics is audiovisual in nature; that is, the composer draws onto a synchronized set of ten 35 mm film strips which overlay a series of photoelectric cells, generating electrical signals to control amplitude, timbre, frequency, and duration. Daphne said of Oramics, "I visualize the composer learning an alphabet of symbols with which he will be able to indicate all the parameters needed to build up the sound he requires. These symbols, drawn freehand on an ordinary piece of paper, will be fed to the equipment and the resultant sound will be recorded onto magnetic tape."[9]

As the playwright Isobel McArthur pointed out, "That gestural interface means all people become composers, conceivably, which ties back into her philosophy which says that, at a molecular level, we are sounds. We are all made up of noisy atoms and vibrations—sound is at the core of who we are. I find that really inspiring."[10]

However, after Daphne left the BBC (in 1959), her research, including Oramics, continued in relative secrecy. Although for many years Oram was rejected by the establishment, written out of the male-dominated

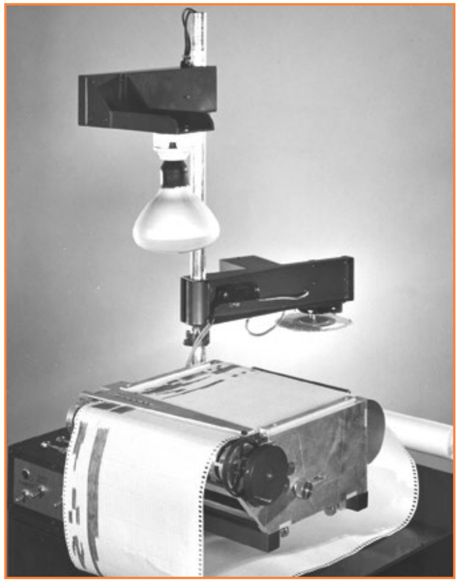


FIG. 3 Hugh Le Caine, Spectrogram, 1954 © National Research Council Canada Archives

FIG. 4 Hugh Le Caine, Spectrogram, 1954 © National Research Council Canada Archives

FIG. 5 Daphne Oram working at the Oramics machine at Oramics Studios for Electronic Composition in Tower Folly, Fairseat, Kent, ca. 1950. Courtesy and © Daphne Oram Trust

history of electronic music, recent years have started to throw new light in her direction.

Perhaps the most fascinating story relates to the invention of the photoelectronic musical instrument called the ANS Synthesizer (its name was derived from the initials of influential composer Alexander Nikolayevich Scriabin), which was built and patented by the inventor Evgeny Murzin in 1957 in Moscow. The story starts as early as in the summer of 1917 in Petrograd when the young inventor Evgeny Sholpo, inspired by the ideas of the composer and theorist Arseny Avraamov, wrote a science fiction essay entitled "The Enemy of Music" in which he described a sound machine named the Mechanical Orchestra, capable of synthesizing any sound and producing music according to a special graphical score without any need for a performer.

In his essay, Sholpo describes the activities of an imagined friend—a sort of polymath, combining the skills of a musician, composer, and analyst on the one hand, and a scientist, technologist, mathematician, and psychophysiologist on the other—who "fulfilled the dream of a mechanical orchestra, of full mastering of timbres [...] And compositions in the form of graphical diagrams [...]."[11]

According to Sholpo's description, the instrument was an exact prototype of the future ANS Synthesizer, built forty years later by Evgeny Murzin. The instrument incorporated a set of sine wave oscillators, based on numerous Helmholtz tuning forks, adjusted on fixed frequencies, forming a discrete microtonal scale, covering the whole audible range with intervals between successive pitches imperceptible to the human ear. Control over the process of sound synthesis was to be carried out by means of a special graphical score with the diagram, representing the spectrum of a sound by means of cut-out transparent strips having appropriate shape and slopes, read by a special optical system, based on selenium photocells.

The bulky construction occupies half a room, with black paper tape stretching from one wall to another with a diagram of music made up of cut-out longitudinal holes similar to those of a pianola, a network of electric cables, and a set of megaphones—all of which can be justified technically, but its basic principles were simply too complicated. Each electromagnetic tuning fork equipped with a resonator had a constant pitch and could be switched on irrespective of the others. Thus, a number of audio frequency generators made rather fractionally tempered scales in a range from low basses up to the highest overtones. [...] Owing to the divisibility of a pitch scale, glissando appears to be almost ideally smooth, having no audible intervals between successive tones. [...] The intensity *of separate sounds, both in a melody and in chords, was set by adjusting a width of cuts of the diagram through which light beams, produced by a special light source and could reach the selenium elements of the conductors that lead an electric current to the magnets of the generator tuning forks.*[12]

In fact, Sholpo offered not simply a new technique, but a new concept for the reconstruction of the technical basis of music, capable of bringing about a paradigm shift in musical thinking, and demanding new theoretical substantiation. It anticipated future approaches of electroacoustic and spectral music. Sholpo writes:

> *Arbitrary access to timbres brings forth a whole arsenal of new laws, previously unavailable to us. [...] I have begun my research with the elementary things—rhythm, melody, and harmony (i.e., the new harmony, based on overtone combinations).*[13]

In fact, Evgeny Sholpo was not the only inventor envisioning a graphical user interface as the best way to replace the classic musical score to control the process of musical performance as a kind of preprogrammed acoustical process. A little later, in 1926, the inventor I. Sergeev patented the Electro-Optical Musical Instrument—a sort of sound synthesizer, based on a rotating disc with discrete concentric optical soundtracks consisting of transparent holes, with the frequency of each track increasing from the disc's center to its periphery. Control over the process of sound synthesis and music production was carried out by means of a graphical score.

Meanwhile, in 1929, the method of Graphical (Drawn) Sound was discovered by Arseny Avraamov, Evgeny Sholpo, and Michail Tsekhanovski. It was a way of creating artificial graphics of a movie soundtrack, based on data of acoustics and mathematical calculations. It was a consequence of the newly invented sound-on-film technology, which made possible access to sound as a visible graphical trace in a form that could be studied and manipulated, which permitted to synthesize difficult polyphonic works without any participation by performers.

Among the Graphical Sound pioneers was the young painter and acoustician Boris Yankovsky, who established his own laboratory in Moscow in 1932. In 1935, in one of his unpublished manuscripts, Yankovsky wrote:

> *It is important now to conquer and increase the smoothness of tone colours, flowing rainbows of spectral colours in sound, instead*

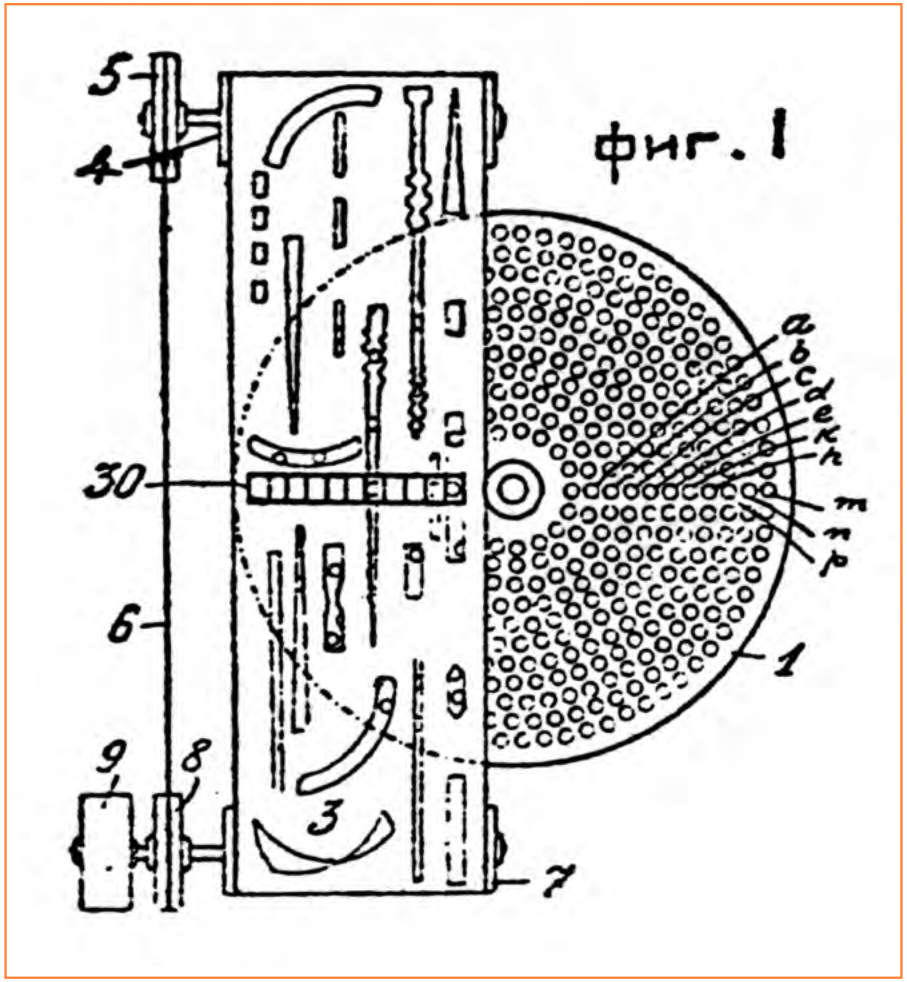


FIG. 6 I. Sergeev, Electro-Optical Musical Instrument, image from the USSR patent N12625, applied in 1928. © Andrey Smirnov Archive

of monotonous colouring of stationary sounding fixed geometric figures [wave shapes], although the nature of these phenomena is not yet clear. The premises leading to the expansion of these phenomena—life inside the sound spectrum—give us the nature of the musical instruments themselves, but 'nature is the best mentor' (Leonardo da Vinci). [...] The new technology is moving towards the trends of musical renovation, helping us to define new ways for the Art of Music. This new technology is able to help liberate us from the cacophony of the well-tempered scale. [...] Its name is Electro-Acoustics and it is the basis for Electro-Music and Graphical Sound.[14]

Boris Yankovsky's intention was to study structural similarities and distinctions among spectra of sounds of different character to limit as far as possible the number of calculations needed for additive synthesis of various complex sounds. His method was based on pure audio computing techniques and possessed properties very common in digital technologies, such as discretization and quantization of audio signals and related spectral data, manipulation with ready-made parts, and operations with selections from databases of the basic primitives (templates) that distinguish it from the methods of analog signal processing. His "spectral templates" were in fact semiotic entities that could be combined to produce sound hybrids, based on a type of cross synthesis. The purpose of his research was to fill the gaps between orchestral sounds by means of developing new types of intermediate tone color production. As options, Yankovsky developed several sound processing techniques including pitch shifting and time stretching.

From the start, Yankovsky intended to work with a modified animation stand called the Vibroexponator, shooting still images of artificially drawn sound waves by means of a rostrum camera. This meant that the discretization of the time scale was predetermined by twenty-four frames per second, with each successive frame containing one stable sample—a sort of momentary snapshot of the constantly changing sound. The change in sound was enabled by cross-fades between successive frames. Another part of the Vibroexponator incorporated a special multi-segment mask to produce fast envelopes with discretization, equal to three steps per frame, to produce amplitude and spectral vibrato. The final processing included using the top part of the Vibroexponator to produce slow graphical envelopes. [15]

Despite its beautiful concept, Yankovsky's method lacked any appropriate user interface. To get at least very rough results without a computer, a researcher had to spend enormous efforts and time,

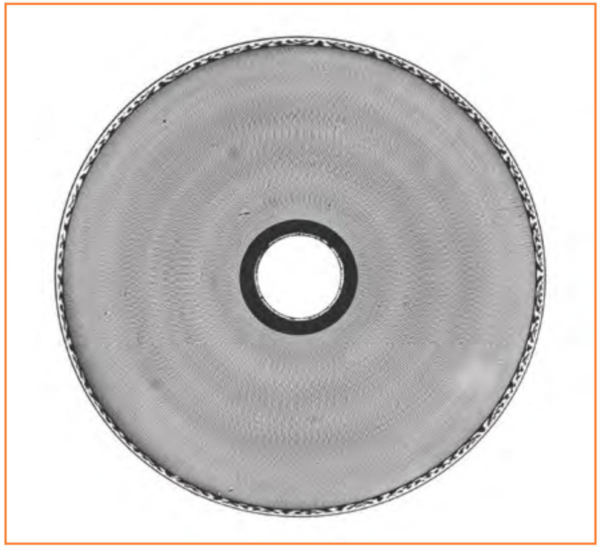
incompatible with a single human life. The solution was found in 1938 when Yankovsky met Evgeny Murzin, a young inventor fascinated by the idea of a universal tool for sound synthesis. By 1939 the concept of the new instrument had been developed and, finally, the photo-electronic tool called the ANS Synthesizer was built in 1957 by Evgeny Murzin without any institutional support, only thanks to the help of his family and friends. For two years the instrument was based at Murzin's summer house in a suburb of Moscow until it was hosted in 1959 by the Scriabin Museum in Moscow. The first composers who had access to the machine were Andrey Volkonsky and, somewhat later, Eduard Artemiev and Stanislav Kreichi.

Based on the Graphical Sound approach the ANS was remarkably close to the concept of Evgeny Sholpo's Mechanical Orchestra. The instrument incorporated a set of optical sine wave oscillators, adjusted on fixed frequencies, forming a discrete scale, and covering the whole audible range with intervals between successive pitches imperceptible to the human ear. Four discs, used in the first version of the instrument, could produce simultaneously 576 sine waves with frequencies covering the whole audible range with an accuracy of seventy-two steps per octave or 1/6 of a semitone. This number of pure tones makes it possible to obtain a smooth variance of pitch. The second version of the ANS was constructed in 1964 and generated 720 tones covering the entire audible frequency range.[16] To obtain pure sinusoidal tones the instrument incorporated twenty half-octave bandpass filters with about one hundred vacuum tubes. It was the first (and last) industrial sample of the instrument, built for a special occasion: the Soviet Industrial Exhibition in Genoa, Italy, which took place in 1964.

ANS could produce the sounding result in real time, permitting a composer to manipulate the spectrum of sound instead of the waveform. Control over the system and the process of sound synthesis was carried out by means of a special graphical score with a diagram, representing a spectrum of a sound by means of drawn transparent strips with appropriate shape and slopes.

Working with the ANS, the composer etched onto a large sheet of glass covered with a tar-like, non-drying mastic, a sonogram—a dynamic spectrum of sound developed in time. The glass was then cranked (by hand or by motor) across light beams. Scraping off a part of the mastic at a specific point on the plate allowed light from the corresponding optic phonogram to penetrate the reading device and be transformed into a sound.

The performance tempo depended on the score-reading rate and could be varied without changing the pitch and timbre of the sounds. The graph of the coded composition resembled its notation in music in that



the horizontal axis represented time while the vertical denoted pitch. The speed of the score could also be smoothly regulated, all the way to a complete stop. All this made it possible for the composer to work directly and materially with the production of sound.

In 1962 a special commission was formed to develop a new version of the ANS Synthesizer and to start its production. It included among others Leon Theremin, Boris Yankovsky, Andrey Volodin (inventor of the Ekvodin Synthesizer), and Andrey Rimsky-Korsakov (one of the inventors of Emiritone). The possibilities of the instrument should be extended so that it would be able to digitize, store, and automatically retrieve the graphic score by means of a newly constructed automated coder and other electronic and mechanical means as well as magnetic-core memory (predominant form of random-access computer memory from 1955 to 1975). According to the initial plan, the ANS would be based at the studio (yet to be organized) at the Moscow State Conservatory, but in the end the plan was changed: the instrument was never extended, and in 1967, the studio of electronic music was established at the Scriabin Museum in Moscow in affiliation with the record company “Melodia.” The ANS Synthesizer was at its core. The composers and researchers working with the ANS included Alfred Schnittke, Sofia Gubaidulina, Edison Denisov, Eduard Artemyev, Stanislav Kreichi, Alexander Nemtin, Pyotr Meschaninov, Oleg Bouloshkin, and Sandor Kalloś. The instrument was used for scoring many films, in particular, several films by Andrei Tarkovsky (for example, Solaris (1972) and Stalker (1979) with music composed by Eduard Artemyev).

After Evgeny Murzin’s death in 1970 the studio was closed in the mid 1970s and the ANS was moved to Stanislav Kreichi’s studio at Moscow State University. From 2004 to 2007 the ANS was based at the Theremin Center at the Moscow State Conservatory, and in 2007 it entered the collection of the State Museum for Musical Culture named after Glinka, where it resides to this day and is maintained in good working order.

The ANS was one of the most successful graphic-based composition machines available until it was superseded by early digital instruments. In the realm of early computer music technology an approach similar to that of the UPIC was experienced in the 1960s by Max Mathews with the Graphic 1—a “remote graphical display console system” created by William Ninke (plus Carl Christensen and Henry S. McDonald) at Bell Laboratories in 1965. It was a large console containing a small control computer (the DEC PDP-5) and, among other things, light pen and trackball input devices. This console was connected to an IBM 7094 mainframe and a Stromberg-Carlson microfilm printer in another room. In 1968, the Graphic 1 system was used by Max Mathews and Lawrence Rosler to develop the interactive

FIG. 7 Evgeny Murzin with the first version of the ANS Synthesizer, Moscow, 1962
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FIG. 8 Optical disc for the ANS Synthesizer containing 144 soundtracks
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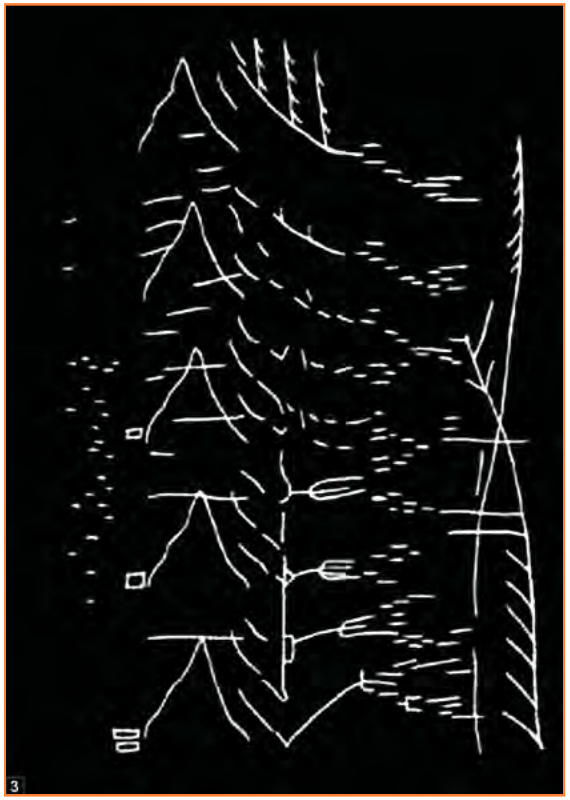

FIG. 9 The ANS score with the coder and controls. © Andrey Smirnov Archive

FIG. 10 Stanislav Kreichi, Graphical score of the ANS, ca. 1980 © Andrey Smirnov Archive

THE STREAM Alfred Schnittke, 1968, 5’55”, composed with ANS Synthesizer at the Experimental Studio for Electronic Music at Skriabin Museum, Moscow, Russia, from Electroshock Records – ELCD 011 *Electroacoustic Music Volume IV Archive Tapes Synthesizer ANS 1964–1971*, 1999, excerpt from 3'03'' to 4'31'' © Alfred Schnittke graphical sound system on which one could draw figures using a light pen that would be converted into sound thus simplifying the process of composing computer generated music.[17] Also in 1970, Mathews and F. Richard Moore developed the GROOVE (Generated Real-time Output Operations on Voltage-controlled Equipment) system,[18] the first fully developed music synthesis system for interactive composition and real time performance using 3C/Honeywell DDP-24 (or DDP-224) minicomputers. The GROOVE used a cathode ray tube (CRT) display to simplify the management of music synthesis in real time, 12-bit D/A for real time sound playback, an interface for analog devices, and even several controllers, including a musical keyboard, knobs, and rotating joysticks to capture real-time performance.[19]

Today, when numerous achievements of musical technology of the early digital era are common and seem ordinary to us, inventions that were invented before the computer age often seem extraordinary and unexpected by comparison. Even in cases when their connection to UPIC does seem particularly relevant, they nevertheless function as important steps in establishing gravitational centers for future musical discourse. In fact Iannis Xenakis's UPIC was a long-awaited physical embodiment of the idea of an interactive environment intended for a sound-oriented, multi-scale approach to the composition of music, "when all levels of temporal organization are freely composable at all steps in the compositional process."[20] Apparently, it was the first successful attempt to develop a universal graphical interface for both sound synthesis and music composition, based on the most recent computer technology at the time.

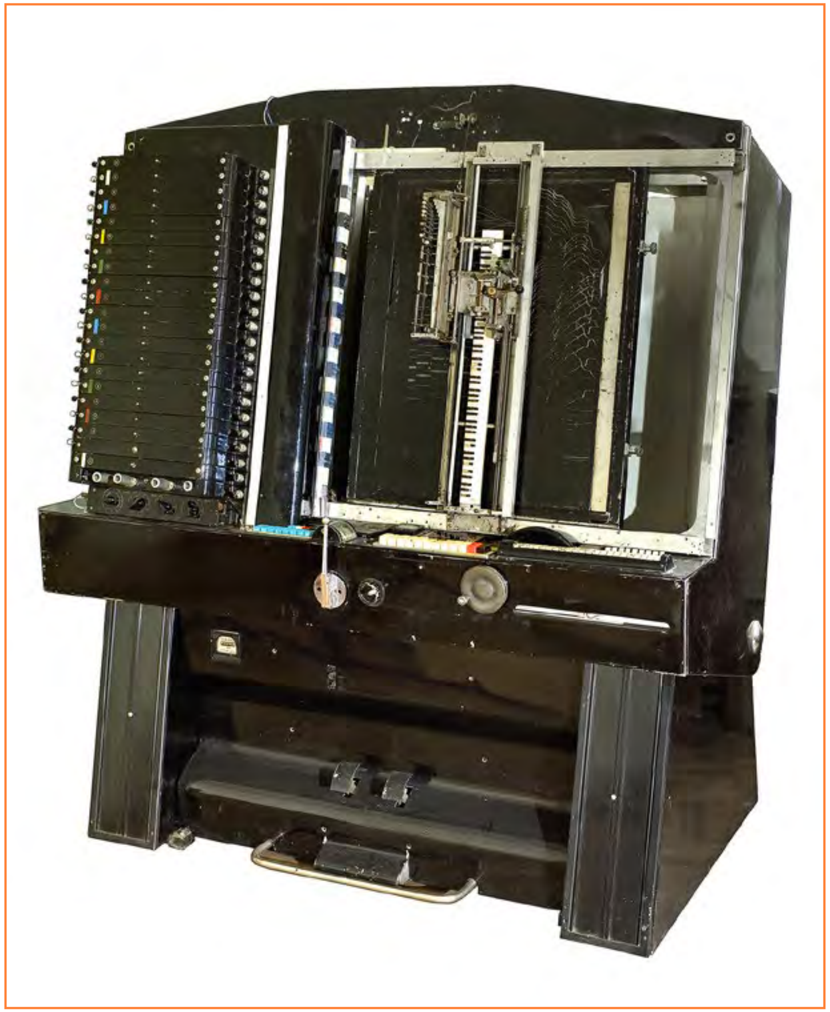

FIG. 11 The second version of the ANS Synthesizer. © Andrey Smirnov Archive

FOOTNOTES

1. See Médigue, this volume.
2. Joel Chadabe, *Electric Sound. The Past and Promise of Electronic Music* (Upper Saddle, NJ: Prentice Hall, 1997), 214.
3. Curtis Roads, *Composing Electronic Music: A New Aesthetic* (New York, NY: Oxford University Press, 2015), 17.
4. Percy Grainger, *Statement on Free Music*, 1938, Grainger Museum, University of Melbourne, Australia, quoted in John Bird, *Percy Grainger* (London: Elek Books, 1976), 283.
5. http://www.percygrainger.org/prognot3.htm
6. https://percygraingeramerica.org/blog/6987441
7. Thomas P. Lewis, *A Source Guide to the Music of Percy Grainger* (White Plains, NY, Pro-Am Music Resources, 1991), 153.
8. https://econtact.ca/17_2/austin_lecaine.html
9. Jo Hutton, "Daphne Oram: Innovator, Writer, and Composer," in *Organised Sound*, 8 (2003), 49–56.
10. http://www.bbc.com/culture/story/20170522-daphne-oram-pioneered-electronic-music
11. Evgeny Sholpo, "The Enemy of Music", unpublished manuscript, Marina Sholpo family archive. Translation by the author.
12. Boris Yankovsky, "Analiz i sintez tembra" (Analysis and Synthesis of Timbre), March 1935, Moscow. Unpublished article, Theremin Center Archive. p. 35. Translation by the author.
13. Ibid.
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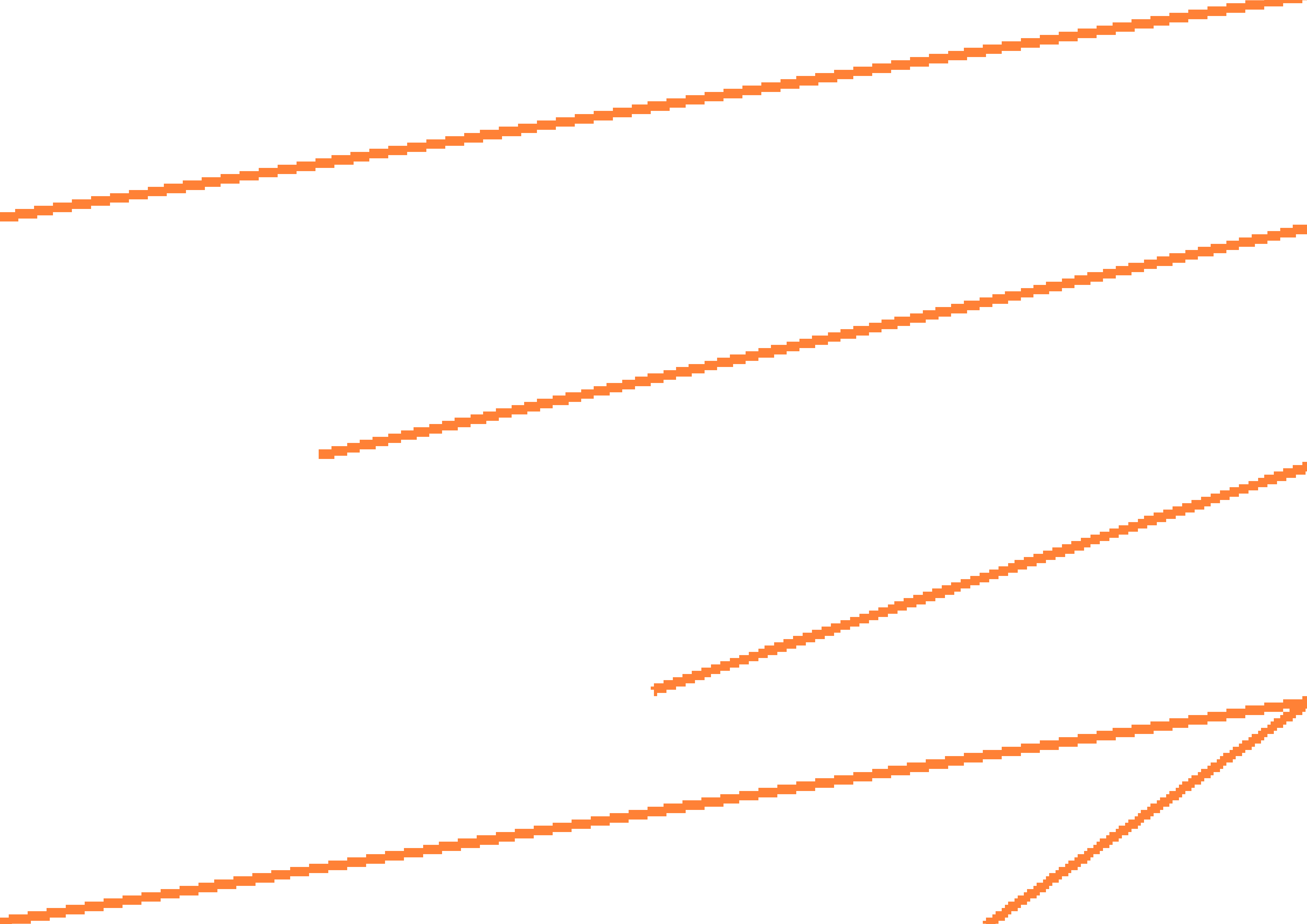
15. Andrey Smirnov, *Sound in Z: Experiments in Sound and Electronic Music in Early 20th-Century Russia* (Cologne: Walther König, and London: Sound and Music, 2013), 208–226.
16. Stanislav Kreichi, "The ANS Synthesizer: Composing on a Photoelectronic Instrument," in *Leonardo Music Journal*, 28, no. 1 (1995), 59–62.
17. http://120years.net/graphic-1-max-mathews-lawrence-rosler-usa-1968/
18. https://en.wikipedia.org/wiki/Max_Mathews
19. Ibid.
20. Curtis Roads, *Composing Electronic Music: A New Aesthetic* (New York, NY: Oxford University Press, 2015), 19.



THE EARLY DAYS OF THE UPIC

GUY MÉDIGUE

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THE EARLY DAYS OF THE UPIC

After having worked as a computer engineer for nearly eleven years at SEMA-METRA International,[1] then at CERCI,[2] which subcontracted me out for several years to participate in the IRIA CYCLADES[3] project (French premises of the Internet), I realized that I really wanted to work in the field of computer music. I first applied to IRCAM, but without success. One of my colleagues at CYCLADES, Jean Lebihan, told me at the beginning of 1976 that Iannis Xenakis, the director of the CEMAMu, was looking for an experienced computer engineer to assist him in his projects. I applied and was interviewed by Alain Profit, then director of the CNET[4] in Issy-les-Moulineaux, who was likewise a founding member of the CEMAMu. He expressed a favorable opinion to Xenakis.

So, in March 1976, Iannis Xenakis asked me to analyze and implement the first version of a conversational system for composing music. He had a commitment with the city of Bonn to present the system, which he was to baptize *Unité Polyagogique Informatique de CEMAMu* (UPIC), at the Beethoven Festival in May 1977.[5] Fearing he might not be able to meet the deadline, Xenakis needed a professional computer engineer to jumpstart the system's implementation. My eleven years of prior experience was immediately put to task as of March 1976 by analyzing and coding the first version of the UPIC system, UPIC A, already in May 1976.

I worked with Xenakis at the CEMAMu until the end of 1980. In this essay, I will briefly describe the context of hardware and computer music at that time, and what exactly my contribution was at the CEMAMu and to the development of the first UPIC.

BRIEF HISTORICAL OVERVIEW: HARDWARE

The mid to late 1970s was the era of minicomputers, although microprocessors were not yet widespread in France (the very first INTEL ones arrived in France in 1971). The level of hardware performance was far from what it is today; for example, the minicomputer SOLAR 16–40, ordered by the CEMAMu for the future UPIC, had the following features:

- words of 16 bits;
- 32K words of main memory;
- one fixed disk and a removable one of 2.5 Mbytes each;
- one million instructions per second (if I recall correctly);
- floating point unit.

COMPUTER MUSIC, COMPOSERS, AND INSTITUTIONS

It is beyond the scope of this essay to describe the various and often very complex ways that people in computer music had for making music at the time. Below, however, is a list of the various teams I knew quite well and that were working at the same time in France:

BBK led by Pierre Barbaud,[6] from 1976 at IRIA. Barbaud was one of the first people in France to be passionate about computer music (algorithmic music).
GRM: Pierre Schaeffer[7] and his disciples
ACROE: Claude Cadoz[8] and his team (Grenoble)
GRAME: Pierre-Alain Jaffrennou[9] and his team (Lyon)
CEMAMu: Created in 1972 as the successor of the EMAMu (created by Iannis Xenakis in 1966), the goals of this association (not-for-profit, law of 1901), as stipulated in its by-laws, were:

- research on musical and graphic composition;
- easy to use computer tools;
- research on pedagogy for using the above tools;
- various users (no discrimination).

At the beginning of 1976 the team of the CEMAMu was composed of: Cornelia Colyer, who worked (very hard!), mainly on creating stochastic programs needed for Xenakis's own research (pieces using laws of stochastic processes, programs in FORTRAN on mainframe computers); Patrick Saint-Jean,[10] who was helping Xenakis define a conversational system using a large graphic tablet connected to a minicomputer (the future UPIC).
IRCAM: The French government created this important center with Pierre Boulez in 1974.[11] Some composers (Xenakis, Jean-Claude Eloy, as well as others) quickly reacted against the monopoly position of IRCAM. However, I personally thought that there was some very interesting research being conducted there at the time, and it surely continues to this day. I had contact in particular with Xavier Rodet and Jean-Claude Risset and was very interested then in their research. Risset was a subtle user of the MUSIC V software then in vogue at IRCAM, and he made synthetic trumpet sounds that even fooled professionals on the instrument. Rodet was especially interested in the human voice, and with his CHANT algorithm, he generated disturbing examples (vocalizations of "Queen of the Night" by a synthetic singer). In 1978, Pierre Boulez invited the CEMAMu team (Xenakis, Cornelia Colyer,[12] and me) for a drink at his large

apartment at the top of the Perspective II high-rise apartment complex along the River Seine. On that occasion, he made an appointment with me to come to CEMAMu to work with the UPIC, however, he never showed up.

My personal feeling is that the tools created by these teams were often difficult for composers to use who were not scientists familiar with computers. In addition, the time needed to hear the result of any work was too long to allow reactivity and empirical choices.

SOME BASIC ACOUSTICS: ANY SOUND

In the following, I will point out some basic acoustics that underlie the technical development of the UPIC and its interface. The parameters that can be changed by users of the UPIC can be traced back to the characteristics of different sound waves.

A sound is no more than a variation of pressure of the air which makes the eardrum vibrate. Therefore, collecting sound pressure values at very close regular time intervals gives a good description of a sound. These numbers are called *samples*. Subsequently, a computer is able to process a sound. The number of samples per second is the *sampling rate* (for example, and in general, 44,100 for a CD).

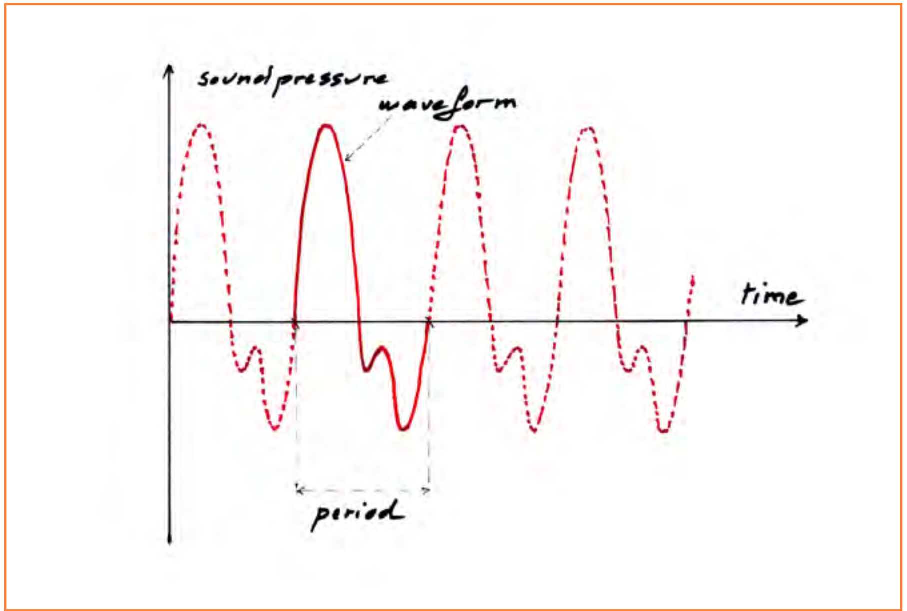
I remember that choosing the sampling rate for processing and outputting digital sounds was a source of controversy between Xenakis and IRCAM.[13] Xenakis thought that it was necessary to work with a sampling rate far higher than the sampling rate strictly needed to hear audible harmonics. Later, experiments were conducted at IRCAM on this subject (with notes of a harpsichord). It seems that Xenakis was right.

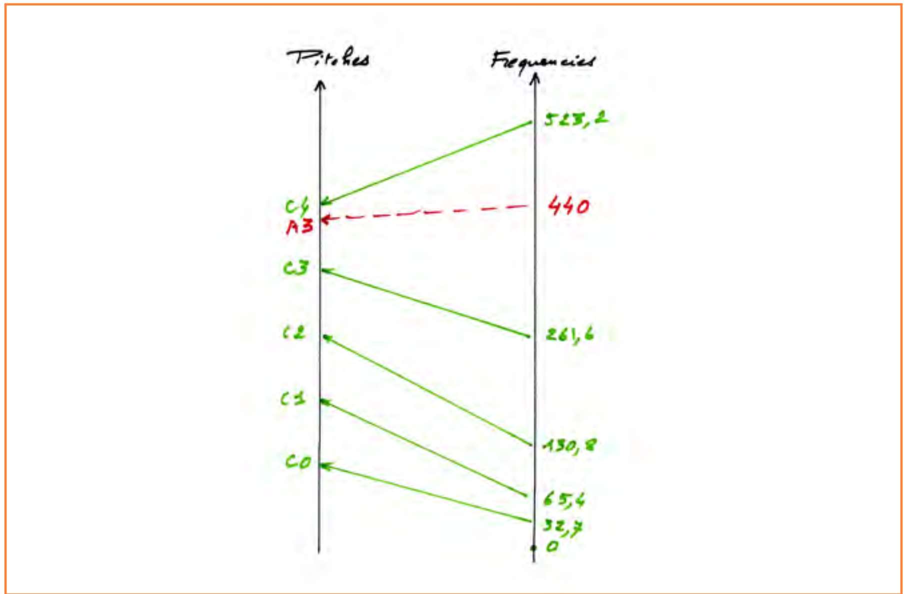
A SOUND WITH A PITCH

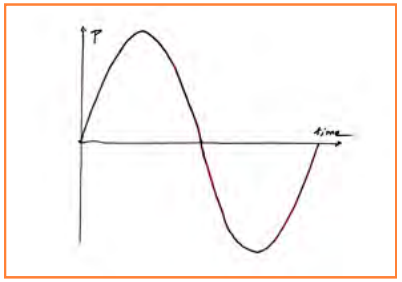
A sound with a pitch is roughly a periodic vibration: this means that the sound wave consists of the same pattern that repeats itself over time. FIG. 1

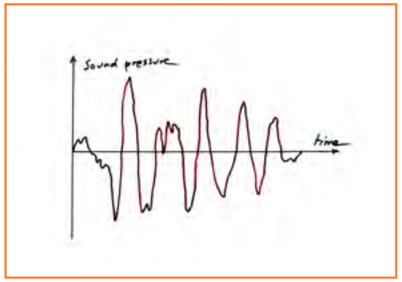
- This pattern is called the *waveform* and its occurrence a cycle.
- The duration of a cycle is called the *period*.
- The number of periods per second is the *frequency*.

The pitch of a periodic sound is linked with its frequency as shown in FIG. 2 (for two consecutive octaves; the frequency of the higher is twice the frequency of the lower one).

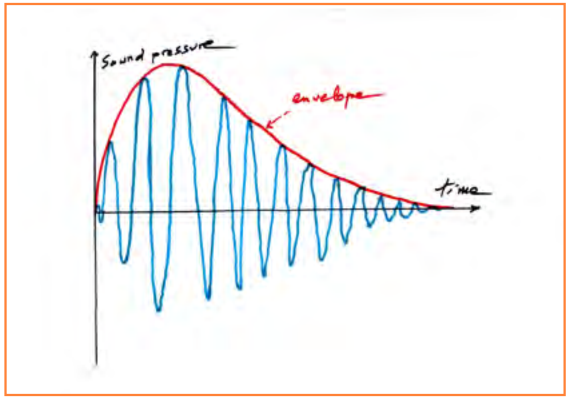








Two examples of waveforms.



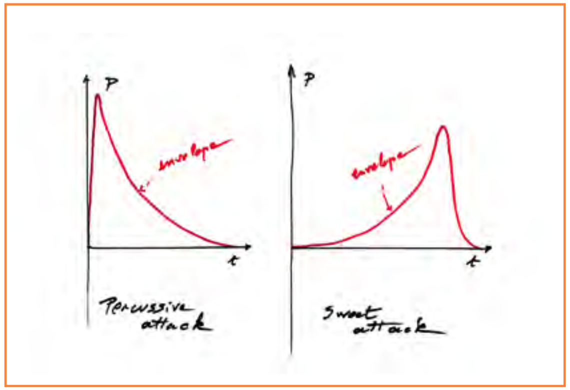


FIG. 1 A waveform and its duration © Guy Médigue

FIG. 2 How pitch and frequency correspond © Guy Médigue

FIG. 3 Sine waveform (pure sound without harmonics) © Guy Médigue

FIG. 4 Letter A (in French) waveform © Guy Médigue

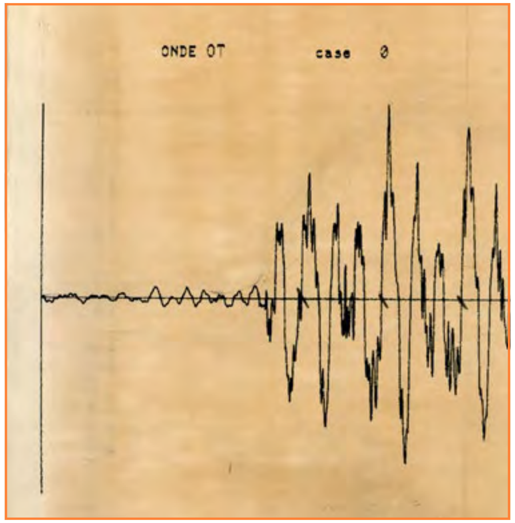
FIG. 5 An envelope describes the evolution of the amplitude of the sound pressure over the duration of a sound © Guy Médigue

FIG. 6 Two examples of envelopes © Guy Médigue

EXAMPLE OF AN ACOUSTIC SOUND WITH A PITCH

Below is an example of an acoustic sound with a pitch: a note of a classical guitar with the duration of half a second. We can see that the sound wave, which is complex at the beginning, becomes more and more simple and smooth.

We notice that after half a second, the waveform is simpler but not yet a sine wave.



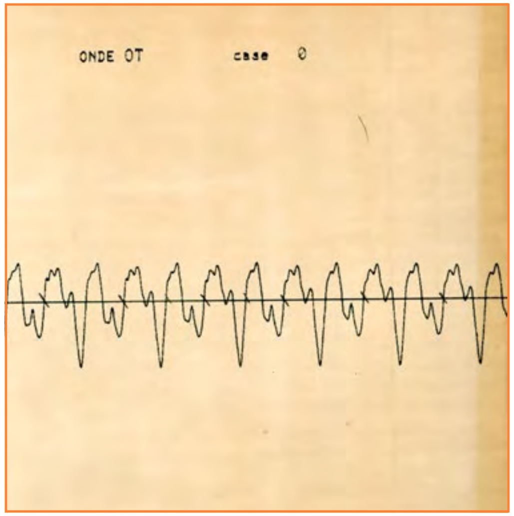


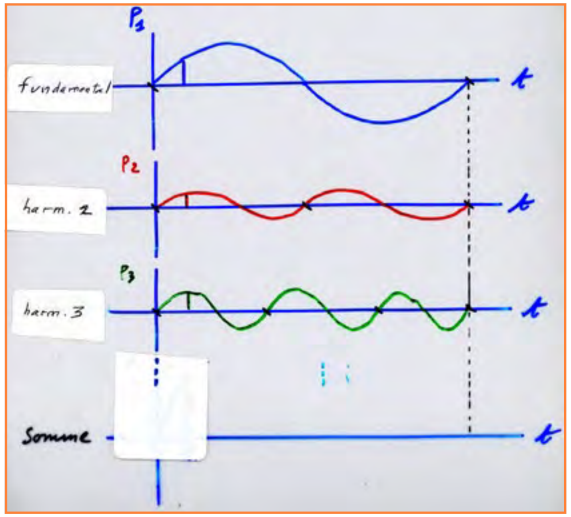
FIG. 7 Classical guitar note (attack) © Guy Médigue

FIG. 8 Same classical guitar note (after half a second) © Guy Médigue

FOURIER SERIES DECOMPOSITION

The sound pressure for any sound is the sum of sine vibrations as shown below:

		Name	Frequenc
p =	a1*sin(vt+w1)	Fundamental	F
	+ a2*sin(2vt+w2)	Harmonics 2	2*F
	+ a3*sin(3vt+w3)	Harmonics 3	3*F
	+		
	+ an* sin(nvt+wn)	Harmonics n	n*F



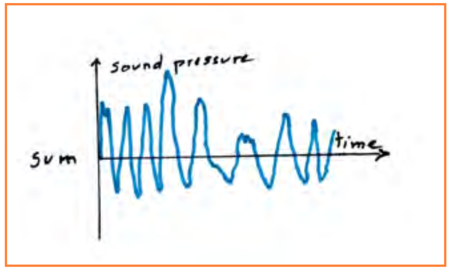
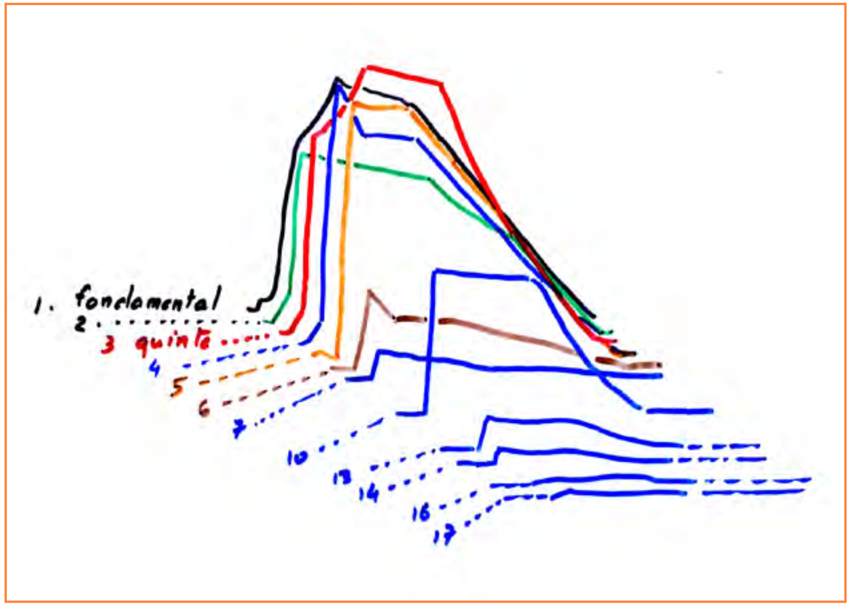


FIG. 9 Decomposition of sound into a sum of sinusoidal vibrations (here no phase shifts) © Guy Médigue

FIG. 10 The sum of the pressure values corresponding to the sinusoidal vibrations of the harmonics, reconstitutes the original sound © Guy Médigue

For an acoustic sound, the fundamental and each of its harmonics have their own envelopes. The particular timbre of an instrument is essentially due to the various amplitudes of its harmonics, and the variations of these amplitudes specified by their envelopes. And everything can change with the pitch of the note! (There are some stationary strengthened frequencies called “formants” and linked to each instrument’s morphology). The drawing below illustrates this point:



We notice that the envelope is shorter when the order of the harmonics increases. So, at the end of the sound, we hear only the fundamental (the waveform is a sine wave).

FIG. 11 The envelopes of the harmonics for a medium-range note of an oboe © Guy Médigue

WHAT WERE XENAKIS’S WISHES?

For me, at the beginning it was not easy to guess what Xenakis actually wanted! However, I had two orientations for my work:

1. The program of activities the CEMAMu proposed in 1976 to the DGRST (Délégation Générale de la Recherche Scientifique et Technique), which was at once very ambitious and very imprecise. The main objectives of the system to be built were listed in this report as follows:
   - recording and storage of graphic forms and sounds in a database;
   - visualize and listen to forms from the database;
   - analyze given forms;
   - simulate given forms;
   - create forms artificially;
   - research on software modules to transform forms;
   - ease of use;
   - research on creating an elementary pedagogy pertaining to visual or sound structures.

2. The ideas coming from our meetings (with Xenakis, Patrick Saint-Jean, and me) to define the system. I quickly made up my mind to keep only the simple and clear ideas that I was able to understand:
   - easy to use conversational system;
   - basic objects drawn on the graphic tablet and recorded in “banks” (waveforms, envelopes);
   - “time*pitch arcs” drawn on the tablet and associated with 3 parameters (“labels”):
     - a waveform from the bank of waveforms;
     - an envelope from the bank of envelopes;
     - a maximum amplitude chosen from the classical list: *ppp* to *fff;*
   - “page of music”: set of time*pitch arcs drawn on the graphic tablet;
   - computation of the “resulting wave” corresponding to a page.

This drastic reduction of the objectives was in fact necessary; first, because of the hardware possibilities at that time, and second, because of the deadline for Bonn: we had to be able to show a first version of the system by May 1977 (Bonn Festival, see[5] and[8]).

HARDWARE ORDERED

This is the list of the hardware the CEMAMu then ordered to build the system:

- minicomputer SOLAR 16–40 with its disk unit (TELEMECANIQUE, then CII);
- graphic tablet 100 cm*80 cm (TEKTRONIX 4954) with 4096*4096 addressable points;
- display console (TEKTRONIX 4014) with 4096*4096 addressable points;
- imager (TEKTRONIX 4631);
- digital to analog converter 16 bits (DATEL DAC-HR16B): a specific interface was needed, because Xenakis wanted to output sounds at the rate of 52,000 samples per second;
- analog to digital converter 12 bits (TELEMECANIQUE AMH-080);
- tape drive (KENNEDY 9000, 800/1600 bpi, 75 IPS): a specific interface with the SOLAR was needed.

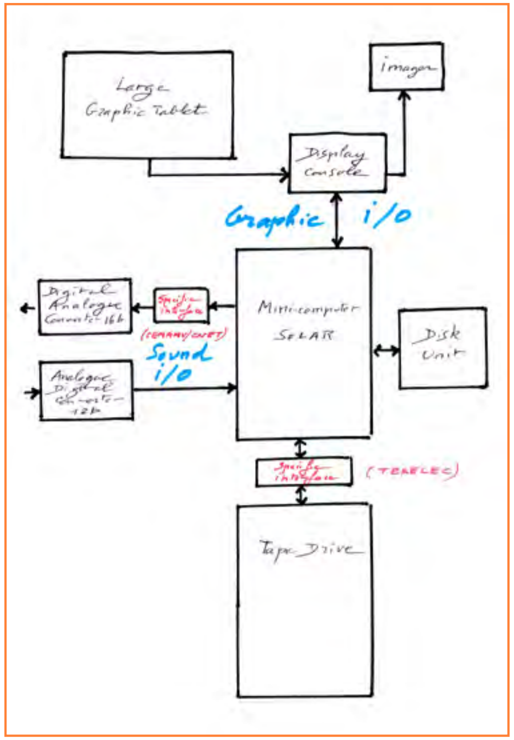


FIG. 12 Hardware configuration for the UPIC A © Guy Médigue

IMPLEMENTATION OF THE UPIC A: LOWERING OF AMBITIONS

Due to technical limitations of the equipment available at the time, we were forced to revise our initial goals. Hardware constraints:

1. It was not possible to record many acoustic sounds into a bank because of the size of disks (with 2.5 Mbytes you could record only 100 seconds at a rate of 25,000 samples per second). Nevertheless, we had a bank of "sound waves," in particular for sound waves resulting from the computation of pages of music.
2. Because of the small size of the main memory, I had to code in assembly language and divide the program into partitions, which were loaded into the main memory only when it was useful (overlays).
3. In addition, we had a lot of problems at the beginning. The minicomputer SOLAR was finally replaced before or around the end of 1976 by a SOLAR 16–65.

BONN FESTIVAL DEADLINE:

At the beginning of May 1976, no hardware components had yet been delivered and the analysis of the system was not completed. I told Xenakis that it was impossible to have an operational version of the system by May 1977. Mika Salabert, Xenakis's publisher and friend, donated 100,000 Francs[14] to enable us to hire a someone temporarily to help me with the coding. I was very fortunate! A former colleague from CERCI, Pierre de Bailliencourt,[15] had just come back from a sabbatical year in America and was looking for a temporary job in France. He was a computer engineer, too, and quickly became interested in the UPIC system.

HARDWARE

We needed to make two specific adaptations to make the hardware function according to our specifications:

- Digital to analog converter:
  As mentioned above, this 16-bits converter was a DATEL DAC-HRB16B and completely passive. Xenakis wanted to output sounds at a rate of 52,000 samples per second. It was a tough problem. TELEMECANIQUE proposed a GPI32 coupling, which would have made it possible to adapt to this prerequisite. Former colleagues of mine from CERCI, very familiar with these kinds of problems, proposed a "FIFO buffers solution," and even suggested the appropriate device: Advanced Microdevices 3341/2841. Patrick Saint-Jean was in charge of the implementation of this adaptation. But I also must mention the very efficient help provided to us by the CNET bureau in Lannion, Brittany. Our last debugging was

accomplished thanks to J. Génin at the CNET in Lannion, when Patrick Saint-Jean was no longer at the CEMAMu.

– Tape drive:
The interface with the minicomputer was analyzed and implemented by TEKELEC using an asynchronous coupler of TELEMECANIQUE (ASV01), but the CEMAMu had to test it with the help of TELEMECANIQUE.

SOFTWARE WRITTEN AT CEMAMu

The following section focuses on the core of the application, which is the interface and its usability for the composer. The drivers and hardware adaptations that were needed to reach this stage will be neglected since this is not so essential in the context of this essay.

Our goal was to compute the samples of a "resulting wave" corresponding to a "page of music" comprised of a set of "time*pitch arcs," each having a "label" (a waveform, an envelope, a maximum amplitude). To compute the samples produced by a time*pitch arc (samples to be added to the current resulting wave), we had to divide the duration of the time*pitch arc into small steps. At instant *t*, the duration of the next step was computed using two parameters of the system: a "pitch grain" (pg) which is the smallest variation of pitch we wanted (half a comma, for example), and "amplitude grain" (ag) which is the smallest variation of amplitude we wanted.

Using the time*pitch arc and the envelope at *t* time, we then compute the corresponding time intervals dtp and dta, as shown in the drawings below:

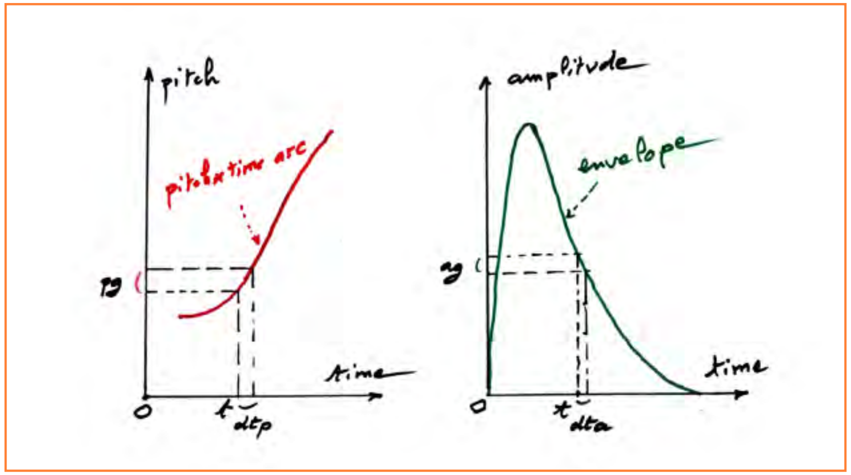


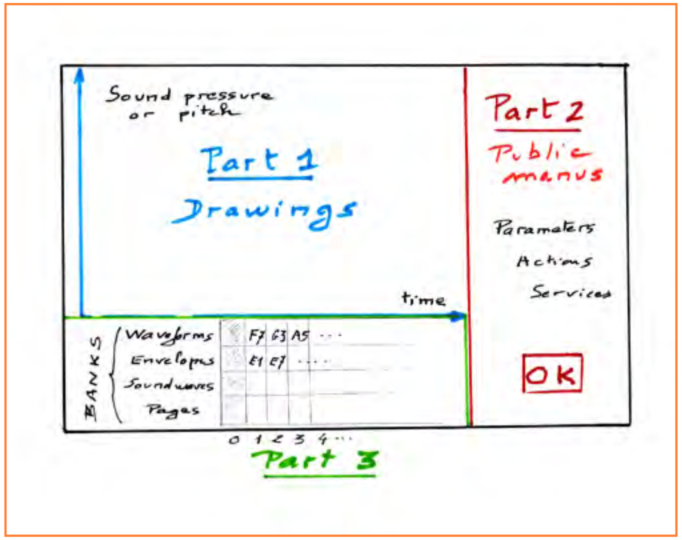
FIG. 13 Computation of the time intervals dtp and dta corresponding to *pg* and ag © Guy Médigue

We chose min (dtp, dta) as the duration of the current step. Then, we assumed that the pitch and the amplitude are constant during the step (values at *t* time). However, notice that we did not take into account the evolution of the waveform over the duration of a sound (when it roughly becomes a sinusoid at the end). This explains the rather aggressive aspect of the sounds of *Mycènes Alpha*, for example.

HOW TO USE THE UPIC A? THE GRAPHIC TABLET

The composer uses solely the electronic pen of the graphic tablet for expression. The composer can draw waveforms, envelopes, time*pitch arcs, or point at the boxes of menus to select an object from one of the banks or to request an action. The graphic tablet is divided into three parts:

1. The largest part is devoted to drawing on a system of reference with two axes. The horizontal axis is always time; the vertical axis can be the sound pressure (drawing of waveforms or envelopes) or the pitch (drawing of a time*pitch arc).
2. The second part is devoted to public menus (actions, services, various parameters, validation).
3. The third part is private, devoted to the objects of the user (personal bank menus).

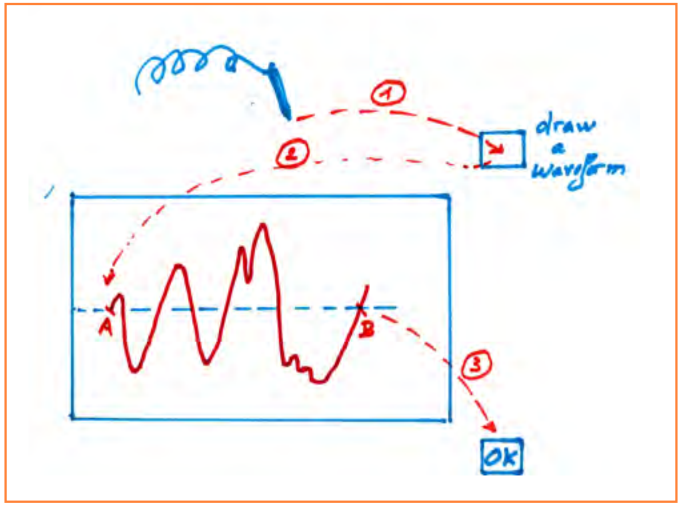


The box 0 of each bank is devoted to temporary objects (not yet recorded in respective banks).

FIG. 14 Organization of the graphic tablet © Guy Médigue

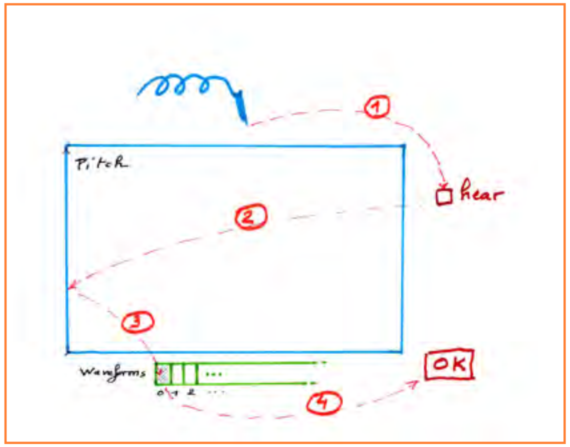
SESSION, PROJECT, ILLUSTRATIONS

Only one user at a time could work on the UPIC A. The time allotted to a user is "a session." During a session, the user can work on one or several "projects," each one corresponding to a particular set of private objects. For each project, the user has a sheet of tracing paper which is adjusted on the graphic tablet; on each sheet, the identifiers of the banks' objects—specific to each project—are written. At the beginning of the session, the user can open a new project or an old one that they want to complete. In this last case, the tape corresponding to this project has to be mounted on the tape drive. Then the user can draw new basic objects (waveforms and envelopes) on the graphic tablet. Each current object is tested, can be changed as many times as desired, and if the user is happy with it, this object is kept and saved in the appropriate bank. One can open a page of music of any personal project and draw time*pitch arcs on the graphic tablet or correct old ones. Before drawing a time*pitch arc, the user has to define its "label," that is, by choosing a waveform from the personal bank of waveforms, an envelope from the bank of envelopes, and a maximum intensity from the classical list (ppp, pp, p ... ff, fff). Some illustrations of the ways the UPIC A was used are given below:

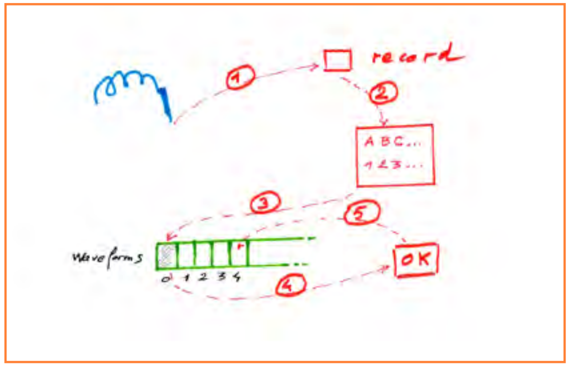


The user points the electronic pen at the box "Draw a waveform," and then draws one anywhere on the graphic tablet. When the user points at the box "OK," the waveform is displayed on the graphic console and recorded as the new current waveform (not yet in the bank of waveforms).

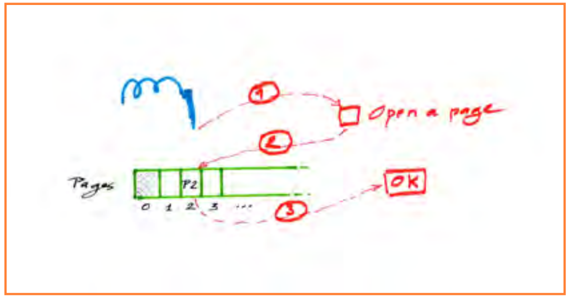
FIG. 14 How to draw a waveform © Guy Médigue



The user can hear the waveform at the desired pitch (for a duration of 5 seconds).



The user chooses an identifier of two characters. By pointing at "OK" the waveform is displayed on the console with its identifier and the box where the user has to write it (for example, G2 box 4).



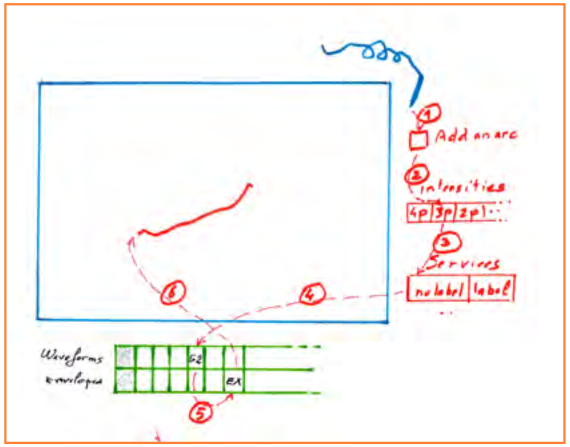
The user can open a new page or an old one they wish to complete. The page is displayed on the screen of the console, which unfortunately was far too small at the time (eventually resolved with larger terminals).

FIG. 15 How to hear the drawn waveform © Guy Médigue

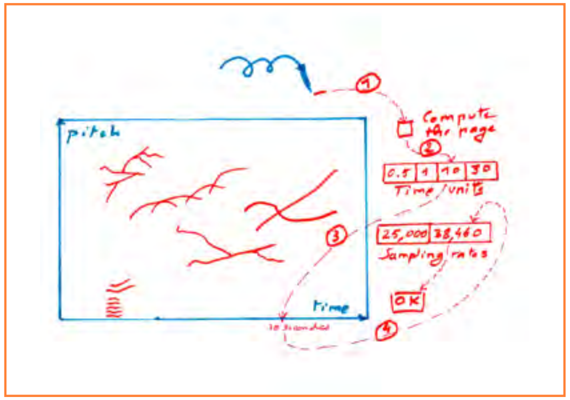
FIG. 16 Saving the drawn waveform into the bank of waveforms © Guy Médigue

FIG. 17 How to open a page of music © Guy Médigue

The user has to define first the label of the arc (including intensity, waveform, envelope), then point to "no label" (or "label" to see the label close to the arc on the display console). Then the user draws the arc (no validation necessary). The arc is displayed on the screen without (or with) its label. If the label is displayed close to the arc, the intensity is the last parameter (G2/EX/2p).



The user defines the unit of time desired (for example, 10 seconds on the time axis), then the sampling rate to use for the computation. The duration of the computation may be long if the user has drawn many arcs on the page (despite careful coding in assembly language). The resulting wave is the new temporary sound wave (box 0 of the sound waves' bank).



Various utilities were added over time (often thanks to multiple users) as well as the functions corresponding to the use of the analog to digital converter. Some of these will certainly be treated by colleagues in the pages of this volume, so I will not expound on them here.

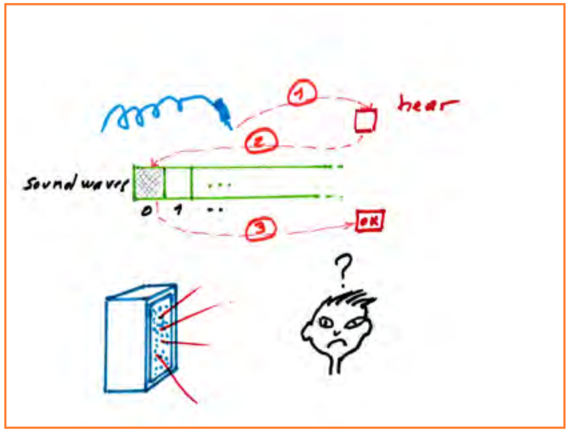


FIG. 18 How to add a time*pitch arc to a current page © Guy Médigue

FIG. 19 How to calculate the samples of the page just created © Guy Médigue

FIG. 20 How to listen to the page just calculated © Guy Médigue

The limitations for one project were as follows:

- 32 waveforms;
- 55 envelopes;
- 2000 time*pitch arcs per page;
- 24 pages per project.

For this first version of the UPIC A, it was not very realistic to have the sampling rate of 52,000 that Xenakis wanted. We were obliged to propose two lower sampling rates to the user: 25,000 and 38,460.

CONCLUSION

The relative success of the UPIC A among composers had mainly to do with its ease of handling. Here is the list of composers who came to CEMAMu to work on the UPIC A and whom I remember (my apologies to the composers I have regrettably forgotten!):

- Pierre Barbaud (BBK team): he came sometimes but not regularly.
- André Dubost.[16]
- Jean-Claude Eloy[17]: a composer fascinated by Japan, who worked extensively with the UPIC A.
- Julio Estrada.[18]
- Wilfried Jentzsch.[19]
- Candido Lima.[20]
- François-Bernard Mâche[21]: fond of birdsong, and used particularly the rhythms of birdsong.
- Frédéric Nyst.[22]
- P. Perio and F. Wu: from the Cristallography Laboratory of ORSAY, who used their knowledge about periodic crystal structure to make music with UPIC A.
- Iannis Xenakis: the very first completed composition with the UPIC A, *Mycènes Alpha*.

The main events at the time that I remember, because I was working very hard on them, were the following:

- Bonn; Beethoven Festival in May 1977
- Aix-en-Provence: Centre Acanthes in the summer of 1978
- Lille: Music Festival in October 1980

In conclusion, considering that the timbre of a sound with a pitch is only described by its waveform was an enormous simplification, both for coding and for the user, yet necessary in view of our time constraints. Who knows whether we would have come up with other solutions, had we been afforded the luxury of more time? The resulting music, often a little "rustic," although Xenakis, for one, tried to offset this by overlaying a great number of time*pitch arcs with various waveforms and sophisticated envelopes, is what, in fact, gave the UPIC its sonic identity.

Today, I am very pleased that some talented and young people are pursuing further research on and about the UPIC using the extraordinary potential of current computer technology. As a UPIC “ancestor,” I am delighted to contribute a historical perspective that may enlighten related present and future research.

LIST OF ABBREVIATIONS

ACROE (Association pour la Création et la Recherche sur les Outils d'Expression) – founded in 1976 by Claude Cadoz, Annie Luciani, and Jean-Loup Florens, in the National Polytechnic Institute of Grenoble (Grenoble INP) with the support of the French Ministry of Culture and Communication. http://www.acroe-ica.org/en

BBK (Barbaud Brown Klein group) – founded by Pierre Barbaud, Frank Brown, and Geneviève Klein http://www.associationpierrebarbaud.fr/biographie4.html

CEMAMu (Centre d'Études de Mathématique et Automatique Musicales) – founded by Iannis Xenakis in 1972, which grew out of the **EMAMU** (Équipe de Mathématique et Automatique Musicales, also founded by Xenakis but in 1966).

CERCI Compagnie d'Etudes et de Réalisations en Cybernétique Industrielle

GRAME (originally called the **G.R.A.M.E.**: Groupe de Réalisation et de recherche Appliquée en Musique Electroacoustique) – founded in 1982 by Pierre Alain Jaffrennou and James Giroudon

GRM (Groupe de Recherches Musicales) – founded in 1951 by Pierre Schaeffer, originally as **GRMC** (Groupe de Recherches de Musique Concrète).

IRCAM (Institut de Recherche et Coordination Acoustique/Musique) – IRCAM was founded in 1970 by the French President Georges Pompidou who invited Pierre Boulez to direct the center, which opened in 1977 in Paris.

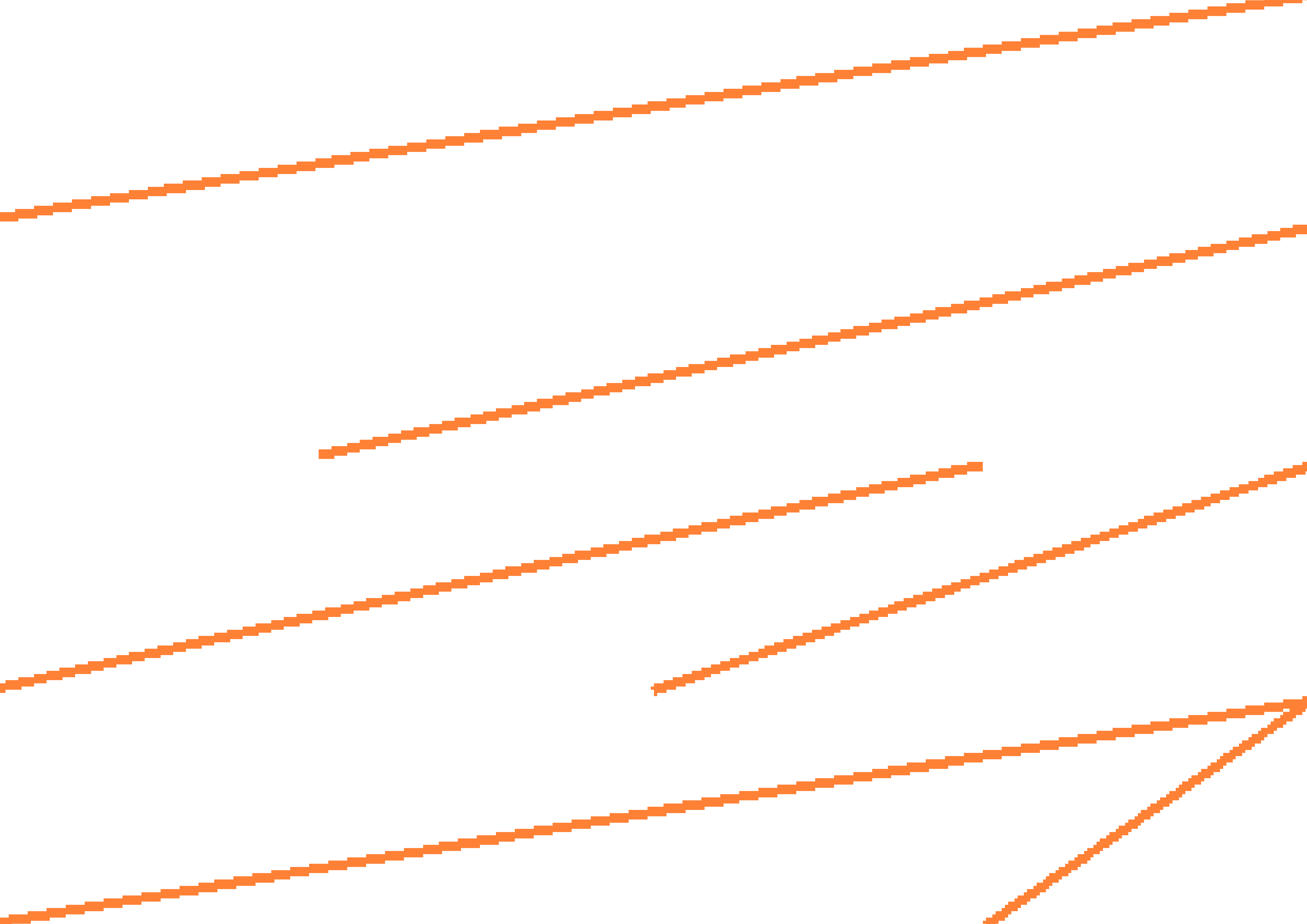
IRIA (Institut de Recherche en Informatique et Automatique), later became INRIA (Institut National de Recherche en Informatique et en Automatique).

UPIC (Unité Polyagogique Informatique **CEMAMu**).

FOOTNOTES

1. SEMA-METRA International, Subsidiary of METRA International, the only IT company of European scope at the end of the 1960s, where I analyzed and developed traffic software.
2. CERCI was developing real-time industrial systems. I mainly designed, developed, and maintained a simulation system on a mainframe for the development of such systems (SCEPTRE).
3. CYCLADES was a project initiated by the Institut de Recherche en Informatique et en Automatique (IRIA): Several years of research supervised by Louis Pouzin with relatively substantial resources, represented a prelude to the Internet as an alternative to the ARPANET with the development and full-scale testing of software for a network of French minicalculators distributed in France and Canada, and according to principles that were ultimately those retained by posterity.
4. The main bureau of the CNET (Centre National d'Étude en Télécommunication), located in Issy-les-Moulineaux right outside of Paris, housed the CEMAMu.

5. Every three years, from 1961 to 1992, the city of Bonn hosted a Beethoven Prize, which was actually an orchestral competition. Iannis Xenakis had been honored three years earlier in Bonn, in 1974, with a major retrospective comprising some ten concerts at which thirty of his works were performed and several peripheral events also took place (exhibition, films, talks, etc.). In 1977, Xenakis was awarded that year's Beethoven Prize for his piano concerto *Erikhthon*, which had received its German première in 1974 in the aforementioned festival.
6. Pierre Barbaud (1991–1990), French composer widely considered to be the inventor of algorithmic music.
7. Pierre Schaeffer (1910–1995), French composer widely considered to be the inventor of musique concrète.
8. Claude Cadoz, French composer considered a pioneer in physical modelling for sound synthesis and computer gestural interactions.
9. Pierre-Alain Jaffrennou (*1939), French composer with a particular interest in spatial sound production and stage direction.
10. Patrick Saint-Jean (*1949), musician, mathematician worked for the CEMAMu between 1974 and 1976.
11. In fact, the founding of IRCAM dates back to 1970, contemporaneous with the decision by President Pompidou to create the National Contemporary Arts Center, also called Beaubourg. However, construction on the site only got underway beginning in 1974 and it opened in late 1977.
12. Cornelia Colyer (1947–2003), long-time collaborator of Xenakis who oversaw much of the computer programming at CEMAMu.
13. Initially, President Pompidou (rather naively?) suggested that IRCAM be codirected by Boulez and Xenakis. See this video https://medias.ircam.fr/xbe8660 where archival resources have revealed the premises of IRCAM under a joint Xenakis–Boulez configuration—especially, from 11'45".
14. The equivalent of 100,000 French Francs in 1976 was roughly 15,250 Euro; the equivalent today is roughly 68,250 Euro.
15. Pierre de Bailliencourt later became the founder and president of ARC Informatique: see https://www.pcvuesolutions.com/
16. André Dubost (*1935), composer who later became an inspector at the French Ministry of Culture.
17. Jean-Claude Eloy (*1938), composer and close friend of Xenakis, composed, in particular, *Etude IV: Points, Lignes, Paysages* (1980), 21' on the UPIC.
18. Julio Estrada (*1943), composer and close friend of Xenakis, composed, in particular, *eua'on* (1980), 7' on UPIC, which he later transcribed for orchestra, as *eua'on'ome* (1995), 10'. Soon after Xenakis's death, in 2001, Estrada was summoned to France from his native Mexico to run the CEMAMu. Unfortunately, this did not come about and the French Ministry of Culture simply closed down the research lab. See Estrada, this volume.
19. Wilfried Jentzsch (*1941), German composer and media artist, who studied with Xenakis in Paris from 1976 to 1981.
20. Candido Lima (*1939), Portuguese composer, who studied with Xenakis in Paris during the late 1970s to early 1980s.
21. François-Bernard Mâche (*1935), composer, teacher, philosopher of music, one of Xenakis's closest friends for decades. See Mâche, this volume.
22. Frédéric Nyst (1939–2011), Belgian composer.



THE UPIC: TOWARDS A PEDAGOGY OF CREATIVITY

ALAIN DESPRÉS

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THE UPIC: TOWARDS A PEDAGOGY OF CREATIVITY

I have been away from the UPIC since 1991 so my contribution to this volume is that of someone who has likely forgotten some details and whose memory may be "selective" at times. However, I shall devote my chapter to the educational aspects of the UPIC and also retrace a more historical perspective; that is, UPIC's first steps around the world. Furthermore, I would like to stress that if indeed the UPIC was born from Xenakis's brilliant intuition, without Guy Médigue[1] *it would never have become a reality.*

TOWARDS A PEDAGOGY OF CREATIVITY: MY PERSONAL CHRONOLOGY WITH THE UPIC

My first encounter with the UPIC was in no way random. In 1979, I had just been hired by the Atelier Régional de Musique du Nord (ARM). For several years, I had already been very involved in a professional approach based on the conviction that every more-or-less normal human being possesses, at one and the same time:

- a significant artistic sensitivity, in one field or another, or in several,
- and a real aptitude—possibly unsuspected—for artistic creativity.

I was convinced that music was an area where things could really move in that direction and had experienced this many times at the Maison de la Culture in Nevers where I had previously worked. In 1979, like every year in autumn, the Lille Festival was one of the highlights of musical life in France. Its director at the time, Maurice Fleuret, invited the ARM to participate in the organization of the 1980 Festival, where Xenakis was to be the guest of honor. Maurice Fleuret told us about the composer (who was also his close personal friend), and about the UPIC, which he wanted to take out of its Parisian research lab and invite to Lille. He needed to appoint someone to be in charge of the project. I didn't hesitate a second, I jumped at the opportunity. And I certainly never regretted it.

The mission actually seemed quite simple: first of all to discover the machine for myself, to perceive how it could be a formidable tool, usable by everyone, and to construct a specific pedagogy around it. Xenakis expressed in his own way my personal convictions mentioned above: "[W]e want to develop this system in such a way as to put the UPIC within the reach of the entire population of the globe so that man can manifest his supreme capacity for abstraction because that is his most interesting power."[2] Understandably, it didn't take much for us to convince each other!

For the presentation of the UPIC in Lille, with Iannis and his assistant, Cornelia Colyer, we decided to organize five very different groups, each of which would come daily over two weeks to work on the machine. One of these groups, comprised solely of visual artists, produced a short piece of four or five minutes that we had the audacity to enter in an electroacoustic music competition in Paris. To everyone's surprise, it won first prize!

Such gratifying experiences allowed me to continue the adventure with Iannis. Then, Iannis and I worked together to imagine a more precise educational approach which would prove that the UPIC was indeed an exceptional tool allowing anyone to develop their own musical creativity.

I would like to stress that the UPIC itself helped us a lot: its approach to musical conception was so innovative that everyone was, at first, very confused: adults, however, more than youngsters, and composers more than non-musicians. In short, the UPIC forced its users to question everything they had previously learned. That was also Iannis's leitmotif: when an aspiring composer came to him for advice, I repeatedly heard him say, "You've taken your classes, so now forget everything you've learned." The UPIC imposed this, from the very beginning.

Another strong point of the system—at least in its first version—was the fact that it was impossible to "cheat" with the UPIC. To obtain an interesting result with the machine, it was hard work: one had to acquire the basic foundations of acoustics, understand the technical notions of timbre, dynamic envelope, pitch/time plane, micro and macro form; in short, all the sound parameters, the notion of sound object, a beam of glissandi, or a cloud of short sounds, etc. Furthermore, at the end of the 1970s, the UPIC trained us to think carefully before acting. It even forced us to do this, by affording us the time we needed. For example, when a user finished drawing a page of music lasting, say, one minute, it could take from 3 to 8 hours of calculation before hearing the result! Such a constraint forces you to think carefully, to make the right choices from the start, so you don't have to recalculate everything and go back to square one!

When teaching the UPIC system, it was important to give users, whether adults or children, musicians or not, adequate time to digest this new approach. Whenever possible, we designed sessions longer than those in Lille; three weeks, ideally, during which small groups of only four to six people worked at a time, regardless of age or previous musical experience. Each group worked together with the goal of creating a common work. Each group had daily access to the UPIC for

two to three hours, depending on their age. This type of organization also afforded people the rest of the day and night to think about what they would do next.

A typical session was conducted in the following manner: after briefly explaining how the machine worked and letting users do some experiments, we asked them to imagine either a story (when working with small children), or an atmosphere, a sound landscape, or even a simple musical construction for the more experienced. As soon as some first elements were built, we calculated and listened to the result: always surprising, of course, but is it good or poor? How can we transform or just improve it? We made corrections, restarted the calculation, listened to the differences, decided either to save it or try something else. Then, we continued, another construction, and another one... And then stopped, a pause at some point: we have retained some first elements, now we will have to make them live together. But is that enough to make a "beautiful piece of music"? Then we approached the notions of macroform, of evolution, possibly of symmetry, of classical form or not, of dramatic progression... How do we want the piece to end? In any case, we are composing. Even with small children, these concepts could be addressed through the UPIC. **FIG. 1**

With each workshop, we suggested forming at least one new type of group, which so far had not been formed elsewhere: after the visual artists in Lille, a group composed only of women in Tokyo, blind people in Mexico, dancers here, or mathematicians there. And, it always worked! However, it was almost systemic that one group had more difficulties than all the others: musicians with classical training, students from music schools. Sometimes, it is harder to unlearn than to learn afresh! **FIG. 2**

I must confess, today I feel a certain nostalgia for this "archaic" period; I actually preferred it to the next one and the arrival of the real-time UPIC. The compositional tool it had been back then was transformed into a digital musical instrument, almost like any other. It had immense possibilities, but was much more difficult to master. With Peter Nelson[3] and Pierre Bernard,[4] two true UPIC pioneers, the three of us created *Un Alliage Rituel*, in 1990, a beautiful collective work that I do not deny, far from it, but I also know that it was difficult for the audience to perceive. They didn't understand anything about the interventions we made with the tip of the pen on the UPIC table and what they were seeing on stage. **FIGS. 3, 4**

By that time, in 1990, it was time for me to turn the page. All along, I had had a secret garden, and I stored stones there. So, I left Les Ateliers UPIC to embark on other adventures, which are also very exciting. Today, I am a sculptor.

FIG. 1 UPIC workshop for children in Mexico City, Mexico, 1988 © Alain Després and CIX Archives

FIG. 2 UPIC workshop for female participants in Yokohama, Japan, 1984 © Alain Després and CIX Archives

FIG. 3 Pierre Bernard (right), Peter Nelson and Alain Després (left) performing *Un Alliage Rituel* at the world première at the International Computer Music Conference ICMC), Glasgow, UK, 1990

FIG. 4 Pierre Bernard, Peter Nelson and Alain Després performing *Un Alliage Rituel* at the world première at the ICMC, Glasgow, UK, 1990

1979–1990: UPIC'S FIRST TRIPS

Organizing a UPIC trip in the late 1970s was no easy task. Today, it is difficult to imagine that a truck was needed to transport the machine. In 1979, every element of the computer was like a large piece of furniture. A disc was 40 cm in diameter and 38 cm high, it had a capacity of one short minute of music! The magnetic tapes were installed in two untransportable cabinets around 2 meters tall. At the time, the UPIC was a laboratory object; experimental, designed to be multiplied and travel, but still very fragile. Taking it out of the Centre d'Etudes de Mathématique et Automatique Musicales (CEMAMu) to transport it to Lille, then later to Japan, was sheer madness. It was necessary in an almost systematic way to plan for a lot of time to reinstall the system after each trip, and also a repair service, whose timing was always random. Generally, everything was usually in order just a few minutes before the first workshop or concert. Yet the UPIC travelled far and wide.

Here, I will try to reconstruct UPIC's adventures during the period when I was in close contact with it, between 1979 and 1990. Fortunately, I have kept some paper documents and some slides. I finally found traces of about sixty more or less significant events. To list them all here would be tedious, so I will simply highlight only a few key moments.

Until 1984, only the CEMAMu had any UPIC systems. Yet finally, in February 1984, thanks to a grant from the French government, the ARM (of which I had become director in the meantime) was able to acquire its own UPIC in a version of delayed time but of more reasonable dimensions. The whole installation fit into a van, and only the graphic table remained like the original one. FIG. 5

Three months later, the CEMAMu organized a first UPIC tour in Japan. Two locations were chosen, Tokyo and Yokohama, and Xenakis asked me to accompany the team on this adventure. FIGS. 6, 7

Xenakis was the guest composer of the Centre Acanthes in Aix-en-Provence during the summer of 1985, an annual event for young professional musicians from all over, focusing on an internationally renowned composer and his main performers who gave master classes. That year, three locations were selected: the UPIC went from Aix-en-Provence to the Mozarteum in Salzburg, and then on to Delphi. FIG. 8

In December 1985, at Xenakis's request, I left the ARM to create Les Ateliers UPIC. Iannis was the honorary president and François-Bernard Mâche, our chairman. We set up our offices and our work studio in what later became the Cité de la Musique at the Parc de la Villette in Paris. Composers from many countries came to work there on the UPIC. We received significant and generous support from the French Ministry of Foreign Affairs, as well as from the French Ministry of Culture. Thanks to these grants, about thirty composers were able to participate in these various events. Amongst them were some Russians and Albanians who could leave their country for the first time, thanks to the fact that the borders were just beginning to open. FIG. 9

In October 1987, Les Ateliers UPIC were awarded the Fiat-France Foundation, Institut de France Patronage Prize. On this occasion, a film was made about our work by an Italian production company. We also received a large sum of money, which enabled us to organize an extensive tour throughout North America and Mexico the following year. The tour began in San Diego, thanks to Iannis's longtime friend and colleague Roger Reynolds, and we installed the UPIC in the Project for Music Experiment at the University of California San Diego (UCSD) for eleven days, where we held composition master classes every day and gave a concert.

After some adventures with the U.S. customs officers, we went to Mexico where we were hosted by Julio Estrada and his university. FIG. 10

Then a jump by airplane took the UPIC to the Banff Center of Fine Arts near Calgary, Canada, with a subsequent stop in Montreal at the Conservatoire. We ended our tour of almost three months in Toronto, where workshops for all age groups and a concert were organized. FIG. 11
1990 was a landmark year for Les Ateliers UPIC: we moved to more spacious premises in Massy, just outside of Paris, and we also received a new machine, lighter, and above all, in real time, from the CEMAMu team.

Around the same time, initiated by Takehito Shimazu and Shigehiro Yamamoto, two Japanese composers whom we had previously invited to work on the UPIC in France, we organized another tour in Japan in October 1990. We presented the new real-time machine and the same spectacle *Un Alliage Rituel* in Tokyo, Kofu, Fukui, and Fukuoka. Some master classes were also organized. FIG. 12

This succinct overview of the nearly sixty events we organized, including the ten or so major milestones, sums up what we did, in addition to our daily life in the studio when the UPIC was in Paris. Besides the outreach workshops we held for children or amateurs, we always managed to add master classes for composers from the country hosting us. Therefore, many professionals were able to experiment with the machine and some subsequently came to pursue their UPIC work in Paris. Thus, around fifty composers created one or several pieces of music; over eighty UPIC works were created during that decade alone.

During our trips, we always met "the people who mattered" in the local musical scene, by Xenakis when he was there, or by us when he could not be present, the machine was presented in front of local political and cultural personalities and the press. We participated in numerous radio and television programs. Several films were made: the machine was

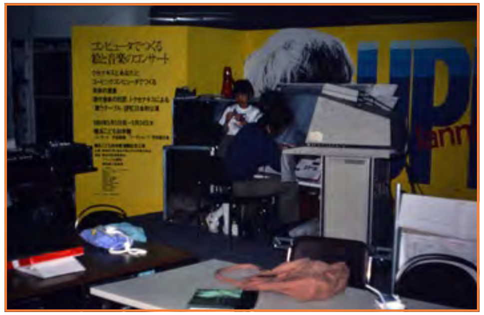


FIG. 5 UPIC's own transporter the Atelier Régional de Musique du Nord (ARM), 1984 © Alain Després and CIX Archives

FIG. 6 UPIC workshop setup in Yokohama, Japan, 1984 © Alain Després and CIX Archives

FIG. 7 A participant who arrived one day to a UPIC workshop in a traditional dress stands in front of the travel version of the UPIC, Yokohama, Japan, 1984 © Alain Després and CIX Archives

FIG. 8 Iannis Xenakis (front) at the Centre Acanthes with Rudolf Frisius (far left), Aix-en-Provence, France, 1985 © Alain Després and CIX Archives

FIG. 9 Peter Nelson (second from right) during a class at the UPIC composition studio at La Villette, Paris, France, 1986 © Alain Després and CIX Archives

FIG. 10 UPIC workshop led by Julio Estrada, Mexico City, Mexico, 1988 © Alain Després and CIX Archives

FIG. 11 UPIC workshop with children, Toronto, Canada, 1988 © Alain Després and CIX Archives

FIG. 12 UPIC workshop, Tokyo, Japan, 1990 © Alain Després and CIX Archives installed on the set of a popular TV show when we were at the Barbican Centre in London **FIG. 13**, it figures prominently in a film directed by French filmmaker Chris Marker, *The Owl's Legacy*, (Episode 8 of the 13-episode series); and today, a UPIC is on permanent display at the Museum of Music at La Philharmonie in Paris.

While we were at Les Ateliers UPIC studio, working an average of seventy hours a week during the 1980s, we just had the feeling that we were living a beautiful adventure. It is only today that I have become aware that, thanks to Xenakis of course, I have also been able to make a very modest contribution to the history of twentieth century music. **FIG. 14**

TIMELINE OF UPIC'S PRESENTATIONS 1977–1990

EVENTS MANAGED BY THE CEMAMU:

1977 May	Bonn, Germany, Presentation of the first UPIC prototype at the World Music Days
1978 June	Paris, France, UNESCO: Presentation of the UPIC machine
1978 Sept.	Mycenae, Greece, *Mycènes Alpha*, Iannis Xenakis, world premiere of the first UPIC work, in Xenakis's *Polytope de Mycènes*, recorded on tape

UPIC EVENTS MANAGED BY THE ARM (IN COLLABORATION WITH THE CEMAMU):

1980 Oct.–Nov.	**UPIC'S FIRST TRIP OUTSIDE OF PARIS:** Lille, France, Festival de Lille (concert, workshops)
Nov.	Bordeaux, France, Sigma Festival (concert, workshops)
1981 June	Paris, France, Forum des Halles (concert, workshops)
Oct.	Bar le Duc, France, Colloqui Informatica Musicale (CIM) (concert, workshops)
1982 Jan.	Chambery, France, Orchestre de Savoie (concert, workshops)
Feb.	Nice, France, Festival MANCA (concert, workshops)
Feb.	Marseille, France, Conservatoire (presentation)
May	**UPIC'S FIRST TRIPS OUTSIDE OF FRANCE:** Lisbon, Portugal, Gulbenkian Foundation (concert, workshops)
June	Middelburg, Netherlands Festival nieuwe muziek (concert, workshops)
Oct.	Gruson, France, Festival du Pévèle Mélantois (concert, workshops)
Nov.–Dec.	Albi, France, Rencontres "Technologie du future" (concert, workshops)
1983 May	Orsay, France, Université Paris Sud (concert, workshops)
June	Bourges, France, Cours du Palais Jacques Coeur (International Festival of the Groupe de musique expérimentale de Bourges) (concert, workshops)
Nov.	Paris, France, Magasin Ham (concerts, workshops)
Dec.	Paris, France, Auditorium du Conservatoire Paris 12éme (concert, workshops)
1984 Feb. 18	l'Atelier Régional de Musique (ARM) acquires its own UPIC

FIG. 13 Peter Nelson presenting the UPIC on a television set, London, UK, 1989
© Alain Despréś and CIX Archives

FIG. 14 Iannis Xenakis presenting the UPIC at La Villette, Paris, France, ca. 1985
© Alain Despréś and CIX Archives

1984 May		**CEMAMU-ARM: UPIC'S FIRST TOUR IN JAPAN**
		Yokohama, Japan, Scientific Cultural Center (concerts, workshops)
	June	Tokyo, Japan, Institut Français (concerts, workshops)
	July	Boulogne s/Mer, France Festival Côte d'Opale (concert, workshops)
1985 Feb.–March		Nevers, France,Maison de la Culture (concert, workshops)
	April–May	Besançon, France, Espace Planoise (concert, workshops)
	June–Aug.	Iannis Xenakis Guest of Honor at the Centre Acanthes
	July	Aix-en-Provence, France Conservatoire de musique(master classes, concerts)
	July–Aug.	Salzburg, Austria, Mozarteum (master classes, concerts)
	Aug.	Delphi, Greece, European Center (master classes, concerts)
1985 Nov.–Dec.		Clermont Ferrand, France Conservatoire National de Région (concert, workshops)
1985 Dec.		Inauguration of Les Ateliers UPIC at La Villette, Paris, France (ARM donates its UPIC to the new association)

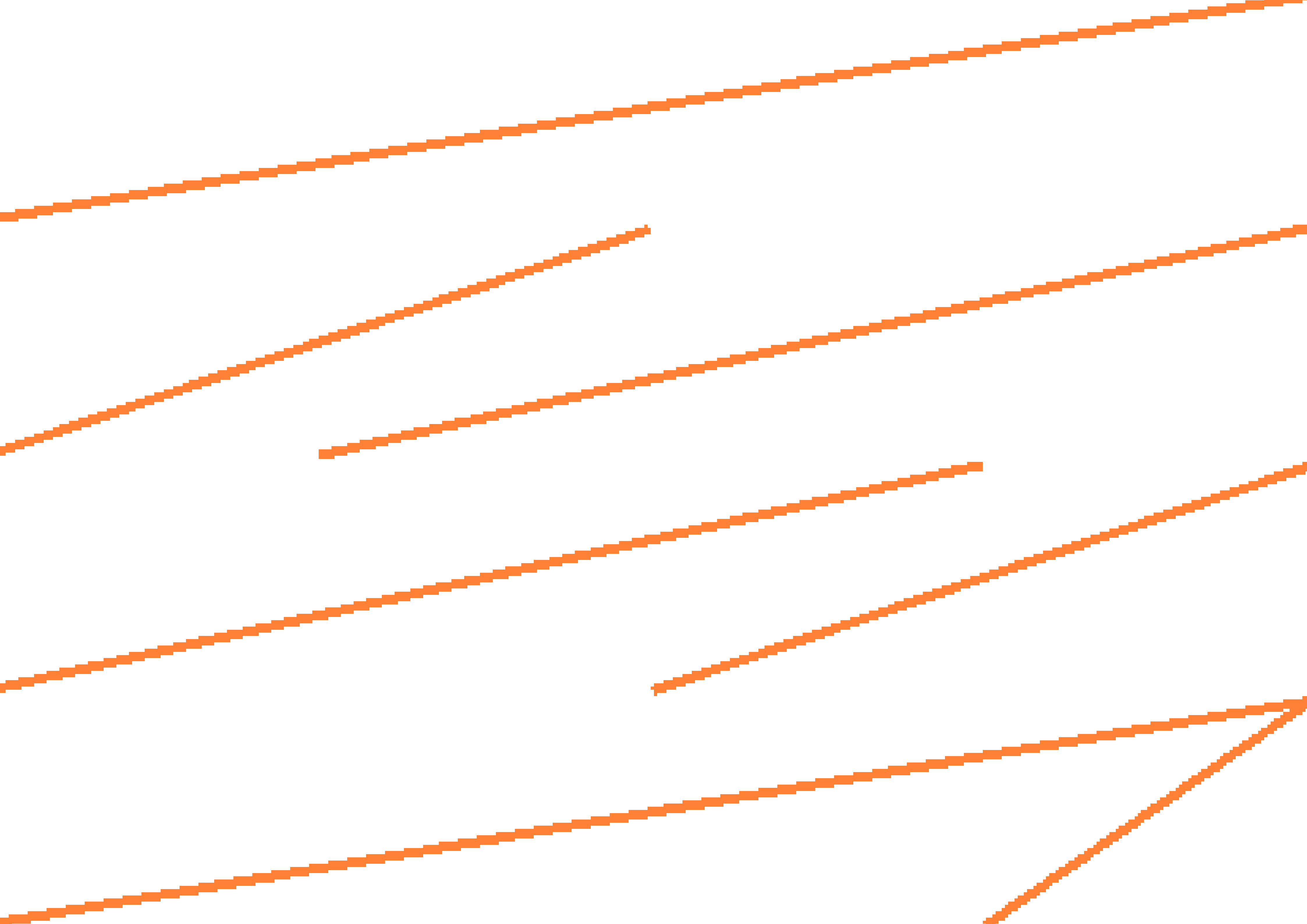
EVENTS MANAGED BY LES ATELIERS UPIC:

1986 Jan.		Paris, France, launch of the French government's Informatics at School campaign
	April–May	St Sever, France, Cloître des Jacobins (concert, workshops)
	April	Blanc-Mesnil, France Centre Musical Erik Satie (concert, workshops)
	June	Rennes, France, Maison de la Culture (concert)
	Oct.	Toulouse, France, Festival FAUST (demonstrations) Concert
	Oct.	Romans, France, Théâtre (concert, workshops)
	Dec. 4	Limoges, France, Auditorium CCSM (concert, workshops)
1987 March		Dijon, France, DRAC (concert, workshops)
	May	Valencia, Spain, Palau de la Musica (concert, workshops)
	May–June	Soissons, France, École de musique (concert, workshops)
	July	Paris, La Villette First International UPIC Workshop. 12 composers, 12 countries represented
	Sept.–Oct.	Stockholm, EMS Fylkingen Kulturhuset Riksradion
1987 Oct.		Château de Chantilly, Fondation Fiat France – Institut de France
	Oct.	Caen, Conservatoire (concert, workshops)
	Nov.	Huddersfield, Contemporary Music Festival (concert, workshops)
	Nov.	Les Ateliers UPIC receive "Les sphères du Mécénat" award from the FIAT Foundation
1988 May		Paris, France, La Villette Conference "Towards an Interactive Culture"
	Sept.	Berlin, Germany, Technischen Universität (concert, workshops)
	Sept.	Turin, Italy, Festival Settembre Musica (concert, workshops)

1988 Oct.		**LES ATELIERS UPIC: UPIC'S TOUR IN USA, MEXICO, CANADA**
		San Diego, USA. PME of UC San Diego (concert, masterclass)
	Nov.	Mexico City, Mexico, Institut Français d'Amérique Latine (IFAL) (concert, workshops)
	Nov.	Banff, Canada, Banff Center of Fine Arts (concert, workshops)
	Nov.	Montreal, Canada, Conservatoire de Musique (concert, workshops)
	Dec.	York, Canada, York University, Dept. of Music (demonstration, concert)
	Dec.	Toronto, New Music Concerts (concert)
	Dec.	Toronto, St. George's College (concert, workshops)
1989 Jan.		Paris, France, Second International UPIC Composition Workshop
	Jan.	London, UK Barbican Center (concert, workshops)
	March	Lyon, France Musée St. Pierre Contemporain (concert, workshops)
	Sept.	Valmy, France, Bicentenary of the French Revolution (participation in a spectacle)
	Dec.	Geneva, Switzerland, Musée Rath (concert, workshops)
1990 May		Massy, France, Inauguration of Les Ateliers UPIC new premises Third International UPIC Composition Workshop
	Sept.	Glasgow. UK, International Computer Music Conference (concert, workshops)
		World première of *Un Alliage Rituel* by Pierre Bernard, Alain Després, and Peter Nelson (first real-time work composed on UPIC)
		LES ATELIERS UPIC: UPIC'S SECOND TOUR IN JAPAN
	Oct.	Tokyo, Japan, Institut de France
	Oct.	Kofu, Japan Yamanashi University
	Oct.	Fukui, Japan International Media Art Festival (concert, workshops)
	Nov.	Fukuoka, Japan, Kyushu University of Acoustics (conference and concert)

FOOTNOTES

1. See Médigue, this volume.
2. See Xenakis in the UPIC Promotional Video here: http://www.centre-iannis-xenakis.org/items/show/674 (especially from 0:48).
3. Peter Nelson is a composer and currently Professor of Music and Technology at the University of Edinburgh. He worked closely with Xenakis in the 1980s and was Editor in Chief of the prestigious journal *Contemporary Music Review* from 1986 to 2014.
4. Pierre Bernard, composer and regular collaborator at Les Ateliers UPIC and at CEMAMu.



THE UPIC—EXPERIMENTAL MUSIC PEDAGOGY—IANNIS XENAKIS

RUDOLF FRISIUS

THE UPIC— EXPERIMENTAL MUSIC PEDAGOGY— IANNIS XENAKIS

OLD AND NEW KEYWORDS

Four letters, a keyword, and a composer, united in a headline: At first sight, this combination may seem strange, not only to the generally interested reader but also to the specialist: as a collage of music technology, music pedagogy, and musicology.

The UPIC (Unité Polyagogique Informatique CEMAMu) is a device for anyone who wants to open up new pathways to music: those who use it can sketch something onto the device's drawing board, and then have it transformed digitally into sound by the machine. The idea of inventing such a device came from a composer who often used his drawings as prompts for his own work: The Greek composer Iannis Xenakis neither studied music at a young age nor worked as a musician, but instead earned his living for many years as an employee of world famous architect Le Corbusier. After some time he found out that not only architecture, but also music can emerge from precisely recorded designs: lines on the drawing surface as pictures of sustained or moving tones in the tonal space. This thought, which was very simple in its basic approach, was thought through so thoroughly that it was able to serve as the starting point for completely new and surprisingly complex music. This music was so rich and interesting, and at the same time also so obvious in its basic approach that it could stimulate new ideas, which led not only to new compositions, but also to new approaches to musical learning: If everyone were able to draw sounds—not just a highly specialized composer—then composing would no longer be a specialty reserved for the very few. Everyone could be inspired in this way to invent music: a composer became the stimulus of new ways of music in new, experimental music education.

This chapter deals with substantive relationships between music technology, music pedagogy, and the thinking and working of a prominent exponent of New Music after 1945. Iannis Xenakis's music pedagogical approach is shown as a consequence of historical, musical, and political references. Also illustrated are the creations and work of the Greek composer and architect in the context of contemporary history

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and the development of his digital learning tool UPIC; that is, a general learning tool for all ages and levels of education used in his research center CEMAMu (Centre d'Etudes de Mathématique et Automatique Musicales), which was founded in the 1960s and active until Iannis Xenakis's death in 2001.

MUSIC AND THE HISTORY OF MUSIC IN THE HISTORY-CHANGING PROCESSES OF THE TWENTIETH CENTURY

The search for alternatives to traditional music education (which focused on singing and instrumental music, on notation and music theory, as well as on works and composers of the past) began relatively late in the age of new music. In Germany, it did not begin concurrently with the radical musical innovations of the early twentieth century before the First World War. The new way of pedagogical thinking only began several years later, after the catastrophe of the First World War and at the same time as the democratic new beginning in the years of the Weimar Republic. New approaches developed in the conflict between the old and the new, in years that were also overshadowed by economic crises and political radicalization. In the years of the National Socialist dictatorship and World War II, this radicalization then led to the narrowing down of music lessons to nationalistic and militaristic singing and traditional national music.

Only with the political and cultural new beginning from 1945 could innovative musical development begin again in the former sphere of power of the National Socialists. This development was also ready to be open to the world, and internationally accessible (e.g., at the Summer Courses for New Music which were founded in Darmstadt in 1946 and rapidly internationalized). Already in the first post-war years this development had extended beyond the field of moderate modernity. Examples are Hindemith, Bartók, and Stravinsky; the music and music education of Carl Orff, who in spite of using recently developed instruments and playing techniques as well as new, partly improvisational practices of collective singing and making music, still remained largely trapped in traditional patterns of melody, harmony, and rhythm.

However, the transition from Hindemith, Bartók, Stravinsky, and Orff to more radical musical innovators took place more rapidly in music life after 1945 than in music education. Due to the promotion of new music at the Darmstadt Summer Courses and by progressive organizers, radio stations, and publishers, a wider interest in new music developed during the first post-war years. This interest sought to escape the shadows of the past by detaching itself from the bonds of traditional (and traditionally strained) tonality.

The trend toward innovation had to overcome considerable resistance in the realm of still largely traditional musical life, and above all in the field of music education. It became clear, especially in Germany at that time, that the resistance to radical musical modernism, which had been outlawed by the National Socialists, also had something to do with the unresolved issues of coming to terms with the recent past (evidenced, for example, by the long-term survival of many politically tendentious songs in school singing lessons). This situation only changed after Theodor W. Adorno challenged traditional music education in the 1950s with radical ideological criticism.

In his essay *Kritik des Musikanten* (1956), Adorno called for abandoning a pedagogically simplified tonal way of thinking, unreflected singing, and playing "music-educational music (Musikpädagogische Musik)." The alternative he suggested was to engage thoroughly with more sophisticated musical works; not only within the confines of a traditional canon of art, but also incorporating more recent art music beyond traditional tonality, such as works by Arnold Schoenberg and composers from his Viennese school. However, in the 1950s (and even in the following decade) the traditionally trained music educators were not prepared for this openness, especially not in the field of musical practice, where simple tonal songs and instrumental pieces could not be easily replaced by atonal or twelve-tone music. Music educators who wanted to incorporate such works into their music lessons were not able to teach this type of music as they had learned it—especially in the field of music practice. Even their knowledge of traditional musicology only helped to a limited extent in dealing with newer approaches and works, since if taught only in a traditionalist manner it could lead to the new style of music being weakened (whether in favor of alleged or actual tonal twelve-tone music, such as Alban Berg, or in transferring traditional methods of work analysis to newer works; for example, focused on approaches of traditional motif and form theory, since they have indeed remained largely effective in the music of Schoenberg and his students).

In traditional music education after 1945, attempts at traditional mastering of the non-traditional could only be successful as long as the most radical current music remained at least partially connected to old traditions. This was true even for music by Schoenberg, Berg, and Webern, but only to a limited extent for the percussion music of Varèse and the young Cage or for important rhythmic and multiparametric innovative works by Olivier Messiaen (especially his piano etude *Mode de valeurs et d'intensités* of 1948, which at the time when it was created impressed many younger composers, including Boulez, Stockhausen, and Xenakis).

The “latest music” of Boulez, Nono, Stockhausen, Xenakis, and others, which prevailed since the 1950s, could not be learned at traditional education institutions during that period, but only through direct contact with leading composers; for example, at the Darmstadt Summer Courses, where innovative composers communicated with each other as well as with musicians and music lovers. An important part played in this was that in the 1950s, many radio broadcasters contributed significantly to the distribution of radical new music (e.g., by commissioning compositions, organizing concerts and broadcasts, especially in France and Germany).

Both in public events as well as in broadcasts and printed publications, a variety of information was offered that was theoretically available to the wider public, but actually, in the still largely traditional music business from the 1950s to the early 1960s, was initially used by only a few music educators. That is why it took many years before new music finally gained more attention in musical life as a whole, and especially in music education.

This was also due to the fact that important innovations in the field of “serious music” were initially made largely independent of the field of popular music: The radical avant-garde music of the 1950s didn’t distance itself less from the (at the time also radically innovative) rock and pop music than it did from the then “moderately modern” and traditional “classical” music. This changed only in the course of the music development of the 1960s; in a period of manifold crossovers between both areas. It was not until this time of generational change that a more effective rapprochement between the areas of “new music” and “music education” took place, in the course of which music pedagogy, which was at that time (and still is) geared towards traditional or classical modern works of art, could radically redefine itself as experimental music education—as a pedagogy that not only made itself available for newer composers and works, but also sought new ways of dealing with music creatively. In this situation it was significant that innovations in music education did not happen, as often before, according to the structures and methods of traditional musical life, musicology and musical pedagogy (vocal and instrumental music or the traditional musical analysis and interpretation), but in close connection with contemporary compositional developments and with innovative, prominent composers dealing with ideas, who, in the context of important social and political changes in the 1960s, and then in the general musical history context, have received more attention.

IANNIS XENAKIS AS AN INNOVATOR IN MUSIC AND MUSIC EDUCATION

Iannis Xenakis holds a special position among post-1945 composers who were interested in social openness and committed to music education

relatively early. Xenakis belongs to a generation that was shaped decisively by the catastrophe of the Second World War and its political and social consequences. Its most important representatives after the end of the war had to break new ground and work on (and possibly overcome) the past. Xenakis himself often stressed how important this was for his first internationally known work. In 1978, in conversation with Bálint András Varga, he specified this more precisely:

> Metastasis*, that starting point of my life as a composer, was inspired not by music but rather by the impressions gained during the Nazi occupation of Greece. The Germans tried to take the Greek workers to the Third Reich—and we staged huge demonstarions against this and managed to prevent it. I listened to the sound of the masses marching towards the centre of Athens, the shouting of slogans and then, when they came upon Nazi tanks, the intermittent shooting of the machine guns, the chaos. I shall never forget the transformations of the regular, rhythmic noise of a hundered thousand people into some fantastic disorder… I would never have thought that one day all that would resurface again and become music:* Metstasis. *I composed it in 1953-54 and called it (my) starting point because that was when I introduced into music the notion of mass […] Almost everybody in the orchestra is a soloist, I used complete divisi in the strings which play large masses (of)* pizzicato *and* glissando.[1]

Even the first idea of the form for the beginning of the piece was quite unusual: Many musicians should start at the same time, all on the same note. Everyone should then move away from that tone, but each in their own way—and all in a different way than in traditional music; namely, in glissando:

- the one ascending in a straight line,
- the others descending in a straight line.

All sliding sound moves stop at the same time. Each tone line has reached a different target tone at this breakpoint, so that a very dense, cluster-like chord results, whose sounds are held rigid for a long time, then pause together, then revive in rhythm and color. FIG. 1

At that time, the young Xenakis had no way of technically implementing this forming process in a studio. Instead, he wanted to show that such an unusual sound process could be realized even with a conventionally instrumented orchestra. The only conventional orchestral instruments that could be used for long-range glissando movements, as Xenakis envisioned them, were the stringed instruments. The starting point for the widening sound movements was the deepest tone of the higher strings, the G of the violins. Xenakis did not first write down the individual tones differently in traditional

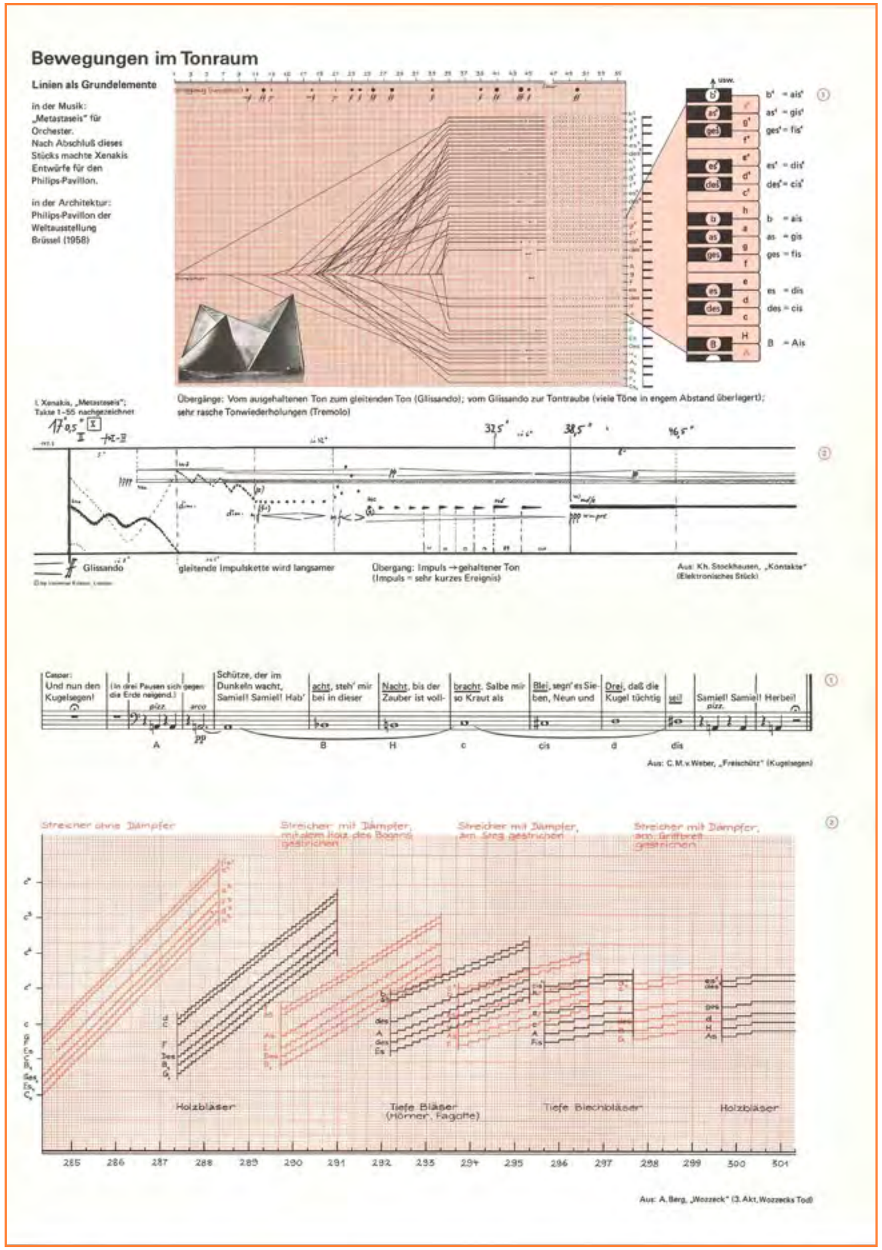


FIG. 1 Xenakis's Metastasis in the context of experimental arts and music pedagogy, Stuttgart, Germany, 1980. In *Bewegungen im Tonraum* (Movements in Tonal Space), in Rudolf Frisius et al., Notation und Komposition: *Unterrichtsmaterialien für die Sekundarstufe I Materialheft* (Stuttgart, Klett, 1980), 2-3 © Rudolf Frisius and Gabriele Sprengler

musical notation, but in graphical notation on graph paper (which was obvious to him since he was employed at the time by the architect Le Corbusier).

Thus, one of the first (initially) unconventionally notated compositions of new music was created. Xenakis, however, then quickly recognized that the music as he had originally (graphically) notated it, could not be performed because the orchestra musicians at that time (and often later) could only play traditionally notated scores. Since Xenakis desperately wanted his orchestral piece to be performed, he had to rewrite his graphic notation as a conductor-legible and traditionally notated score (on which basis traditionally notated orchestral material could be made). Thus, it became possible for many highly specialized musicians to realize a completely new type of music in terms of sound, and that the entire piece, consisting of extremely dense and complicated sound movements of many individual instruments, produced a concise and meaningful forming process for the listener.

The paradox that here the music had to be performed according to different notation than according to the original score, Xenakis explained later plausibly, for example, in 1984 in Karlsruhe, during the introductory lecture to a concert on 28.2.1984 at Winter Music '84, which was dedicated to him, with the title *Music: Moving Architecture* (Musik: Bewegte Architektur). Xenakis said that the graphic notation is readable, but not playable, whereas the multiline traditional score is playable, but unreadable.

Especially in the most famous parts of the orchestral piece *Metastasis*, at the beginning and in the final section,[2] the relationships between a graphically noted fixation of the compositional idea and details fixed in a traditional score for their detailed execution are so precise that even someone who does not know the graphic output notation of the composer can reconstruct it from the traditional score, and that the conclusion traditionally noted in the score can easily be compared with Xenakis's later published graphic notation.

Traditional and graphical notation present themselves here as different variants of *production notation* (which concentrate on the intial compositional idea and on precise instructions for its aural realization). Both notations are different, but serve the same purpose and are thus substantially different from the purpose of *reception notation* of the same music, which attempts to determine how the notated music actually sounds in a particular performance or recording, and which, in turn, can be compared with representations of the sound reproduction on the screen of a computer.

The distinction between different functions of the *notation* and, associated with it, the detachment from the primacy of the traditional notation, which was allegedly equally binding for composers, performers, and listeners, was one of the first radical ideas of reform in music development after 1945 that was far from traditional thinking.

Notation reform developed in various stages. Since the early 1950s, it has become concrete in experimental compositions. This began in 1952 in instrumental and technically produced pieces by John Cage—for example, in the very detailed but in the tonal details indefinite score *Williams Mix* (1952–53)—or in works by members of the New York School such as Earle Brown's aural and interpretatively indefinite graphic notation *December 1952.*

From 1953–54, Iannis Xenakis began with precisely graphically recorded compositional designs, which were later rewritten into traditionally notated scores for performance-related reasons. The new approaches of graphically notated new music, especially the approaches of the New York School and those that followed later in new European music, since the 1970s have led to replacement of the primacy of traditional notation in the field of music education. This furthered the shift away from traditional, well-established production- and reception-oriented music education, focused on making music and listening to traditionally recorded music, to newer forms of notation, which also give young people and non-musicians their own ways of listening to and playing newer sounds and music. In doing so, students either write down newly invented sounds and music intended for aural realization using words or characters, or they describe words or signs that have been heard, possibly also visually observable sounds and music on the computer screen.

Design notation and performance instruction, audio recordings, and computer presentation may present themselves in many works of contemporary music, especially in many of Iannis Xenakis's works, with varying degrees of precision and ambiguity. For example (and in particular), Xenakis's music in many cases already demonstrates what different possibilities arise when one compares the beginnings of various compositions, for example, the beginnings of various pieces with which Xenakis caused a sensation in the 1950s:

> *Metastasis* for orchestra (1953–1954) **FIG. 3** in comparison with
> *Diamorphoses* electroacoustic music for 4-track tape (1957) **FIG. 4**
>
> *Pithoprakta* for orchestra (1955–1956) in comparison with
> *Concret PH* electroacoustic music (1958)

The first two pieces, *Metastasis* and *Diamorphoses*, begin with long-range and straight-line movements of sliding sounds; the following two, *Pithoprakta* and *Concret PH*, with densely massed impulses

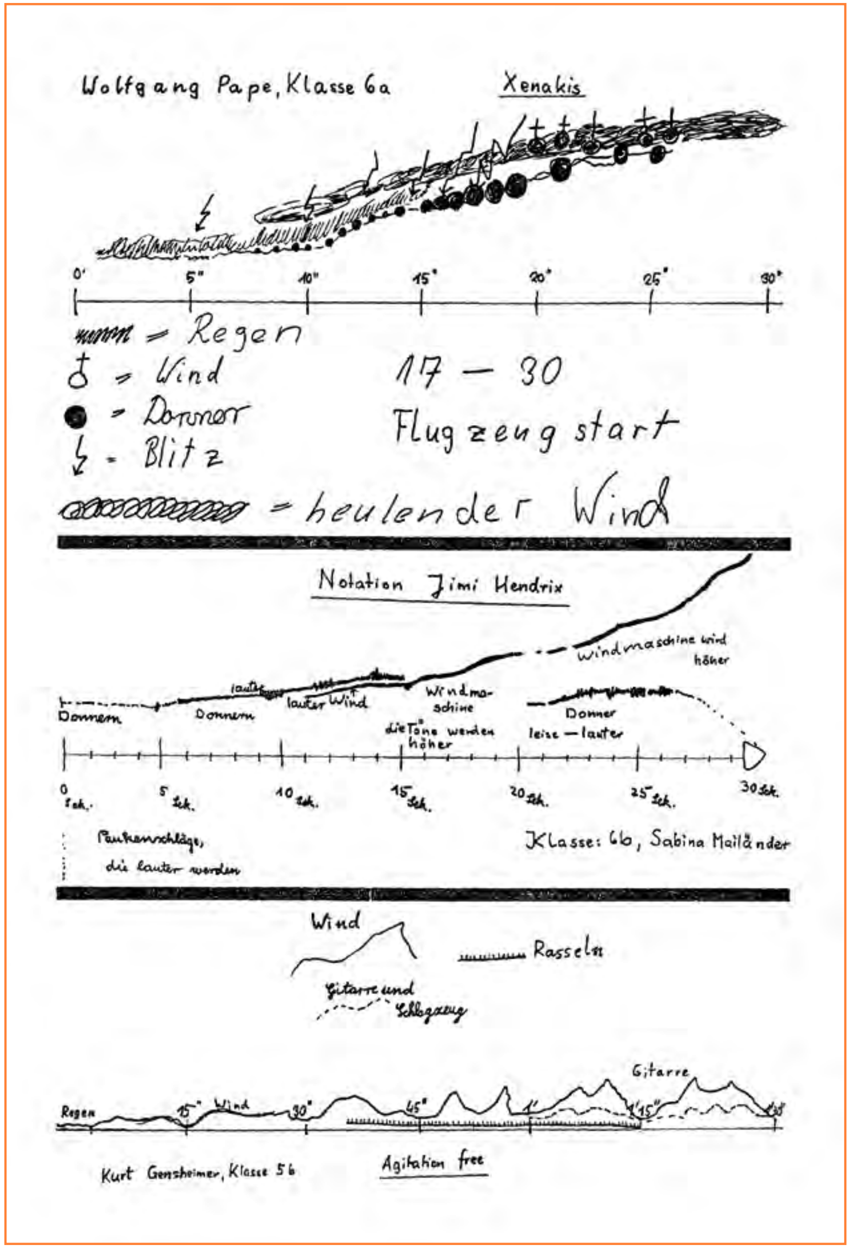


FIG. 2 Musical scores of schoolchildren to sound examples by Xenakis (*Diamorphoses*), Jimi Hendrix (*EXP*), and Agitation Free (*Second*), Stuttgart, Germany, 1976. In Rudolf Frisius et al., *Sequenzen: Musik Sequenzen, Musik Sekundarstufe 1, 2. Folge, Tonbeispiele*. The audio scores were created in teaching experiments at the Realschule (teacher: Klaus Maichel)

(sound points). The *production notation* of the two orchestral pieces are published as traditional scores, that is, as precise instructions for the performers (they are also comprehensible for the score reader familiar with traditional notation). The composer did not publish scores with comparably precise details of the two electroacoustic compositions, which is why it seems reasonable to assume that the four pieces, especially their beginnings, are not based on precise information given by the composer, but on the sound impression, possibly incorporating computer screen representations and reception notations. The results of experimental music pedagogy (see **FIG. 2**) could also be used for this purpose as these are not based on the traditionally fixed notation dictation, but rather attempt to stimulate listening and listening and imitating of unknown music, as this can be done in general education schools with students without special musical training, if these students find the music interesting and they are able to compare the music heard with other, known everyday sounds and describe the music examples (see **FIG. 3**: sonogram *Diamorphoses*).

In these notations by school children, the sounds and sound movements are graphically notated based on an auditory impression and supplemented with words related partly to the music (e.g., volume and information about the instruments) and partly to associated or actually heard noises. These reception-based notations refer to technically produced music, which—even in the case of the piece by Xenakis—does not originate from a composer's score, but from sounds and sound structures created, recorded (and, especially by Xenakis, technically processed) directly in the recording studio, and which cannot be preserved by traditional notation methods—and which also for Xenakis's music, beyond known instruments, is notably exceptional.

A characteristic example of reception notation in the field of experimental music education is published in the teacher's manual for a textbook from the 1970s (see **FIG. 2**): three notations from pupils of heard music examples, each notated as audio score (reception notation):

- The beginning of a piece by Xenakis (*Diamorphoses*)

and two excerpts from pop records popular at the time:

- Jimi Hendrix, *Electric Ladyland*
- Agitation Free, *Second*

Based on their auditory impression, the sounds and sound movements are graphically notated in these schoolchildren's notations and supplemented with words that are partly related to the music (e.g., volume and instrument information), and partly to associated or actually heard noises, which cannot be fixed exactly in traditional notation, and which are also, even for Xenakis, unusual instruments.

Similar to the beginning of the composition of *Metastasis* and *Pithoprakta,* and also in many later (mostly instrumental) works, Xenakis first noted precisely and graphically important compositional ideas, and then rewrote them in traditional notation which can be executed by interpreters—in full knowledge that the graphical design notations for describing his compositional ideas were usually much better suited than examples from traditionally notated scores. There was much to suggest that new musical thinking would be easier to enforce here and elsewhere in connection with new notation methods, even beyond narrower avant-garde circles.

Since the 1960s, Xenakis had been thinking in that sense whether his method, which leads from precise graphics to concrete sound, could also stimulate others to deal creatively with sounds—whether other people (e.g., children or non-musicians) could also invent and (graphically) notate sounds and sound structures, so that a detailed "notational" sound realization would be possible. The path from the graphics to the resulting sound would no longer be conveyed by the traditionally notated score, but by computer technology that enabled the immediate transformation of the drawing into real sound.

Xenakis imagined that even children could make such drawings and familiarize themselves with the (computer-assisted) sound results. He assumed that musical creativity is not only a privilege for the few, for example, only appreciated and promoted by specially trained people, but rather a broad potential without limitation based on individual age or educational levels. In the 1960s, in order to create the necessary institutional and technological conditions, Xenakis founded a research group (EMAMu: Equipe de Mathématique et d'Automôme Musicales/ Research Group for Musical Mathematics and Automatics) and later a research center (CEMAMu, the center assigned to the group/Research Center), and he developed ideas for the technical equipment for the research. This initially focused on the invention of a device that allows the digitally-mediated transformation of drawings into sounds and is also usable by children and amateurs: Emanating from graphic notation and computer-generated sounds, his learning system UPIC presents itself as a modern alternative to the Orff-Schulwerk, which is based on traditional notes, songs, and instruments, and as a learning tool for the creation of aural realization of music, not for the reproduction of already existing music.

Xenakis had high hopes that his invention of a simple learning and production device would inspire the enjoyment of sounds and music in many people, including children and non-musicians. However, unlike Pierre Schaeffer (the founder of musique concrète) and his collaborators, Xenakis did not want to start with sound experimentation, but with drawing, as is common in childhood. He also insisted on this in a lengthy interview with Francois Delalande, a musicologist who worked in the research group GRM (Groupe de Rechercherches Musicales) founded by Schaeffer, and who sympathized with his empirical sound research. Xenakis, however, preferred a different starting point:

> *If you draw lines on a blackboard, you can [...] create sounds and music (with some rules that can be learned very quickly). Not just sounds, but also developments of rather complex sounds, that is to say, of music. [...]*
> *And drawing is an ability of every human with a hand and a brain; the hand is the organ closest to the brain. [...]*
> *Giving everyone the opportunity to compose music leads to a double result: on the one hand, you make the creative activity available to everyone, and on the other hand, there is no longer this abyss between any avant-garde (there are always avant-gardes) and the rest of the audience.*
> *Rather, it's about building bridges and being able to think music, meaning creating music with everything that comes with it. [...]*
> *For everyone. From the age when the child can hold a pencil and listen, to adulthood and until death.*[3]

This understanding of music can lead to the question of and to what extent the composer, who expresses himself in this way, wants to position himself in a concrete social situation. This question poses itself with Xenakis, not only for his early sensational *Metastasis* and its contemporary historical context, but also for later works in which he uses his pedagogically oriented UPIC system compositionally—for example, in the radio play *Pour la Paix* (1981): music with narrative texts, choral passages and UPIC sounds leading to a radio play text by his wife Françoise, who, like him (but in another country), was active in the resistance during the Second World War against invading aggressors.

After a short introduction with violent electronic sliding sounds, the

Une guerre.	*Voici dans son horreur, la guerre.*
Atrocités, massacres, torture,	*infinie souffrance des hommes, des femmes.*
Nous sommes n´importe où.	*Là où on pend, fusille, massacre.*
The war.	There it is, in [all] its cruelty, the war.
Abomination, massacres, torture.	Endless suffering of men, of women.
We are somewhere.	There, where one hangs, shoots, massacres.

radio play begins with the following text (here quoted from the taped recording of the radio play):[4]

Contemporary historical references, which Xenakis specifically addressed for his early work *Metastasis* in subsequent commentaries, not in the music itself, are heard here directly as components of the radio play text. This changes the listening perspective for the rest of the piece—for example, in explosive impulsive sounds that might remind one of echoing gunshots, or in an exploding grenade sound that accompanies the radio play's report on the death of a young soldier.

Unlike in the early orchestral pieces *Metastasis* and *Pithoprakta*, the UPIC sounds do not appear primarily as a representation of abstractly introduced sound structures, but as a direct appeal to extra-musical listening experiences; as an open illustration of what had remained even more ambiguous in the constructive encryption of older orchestral pieces. In the early orchestral pieces, this can be interpreted as an attempt at the constructive processing of years of traumatic war experiences in the past; in the radio play as confronting the looming threat of nuclear war at the time it was written (1981). The more illustrative sounds and sound sequences in the radio play could be understood in such a way that Xenakis no longer wanted to speak primarily to a select avant-garde audience, but to a broader public, which he tried to engage in new sound worlds with the UPIC, and also wanted to encourage in his compositions to develop a modern, possibly musical mindset capable of facing current threats—but within the limits of a then and still largely traditional musical life, in which contemporary developments had difficulty finding their place and often laboriously had to deal with competing tendencies in their own areas.

Developed since the early 1960s, Xenakis's approaches to digitized sound production and music training—and also at the spreading of such music—found competition in France from the early 1970s with the activities of an institute for (mainly live electronic) computer music more focused on a musical elite, as Pierre Boulez was then planning and later realized with the support of the then conservative French President Pompidou. The competition between the antagonistic approaches of Xenakis and Boulez also shaped the ensuing years of politics and culture in France, even a later presidential campaign during which conservative presidential candidate Chirac publicly favored the Boulez-led IRCAM in 1980, while Xenakis, who favored a more broad-based music policy—as did the later victorious candidate Mitterand—criticized the IRCAM's concept and spoke out for alternative approaches. Although Mitterrand won the presidential election, Xenakis and the research center CEMAMu were unable to bridge the gap to the preferred IRCAM in the long term, especially in the years that saw a return to a conservative government majority.

Xenakis, in 1989 in a conversation with Bálint András Varga, complained that his research activities, especially his efforts to create a new, scientifically sound-based, far-reaching cultural endeavor, were hindered by various external obstacles, not least for reasons of cultural policy:

> *It was much better during the first socialist government because we were helped by the director of music, Maurice Fleuret. Then a right-wing government came to power and subsidies were cut by half. We have to reapply every year. This means that people working there have no security. They perservere nevertheless because they're really devoted to their work. […] It also means we can't have the best equipment, nor can we employ as large a staff as we need.*[5]

In his preliminary remarks to the interview cited above, Bálint A. Varga, Iannis Xenakis's most important interviewer, gave a more precise account of the concrete effects of the difficulties faced by the composer and director of the CEMAMu and the UPIC project. In 1989, when he visited the composer in Paris for newer interviews, he visited the UPIC studio together with Xenakis and later described some difficulties that were obvious there (in preliminary remarks to the second part of his interview book):

> *The premises—three rather cramped rooms in a modern block—provided ample explanation for the composer's bitterness about the meagre funds placed at his disposal. The contrast with the underground phalanstery of IRCAM is all too stark. The actual UPIC machine is housed in a small, narrow room.*[6]

Varga also described some difficulties working with the UPIC as an untrained layman. Regarding the operation of the drawing device, he writes: "I had expected its operation to be child's play after hearing how simple and straightforward it was."[7]

> However, difficulties arose during simple recording attempts:
> *I had to start several times for I kept forgetting that I was supposed to move the electric pencil in one direction only. Another requirement I was hard put to observe was that each parameter (such as, for instance, the tempo) of my 'piece' had to be separately fed into the equipment, by bringing the pencil in contact with different points of a diagram.*[8]

What remains an obstacle to disseminating Xenakis's musical thinking and related music education ideas (including the use of his learning tool UPIC in music education) is the still too great distance between music-related reform ideas and policy frameworks. Only in a few but important exceptional cases has it been possible to document accurately and evaluate thoroughly both concrete planning ideas as well as compositional, music pedagogical, and musicological results developed on their basis—also as a basis for future, generally usable updates and further developments.

It is worth remembering that Xenakis did not consider music, musicology, and music pedagogy as isolated disciplines in his musical thinking or in his musicological and music pedagogic activities, but as interdisciplinary networks with many other disciplines. In this regard, he was active in the 1960s; for example, in 1968 in Paris. At the spectacular festival programmed by Maurice Fleuret, *Les journées de musique contemporaine de Paris* (Paris Days of Contemporary Music), Xenakis did not only appear as a compositional innovator, but also as a music political and music pedagogical stimulator, who developed new, interdisciplinary, and diversely connected ideas for music education and musicology (at an event accompanying several spectacular concerts with his music).

In the Paris Festival's 1969 publication *La Revue Musicale*, Xenakis cited several reference disciplines for the interdisciplinary activities of the working group founded and chaired by him: "Psychoacoustics, acoustics, room acoustics, electronics, psychology, musicology, music education, mathematics, physics, computer science."[9]

In interdisciplinary contexts, not only the artistic and scientific ideas developed by Xenakis, but also his music policy activities (to establish the UPIC in international musical life and in particular to modernize music education), can be understood: not in the sense of specialization in a particular technology, but as an impulse for the renewal of music thinking in an epoch of interdisciplinary connections, in which previously isolated areas such as music and music education should be included in larger, also contemporary historical cohesions and developments.

This approach has remained up to date—and the endeavor to realize its musical, technological, music pedagogical, and music political mission remains to this day.

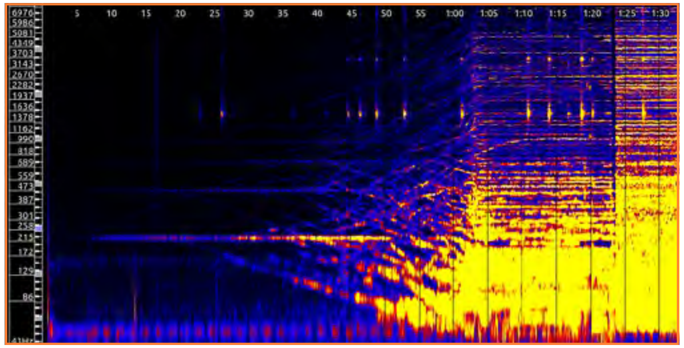


FIG. 3 Sonogram *Metastasis*, beginning (compare with graphic notation Fig. 1)

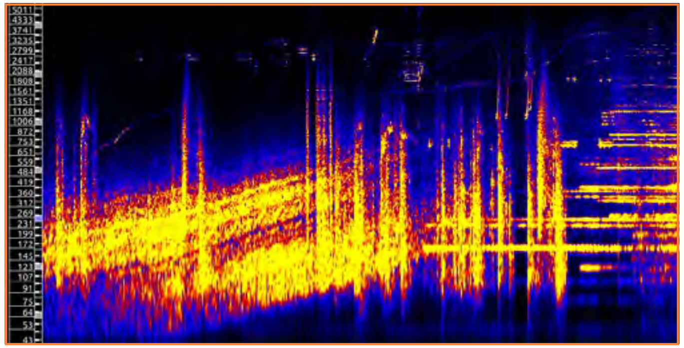


FIG. 4 Sonogram *Diamorphoses,* beginning

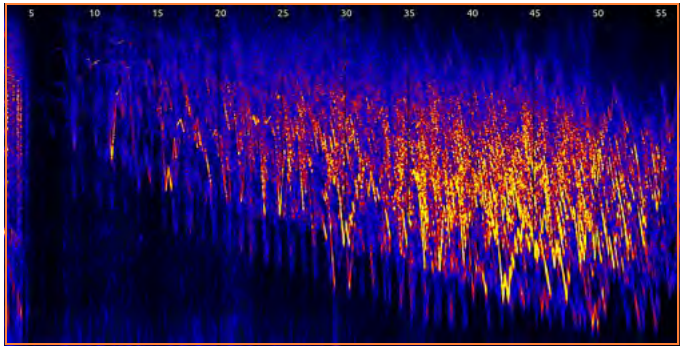
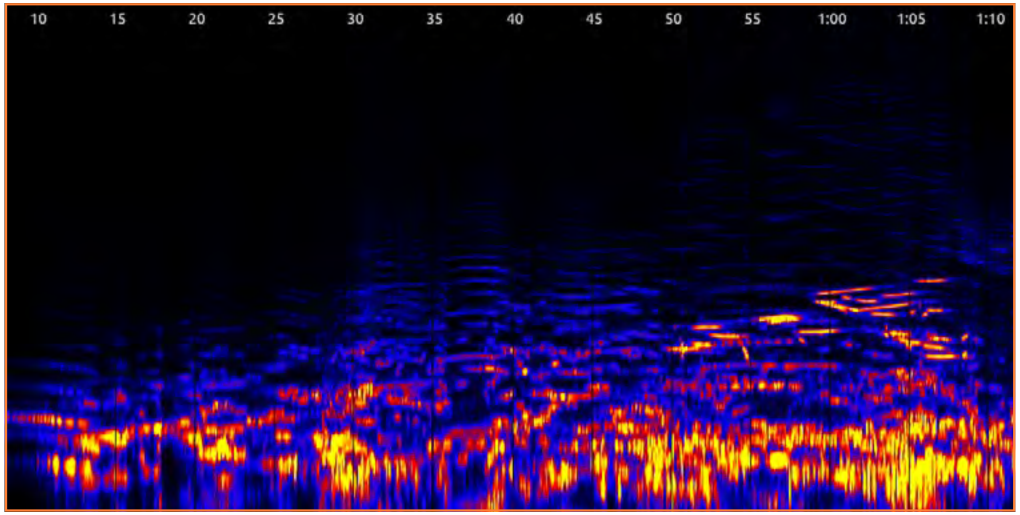


FIG. 5 Sonogram *Pour la paix*, beginning

FIGS. 3–6 Representation of pitch gradients on the computer screen (sonograms): Orchestral music (Fig. 3)—technically produced music (Figs. 4, 6)—music produced technically with UPIC sounds (Figs. 5, 6) © ZKM | Center for Art and Media Karlsruhe, images: Hans Gass



Xenakis on *Taurhiphanie* (1989):

I was asked to create a work which would involve bulls and horses of the Camargue. Now, bulls are linked with ancient religious traditions in Crete.
[...]
I accepted the commission on the understanding that the performance would take place in the Roman amphitheatre of Arles, where at one time Christians were slaughtered. I asked for a hundred bulls but the organizers got cold feet and only gave me twenty...
[...]
We built a wooden tower in the middle of the amphitheatre and on top of it, about two or three metres above ground, was a table. The UPIC equipment was placed beneath it, inside the tower, so that I could improvise as the performance was going on. This is now possible with the system. I also had control of the speakers.[10]

FIG. 6 Sonogram *Taurhiphanie*, beginning © ZKM | Center for Art and Media Karlsruhe, image: Hans Gass

FOOTNOTES

1. Bálint András Varga, *Conversations with Iannis Xenakis* (London, Faber & Faber, 1996), 52.

2. *Metastasis* begins with long-range tone movements: starting from a common initial tone of all 46 strings;
- in the superposition of 46 different glissandi extending in the sound space;
- sliding sounds upwards from the higher strings, downwards from the lower strings; with consistently different starting times and speeds;
- opening into a dense and spacious chord (after a simultaneous stop of all glissandi), which then revives afterwards.

The piece ends with the opposite form process: the transition from spacious tonal layers to the common final tone (again in the middle position, one semitone higher than at the beginning).

3. Iannis Xenakis, in François Delalande, *Il faut toujours être un immigré*: *Entretiens avec Iannis Xenakis* (Paris: Buchet/Chastel, 1997), 141.

4. In the radio play Xenakis used text excerpts from books by Françoise Xenakis: Ècoute. roman-récit (Paris: Gallimard, 1972) and *Et alors les morts pleureront* (Paris: Gallimard, 1974).

5. Bálint A. Varga, op. cit. 197.

6. ibid, p. 194.

7. ibid.

8. ibid.

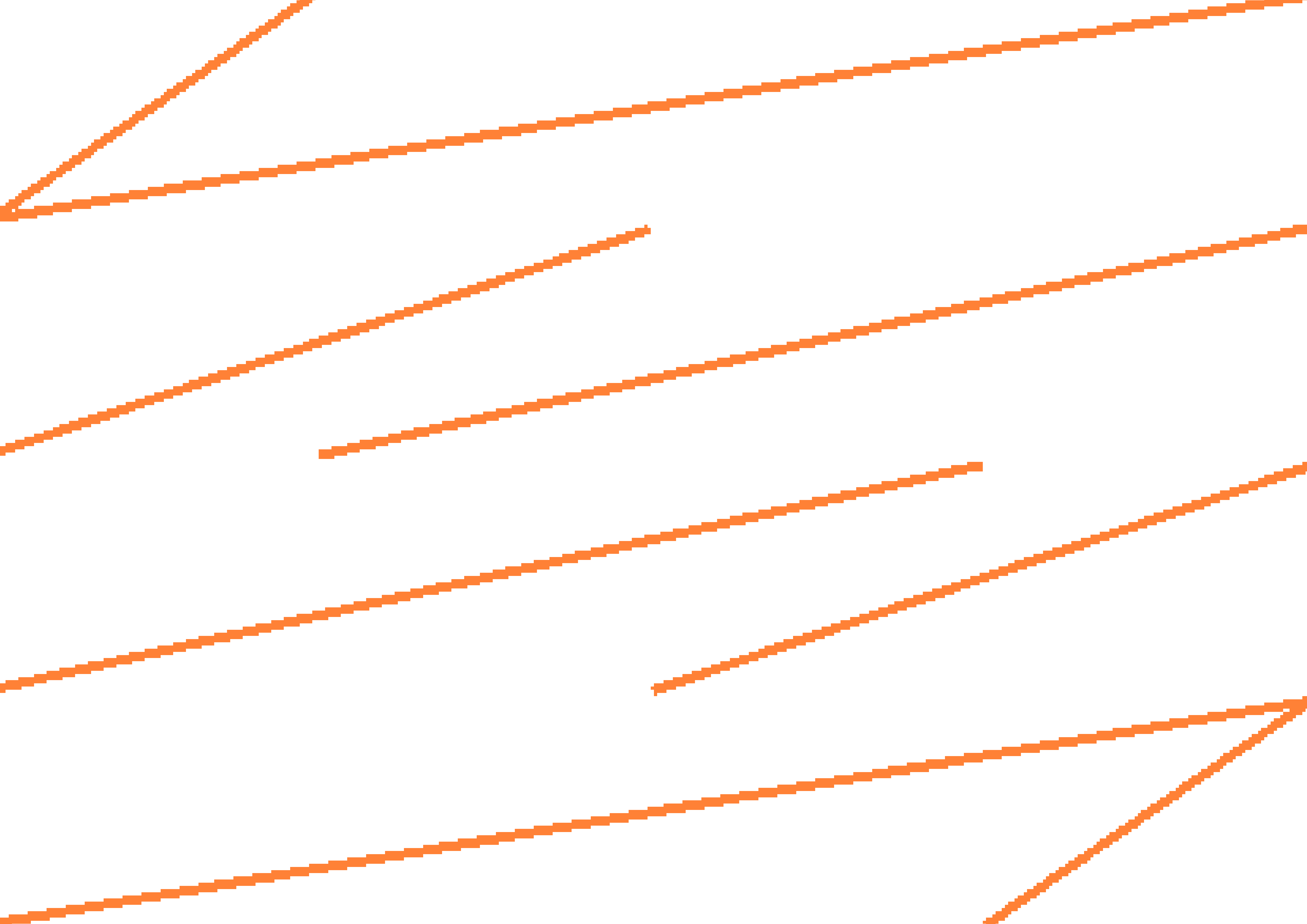
9. *La Revue Musicale,* Special Issue, no. 265–266 (1969), 57.

10. Bálint A. Varga, op. cit. 192f.

ADDITIONAL NOTES

The music pedagogically related illustrations are taken from the following publications, oriented towards school practice and teacher training. They were produced based on teaching experiments in collaboration with teachers:
- Rudolf Frisius in collaboration with Rolf Kalmbach, Franjörg Krieg, Günter Klüh, Hildegard Schmidt-Frisius: *Sequenzen: Musik Sequenzen, Musik Sekundarstufe 1, 2. Folge, 3. Teil: Musik aus dem Lautsprecher* (Stuttgart 1976), 197.
- Rudolf Frisius in collaboration with Helmut Hesse, Rolf Kalmbach, Gänter Klüh, Klaus Maichel, Alexander Schwan and music publishing office/Gisela Kiehl: *Notation und Komposition*, (Stuttgart, 1980), 2–4.

Starting from and following those publications, numerous radio broadcasts were produced about Iannis Xenakis (see the essay by R. Frisius in *Musik-Konzepte* 55/56, pp. 91–60 on this subject - also related to several weeks of analysis seminars by the author, organized by the Centre Acanthes 1985 in Aix-en-Provence, Salzburg and Delphi) and about the auditive structure und presentation of his music (DLF, HR, SWR, WDR: on rhythm, tonal space, sound media and aspects of meaning in Iannis Xenakis as well as a series of school radio broadcasts by Hessischer Rundfunk inspiring new practical music activities. At that time Alexander Schwan had founded a working group with secondary school pupils which performed four group compositions at a music festival dedicated to Xenakis in Karlsruhe (*Wintermusik '84* Iannis Xenakis, February 27–28 1984 at the Pädagogische Hochschule Karlsruhe) in the presence of the (surprised and quite satisfied) composer. Alexander Schwan has worked on the practical musical work with his pupils and the Karlsruhe workshops dedicated to these pieces in the program booklet of the festival and in his dissertation: *Improvisation und Komposition im Musikunterricht in allgemeinbildender Schulen der Sekundarstufe I*, Frankfurt 1991. Recent teaching practice-oriented publications that incorporate the music of Xenakis have appeared in the series RAAbis Musik by the Stuttgarter Raabe Verlag, including *Geräusche aus Natur und Umwelt* (2005), *Rhythmmusik von und frei nach Xenakis – Erfinden, Spielen, Hören, Beschreiben* (Cl. 5–7, 2010). Recordings of analytical introductions and related performances were made in 1984 at the Pädagogische Hochschule Karlsruhe and in 2017 at the Musikhochschule Karlsruhe (concert with Leonie Klein with Xenakis's *Psappha* and other contemporary solo pieces [Stockhausen, Lachenmann, Cage]).



COMPOSING WITH SOUND AT LES ATELIERS UPIC/CCMIX

GERARD PAPE

GERARD PAPE

COMPOSING WITH SOUND AT LES ATELIERS UPIC/CCMIX

Gerard Pape (in conversation with Rodolphe Bourotte and Sharon Kanach[1])

SK How and when did you, Gerard, as an American composer living in the States hear about the UPIC?

GP For me, it all began when I read the article about the UPIC published in *Computer Music Journal* in 1986.[2] I was living in Ann Arbor, Michigan, at the time and had just begun to create my own studio in my home. I had always been attracted to the idea of drawing music but was unaware of the UPIC until then. In my studio, I already had a Fairlight CMI Series II synthesizer with which one could draw waveforms and envelopes, although it didn't carry the idea of creating a score. It had a regular keyboard like other MIDI or digital synthesizers of the 1980s.

I was already an admirer of Xenakis and when I read about the UPIC, I wanted to learn more, to experience its possibilities. I thought the best way of going about it would be to call Xenakis on the phone. I asked him whether it would be possible for me to come to Paris and see/hear the UPIC because I might be interested in purchasing one. He was astonished and said, "Sure, come whenever you like!" We agreed on a date for me to come to the Centre d'Etudes de Mathématique et Automatique Musicales (CEMAMu) in 1987. Les Ateliers UPIC already existed at the time, and some composers worked there while others worked at CEMAMu. I got to see the UPIC at the CEMAMu, not at Les Ateliers UPIC. At Jean-Claude Eloy's CIAMI,[3] I was fortunate to be given a long demonstration of the UPIC by the composer Patrick Butin. I was immediately struck by the large architect's table, and therefore the possibility of making very large A1 format drawings. Also, the fact that it was a compositional tool that produced a score, while being at the same time a synthesizer with a graphic interface, really appealed to me. Following that initial introduction, I spent a few more days at CEMAMu trying things out on the UPIC, discussing its possibilities with the engineers working there, and also asking Xenakis some questions. The only UPICs at that point in time, aside from those at Les Ateliers UPIC and the CEMAMU, were at the Université de Strasbourg, thanks to François-Bernard Mâche,[4] and in the KSYME center in Athens.[5] However, none of these UPICs were generating sound in real time. When I asked the engineers whether it would be possible to have a UPIC system built for me, they were, of course, surprised, but also very encouraging. They told me they were perfecting a new real-time version that had just come out, and that it would be worth my purchasing that version. They showed me a prototype of this 1987 real-time version. After hearing some of the stories about how long one needed to wait for the system to calculate complex pages on the non-real-time versions of 1978 and 1983, I was convinced it was worth waiting for the new model, which took about two years to build and was only delivered in April 1989 to my home studio in Michigan. I had founded a contemporary music festival in Ann Arbor in 1986 called the TWICE Festival, and in 1989, I invited Xenakis and George Crumb to be the guest composers. So, it was a double occasion: to install the first UPIC in the States, to show the studio to Xenakis, and for him to come as an invited guest of this festival. It was quite special because he came to my house and saw the UPIC set up in my home studio and exclaimed "Ah, ça c'est formidable!" He was truly delighted because it was the first and, finally, the only one ever to be installed in the whole of North and South America.

SK You installed the UPIC in your home studio and not in any institution or university environment?

GP Before I lived in this house, it belonged to my composition teacher, George Cacioppo,[6] and when he died, I purchased it and turned the basement into a computer music studio. I called it "Sinewave Studio," a name originally proposed by my friend, the composer Gerald Brennan who, in 1980 founded a series of concerts that I participated in which were called the "Sinewave Sessions" (a name taken from Thomas Pynchon's novel *Gravity's Rainbow*). The composers who came to work there were members of the "Sinewave Studios" collective. It was a bit like my current collective of composers, the Cercle pour la Libération du Son et de l'Image (CLSI), which I founded as a non-profit association/ensemble in Paris in 2007.[7]

RB Who were the other composers?

GP We were a small collective of composers based in Michigan, but with no affiliation to the University of Michigan at that time. All the composers in the collective were independent and used my home studio precisely because they didn't have their own home studios or access to academic institutions for their creative work. (I personally did study electronic and computer music at the University of Michigan, and had taken composition lessons with the head of the composition department, William Albright, after the death of George Cacioppo.) One of the reasons I was attracted to my first teacher, Cacioppo, was because he was part of

the Once Group[8] that held a famous festival in Ann Arbor in the 1960s. All of their founding members were university music students in composition who rebelled against serial music's academicism and were much closer to John Cage, Morton Feldman, and the American "sound-based" avant-garde. One of the composers in the Sinewave group who composed a number of purely electronic works on the UPIC was Kurt Carpenter, who had graduated from the University of Michigan with a Master's degree in composition. My challenge at the time was to see if we could make Ann Arbor the location of "ONCE again," thus, TWICE, a center for avant-garde music the way it had been in the 1960s. We invited many famous composers, some of whom had been cofounders of the ONCE Festival: Robert Ashley, John Cage, Luciano Berio, György Ligeti, Iannis Xenakis, George Crumb, and Gordon Mumma. When Xenakis was our guest, I was particularly happy. The Arditti Quartet played *Ikhoor*, *Tetras* and *Akea*. I remember two Ann Arbor chamber ensembles/orchestras played *Waarg*, as well as *Jalons*.

RB Are you from Michigan yourself?

GP Oh no, I was born in Brooklyn, New York, but I went to Ann Arbor to study psychoanalysis and musical composition. But I have to add, from the moment I went to Paris and to the CEMAMu, I started dreaming of moving to Paris one day. I stayed in touch with the engineers at the CEMAMu between 1989 and 1991, after two of them installed the UPIC in my studio and Xenakis attended the Festival. Then, one day, out of the blue, Jean-Michel Raczinski, head hardware engineer of the CEMAMU, called me and said that the Ministry of Culture was looking for a new director for Les Ateliers UPIC. I needed to write up a project quickly and travel to Paris to discuss this project with the Ministry of Culture to be considered a candidate. My project was chosen, and I became director of Les Ateliers UPIC in September 1991. When I arrived in Paris, the Ministry said that they were giving me a six-month contract and would closely monitor the progress of my project and, that after that trial period, they would make the decision to either continue Les Ateliers UPIC with me as director, or they would simply close it. Fortunately for the center, after six months, they liked what I was doing, decided to keep the center going, and increased their financial support for the center significantly over my first five years.

RB Can you tell us more about your initial project?

GP Yes: in a word, my project was to integrate the UPIC as a serious and powerful tool of computer music, affirming its place in that realm at large. Another goal was to get as many composers, from as diversified backgrounds as possible, to work on the machine so that the UPIC would be taken more seriously and generally accepted, and no longer be seen simply as a tool for Xenakian composers and for initiating children into music. Also, I was keen on developing possibilities of using the UPIC not only for purely electronic music, but also to combine it with instruments or voices. We had already explored such possibilities with the UPIC in Michigan. The Ministry accepted this project and that's what we immediately set out to do. As a consequence, in 1992 and in 1994, we presented four concerts at Radio France in collaboration with Claude Samuel, who was then the Radio France's music director. In 1992, for Xenakis's 70th birthday, we had concerts for ensemble and UPIC as well as percussion and UPIC with Rohan de Saram and Michael Pugliese as our guest soloists. In 1994, the theme was the UPIC and string quartet with the Arditti Quartet as our special guests. I commissioned François-Bernard Mâche (*Moires*) and Roger Reynolds (*Ariadne's Thread*) to make new works for string quartet and UPIC. Xenakis very graciously also accepted my request to make a new Gendyn piece called *S709*, which was partially composed at CEMAMu and partially at Les Ateliers UPIC. The other theme in 1994 was pieces for UPIC and non-western instruments. The guest composers from Japan were Yuji Takahashi and Takehito Shimazu.[9] There were also some extraordinary purely electronic works that I commissioned which were composed by Bernard Parmegiani and Daniel Teruggi, among others. Teruggi and Parmegiani combined UPIC sounds with the processing of these sounds by Groupe de recherches musicales (GRM) tools. I have to say, I was not shy about discussing the UPIC's limitations with those composers who I just mentioned. In the beginning, we focused really on timbre, how to improve the timbres the UPIC could produce.

SK Did you discuss this with the engineers at the CEMAMu?

GP Brigitte Robindoré,[10] the first person I hired as a musical assistant, came from a more musique concrète orientation. She filled me in about how composers from that realm felt about the UPIC. For them, the idea of drawing a waveform was not credible, because how could one know how to really draw a waveform? So, we started making samples, which, in fact, Xenakis had already done for his piece *Taurhiphanie*.[11]

UPIC samples, at the time, were short and not really samples but pasted waveforms taken from samples. A waveform that was able to be extracted from a sample was the equivalent to 1/10th of a second of sampled sound. So, we made many experiments regarding how to make the UPIC sound richer. The idea behind UPIC that no other system had was the idea that composing a graphic score involves controlling 64 oscillators of additive synthesis. This is the aspect we really wanted to preserve; that one actually shapes the sound in its interior by drawing its micro and macro parameters. This is where I found a connection between the approaches of Scelsi and Xenakis. I tried to bring in a kind of Scelsian orientation to Les Ateliers UPIC because I thought that combining their two respective points of view would be something very rich, compositionally speaking. I introduced the idea that when you are drawing a page on the UPIC, you are not necessarily drawing a complex score, a large sound mass, like the graphic score of *Metastasis*, but that a UPIC page could be the interior of a single sound. For example, I experimented by drawing 64 arcs within a small frequency range to create beats and interferences between the oscillators, thus creating something like a Scelsian tone cluster. That approach actually worked quite well in my piece *Two Electro-Acoustic Songs* for soprano voice, flute, and UPIC tape.[12] Still, I didn't impose my solution as the only one. The main guideline I gave to those who came to work on the UPIC was: "Make the machine work for you. There is no right or wrong way to use it." It is a tool which is there to help composers compose what they want to compose, and it was adaptable to their aesthetic. For our research on the problem of the timbre of the UPIC, there was interaction between Les Ateliers UPIC and CEMAMu. We met with the engineers there frequently. They had put out the new Windows version of UPIC in September 1991, which coincided with my arrival. In fact, one of the first things that happened when I arrived in Paris in September 1991 was that my own UPIC, which I had brought with me from the USA and put at the disposal of Les Ateliers UPIC for free, was updated to become a Windows system. I still have this instrument at home, with the original Windows 3.0 computer still working and the original real-time additive synthesis cards developed at CEMAMu still working as well! We were discussing all the time with CEMAMu about how to make the timbre richer. Still, this was not the only possible solution. In 1992, Jean-Claude Risset came to work on the UPIC at my invitation to write a piece celebrating Iannis's 70th birthday. Risset used the drawings of *Metastasis* to make a piece for saxophone and UPIC called *Saxatile*, premiered by Daniel Kientzy, which has now become a classic piece for saxophonists.[13] Others would use the UPIC to generate raw material that they would then transform further with other computer music tools. The whole point was for every composer to use the UPIC to their and its best advantage. And this corresponded precisely with Xenakis's approach: he never wanted to have "disciples;" in fact, he vehemently discouraged that. What he thought and that we at the center promoted was at once an ethical philosophy and a compositional discipline: each composer must find his or her own voice, above and beyond our promoting the UPIC. In our studio, it was one tool among several that could be used.

Another important musical event that occurred when I arrived in September 1991 was that it coincided with Xenakis's completion of his great work, *GENDY3*, based on his Dynamic Stochastic Synthesis. Hearing this piece gave me a new idea for the UPIC: I composed, playing the UPIC in real time, by redrawing the UPIC waveforms in real time and recording them. It wasn't using stochastic functions because I was drawing the changes by hand. My ears and my hands replaced mathematics in this case. This led to my electronic work *Varesian Variations*.[14]

SK How did you go about recruiting composers for the center's sessions and workshops? Were there open calls?

GP People were contacting me all the time—phone calls, letters, messages… There were far more people who wanted to come and work than we could accommodate. Sometimes, it was a tough call deciding who would get a residency and who wouldn't. For our courses (the 8-month cursus or our 1-month summer sessions), there were open, public calls for students. These were, however, paid courses, not free, like the one-month composition residencies.

RB Did you hold both types of sessions (short and long) from the beginning of your tenure?

GP No, at the beginning, only short UPIC Workshops, the same way as my predecessor, Alain Després, operated;[15] we were often travelling with the new real-time UPIC: to Arnhem, Stockholm, Vienna, Salzburg, Munich… many places. Sometimes we were invited along with Xenakis, for example, to Greece, in Delphi and then later in Athens. The vast majority of these UPIC workshops and concerts were short and mainly for young professional composers studying computer music.

SK These were 2-week workshops?

GP No, much less—maximum 1-week, or less; workshops followed by concerts. We also went to Japan twice—for the 1993 International Computer Music Conference (ICMC) and then again, some years later. In general, my goal was to get people to take the UPIC more seriously, because its reputation was suffering due to the timbral limitations we discussed earlier. I was convinced that the more people could hear about the machine's possibilities and then get hands-on experience with it, the more it would be respected. Also, once we openly admitted that timbre was a problem, and one we were aware of and working on, the more composers would see it as a challenge to compose on the UPIC: how to work around this limitation and figure out a way, for themselves, to make it their own. Working with the UPIC was also taught as an *ethic*, a way

of being, something that Xenakis personified in his rigorous way of being himself, like no one else. When he came to speak with the students for our 8-month course in computer music and composition, he emphasized only one thing: *freedom*; that each composer needs to remain free. With freedom, the composer becomes responsible to make sure that their work is *original*. Iannis didn't believe in improvisation—it wasn't that kind of freedom he meant. Rather, it was music composition as "cold fire," as he called it: something very powerful you pull out of yourself as an *ek-stasis*, a going beyond oneself. At the same time, composition, as an act, needs to be treated with extreme ethical rigor. That, in a nutshell, was the philosophy of what was taught at the center. Whether you compose with the UPIC or with something else, the Xenakian compositional ethic still stood. How to find your own compositional path, to compose music that no one else but you could compose.

RB It's true, when at the Centre Iannis Xenakis (CIX) we started doing UPIC workshops again, even with the 2001 PC version, some newcomers to the system produced very interesting results. I don't know of any other tool from that era that can say the same.

GP There are other tools people have developed, thinking they were following Xenakis's vision or direction, but actually, they were not because they got confused by this idea of "drawing." Drawing on the UPIC is just a method, not the goal; it never was and never should be. The idea behind the UPIC is not to turn an image into a sound; you have to first start with composing the sound. The image *per se* is unimportant. You can have a completely uninteresting image but that creates a rich sound. It doesn't matter what the sound looks like.

SK I agree, of course, but what about UPIC as a pedagogic tool, where notation is demystified by the simple act of drawing, something that basically anyone can do? And, it is certainly effective in breaking down the *solfège* barrier. In particular with UPISketch, we've seen it happen: in literally 10 minutes, kids who never thought they could make music, start composing, thinking about what that means, appropriating the tool, all thanks to drawing.

GP If you get them young enough, children can still use their imagination without fear or preconception. A little older, they might try to imitate what they already have been taught is "music."

RB Little kids can bang on a piano, and have fun making sound, but they're not listening, they're not *making* something. Drawing music seems to impose on them a compositional thrust that makes them want to create a piece they can call their own.

GP Getting back to Xenakis insisting on freedom and originality, it is actually one of the reasons I proposed to rename Les Ateliers UPIC the CCMIX: Centre de Création Musicale Iannis Xenakis in 2000. It was to emphasize more of an affiliation with Xenakis as a creator and thinker, generally, rather than being exclusively focused on the UPIC. Musical creation—with or without the UPIC—that was indeed what we tried to encourage at the CCMIX. Some composers-in-residence were shown the UPIC but decided that the UPIC was not for them. The other tools available at the center were very Scelsian, enabling one to enter into the "heart of sound," as Scelsi said, and as the UPIC indeed did, too. Students at the CCMIX could not only use various tools in addition to the UPIC, but also learn how to use them from the very designers of these tools: Kyma with Carla Scaletti, Composers Desktop Project with Trevor Wishart, Pulsar Generator and Cloud Generator with Curtis Roads, and ChaoSynth with Eduardo Miranda. Xenakis himself composed with many different tools or approaches at different moments, depending on what he was researching. The GENDYN program, for example, was the last.

SK But Iannis developed GENDYN!

GP Of course, but if he needed that, it's because it was what interested him at the time. GENDYN goes in a different direction than the UPIC. Rather than combining many arcs derived from combining drawn waveforms or ones copied from samples, as in the UPIC, GENDYN creates stochastically generated waveforms that you can combine. The UPIC, quite different than GENDYN, has other advantages. It allows one to operate differently on the micro level (waveforms, envelopes), the meso level (whether you compose a tone, a harmonic series, a cluster, or a noise depending on how you combine your arcs), and on the macro level of texture (order, disorder, chaos). I chose, as director of CCMIX, but also as a composition teacher of our students, in the context of our 8-month or our 1-month course in "Computer Music and Composition" to study all of Xenakis's book *Formalized Music* and not just the part about the UPIC. We discussed the whole gamut of Xenakis's research and compositional approaches.The UPIC is fascinating, but it is not his sole musical achievement. The theme of our courses, in general, was composing with sound. Often, the musicologist Harry Halbreich, in his lectures to our students, analyzed not just Xenakis's scores, but also those of Scelsi, Nono, Varèse, and Claude Vivier—all composers who composed with sound itself.

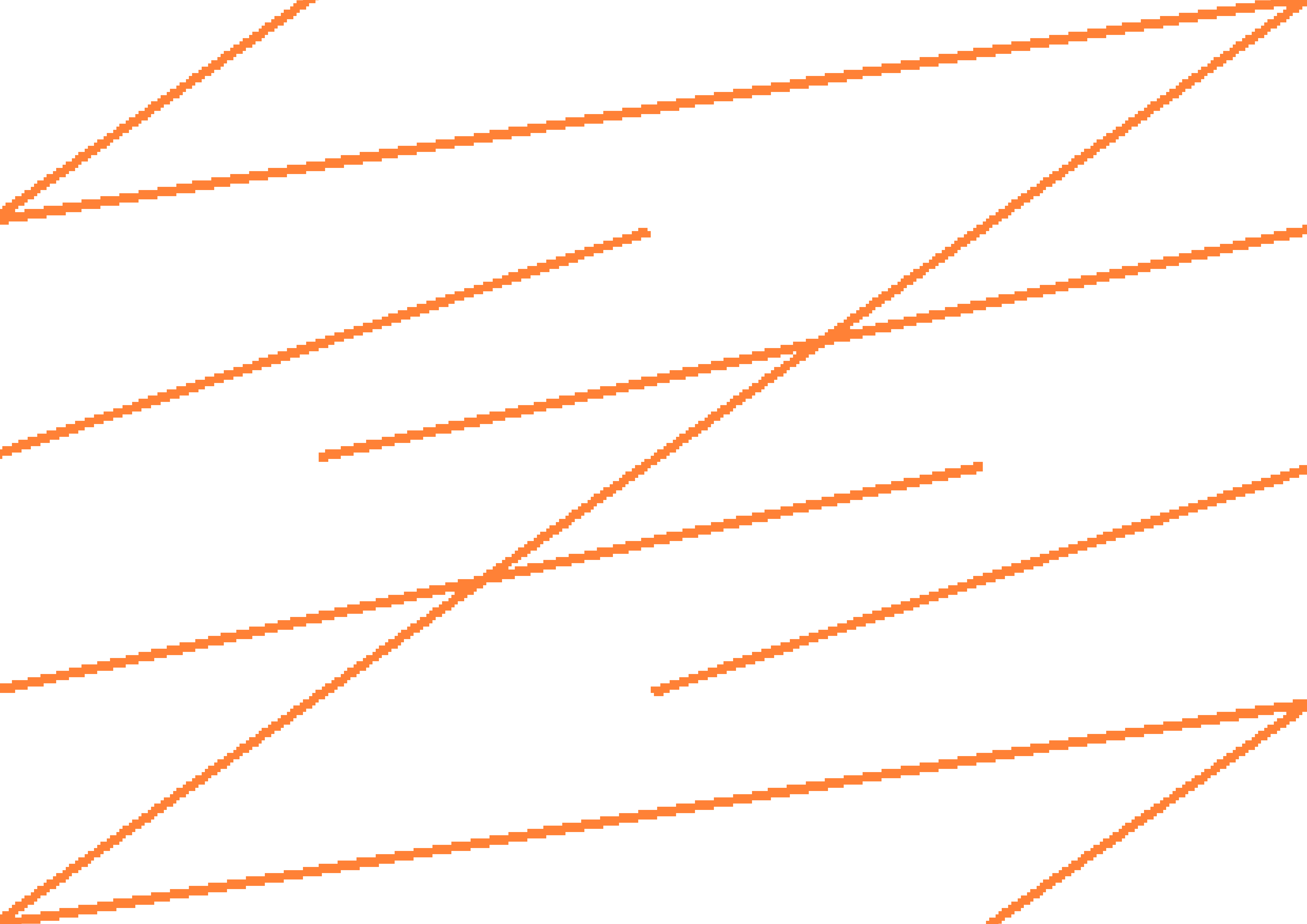
RB If we go back to your idea that the UPIC as a tool resembles the personality behind it, I have to say I beg to disagree, because if at CIX today we can and do have the ambition to pursue and further develop this idea and tool, it is possible because there's something there, at the base, that goes beyond the personal and rather touches upon the universal. As UPISketch's main developer, what I'm striving for is, in fact, even greater universality. One of our goals in this direction is incorporating Dynamic Stochastic Synthesis in this tool.

GP I was speaking about Xenakis's compositional ethic, the rigor of his compositional thought, and did not intend to evoke the sound of his music, as such. To not imitate other composers, no matter how much you love their music, is a fundamental Xenakian ethical principle. The UPIC was always destined to be a tool for the graphical representation of the inner life of sound, in a very broad sense, not necessarily and uniquely through drawing and indeed, there are many ways of generating such graphical representations.

FIG. 1 Group photo at the CCMIX studio, 1996, from left to right: Harry Halbreich, Ron Fein, Gerard Pape, N.N., Iannis Yenakis, Curtis Roads, N.N., Leon Milo, Brigitte Robindoré, Bernhard Gander © CIX Archives

FOOTNOTES

1. This exchange took place in Paris on November 17, 2018.
2. In fact, two entries appeared in the Winter 1986 edition of CMJ related to the UPIC: Henning Lohner, "The UPIC System: A User's Report," in *Computer Music Journal* 10 (1986), 42–49 and Henning Lohner and Iannis Xenakis, "Interview with Iannis Xenakis," in *Computer Music Journal* 10, 4 (1986), 50–55.
3. CIAMI (Centre d'Informatique Appliquée à la Musique et à l'Image): founded in 1981 by Jean-Claude Eloy at the request of Maurice Fleuret, the then newly-appointed Music Director of the French Ministry of Culture under François Mitterand. This Center, in a sense a response to IRCAM's publicly alleged despotism ruled by Pierre Boulez, aimed to create a well-equipped alternative studio (including IRCAM's 4X, GRM's Syter, and a UPIC) where composers such as Pierre Henry, Xenakis, and Eloy could work free of any aesthetic hegemony. Located in the outer suburbs of Paris, in Rueil-Malmaison, the Center's goals and missions were never to be fulfilled, forcing Eloy to resign in 1988. The CIAMI was ultimately disbanded in 1990 by the French government. http://www.eloyjeanclaude.com/Ciami-info.html
4. See Mâche, this volume.
5. See Kamarotos and Tsioukra, both this volume.
6. For more about George Cacioppo (1926–1984), see http://www.moderecords.com/profiles/georgecacioppo.html
7. See http://clsimusic.free.fr/
8. ONCE Group, a 1960s Ann Arbor composing collective that included Robert Ashley, Gordon Mumma, Donald Scavarda, Roger Reynolds, and Robert Sheff.
9. See Shimazu, this volume.
10. See Robindoré, this volume.
11. Xenakis's *Taurhiphanie* (1987–1988), in its two-channel version, is available on the Neuma CD 450–86 from 1994.
12. Pape's *Two Electro-Acoustic Songs* (1993) can be found at CIX Archives under (id951).
13. A recording of Risset's *Saxatile* is available on the CCMIX - *Paris New Electroacoustic Works*, 2-CD set released in 2001 by Mode Records (99–99).
14. Pape's *Varesian Variations* (1992) can be found at CIX Archives under (id493).
15. See Després, this volume.



ONE MACHINE—

TWO

NON-PROFIT STRUCTURES

HUGUES GENEVOIS

HUGUES GENEVOIS

ONE MACHINE— TWO NON-PROFIT STRUCTURES

Hugues Genevois in conversation with Sharon Kanach

SK Hugues, when Les Ateliers UPIC were created, were you already working at the Ministry of Culture?

HG I arrived at the Ministry just after the Les Ateliers UPIC association was founded, in 1986. I was first a scientific advisor for music research until 1989, when I created a music and dance research council. After that department merged with the theater department, I was then in charge of the office dealing with writing and research (which included music commissions, drama writing grants, etc.)

SK Did you already know Xenakis at the time?

HG I was at the Ministry from 1986 to 2004, but I met Iannis before I joined the Ministry, as a participant in the Centre Acanthes during the summer of 1985. At the time, I was working for an aircraft manufacturer as a software developer. But I practiced music as well, so I was following, with interest, the research that was being done in new music. When the opportunity arose to participate in the Centre Acanthes's sessions in Aix-en-Provence and Delphi, I jumped at it!

SK You did both sessions?

HG Yes, both, and that's where I met Makis Solomos, who was still a student at the time, and where I got to know other people, such as François Picard who is a professor at the Sorbonne Université. It was a great event and I think I was probably the only one there who had an engineering background at the time.

SK Iannis must have liked that!

HG Yes, he liked to talk about his relationship to science and technology. This was my first real and direct contact with Xenakis before I joined the Ministry of Culture, which happened about a year later. From that summer's experience, I made every effort to make sure that this scientific universe, my tastes and musical activities would somehow meet.

One day, I saw a job advertisement in the paper by the Ministry seeking someone to coordinate research and creation. At the time, there were so-called "research centers," but still no mention of any "national centers for musical creation." There were quite a few of these research centers throughout France at the time and the Ministry decided it needed to take stock of their activities. Mind you, many of them were not really research centers but rather creative studios. It was at that moment that I was finally able to bring together the two worlds that had been quite separate for me until then, but not completely. In fact, I had done my Master's degree in physics in Marseille where, Jean-Claude Risset was my professor. So, we obviously talked, became friends, but my other teachers advised me to pursue an engineering degree instead. I noticed that there was one school, Télécom/Paris, that offered a "sound and image" major. So, I focused on this school, where I was accepted, and took this major with a particular focus on everything that was acoustic: signal response, image analysis, and so on.

SK I can just imagine Iannis rubbing his hands!

HG I rubbed my hands, too! Furthermore, I had participated in other courses of the Centre Acanthes, notably with Pierre Henry, but it was a little complicated. Iannis, however, was someone who was open, without barriers; his class was very pleasant, like him and all the teachers. At the time I played the cello and taking classes at the Centre Acanthes was quite something!

SK Musically, were you already composing or "just" playing?

HG I was playing. There was this instrumental side and another, an electroacoustic side, and they were two separate worlds for me at the time. Electroacoustics was not yet doable in real time, that was unthinkable, and so I felt a little torn between the pleasure of playing with others and the solitary activity of a studio. Alone in the studio we try to act as if at the end of the creative process, we give the illusion of a gesture, of an *agogic*, yet completely constructed. At the time, all my research focused on this: how to make sure that sounds that attracted me—which were not instrumental sounds but rather noise, or sounds of nature and the like—I could play as if they were a musical instrument.

And, for over ten years now, that has actually become possible. But at that time, I was being pulled in two different directions: on the one hand my scientific competence, and on the other, my musical appetite—the two had trouble joining together. And, in making music, the pleasure of playing with others and my preferences led me towards musique concrète, world music, and things that could not be played with others live.

SK At Acanthes in 1985 the UPIC was there?

HG Yes, there was notably the UPIC plus several workshops around the string quartets with the Arditti Quartet; percussion with Sylvio Gualda; and piano with Claude Helfer. We were surrounded by absolutely incredible people! I find it extremely unfortunate that all this has stopped now, because being in direct contact with performers of that level, all of whom were quite approachable, it was really fantastic! We talked, we had coffee together, we worked: it was unique and extraordinary.

SK I've been told by other participants that basically all of those sessions were well documented and recorded. What an incredible treasure trove of unique, first-hand material that has to be. I, as well as several colleagues, have been unsuccessful in our attempts to consult these. It's a real pity that all the recordings made during those sessions are not publicly available today.

HG However, there was no shortage of approaches at the time. At the Ministry, we were wondering about the sound archives of the creation centers, and we approached the then director of Acanthes, Claude Samuel, several times. I believe he wanted to try to publish them at one point, and that's why he kept everything. But this never happened.

SK I am rather shocked by such stories about archives. The French government gave so much tax-payers' money for creation, and especially for Acanthes, doesn't it have the power to say that these archives belong to the public?

HG No, because we supported associations, which therefore remain the owners of their own collections. Some have taken good care of their archives, such as Bourges, which had an archiving policy from the beginning, while others did not plan anything. One exception is Pierre Henry, who really took care of such things and kept all his many reels.

Today, what is valued is to create something new all the time. To question the past, apart from a few exceptions, we don't know how to do this work of memory. Bourges, for example, knows how to make retrospectives: 20 years of creation, fascinating stories, the birth of movements in 1975 to 1980, and transversely, with different branches of history. Otherwise, we stay with our noses stuck in the present, without taking a step back, and it's a great pity, especially when it comes to unwritten music, like electroacoustics.

SK Indeed, this is a real problem. We are lucky, at Centre Iannis Xenakis (CIX), to be in close contact with many of Iannis's former collaborators, and everyone is very grateful to him for having given so much and are happy to know that we are trying to perpetuate his work and his memory. We have received several unique and significant bequests from them for our archives. But, as you well know, it costs a lot of money to digitize and maintain such archives with technologies that evolve so quickly.

HG In general, for twentieth-century musicology, access to sources and data is a real problem. This costs money and, above all, it is not valued: it is the centers that must strive to keep a living trace of the past.

SK Let's get back to your joining the Ministry. Was there competition for the position? Not being a trained "civil servant," did you have to take some sort of equivalency test?

HG In 1986, a very long time elapsed between when I saw the ad and wrote up—the very next day!—my file and CV, and when I was actually hired: it took over six months. On the one hand, there were a lot of candidates and, on the other, the position had not yet been created!

SK Maurice Fleuret was the Director of Music within the Ministry at the time, right?

HG Yes. I think I was chosen because I had a letter of support from Jean-Claude Risset and one from Iannis, too, which must have counted. There were other profiles similar to mine. But the fact that I was in contact with these great figures in computer music must have counted. Plus, I got along well with Maurice Fleuret. For me, he remains the musical giant in this Ministry's history. He had an immense curiosity for all kinds of music, a fierce appetite, insatible… for music. After him, the administrators who were there could have just as easily been in any other Ministry…

My tenure there enabled me to acquire a fairly complete overview of the entire French musical landscape and of what was then called "music research," but which was not always research! This was sometimes due to the endowments that made it possible to purchase equipment. It became necessary to clarify things and separate what was an activity that could be evaluated in terms of research and was supported by a studio from what was unrelated. And there were not so many real places for music research; there was of course IRCAM, with which I always had difficulties—and I am not the only one; difficulties related to its institutional and almost philosophical positioning at the time.

I remember Laurent Bayle's speech when he became the head of IRCAM and echoed a Boulezian idea as an act of allegiance: "IRCAM is something extraordinary that embodies music research. Of course, before, there were handymen, like Pierre Schaeffer and Xenakis […]." Besides the fact that it seemed historically unfounded to me, I could accept that he considered Schaeffer and Xenakis as being experimenters, different, but not handymen! "Experimental" does not mean tinkering: someone who experiments rubs up against reality and welds together sound material.

If no risks are taken, what is the purpose of research? Can we, at the Ministry, support such a discourse or institutional posture? Can the State justify investing in a single team, a single institution?

SK It was disproportionate from the beginning.

HG Yes, IRCAM alone received 75% of the research budget, so it was indeed extremely disproportionate. What happened next was that Pierre Boulez, the founding director of IRCAM in 1970, had a tremendous organizational capacity that others did not. Iannis, as he freely admitted himself, was not an organizer and at the CEMAMu, sometimes it was complicated. He didn't really know how to get rid of certain people and I was made to understand that we had to do it because he wasn't up to it. Ideally, there should have been someone between him and the team, an administrator, a person in charge of running the operation; he was in too direct contact and it was delicate; the situation became untenable and it caused problems several times. For example, at the time, the CNET, which was in Issy-les-Moulineaux, housed the CEMAMu in two not very large rooms, and no one from the CNET really cared about them. I had kept in touch with my Telecom engineering school and the man who was in charge of acoustics told team, which would be an opportunity for all to have art trainees available." Iannis's team worked at their own pace, with no one bothering them, a little marginal, and producing results rather slowly. One or two members of the team welcomed the idea but Iannis was not able to impose this on the whole team.

SK This intersects with several things, in fact… I've been working quite a bit lately with Alain Després, who was the first director of Les Ateliers UPIC and whom you must have known.[1] He confessed to me that one of the reasons why he threw in the towel, even if he never counted his hours and was as enthusiastic about the UPIC as Iannis, was that when the UPIC won the FIAT prize, 500,000 French francs, which was quite a bit of money, the CEMAMu thought that the award should go to them. But Iannis decided to give it to Les Ateliers UPIC, which enabled them to make a major tour of North America, Mexico, and Canada as well as a second tour of Japan; enough to really launch the UPIC on an international level. And the CEMAMu team was furious and tried putting obstacles in his way. Iannis depended on them, he wasn't the one who developed the UPIC system, the engineers did, but the team was getting nowhere.

HG Furthermore, they were absolutely not looking to build relationships with the engineers on CNET's site, which could have certainly expedited a lot of tasks. There were surely other people, too, musicians, who would have been interested in participating in the adventure. I asked

Iannis for permission to go there to work with the UPIC because writing files about it for the Ministry is one thing, but I wanted hands-on experience with it, too, so I proposed a creation. Iannis accepted and from the moment I arrived the first morning, there was basically no exchange with them, apart from with Jean-Michel Raczinski, who was very open and competent. Basically, they were cut off from the academic world of research, from any flow of trainees and young people, and from the possibilities of theses and doctorates, so they lived a bit in a closed circuit. They were not in the creative world because they were engineers, not creators, and they cut themselves off from their original environment—science and technology.

SK You know, we're trying to restore our old UPIC units at CIX, so we took a shot a contacting Raczinski, after all these years, to see if he was interested. This past February, I received a reply from him: "I have almost unlimited esteem and admiration for Xenakis. I was lucky enough to be able to work with him for almost 18 years. It was a unique and exceptional experience. He gave me the opportunity to think out of the box, to push the limits, my limits. So, I would be very happy now to renew these years, or at least try."[2]

HG If it had only been Raczinski, the CEMAMu would have moved to Telecom and who knows what could have been developed there then? But the others joined forces against him.

SK Although it is true that Iannis was not an organizer, he was so perseverant. When working with him on *Music and Architecture*,[3] I was amazed at how much trouble he took writing, for example, tons of letters trying to organize places for his *Diatope* to tour, not to mention several other projects that ultimately never worked out. I'm surprised he didn't bang his fist on the table and say, "Guys, we're going to Telecom!"

HG Maybe he was already tired... But above all, I think that an artist cannot be his own agent. At some point you need someone who can say "No! Not like that!"—someone who is not in a relationship of admiration.

SK Do you know why or understand why there were two independent structures—the CEMAMu, on the one hand, for developing the UPIC system, and Les Ateliers UPIC, on the other, to promote the tool? I always found it rather difficult, at the time, to comprehend who did what.

HG Now, I have to admit I don't know. When I arrived in 1986, Les Ateliers UPIC already existed. Why this split when other groups did not work like that? Lyon, Arles, Marseille...all had activities of production,

research, diffusion, pedagogy; there were exchanges among teams in-house. I was not convinced it was a good idea to separate research and Les Ateliers UPIC. The developers were already cut off from everything... Under one and the same roof, they might have been forced to get more involved. In retrospect, separating the two activities under two different structures was absurd. Even though the CEMAMu team worked every day, it was a small team compared to other computer developers. But then, it wasn't as easy as nowadays. When you think of what existed at the time, even IRCAM's 4X, they were huge machines that were slow to develop.

SK And with inconceivable limitations, especially in terms of memory. Guy Médigue, who worked on the first UPIC prototype, says that the first machine had a memory of 32K![4]

HG Before joining the Ministry, the planes I was working on had a memory of 64K! To save more space, we didn't use much graphic language, they were codes and we exploited the processor up to the last few digits. With 64K, we had all the software of an aircraft with management, radars, displays for pilots, controls. We could do things with very little, but in real time, it became very complicated. At one point, a processor's cadence, its speed of processing information, is an unavoidable frontier. For the real-time UPIC, they had to develop a card, as most software manufacturers did at the time who wanted to do real-time audio. The first protocols also worked with a card that needed to be put in your computer because you couldn't only rely on the processor. And there were not many who could develop a card. When I came in contact with the CEMAMu there were four engineers; it was a microscopic team that could have been more efficient had they been more in touch with the scientific and technological community of their time. Especially, at the time, it was relatively easy to motivate institutions—Xenakis was not just anyone!—and the contacts with Telecom had gone well, young interns were numerous there, so there was a potential workforce... Once again, I think that a creator who finds himself alone in front of his developers must have a particular character, and this was not the case with Iannis. We needed someone who would have been in charge of management, human management, presence...

SK Did you suggest that to Iannis?

HG Yes, on several occasions I told him... It was problematic for him... but at the same time I think that by going to the CEMAMu studio, he felt like he was part of the team and young. Maybe I'm fantasizing... He would not have liked to have the position of the great Manitou, a big shot, even if he was one, in fact. There, he was relatively relaxed, he never imposed his authority.

SK He was not a boss.

HG Not at all! He was someone who was searching, I'm not saying someone who doubted, but someone who was looking, ready to exploit things, to abandon them, to go back to the drawing board.

SK By hiring a manager would he have been obliged to cut another position? Was it a problem of resources?

HG At the time, between 1986 and 1988—everything changed after that—we were still in an era where, if it had been necessary to create even half a position for an administrator, it would have been feasible. Frankly, he could have succeeded in convincing Fleuret; all he had to do was present a project, defending the necessity to reorganize things. There was a time when the Ministry said: "In creative centers you need real managers." More recently, the Ministry has gone back on that policy; well, in fact, it changes all the time. I have the impression that the formula that does not work too badly is one that foresees both. There is nothing extraordinary about that, it's like that everywhere; creators must be helped by being free of administrative tasks, otherwise they become exhausted or don't do the job well.

SK Did you ever suggest that the two structures be merged?

HG No, it was like that, and everyone seemed so convinced that it was a good idea… and on the spot, I didn't understand. I thought it could be problematic, but it was only after the fact that I understood that it was, in fact, absurd.

And then we arrived at a period, quite quickly, when it became difficult to redirect the activities of a center because we had set up research evaluation tools with a desire to be open: not only computer music, but other activities too, dance, etc.… and my job was to allocate public funding to research, distributing it where it would be most effective. But in fact, I quickly realized that when I was able to save some money in one place, that money would disappear in the process! So, it was getting very difficult. How can you try to build a policy if you don't have control over your financial envelope, and research is clearly no longer a priority? There had been a research department, which was effective for several years, but it ceased to exist when Frédéric Mitterand was the Minister of Culture. Moreover, I am one of the rare survivors: in 1986 my position was the last one created in the field of music at the Ministry of Culture. Afterwards, and since then, no positions were created; I was the last one. There is still a framework agreement between the Ministry of Culture and the CNRS[5] but it is freewheeling because there is no longer any political volition. Artistic research is clearly no longer prioritized in France.

SK Was yours really the last new position created in the Ministry of Culture? Ever since 1986?

HG In the musical field, yes.

The one who could have developed an activity because he was a recognized figure in the field, but who could not do so either, was Jean-Claude Risset. He was at the very heart of the CNRS institution with a prominent position in computer music, an emblematic figure… but he was not a leader either and he had a microteam. He never fought for his team to develop, even when he could have afforded it. So, there were many missed opportunities!

For example, here at the LAM,[6] we are twelve permanent employees, it's not that big a deal, but twelve salaries: a subsidy of that amount would never be possible! And in addition, the premises, equipment, etc…

SK But the LAM, which you direct, is housed at Sorbonne Université, at Jussieu. Don't you receive financial support from the university too?

HG Like all public research labs, we are under the supervision of our university and the CNRS, so all the partners contribute a little money, distributed on a per capita basis, if I may say so. We have a small grant from the Ministry of Culture, it's better than nothing, and the rest are contracts: ANR[7] grants, the *Fondation de France*, for example. As a public lab, we can hope to create a position from time to time, because at the University, even if things are going poorly, teachers are a vital necessity; while an association has no vital need! So, we must be able to preserve our autonomy and creative spirit and at the same time have a little institutional anchoring: very general considerations that go beyond just the UPIC's scope! But it gives a general picture of how things have evolved. To think of research outside the university framework is to take the risk of weakened research, not necessarily of lower quality, but which will not be able to be maintained in a sustainable manner.

That is why I had campaigned for the CEMAMu to be hosted by Télécom. There were some very strong people there at the time in signal processing. The acoustics teacher was very musical, very interested. The buildings belonged to the Post Office, which vacated an entire floor…

SK In what year did all this happen?

HG 1993–94 or maybe slightly before. Frankly, I felt Iannis was a little demotivated. And perhaps there was some pressure from his wife Françoise, too…

SK I remember, around that same time, Iannis called me one morning and said, "If you are free tonight, come to dinner, the Brendels will be here!" We had already met and got along well and I was indeed free. So, we were all there, waiting... and no Iannis! This was before cell phones! In fact, he was at the CEMAMu, must have become absorbed in his work and completely forgot about us and dinner! When he finally arrived, at around 9:30, we were all relieved to see him, finally. And Françoise said to him, "So, did you at least discover your unheard-of sound?" He looked down and simply shook his head: no.

HG I think she, Françoise, had a strong animosity against CEMAMu and realized that the team, whose members she vaguely knew, was not up to snuff. So, at one point, Iannis just gave up.

SK How was the money distributed between the CEMAMu and Les Ateliers UPIC?

HG The CEMAMu received a much larger subsidy than Les Ateliers UPIC, mainly because it financed four or five, not ridiculous, salaries of developers and engineers. Their subsidy was around one million French francs. Some years, operating and equipment grants were combined. They didn't have to pay rent but there were other expenses.

Apart from IRCAM's grant, it was one of the biggest at the time. Why? Because the other centers were co-supported by the Ministry and local authorities. But for the CEMAMu, 100% of their subsidy came from the French government.

SK And the Ministry agreed to that?

HG At the time, yes. Today, IRCAM is still a special case: the city of Paris does not contribute a cent! But then, IRCAM has its own resources generated by international contracts and they are active in this area.

SK So, Les Ateliers UPIC were getting much less?

HG Yes, their subsidy covered basically a salary and a half, which was not commensurate with the positions and seniority at the time. CEMAMu, on the contrary, was one of the better payers.

SK Finally, Les Ateliers UPIC were, in good part, self-financed, with workshops, residencies, etc?

HG Yes, and they had to generate income, if only to pay the rent!

SK After Iannis died, were you the one at the Ministry who commissioned Thierry Coduys to explore whether or not to pursue CEMAMu's activities?

HG No, not me. Thierry had his structure, La Kitchen, at the time and knew the Ministry's inspectors well. Like all directors of creative centers, he was constantly on the lookout for any opportunities to recoup funding. I did meet him at that time and he was very energetic. He probably hoped for a consulting activity and to recover the CEMAMu, but that structure's inherent problems would not have been solved. Thierry did receive funding, though, to finance the first version of UPIX, inspired by the UPIC but extrapolating other tracks too.[8] There was a graphic idea still behind it, certainly, but in the end, it had little to do with the UPIC.

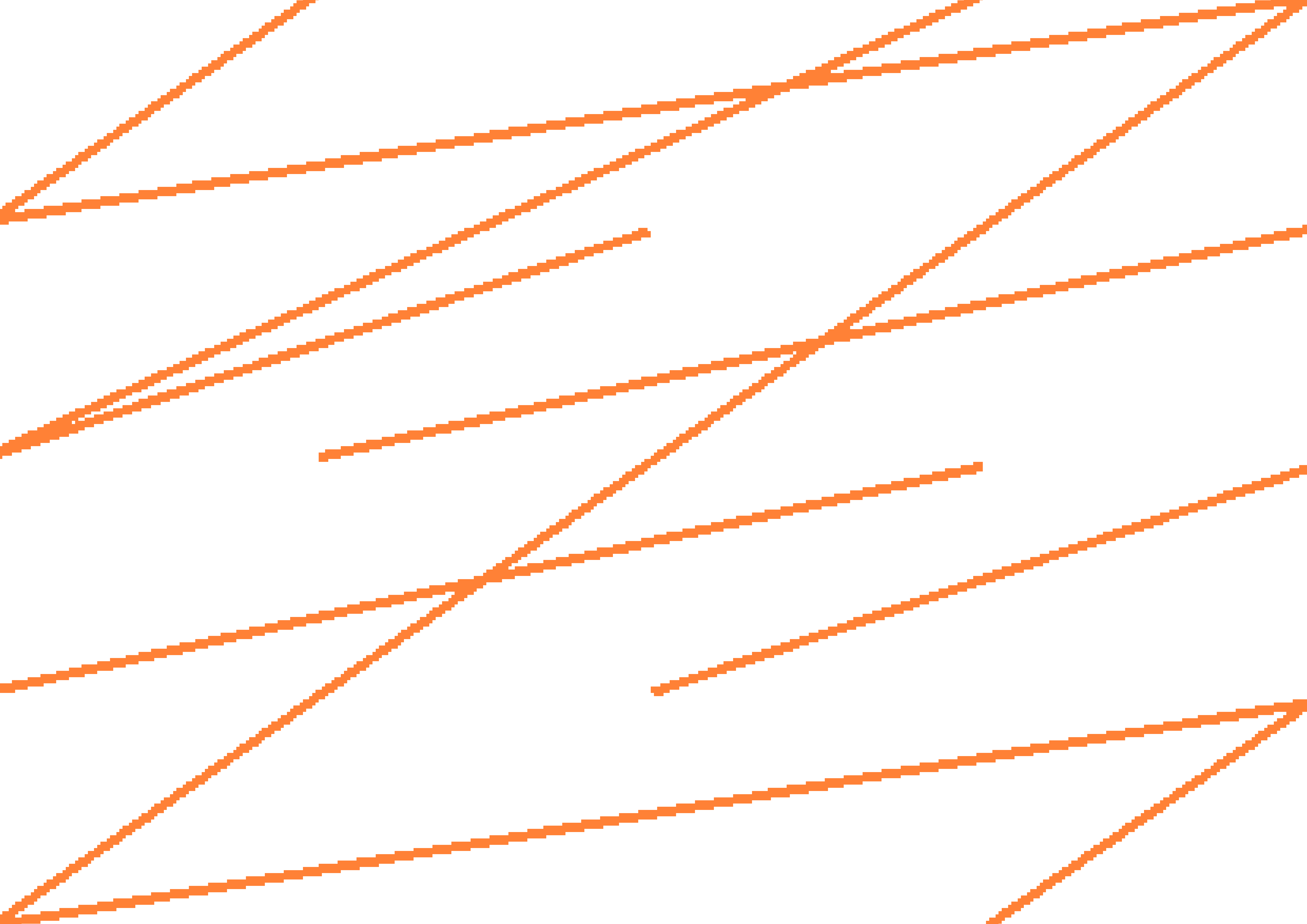
SK Apparently, Iannis received significant financial support from the Gulbenkian Foundation in Lisbon, in particular for CEMAMu's first digital-to-analog converter. Why, how Gulbenkian? Do you have any idea?

HG I think Gulbenkian provided support on several occasions, not only at the very beginning of CEMAMu, but also for a tour, and perhaps for other things. Remember, they had commissioned Iannis's *Nuits*, already back in the 1960s and continued to commission him into the 1990s, so he obviously had some great contacts there.

SK It's true, I remember that Luís Pereira Leal, who was for a very long time the head of the Foundation's music department, revered Iannis. In a way, he personified that Foundation's statement of purpose at the time: "The results of research are unpredictable, as are all pioneering projects, but the important thing is that the research is done. There is always a risk to be taken in scientific investigations, this risk being the price of any progress."[9]

FOOTNOTES

1. See Després, this volume.
2. Email exchange between Jean-Michel Raczinski and Sharon Kanach, February 9 2019.
3. Iannis Xenakis and Sharon Kanach, *Music and Architecture: Architectural Projects, Texts, and Realizations* (Hillsdale, NY: Pendragon Press, 2008).
4. See Médigue, this volume.
5. CNRS—Centre National de Recherche Scientifique (National Scientific Research Center).
6. LAM—Lutheries, Acoustique, Musique research team, headed by Hugues Genevois, housed at Sorbonne Université, Paris, Jussieu.
7. ANR - Agence Nationale de la Recherche (National Research Agency).
8. See Scordato, this volume, for more about UPIX and IanniX.
9. "E.m.a.mu. (Equipe de Mathématique et Automatique Musicales)", *La Revue Musicale*, Special Issue 265–266 (1969), 53–59, here 53.



CENTRE IANNIS XENAKIS: MILESTONES AND CHALLENGES

CYRILLE DELHAYE

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CENTRE IANNIS XENAKIS: MILESTONES AND CHALLENGES

The history of the Centre Iannis Xenakis (CIX) dates back to the founding by Iannis Xenakis of Les Ateliers UPIC in 1985[1] to promote the UPIC system internationally, followed by the renaming of that institution in 2000 as the Centre de Création Musicale Iannis Xenakis (CCMIX)[2]. Then, in 2007, in response to an audit by the French Ministry of Culture,[3] the CCMIX's team was replaced by a new one[4] whose mission was specified as to "redefine the objectives of the association, focusing on the preservation, promotion, and dissemination of the intellectual legacy of Iannis Xenakis's work." Indeed, after the death of Iannis Xenakis, the founder of Les Ateliers UPIC/CCMIX, it seemed more appropriate for the new team to rename the association the Centre Iannis Xenakis (CIX), which was unanimously decided at an Extraordinary General Meeting on June 3, 2009. The French Ministry of Culture had closed Xenakis's original research lab, the CEMAMu (Centre d'Etudes de Mathématique et Automatique Musicales), where the UPIC was first developed, soon after the composer's death in 2001.[5]

Since December 2010, after a brief interlude at the then Centre culturel de rencontre La Tourette, the Université de Rouen hosts the CIX: under the intellectual auspices of the research lab GRHis (Groupe de Recherche d'Histoire), the CIX archives are now on the shelves of the University Library (SCD de Lettres et Sciences Humaines), and its historic studio and office are set up in spaces provided by the Research Pole of the Maison de l'Université (student center).

THE ARCHIVES OF CENTRE IANNIS XENAKIS

Considering the incredible vitality of this historic center for music composition for nearly forty years (over 130 composers—and still counting—have worked in connection with the association),[6] it is logical that the documentary resources of our archives are exceptionally rich, occupying over forty linear meters of shelving. In addition to historic holdings, our collection is constantly growing thanks to generous bequests made mainly, but not exclusively, by former Xenakis collaborators,[7] who share our deep concern to make such documentation readily accessible for future research by scholars and musicians.

After establishing a pre-inventory[8] (beginning in 2012: protecting our collections following library preservation norms), the CIX, under the aegis of the GRHis, obtained support from the French Ministry of Culture under a national digitization program, as well as funding from the GRR Culture et Société en Haute-Normandie (Major Research Network of Upper Normandy) to begin digitizing and cataloguing our holdings. We also continue to receive support, albeit modest, from the Drac-Normandie (Ministry of Culture's regional office of cultural affairs). Thanks to our agreement and well-functioning cooperation with the University Library, brief or extended consultations of our archives by doctoral students occur regularly.[9]

THE PAPER ARCHIVES

Around one-third of our core collection, about eleven linear meters of shelving containing ca. 60,000 pages, are paper archives: correspondence, course notes, research notes, hardware and software documentation, press clippings, program notes, etc. FIG. 1

SHEET MUSIC AND PRINTED MATERIAL

The CIX has approximately 450 scores, most of which are unpublished. The current state of research suggests we can assume that many of them originated from calls for candidates for courses in music composition previously organized by the center. Some of them, however, especially the graphic scores and scores of composers in residence, were written specifically at the center.

Printed (published or unpublished) documents often focus on the center's research activities or on the UPIC system. In addition, hard copies of academic theses and dissertations (MAs, PhDs) are also included in this category. FIG. 2

MULTIMEDIA MATERIAL

Multimedia materials (3500 items) account for over half of our archives. Although this collection is heterogeneous, audio documents constitute the majority. Not counting vinyl records, published cassettes, and commercial compact discs (which represented the center's music library), other resources (such as DATs, tapes, and engraved CDs) are mainly unpublished documents. This is a unique collection of recordings that includes concerts, sound banks used by electroacoustic composers, as well as completed published or unpublished works.

Iconographic sources are also significant: photographs, for example, often reveal a documentary attractiveness, such as portraits of composers in action. More recent photographic bequests, such as that of Bruno Rastoin (exclusive and rare material concerning Xenakis's polytope *Diatope* (1978) both in Paris and in Bonn in addition to various UPIC workshops) or that of Henning Lohner (including several unique portraits of Xenakis in

FIG. 1 CIX paper archives in the Université de Rouen library, 2019 © Cyrille Delhaye and CIX Archives

FIG. 2 CIX score archives in the Université de Rouen library, 2019 © Cyrille Delhaye and CIX Archives

FIG. 3 Panoply of CIX archives in the Université de Rouen library, 2019 © Cyrille Delhaye and CIX Archives

action, both publicly and privately) constitute real treasure troves.

Although video sources are not numerous, they are nevertheless very relevant: they include documentaries around the UPIC for internal or promotional use, some by Xenakis himself, or unprecedented films of concerts.

Finally, the archives also contain many old media. This is an ongoing process of figuring out how to extract and save in a sustainable manner the data on these old floppy disks, Syquest cartridges, QIC cartridges, or other, even older data cartridges. **FIG. 3**

DIGITIZATION OF ARCHIVES FOR PRESERVATION

We continue to digitize CIX's collections according to the funding available for this purpose. At the time of writing, most of the multimedia items have been digitized (except for some old still-unreadable media), but much of our paper holdings remain to be done. Because of their fragility, our 534 burned compact discs and eighty ¼ inch magnetic tapes were digitized first. Oversized papers (some scores, posters, UPIC tracing pages) have been completely and professionally digitized. All of our DATs, as well as photographs from Rastoin's bequest, have also been preserved. Several more recent bequests have arrived at least partially digitized. Finally, the CIX actively remains on the look-out for little or previously unknown sources and collaborates with new private or institutional partners in rendering them available for research purposes under Creative Commons.

VALORIZATION ACTIVITIES: DIGITIZED ARCHIVES ONLINE

In addition to the permanent conservation of documents, the French national digitization program with which we began this process requires the dissemination of our archives via our website. For this purpose, another partnership was created with the Portail de la Musique Contemporaine (Gateway to Contemporary Music) to promote data and metadata from our digital collections.[10] Such online resources further facilitate public access to the works created and archived at CIX, as well as the creative processes associated with them. All such data is available under conditions protecting the intellectual property of their authors and/or assignees, according to the agreements negotiated by the Gateway's collective rights management agreement (compressed image formats, streaming extracts in compressed format for audio and video).

After much debate, the CIX chose the digital library platform Omeka for its website. It is free software under the free General Public License (GPL), developed for the Roy Roszenweig Center for History and New Media.[11] This platform is part of the digital humanities movement and is used by the U.S. Library of Congress and by the Europeana portal, among many others. It is noteworthy that since February 2018, CIX's Omeka entity is hosted by the TGIR Huma-Num of the CNRS,[12] and is fully integrated in Isidore, the federated search engine for humanities data in France,[13] which offers sustained scholarly exposure of our collections.

The Omeka platform allows for digital editorialization of archives, the creation of virtual exhibitions, and the possibility of adding comments or even curation by registered users. In 2012, the CIX curated a travelling exhibition that is available in French and English. It traces the history of the UPIC, mainly from documents in our archives: correspondence, concert posters, photographs, video testimonies highlighting the experiences of composers, and the many educational workshops conducted with children or blind people.[14] In May 2015, a web editorialization of this exhibition was created to extend the experience and establish a link with CIX's catalogue of digital collections: visitors are invited to discover new archives that are highlighted, as well as to continue their research with the help of the online catalogue.[15]

CENTRE IANNIS XENAKIS'S ACTIVITIES

In addition to activities concerning our archives, the CIX is also active on the campus of the Université de Rouen, organizing many lectures and concerts there, including our regular participation in the Université de toutes les cultures (UTLC), a lecture series designed to address the general public on very specific subjects.[16] We also collaborate closely with the nearby Ecole national d'architecture—Normandie, having jointly hosted several international forums and colloquia, for example, *Xenakis's* Polytopes: *Music and Architecture*, and have coproduced a collective book subsequent to another joint symposium, *Xenakis et les Arts*.[17] In 2015 and 2016, with the ENSA-Normandie and also the European University of Cyprus's music department and the architecture department of the University of Cyprus, we co-organized a major international conference on the *Continuum in Music and Architecture*.[18] Furthermore, like our predecessors Les Ateliers UPIC and the CCMIX, we are regularly invited to hold UPIC workshops for children, in schools of fine arts, and for the general public in France and abroad.

Several of our individual members are quite active, regularly participating in international conferences on various subjects related to Xenakian and/or archival topics.

In 2016, we were invited by the coordinating partner, Onassis Stegi, to participate in the Interfaces project, cofunded by the Creative Europe program of the European Union as an associate partner.[19] The project's main focus is to develop "new models and practices for audience development in contemporary music in Europe." It was through this project that, on the one hand, we collaborated closely with the European

University of Cyprus to develop the software application UPISketch for mobile devices,[20] and on the other hand, enjoyed coordinating with the ZKM | Center for Art and Media Karlsruhe both the "UPIC: Graphic Interfaces for Notation" conference,[21] as well as this publication.

PROJECT FOR A JOINT DIGITAL ARCHIVE LIBRARY OF KSYME AND CIX

Since February 2015, subsequent to the events organized to celebrate KSYME's 35th anniversary, the contemporary music research center which was founded in 1979 by Iannis Xenakis, Giannis G. Papaioannou, and Stephanos Vassileiadis in Athens,[22] our two institutions plan to create a joint library of digitized archives focusing on the UPIC. KSYME's recent move to the Athens Conservatoire should now expedite this process.[23]

In order to create a joint library of digitized archives with the KSYME, it is possible to set up an open archive warehouse via Omeka (based on the OAI-PMH protocol). The CIX has already used this protocol to disseminate our archives to the other research centers and gateways mentioned above. This is a long-term project but a very exciting one. KSYME has begun digitizing some of its archives and has started uploading them to their own Omeka website: https://ksyme.omeka.net/.

COMPOSING ON THE UPIC BETWEEN PARIS AND ATHENS: DIMITRIS KAMAROTOS

This joint digital archive of the CIX and KSYME has already proved to be fundamental in shedding light on the trajectories of composers who have composed using the UPIC across Europe. The first research project, for example, has brought to light two particularly significant cases: that of the Greek composer Dimitris Kamarotos and that of the Hungarian composer Ivan Patachich.

While preparing a keynote I was due to give at the conference "Échanges musicaux entre la France et la Grèce à l'aube du xxie siècle, 1980–2010 (Musical exchanges between France and Greece at the dawn of the 21st century, 1980–2010)" at the Sorbonne in 2018,[24] I had the opportunity to correspond, by email, rather extensively with Dimitris Kamarotos (*1954),[25] which brought to light the unique experiences of this composer who very early applied himself to using the UPIC both from a pedagogical and a purely compositional point of view.[26] He discovered the UPIC at the CEMAMu in Paris in 1981 after meeting Iannis Xenakis in his courses at the Université de Paris I.

In 1987, Kamarotos composed *Epiphineia* for UPIC, clarinet, piano, and double bass. This piece also uses a computer program (Gen 2/1) that generates polyphonic musical structures based on chaos theory. He shared with Xenakis the neologism he originally coined for this UPIC piece: *Epi-Finie* (the prefix *epi-*, meaning "on" in Greek plus the suffix *-finie*, "finite" in French) which to Kamarotos indicated a space with *finite* properties. Xenakis suggested to him the definitive title *Epiphineia* in reference to the Catholic religious holiday of the Epiphany as well as its connotation of revelation. Kamarotos's piece was premiered during a collective concert that featured various new works by Greek composers who had worked on the UPIC at KSYME. Further, Dimitris Kamarotos recounted, for example, having played an alternative version of *Mycènes Alpha* in the presence of Xenakis at that concert. The concert also featured a piece by Haris Xanthoudakis (*1950) created in 1983–84 at the CEMAMu in Paris: *L, comme Buñuel ou La Forêt des symboles*. The latter went to Paris with Kamarotos to discover the UPIC at the beginning of the 1980s. Finally, a piece by Vasilis Riziotis (1945–2016) closed the concert: *At a Dream's Constellation* for piano/celesta and UPIC, composed the same year during an UPIC workshop at the Goethe-Institut in Athens. Fully recorded, this concert gave rise to the first disc of pieces for UPIC in Greece published and produced by the KSYME.[27]

COMPOSING ON THE UPIC IN PARIS AND IN ATHENS: THE EXAMPLE OF THE HUNGARIAN COMPOSER IVAN PATACHICH

Already, the work jointly carried out at CIX and KSYME has made it possible, for example, to single out the work of Ivan Patachich, who worked in both our centers—CIX (at the time Les Ateliers UPIC) and KSYME—and composed works overlapping his experience with the UPIC in Athens with one in France. Ivan Patachich (1922–1993) was a Hungarian composer and pioneer of electroacoustic music in Hungary.[28] His works have won numerous international awards; he travelled extensively and composed at Columbia University, New York (1969), in Stockholm (1974), Bourges (1980), Athens (1987), and Paris (1988).

According to Costas Mantzoros (composer, researcher, and longtime collaborator of KSYME), Ivan Patachich began to produce the piece *Musique dessinée*[29] at KSYME in Athens in July 1987, and then edited it in Budapest at Hungarian Radio.[30] More precisely, according to musicologist John G. Papaioannou, Ivan Patachich met the composer Takis Velianitis[31] (*1963) at the KSYME in the summer of 1987,[32] where he was working as a UPIC instructor and collaborated with Patachich on *Musique dessinée*.

In the CIX archives, we discovered that a few months later, in 1988, Ivan Patachich composed a second work on the UPIC: *Chanson nocturne du poisson* at Les Ateliers UPIC. While searching for this reference, we noticed that there are actually copies of both of Patachich's two works for the UPIC in CIX's archives.

CONCLUSION

The singular approach of the research and pedagogy of composition and research that was conducted originally at the CEMAMu, and later at Les Ateliers UPIC, then at CCMIX, and finally at CIX has attracted composers from around the world wanting to know—and for many, to try—another way of composing. The archives they have left (and others continue to donate to our collection) often exemplify the stratification of their creative processes, generating a unique and valuable documentation. The challenge now is to maintain and ensure the importance of this knowledge by sharing it with the greatest number of parties, fulfilling our mission of open dissemination of Xenakis's legacies. To achieve this, digitizing documents, cataloging and formatting metadata that meet international standards for interoperability are clearly the on-going stages of this project.

In addition, recent work by Rodolphe Bourotte around the UPIC and UPISketch workshops have shown that this tool for musical composition by drawing still inspires many composers, beginners or not[33]. It is therefore CIX's goal to preserve this technical heritage (the UPIC) and enhance the development of its software versions.

Finally, the CIX will continue, both alone and with selected partners, to promote the intellectual heritage of Iannis Xenakis's influence through conferences, lectures, and publications, such as this one.

FOOTNOTES

1. See Després, this volume.
2. See Pape, this volume.
3. Internal report by Fernand Vandenbogaerde, Inspecteur Général à la Direction Générale de la Création Artistique du Ministère de la Culture, December 6, 2006 (CIX Archives, uncatalogued).
4. Founding members of the new team included: Françoise Xenakis (Honorary President), Paul Méfano (President), Jean Louis Villeval (Vice-President), Sharon Kanach (Vice-President), Bruno Rastoin (Treasurer), and Marie-Emmanuèle Verrier (Secretary). A full list of current members and officers can be found here: http://www.centre-iannis-xenakis.org/membres
5. See Genevois, this volume.
6. For a full, on-going list of composers see: http://www.centre-iannis-xenakis.org/upic_compositeurs?lang=en

7. Some such former collaborators are logically represented in this volume as well: Després, Kanach, Lohner, and Médigue, although several others have also made generous bequests of precious original documents.

8. See our general inventory: http://www.centre-iannis-xenakis.org/inventaire_archives?lang=en

9. For instance, another contributor to this volume, Victoria Simon, was in residence in Rouen for several weeks in early 2016 while a PhD student at McGill University, Montreal, Canada.

10. http://www.musiquecontemporaine.fr/fr/search?so=da&archiveIds=55

11. https://omeka.org/

12. Huma-Num (TGIR) - très grande infrastructure de recherche) : Digi(tal)Huma(nities) very large research infrastructure https://www.huma-num.fr/ of the CNRS (National Center for Scientific Research).

13. https://isidore.science/collection/10670/2.ofsr4v

14. http://www.centre-iannis-xenakis.org/cix_expositions?lang=en

15. At present, only a French version of the virtual exhibition is available: http://www.centre-iannis-xenakis.org/exhibits/show/expo-upic

16. http://culture.univ-rouen.fr/conferences-grand-public-395031.kjsp (At the bottom of the page, there are links to videos of each conference, according to year.)

17. Multi-author publication: *Xenakis et les arts: miscellanées*, ed. Pierre Albert Castanet and Sharon Kanach, (Rouen: Éditions Point de vues, 2014).

18. http://www.centre-iannis-xenakis.org/continuum_home

19. http://www.interfacesnetwork.eu/article.php?pid=1-the-project

20. See Bourotte, this volume. See also:
http://www.centre-iannis-xenakis.org/upisketch.
Also, the link to the very first UPISketch workshops:
https://www.boccf.org/Templates/Pages/Event.aspx?id=4756

21. http://www.interfacesnetwork.eu/post.php?pid=217-upic-graphic-interfaces-for-notation-conference

22. https://cmrc35years.wordpress.com/

23. See Tsioukra, this volume.

24. http://relmus.org/?page_id=20

25. http://dimitriskamarotos.com/

26. Numerous emails were exchanged between the author and Kamarotos in the period April 19 – May 6, 2018

27. POLYAGOGY, LP with four compositions by Xenakis, Xanthoudakis, Riziotis, and Kamarotos, Music-Box-records 1987 X33SMB13018.

28. Among other achievements, Patachich founded the ExAStud Studio (Expermentum Auditorii Studii) in Budapest in 1971.

29. Ivan Patachich, *Musique dessinée*, Archives du Centre Iannis Xenakis, Université de Rouen, CIX 754, cote 87. To hear an excerpt from this work: http://www.centre-iannis-xenakis.org/items/show/171

30. Costas Mantzoros, “Re: Ivan Patachich”, email addressed to the author, January 30, 2018.

31. https://velianitis1.wixsite.com/velianitis/biography

32. John G. Papaioannou, *20th Century Greek Avant-garde Music: A Cross Section (liner notes* (Athens: Eteba, 1998), 137–38.

33. See Bourotte, this volume.

ESTABLISHING A XENAKIS CENTER IN GREECE: THE UPIC AT KSYME-CMRC

KATERINA TSIOUKRA

ESTABLISHING A XENAKIS CENTER IN GREECE: THE UPIC AT KSYME-CMRC (CONTEMPORARY MUSIC RESEARCH CENTER)

After the collapse of the seven-year military junta in Greece and the restoration of the Republic, Iannis Xenakis was finally allowed to return to the country in 1974, after 27 years of political exile. At that time, the Hellenic Association of Contemporary Music (HACM) played a leading role in officially representing Greek modernists and introducing the Greek audience to both national and international contemporary repertoires through monumental concerts and festivals, such as the five Hellenic Weeks of Contemporary Music (1966, 1967, 1968, 1971, 1976); the Xenakis Week in 1975; and later, the World Music Days in 1979. A key figure and significant for promoting modernism in music was the dilettante musicologist, professional architect, and city planner John G. Papaioannou. Papaioannou personified nearly all activities relating to contemporary music in the country since the late 1950s in lessons and public lectures. He was also actively involved in founding several organizations that sought to promote modern music, such as the Goethe Institute's Studio für Neue Musik (Studio for New Music) (1962), the Greek branch of the International Society of Contemporary Music (1964), and HACM (1965), all located in Athens where Papaioannou held important positions. Papaioannou had gained the trust of most of the foreign institutes in Athens (USIS, Hellenic-American Union, Goethe Institut, Instituto Italiano di Cultura) and collaborated with them artistically and financially to promote modern music in Greece.[1]

Beginning in the mid-1950s, Xenakis frequently corresponded with Papaioannou and they soon developed a relative familiarity that can be detected in their letters.[2] Papaioannou contributed to introducing the exiled Xenakis to the Greek audience on numerous occasions. He presented his works along with those of other modernists in a concert

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held by the then newly founded Hellenic-American Union in 1959.[3] Papaioannou was also the person who was willing to overlook certain formalities regarding the submission of *Amorsima-Morsima* to the Music Competition 1962, in which both Xenakis and Anestis Logothetis were formally introduced to a wider Greek audience after winning the first Manos Handjidakis prize *ex aequo*.[4] In addition, he included Xenakis in the New Greek School of composers—a characterization of his own coining—and regularly promoted Xenakis in his publications on the development of modern Greek music and composers.[5] Papaioannou was the link between Xenakis and the existing foundations of contemporary music in Greece; the man behind their establishment, operation, and artistic planning who was fully aware of how to promote a noteworthy composer to the Greek audience.[6] After the country's regime change in 1974 and during Konstantinos Karamanlis's conservative and "Europeanisational" administration, HACM received unprecedented support and financial aid from the Greek government thanks to the efforts of Papaioannou. Xenakis also benefitted from the Greek government's artistic encouragement through the week-long festivities dedicated to him in 1975 that were organized by HACM.[7]

Xenakis's plan to establish a center for contemporary music in Greece, similar to the French Centre d'Etudes de Mathématique et Automatique Musicales (CEMAMu), can be traced back to this period when his Greek passport was restored to him, and the government began welcoming him. In fact, creating this new center was for Xenakis "the first thing he asked to do" in Athens.[8] At that time, "[his] joy was great and [he] was ready to contribute to the new [sic] reconstruction of the culture of [his] country," which had recently experienced the collapse of the military junta.[9] A strong reason for establishing the new Contemporary Music Research Center (KSYME-CMRC)—hereinafter KSYME, its acronym in Greek—was to domicile Xenakis's latest invention in Greece, as soon as the UPIC became available. John G. Papaioannou and the composer, popular music pedagogue, and choir director Stephanos Vassiliadis were introduced to UPIC's artistic and educational potential during the World Music Days in Bonn in 1977, when its first public demonstration took place. It was then and there that it was decided to have a UPIC in Greece, fulfilling Xenakis's dream of founding an institution in Athens.[10] In 1978, KSYME's statutes were signed by twenty-five founding members and the center was officially founded in 1979.[11] Its temporary management committee included John G. Papaioannou, Stephanos Vassiliadis, and Alkistis Soulogianni; the first Board of Directors included Iannis Xenakis (as president), John G. Papaioannou, Manolis Protonoratios, Stamatis Chrisolouris, and Stephanos Vassiliadis, who served as KSYME's director.[12]

Xenakis's vision about establishing a center in Greece that followed the same objectives as the CEMAMu is revealed in KSYME's first promotional material, although the relationship between the two centers is not explicit in their respective statutes. CEMAMu's brief "goal" was summarized as "the study, the teaching, and the practice of the sciences and the techniques applied to audiovisual artistic creation, and this by means of its choice and in particular the use of electronic devices."[13] John G. Papaioannou's and Stephanos Vassiliadis's contribution to the wording of KSYME's statutes is reflected in the following paragraph of the center's goals:[14]

- A Promoting research for the broadening of sonic possibilities, capable of being used in contemporary music composition.
- B Research on acoustics and the psychophysiology of hearing.
- C Development of intertwined methods for the simultaneous study of music, mathematics and other sciences or arts.
- D Education, through consistent teaching of the aforementioned disciplines, suitable personnel, with an emphasis on youth and allotment of scholarships.
- E Exploration and development of pedagogical methods for music, which will be applicable in the future in other similar centers in Greece, without age, gender or racial restrictions.
- F Informing and cooperating with educational institutions (elementary, middle and higher education, general or specific, technical or artistic).
- G Promoting music creativity based on the aforementioned research methods.
- H Promoting music analysis and research of sonic structures of folk music of various civilizations and especially Greek folk music (Byzantine, traditional, etc.) and the sounds of the Greek environment.
- I Development of Greek and international contacts through workshops, conferences and other social events, centered around the aforementioned Center's activities.
- J Development of public events—lectures, listening sessions, discussions etc., in Greece and abroad, where the results of the Center's activities will be presented.
- K Publications based on the aforementioned research results.

KSYME's goals were formulated in an analytical way, primarily promoting Xenakis's views. Secondarily, however, references to awarding scholarships, research on various civilizations, lectures, workshops, public events, listening sessions, and publications are highly relevant to Papaioannou's own activities in music. Further, music pedagogy, educational cooperation, and musical "Greekness" are largely related to Vassiliadis's views.[15] It is worth mentioning that KSYME's inclusivity was expressly formulated in its statutes. Despite an analytical approach, there was no reference to electronic media or devices or even the UPIC, even though it triggered the center's establishment and, a few years later, its activation and full operation.

Although the center was officially founded in 1979, its operation was significantly delayed due to the lack of financial resources, which would have permitted the immediate purchase and delivery of a UPIC, as well as KSYME's simultaneous commencement. It took almost seven years (1979–1985) to amass a substantial amount of money, primarily through state funding and donations, following the example of the state-funded CEMAMu. Until its activation, KSYME's main grants specifically came from the Ministry of Coordination (Scientific Research and Technology service) and the Ministry of Culture and Science.[16] KSYME's first attempt to purchase a UPIC was in 1984 when its price began to drop. It was the center's first investment, which was completed in March 1985. Until KSYME's official opening, its technician, Andreas Staphylopatis, had the opportunity to "thoroughly test" the UPIC in Paris.[17] In the summer of 1985 the UPIC arrived in Greece.

Although in KSYME's promotional material the Greek UPIC was said to have been presented in the "Xenakis Seminar" held in the Centre Acanthes in 1985, Staphylopatis specified that only parts of it were used, complementary to the two French UPICs brought to Delphi for the seminar.[18] The Centre Acanthes, participating in the European Year of Music, hosted "one of Europe's major events in contemporary music in 1985," a seven-week seminar in Aix-en-Provence, in Salzburg (in the New Mozarteum), and in Delphi, Greece (in Delphi's European Center). In Delphi, the first demonstration of the UPIC in Greece took place, even though it was not exactly the one KSYME had received that summer. Nevertheless, Xenakis's status contributed once again to bringing Greece into the spotlight during the European Year of Music, this time thanks to the promotion of this invention to dozens of European musicians in three different cultural destinations on the continent.[19]

However, a proper celebration of the arrival of Xenakis's much anticipated innovation in 1985 could not take place during the same period, even though the UPIC had already been received. KSYME was facing another problematic and pressing issue since its foundation: finding premises for its headquarters. Even though infrastructure was not the primary issue KSYME had to solve compared to its financial problems, the lack of a suitable place for its artistic and educational goals definitely contributed to delaying its opening. The search for such a location started immediately after KSYME's foundation, but due to its financial status and other misfortunes, it did not immediately bear fruit. The older HACM's and the newly founded KSYME's headquarters, both having Papaioannou's organizational signature, were intended to be housed together. Major plans for a Cultural Center in Athens appeared among the first solutions. Without a doubt HACM and KSYME were both considered part of the city's planned Cultural Center. They were also intended to be a part of a future Music Academy House. Xenakis's reputation expedited the proceedings and it was planned that the two music institutions—KSYME and HACM—would be temporarily accommodated in the basement of the Athens Conservatoire's new building, then under construction (also part of the Athens Cultural Center), until they could find a permanent home.[20] Xenakis, as the president and founder of KSYME, truly supported the plans to accommodate this Greek center in the future Athenian Cultural Center. In fact, Xenakis wrote to the president of the Hellenic Republic, Konstantinos Karamanlis, that "[he] was ready to contribute with [his] own power to the country's cultural reconstruction [...] by relocating [his] artistic and educational activities"; providing that KSYME would be a part of the Cultural Center, "[it would have been] an opportunity for the beginning of [his own] relocation to Greece."[21] However, the Athens Conservatoire's new building had not been completed yet, and it remains to this day an incomplete "monument" of contemporary Greek architecture.[22] Thus, KSYME continued to exist as a center without a physical presence for five more years.

Then, in 1985, after clearing customs, the UPIC was installed in Vassiliadis's famous personal studio in the Holargos suburb until it was transformed "temporarily" to accommodate all of KSYME's operations.[23] The center's opening ceremony took place on April 23 1986. Xenakis was present at the ceremony along with the Board of Directors. Not only did he demonstrate his own "Polyagogy," he also promoted KSYME's general goals, underlining the center's close relationship to the CEMAMu. Technicians from both centers were also present to support the opening of Xenakis's Greek center, Carmello Cappiello from the CEMAMu and Andreas Staphylopatis from KSYME.[24] Much publicity was given to KSYME's opening ceremony and Xenakis's visit to Athens, and the general public's introduction to the UPIC really caught the press's attention. In an interview Xenakis gave at the time, he presented the UPIC as a means of changing the traditional way of composing music into a "more approachable [procedure] that [was] interesting and not only for specialists [...] even for students of elementary school and kindergarten."[25] Further, KSYME's opening ceremony was held almost a year after Xenakis's proposal for the *Polytope of Athens* had been rejected by the Ministry of Culture.[26]

However, Xenakis's response to a related question in the same interview reflects a new beginning for him in Athens and a genuine interest in his Greek center at that time. He said, "I am intent on what I started, provided that it can be realized. [...] This year I came back because the Contemporary Music Research Center [KSYME] has interested me for several years now. We delayed [its opening] due to the lack of financial means and a location. I believe very much in this center. Besides, it is not something new; in France, the CEMAMu is operational since 1972."[27]

Nearly a decade later, Xenakis continued to promote the UPIC in Greece as a compositional and educational tool, even though he had stopped creating works with it at that time. Xenakis was interviewed by the famous Greek poet and writer, Titos Patrikios, for a documentary portrait of him by Dimitris Anagnostopoulos, and it is one of the very few times that Xenakis spoke in Greek about the story of the UPIC:

> *This inclination of mine to draw, not to write notes that are bothersome, dates back to the 1950s when I was sketching out music—albeit with great accuracy—and I was able to convert those drawings into performable notes. The idea was more general than notes. Notes are a descendant of a neumatic tradition, because music, apart from the ancient one which was somewhat alphabetical, later became neumatic. The hand rose and the pitch of the voice rose; it lowered, and the sound lowered, or the neume was like oligon [sic] in Byzantine music that indicated the same pitch. This was abandoned at the end of the ninth century in the West, while in Byzantium, it continued and still exists. Drawing, meaning the sketching of music, has deep roots and it is much more natural for a human to see a shape and describe whether the pitch rises or falls. This is how we learnt.*[28]

A large number of people (children, teenagers, and adults) came into contact with the UPIC at KSYME in Holargos, not only through KSYME's educational programs but also as visitors. Although KSYME's promotional material refers to an extremely large number of students, the center's diaries in which its full activities were recorded do not specify any number of works. However, KSYME's creation, its philosophy and goals, Xenakis's influence and presence, and the center's artistic activity all contributed to educate a generation of young composers in Greece, at a time when electronic music had not been introduced in higher education. During KSYME's first and fruitful years, many of them created works using the UPIC. In addition, UPIC's presence at KSYME's studios remained an inspiration, even after it stopped functioning. The electroacoustic

composer Katerina Tzedaki mentions that "UPIC's presence influenced in a certain way any compositional procedure in that space [KSYME's studio], not only by changing its acoustics, but as an idea, as a reassurance of the potentiality of approaching music in infinite time scales."[29]

This year KSYME celebrates its fortieth anniversary since its foundation. Interestingly enough, it has found its "permanent" home in the Athens Conservatoire building, along with its precious archives and equipment. In addition, since mid-2018, KSYME's and the Chourmouzios-Papaioannou Foundation's Unified Archives are being organized as a whole by the Center of Research and Documentation of the Athens Conservatoire, under the direction of KSYME's former colleague and Xenakis pupil, Haris Xanthoudakis. The Greek UPIC, even though it is not in use any more, has its own place for public display in the Athens Conservatoire as a part of KSYME's history. This article is the first effort to tackle KSYME's historical and artistic impact through research on the center's archival material, currently being catalogued. The entire research procedure led to the need for creating a catalogue of the works that featured KSYME's UPIC, which can be visited online at the center's official website.[30] This first attempt to collect all the works related to KSYME's UPIC remains a work in progress and demonstrates the tool's footprint on Greek electroacoustic music, and also on a significant part of KSYME's artistic and educational contribution to the county's recent music history

FOOTNOTES

1. Ioannis Tsagkarakis, *The Politics of Culture: Historical Moments in Greek Musical Modernism* (PhD diss.), vol. 1 (London: Royal Holloway, University of London, 2013), 147–148; Katerina Tsioukra, "The Concert Series of USIS and the Hellenic American Union in Athens during 1952–1959," in *1st Conference for Post-graduate Students and Young Researchers* (Corfu: Ionian University, Department of Music Studies, [publication of proceedings in progress]).
2. Twenty-two handwritten letters from Iannis Xenakis to John G. Papaioannou have been discovered at KSYME (CMRC)-ChouPaF Unified Archives. The first one was sent on 25.2.1956. ChouPaF stands for the Chourmouzios - Papaioannou Foundation (Emile Chourmouzios was the husband of the famous pianist Marika Chourmouziou-Papaioannou, therefore the brother-in-law of John G. Papaioannou). The ChouPaF archives comprise the archives of Emile Chourmouzios, Marika Chourmouziou—Papaioannou, John G. Papaioannou, and Nikos Skalkottas. KSYME and the ChouPaF have the same board of directors and currently share their headquarters at the Athens Conservatoire. In addition to its own "audiovisual", "administrative", "activity records", KSYME's archives also contain the archives of the Hellenic Association of Contemporary Music (HACM) and the Greek Studio for Electronic Music. The two sets of archival holdings have recently been unified.

3. Katerina Tsioukra, “The Concert Series of USIS and the Hellenic American Union in Athens during 1952–1959,” op. cit.

4. Even though the call of the 1962 Music Competition was for unperformed/unpublished works—until December 16, 1962 - *Amorsima - Morsima*, a work that has not been published and is not included in Xenakis’s current catalogue of works, had already been performed on May 7 and May 24, 1962 according to a handwritten analysis that Xenakis provided to the two jury teams. This fact was overlooked by John G. Papaioannou who was a member of both, the person responsible for all organizational issues and the one who corresponded with Xenakis giving him information about the competition. For a more detailed analysis on this issue see Katerina Tsioukra, “1962 Music Competition: Manos Handjidakis’s Prizes” (MA thesis) (Corfu: Ionian University, Department of Music Studies, 2018), 72–76, 85.

5. Nicolas Slonimsky’s and Brigitte Schiffer’s papers on presenting and promoting Greece’s modernism in music were highly influenced by Papaioannou. Especially in Schiffer’s case; she had developed a friendship with Papaioannou and had strongly supported his activities regarding contemporary music in Greece, such as the Hellenic Weeks of Contemporary Music and Xenakis’s Week. See Nicolas Slonimsky, “New Music in Greece,” in *The Musical Quarterly* 51, (1965), 232–233; Brigitte Schiffer, “Neue griechische Musik,” *Orbis Musicae* 1, (1972), 196–197; Brigitte Schiffer, “Xenakis Week, Melos (July, 1975),” 18, in Ioannis Tsagkarakis, *The Politics of Culture: Historical Moments in Greek Musical Modernism* (PhD diss.), vol. 1 (London: Royal Holloway, University of London, 2013), 201.

6. Papaioannou orchestrated the promotion of the life and works of Nikos Skalkottas, after the Greek composer’s early death.

7. Ioannis Tsagkarakis, *The Politics of Culture: Historical Moments in Greek Musical Modernism* (PhD diss.), vol. 1 (London: Royal Holloway, University of London, 2013), 194, 241.

8. As Stephanos Vassiliadis stated in an interview, after KSYME had commenced operations: Kostas Stratoudakis, “Polyagogy and Contemporary Hellenic Electronic Music, 1st Part,” in *Ichos & Hi-Fi,* 164 (1986), 36.

9. From a copy of a handwritten letter by Xenakis that was apparently sent to Konstantinos Karamanlis. Even though the original letter has not yet been located in the Konstantinos Karamanlis Foundation’s archives, nor in any other correspondence between them, it nevertheless demonstrates the views of the composer particularly regarding the cultural reconstruction of Greece. “Iannis Xenakis […] Κύριον Κωνσταντίνο Καραμανλή: Πρόεδρον της Ελληνικής Δημοκρατίας [Mr Konstantinos Karamanlis: President of the Hellenic Republic] [24.6.1980]” in KSYME (CMRC)-ChouPaF Unified Archives.

10. “Press Release: KSYME’s opening, Wednesday April 23, 1986, 12.00 noon: History,” p. 1, in KSYME (CMRC)-ChouPaF Unified Archives.

11. “Founding act and constitution” (September 20, 1978) in KSYME (CMRC)-ChouPaF Unified Archives.

12. “Press Release: KSYME’s opening, Wednesday April 23, 1986, 12.00 noon: History,” p. 2, in KSYME (CMRC)-ChouPaF Unified Archives.

13. “Centre d’etudes de mathematique et automatique musicales: Statuts” (1972). [Xenakis, Iannis. Auteur], “CENTRE D’ETUDES DE MATHEMATIQUE ET AUTOMATIQUE MUSICALES. STATUTS,” Centre Iannis Xenakis, http://www.centre-iannis-xenakis.org/items/show/728 [translation by author].

14. “Founding act and constitution” (September 20, 1978) pp. 1–2, in KSYME (CMRC)-ChouPaF Unified Archives. [author’s translation].

15. Στέφανος Βασιλειάδης: Βιογραφικό σημείωμα (*Stephanos Vassiliadis: Curriculum vitae*), http://composers.musicportal.gr/?lang=el&c=vasiliadis

16. KSYME’s Balance Sheets from 1981 to 1985. KSYME (CMRC)-ChouPaF Archives.

17. KSYME’s promotional material “Brief History of K.SY.M.E”, *K.SY.M.E* [ca. 1990], p. 6, in KSYME (CMRC)-ChouPaF Unified Archives.

18. Ibid; Kostas Stratoudakis, “Polyagogy and the Contemporary Hellenic Electronic Music, 1st Part,” in *Ichos & Hi-Fi*, 164 (1986), 38.

19. Henning Lohner, “The UPIC System: A User’s Report,” in *Computer Music Journal,* 10, (1986), 42.

20. “Pavlos Hatzithomas: Athens, September 10, 1980 […]” 391/1/10/5, p.2, in the Historical Archive of the Konstantinos G. Karamanlis Foundation.

21. “Iannis Xenakis […] Κύριον Κωνσταντίνο Καραμανλή: Πρόεδρον της Ελληνικής Δημοκρατίας [Mr Konstantinos Karamanlis: President of the Hellenic Republic] [24.6.1980]” in KSYME (CMRC)-ChouPaF Unified Archives.

22. ελc Team, Νεότερο Μνημείο χαρακτηρίστηκε το Ωδείο Αθηνών (13.10.2017) https://www.elculture.gr/blog/article/νεώτερο-μνημείο-ωδείο-αθηνών/

23. Vassiliadis’s personal studio was just a “temporary” solution, but ended up being the permanent home of KSYME until very recently.

24. “Contemporary Music Research Center (KSYME), POLYAGOGY: A New Path for the Creative Approach to Music.” Program notes for the opening ceremony on 23.4.1986, in KSYME (CMRC)-ChouPaF Unified Archives.

25. Elena Chouzouri, “Giannis Xenakis: Art Is the Liberating Power of the World,” in *ENA* (May 1986), 134 [author’s translation].

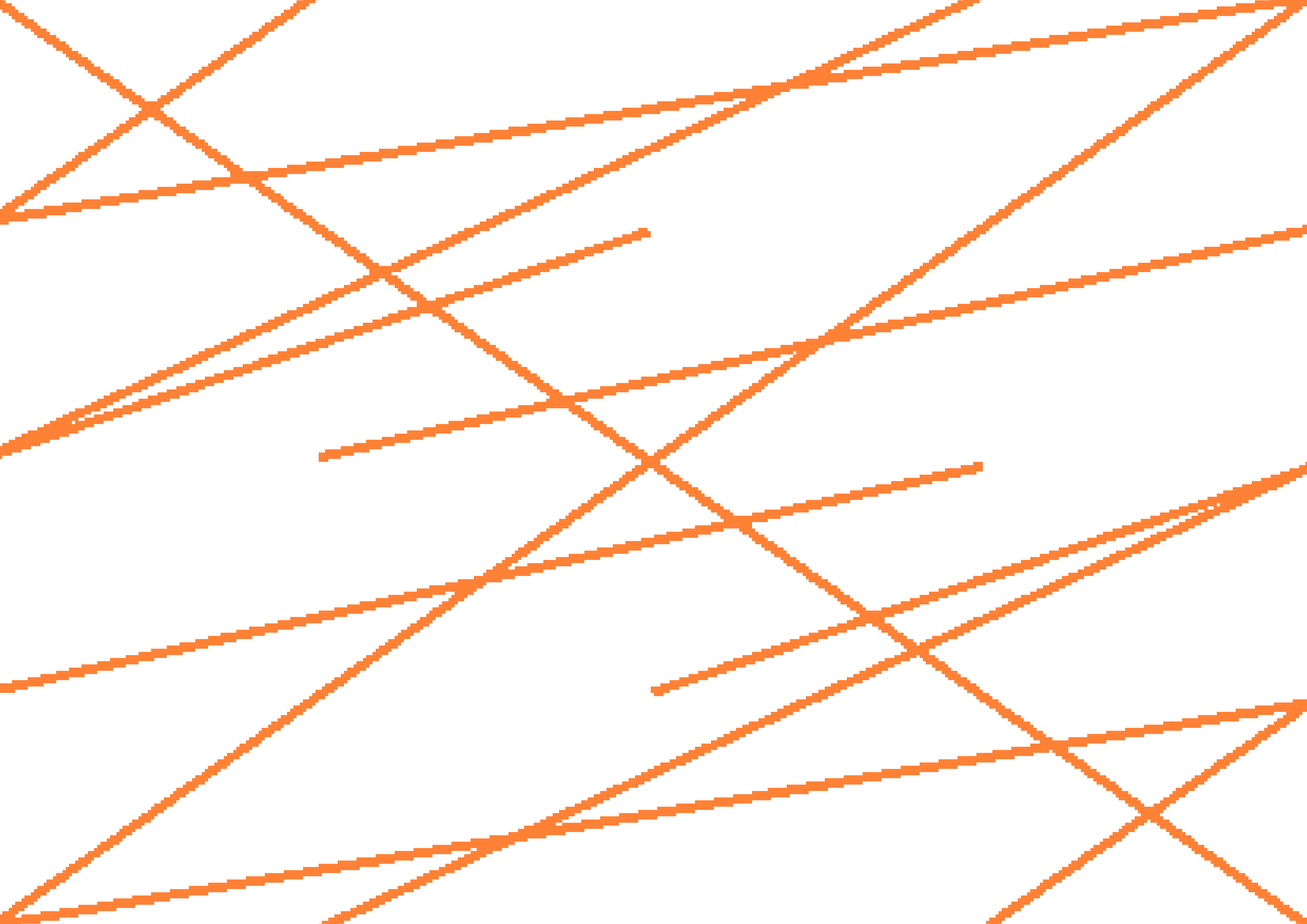
26. Ioannis Tsagkarakis, *The Politics of Culture: Historical Moments in Greek Musical Modernism* (PhD diss.), vol. 1 (London: Royal Holloway University of London, 2013), 237–239.

27. Elena Chouzouri, “Giannis Xenakis: Art is the Liberating Power of the World” in *ENA* (May 1986), 133 [author’s translation].

28. In mentioning the “oligon,” Xenakis was in fact referring to the “ison” symbol in Byzantine music. According to the Xenakis scholar Nikos Ioakeim, Dimitris Anagnostopoulos’s documentary on Iannis Xenakis was produced in 1995 and was broadcast by National Television. Some years later the documentary was also broadcast by the Hellenic Parliament TV channel with the addition of several other clips on Xenakis. After contacting the personnel of both channels, neither version of the documentary has yet been located, neither in their archives nor even in their catalogues. For the purpose of this chapter, the author has located the second version of this documentary online. https://www.youtube.com/watch?v=ezU4vR50m2Y&feature=youtu.be [excerpt can be found at 44:33– 47:00]

29. Personal communication with Katerina Tzedaki on March 29, 2019.

30. *UPIC*, https://www.ksyme.org/upic.html



KSYME:

THE UPIC IN GREECE—TEN YEARS OF LIVING AND CREATING WITH THE UPIC AT KSYME

DIMITRIS KAMAROTOS

KSYME: THE UPIC IN GREECE—TEN YEARS OF LIVING AND CREATING WITH THE UPIC AT KSYME

1978 AND AFTER

I first saw the UPIC unit installed at KSYME[1] a few weeks before the official opening of the center. That was in early spring 1986. FIG. 1 It was just a few months after I had returned to Greece after studying music in Paris for eight years. During those years of university, with instrument and composition studies, I had the opportunity to attend concerts of Xenakis's music and most of his lectures at the Université de Paris I.

It was much earlier, in September 1978, that I became very interested in his music, writings, and ideas. I participated as a volunteer in the setting up of his *Mycenae Polytope.* In southern Greece, on a hill close to ancient Mycenae, a huge sound system was installed to playback electronic music tapes, with microphones for acoustic instruments played by amazing soloists and voices, as well as lighting effects using huge anti-aircraft searchlights. During the interpretation of the piece, herds of sheep and goats with bells were moving across the neighboring hills and naturally mixing their sounds with percussion, solo voice, choirs, and electronic sound. The electronic composition was created at the CEMAMu with a first version of Polyagogia, a prototype, the first generation of the UPIC. All of these elements were parts of a music composition with colossal sound and spatial dimensions. Although I was participating by doing small things for the production, I had the opportunity to see and listen to Xenakis, the musicians, and the organizing team. Being close to the creative team, in combination with the event itself, made this experience one of the most influential and inspiring in that period of my life.

During those days, close to Xenakis and to the project, were two important figures who I met and worked with later, after my return from France and when I began working at KSYME with the UPIC. Xenakis himself refers to them in the credits of the *Mycenae Polytope* program as follows: "But nothing would have happened without the tireless interest and the long-range effort of my friends John G. Papaioannou and Stefanos Vassiliadis, who coordinated everything within and outside

DIMITRIS KAMAROTOS

FIG. 1 The UPIC installed in the KSYME studio, May 1986 © Dimitris Karageorgos

Greece with such devotion and love."[2] Immediately after this experience with Xenakis's *Polytope*, having just finished my studies in Greece, I was preparing to continue my music studies in Paris. My ideas about what music actually was were broadening every day, and already I had planned to study a combination of subjects: music composition, musicology, and computer science. At that time (end of the 1970s), computer music was not yet a distinct area of study neither in Greece nor in France. In the years to come, in parallel with my studies in France, my inspirational relation with Xenakis's music was mainly centered on his ideas and less on his music. I was studying with Daniel Charles and my ear was leaning more towards John Cage and less to the abyssal—as they sounded to me then—clusters that Xenakis was creating in orchestral and solo instrumental works. Nevertheless, some situations and events turned my attention back to his music again.

First and incidentally, my composition teacher, Émile Damais, did not consider Xenakis a "real" composer, but rather an "illusionist" in music. That had the exact opposite effect on me: it revived my interest in Xenakis's music! On the other hand, a new age of frenetic developments in computer music was happening, especially concerning industrial production and design of hardware and software. So, when I heard from Xenakis himself about the new UPIC system, I was captivated by the idea of an "all-comprising" audio processing unit. It promised a unified field between sound generation and music composition, a concept that was directly emanating from his ideas.[3]

EXPERIENCE WITH THE UPIC IN FRANCE AND IMPLEMENTATION OF THE UPIC SYSTEM IN GREECE

FIRST YEAR: PERSONAL IMPRESSIONS AND RESPONSIBILITIES

Once in France, I contacted the CEMAMu, visited it, reserved time there, and was finally able to work with the system. Unfortunately, these first contacts were inconclusive. The time I had with the UPIC system was limited (around 30 min per session); moreover, the machine itself was notoriously slow. As a result, there was no time really to set a goal and achieve some progress. Not only a whole composition was impossible, but even a moderately complex sound structure or experimenting with an elaborate sound wave were beyond reach. I was used to working in university studios with ample time and numerous recording possibilities, something that did not exist at CEMAMu.

PASSAGE FROM IRCAM

By the end of my studies in Paris (1984–85) I had been given the opportunity to work at CEMAMu's "rival" IRCAM with the 4X machine.

Marc Battier and Horacio Vaggione, two composers I had met and worked with at the Faculty of Paris VIII, helped and supported me in this venture. I was invited, as a young composer, to create a new piece. I had a short introduction on how to handle, boot, and reset the system, and was given a personal external hard drive to store my work, and I even had the possibility to write small parts of code in order to program some new functions. To control the 4X, I used a highly practical and innovative hardware interface called Pacom. I was offered many nights a week for two months: I was alone with the machine from 10 pm till the following morning (if I so desired). This, plus countless espressos from the automatic coffee machine, was something equivalent to heaven for me at the time! As a result, I was able to create a new piece that was premiered at IRCAM's venue, Espace de Projection. That ended up being something much more comprehensive, regarding a system and its musical abilities, than the limited experience I had had with the UPIC.

REDISCOVERING THE UPIC IN ATHENS

Although inconclusive, the first sessions with the UPIC had nevertheless been promising, and unexpectedly continued the following year when I was back in Athens. The announcement about the opening of the KSYME, and the installation of a UPIC unit, was lauded in every newspaper and newscast for days.

In parallel, there was a lot of discussion about the system's possibilities, the pertinence of electronic and computer music, costs, and so on. Then, Xenakis himself arrived in Athens for the official opening. Shortly prior to this, KSYME launched a rather modest call for composers. This call came from the two influential people mentioned above: John G. Papaioannou and Stefanos Vassiliadis. Stefanos was the general manager and artistic director of the Centre. He planned to get acquainted with and eventually to bring all the Greek composers he could to the Centre, especially the ones oriented on and educated in electroacoustic, electronic, mixed, and computer music. Hence, in March 1986, I was at KSYME with my résumé and my music: some tapes of instrumental pieces, analog electronic compositions, scores for small ensembles, and the piece I had composed and produced at IRCAM. The few hours of experience I had had with the UPIC at the CEMAMu seemed to be an important factor, because the one in the Athens studio was an exact copy of it (hardware and software).

From my discussion with Vassiliadis I acquired some new information concerning the relationship between KSYME and Xenakis and the personnel already at KSYME. Also, I was briefed on some technical issues about the unit. I learned that the idea to create the Centre, bring the UPIC system to Greece, and equip a full creative sound studio around it had been under discussion for some time (since the *Mycenae Polytope*), and major efforts had been underway over the previous five years to make it happen.[4]

MEETING THE PEOPLE

During the following month, I had the opportunity to meet and start working with some of the principal collaborators of the years to come. In particular, Haris Xanthoudakis, the other Greek composer who had studied in France and had just arrived back in Greece. He, too, had experience with the UPIC at CEMAMu. I also met Andreas Stafylopatis (professor at the National Technical University of Athens computer science department). He was collaborating closely with CEMAMu and KSYME at this time, and carried full responsibility for the technical installation of the unit in Greece. Thus, he assured the technical link connecting the two institutions. FIG. 2

FIRST PHASE OF KSYME

After the official inauguration on April 23 1986, we began to hold regular and informal meetings in the Center to organize upcoming activities. Following the recommendations of Vassiliadis, some first responsibilities were delegated. It seemed very important to develop a platform to get active groups of composers and musicians interested in learning, working, and creating with KSYME's new UPIC system. Xanthoudakis and I were responsible for formulating a call and drawing up a first syllabus for composers interested in working with the system. More specifically, Haris focused on mixed composition (acoustic instruments and the UPIC), and I on more computer-based and structural compositional matters. For these first courses, I was interested in including some basic ideas from Xenakis's book *Formalized Music*, and also in not just giving practical instructions, but also adding some technical notions on the UPIC's unique design: a system that permitted unified compositional thinking from micro-form, (such as designing a sound wave), to macro-form—a music creation system capable of producing both sound textures and musical forms. A tool permitting the transformation of a mathematical abstraction into musical form[5], a system that, as I discovered much later, potentially enabled the user to transgress sound material[6], a basic concept that could end up breaking some rules incorporated and formally prescribed in Western composition over a number of centuries. This potential of transgression, I now believe, was always present in the core of Xenakis's music.

During the first months, I developed a closer collaboration with Andreas Stafylopatis. This was partly due to the fact that I had some knowledge and practice in computer programming, and in particular for

FIG. 2 Andreas Stafylopatis and Iannis Xenakis, April 1986

sound generation and processing. Another important reason was that I had become extremely interested in discovering more about the UPIC and its possibilities. Hence, I spent most of my time at the Centre.

By September 1986, Stafylopatis had completed the first user manual of the KSYME UPIC in Greek. It was a detailed 20-page document, covering:

1. Startup and Shutdown processes
2. Functional description and Operations
3. Saving and Loading

This manual, although well structured and adapted to cover the system's particularities, was still considerably complex for traditionally trained (non-technically oriented) composers. Over the years, working with three generations of composers in the KSYME studio, this manual was of little use to most of them.

One reason why many surprising technical difficulties for the users remained after their first contact with the system was due to the influence of how the system was promoted: as an intuitive, non-technically inclined system encouraging creativity. People were promised they would be able to make music, or at least complex, interesting sound structures without any knowledge of computers, or even music. This was what the media proclaimed when the UPIC was first announced at KSYME. Further, this was derived from Xenakis's own comments on the system, after a filter of over-simplification was applied to his words by journalists. Being responsible for the courses with composers, and later for the special program that introduced primary and secondary school pupils to the system, I retained this same line of presentation when working with the system. Consequently, I presented the main functionalities of the system as a music-making machine open to free, impulsive, and associative experimentation, at least to very young future composers. For adult musicians and composers, I emphasized and encouraged them to use modelling: get an idea to comply or to try to formalize an existing one through mathematical, graphical, trigonometrical, physical, or musical implements. This approach opened new horizons for some of them who had previously only had traditional, classical-oriented musical training.

For the first six months or so, we experienced several malfunctions with booting, saving, and the handling of data. Soon afterwards, though, some of these problems became rarer, after numerous subsystem and main program updates resulting from our collaboration with CEMAMu's engineers.

THE CREATIVE STUDIO AROUND THE UPIC SYSTEM

In the first days of the UPIC at KSYME, a sound studio was equipped and set up to add functionality to the UPIC. This studio was not a formal recording studio, but it nevertheless offered a lot of potential for creative work.

The location, however, was not ideal; it was an apartment that belonged to the director of the center, Stefanos Vassiliadis. KSYME occupied the ground floor of a multi-storey apartment building in a densely populated Athens suburb. It was insufficiently insulated, yet convenient for the flow of a large number of people at any time of the day as it had a separate entrance and none of the adjacent apartments were inhabited.

This sound studio was, in a way, a second-generation music lab after the one that existed in another basement in the center of Athens during the 1970s, the ΕΣΣΥΜ, the Hellenic Association for Contemporary Music, whose studio was built around a prominent EMS vSynthi-100 unit. This older studio had some of the equipment which the UPIC—KSYME studio inherited: Revox tape recorders, hardware audio filters, patch-bay, oscillometer, and two EMS VCS3 analog modular synthesizers. Additionally, there were some newly purchased tape recorders, studio monitors and mixers, a number of microphones, headsets, and all kinds of cables. During the next year, as soon as they appeared on the professional market, CD and DAT digital recorders were purchased.

It is important to note something concerning the creative profile of this laboratory: although the main unit was the UPIC, there were a lot of combinatory capabilities using different techniques. That gave the studio a profile closer to a university music faculty studio than to a dedicated one-unit laboratory. This resulted from decisions regarding the equipment made by the artistic manager Stefanos Vassiliadis. It also had to do with my personal inclinations as an active member of this team. This kind of open-minded view on music creation through different media, systems, instruments, and styles was something I preferred and aimed for. These technical characteristics of the initial UPIC—KSYME lab seemed to me to be close to Xenakis's idea of an open creative system. The multifunctional environment of the studio was shaped around the same principles, but in a modular way, equally using new digital and older analog equipment. This mind set of a "no-simplicity, no-clarity, no-minimalistic" approach to compositional tools, in opposition to an intense search for clarity in form and the resulting composition, was something that captured the attention of many young composers I was working with during the first years of the UPIC—KSYME lab. Over the next ten years, it also shaped the proposals and the completion of educational and research programs by KSYME. In parallel, dedicated activities concerning creation and education exclusively with the UPIC coexisted.

THE FIRST SET OF ACTIVITIES

The first educational and creative programs took shape during the next six months of 1986:

1. Call for young composers to attend UPIC workshops with the option to reserve time later for music creation;
2. Personalized communication with older composers who had already worked with mixed and electronic media (such as tape and instruments or analog electronics). Inform them about the existence of and the options concerning the UPIC and the opportunity to work with it. Invitations to foreign composers for residencies at KSYME to work with the UPIC;
3. Call for musicians to contact the center in order to establish a music ensemble specialized in mixed compositions with the UPIC (instruments and tape);
4. General call and personal communication with scientific collaborators for the creation of groups focusing on research proposals and consortiums;
5. Collecting and making available all documentation and support for the system's technical functions. Investigating technical improvements of the UPIC and the supporting studio.

In the following months, some of the goals began to develop and became the center's main activities.

COMPOSERS' WORKSHOPS

A call for young composers was issued at the official opening and was renewed via the media from time to time over the summer. Many music students and about ten young composers expressed interest and started attending the workshops as of May 1986.

In these workshops there was a short introductory technical course with Andreas Stafylopatis and then courses on theory and practice. The prescribed time was about 12 hours per week, but in practice this expanded into much longer because some students asked for and had extra personal time with the system. Not all of them were equally motivated, so giving some of them personal assistance seemed to be more efficient, either individually or in small groups of two or three. Their technical ability with the system advanced gradually, and the young music students and composers became more confident with the UPIC. Personal studio time during this period was mainly granted at night.[7] In parallel, I was achieving a more profound appreciation of the system's potential. These courses continued over the years in the lab, but also in external workshops when the unit was travelling.

One important element in these educational and creative activities was the system's processing time. Even for a relatively experienced user, that is, without creating anything that would uselessly slow down the machine, the time required for computation was by today's standards unbearable. In practical terms, depending on the complexity of waveforms and the density of lines in the macro-form (arcs on timeline), it could take from half an hour to several hours to create and listen to a few minutes of recordable sound. It was not unusual for inexperienced users to make a wrong choice of parameters. In such cases, the waiting time could end up producing something unexpected or simply unusable. The slowness of this version of the system never changed throughout the years. From the very beginning we were all hoping for a faster system; what we used to call an "accelerated version." In the summer of 1987, I had the opportunity to discuss this matter directly with Xenakis. This disadvantage of the UPIC at KSYME was never eliminated nor improved, although the next generation UPIC[8] was remarkably faster and capable of some parallel functions during sound calculation. For this same reason, some practices were suggested during the workshops and a few others were invented by the composers themselves who worked with this system. In particular, two choices were proposed to the composers in order to best use the available time:

- Use of loops. Whenever the sound did not change for some time, a properly edited loop of prerecorded material was preferable to extra processing time.
- Use of handmade sketches of the macroform, if possible, on a 1:1 scale. This gave the possibility of thinking and discussing the form and its possible result before entering the processing mode. **FIG. 3**

While calculating sound, if some given parameters were wrong (out of domain), there was a big risk of the system defaulting into an endless calculation loop. Undoubtedly, these considerations influenced the creative results.

The first workshop ended on September 6, 1986 with a first presentation of resulting compositions. Haris Xanthoudakis and I then started collaborating on the syllabus and management of the next courses.

During the second workshop of the first year, courses were also given by Andreas Stafylopatis, the composers Vangelis Katsoulis, Minas Alexiadis, and Costas Moschos, the acoustic engineer Gottfried Schubert; and the director of KSYME, Stefanos Vassiliadis.

From such activity and creative workshops, some young composers created their first electroacoustic or purely electronic music pieces, notably: Akis Daoutis, Nikos Poulis, Takis Velianitis, and Spyros Faros.

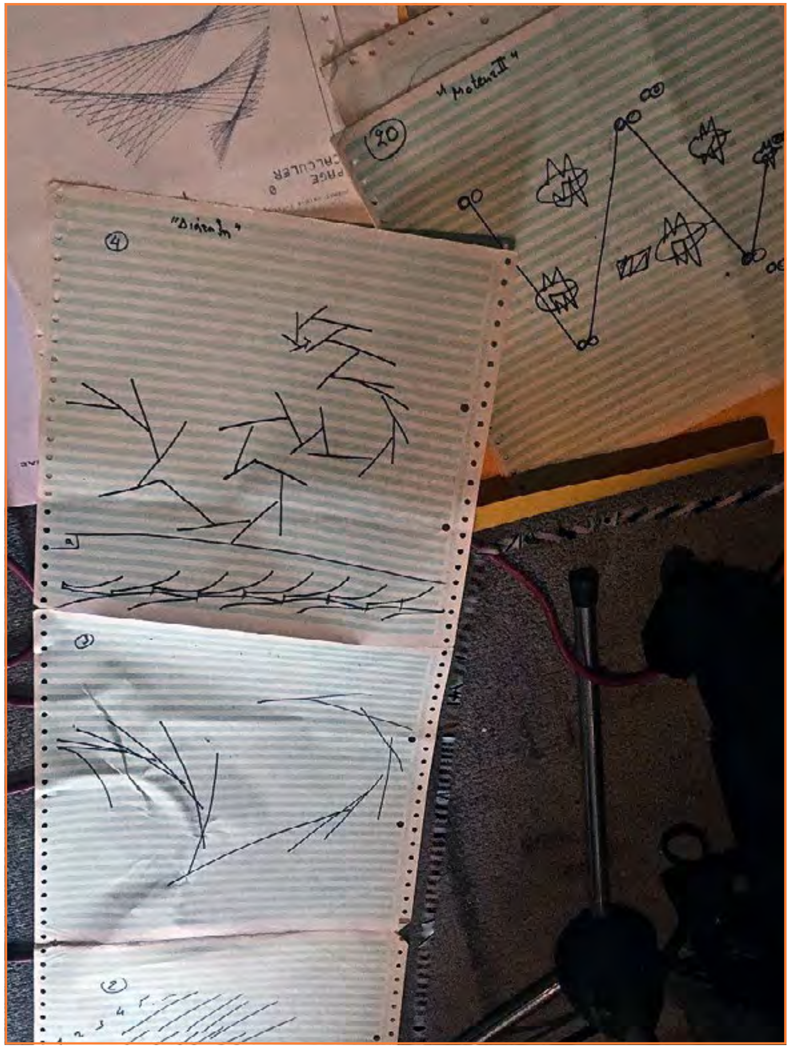


FIG. 3 Pre-sketched material for the author's *Intermediary Space*, UPIC composition 1986 © Dimitris Kamarotos Archive

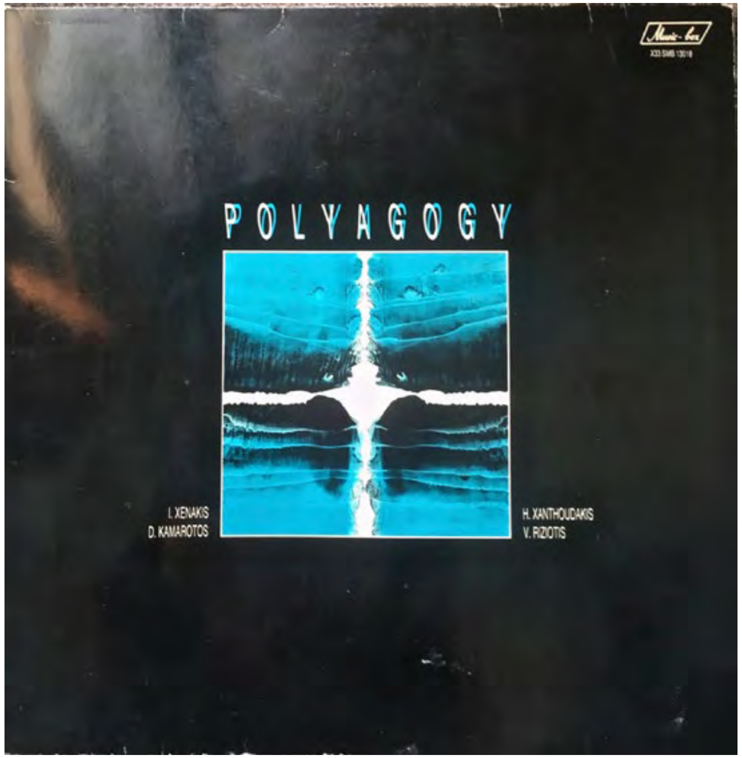


FIG. 4 The *POLYAGOGY* LP with four compositions, by Xenakis, Xanthoudakis, Riziotis, and Kamarotos, 1987, Music-Box-records X33SMB13018 © Dimitris Kamarotos Archive

Just before them, three first works by an older generation of composers were completed by Haris Xanthoudakis, Vassilis Riziotis, and me. These first creative results were presented in concerts over the following months.

In October 1986, while a second series of courses on the UPIC was underway, three commissions for new compositions using the UPIC were granted to V. Riziotis, for tape and piano, H. Xanthoudakis for tape, and me, for tape, clarinet, double bass, and piano.

These new creations were presented in April 1987 at the Goethe Institute of Athens, recorded and released on LP.[9] FIG. 4

COLLABORATING WITH EXPERIENCED COMPOSERS

We contacted well-known Greek composers who were interested in or already using electronic sound in their compositions. Of these, three were particularly involved: Michalis Adamis, Nikos Mamangakis, and Nikiforos Rotas. I contacted them personally and assisted them with various activities around the UPIC system, the KSYME lab, and computer music in general.

Especially Michalis Adamis and Nikiforos Rotas continued to be interested and used new compositional, computer-based tools, even after the functional period of the KSYME—UPIC system ended. I continued to visit them in their personal studios and followed their involvement with new technologies during the 1990s. They experimented with the first UPIC-generated sounds, and later continued with the NeXT system of KSYME and Mac computers (more on that below).

We must not forget a fourth important Greek composer who was interested in and creative with the UPIC: Stefanos Vassiliadis, who, besides being a very productive analog electronic music composer and personal friend of Xenakis, also inspired and supervised most of KSYME's activities.

In 1987, two foreign composers were invited for a residency at KSYME to compose using the UPIC: Iván Patachich (Hungary) in June 1987, and Thortseinn Hauksson (Iceland) in November 1987.

From November 11–20, 1987, a special workshop and concerts were organized with Daniel Kienzy, French saxophone soloist and composer. He experimented with students and composers at the KSYME lab and demonstrated possibilities of his instrumentally produced textures combined with the sound of the UPIC.

FORMATION OF A MUSIC ENSEMBLE

Many professional performers were invited for sessions and participated in recordings and concerts. I was particularly interested in creating a small, resident, contemporary music ensemble that would be available for mixed compositions with electronic parts made with the UPIC system and acoustic instruments. Any real-time processing of instrumental sounds was impossible at that time because of the design of the system and its computational capabilities.

But even without real-time capability, during the first years of the UPIC at KSYME, a research project with a music ensemble was created, with the acronym title: "ΠΡΟΣ."[10] For four years, many musicians joined this group and some of them participated in most of the concerts and studio research sessions.[11]

SCIENTIFIC COLLABORATION: RESEARCH PROJECTS

From the first months after the opening of the center, many members of the scientific academic community became interested. They were involved in formal research projects and activities.[12]

THE RESEARCH PROJECT "HXE"

During the years 1986–1994, research projects were conceived, proposed, and realized at KSYME. Most of them were related to the UPIC system in collaboration with other research partners. A significant project was proposed to and endorsed by the Ministry of Education in 1989, called *HXE*. (acronym in Greek for *Sound Map of Greece*). Its intent was to research tools for automated comparison of sound patterns using a sound data base composed from rural soundscapes around the country. A research consortium was created with KSYME, NTUA, and ERT.[13] Xenakis was particularly interested in this project; formally, he was a scientific advisor of the program and wrote a letter to congratulate the National Secretary for Research and Technology, Perikles Theoharis, for endorsing the project and to affirm his own support for the goals of the research.

In this research project, Elias Koukoutsis was the scientific coordinator for the NTUA and I represented KSYME. The project fulfilled different tasks and deliverables over three years. A first large database with sounds from non-urban sites was created, based on numerous recordings from all over the country. The first tools of automated sorting were based on a codification of each sample's name. In a second phase, sorting was based on digital information on the header of every sample file; in a third phase, an attempt was made to directly compare patterns of extracted data from every sample. In its final phase, the plan was to integrate the results with the new real-time version of the UPIC. This did not happen because KSYME never acquired the new version of the system. Instead, a new application was designed and delivered, in a Windows environment as a GUI for the handling of the map related to the database of sounds.[14]

TECHNICAL SUPPORT, DOCUMENTATION

KSYME's UPIC was documented and maintained functional for about ten years by Andreas Stafylopatis. During that operational period few people could perform the basic commands to reboot and restore the system in the event of complications. In parallel, great efforts were made to remain informed, prepared, and to search for funding to upgrade our UPIC to the new real-time version.

THE EDUCATIONAL PROGRAM FOR YOUNG STUDENTS: A VALUABLE EXPERIENCE WITH SOUND AND MUSIC USING KSYME'S UPIC

The concept of the program was a practical experiment based on Xenakis's ideas about universality and humanistic use of research on sound. In December 1986, with Xenakis in Athens, a new program of the UPIC—KSYME lab was announced in collaboration with the Ministry of Education. This activity consisted of opening the KSYME studio to groups of young people so that they could come in contact with the expressive capabilities of sound and experiment with the UPIC. At the press conference, Xenakis remarked: "This opportunity for young people to come to the center to learn about and play with sounds is as valuable an experience as visiting the Acropolis or the National Museum."[15] The program was co-organized with the National Secretariat for the Young Generation. I undertook the coordination and a large part of the teaching. The UPIC—KSYME lab was available for one year, three times per week, to groups of young people. There were two different age groups: 10 to 15 years old and 15 to 25. In practice, due to demand, it was extended for a second year, and the vast majority of the groups were from 10 to 16 years old, mainly school classes. That created a major problem because the activity had been arranged for groups of maximum 10 people. After the second month, we had to divide the larger groups into two or three sessions. A total of about 4500 young people in this age group came to the UPIC—KSYME lab over these two years. The program we devised consisted of a short introduction showing, through examples, how sound can be a flexible expressive medium. Then, a second part consisted of a demo with functions and structures of the UPIC. The third and most important part was to form small work groups, define an achievable goal, and create a sound structure with the system. The duration of each course was 3–4 hours. I hired two or three assistants from the group of young composers already working in the lab, mainly to help me with the third part of these sessions that involved many groups working in parallel. My experiences of this sensitive and demanding job were multiple and rich: I often was surprised by the genuineness of these young creators' imaginations. Their ideas about sound were, in

FIG. 5 Young pupils with the author, working with the UPIC, 1987 © KSYME (CMRC) — ChouPaF Unified Archives[16]

many cases, unanticipated and their collaboration in groups (from 2 to 5 people), both impulsive and rewarding. One frequent thing the youngest did was to make a simple sketch of a familiar machine (a car, an airplane) or something imaginary (a robot, a rocket). Since I was giving them this possibility under the arc design function, a different sound texture was produced each time. As a next step, they were given the possibility to prepare a simple page with one horizontal line we called "horizon" and some short lines we called "birds." Then, with pre-chosen waveforms, we obtained some seconds of sound (30–40 sec), which often motivated them to experiment in other directions. A common observation was that after four hours of working, we were just starting to find good communication and interesting interaction. Unfortunately, the program provided only a single session per group. Once again, the system's inability to produce sound with shorter computational processing time was a serious disadvantage. However, the benefits of getting the children to think, discuss, use a computer interface, all together, cannot be underestimated. FIG.5

THE UPIC-LAB USED BY A NEW GENERATION OF GREEK COMPOSERS—IMPRESSIONS AS MANAGER OF THE PROGRAM

The first call for young composers interested in working with the UPIC was particularly appealing because no fee was charged for this. That created some extra work—reading all the applications and in many cases, some extra interviews—before making the final selection. In all cases, there were more candidates than available places on the courses. During the first months, this was extremely demanding because of the small number of people working at the center. There was a much larger group that supported the center in many and necessary ways (administration, public relations and relations with the ministry, relations with educational institutions) but the day-to-day operations relied on just four or five people. Soon, however, this changed. Within six months, a much larger group was taking on and exchanging functions of different responsibilities.

We had administrative meetings whenever possible, certainly more than once a week. At these meetings, Stefanos Vassiliadis was always present, helping to keep everything running. The only meetings without him were some technical sessions with Andreas Stafylopatis and Achileas Aggelidis.[17] Another important person who followed the first steps of the newborn UPIC studio and became increasingly involved, participating in concerts and research projects after 1990, was the Byzantine chanter and musicologist Lycourgos Angelopoulos.[18]

In terms of selecting young musicians (composers and students of composition), we took great care to create homogeneous groups, with regard to their level in music theory and acoustics, their experience as composers, and their ways of approaching compositional subjects. This was not always successful; nevertheless, such differences created very interesting dynamics within groups. The overall concept was to create small groups working on:

- General knowledge—quite basic—of sound and acoustics.
- Reference to compositional techniques and principles that could be valid for both electronic and instrumental sound.
- General description—schematic—of the UPIC system, with emphasis on Xenakis's concept behind it.
- Practical instructions to get them prepared to work with the UPIC.
- Also, practical instructions on how to work with analog audio signals in the studio.

This last point, although it might not seem so, was absolutely essential. In fact, every successful use of the UPIC system, producing anything from a simple waveform to a complete sound structure of several minutes, needed to be properly recorded. There was no capacity to store sound within the system, just values of parameters on huge floppy disks. **FIG. 6** The only way to get the material was to pass through patch bay, filters, effects, and studio mixer to end up with good quality sound on stereo tape. This, for most of the users, was not an obvious procedure.

More significantly, after two years, the composition and electroacoustic music class was established at the Athenaeum Conservatory of Music, **FIGS. 7, 8** Although the Conservatory was not formally related to the UPIC—KSYME studio, it had great importance for us. We were the same people teaching at both institutions (with a different syllabus). Besides compositional matters, the courses of this new class covered studio techniques, sound processing, editing, and recording. Many of the students were already working with UPIC and others came to KSYME during the following years to work with UPIC. In this way, the average technical knowledge of studio sound reached a higher level and working in the UPIC KSYME lab was more easily directed into music creation.

The last and most decisive part of the workshops with young composers in the UPIC KSYME lab was the personal creation of a complete composition. We worked together mainly at night, assisting composers one by one to create their first piece with the system. This is how the first group of composers finished their works, which began to appear over the following six months. There were many ways of presenting the works of this informal group, a group that over the following five years involved 30 to 40 young composers and musicians as well as 10 to 15 composers of older generations. These presentations and concerts took place at some of the main venues in Athens for contemporary and electronic music (such as The Pallas venue, Goethe Institute, French Institute, Greek-American

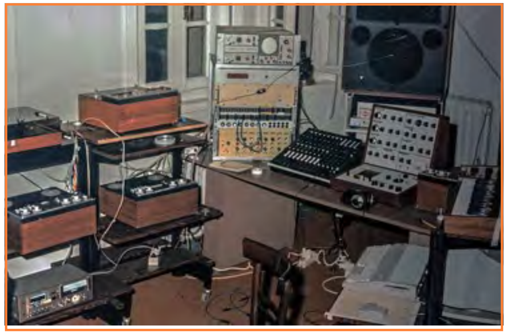


FIG. 6 Double density, double sided, 8-inch floppy disk used by the UPIC © Dimitris Kamarotos Archive

FIG. 7 Opening of the electroacoustic composition class in the Athenaeum Conservatory, Nov. 1987, with: H. Xanthoudakis, G. Papaioannou, S. Vassiliadis, D. Kamarotos and I. Xenakis © KSYME (CMRC) — ChouPaF Unified Archives

FIG. 8 The analog studio of the electroacoustic composition class in the Athenaeum Conservatory, 1988. The studio was equipped by KSYME and functioned with courses and studios for composers working with the UPIC. © KSYME (CMRC) — ChouPaF Unified Archives

FIG. 9 Before an electronic music concert in the Eymaros gallery, 1990, with composers T. Velianitis, D. Kamarotos and D. Karageorgos © KSYME (CMRC) — ChouPaF Unified Archives

Union, and later, the Megaron Athens Music Hall), but also in more informal concert spaces. Many of these events combined speech (text, poetry), video creation, and visual arts (modern sculpture and design) with electronic tape music. Two of these spaces staged around 30 different events with works composed on the UPIC between 1989 and 1991[19]. FIG. 9 Another of these concerts took place in the ancient planetarium of Athens during the first Athens Conference on Psychoacoustics.

Over the following years, these educational activities became much more organized and were frequently offered as part of specific programs. Two of these programs or courses were adapted and financed by the Ministry of Education:

1. *Emmeleia* Course (1988–1992)
   For 45 young musicians and composers. The course aimed to enrich and intensify the study of writing music with new digital tools and of studio techniques as a part of a creative compositional process, music production, and music education. In this course, learning and working with the UPIC was a basic requirement.

2. The *Chroai* Course (1990–1992)
   For 45 young musicians and sound engineers, devoted to the digitization of sound archives, old scores, Byzantine traditional music writing, and digital techniques for comparative processing.

Lycourgos Angelopoulos directed the Byzantine music part of this program. The UPIC was used in a very specific way in this educational program: to imitate and reproduce, with simple synthesized sound, the extremely elaborate microtonal movements of Byzantine vocal traditions. This kind of vocal expression is called *melisma*. We elaborated a protocol to analyze these small recorded vocal parts and then imitate their movements with the UPIC. Then, these patterns were saved as models in a special database. The *Chroai* course was funded entirely by the Ministry of Culture, not only the teaching, but also the equipment, field research, and even some monetary compensation for the student collaborators.

As mentioned above, after 1990 the use of computational tools with better performance was urgently needed. In parallel with the research projects and collaboration of KSYME with universities in the USA, a NeXT system was acquired.[20] After this, all projected research and educational activities were adapted to this environment. Nevertheless, composers continued working with the UPIC system at KSYME until 1995/1996; they mainly produced small parts or samples created with the system and integrated these into more complex compositions.

SOME TECHNICAL ISSUES AND PARTICULARITIES OF THE SYSTEM, POSSIBLE OPTIONS TO DEVELOP THE SYSTEM AND COLLABORATION WITH TECHNICAL STAFF AND PARTICIPATION AS THE UPIC SYSTEM MANAGER

There were some special technical characteristics of the system that a user interested in producing sound had to take into consideration. In particular, saving work while working was a very important part of the process. Although this was formally possible, it was practically unattainable. The external floppy disks (8-inch double sided, double density) were rather difficult to find. Only one company in Athens was importing these floppy disks which were used by the aviation computers of Olympic Airways. They were quite expensive and their capacity, although large for the time, was not sufficient to save considerable parts of a work. One would need 2–3 disks to save just one minute of sound. Few people used these disks, and when they did it was to save parameter values—code, design of waveforms, and partitions—rather than sound. (By way of comparison, 5 or 6 years earlier, when I was working with IRCAM's 4X, I had been given a huge hard disk (diameter: ca. 50 cm) that was capable of storing most of my work in sound per session (up to ten minutes of 44 kHz stereo sound).

Besides this difficulty of saving work, there was another important functional problem when working with the UPIC, which had to do with the capacity of the main memory storage. The capacity of the machine's internal disk was 35 Mb. Depending on the complexity of waveforms and the design of music structures, this corresponded to something like 10 min of sound or much less if very complex. Because of this, unused material could never be left on the internal disk when working with the UPIC because "<E$PACE ....>" was likely to appear on the TeleVideo monitor. **FIG. 10** This meant that the last few hours or so spent waiting were all for nothing, because the machine would crash and need rebooting, so everything was lost. The use of this internal disk as intermediate storage during processing was part of the code. Changing the capacity of the internal disk would only have solved the problem if parts of the software were rewritten as well.

All unexperienced composers, young and old, needed assistance. In order to avoid receiving very late-night distress calls at home, I Scotch-taped a photo from the first *Alien* movie to the inside panel of the system, the one that had to be opened to check if it was actually still in processing mode. I added a paraphrased line from the movie, which said (in Greek): "Deep in the night, at KSYME, no one can hear your screams!" I was amazed to see that this relic is still there, inside the door of the central processor. **FIG. 11**

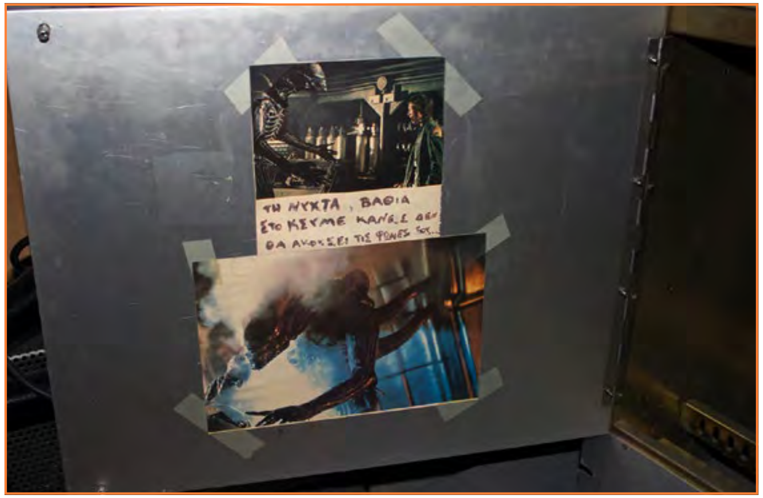


FIG. 10 The text monitor of the system, the TeleVideo screen © Dimitris Kamarotos Archive

FIG. 11 The inside panel of the main system door reveals a 30-year-old joke © Dimitris Kamarotos Archive

Additional archive material belonging to Kamarotos's contribution is available online.

To summarize:

The system came to Athens after several years of tireless efforts by a small group of people in Greece, mainly John G. Papaioannou and Stefanos Vassiliadis, but also with the support of Greek administrators, namely Melina Mercouri, as acting Minister of Cultural Affairs when the system was bought, and Thanos Mikroutsikos as Minister during the next years of the UPIC at KSYME, as well as, continuously throughout all those years, Alkistis Soulogianni, Director of the Department of Letters at the Greek Ministry of Culture. It was natural, from Xenakis's optimistic view of things, to deduce that this would continue, and in some way, KSYME would become another center for the research, development, and creative use of the system, collaborating with the CEMAMu. However, this was not the case, mainly because the natural reaction of the Greek cultural administration at the time was procrastination. The great efforts and funding that made it possible to start this endeavor with the UPIC in Greece did not continue. Also, changes in the administrative personnel, local and national politics, therefore of financial priorities, amongst others, explain this. Xenakis discussed this with me during the Patra's International Festival.

The system that arrived in Greece was considered by Xenakis himself and his team as no more than a functional, working version of the system, which was always intended to be advanced and improved.

In retrospect, we now know that although discussed, the "new—accelerated—UPIC" was not yet deliverable in 1987. It was officially announced and technically described as being functional at the Glasgow ICMC 1990.[21] From a financial point of view, KSYME could not at that time purchase this new machine. The major part of the center's finances was dedicated to the two main courses mentioned previously: *Emmeleia* (1988–1992) and *Chroai* (1990–1992). These projects used the UPIC, but did not devote any resources to its development; that was considered the responsibility of CEMAMu.

THE UPIC SYSTEM OUTSIDE THE KSYME STUDIO. (THREE CASES: FRENCH INSTITUTE OF ATHENS, PATRA'S FESTIVAL, CONFERENCE OF DELPHI)

The Athens UPIC system was composed of several modules, interconnected in order to have the system fully functional:

- The master console, used to give commands for basic functions, like reset, reboot, shutdown, system restore;
- The graphics display monitor and control keyboard, with the functionality of graphic representation of parameters, waveforms, envelopes, and the possibility to control and directly debug the graphic processing core;

- main internal hard disk (35 Mb); the graphic tablet: a graphic input interface working with an electromagnetic stylus, with a set of commands set as stylus-activated buttons on the right;
- an electromagnetic stylus, connected by cable to the stylus converter;
- the stylus converter—Summagraphics control unit;
- main CPU/Intel 512K RAM, with double processor 16 bit A/D and D/A converters;
- a unit for an external, exchangeable 8-inch floppy disk;
- a black ink monochrome printer;
- a cubical rack containing the main CPU cards, the graphic processor, the D/A and A/D converters, and the main HD unit, equipped with cooling fans.

In order to listen to, record, and edit the synthesized sound a peripheral sound installation was needed. This peripheral system consisted of a sound mixer, amplifiers, studio monitors, stereo tape deck recorder (more than one, in order to perform sound-on-sound processing), a multi-track analog recorder and, not required but in high demand, good quality effect units (spring or plate reverb and delay). The system was not complete and functional unless connected with a multitude of connecting cables of different sizes and specifications. Once the system was connected, a careful boot-up procedure needed to be performed. This was critical because the system was prone to unstable connections, and poor connections could result in software malfunction. In practice this meant that every time we relocated the system, we needed to spend time connecting, reconnecting, and testing with the boot sequence until the system ran properly. When packed up, the volume and weight of the system needed a small truck or a large van to transport it safely. Thus, moving and relocating the UPIC was complicated, costly, and carried a risk of damaging equipment that would be difficult to replace.

As far as I recall, the system was moved to:
- IFA (French Institute of Athens), 1986
- Patra's International Summer Festival, 1987
- Athens Computer Technology Fair, 1989
- Thessaloniki, *Echorama* - Fair, 1990
- Some (2–3) of the destinations for the *Chroai* project, 1991
- Delphi Computer Music Conference and Concerts, 1992

THE FRENCH INSTITUTE OF ATHENS 1986

The first relocation of the system was in November 1986. This was the first year that the UPIC—KSYME studio existed. It was transported and installed on the top floor of the main building of the French Institute of

Athens; a penthouse in the center of the city below Lycabettus Hill with a very open and impressive view over Athens. The premises were later transformed into the library of the same institution. The UPIC event was co-organized by the Greek Ministry of Culture, the French Institute, and KSYME.

A fully functional sound facility, furnished and supported by KSYME, accompanied the UPIC system. The whole setup gave the impression of a very high-tech home sound installation rather than a computer music studio. However, it was totally adequate to create electronic music and to demonstrate the system. I was responsible for coordinating the part regarding the UPIC system.

Xenakis was invited for one week. I remember him in the nearby Lycabettus Hill Hotel (today St. George Lycabettus hotel). I also remember him specifically asking for this hotel because of the view over Athens and the absence of traffic noise.

The project included a Xenakis concert in the Pallas concert venue of Athens: his *Medea* was performed as well as *Psappha*. Sylvio Gualda came to Athens for this occasion. The other part of the project was the ongoing Institut Français d'Athènes activities. We gave daily demonstrations of the UPIC and held a 10-day workshop with a small newly selected group. We also programmed the premieres of the “Music Sketches,” simple and short music compositions by those attending the workshop. Finally, we opted for a collective work combining all the individual compositions, which I edited at the end of the workshop. The tapes from this workshop are still in my personal archives. We also organized a concert at the end of the workshop, a presentation of the first works made with the UPIC at KSYME, the collective work mentioned above, and Xenakis's *Mycènes Alpha*.

During these days, the composer François-Bernard Mâche, a close friend of Xenakis, came to Athens for the performance of his work *Phenix*, in the same concert as Xenakis's *Psappha* and *Medea*. I met with Mâche at Kolonaki square in Athens for a coffee and we had a discussion (in both French and Greek) about what I was mainly interested in at the time: creative and pedagogic uses of the UPIC. I can't recall all the details, but I do remember—because it was a kind of mild shock for me—that although he believed very much in the principles that led to the design and the first development of the system, he also thought that its best qualities would only be attainable in the next versions, with improved computational performance.

PATRA'S INTERNATIONAL FESTIVAL 1987

The KSYME UPIC system was also presented during summer 1987 at the International Festival in Patra (in southern Greece). The system was moved to Patra for about 15 days.

The festival, presided by Thanos Mikroutsikos, a composer himself, included an international conference on the innovative (for 1987) subject of *Music and Micro-computers*. It also hosted dedicated activities as well as concerts on the subject. Mikroutsikos invited Xenakis as a guest of honor and president of the conference. He also invited KSYME and the the UPIC to give demonstrations and a workshop, and we produced a series of open-air contemporary and computer music concerts.

Xenakis's music was performed in the open-air concerts. Also, some of the first complete works made in the UPIC—KSYME lab were once again performed. The Xenakis Ensemble and many other invited musicians participated.[22] The activities (workshop and demonstrations) around The UPIC took place from July 20–30, 1987. Here, the unit was installed in a bigger, noisier, and less appropriate space. Also, there were too many people participating; therefore, a creative process for the participants was unachievable. Nevertheless, this was another good opportunity for a large number of people to learn, see, and "touch" this machine.

Collectively, at KSYME, we were interested in the future development of the studio through collaboration with more composers, musicians, and researchers. During the festival, we had the opportunity to meet with people interested in the field. Some of the future collaborations I had with Patra's University and the ITY[23] were initiated during those days.

The open-air concerts were remarkably interesting because it was the first time we had designed and built such an installation (open-air for mixed and electronic music). We had a dedicated space on the top of the Castle of Patra, a small hill on the edge of the city. The acoustics were very interesting because of a rather silent environment and a huge stone wall (remains of a medieval castle) reverberating and gently diffusing electronic and amplified instrumental sounds.

To respond to the requirements of these concerts the festival had bought a Steinway grand piano some months prior. The instrument was there, on the top of this hill, and it probably still belongs to the municipality of this city. I remember that we assisted in the design and construction of a special cover that would protect the instrument from high temperatures and dust.

Pieces previously composed with KSYME's UPIC and a number of new works by the invited composers, not made with the UPIC, were performed at these concerts. Those present and who performed their works were: David L. Wessel (U.C. Berkeley), Clarence Barlow (U.C. Santa Barbara), Barry Truax, Wilfried Jentzsch, Nikos Panagopoulos, Kostas Moschos, Vangelis Katsoulis, Christos Hatzis, and Juan Blanco. Further, represented by their works but not present: Françoise Barrière and Anestis Logothetis. The first pieces with UPIC by the Greek composers presented the previous

year in the IFA were also performed (Xanthoudakis, Riziotis, Daoutis, Velianitis, and the author). At these concerts, the mixed pieces (for UPIC-created electronics and instruments) were performed by KSYME's instrumental ensemble PROS.

The above-mentioned composers who came to Patra also participated in the conference and gave workshops.

AN UNEXPECTED DISCUSSION WITH XENAKIS IN THE CAR

Since Xenakis was there for the conference and we had a UPIC workshop and concerts, I was very close to him on a daily basis, along with a lot of other people. One evening, two days before the end of the festival, we were all invited by the festival director Thanos Mikroutsikos to dine in a Greek tavern by the sea in the town of Rio, about half an hour's drive from the festival.

While we were still at the conference venue, I had exchanged few words with Xenakis on the subject of everyday use of the UPIC at KSYME. So, when we travelled together in my little Japanese car to the dinner, it seemed natural to me to continue our discussion. I had, on several occasions, exchanged some thoughts or questions with him on subjects related to his ideas or, more concretely, on compositional methods used in his works. That was in public places during my university years and later, about a year prior, during the official inauguration of the UPIC lab in Athens. I knew that he was a kind of "lonely thinker," and avoided spending time on conventional social conversations. He would prefer, in my view, to stay silent and think about what was critical, avoiding any useless exchange of words. Therefore, I was prepared to have, perhaps, a silent journey with him. Yet on the contrary, he was eager to continue the conversation and interested in the use of the system in Athens even more. He wanted to know what the people working with the system considered important for its advancement. Obviously, I told him about the real-time (accelerated) system, and the expectations for something much quicker for all functions and even capable of some parallel tasks. He responded as though these were obvious, but minor details of a future update. He told me about many potential enhancements of the machine as a compositional tool. He even referred to it as a thinking aid for the composer, in Greek ("απελευθερωση της σκέψης του συνθέτη."[24]) He also spoke about the use of color in the interface. I was surprised, because color was already part of the existing interfaces of commercial systems at the time and I would have never thought of it as a crucial upgrade for the UPIC. From his very concise remarks, I understood that for him, color was a way to handle more parameters in the simplified interface of the UPIC. He expressed this as: "giving multi-dimensional control of sound."

In the meantime, I had managed to get lost on the little dark roads between Patra and Rio, and since GPS didn't exist, I was a bit anxious. But, unintentionally, it gave us more time for our discussion. I tried to keep him interested and learn his opinion about the work we had accomplished by getting young composers to work with the UPIC, and the music that he had had the opportunity of listening to in concerts the previous days. He made it very clear that although this is a natural continuation of the center, he was hoping, or shall I say, seriously thinking, about something else. He told me about it during the last ten minutes of our journey. Doing my best to recall this after so many years, he expected KSYME to follow and support the CEMAMu by purchasing the new version, and even by using KSYME's relationships with universities and its research funds to expand the development and industrial production of the UPIC in Greece. This may sound irrelevant now, but it didn't sound strange to me and it wasn't at that time. He knew we had started to collaborate with NTUA, and I had personally asked him to participate as a scientific advisor to a research proposal (HXE "Sound Map of Greece") mentioned above.

After this, we arrived at the tavern near the sea, and with a lot of people from the conference and festival around a long table, our conversation couldn't continue. My next opportunity to have this kind of personal discussion with him came five years later at the International Conference on Computer Music in Delphi.

Related to this concern and desire of Xenakis to continue the development of the system and keep KSYME updated with the newest version of the UPIC are the following letters. Through these, I can remember the evolution of this subject:

First, a letter was addressed by Stefanos Vassiliadis to Xenakis and the CEMAMu in November 1986 regarding this upgrade and confirming the need for it. FIG. 35

In 1988, a little over a year later, another letter was addressed to the CEMAMu by KSYME, mentioning it should be read by Xenakis. The letter first gives a general description of KSYME's activities with the UPIC system during the first two years, and then again expresses the need for the new version of the system, and the request to find a way to lower its cost. I don't know whether there was any response to this letter.

There is a third letter I know of (from Andreas Stafylopatis's personal archive) about the same issue, addressed by Stafylopatis to the director of KSYME, Stefanos Vassiliadis. In it, there is reference to the second letter, of June 15, 1988 and a description of the system upgrades from 1985 to 1994. It confirms that although there was a very good relationship between KSYME and the CEMAMu studios, and that the KSYME—UPIC system had been in full use for years, only wishes about acquiring the new version were exchanged. I can confirm that I had exactly the same understanding about this subject.

THE DELPHI CONFERENCE 1992

The last, as I recall, transport and relocation of the KSYME UPIC unit was for the Delphi Computer Music Conference from July 1–6, 1992. This conference and festival was organized by KSYME in collaboration with the European Cultural Centre of Delphi and the Ministry of Culture.

The UPIC system and sound equipment belonging to KSYME was transported to Delphi one week before the event, together with all the rented equipment. In the context of this international event on computers and music, a large number of parallel activities were sponsored in different locations:

- The main conference room, a venue with a capacity for simultaneous translation into three languages.
- An auditorium for indoor concerts.
- Four small studios, as demonstration rooms, where some teams had installed their own software and hardware. That was the case with the CEMAMu (along with Les Ateliers UPIC) with the new Windows-based UPIC.
- A large basement room transformed into a quadraphonic computer music studio. There, the IRCAM team installed the hardware for the new real-time version of their software (under Opcode, at the time).
- An outdoor concert location, in the garden of the nearby historical Sikelianos Villa,
- A large open area, on the edge of this mountainous location, chosen and equipped with sound equipment, for the big computer music concert that ended the conference and the festival.

Just one day before the official opening, I arrived in Delphi having driven from Athens, together with Stefanos Vassiliadis and Iannis Xenakis. As we arrived, a meeting was arranged with the Minister of Culture, Madame Anna Psarouda-Benaki, who was already present. This meeting was quite unofficial. We were all sitting around a low square table in the lobby of the conference center with a breathtaking view over the Itea valley and, far away on the horizon, the sea. Stefanos Vassiliadis gave an introduction about the importance of the conference that was to take place and the presence of so many remarkable composers, researchers, and academic teams. He was also obviously aiming to initiate a discussion about further and more substantial financing of KSYME and particularly, with the presence of Xenakis at the table, about acquiring the new UPIC. When Xenakis spoke I was surprised because, in contrast to what I was used to hearing from him on such occasions in previous years, he vigorously supported a much more general argument. He insisted that what was needed and achievable in Greece was massive support of education and research. Furthermore, that the potential for breakthrough research in music was already present and should not be neglected. I don't recall the minister reacting directly to Xenakis's argument.

In addition to Xenakis, Paul Lansky, Roger Reynolds, Tristan Murail (who was about to leave for Columbia University), Jean- Baptiste Barrière, Brad Garton, Perry Cook, Fred Malouf, Stanislaw Krupowicz, Chris Chafe, Cort Lippe, Simon Emmerson, and François-Bernard Mâche were also invited and present at this conference. Additionally, many Greek composers who had worked at KSYME in previous years were there. Compositions by Titi Adam, Giannis Manolessos, Panos Doukas, Dionisis Tsaglas, Giorgos Filippis, Katerina Tzedaki, Alexandros Kalogeras, Athanasios Zervas, Nikos Perakis, and the author, were performed. A great number of international soloists came to participate in the concerts.

For a better understanding of the situation, it is useful to know that during the previous two years, many international exchanges, collaborations, and joint research projects were initiated. An important component in this international research cooperation with KSYME was the NeXT computer system. This system, Steve Job's creation after he left Apple, was considered to be the most advantageous and compact environment for the future of computer music. In Greece, KSYME put together a team, headed by Professor Thanassis Rikakis, which organized and promoted the use of this system as well as international exchanges with a view to installing and developing such a system at KSYME. Since I was part of this group from the beginning, I have a comprehensive overview of how this new technology compared with the existing UPIC and what effect it had on the activities related to it.

By 1992, a new studio based on a NeXT computer system was already working at KSYME. It was installed on the top floor of the building. The UPIC remained in the ground floor studio, still functional but rarely used. Many activities revolving around the NeXT studio were similar to those undertaken during the first years of the UPIC. These activities were initiated locally by a small team with Rikakis and me, but were also actively supported by Professors Perry Cook (Stanford University) and Brad Garton (Columbia University). These two composers, researchers, and friends came to KSYME several times in order to help us acquire the hardware, build the software environment, and structure the studio. After they left, I assumed a similar role of system supervisor that I had in the beginning of KSYME with the UPIC. However, there was a big difference: this was a UNIX-based system with a hierarchical structure, and we could already exchange many things with our supporting partners in the USA on a daily basis, via the Internet. This was a major difference to the previous situation with the UPIC. Already, with this team, we had shared some joint research (published papers and international conference preparations like the one in Delphi.[25]) Later, these international collaborations resulted in the organization of the ICMC 1997 in Thessaloniki and the program on psychoacoustics at the Aristotle University of Thessaloniki.

In Delphi, in the summer 1992, this new potential within KSYME was already palpable. It contributed to the successful organization of this significant international event on computer music. During this event, although Xenakis was a prominent guest and a founder of the KSYME, with the Center's UPIC system still in its first version, it was not as appreciated and promoted by the organizers as it would have been a few years earlier.

At this conference and festival many computer music laboratories were present with their recent achievements, in terms of music and software: Columbia, Princeton, CCRMA-Stanford, and UCSD universities, plus IRCAM and Les Ateliers UPIC. Thus, the new version of the UPIC was present and demonstrated by the team that developed it. Gerard Pape, then director of Les Ateliers UPIC, was also present.

During the days of this conference, a new (not yet commercial) version of IRCAM's Max/FTS ("Faster Than Sound"), a version of Max ported to the IRCAM Signal Processing Workstation (ISPW) for the NeXT was brought and installed with its full functionality on KSYME's NeXT environment. Cort Lippe was responsible for this; he brought with him the triple DSP IRCAM card and installed it on our system. This was located in a large room in the basement of the Delphi Centre. I remember myself, together with some composers (mostly students from the first UPIC workshops), working furiously all night with it. We were certainly amazed by the user-friendly interface, but also, for someone with experience of the UPIC, by the impressive speeds of this real-time system. This version impressively performed real-time algorithmic processing of instrumental sound and voice, which was already a main feature of this environment from 1989, yet this represented an important advancement. Experiencing this, Xenakis's view about a minimalistic interface aiming at conceptual formalization in music no longer seemed to be our only holy grail. Promising, real-time algorithmic compositional tools were already in our hands.

Although, as mentioned, the old UPIC was also present, more as a unit of reference than as an efficient music system, there was, nevertheless, a lot of thinking and discussions about it and a possible future for it. Most importantly, Xenakis was there with his ideas and his music. During the conferences a lot of important issues were discussed in organized panels.

A very remarkable one was with Xenakis, Reynolds, Lansky, and Mâche discussing computer music, with Thanassis Rikakis as moderator. I will get back to this, below.

THE DELPHI CONVERSATION WITH XENAKIS

During this conference I had another important private conversation with Xenakis. This moment remains very vivid in my memory. After a paper I had presented,[26] I initiated a discussion with him on its subject. He seemed interested and made some very important remarks about it. But the conversation naturally shifted to the subject of the UPIC, which I saw as declining, at least as a practical and usable system at KSYME. I made a comment alluding to a comparison with other compositional and creative sound tools showcased at the conference. I presented to him a case for providing the system with a sampling function, an opinion shared with many of the KSYME UPIC users. He responded with the same reasoning he had aired the previous day in a discussion about introducing expressivity in his music:

> *I don't need to try with computers to imitate a sound that exists already. You don't need that. What is interesting is to explore other paths or ways or sounds or even evolutions of sounds that have never been done or realized, and that is the interesting point.*

Those were his words during that panel discussion, and they were almost identical to his response when I brought up the issue of sampling for the UPIC,[27] a function that was not possible with KSYME's UPIC.

By this he insisted on the fact that he considered sampling an alternative (and maybe faster?) way to create new waveforms and textures but not to imitate acoustic instruments.[28] Xenakis was then seventy years old. We had a celebration for his 70th birthday in Athens with concerts and exchange of letters, some months previously. At this afternoon discussion in Delphi, he seemed to me to be as sharp and perceptive as some twelve years earlier, when I heard his lectures in Paris. It was obvious that he had a similar global view as then, regarding computer music technology, the potential of academic teams in the USA, and their dynamic presence at this conference. But in our conversation at Delphi, he was less practical and more visionary and idealistic, at least that is how I perceived it. He told me more about what a tool such as the UPIC could mean for the human mind, for a "researcher *universalis*". He kept speaking about art (and not specifically music) as a field where human potentiality can be liberated. For this we would need a "special tool" (the UPIC?) to bring art closer to a much greater number of people. He gave me the surprising impression that this was not necessarily connected with musicians or composers. Perhaps he meant that a composer should be more of a researcher of philosophy than of sounds, first and foremost judging for himself.[29] Following his own spontaneous associations, he returned to

his personal perspective before, or in parallel, with the technical reality of the UPIC. He spoke to me about a machine that would be able to verge towards mathematic developments although the user need not be a mathematician, and to urban creation without needing to be an architect. Such a machine would be able to handle *ποίησις*, the Greek word he used, which means *poetry* in modern Greek but, *creation* in ancient Greek. And, of course, he meant it in this latter sense. This was the second *apocalyptic* moment I had with Xenakis in my life (*apocalyptic* in the original Greek meaning of the word, in this case, something like: oracular, revealing). The first one was at the *Mycenae Polytope*.

In this Delphi discussion, it was maybe a reflection of thirty seconds, or one minute long, within his speech. I was so marked and unsettled by this, that, right afterwards, I made a note of his argument. A note I still have, and that is why I can recall it. It was surely just an attempt to jot down my general impression, to keep a note of what, exactly, I thought he meant.

That same night, we had a final big concert at the specially prepared open space, under the stars of that July night, looking over the valley from the ancient site of Delphi. Everyone participating in the conference had prepared something special for that night. The technical sound setup consisted of just four towers of loudspeakers encircling the large area, but we had the impression of something much more complex. Over the years, whenever I see someone who was present that night, we recall the moment together with great emotion, and confirm that this was a unique and amazing experience.

The Delphi International Conference informally marked the end of the UPIC's productive life at KSYME. The unit remained functional for about tree to four more years, but it was used less and less by composers. Thus, it was not showcased as an efficient system at the next important international event organized by KSYME: The International Computer Music Conference 1997 (ICMC 1997 in Thessaloniki).

Personally, I continued to design and produce small sound structures with it, up until 1996. At a rough estimate, I spent between five and ten hours per week on the UPIC, or about 450 hours per year for the first four years. Over the following four years, this diminished and became less and less, mainly to get some special textures and forms and then integrate them into completely different sound generative environments, like C-Sound or PD.

A directly related question is: Should the original UPIC be considered a system for the production of synthesized sound or rather as a generative[30] music machine? Technically, the system could be used as a sound synthesis machine (like Music V in the previous years). However, the continuity between the creation of a waveform and musical form is the main principle that is promoted by this tool. I believe that separating these two would be like thinking that a "'normal" use of a digital calculator is to make divisions and multiplication, while the remaining operations would be completed with pen and paper. Despite what seems to be its obvious intention, the system we had at KSYME could not incorporate the generative process compositional algorithms, unless of course they were divided into fragmented mathematical functions and then fed into the machine. Such an ability became standard and a main advantage of other productive music environments at the time. Xenakis was interested in this and he already attempted and presented such features in his orchestral works from the 1950's,[31] but he was severely constrained by the technology available to him at the time.[32]

Seeing all the capabilities of the system together, I was convinced that it was not meant for such fractional functionality, like merely creating a texture or making a rough sketch of a composition in arc-mode with macro-functions (marked: "*parasimansis*"[33] in the Greek version of the system). **FIG. 39** However, one was free to do this. Perhaps the UPIC could be useful in the context of a researcher's *studium*, as a tool for contemplation, unlocking new paths to seek and find solutions. And indeed, this is a very interesting model for compositional thinking.[34]

FOOTNOTES

1. KSYME—CMRC, Contemporary Music Research Center of Athens.
2. *Mycenae Polytope* Program, 1978 published by the Hellenic Association for Contemporary Music and the National Tourist Organisation of Greece.
3. Iannis Xenakis, *Formalized Music. Thought and Mathematics in Composition* [1971], trans. Sharon Kanach, revised edition (Stuyvesant, NY: Pendragon Press, 1992), 200: "I believe that music today could surpass itself by research into the outside-time category, which has been atrophied and dominated by the temporal category." and, "It has a considerable advantage: its mechanization—hence tests and models of all sorts can be fed into computers, which will effect great progress in the musical sciences."
4. For more details about the founding of KSYME, see Tsioukra, this volume.
5. Simon Emmerson, *Music, Electronic Media, and Culture* (Farnham: Ashgate Publishing, 2000), 203: "We *hear* the results of deterministic yet chaotic processes all around us: from control systems in buildings to computer noises, to the resulting 'noise' of the World Wide Web. These are steadily becoming their own 'indicative fields'. An algorithmic process of generation may then—unexpectedly, without necessarily the intention of the composer—relate to a 'sounding model' in some process in the real world. In a profound sense, this was predicted by Iannis Xenakis, whose works move to and fro across what appears to be a divide between those having a clear sonic metaphor in the real world (the 'mass sounds' of *Pithoprakta*, the arborescences of *Cendrées*) to those apparently embedded firmly in mathematical abstraction (the *ST* series or *Nomos Alpha*)."

6. Christopher Haworth, "Giving Voice to the Inaudible: Perception and Non-perception in Iannis Xenakis's Late Electroacoustic Music," in *Proceedings of the International Symposium "Xenakis. The Electroacoustic Music,"* ed. Makis Solomos (Université Paris 8, May 2012), accessible online: http://www.cdmc.asso.fr/sites/default/files/texte/pdf/rencontres/intervention6_xenakis_electroacoustique.pdf
   By transgression, the unity of timescales model illuminates a hierarchy of different rules and discourse types which act upon and structure musical space in advance."
7. An exhaustive list of UPIC—KSYME composers is currently being crowd-sourced and verified here: https://www.KSYME.org/upic.html
8. The "real-time" UPIC was developed at the CEMAMu, but never installed at KSYME.
9. On this LP, my composition *Epiphineia* was wrongly transferred to the master from a recording made by National Greek Radio with only the microphones for the instruments: therefore, the UPIC sound is practically absent. The full master of this piece and a copy of it exists in the KSYME (CMRC)—ChouPaF Unified Archives.
10. "*PROS*" in Greek, meaning "TOWARDS."
11. These musicians included: Vassilis Papavassiliou, double bass; Minas Alexiadis composer, pianist; Dimitris Mangriotis, cello; Daniel Cholette, piano; Thodoros Kotepanos, piano; Vicki Vassiliadi, flute; and Andreas Symvoulopoulos, piano, keyboards.
12. Some of the researchers who collaborated on KSYME's projects 1986–1994: Prof. Emmanuel Protonotarios (member of the board of KSYME), NTUA (National Technical University of Athens); Prof. Andreas Stafylopatis (technical advisor, responsible for the UPIC), NTUA; Prof. Brad Garton, Columbia University; Prof. Perry Cook, CCRMA Stanford University; Prof. Thanassis Rikakis, CMC Columbia University; Prof. Sergios Theodoridis, Signal Processing, Athens University; Prof. John Kontos, Athens University; Prof. Elias Koukoutsis, NTUA; Prof. Konstantinos Papaodyssefs; NTUA.
13. ERT: Greek National Radio and Television Network.
14. This research project is filed at the National Secretariat for Research and Technology as "HXE" n# EK8932.
15. *Mesimvrini* newspaper: "A 'music University' for children proposed by Iannis Xenakis," December 6, 1986.
16. KSYME (CMRC) ChouPaF Unified Archives: ChouPaF stands for the Foundation of Emilios Chourmouzios—Marika Papaioannou (Emile Chourmouzios was the husband of the famous pianist Marika Papaioannou, therefore the brother-in-law of John G. Papaioannou). The ChouPaF archives comprise the archives of Emile Chormouzios, Marika Chourmouziou-Papaioannou, John G. Papaioannou, and also Nikos Skalkottas. KSYME and the ChouPaF have the same board of directors and currently share their headquarters at the Athens Conservatoire. In addition to its own "audiovisual", "administrative", "activity records", KSYME's archives also contain the archives of the Hellenic Association of Contemporary Music (HACM) and the Greek Studio for Electronic Music. The archives have recently been unified, see also Tsioukra, this volume.
17. Achileas Aggelidis was a very experienced sound technician and electronic engineer who also supported the previous ΕΣΣΥΜ lab.
18. Later, as of 2005, Lycourgos Angelopoulos was president of KSYME.

19. Athens contemporary art spaces Ileana Tounta and Evmaros.

20. A NeXT computer station, provided with NeXT STEP software by NeXT, Inc. In this same environment, the World Wide Web was invented by Tim Berners-Lee, and NeXT's OPENSTEP system was later the basis for Apple's MacOS.

21. See: https://www.jstor.org/stable/833053?seq=1#page_scan_tab_contents

22. *Performance to M.E* for tape and dancer by Vassilis Riziotis; *Mi Monan Opsi* for tape and oboe by Haris Xanthoudakis; *Intermediary Space* for tape by the author. Many invited musicians also participated, including the Xenakis Ensemble from Holland. Xenakis's works performed: *Akanthos, Ikhoor, Psappha, Jalons*, and *Thallein*. This concert took place in the ancient Roman Odeon of Patra on July 21, 1987.

23. Computer Technology Institute of Patra's University.

24. Translated from the Greek: "liberating composer's thoughts."

25. An example of this collaboration: Perry Cook of Stanford CCRMA, Taxiarchis Diamantopoulos, Giorgos Philippis, and the author, KSYME, "IGDIS (Instrument for Greek Diction and Singing): A Modern Greek Text to Speech/Singing Program for the SPASM/Singer Instrument/A Greek language text reading program had been constructed which generates control files for the SPASM/Singer physical model of the human singing voice", *Proceedings of the 1993 International Computer Music Conference*, September 10–15, Tokyo, Japan.

26. D. Kamarotos, "@music' a new model for the understanding of music functionality on human evolutionary behaviour", *Proceedings of the International Computer Music Conference and Festival*, Delphi, 1992.

27. Xenakis, Reynolds, Lansky and Mâche discussing computer music, with Thanassis Rikakis as moderator. This discussion was recorded and transcribed by Karen Reynolds. It is available online:
http://karenreynolds.com/xenakis.html?fbclid=IwAR0DYDeYH-UFckYNGhjv1WL8_Xaj3YW7SXpEeEYnsoRMCVqN8E4dhmgQUiE
Here is another relevant excerpt from the same discussion: Xenakis: "About musical phrasing and things like that, they have to be part of the mathematics. If you heard phrasings, I didn't do anything at all, which means that it is, as Meyer-Eppler distinguished fifty years or so before, the tiny things that you are conscious of after a while. This is the interest of probability functions, because although you do not control them point by point, they have an average evolution, a very tiny one, which goes into this domain: the liveness of the sound. I thank you that you have heard it, because that's an important feature of it. It's not produced by any kind of pianissimo or something like that, the evolution of pitch and so on. It's directly taken from the result of the probability functions with the parameters that I told you about."

28. And indeed, a sampling function was included in the UPIC real-time version, and was widely used by most composers working on that system.

29. Xenakis confirmed this elsewhere as well. See, for example: "(I)t seems that a new type of musician is necessary, an 'artist-conceptor' of new abstract and free forms, tending towards complexities, and then toward generalizations on several levels of sound organization. [...] The 'artist-conceptor' will have to be knowledgeable and inventive in such varied domains as mathematics, logics, physics, chemistry, biology, genetics, paleontology (for the evolution of forms), the humanities, and history; in short, a sort of universality, but one based upon, guided by and oriented toward forms and architectures. [...] (i)t is apparent that the artist, and consequently art, must be simultaneously rational (inferential), technical (experimental) and talented (revelatory); three indispensable and

coordinated modes which shun fatal errors, given the dimensions of these projects and the great risk of error." Iannis Xenakis,. *Arts/Sciences: Alloys: The Thesis Defense of Iannis Xenakis before Olivier Messiaen, Michel Ragon, Olivier Revault d'Allonnes, Michel Serres, and Bernard Teyssedre*, trans. Sharon Kanach. (Stuyvesant, NY: Pendragon Press, 1985) 3–5.

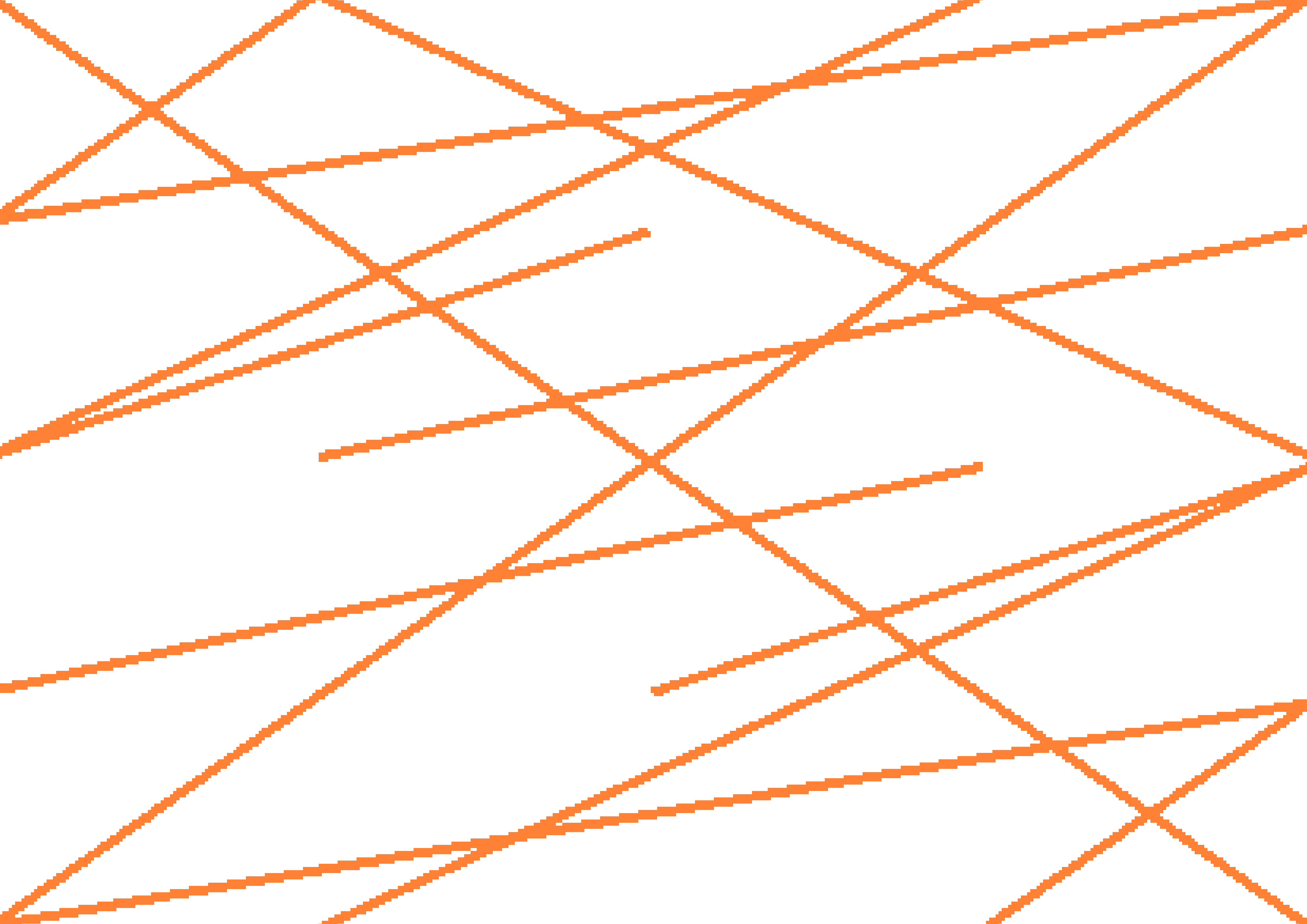
30. Generative, in this case as having the function of originating or producing music.

31. *Metastasis* (1954), *Pithoprakta* (1955–56).

32. Tim Rutherford-Johnson, *Music after the Fall: Modern Composition and Culture since 1989*, (Berkeley, CA: University of California Press, 2017), 344.

33. *parsimansis* refers to the writing of Greek Orthodox ecclesiastic music after the reform of 1814. It is a code for graphic description of vocal sound movement with details of the micro-movements and texture. '

34. Frédérick Duhautpas, Renaud Meric, and Makis Solomos, "Expressiveness and Meaning in the Electroacoustic Music of Iannis Xenakis. The Case of *La Légende d'Eer*", in *Electroacoustic Music Studies Network Conference -Meaning and Meaningfulness in Electroacoustic Music* (Sweden, 2012), 10, hal-0076989500769895, from the abstract: "Xenakis has sought to escape the language model in favor of a conception of music as an "energetic" and "spatial" phenomenon." (1), From the Conclusion: "Xenakis' (*sic*) approach as a new form of naturalism in music. It does not seek to represent or paint images of nature or communicate messages. Rather, Xenakis seeks to immerse the listener in the underlying undetermined processes found in nature. Composer F.-B. Mâche made the following comment about this type of approach: 'In the twentieth century, one large characteristic of music is not to realize the humanist ideal of communication between men, but to rediscover the function the universe once had: the sacred; that is an interrogation about the universe and not just the psychological and the social dimension.' Mâche, François-Bernard, *Entre l'observatoire et l'atelier*, (Paris, France: Kimé, 1989), 41.



PROBABILITIES, DRAWING, AND SOUND SYNTHESIS: THE MISSING LINK

RODOLPHE BOUROTTE

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INTRODUCTION

This chapter is a collection of reflections by the author about Xenakis's UPIC and its possible evolutions. In this sense, it owes much to the creation of the UPISketch application. Today, in 2019, there is already some literature about UPISketch's present state and its origins;[1] Here I shall focus on the future development of UPISketch, and more broadly speaking, on imaginable software iterations.

Considering the UPIC as a reference point, we start from a solid basis, with clear features: to sum up, we have a page (like a score, but in the continuous domain) on which we draw arcs that represent the pitch of synthesized sounds against time. But drawing can also be used for determining the envelopes of these arcs, or the waveforms themselves.

So, what kind of thoughts did the idea of a software program designed, literally, for drawing sound inspire in us? This is what I shall develop below, with an emphasis on the questions raised, which are very diverse. Naturally, the following topics must be addressed: pitch, time, dimensions, continuousness/discreteness, lattices (or sieves), and finally probabilities, as a proposition for a feature that did not exist in the original UPIC.

There are several ways of producing music. Roughly, there are three main types: composition, improvisation, and generation of interactive systems. All these are possible whether the hardware utilized is instrumental, or electroacoustic, or mixed. This chapter is primarily interested in composition and the way it links imagination to a result; therefore, the word "notation" will be used in its anticipated sense, in a way that allows us to prepare something we have in mind. Here notation will not be discussed as a way of translating an image into sound, as long as this image has not been intended for a musical meaning in the first place. Such a case could be considered more as a "sounding notation," like in sonification, for example: as musical as the result may sound, the material that produced this result did so incidentally (or by laws inherent to nature), but not because of a conscious decision by

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a human being.[2] As one subject dealt with in this volume is graphic notation, it seems appropriate to develop a bit the meaning of this word "notation." Citing Wikipedia:

In linguistics and semiotics, a notation is a system of graphics or symbols, characters and abbreviated expressions, used (for example) in artistic and scientific disciplines to represent technical facts and quantities by convention. Therefore, a notation is a collection of related symbols that are each given an arbitrary meaning, created to facilitate structured communication within a domain knowledge or field of study.[3]

For the purposes of this text, the notion of notation will be narrowed down to an unambiguous, nonsymbolic technique, but without belittling other ways of considering it.[4] Finally, the possibility of using graphic notation for describing probabilistic events will be explored. According to this hypothesis, the unambiguity of notation mentioned above refers to a precise definition of the amount of deviation at a given time for a given value, thus not to any exact value but rather drawn at random.

THE CONCERN ABOUT PITCH IN MUSIC CREATION

Pitch, according to the Oxford English Dictionary, is defined as "the quality of a sound governed by the rate of vibrations producing it; the degree of highness or lowness of a tone."[5] The "highness" of a tone, however, is already a disputable concept:

The conception of high and low as applied to sound seems to have come to the Greeks but slowly; and when they were obliged for teaching purposes to give names to the strings of their lyre, they called the lowest string of the tetrachord *Hypate*, which means "highest," for in instruments of the harp shape, such as the trigon, this string was the "highest" when placed upright, or, as we should say, the longest.[6]

For music creation, we will stick to a slightly modified definition by replacing the word "tone" with "sound." Then, it is general enough to cover all the usages of pitch in music, because psychoacoustics has shown us that the relationships between a perceived note and the sound spectrum are rather complex. In this respect, pitch can be either a precise note in the classical Western meaning, or an overall tendency of the sound spectrum, as can be related in some cases to the spectral centroid.[7] Meanwhile, in the twentieth century, several approaches have shown less interest in pitch as a harmonic function and as a physical entity to compose with (electroacoustic music being one prominent domain for this kind of approach), it seems rather difficult to conceive music without having in mind at least an overall pitch contour.

Indeed there appears to be a wide consensus about the fact that pitch is of primary importance in composition. It is important to point out that pitch, like any physical quantity, needs time to be perceived.

THE CONCERN ABOUT TIME IN MUSIC CREATION

Music is time-based. Time is the container of our musical output. Again, there have been different creative approaches in the musical domain. Generative music questions how we conceive a piece: we work on setting up a process, and it is this process that will take the role of unfolding the details of the art piece in time. People, including Mozart, have composed systems for generative music, and have created algorithms for composing music. Even Iannis Xenakis's concept of "outside time", a method he developed to work beyond the limitations of the linear time concept, can give us a glimpse of the idea of something that is able to define music without being instantiated. We can define a set of rules and decide that this is enough for describing the desired musical result. For instance, we can imagine an infinite number of versions of Xenakis's pieces *Herma* (1961) and *Nomos Alpha* (1965), as suggested in a publication by the Musical Representations Team at IRCAM.[8] But what can be said about the final product, if not that it uses time? The distinction lies in the composition process. It's amusing to think that the question of authority might be related to that of time instantiation—but the question of attributing or not the authority of a piece when it is still in its conceptual state, and not yet realized in time, is far beyond the scope of this chapter. However, instantiation in time is to be a key aspect for the present discussion, since the goal is to integrate probabilities in a compositional process. However, as long as the description of these probabilities is not processed into real events, the physical experience of hearing an instantiated result is not possible.

THE PHYSICAL REPRESENTATION

The following statements by Heinrich Hertz reveal a fundamental feature of the scientific method: the inner formation of images representing phenomena occurring in the outside world, allowing us to infer laws and anticipate how things are presumed to happen. By extension, his words are also a fairly good introduction to the reasons for creating graphical representations of the physical world:

> *The most direct, and in a sense the most important, problem which our conscious knowledge of nature should enable us to solve is the anticipation of future events, so that we may arrange our present affairs in accordance with such anticipation. As a basis for the*

solution of this problem we always make use of our knowledge of events which have already occurred, obtained by chance observation or by prearranged experiment. In endeavouring thus to draw inferences as to the future from the past, we always adopt the following process. We form for ourselves images or symbols of external objects; and the form which we give them is such that the necessary consequents of the images in thought are always the images of the necessary consequents in nature of the things pictured. In order that this requirement may be satisfied, there must be a certain conformity between nature and our thought. Experience teaches us that the requirement can be satisfied, and hence that such a conformity does in fact exist. When from our accumulated previous experience we have once succeeded in deducing images of the desired nature, we can then in a short time develop by means of them, as by means of models, the consequences which in the external world only arise in a comparatively long time, or as the result of our own interposition.

We are thus enabled to be in advance of the facts, and to decide as to present affairs in accordance with the insight so obtained. The images which we here speak of are our conceptions of things. With the things themselves they are in conformity in one important respect, namely, in satisfying the above-mentioned requirement.[9]

When Xenakis constructed a timeline comparing the historical evolution of music and mathematics, he showed a great interest in the "Invention of the bi-dimensional representation of pitches versus time by the use of staves and points (Guido d'Arezzo), three centuries before the coordinates by Oresme"[10] His point was possibly to emphasize the close interlinkage of knowledge in the arts and sciences throughout history. By citing Oresme (ca. 1350), Xenakis may not have known about this graph **FIG. 1**, part of a manuscript discovered by Sigmund Günther in 1877 which supposedly dates back to the tenth century. The mathematician and historian Howard Gray Funkhouser (1898–1984) says about it:

"The graph given here in facsimile is of significance in the history of graphic methods in that it appears to be the oldest extant example of an attempt to represent changeable values graphically which in appearance closely resembles modern practice. The distinguishing feature is the use of a grid as a background for the drawing of the curves."[11] **FIG. 2**

What is more it seems incredible that the scientific breakthroughs suggested by the examples above did not come into common use until the nineteenth century![12]

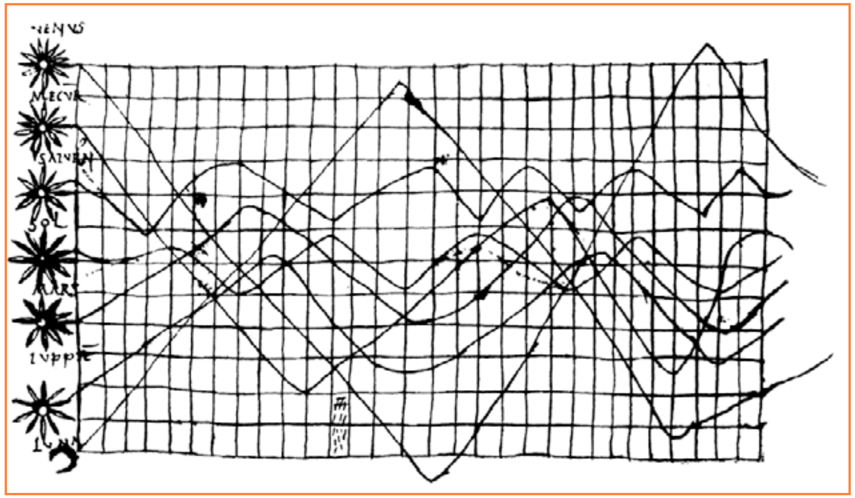


FIG. 1 Nicholas Oresme (1323–1382), *Tractatus de figuratione potentiarum et mensurarum, Venice,* Italy, 1505. *In Tractatus de latitudinibus formarum*, edited by Biagio Pelacani da Parma © Wikimedia Commons

FIG. 2 Unknown author, ca. 1000. In Howard Gray, Funkhouser. "A Note on a Tenth Century Graph." Osiris 1: 261 © The University of Chicago, 1936

The choices Xenakis made in his timeline chart are naturally open to discussion, but we adhere to his graphical orientation: if graphics were not so important, Xenakis could have willingly cited the one of the first known notations for music, in the form of alphabetical signs, which happens to be of Greek origin.

Music notation is the representation of several physical values evolving over time. Since the nineteenth century, experimental physics has made much use of graphs and plots—visual representations to visualize experiments or observations.

Interestingly, the notation of music is a reversed process compared to scientific graphs: instead of representing observed values, music notation describes, like a timed map, the physical state we seek to observe (with our ears) in our environment at successive moments.

There is indisputable magic in the act of making plans. Music creation has much in common with any architectural or building process: as humans, we are delighted when taking control over matter. We like to link our imagination to the real world. In the case of music, it is somehow much easier to create a modified space around us: molecules of air being lighter than bricks, they allow us to deploy our imagination in an immense domain of possibilities. Also, the physical metaphor created by acoustic movement cannot be ignored. The emotional effects from loudly projected sounds are great, because they are instinctively linked to a supposedly large physical cause.

In short, in the domain of electroacoustic music, a system that would aid representing physical values related to music and translate them directly into audible sound would be very valuable. This was the purpose of the UPIC system, and with UPISketch and its future iterations, it is also ours.

A MATTER OF DIMENSIONS

On the various occasions we had to present the concepts behind the UPIC and speculations about its future, there was often feedback like "What about 3D?" I will address this question here.

First, our current state of knowledge assumes that the universe can be properly described with the notion of space-time: three dimensions of space and one dimension of time. The difference between time and space is a rather interesting question, still challenging for physicists and philosophers. However, something appears to be universally agreed: time is a line. Again, the strategy about time in this chapter is different from some uses in aesthetics where time is indeterministic. Here, time is considered in the spirit of anticipation of what we want to see/hear happen at a desired time. This—time as a line—seems to be a good basis,

for example, as Bradford Skow suggests: "Intuitively speaking, to say that time is one-dimensional is to say that we can represent time as a line, and that all events that occur in time can be assigned a position on that line."[13]

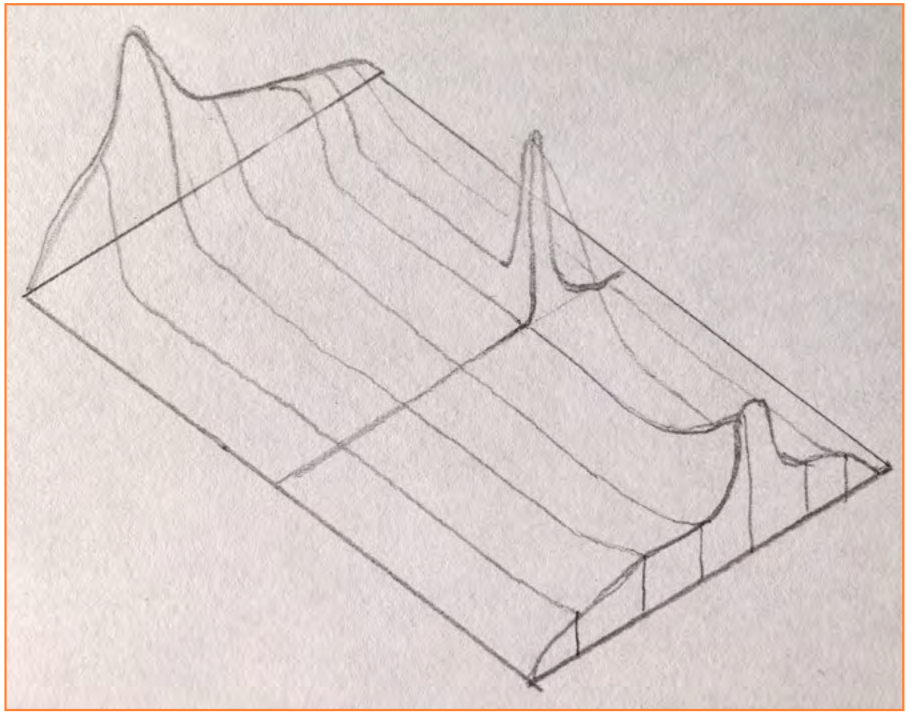
Back to notation: for most of its history until now, notation has been deployed on two-dimensional physical media. In fact, a 2D medium can help us represent 3D values without much of a problem, sacrificing a little precision, however, for the third dimension: FIGS. 3, 4

We can even push to four dimensions. That is the case with a map, with its contour lines suggesting the third dimension and its colors that can be assimilated to the fourth dimension. Then, what could we do with a 3D physical medium? Not much more, since for a fourth dimension we would need a plastic material, at once transparent and capable of bearing information for each coordinate of a 2D slice of it. FIG. 5 is an example of a possible "score," in a non-transparent dough, so that the overall view doesn't provide access to the fourth dimension data that may be stored in the individual slices.

Of course, with the advent of Virtual Reality, nothing can stop us from imagining a notation system in 3D. Let us say the maximum quantity of dimensions that can be visualized will probably be four: three dimensions in virtual space, and one of color. Many attempts have been made to represent more-than-three dimensional spaces—the light cone in special relativity theory and the hypercube are good examples of these—but we can't really see them as straightforward. However, a musical process, such as has been profoundly explored by Julio Estrada with his concepts of "macrotimbre" and "multiparametric composition,"[14] can easily require a description of at least six different values for each instant. So, we seem to be a little stuck, and we are not sure that going 3D offers any great advantage.

THE DIALECTICS OF CONTINUOUS VERSUS DISCRETE

Again, this is an old debate, but we humans have still not resolved this issue. There are even arguments as to whether, in the case of a component of space-time being discrete, it should be time or space, or both. Measured data is no exception to this uncertainty. When representing data, we often face the question whether the original quality of this data was discrete or continuous. The function of the real variable x, $f(x) = 2 * x$ may look continuous, but does this reflect physical reality? Also, in computer music we are used to manipulating samples, measured from real values, each being 22.6 μs in the case of the CD format. And from a different perspective, pitch analysis as performed by the ear does reflect a very special characteristic of acoustic reality: the fact that harmonic



FIGS. 3, 4 Rodolphe Bourotte, *Some 3D Graphs in Levels of Gray*, 2019

spectrums are composed of frequencies showing an integer ratio between them. This gives way to a natural tendency to "discretize" our perceived universe: the generally decreasing energy of harmonic partials, from the fundamental to higher frequencies, suggests that we use sets of discrete frequencies for making music (so-called musical scales used traditionally in any culture of the world). What about dividing the pitch continuum by discrete steps? We did so. An advantage of this (generally static) division is that it provides a finite number of items that can be manipulated by means of addition or of other kinds of operations. This is what led to the glorious music of Bach. Once the process is theorized, there are no limits to further manipulations: several authors, including Xenakis with his sieve theory,[15] or Wyschnegradsky with ultrachromatism,[16] did think about dividing the pitch continuum differently than following any tradition. Reflections about scales, including thirds tones or quarter tones have existed since a long time ago, notably with the Greeks around the fourth century BCE:

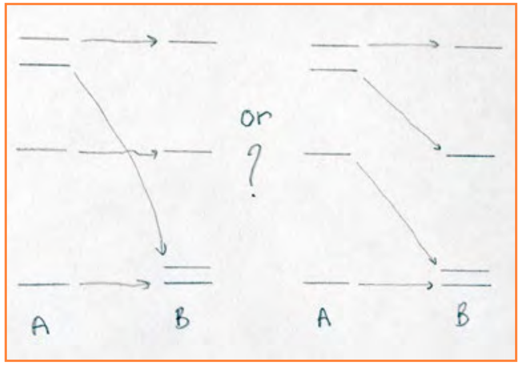
"The diatonic scale, which is obtained by tuning pure fourths and fifths by ear [...] was altered to the soft diatonic of Polymnastus; in this scale the *lichanos* of each tetrachord was flattened by a quarter of a tone: producing the intervals (ascending) semitone, 3/4 tone, 1–1/4 tone."[17]

WITH OR WITHOUT LATTICES

Dealing with discrete values means creating lattices. As suggested in the previous paragraph, lattices have this kind of numeric property, appropriate for arithmetic calculus. So, choosing a lattice for one property of a sound has important aesthetic implications. This means that for a certain amount of time, one of the properties of the sound will only have a finite amount of possibilities. We can therefore be tempted to imagine lattices that change over the duration of a musical piece. This has of course been done by several composers, but in general, by discrete steps: for a period of time we constrain pitches (for example) to lattice A, then for another time period to lattice B. What if we made a continuous transformation from lattice A to lattice B? It would be more consistent with the idea of dynamic morphology, as coined by Trevor Wishart in his book *On Sonic Art*.[18]

First, we may want to implement a version in which there is the same number of elements in A and in B. We will not address the cases when the distribution (the way they are spatially distributed) of A and B are very different. **FIGS. 6, 7**

Intuitively, we see that for the transition to be perceived, we need a minimum density of events between the two. There would be some kind of equation defining an approximate minimum density f, like $f > alpha * m/T$, where f is the number of events per second, alpha some factor to



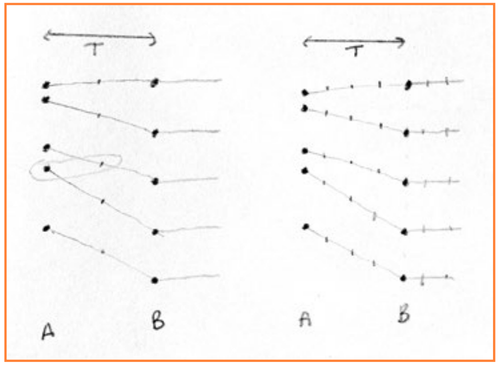


FIG. 5 Rodolphe Bourotte, A Hypothetical Score a la plancha, 2018, modelling dough and acrylic paint © Rodolphe Bourotte

FIG. 6 Rodolphe Bourotte, Sketch of Evolving Sieves: Interpolation between Sieves, 2019 © Rodolphe Bourotte

FIG. 7 Rodolphe Bourotte, Sketch of Evolving Sieves: Ambiguity in the perception of individual "sieve voices", 2019. Slow trig rate is circled on the left. © Rodolphe Bourotte

refine, m the maximum derivate among the various values changing over the time T. The question begins also to raise some paradoxical thoughts: there will be a point where the evolving sieve could be assimilated to an instantiated curve *per se*. It will be when the time density of considered events to be triggered will merge into a perceived continuum.

Finally, more philosophically (or even tricky): perhaps one component (#1) of a sieve could be considered a track, containing all the possible values for every given time within a piece. The composer would decide afterwards when events should happen on this and other tracks. Let us keep in mind that the decision of creating timed events is of the same nature as a discretization, that is, the discretization of time. It is extremely rare to consider time as continuous in music, especially at the meso level.[19] Indeed, "sound objects" are individual entities, hence discrete.

There is also a link to probabilities: probabilities mean "drawing a lot" (which is a discrete event). In computer music, if we think of probabilities, it is often on the micro level (for instance, at the sampling rate), as a way to produce a result that sounds continuous on the macro level (the sound we hear).

PROBABILITIES AND DRAWING

Drawing would be a very efficient way of describing probabilities. There is not, to our knowledge, any intention formulated by Xenakis to use drawing instead of formulas for describing probabilities of events. This is surprising, because it would lead to a unification of both worlds in a simple fashion. A drawing by Xenakis for his piece *Achorripsis*[20] reflects such a position, by dividing time into segments of fifteen seconds, and filling the matrix with values of the number of events from 0 to 5:

The same approach has been observed in Xenakis's GENDY pieces (1991–1994): for the eleven sequences of *Gendy3,* as shown by Peter Hoffmann,[21] each corresponds to a different "sound synthesis parameter set" applied to "a GENDYN sequence entity."

Our proposition is that instead of using probabilities in their rigorous mathematical description, which may certainly seem closer to natural models, one can decide on artificial, arbitrary probability distributions, conceiving scores by providing for each voice at every point in time a value and an amount of deviation from this value. This would be described properly either by a 2D graph with gray levels, or by a 3D graph, as described in Figures 3 and 4. Then, at a given slice of time (accessible at any scale), the probability distribution would look like visualized in **FIG. 8**. The plot represents the probability for the pitch that will be triggered at the time of the slice.[22]

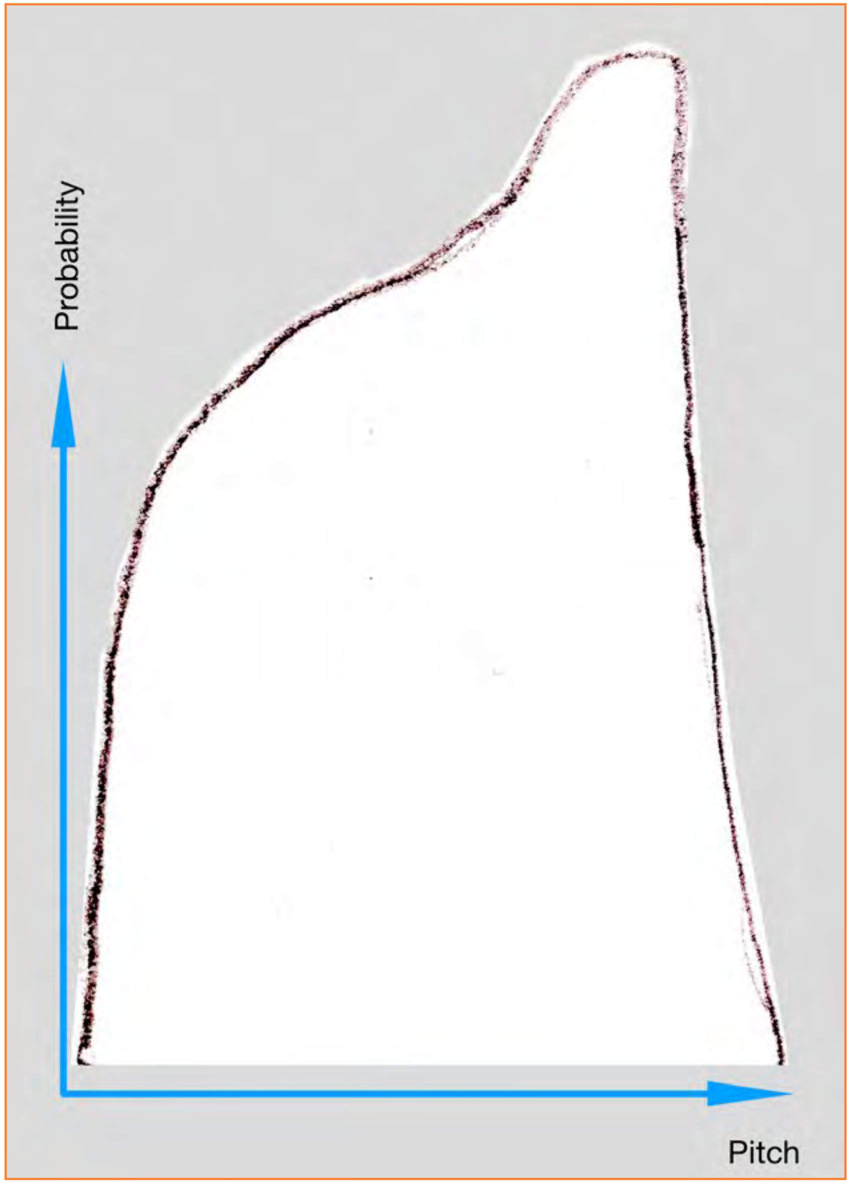


FIG. 8 Rodolphe Bourotte, *A Single Slice of Time*, 2019 © Rodolphe Bourotte

CONCLUSION

UPISketch's *raison d'être* is its UPICian heritage, but its creation was also motivated from the outset by possible new developments. The most important feature is notational: we want to use drawing as a way of describing/organizing sound events. The goal of this chapter is to give an overview of the ideas that link probabilities, sound synthesis and drawing, and to show how this process implies multidisciplinary thinking, including how we understand the world we live in.

FOOTNOTES

1. Rodolphe Bourotte and Sharon Kanach, "UPISketch: The UPIC Idea and Its Current Applications for Music Pedagogy," in *Organised Sound 24/3* (Cambridge: University Press, 2019), 252–260, doi: 10.1017/S1355771819000323.
2. Sonification is the process of translating a physical value into an audible sequence. It can be applied to anything, for example, stock market prices, see David Worrall, "Using Sound to Identify Correlations in Market Data," in *Auditory Display*, Lecture Notes in Computer Science Series, ed. Sølvi Ystad, Mitsuko Aramaki, Richard Kronland-Martinet, and Kristoffer Jensen, (Berlin: Springer, 2010), 202–18.
3. Wikipedia Contributors (2018), Wikipedia entry on *Notation*, https://en.wikipedia.org/wiki/Notation
4. For a reference book about graphic notation in music, see Theresa Sauer, *Notations 21* (New York: Mark Batty, 2009).
5. *Pitch*, Definition of pitch in English by Oxford English Dictionaries, https://www.lexico.com/en/definition/pitch
6. Charles Francis Abdy Williams, *The Story of Notation* (London: Walter Scott Publishing Co. Ltd.; New York, C. Scribner's Sons, 1903) 12, https://archive.org/details/storynotation00willgoog/page/n9
7. For a detailed description of various audio features, see Geoffroy Peeters, "A Large Set of Audio Features for Sound Description (Similarity and Classification) in the CUIDADO Project," IRCAM internal report, 2004, p. 13, http://recherche.ircam.fr/equipes/analyse-synthese/peeters/ARTICLES/Peeters_2003_cuidadoaudiofeatures.pdf
8. Moreno Andreatta, Gérard Assayag, Carlos Agon, and Stephan Schaub, "Formal Aspects of Iannis Xenakis' 'Symbolic Music': A Computer-Aided Exploration of Compositional Processes," in *Journal of New Music Research*, 33:2 (2004), 145–59. https://doi.org/10.1080/0929821042000310621
9. Heinrich Rudolph Hertz, trans. D. E Jones and John Thomas Walley, *The Principles of Mechanics Presented in a New Form* (London: Macmillan, 1899). https://archive.org/details/principlesofmech00hertuoft/page/xxviii
10. Iannis Xenakis and Benoît Gibson, *Kéleütha: écrits* (Paris: L'Arche, 1994), 34–35, author's translation.
11. Howard Gray, Funkhouser, "A Note on a Tenth Century Graph," in *Osiris 1* (January 1936), 260.

12. Historians seem to agree on the fact that one of the most important contributions to data graphics is by William Playfair (1759–1823): "William Playfair is the principal inventor of statistical graphs. [...] Playfair's graphs were elaborate and well constructed: they appeared regularly in several publications over a period of more than 30 years and they introduced a surprising variety of devices and techniques that are in use to this day. He invented three of the four basic forms: the statistical line graph, the bar chart, and the pie chart." in, The *Encyclopedia of Social Measurement*, ed. Kimberly Kempf-Leonard (Amsterdam: Elsevier, 2005).

13. Bradford Skow, "What Makes Time Different from Space?" *Nous 41*, 2 (2007), 227–52. https://doi.org/10.1111/j.1468–0068.2007.00645.x

14. Julio Estrada, "JULIO ESTRADA: THÉORIE DE LA COMPOSITION (II)." https://www.academia.edu/8456158/JULIO_ESTRADA_TH%C3%89ORIE_DE_LA_COMPOSITION_II_

15. Iannis Xenakis, *Formalized Music: Thought and Mathematics in Composition* (Hillsdale, NY: Pendragon Press, 2001), Chapter 11.

16. Ivan Wyschnegradsky, *La loi de la pansonorité*, ed. Pascale Criton and Franck Jedrzejewski (Geneva: Éditions Contrechamps, 2017).

17. Charles Francis Abdy Williams, *The Story of Notation* (London: Walter Scott Publishing Co. Ltd.; New York, C. Scribner's Sons, 1903), 21. http://archive.org/details/storynotation00willgoog

18. Trevor Wishart, *On Sonic Art*, New and revised edition, ed. Simon Emmerson, Contemporary Music Studies Series, Book 12 (Amsterdam: Harwood Academic, 1996).

19. "Meso" is an important and useful term, often used in Curtis Roads's seminal book *Microsound*: "The mesostructural level groups sound objects into a quasi-hierarchy of phrase structures of durations measured in seconds," in Curtis Roads, *Microsound* (Cambridge, MA: MIT Press, 2004), 14.

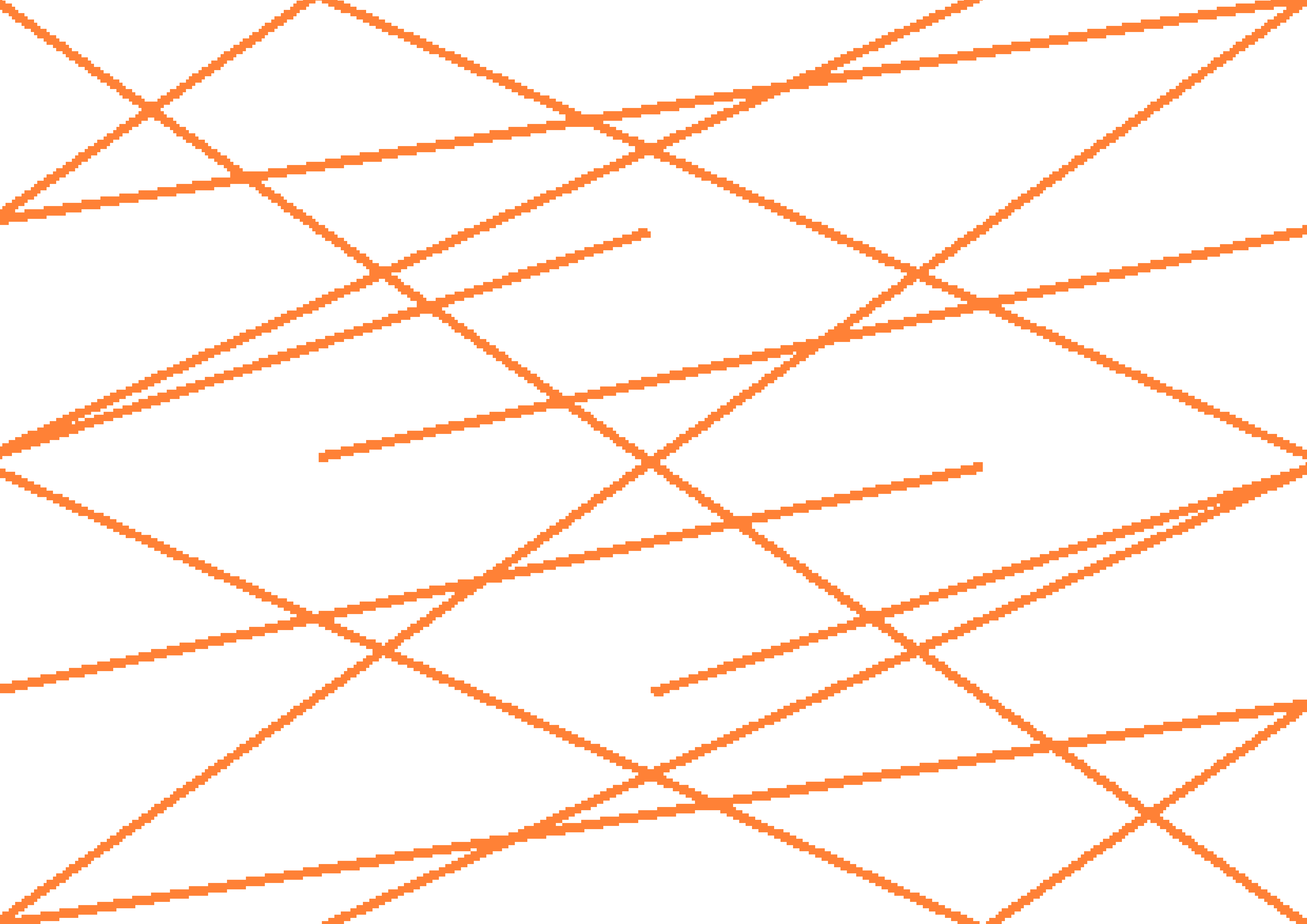
20. For this particular drawing please see Iannis Xenakis, Composer, Architect, Visionary (The Drawing Center, 2010), 57. https://issuu.com/drawingcenter/docs/drawingpapers88_xenakis

21. Peter Hoffmann, *Music Out of Nothing? A Rigorous Approach to Algorithmic Composition by Iannis Xenakis*, published by Technische Universität Berlin, Fakultät I: Geisteswissenschaften, 2009. http://opus.kobv.de/tuberlin/volltexte/2009/2410/

22. This video shows the operational principles behind drawing probabilities. http://rodolphebourotte.info/GraphicNotation/PGSSDraft.mp4

COMPOSERS EXPERIENCING THE UPIC

JULIO ESTRADA
RICHARD BARRETT
FRANÇOIS-BERNARD MÂCHE
TAKEHITO SHIMAZU
BRIGITTE CONDORCET
(ROBINDORÉ)



THE LISTENING HAND

JULIO ESTRADA

JULIO ESTRADA

THE LISTENING HAND

This text is closely related to my activities in research on musical-creation—not necessarily composition—and on the continuum, as well as my experience teaching at CEMAMu between 1980 and 1998, where from 2000 to 2001 I was invited as director to lead research aimed at creating a new model for the UPIC system.[1]

Starting from a simple principle—graphic rendering of musical material—Xenakis's UPIC demonstrates a pedagogy for music that is open to a broader public, whether musicians or not. It is the user who obtains all results without being guided by academic aesthetics or by new technologies. The UPIC is a kind of musical creation table where each user must explore on their own what suits his or her imagination and thought. Direct access to musical creation without previous knowledge of a musical language—but sound processing through drawing, or pedagogical approaches generated by the system—are aspects to be maintained in future developments of the UPIC system.

UPIC VERSIONS

In 2000, the music department of the French Ministry of Culture invited me to direct the CEMAMu, where I worked with Gérard Marino and Vincent Fontalirant, computer scientists whose ongoing task was to complete a UPIC PC version. After the CEMAMu's Scientific Committee accepted my approach to develop a "21st century UPIC PC soft," I formally proposed to integrate theoretical proposals from Xenakis and also to incorporate my own research on the continuum, which in turn aspired to open other musical horizons. Neither CEMAMu's Scientific Committee nor its Board of Directors had the musical authority or the scientific commitment necessary to defend such a new project, which forced me to resign in June 2001. The Ministry of Culture decided in September of the same year to close the center.

The main ideas of my approach to develop the system were to reintegrate functions of the various UPIC versions produced since 1977 that had disappeared in subsequent iterations. It was also imperative to integrate Xenakian stochastic timbres, or the expansion from functions of the micro type to functions of the macro type. The idea of building a new UPIC system came from my research in musical creation since 1980. I introduced Xenakis to some of those theoretical approaches[2] at a conference in Zurich[3]:

1. rhythm-sound continuum
2. music creation by three-dimensional drawing
3. conversion of graphic renderings to music notation
4. continuum-discontinuum fusion

I shall go into more detail about these four proposals:

RHYTHM-SOUND CONTINUUM

The notion of continuum naturally leads to the observation of the physical unit rhythm-sound,[4] where rhythmic frequencies are fundamental to sound frequencies. Electroacoustic tools enable one to observe that frequency, amplitude, and harmonic content data of any waveform preserve their structures in the ambitus of low frequencies. This gives an objective and homogeneous identification of the respective components of sound and rhythm:

A frequency
- rhythm: duration
- sound: pitch

B amplitude
- rhythm: attack
- sound: dynamics

C rhythm: micro-durations[5]
- sound: color

All six of these components constitute a rich object whose material, as audible as reality itself, highlights rhythmic and sound data; their diversity requires unifying them as a *macrotimbre*. The physical nature of the rhythmic-sound macrotimbre leads in turn to the notion *of chronoacoustics,*[6] which integrates modern Einsteinian thought concerning the spatiotemporal fusion of matter, in contrast to traditional acoustics.

In 1980, I proposed to Xenakis to expand the range of the UPIC to rhythm as part of the musical frequency continuum. This idea was refused because of Xenakis's assumption that the UPIC system allowed generation of rhythms with envelopes. I was struck by the 1983 version of the UPIC whose drawing table was twice as large as the first one; this would enable increasing its original ambitus to rhythm. Later, the 1990s version opened towards low frequencies, reaching durations longer than one minute. Although this proved that the CEMAMu had modified its initial vision, no new works resulted from these enhancements.
I insisted on my initial approach in 1981, when I experimented with the superposition of several frequencies close in pitch at Stanford University's CCRMA (Center for Computer Research in Music and Acoustics), obtaining a tight nucleus of fundamentals whose harmonics were perceived as rhythms, rhythms-sounds, and sounds. Afterwards, I developed a method of drawing rhythm-sound continuums in the field of written acoustic music with *eolo'oolin* for 6 percussions, 1983.[7]

I confirmed these results with UPIC's own methods with the project *yuu'upic* (1993),[8] using low frequencies as generators of new musical material.

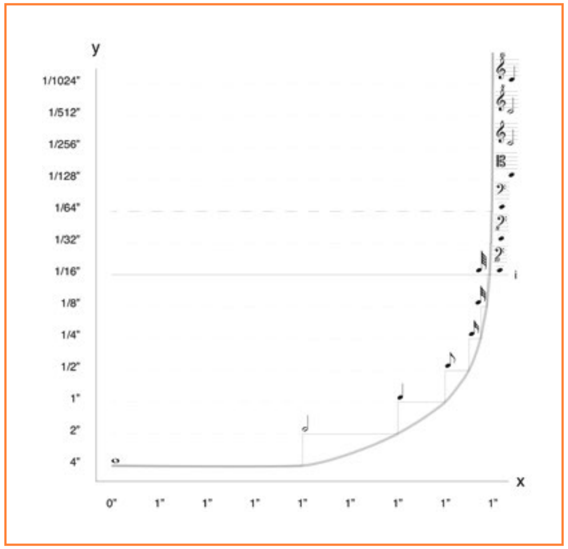
Working on *eolo'oolin* and on the *yuu'upic* project required drawing rhythm, a convenient method for a design-based system. The attempt to transcribe rhythm through drawing cannot avoid the relationship between time and duration: any line representing a duration is obliged to remain fixed, to be discontinuous, until the duration has been achieved. **FIG. 1**

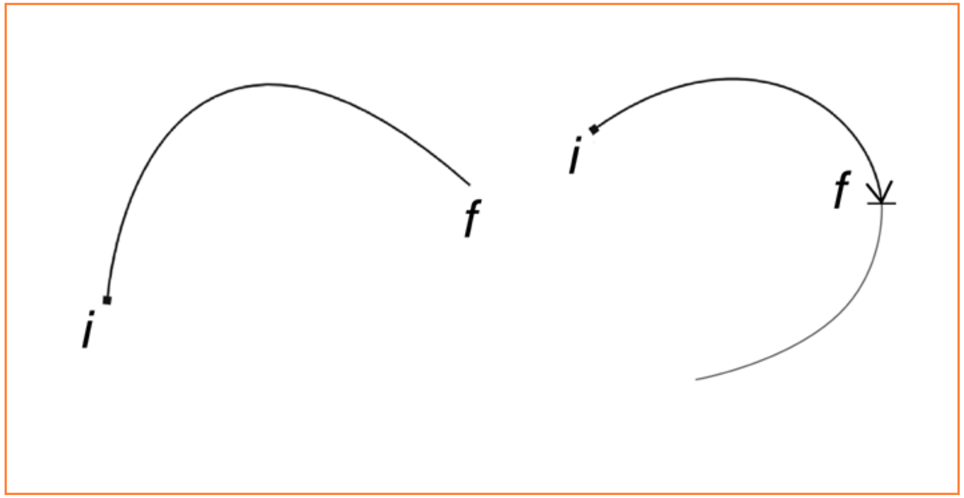
MUSIC CREATION BY THREE-DIMENSIONAL DRAWING

With the UPIC, time becomes the *x* coordinate while the *y* coordinate represents the energy level of the pitch frequencies, envelopes, or waveforms **FIG. 2** By fixing time as a parameter, a drawing is obliged to follow the course of time or be partially cancelled. In the trajectory on the left the initial point *i* and the final point *f* evolve without contradictions, whereas the trajectory on the right must end before concluding its counter clockwise motion.

Both curves in Figure 2 also illustrate the contradictory design of rotations of curved trajectories. For instance, the attempt to draw a circle with only one trajectory requires drawing a second trajectory to complete the figure, a counter-intuitive solution that characterizes the music creation by the drawing. Such contradictions encourage us to extend our graphical rendering method to trajectories with three or more dimensions; more difficult to draw but richer and helpful, because in such cases, the trajectory may refer to an evolution where time is not necessarily one of the main coordinates. A graphical clock of time's evolution is sufficient to trace the trajectory and frees up the coordinates from this task. For simultaneous representation in a given collective trajectory of other rhythm or sound components, all will be synchronized by the speed of time flow. This could allow for a visual reading clear enough to become an equivalence of the musical information it contains: self-sufficiency similar to a graphic pre-score. The advantage of multiple trajectories integrating time evolution is their ability to design information-rich macrotimbres. The time-counter (clock) is identified by constant units of duration—lines with points at the center cutting the path of the work. **FIG. 3** The coordinates: *x*-range of the vowels; *y*-range of pitches; *z*-vibrato, in fractions of a second. Three new coordinates of the trajectory, not specified in Figure 3, are, for example: *u*, thickness of the line, evolution of the amplitude; *v*, lines inserted in the rough face with diagonals, pressure in voice emission; *w*, lines in the smooth face, density of vocal granulation.

The design of the 21st Century UPIC would simultaneously represent all the data inside the body of an entire trajectory; the unfolding of present time would become its frontal face, like a mouth. The inclusion of multiple trajectories may use arbitrary correlations or relative equivalences between rhythmic-sound frequencies and visual elements; that is, low frequency





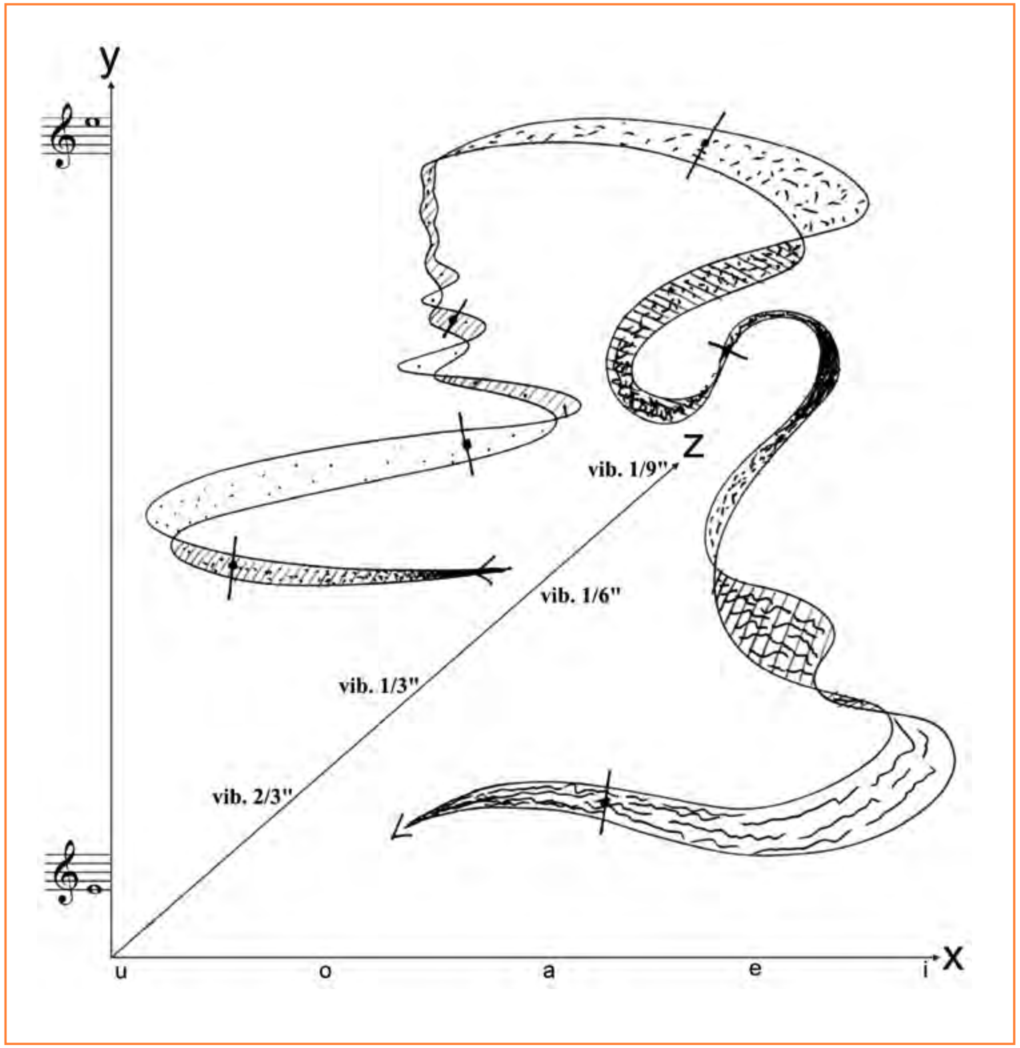


FIG. 1 Chronographic representation of rhythm and sound, 2010. Horizontally, the drawing of the durations advances by thresholds up to the rhythmsound limit (1/16"), or the line tends to curve as it approaches the vertical axis. Drawing by the author in 2010, digital version by Christian Morales, in further musical digital drawings referred to as Ch.M., in 2019. © Julio Estrada and Ch.M.

FIG. 2 Curved temporal trajectories, 2000 © Julio Estrada and Ch.M.

FIG. 3 Trajectory for a voice: 3-dimensional space with a 3-dimensional trajectory, 1994 © Julio Estrada and Ch.M.

duration (visual rhythmic pulsation), attack intensity of the duration (initial light), rhythmic harmonic content (granulation of light material), sound frequency (colors), sound amplitude (light intensity), waveform harmonic content (closed geometric shapes), pressure in the emission (molecular focus), texture (image filters), etc.

CONVERSION OF GRAPHICAL RENDERINGS TO MUSIC NOTATION

The opening and closing sections of Xenakis's *Metastasis* demonstrate the case of writing produced by an exchange between graphical data and musical data. In the method of rendering musical data through drawing, musical writing is not a *transcription* since this would imply a change from one type of writing to another. Instead, the notion of *conversion* becomes more representative of the passage from graphical data to the code of music writing, and in turn leads us to the notion of a *resulting score*, established only *after* the graphical form.

Among their resources current technologies integrate new methods of music notation; however, writing music generated from graphics requires considering musical values in terms of *chronoacoustic* physics. A way to get closer to this task could start by analyzing what is comprised in a waveform in order to convert its physical data into musical code equivalents. Converting durations into written values can be simplified by the reference to arbitrary units (i.e., 3, 5, 7, 11), whereas the amplitude can use a referential range of dynamics (from 0 db at 3*p* to 3*f*). **FIG. 4**

As we can see on the right **FIG. 5**, the conversion of the six data extracted from the waveform allows for their macrotimbre to be identified: (a) general duration, quarter-note = metronomic velocity of 60 strokes per minute; (b) pitch, 1/64"; (c) accent, loudest dynamic, <3*f*; (d) overall intensity, dynamic mean of the waveform, *f*; (e) vibrato[9] or micro-duration; (f) timbre, harmonics identified in relation to the grid. At the bottom, on the left: a sequence of small pulsations of the rhythmic data; on the right: a fleeting succession of the order of appearance of harmonics.

The interest in converting the drawings I made in 1980 for *eua'on*[10]—Náhuatl (Aztec): *eua*, fly away; *on*, distant—my only work made on the UPIC—into instrumental music led me to produce a set of complementary drawings for the creation of a large orchestral score, in 1995, *eua'on'ome*—Náhuatl: *ome*, two. Its orchestral macrotimbre was based on research designed to be applied to strings, wood, metals, and percussion, oriented to create a homogeneous writing whose goal was to erase their differences by sharing similar articulations of pitch, dynamics, color, attack pulse, micro-duration, and pressure in the emission. The orchestral mass individualizes nearly fifty voices made up of the addition of eight simultaneous macrotimbres.[11]

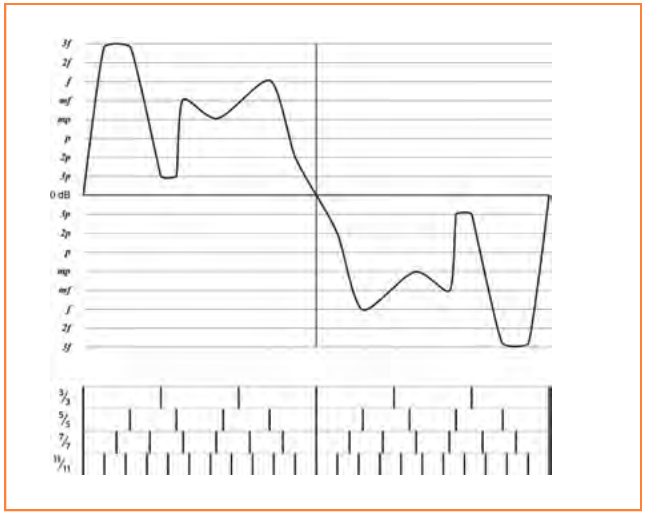


FIG. 4 Waveform and rhythmic value grid, 1994 © Julio Estrada and Ch.M.

FIG. 5 Conversion of the data extracted from the waveform above in Figure 4 into musical notation, 2018. At the bottom, two synthetic forms of micro-temporal evolution © Julio Estrada and Ch.M.

EUA'ON'OME Julio Estrada, e.16b, for orchestra, 1995, premiered and recorded with Baden-Baden Orchestra, Südwestfunk, conducted by Olaf Henzold in Donaueschingen, Germany, October 20, 1995. In *Xenakis, UPIC, Continuum, Electroacoustic and Instrumental Works from CCMIX Paris*, Mode 98/99, 2 CDs, Éditions Salabert, excerpt from 7'45" to 10'44" © juliusedimus

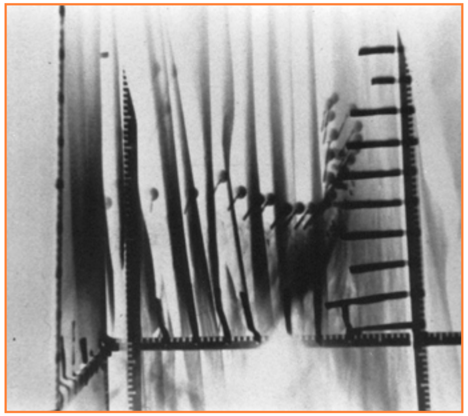
The interest in a new UPIC version or other systems that allow conversion of data from complex trajectories into a score is based on the need for a fast calculation tool in order to develop modern musical writing for voice and instruments. Nevertheless, although codification obstructs the processes of analogical representation of the musical imagination, in the case of score conversions, it offers the advantage of analyzing both the writing-to-matter relationship and the audible results.

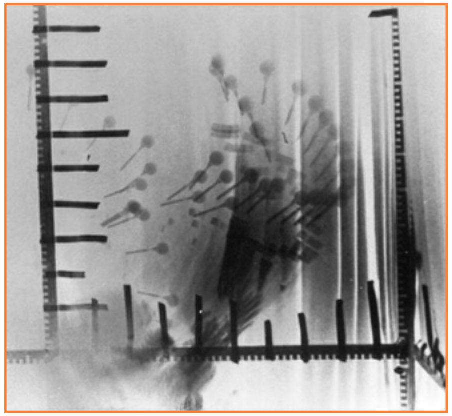
At the University of Mexico, we developed the *eua'oolin* system—Náhuatl: *oolin*, movement—a modest but effective tool for recording three-dimensional trajectories in real time for their conversion into sound results and musical notation.[12] Sound is converted using a commercial synthesizer controlled by software that allows a maximum conversion of eighths of a tone, close to the continuum. Unfortunately, timbres are limited to instrumental colors of the modest synthesizer we used for sound generation. Rhythmic writing divides the second into five equal parts. Using a small wand with a ball on its tip, the user draws free trajectories in a cube with dimensions between 40 and 80 cm per side. Two synchronized cameras record the small ball, one placed on the *x-y* plane and the other on the *x-z* plane; each stroboscopic pulse lengths 1/10th of a second. **FIGS. 6, 7**

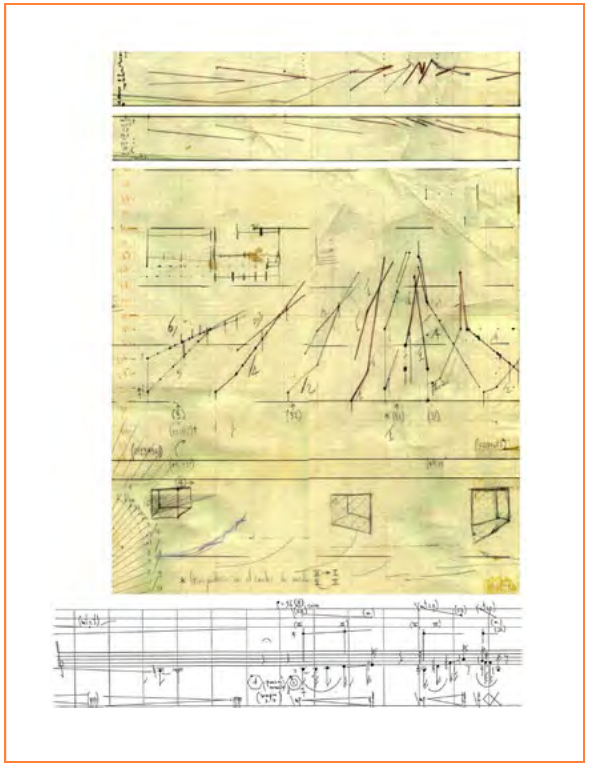
Listening by hand implies combining the ear and sight in a synesthetic perception, the basis of a new method of musical representation of physical matter. The generalization of the graphic method to represent all the possible components of the macrotimbre eliminates the old academic division that musical conceptions only pass through the ear. Therefore, the frank integration of the audiovisual field into musical thought offers the mind a clearer perception of the temporal transformations of matter, their movement—a fundamental aspect in music.

The creative process behind *ishini'ioni* (Purépecha): *ishini*, always, *ioni*, time—for string quartet (1984–1990), originated from the conception of the eua'oolin system, which led me to develop transformations of movement through topological variations that control pitch, intensity, color, and rhythmic bow articulation. **FIG. 8**

The ability to create an image—and consequently imagine—everything that moves through the drawing leads to the observation of the action itself, its intrinsic energy as a physical value attributable to any drawing. This energy, whether physical or even abstract, represents information as important as that of the specific component assigned to a macrotimbre. For musical thought, drawing becomes a dynamic alternative that extends the methods of assigning macrotimbric data. For example, a vector with the same amount of energy as another—at the level of the ambitus of each component—can always express itself with an equivalent value







FIGS. 6,7 Two synchronic sequences of a 3-dimensional trajectory, 1990, both photos made with stroboscopic pulse lengths of 1/10th of a second light, length about 3 seconds. 3D trajectory by Julio Estrada 1990 © Julio and Benito Estrada [13]

FIG. 8 Julio Estrada, Topological variations, 1986, fragment of a passage of *ishini'ioni*. One of the series of four trajectories, one each per string instrument, containing five components, is converted into the cello score: from top to bottom, string color, bow speed, pitch (two voices), vibrato speed, and dynamics. Ink and color pencil drawing by the author on graphic velum paper, 72 × 48 cm. © Julio Estrada Archives

ISHINI'IONI Julio Estrada, e.19, 1990, for string quartet. In *Julio Estrada. Chamber Music for Strings*, Arditti String Quartet, Arditti Quartet Edition 27, Auvidis Montaigne, MO 782056, CD, digital recording by Radio France, Paris, France, excerpt from 6'30'' to 8'03'' © juliusedimus through another component. The ear will move from a forward listening directed towards a single data to a listening that will rather perceive the way information moves. A visual example helps us to grasp this idea better: a simple trajectory originally applied to a vocal or instrumental color starts from the vowel *o* and passes continuously to the vowel *a*, a little lighter than the first. The energy of the same trajectory can be attributed to, amongst others, datapitch, dynamics, color of the bow on the string, the articulation of the bow-pulse, voice's respiration, brass's breath—or spatialization. **FIG. 9**

CONTINUUM-DISCONTINUUM FUSION

Science observes physical states of matter in various forms, the most commonly known being gas, liquid (of continuous order), and solid (of discontinuous order). What we come to know through science or our beliefs becomes at the same time referential knowledge for the processes of representing fantasies that maintain certain relationships with reality. This is particularly striking in the arts, which, in conscious or unconscious ways, use this knowledge in the manifestation of creations which, transmitted perceptually, often carry their fantasies in forms close to matter.

In contrast to the continuity of music inspired by fluids, the universe of scales approaches solids, information expressed in the form of fixed pitches and intervals. Traditional methods associated with scales seem to be influenced by the inherent fixity of their data by forcing rhythmic durations to nail themselves to the pitches of melodic writing, for counterpoint to be conceived as the mechanics controlling the point-to-counterpoint ratio, for harmony to maintain itself in an ever-synchronous verticality, and for musical micro- and macroforms to remain crystallized as a memory that predicts the course of time.

Towards the beginning of the twentieth century, a constant search for new scales led creators and researchers to focus on experimenting with a diversity of new scales produced by the division of the tone (Carrillo, Hába, Wyschnegradsky), of the "octave" or *frequency replication interval* (*fri*) (Novaro), and later in scales produced by harmonics that can be reduced to the ambitus of the *fri* (Partch), scales outside the *fri*, inspired by non-European music (Xenakis), or a continuum of scales, in or out of the *fri* (Estrada).

In order to be able to project the spatiotemporal relationships of the new scales easily, we need to approach them through research outside their specificity by integrating them into a kind of discontinuum-continuum, meaning a space outside hierarchies and with lower resolutions than those of our perception of continuities. By moving away from systems one can look at the elementary distances between their intervals to allow their

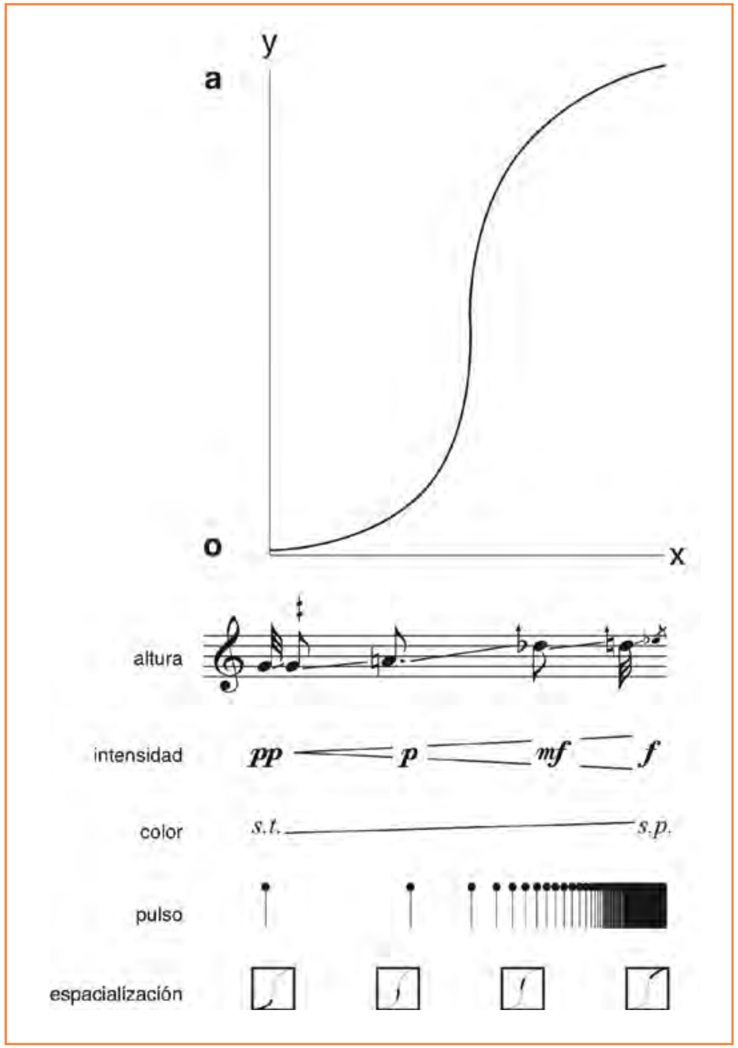


FIG. 9 "*oa*" trajectory and its attribution to several alternatives among the components of a macrotimbre having comparable degrees of energy, 1994 © Julio Estrada and Ch.M.

combinatorial structure to be derived easily from their interval classes. If we work with scales as a continuum matter, we will be able to get closer to their singularities. Thus, the possibility of traversing the space of any scale with intervallic transitions of minimum distances, *d1*—step by step—makes it possible to obtain all the combinatorics through their interval classes. From there, the expectation of projecting their sequential and vertical relationships becomes both logical and necessary. The origin of the interval class theory and its integration in a melodic-harmonic sole texture have been developed in *Canto naciente* (1975–78), 8 brass, choral section, *juliusedimus* [4’04’’ to 7’02’’ of the complete performance]. **CANTO NACIENTE**

The combinatorial potential of intervals of the scales makes it possible to reduce all their possible aggregations of intervals to a minimum.[14] For example, an aggregation or *identity of the intervals* comprising 1 semitone, 1 tone, and 1 major sixth (1–2–9) will generate a series of 6 permutations intertwined with each other by small transformations of the order *d1* (1–2–9, 2–1–9, 2–9–1, 9–2–1, 9–1–2, 1–9–2). This series of cyclical permutations constitutes a *permutahedra*, a mathematical structure that allows all possible permutations of interval identities to be continuously generated. **FIG. 10**

I proposed combining the UPIC with MuSIIC-Windows software, designed to obtain the combinatorial potential of pitch ranges or durations ranging from 3 to 53 divisions of the *frequency replication interval* (*fri*),[15] which can be used to explore different types of conversion resolutions in new musical scores.[16]

The 21st Century UPIC project envisaged the integration of the vast continuum of scales contained in the MuSIIC software, so that the mathematical organization of the discontinuous and continuum universes could intertwine and give rise to a fusion open to new creative and theoretical exploration.

A window remains concerning the continuous transformation of timbre: in the field of acoustics, I propose, together with Víctor Adán, using the methods of combinatorial interval potential theory to reduce complex structures such as waveforms to a series of intervals representing either the micro-temporal evolution of their frequency or of their amplitude. This requires the frequency and amplitude level structure of the waveforms to be made discrete in advance at frequency and amplitude intervals. Aiming for a continuous variation of color as a central goal, this approach proposes the ultra-fast generation of continuous transitions between sequences of intervals whose content can follow various series of permutations within a waveform identity constituted by two simultaneous identities: one of frequency and the other of amplitude.

CANTO NACIENTE Julio Estrada, e.8, 1975-78, for brass and choral section, premiered and recorded with UCSD Brass ensemble, conducted by Tom Lee at Intercon 82, Festival of Pan-American Contemporary Music, Center for Music Experiment, Music Department, University of California San Diego, La Jolla, California, USA, April 17, 1982, excerpt from 1'18'' to 2'59'' © juliusedimus

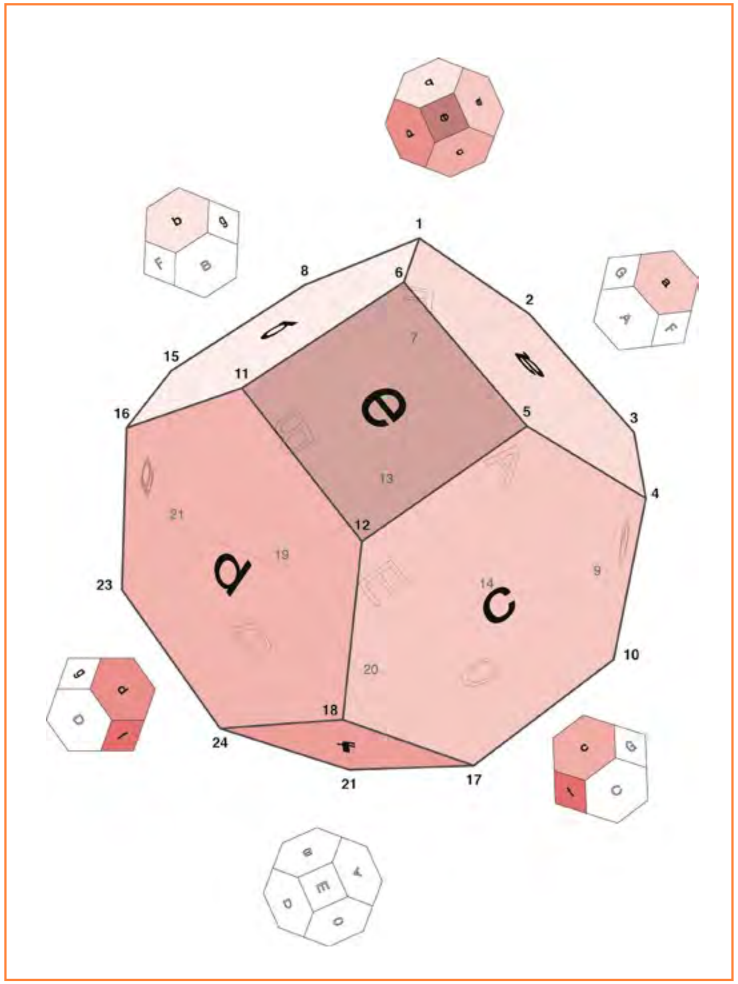


FIG. 10 Permutahedra of an identity of the type [a b c d], 1994, 4 different intervals producing 24 permutations, ordered in the figure from A to G and from a to g. Geometrical structure by Julio Estrada in 1994, digital version by Ch.M. in 2019 © Julio Estrada and Ch.M.

These continuous color changes would be the product of constant permutation of the two groups of intervals and their independent transitions to other frequency and amplitude identities belonging to their starting scales or to adjacent scales at *d1* distance. The previous step was taken to a modest level by the MuSIIC-Win software, which made it possible to create fairly simple waveforms characterized by small numbers of frequency and amplitude intervals.[17]

A SPACE OF EXPLORATION-CREATION

Creative exploration of the continuum occurs outside of didactic memorization: *exploring* this territory becomes an unheard-of training experience that encourages auditory research. The nature of the continuum allows us to see the widespread equality of information where no signal indicates the existence of a single reference point other than the limits of its own space. Creating music—in opposition to composing—in this continuum becomes significant through one's intentionality facing a homogeneous space that leads one to discover answers alone. Learning through such nudity is like witnessing a construction, step by step. Finding or losing oneself inside such a fluid space relies on evaluating through sight and listening how to understand the perceptive, rational, and artistic experience of grasping the value of what is created. Discovering freedom of action through matter itself places one in pedagogical exile that is close to a painter's intuition; therefore, attainment depends solely on one's own gift.

This great discontinuum-continuum, comprising long durations to micro-durations, links the spatiotemporal domain of music, marking a reference point that integrates scientific notions with musical theories using physics as a basis. Naive acoustics that serve the dogmas of musical languages do not manage to detach themselves from academic atavisms; on the contrary, accepting musical material as it is—plus the tools of mathematical organization—lead us to assume that scientific knowledge may be shared by the imagination, and thus gives way to its scope. The new perspective of this discontinuum-continuum, coupled with the basic references offered to the imagination by the physical states of reality, enable one to consider that the metaphysical substance of such fantasies can generate creative metaphors capable of transforming the musical art from its roots.

FOOTNOTES

1. Parts of this text are taken from a working report to CEMAMu: “The UPIC of Iannis Xenakis: Its Future Development,” a synthesis of which was published as: “Neues Kompositionswerkzeug. Das UPIC-System und seine zukünftige Entwicklung,” translated into German by Gisela Gronemeyer, MusikTexte, Zeitschrift für Neue Musik 89 (2001), 58–59. Some other passages derive from my recent book, *Realidad e Imaginación Continuas. Filosofía, Teoría y Métodos de Creación en el Continuo* (Continuous Reality and Imagination. Philosophy, Theory and Methods of Creation in the Continuum), UNAM, México, in press.

2. J. Estrada, “Théorie de la composition: discontinuum-continuum,” PhD dissertation, Université de Strasbourg Sciences Humaines, 1994. https://unam.academia.edu/julioestrada/Thesis-Chapters

3. J. Estrada, “Computer-assisted Music Composition: Software on the Combinatorial Potential of Scale Intervals and the *eua’oolin* System,” concert series of computer music and symposium, Musikschule Konservatorium Zürich, Switzerland, December 11, 1988.

4. An idea proposed by Henry Cowell in *New Musical Resources* (See www.ubu.com/historical/cowell/Cowell-Henry_New-%20Musical-Resources.pdf) and reprised by Stockhausen in “how time passes...” based on his experience with electronic music, see https://www.artesonoro.net/artesonoroglobal/HOW%20TIME%20PASSES%20BY.PDF

5. This phenomenon can be observed with a bass drum: after a single, strong percussive attack, a series of micro-durations resulting from the attack is produced during the evolution of its sounding.

6. J. Estrada, “Théorie de la composition,” fn. 17, 497.

7. See an excerpt here: https://www.youtube.com/watch?v=K-4IwHieYI0

8. The title refers to the series of *yuunohui* (Zapotec: *yuu*, clay; *nohui*, humid).

9. Apart from Xenakis’s “beats,” vibrato being the artificial equivalent of micro-duration in terms of traditional writing.

10. https://www.youtube.com/watch?v=9LUNXqcVUOg

11. See Robindoré, this volume, Figure 4, for an excerpt of the UPIC score of *eua’on*.

12. J. Estrada, and M. Peña, *eua’oolin* project, Instituto de Investigaciones Estéticas e Instituto de Investigaciones en Matemáticas Aplicadas y en Sistemas, Universidad Nacional Autónoma de México, UNAM, 1989–1995.

13. J. Estrada, “*eua’oolin*: desarrollo de equipo musical por trayectorias temporales multiparamétricas y su transformación algebraica,” *Memoria, Tercera Conferencia Internacional: Las Computadoras en Instituciones de Educación*, México, Cómputo Académico, UNAM, UNISYS (1987), 118–121.

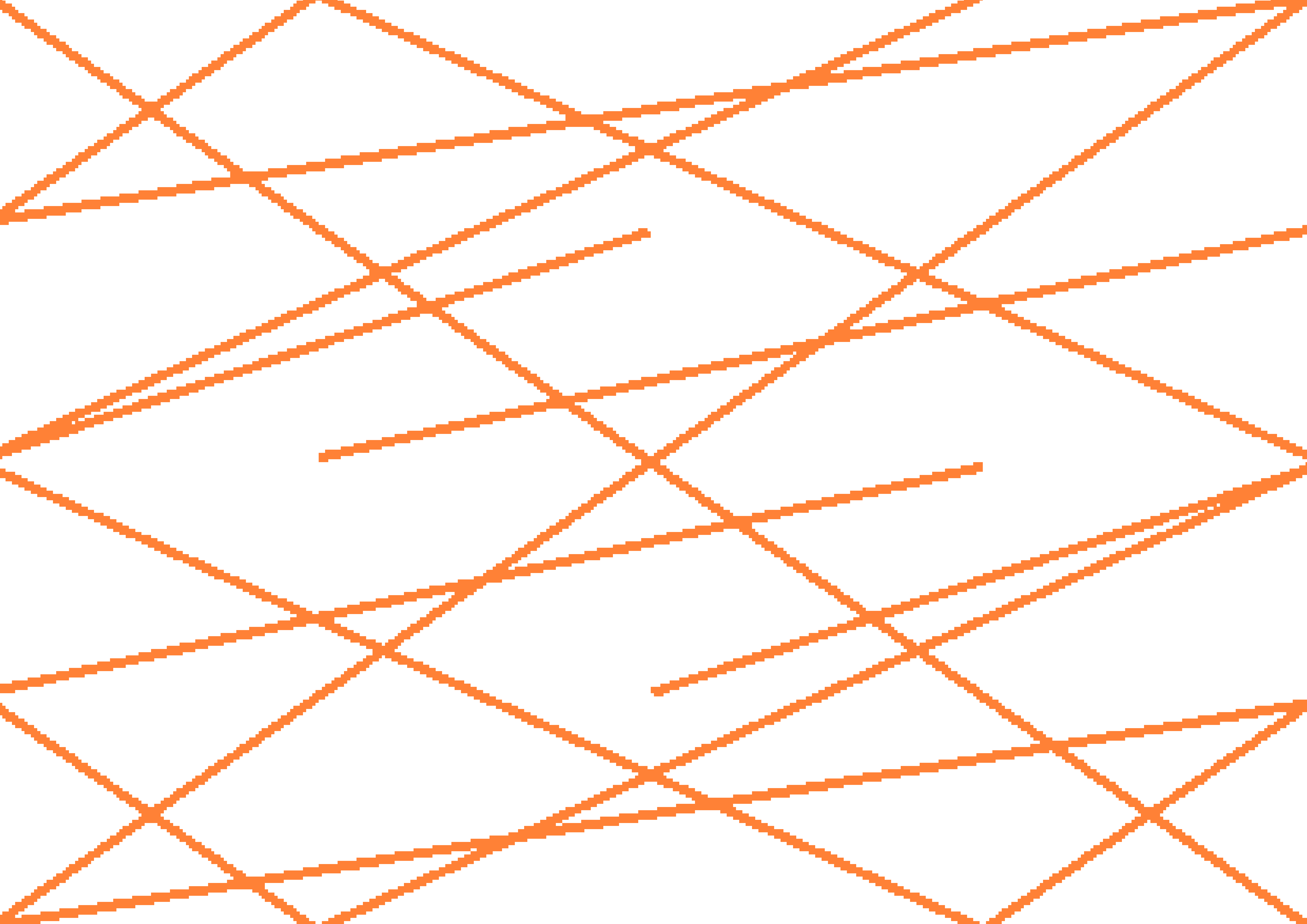
14. J. Estrada, “Théorie de la composition,“ 1994, 139–235.

15. *Teoría d1, MúSIIC-Win*, Música, Sistema Interactivo de Investigación Creación, Julio Estrada, theory; Max Díaz and Víctor Adán, software, México: Escuela Nacional de Música, Laboratorio de Creación Musical, UNAM, México, 2006.

16. In terms of notation, MuSIIC-Win uses new signs for scales whose intervals are multiples of the prime numbers 2, 3, and 5, while the rest of the scales must be expressed in fractions.

17. Julio Estrada and Víctor Adán, “Transformación continua de la forma de onda por medio de la permutación de sus intervalos de tiempo,” International Society of Musical Acoustics, Escuela Nacional de Música, UNAM, México, 2002.

DISQUIET Richard Barrett, 2018, 26'54", 8-channel, stereoversion © Richard Barrett



MEMORIES OF THE UPIC: 1989–2019

RICHARD BARRETT

RICHARD BARRETT

MEMORIES OF THE UPIC: 1989–2019

> *The products of the intelligence are so complex that it is impossible to purify them in order to submit them totally to mathematical laws. Industrialization is a forced purification. But you can always recognize what has been made industrially and what has been made by hand. Industrial means are clean, functional, poor. The hand adds inner richness and charm.*[1]

This present text is based on a combination of my typewritten report to the UPIC, submitted in February 1989 (and recently unearthed and scanned by Sharon Kanach, to whom many thanks), and a lecture I gave on working with the UPIC at the Institute of Sonology in The Hague in November 2007, together with additional remarks added in March 2019.

In 1987 I took part in a two-week UPIC course under the auspices of the Huddersfield Contemporary Music Festival in England. Subsequently, I worked at Les Ateliers the UPIC on a tape composition using the system from January 3–9, 1989, and shortly afterwards (January 14–27) completed this piece, entitled *The Unthinkable*, while at the same time teaching and demonstrating the UPIC system to students, schoolchildren, and members of the public at the Barbican Centre in London. It was my first attempt to compose a piece of electronic music.[2]

At that time, Les Ateliers UPIC was established in a number of temporary shacks in the middle of a building site near the Paris Périphérique which would subsequently become the new home of the Paris Conservatoire. I had travelled to Paris on a tiny grant from the Arts Council of Great Britain with my friend and colleague Ian Willcock, who was also realizing a UPIC piece at the time. We shared a studio, one working at the UPIC board while the other sketched and calculated materials, in the same hut where the Swiss composer Klaus Huber was working extremely loudly on a composition of his own, and the "studios," of course, had no soundproofing, either from the building works outside or from Huber's UPIC activities next door. Ian and I eventually decided to work mostly at night, although the bedroom we were also sharing was in a hotel that seemed to rent its rooms out by the hour, so there was always plenty of noise of a different kind going on there during the daytime. I finally finished editing my piece, back in London, at 7 o'clock on the morning of its first public performance.

THE UNTHINKABLE Richard Barrett, 1989, 6'28'' © Richard Barrett

Since there were no outputs for digital audio from the UPIC system at that time, making a composition involved recording its sections from the UPIC onto an analogue tape recorder and then physically splicing them together, unless the whole piece were made from a single "page." A page could contain up to 1024 arcs, each of any degree of linear complexity, and, in the version I used, it was also possible for one arc to perform frequency modulation on another instead of being routed to the outputs. It was also possible to use sampled waveforms for the arcs, but only single waveforms: some of the sounds in the piece I composed there were made by using an entire struck gong sample as a single waveform. (These can be heard as high-pitched tinkling sounds, at 0'51'' for example.) Playback was initiated by touching the board with the pen at the time-point one wishes to start from (usually at the left-hand edge), but the pen could also be used to "scrub" to left and right across the board. Bernard Parmegiani's composition *Exercisme IV*, composed with the UPIC in 1986, clearly sounds as if the composer were recording a "performance" using this scrubbing function, and then editing the result as if it were the kind of "concrete" material he more often worked with. The result is something which sounds clearly like Parmegiani in terms of its phrasing and timing, even if its sonic material is very uncharacteristic.

As Richard Toop points out in his liner note to *La Légende d'Eer*,[3] at a time when Boulez at IRCAM was overseeing the development of systems whose operation could only be understood by professional computer technicians rather than by musicians, Xenakis was busy developing a system which could be understood and used as easily by children as by composers, if not more so: in my brief experience teaching with the UPIC I found that children were a lot freer with their imaginations when let loose on the machine than were most adults, realizing immediately, for example, that an arc shaped like the flight of a bee would indeed *sound* like the bee, while a picture of a house wouldn't sound like anything in particular. Xenakis's own UPIC pages for his composition *Mycènes Alpha* (1978) are reminiscent sometimes of ancient ruins, sometimes of trees or microorganisms (often looking simpler than they sound, on account of using complex envelopes which can't be seen but which impact strongly on the sound textures), and of course one can readily see the connection between their forms and the ruled surfaces of *Metastasis* (1953–1954) or the glissando clouds of *Pithoprakta* (1955–1956). My own pages looked rather more like the aftermaths of a series of explosions in broom cupboards, that is to say quite inelegant in graphical terms. I was never intending that they should be looked at, although during composition I would often lay out the thermal printouts of the pages in different orders on the floor to try and get an idea of how some particular concatenation would sound, and indeed after some time they faded from brown to yellow and finally to white, so that the sound is ultimately all that remains.

The Unthinkable in its original form existed as a 15ips stereo analogue tape, which was copied to a Betamax PCM digital tape and eventually to AIFF format. It was composed as 23 UPIC pages in sequence (not mixed or overlapped), using the maximum *ambitus* setting (LA-2 to RE#9). Each page represents a distinct musical unit—thus the inevitable division into pages of the music was made a primary feature of the composition—22 of the pages have durations according to a Gaussian distribution centered on a mean of 15'' (the range is 10.3'' to 20.6'') while one, the penultimate page in the sequence, lasts 1'11.4''. The pages follow one another without intervening gaps; some contain, or end with, short silences, many of which were reduced somewhat in the final version (editing on a digital audio workstation (DAW), which of course was not possible in 1989) so that the original duration of 6'48'' was reduced to 6'25''. This durational scheme is the only remnant of an initially complex and rigorous precompositional plan, which was abandoned aspect by aspect, as it became clear that, given the strictly limited working time (which in London had to fit around student sessions), an essentially empirical, improvisatory mode of operation was the only one likely to generate useful results—although even then, several embryonic lines of enquiry would have to be abandoned because of not guaranteeing usable products within the time constraints.

One or two of the more interesting sounds (to my ear) in the final composition arose mysteriously and unintentionally (for example, the accelerating sounds that begin at 5'19'', which don't correspond to anything on the page and must be some unpredictable artifact of the frequency modulation). There was no time to analyze and investigate further their composition and provenance, and so no possibility of reproducing and/or transforming them; immediately after my working period with the UPIC I hoped to have the opportunity to return to some of these phenomena so as to be able to expand the repertoire of coherently usable possibilities on the UPIC, although in the event this never took place. In my 1989 report I wrote:

> *Of course, it is absolutely necessary, when working with any musical medium, to be able to realize, in notation or otherwise, sounds which one has previously envisaged—it may be interesting, but is not usually musically fruitful, to grope blindly for miraculous accidents, and one corollary of the speed of operation of UPIC is that it could discourage the reflective and analytical aspects of composition in favor of aimless and unclear thinking. Or that, at least, is the way I see it, which probably means I have not managed to avoid such pitfalls myself. In any case, the result was that the range of sound materials in* The Unthinkable *is a limited one—limited to those materials I had been able to master rather than be enslaved by—which may be no great disadvantage in itself, except that I feel these limitations to have arisen largely as a result of exigencies not immediately related to the experience of composition (whatever that is).*

Thirty years later this statement seems like a somewhat desperate apology for having had to admit "too much" spontaneity into the composition process, from a composer who at the time was committed to a much more rigidly systematic working method. These days I would say something more like "part of one's self-training as a composer is to develop the ability to attract 'miraculous accidents' to oneself, and, just as importantly, to recognize them when they occur," and that one of the primary purposes of systematic composition procedures is indeed to enable a rapidity and spontaneity in one's exploration of their potential, to take care of the "reflective and analytical aspects," so as to liberate the imagination to improvise and to be intensely present at each moment. In 1989 my activities as an improvising musician were taking place, so to speak, in private—Paul Obermayer and I had started working together as FURT about three years earlier, giving a couple of public performances in 1987 and then "retiring" until 1991 to explore and develop our work together through a long series of recordings.[4] In retrospect it is clear to me that the UPIC experience was an essential catalyst in the process by which I passed through a necessary phase of radical systematization of my compositional means, and began to approach the integration of an equally radical spontaneity into those means.[5] Being forced, against my better judgement, to compose spontaneously and empirically is a theme that runs throughout my notes from 1989. I wish I (or anyone else) could have told my younger self to let go of his preconceptions and free his imagination, that this wouldn't lead to compromise and (the wrong kind of) incoherence.

Much of *The Unthinkable* emerged from investigations into the frequency modulation function of the UPIC. It seemed less interesting and more time-consuming to examine frequency modulation (FM) from the point of view of precisely calculated relationships between *arcs sonores* and *arcs modulants* (the latter always being assigned to channel 0 so that they wouldn't be heard in themselves), as well as less idiomatic to the graphic input of the UPIC. More general topological/morphological relationships were sought, including the following:

A General registral relationships: especially where the modulating and/or modulated arc has a complex *forme d'onde* whose timbre changes unpredictably and discontinuously above a certain (sometimes quite low) frequency, a "fault" of the UPIC which could be turned to compositional advantage.
B *Arcs sonores* higher than, lower than, or crossing over *arcs modulants*: this relationship gives rise to two distinct "families" of sonorities, with an intervening discontinuity.
C Rate of pitch change (gradient of glissando) and the rate of change of this rate, and the general morphology of the arcs (linear, curving, with or without singularities, etc.): nearly all arcs were drawn *point par point*, even where supposedly smooth curves occur, so as to exclude as far as possible any impression of "painterliness" and to concentrate instead on creating forms reminiscent, for example, of exponential or chaotic functions.
D Relative intensity between carrier and modulating arc, obviously giving a range between almost pure timbre and almost pure noise, and facilitating continuous (or otherwise) transformations between the two.
E Envelope relationships: some increasing and some decreasing in intensity, or with several peaks of intensity and so on;— a sound could thus be given a simple or complex timbral evolution (experiments with mixing and crossfading unmodulated timbres having proved to be laborious and only intermittently and unpredictably successful).
F The relative complexity of waveforms: Drawing a waveform by hand with a precise idea of the timbre it will produce, is almost impossible. Waveforms which look very different on the graphics tablet end up sounding like similar examples of a generalized somewhat thin and reedy sound. What I ended up doing was making a "family" of progressive stages of (graphic) distortion of an initial sine wave (which can be heard at the end of the piece, from 6'23" onwards, on a single pitch, in reverse order, ending with the sine tone), and all the arcs in my piece were derived from that family, except those derived from percussive *ondes musicales* (tabla, gong, and, eventually, drawn waveforms reproducing their characteristics) to give "pulsed" sounds, the pulses individually having a much higher frequency, of course. These pulsed sounds were also used unmodulated at various points.
G Single *arcs modulants* of complex morphology, acting upon whole structures of *arcs sonores*.

In these ways, sounds of generally high but controllable complexity were generated, many contradicting the tendency of the UPIC to favor the production of pitched sounds, even if containing glissandi, untempered intervals and clusters, etc. The composition could eventually be seen as having taken place in several stages:

A Undirected, then directed, experimentation, mostly in areas not directly relevant to the end product but more concerned with achieving a necessary fluency with the system and an initial overview of its potentialities.
B Having discovered (somewhat later than envisaged) some sound material, not only usable in itself but also sufficiently pregnant with possibilities for more extensive elaboration to be contemplated, the primary structures of the music could be composed in skeletal form, without as yet finalizing the order of the pages. I used a number of large pieces of tracing paper overlaid on the tablet, each of which contained a number of basic graphic sound objects. These then appear in different kinds of superimposition on many of the 23 pages that the piece consists of, giving rise sometimes to almost exact recurrences of sound forms and at other times to more oblique reminiscences.
C after a period of listening to this primary structure, roughly recorded in a chosen order on cassette, it was articulated, "orchestrated," contradicted, annihilated, etc., by superimposing related or unrelated sonorities as transients, colorations, copulae, alternatives, and so on.

The latter two stages involved more listening than drawing, especially C, frequently to the point of (and beyond) fatigue and disgust with the materials. Such a working method contrasted strongly with my usual compositional methods (for notated music) at that time, which were far more "considered," both in the sense of being more reflective and in that of using statistical strategies to build up superimpositions of interlinked musical processes, with no perceived need to tinker with the results. In 1989 I suggested that any future work I undertook with the UPIC should attempt to move the compositional emphasis back towards processes, rather than the gestures that *The Unthinkable* consists of, which depended, as I wrote at the time, on "the 'irrationale' of the ear making decisions and connections without recourse to a 'coherent' or 'constructed' overview", such as a system of structural proportions, and/or one of pitch relationships, pervading the different temporal layers of a composition. I made a comparison with free improvisation, which I was already involved in at that time, though with the difference, that the effect—and, in particular, the precise timing—of hearing all the pages in sequence had to be abstractly imagined rather than experienced as a whole before the tapes were spliced together. (Indeed, I made all the splices in a single session, without listening to them until the piece was complete.) I wrote at the time that “a slight retiming of one or two events, and some rebalancing of adjacent ones” would be desirable, and that was the extent of my later interventions into the composition. On the other hand, the intuitive way in which it was conceived and composed has actually characterized most of the electronic compositions I’ve made since then, not dissimilarly (and for not dissimilar reasons, I think) to the difference in approach Xenakis would apply to instrumental and electronic work. I was pleasantly struck to discover the similarities in sound between *The Unthinkable* and my most recent electronic composition, *disquiet* (2019), which should be quite apparent on listening to them one after the other, even though the newer piece is four times as long, generally involves much less rapid sonic transformations, and was made by completely different methods; namely, a software version of the ARP 2600 synthesizer.[6]

My work with electronic music subsequent to *The Unthinkable* tended strongly towards using transformations of recorded (sampled) sounds rather than synthesizing them *ex nihilo*, although my interest in synthesis eventually revived after it became possible, using more flexible digital resources, to achieve the same degree of sonic intricacy that the UPIC was designed to generate. It’s only quite recently that *The Unthinkable* has come to seem to me less like an experimental sidetrack in my musical output, and more like a pointer whose direction was further explored only after more than twenty years, with a decisive move towards synthesized sounds in *life-form* (2012) for cello and electronics.

Although the sounding arcs could be assigned to one of only two audio outputs, it was still possible to incorporate somewhat primitive spatial features. A minority of sounds emanate from only one channel, several events move across the stereo spectrum by the superimposition of collinear arcs with different envelopes for the two channels, while most sounds were “doubled” by placing almost-collinear arcs with identical envelopes in both channels. The degree of collinearity varies, so that the precise pitches from the two channels (during an event) may converge and diverge, thus manipulating the spatial complexity of the stereo image as well as the timbral profile of the conglomerate sound. Since the *arc modulant* for a given “bundle” of almost-collinear arcs is always the same one, a certain amount of the sound information is inevitably shared between the channels, depending on the variables related to FM mentioned above, so that the conglomerate sounds acquire a changing extension in space rather than mobile positions.

I did make what I thought were some rather interesting discoveries which ended up being crucial to the composition, and were quite idiomatic to the UPIC system. One was to use extremely rapid glissandi,

DISQUIET Richard Barrett, 2018, 26'54", 8-channel, stereoversion © Richard Barrett covering several octaves in a fraction of a second, either as audible arcs or as modulators, and another was the fact that some fascinating artifacts could be discovered by examining tiny sections of a complex texture and playing them back at extremely slow playback rates. A third was to take advantage of the fact that the resolution of the tablet enabled an arbitrary degree of rhythmical complexity to be realized. And a fourth was that one could make the rather characterless sound of the machine much more gritty by concentrating on the lower end of its pitch range, which is why, if you saw my pages, you would find much going on at the bottom of the page and very little elsewhere. Also, I made quite extensive use of the possibility of selecting a number of arcs and then copying, resizing, shifting, or rotating them.

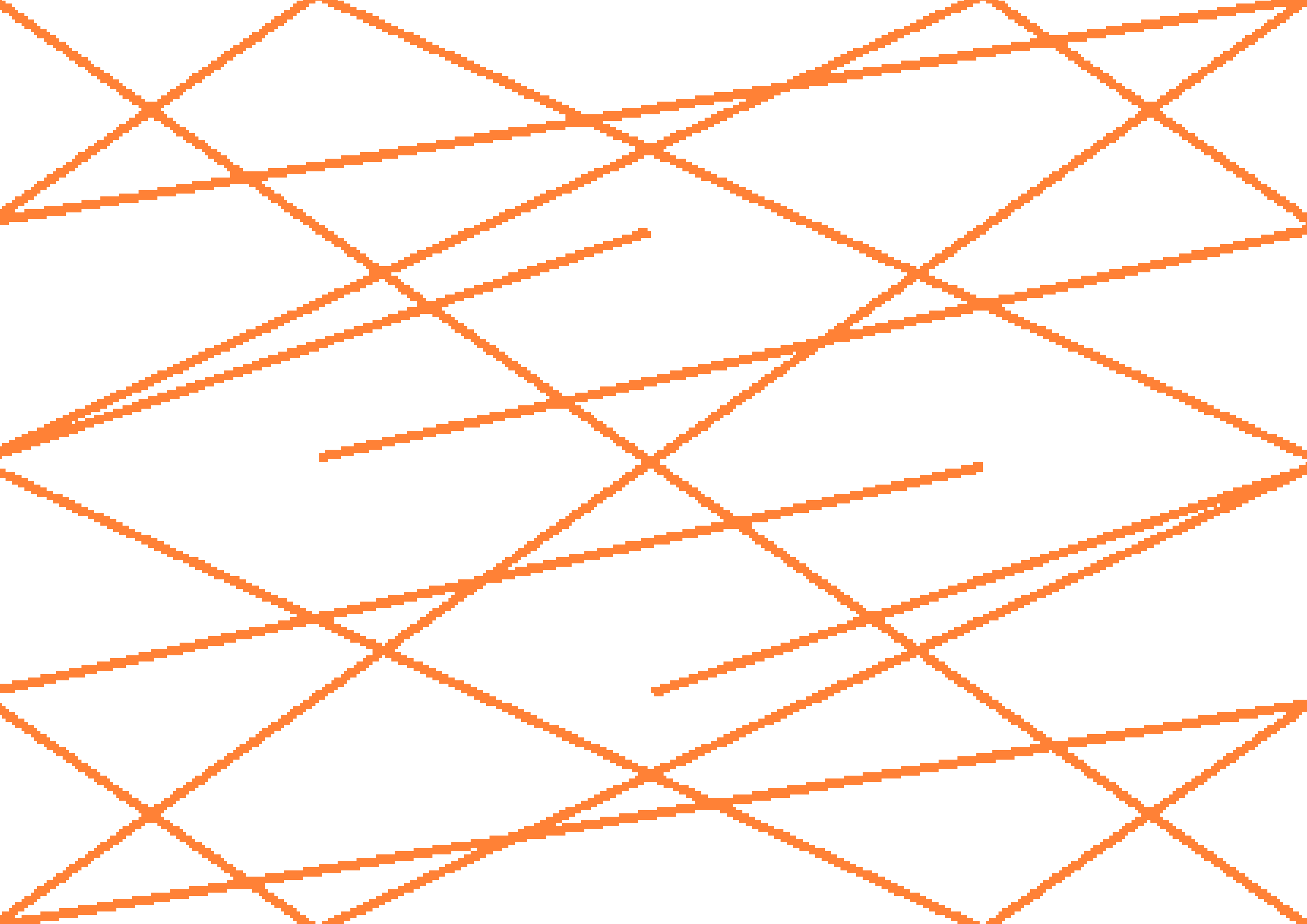
In my 1989 report, I made a few suggestions for improvements that might be made to the UPIC system:

- **A** A *reflection* function could be added. This would seem more musically productive than the present *rotation* function. If reflection in a centrally placed vertical axis were also available to envelopes and *ondes musicales* it would greatly aid the system's flexibility in various areas, including (with envelopes) spatial composition, of which more below, and (with *ondes*) the generation of new timbral resources.
- **B** Where events are transferred between pages by the *réduction* function, the numbering of *arcs sonores* in the transferred event is changed to follow the numbers already present on the destination page, but their *arcs modulants*, if any, retain their original numbers. It is essential that this limitation is corrected, since it would very simply save a great deal of time-consuming reassignment, and thus facilitate more extensive use of the two functions in combination.
- **C** The *ambitus* of a page (also during *entendre*) should be constantly visible on one or other readout screen, since at present it is easy to forget, and impossible to check the particular *ambitus* within which one is working (unless one risks changing it!). In my own work this problem was minimized by the use of a constant *ambitus*, but it does seem inconsistent that when in the *calculer* mode one is able to specify the horizontal extent (duration) of the page while retaining the graphic display, but not its vertical extent. Given that the time constraints placed on composers (and students) is not likely to change, any alteration in the system which can thus save needless waiting (for example, for the computer to redraw the page) would be a great help. It would also aid the inputting of accurate information to have a constant readout of the coordinates of the pen's position on the board.
- **D** When inputting envelopes, the vertical scale should be linear in perceived intensity rather than in decibels, or there should be some means of converting between the two. This feature would not only increase accuracy, but also render the envelope functions more accessible to younger operators. Otherwise the intensity scale on the right of the board should be explicitly calibrated in decibels (dB), since at the moment it is impossible to gauge the intensity in dB of an arc before having drawn it.
- **E** The *choisir* function should be accessible by drawing nonrectangular areas on the board (*dessiner continu or point par point*). Also, it should be possible to choose more than one parameter at a time (e.g., a specified *forme d'onde* and channel).
- **F** There should be a direct digital output to facilitate recording onto digital tape without an intervening analogue stage, thus (if a digital editor were available) disposing of the need to cut and splice tape. I do not mention this out of a blind worship of everything digital, but because it seems incongruous to have to engage in the anachronistic process of tape-editing at the end of having worked with a highly sophisticated computer system. It also seems (at the risk of sounding oversensitive) that insufficient attention has been paid in general to sound quality, which is a shame in view of the obvious advantages of working with a system like this.
- **G** More output channels should be available to facilitate spatial composition, surely one of the potential strengths of any music composed on tape, and/or the addition of a function to allow sounds to move smoothly between channels, perhaps by choosing an area analogously to *choisir* and assigning to it a scheme of channel transference, or by specifying an origin channel and a destination channel for each arc in a similar way to that in which its (single) output channel is presently specified.
- **H** The lower frequency range of the board could be extended as far as, say, 0.5 Hz (or even further), which would greatly extend the possibility of FM-related sounds (using the *arc modulant* as a "low-frequency oscillator") to increase the UPIC timbral potential, as well as rendering it possible to use *ondes musicales* in a similar (but more flexible) way to the sampling functions on other systems. But perhaps this would then no longer be the UPIC...

I'm not sure whether any of these features ever found their way into the system. As previously mentioned, this was my first attempt at electronic composition, and, since then, most of my increasing activity in electronic music has been in the opposite direction from fixed media compositions like *The Unthinkable*, developing instead a specifically and fluently instrumentalistic approach to the medium, especially in the context of partly or completely improvised music. In another sense, though, this development fulfils Xenakis's insistence on the crucial importance of the hand, an "instrument of the mind" which "stands between randomness and calculation."[7]

FOOTNOTES

1. Iannis Xenakis, "Xenakis on Xenakis," interview with Roberta Brown and John Rahn, *Perspectives of New Music* 25, 1 (1987), 23.
2. https://soundcloud.com/r-barrett/the-unthinkable-1989
3. Richard Toop, liner notes for CD of *La légende d'Eer* (Disques Montaigne), 1995.
4. Richard Barrett and Paul Obermayer, "Statement for Nic Collins," (2000), https://furtlogic.com/node/7
5. Richard Barrett, *Music of Possibility* (Chipping Norton: Vision Edition), 2019, *passim*.
6. This was the ARP2600 V3 software produced by Arturia: https://www.arturia.com/products/analog-classics/arp2600-v/
   A stereo version of *disquiet* (which was composed for 8-channel playback) may be heard and downloaded here: https://soundcloud.com/r-barrett/disquiet-2018-electronic-music-originally-in-8-channels
7. Xenakis, op. cit.



THE UPIC UPSIDE DOWN

FRANÇOIS-BERNARD MÂCHE

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THE UPIC UPSIDE DOWN

As the original form of the UPIC is now more a memory than a still-available device, and since I may have been its first user, after Xenakis, I will begin by evoking some historic landmarks which characterized the origins of the UPIC system, and justify the way I intended to make use of it. I used the UPIC not only as a graphic synthesizer transforming drawings into sounds, but also the other way around; that is, transforming sounds into workable drawings, and I will explain my reasons for making such a choice.

Xenakis had abandoned Pierre Schaeffer's Groupe de recherches Musicales in 1962. He was disappointed by Schaeffer's hostility towards *Bohor* (1962), a piece Xenakis dedicated to him. He was also hurt by Pierre Boulez's criticism of *Eonta* the following year, 1963. Xenakis began teaching that same year in the USA at Tanglewood, and then a couple of years later at Indiana University, Bloomington. But neither Schaeffer nor Boulez, nor Xenakis's American employers were willing to seriously support his project of a center devoted to music synthesis by digital means. His use of mathematics and references to physics had to remain purely intellectual until he founded the EMAMu (Équipe de Mathématique et d'Automatique musicales), in 1966, with the support of high-level computer scientists, and philosophers like Dufrenne, Francès, Revault d'Allonnes and Levi-Strauss,[1] The EMAMu, first hosted in the École pratique des Hautes Études, was connected to the nuclear physics laboratory of the Collège de France in 1969 thanks to the physicist Louis Leprince-Ringuet. Also in 1969, Xenakis was requested by then President Georges Pompidou to collaborate with Pierre Boulez on the creation of a new institution to be called IRCAM (Institut de Recherche et de Coordination Acoustique/Musique), devoted to science allied to music, and they both publicly presented the project. But soon Boulez, being more skilful than Xenakis at dealing with politicians, ousted Xenakis and remained solely responsible for IRCAM.

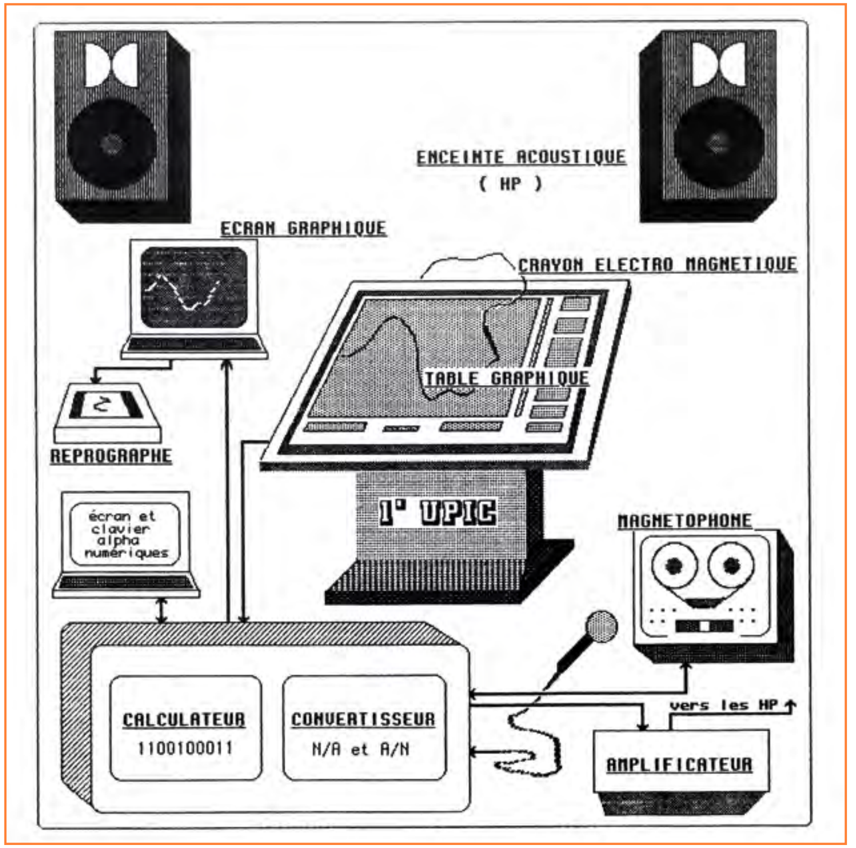
In 1972 the EMAMu became the CEMAMu, which at last was equipped with a digital-to-analog converter built by the Centre National d'études des télécommunications. The system was a digital drawing table, the same size as the desk on which Xenakis had been elaborating his scores as well as his architectural projects. Here one drew on tracing paper with a special pen, both electric and graphic. The scale of the millimetric surface could be selected, so that the vertical axis could correspond to any interval, and the horizontal axis to any duration. Practically no limits were fixed to the amount of simultaneous time and pitch units, called *arcs*, since one single so-called *page* could comprise up to 2024 arcs. Each page had access to 128 envelopes in one bank, and they could be combined. Similarly, 128 waveforms were stored in another bank. The normal ambitus of a page was 6 octaves, but it could also be fixed to up to 10 octaves, including infrasounds and ultrasounds, or be limited to a very small interval. One could choose either discrete pitch steps or continuous lines. Such a page could be used to elaborate one sound, one sequence, or the whole composition. **FIG. 1**

The same year, 1972, I had composed *Korwar*, for harpsichord and tape. The tape organized sounds taken from speech (in Xhosa), frogs, birds, boars, whales, and rain. I also published a paper entitled "La musique est une fonction biologique" ("Music is a biological function"). The main themes of this paper were:

- There is no purely acoustic difference between noise and music, or between natural sound and human-made music. What matters is the encounter between thought and sounds, which depends mainly on context.
- The musical atom is neither a note nor any quantum, but a *quale*, a difference similar to the one that exists between phonetics and phonology.
- Music is not basically a message, but a biological function, which is not limited exclusively to the human species, and which probably has its roots in playing.
- Cage is wrong in rejecting any voluntary action on the sounds. Nature only acquires meaning when responding to humankind's respectful action.

The same year, 1972, I shared with Xenakis a monographic issue of the review *l'Arc*, where I had published an article entitled "Xenakis and Nature." We were close friends, but we had different orientations. Xenakis appreciated nature as much as I appreciated rationality, but with different outcomes. I was both willing to support the UPIC and curious to explore its possibilities, someday, in spite of harboring a basic distrust about any systematic approach, such as serialism. My own experience of musique concrète since 1958 had taught me that there is often something more interesting and richer in acoustic, natural sounds, than in synthesized structures that *a priori* follow some fixed system.

In 1977, two years before the commercial release of the first digital sampler, the Fairlight CMI, I started exploring the UPIC; that is, its first version. At that time, it was far away from real-time computing, and long



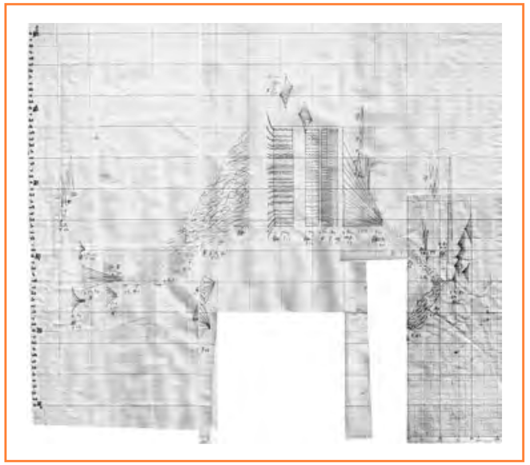


FIG. 1 Schematic diagram of the UPIC's setup from an internal document of Les Ateliers UPIC: L'UPIC du CEMAMu © CIX Archives

FIG. 2 Page 12.12.77 (tracing paper 5 octaves, 1 semitone = 1cm), 1977 © François-Bernard Mâche waits were needed before one could discover the sounds that corresponded to the drawings on a page. I particularly realized that remarkable drawings did not guarantee remarkable sounds, or even simply meaningful results, and that they often conveyed misleading illusions. FIG. 2

In 1978 Xenakis composed *Mycènes alpha*, the first piece entirely composed on the UPIC, which was premièred on the August 2, 1978 at Mycenae in Greece, where the composer was at last authorized to return, 30 years after his death sentence *in absentia*. We can see in it a fascinating visual analogy to da Vinci's analytical drawing of vortices. FIGS. 3, 4

In 1979 I heard about the first digital sampler. Unfortunately, it was extremely expensive and therefore first reserved for entertainment music. The same or the next year, Publison commercialized its DHM89B2 and KB2000, later nicknamed "the French Infernal Machine 90", (an English name, probably to appear more serious and reliable...), and met with immediate success. FIGS. 5, 7 I talked about it to Xenakis, who taught me that the UPIC had an analytical feature which might yield some comparable results.

Among other possibilities, the DHM offered a harmonizer, an envelope generator, an evolutive vibrato, a delay, a reverb, etc. The keyboard allowed separate treatment of pitch and duration; for example, automatically keeping the duration of a sample when transposing its pitch. I used that in the finale of *Aulodie* in 1982, where a soloist synchronizes in unison with the complex rhythms of two recorded tracks.

A few other historic details explain my expectations about the UPIC. In March 1980, Xenakis was the supervisor of my doctoral dissertation: "The Idea of Model in Today's Music." Four months later I received a commission to write music to accompany an exhibition near Avignon, whose theme was "Water," and I composed four "*Phonographies de l'eau*," a term I had coined 17 years earlier to refer to art that parallels music just as photography parallels painting. Walter Ruttmann's *Wochenende* (Weekend) from 1930, a talking movie without pictures, was probably the first example of such an art. Already in 1980 the UPIC could function as a crude sampler, respecting the pitch of a sound signal, but allowing some rhythmic invention. One of my *Phonographies*, entitled *Proteus* (1980), used this possibility. Unfortunately, I was the only composer interested in such a function, which subsequently disappeared from the newer versions of the UPIC; otherwise it could easily have developed a full sampling capacity.

At that time Jean-Claude Eloy composed *ETUDE IV: Points-Lignes-Paysage* (1978–80) on the UPIC, and I composed *Hyperion* (1981) entirely on the same system. At Xenakis's request I was teaching a course entitled "Music composition in the biosphere" at Paris 1 University. In tune with my practice of natural models, I used the ability of the UPIC to extract

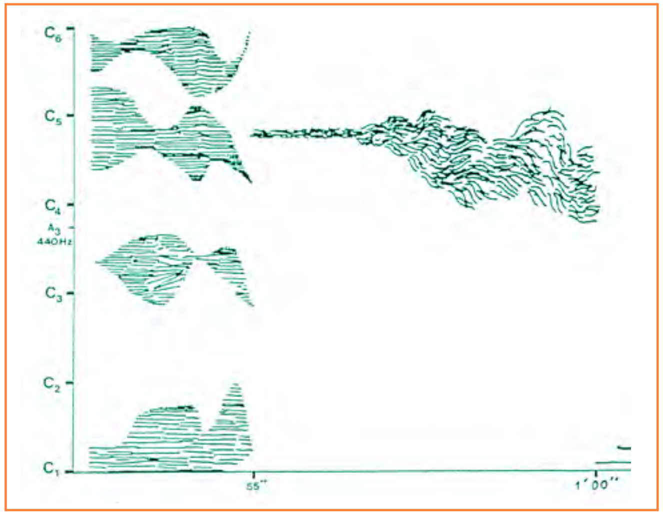


FIG. 3 Iannis Xenakis, *Mycènes Alpha*, 1978, UPIC score page © 1978 Editions Salabert—Paris, France, reproduced by kind permission of Hal Leonard Europe S.r.l.—Italy

FIG. 4 Excerpt from Leonardo da Vinci's notebooks © Wikimedia Commons

FIG. 5 DHM89B2 harmonizer, 1978, scan of the packaging. This was the first sampler in the history of music. © Publison

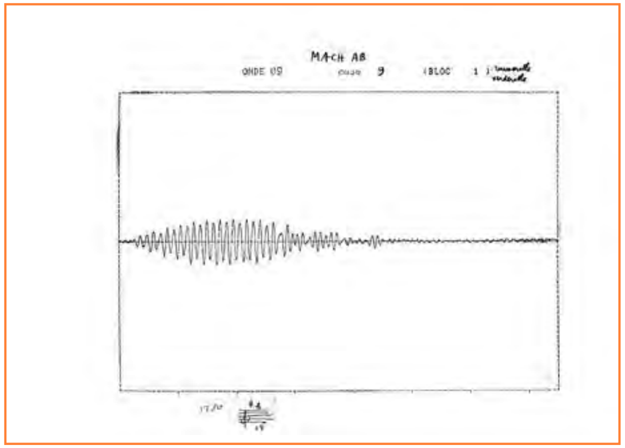
FIG. 6 François-Bernard Mâche, *Aulodie*, 1983, finale (pages 16 and 17)

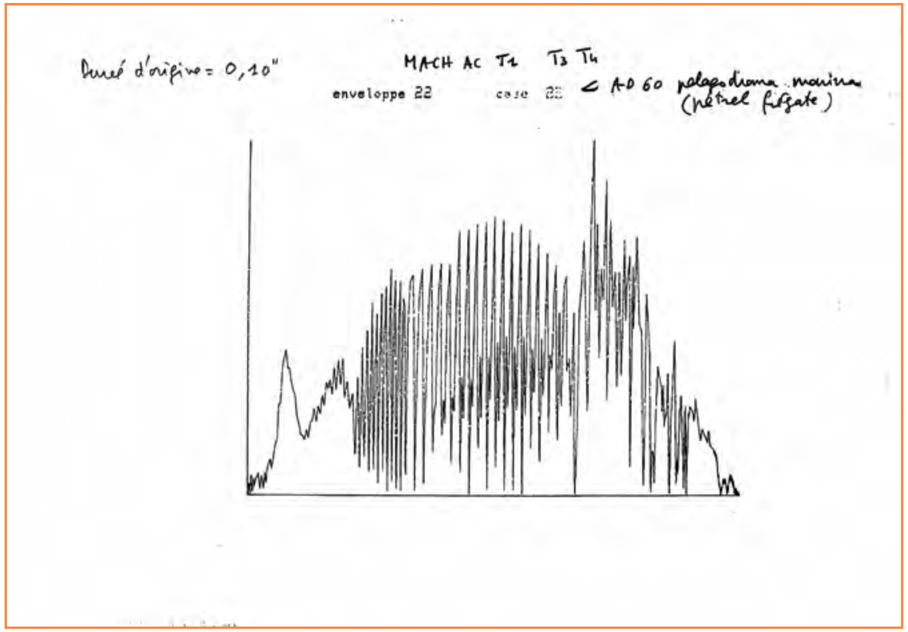
FIG. 7 Three Octave Keyboard KB 2000, 1980, scan of the packaging.

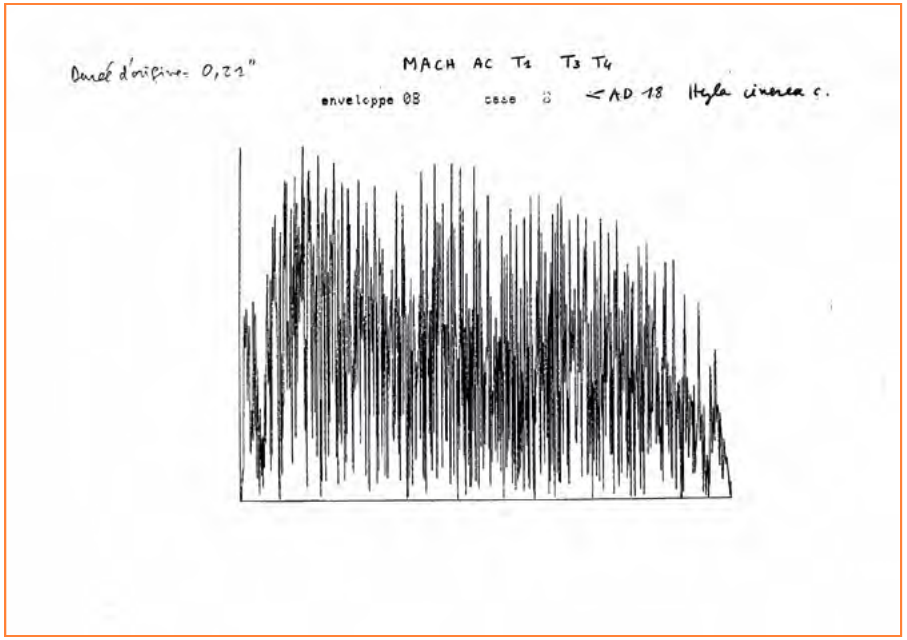
AULODIE François-Bernard Mâche, 1983, for soprano saxophone, from *Aulodie: Ruth Velten*, CD Genuine GEN 16424, Éditions Durand, 1983, excerpt from 7'21" to 7'53"

AMPHIBIAN François-Bernard Mâche, with rhythm excerpt (39") from *Proteus*, 1980, undated and unpublished, excerpt from 4'32" to 5'09" © François-Bernard Mâche

HYPÉRION François-Bernard Mâche, 1981, unpublished, from *Hypérion*, CD Jade 015/12 19 34, excerpt from 0' to 1'58" © François-Bernard Mâche







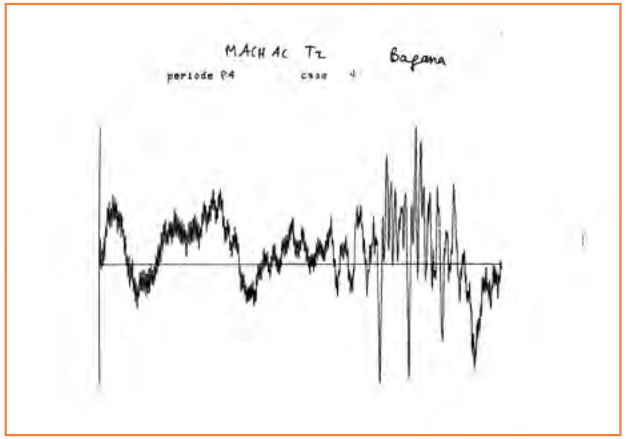


FIG. 8 Very simple spectrum of the marsh warbler (*acrocephalus palustris*), sonogram © François-Bernard Mâche

FIG. 9 Complex envelope of the white-faced storm petrel (*pelagodroma marina*), sonogram © François-Bernard Mâche

FIG. 10 Complex envelope of the white-faced storm petrel (*pelagodroma marina*), sonogram © François-Bernard Mâche

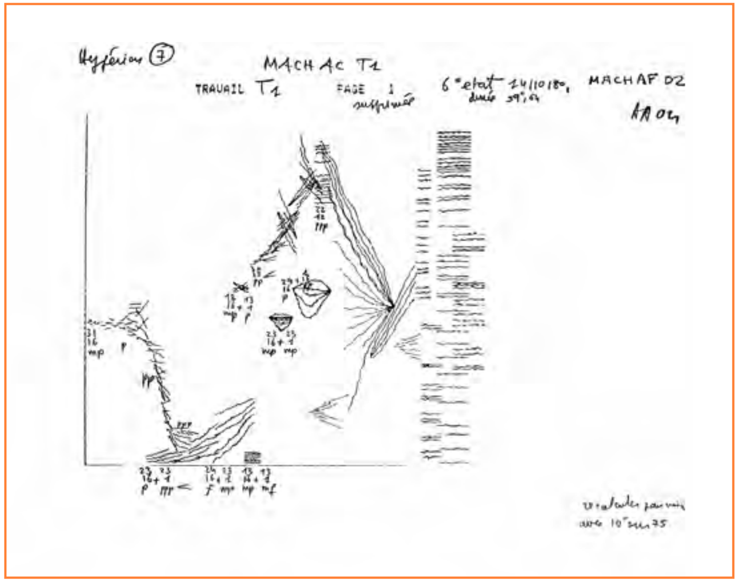
FIG. 11 Complex envelope of the white-faced storm petrel (*pelagodroma marina*), sonogram © François-Bernard Mâche two features from different sounds: dynamic envelopes and spectrum waveforms. Most of my models were different animals, plus a few non-European instruments like the Ethiopian *bagana*. For the second time I used technology which enabled me to analyze natural models with greater accuracy than pure listening. I had done something similar in 1964, using a Kay electric spectrograph for speech analysis in *Le son d'une voix*, a piece stemming from a phonetic model, which Michael Gielen conducted at the Royan Festival, and that, in fact, anticipated the spectral school by some ten years. **FIGS. 8, 9, 10, 11**

While experiencing some morphing, that is, combining dynamic envelopes and waveforms coming from different analyses, I noticed that using complex envelopes with simple waveforms was much more efficient than the other way round (complex waveforms with simple envelopes). The nature of synthetic timbre did not so much depend on the common view of steady spectrum contents, but chiefly on the multiple small dynamic movements of the envelope. At the same time, Jean-Claude Risset was scientifically developing his analysis of sounds and could describe the same phenomenon with great accuracy, leading henceforth to more subtle synthesis of acoustic instruments. The beginning sequence of *Hypérion* is made with the simplest sine waveform associated with complex envelopes, and with a background using slow continuous glissandi. This work was premièred at Lille on November 4, 1980 (partial), and in Paris on June 19, 1981 (complete). **FIG. 12**

Three months after *Hypérion*, in 1981, I tried quite a different experience in *Nocturne*, a piece for piano and tape. **FIG. 14** The electronic tape was made on the UPIC as a complex canon of melodic contours. A basic outline of some 20 arcs was varied at different durations, registers, ambitus, intervals, and waveforms, initiating complex canonic counterpoints between the soloist and the tape, and between different layers on the tape itself. The intervals of the contour could change in many ways, although without ever changing their direction.

The idea of such a particular canon had some affinities on the one hand with Xenakis's arborescences, as he developed in *Synaphai* (1969), for example, and on the other hand with Mandelbrot's fractals, which at that time had been fashionable among artists for ten years or so.

After 1983 I used the UPIC more rarely, in spite of the new possibilities of listening to the results of drawings in real time, which, in fact transformed it into a kind of live instrument fit for the stage. The reason is that samplers were finally becoming affordable, and I thought they could cumulate the benefits of handling any kind of sounds, any scales, with all the flexibility of musical instruments, all while offering the liberty to overcome their limits and routines. Hence, from 1983 on, I rather used



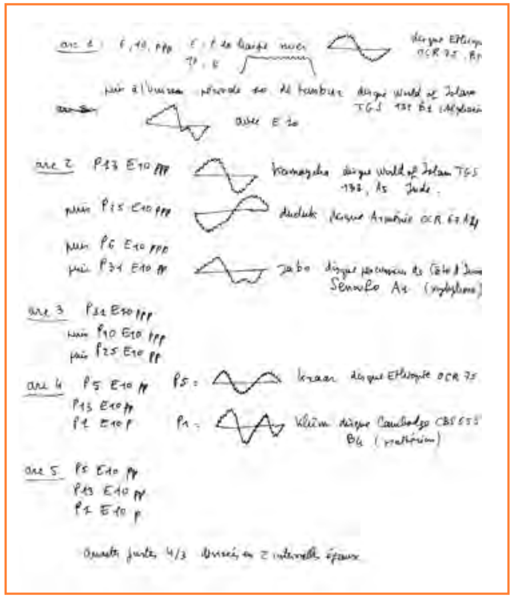
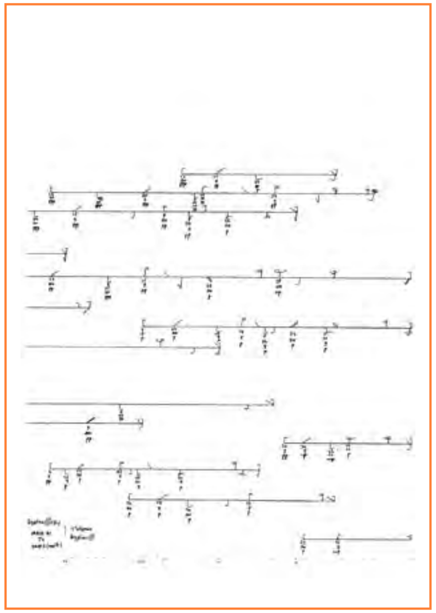


FIG. 12 François-Bernard Mâche, *Hypérion*, 1981, page T1 © François-Bernard Mâche

FIG. 13 François-Bernard Mâche, *Hypérion*, 1981, page 1b (waveforms from exotic instruments) © François-Bernard Mâche



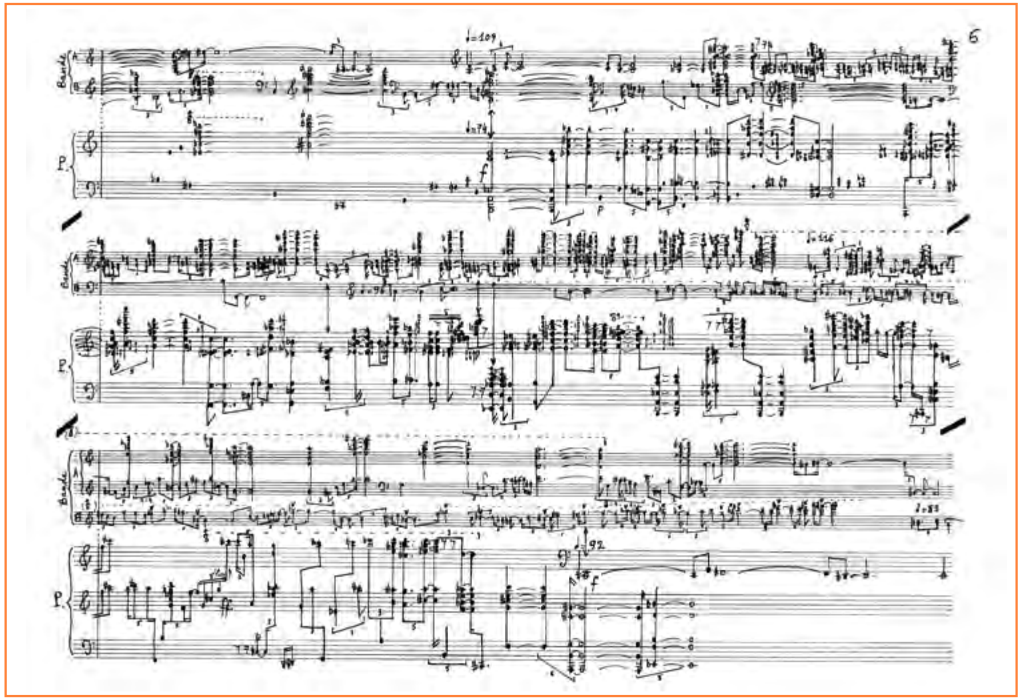


FIG. 14 François-Bernard Mâche, *Hypérion*, 1981, notation of evolving unisons © François-Bernard Mâche

FIG. 15 François-Bernard Mâche, *Nocturne,* 1981, page 6 © François-Bernard Mâche

NOCTURNE François-Bernard Mâche, 1981, for piano, from *Nocturne: Andrew Infanti*, CD Musiques sournoises, 2001, Éditions Durand, excerpt from 5'51" to 6'42" the "French Infernal Machine" which I already mentioned above. And as soon as the Mirage could be purchased, I managed to buy one. That was in 1985, which was also the year when Les Ateliers UPIC were founded. I presided over it for several years, and, in France as well as abroad we hosted a great number of training sessions, concerts, residencies for foreign composers, and various educational activities.

Two years prior to this, I had been elected Professor of Musicology and Director of the Music Department at the Université de Strasbourg. There, I managed to raise the funds to buy a UPIC system, and in 1987 I organized a center and targeted curriculum called *Primus*, in order to train *Tonmeister* (sound engineers) capable of reading a score, of possibly writing one themselves, and of managing recording and post-recording sessions, something that did not exist in France at that time. The students also learned to work with the UPIC system. We had it along with a Fairlight VT5 Voicetracker (acquired in January 1986) to transform sounds into midi data. Personally, I owned a Commodore computer (as of May 1986) and soon got a sampler better than the Mirage, namely an Akai S900, which I used for my pieces *Aliunde* (1987), *Tempora* (1988), and *Kengir* (1991). Among the samples I used, many were borrowed from the UPIC.

Tempora was written for three samplers, each one with a Midi keyboard, and they played animal sounds as well as synthetic or acoustic samples, all working as imaginary instruments. I believed that whole orchestras made of, or including, samplers would soon be available and grant electronic sounds the same possibility of expression that the traditional acoustic instruments had kept. The UPIC itself had already acquired the flexibility of a real-time music instrument. The commonplace of endless crossfades between audio fluxes would no longer be the main way of developing an electronic work. What a deception when I was soon to realize that such a beautiful dream was hopeless! Everything in the electronic business, and specifically in the digital acoustic domain, was ruled by the sole obsession with profit, and with innovation at all costs being the motto (be it smoke, mirrors, or real); this made programmed obsolescence a rule. For many electronic compositions, the only hope for a long survival would be henceforth inevitably brought back to unchanging recordings, since porting to new sampling platforms is hardly possible, and anyhow, even when successful, doomed again to shorter and shorter life expectancy. Most of the time, digital archives will die before their authors. With regards to the UPIC, its current survival in the Université de Rouen, under the form of "UPIX" (for Windows in 2001, and more recently for other platforms like UPISketch for mobile devices), is so far one of the few notable exceptions.

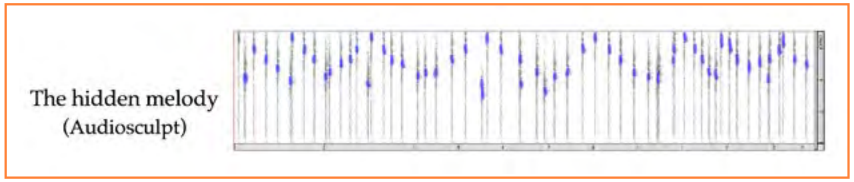
My last commitment for a composition entirely made with the UPIC was in 1987, when I started composing *Tithon*. In 1980, on a Greek island, I had the opportunity to make a close recording of an interesting insect, probably a "wart biter" (*decticus verrucivorus*), which had ventured into my house. Contrary to the monotony of many insects, the song of this one was rhythmically varied and even contained a hidden melody. I decided to adopt it as a model. Below, I indicate extracts of its song and of the treatments I applied to them, thanks to the UPIC and some other devices, in the composition *Tithon* (1980):[2]

1. Extract from the original recording (46")
2. Other extract, at a slower pace: minus 1 octave (13")
3. Same kind of rhythmician insect (wart biter = *decticus verrucivorus*) 19"
4. Sound of the hidden melody (30") **FIG. 16**
5. Same melody minus 3 octaves. (45")
6. A midi file from the same melody (through Melodyne), (just for fun, for in the end I did not use the melody at all…) (45")

Tithon is not a program music, even if the title refers to a beautiful Greek legend, which I cannot help telling. Dawn is in love with Tithonos, a beautiful Trojan prince, brother of Priam, and nephew of Ganymedes. He is also in love with her since the day when she abducted him one morning while he was leading his flock. At that time princes could also be shepherds. Sometime later they had two children, and Dawn started feeling worried about their future. Her husband Tithonos, being a nephew of Ganymedes, had access to Olympus. She decided to beg Zeus to grant Tithonos immortality. Zeus is usually very thrifty with such favors, but he accepted, taking into account the extended, distinguished service of Dawn. The only problem was that she forgot to also require eternal youth for her lover. Day after day Tithonos deteriorated, until he shriveled and shrunk to such an extent that he became a poor grey thing hanging on some sprigs, hereinafter referred to as a "cicada." But he was still in love with Dawn and greeted her loud and clear every morning.

Indeed, *Tithon* is not a program music, but nearly every sound originated in insect recordings, and the piece is imbued with different moods, typically blooming in summer, like insects' songs.

In guise of a conclusion, I would like to move from an historic recapitulation to a tentative reflection about the future of what the UPIC and the like represent. In spite of their many drawbacks, there are so many benefits in computer music and bioinformatics that I think they will not be abandoned. With data processing, the composer can conceive as a whole the laws of assembly and the sound identity of what is assembled.



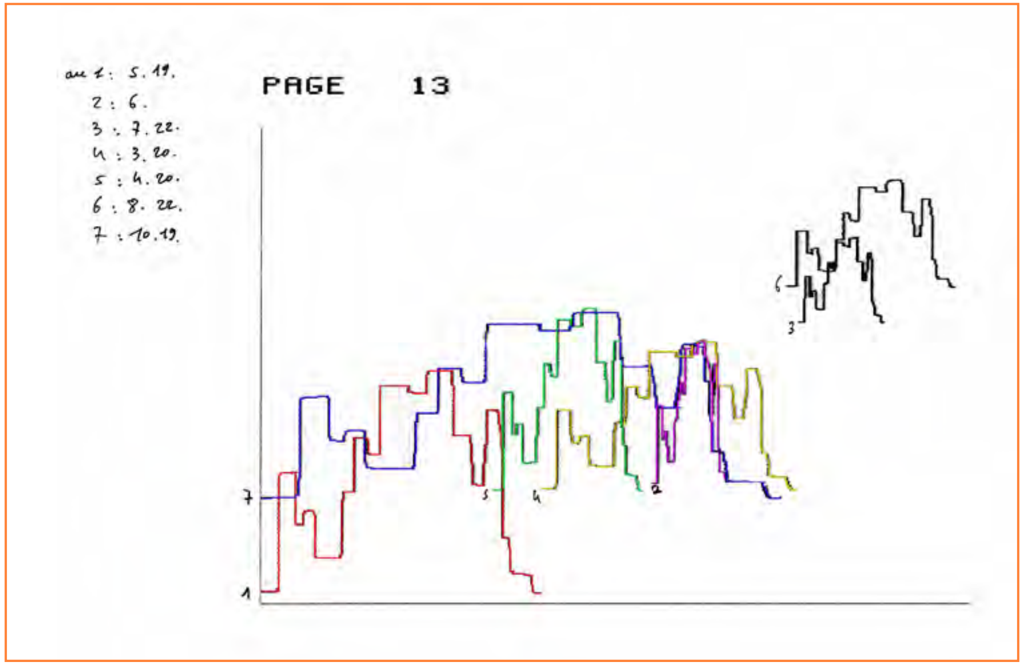


FIG. 16 François-Bernard Mâche, *Tithon*, 1980, hidden melody emphasized with the software AudioSculpt by IRCAM © François-Bernard Mâche and AudioSculpt

FIG. 17 François-Bernard Mâche, *Tithon*, 1980, page 13. Each of the seven colors represents a particular waveform for the chosen contour. © François-Bernard Mâche

Instead of dealing with all the limited possibilities and constraints which a music instrument offers, it seems that there are no limits other than those of his/her own competences and imagination. A computer can be commanded to produce such or such sequence of preset sound events according to laws which will have been formalized in a program, and this program, for example, can itself present all the complexity and the training ability of a neural network. Instead of subjecting writing music to the auditive anticipation of the result of a future performance, one can launch algorithms whose final sound realization is no longer entirely foreseeable. This approach, to this day, having allured more than one follower of musical data processing, presents the double character of a total rationalization—because everything, including indetermination, must be specified in a program—and paradoxically, an adventure where what is produced by the computer has the multifariousness and sometimes mysterious character of one second, factitious, nature. Instead of composing a work, some aim at composing a program suitable for generating an infinity of achievements. One thus explores the algorithms (which one believes to author), arousing an external universe of a strangeness that is sometimes threatening. This approach ends up returning the composer, assuming s/he is not absorbed in the illusion of absolute power), to his/her most traditional, and least rational, responsibilities: personal taste, intuition, experimentation, the aptitude to feel in advance the emotions s/he will organize in the duration, all capacities without which no choice is legitimate nor even possible among the machine's sometimes innumerable proposals. The formalization of such selection criteria would be possible in its turn only if the knowledge of the human brain were complete, a still remote utopia. Thus, the way followed for one half-century by musical data processing has not been without reminding us of certain aspects of what the revolution of writing music had produced near the end of the fourteenth century. In a somewhat comparable way, some six centuries later, the computer has contributed to prolonging the experimental spirit which had dominated the 1950s and 1960s of the last century, by proposing novel facilities. It is, however, necessary to be disillusioned a little when certain provisional appraisals are made. The computer certainly enables incredible time savers. But a short handling error can also sometimes cause the instantaneous loss of several days of work. The complexity of certain software sometimes involves anomalies that the best data processing specialists struggle to identify, even with the help of their best repair software.

Furthermore, paradoxically, sound synthesis transformed the production of amazing sonorities into a kind of standardized category.

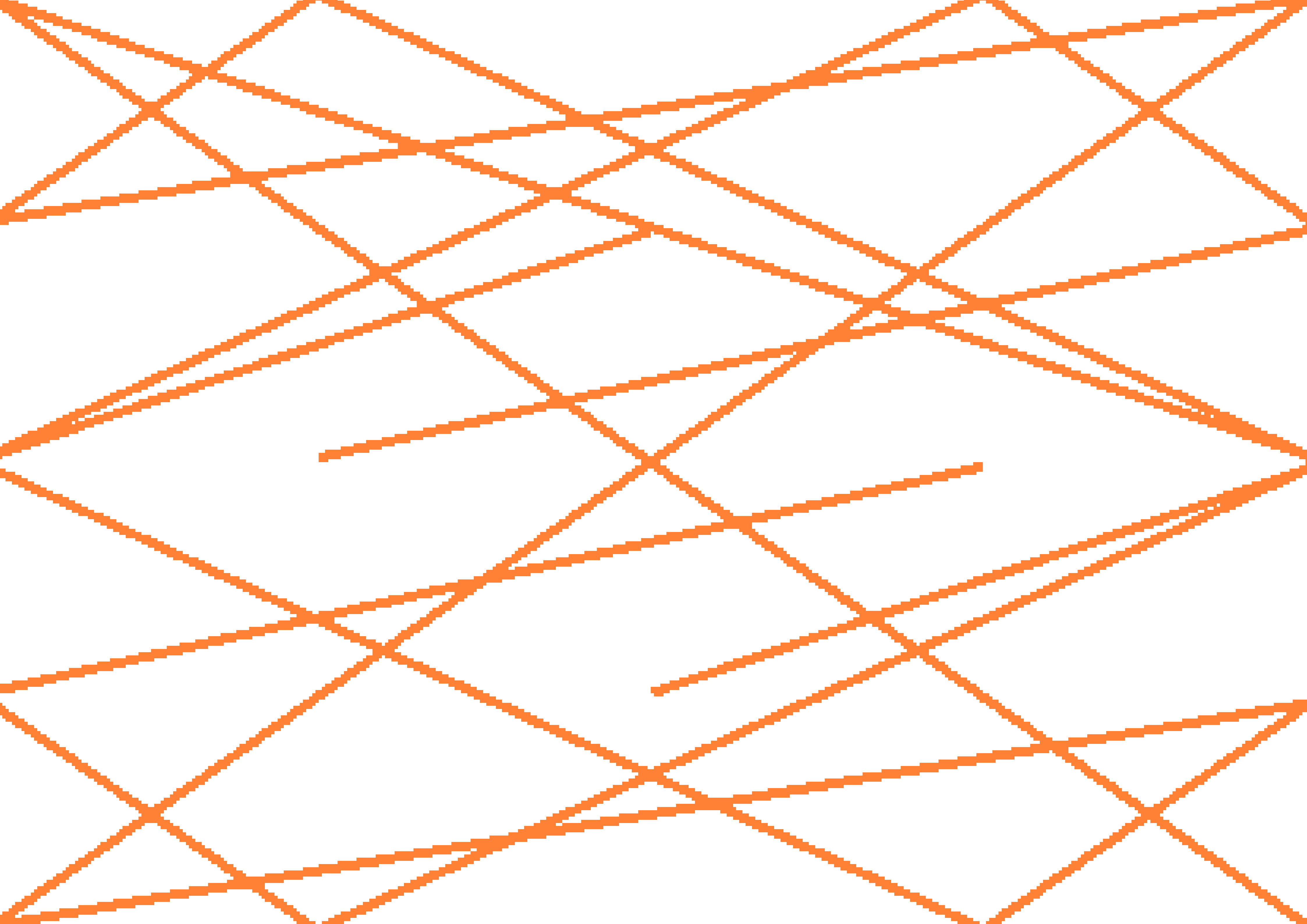
Those, as a result, lost so much of their attraction that they could be used as a negative argument in favor of some reactionary aesthetic choices. Whereas it is easy to simulate an organ or a vibraphone almost to perfection, synthetic string instruments, however, often appear caricatural. And in any case, the results always come out of loudspeakers, with the constraints and characteristics inherent in these transmitters. Data processing seems more dedicated to providing prostheses to acoustic instruments than to replacing them, and it is C.A.D. (computer-aided design) which is undoubtedly one of the best possible uses of computers, wisely retrogressed from the role of demiurge to that of secretary. They can help outline and write scores, without the listener even suspecting their intervention. Even on this level, commercial availability of innumerable software programs for harmonization, orchestration, arrangement, and composition, can unfortunately support, along with some dose of amateurism, a certain idleness of mind. By spreading an illusion of creativity which tolerates sleepy imagination and careless listening, it often causes sound floods where the best is drowned amongst the worst. Matching the irresponsibility of the listener, transformed into a passive and inattentive consumer, looms the irresponsibility of composers fascinated by the complex proliferation of sounds of which they control neither the birth nor the evolution. In other cases, on the contrary, their irresponsibility consists in getting a completely formalized control of a production process, without worrying much about the thought, or the absence of thought, which will result for those who are being addressed.

The composer, as a data processing specialist, is ultimately always constrained to admit that music is completely formalizable and only at the cost of a—sometimes—dangerous reduction. The principal challenge that data processing confronts, by facilitating certain tasks, is to have to reflect about the difficulties inherent in a given work, even about its very finality. Ultimately, music, like any art, rests on desire, much more fundamentally than intelligence. Data processing gives the opportunity to check what the ancient Greeks already knew: Eros, born much earlier than Zeus and Athena, nevertheless always remains young. Data processing, be it with the UPIC or any other tool, should remind artists that they should be philosophers rather than technocrats.

Personally, I have always tried to combine my interest in powerful computer resources with a vision broader than technology or language. The latter maintain the musician (creative and listener) in the circle of social relationships and social emotions, while music also has a more mysterious function of harmony with nature, not only with feelings, but also with the consciousness of the limits and the natural requirements, to harmonize with invention in order to avoid the divorce between humankind and nature. Music can contribute to sparing us certain disadvantages of hybridization with "artificial intelligences."

FOOTNOTES

1. Founding members of the EMAMu were the mathematicians Marc Barbut, François Genuys, and Georges-Théodule Guilbaud; the philosophers Mikel Dufrenne and Olivier Revault d'Allonnes; the psychologists Paul Fraisse and Robert Francès; and the anthropologist Claude Lévi-Strauss.
2. Hear: http://www.centre-iannis-xenakis.org/fbm_tithon_examples



THE UPIC FOR A JAPANESE COMPOSER

TAKEHITO SHIMAZU

THE UPIC FOR A JAPANESE COMPOSER

As a non-European composer, my encounters with the unique and characteristic computer music system UPIC, which began nearly thirty years ago, generated unexpected results and opened new avenues for my composition which I shall develop below. These same processes may still yield some hints for composers of the younger generations, regardless of their various compositional, experiential, ethnic, or cultural backgrounds.

In my case, this then new system—but still valid today—generated some ideas:

- Understanding its hierarchical structure, such technology is often found now in nearly all IT music-related equipment and applications. But discovering it as a young composer, I learned to compose scores not only using the UPIC's surface (or drawing table) but to comprehend the more complex thinking behind creating scores or notes.
- How to obtain "originality" in my work (composition) using a system that has specific limitations and/or strong characteristics inherent in the original system? I found some solutions by pursuing the extreme limits or margins of the system, and also by engaging with some ideas from my cultural background: in the first example cited below, I used only very simple lines and integrated ideas and thoughts from Japanese traditional works, Haiku poems, Noh theater, etc.

These results gave me unique possibilities to compose new work, not only for my compositions using computer technology but also for my instrumental music.

FIRST ENCOUNTER WITH THE UPIC

My first encounter with the UPIC dates back to when I attended an UPIC workshop in July 1990, held at Les Ateliers UPIC studio, then in Massy, just south of Paris. However, before that, the UPIC was already well known in Japan. The most significant opportunity for the UPIC and Japanese composers at an earlier time was surely the concerts and presentations in Yokohama and Tokyo (at Tokyo's Eurospace of and at the Kunitachi Music College) in 1984.[1] Unfortunately, I couldn't take part in those events, but often heard reflections about them from some participating composers, such as Yori-Aki Matsudaira.

TAKEHITO SHIMAZU

During the one-week workshop in 1990, I produced my first piece for the UPIC, titled *Monodie IV.* The short period of the workshop was, of course, not long enough to explore all the creative interests it provoked, but I could not resist my strong interest as a composer to make a properly formed composition. Under such conditions, Alain Després, then director of Les Ateliers UPIC, kindly reserved two hours every day for me for four days on one of the UPIC setups (out of two available, as I recall), even though there were more than ten participants. This private time on the machine, in addition to the tutorials offered, enabled me to complete this work.

MONODIE

My first question when confronting the machine was how I could express my individuality, because the UPIC system seemed to be the result of an idea by the great composer, Iannis Xenakis, who had built this system first and foremost for himself. And I was afraid that drawing lines or figures on the graphic table could and would produce music that would be very (too) similar to that of the creator of the system. Or, ultimately, one might make just a very ordinary and uncharacteristic piece, like a woodcut. Then, I recalled an experiment that Yori-Aki Matsudaira (1931–), one of Japan's leading composers to this day, had told me about when he attended one of the UPIC workshops in Japan in 1984. He had drawn some lines at the very corners or extreme edges of the graphic table, intending to see how they would sound. What he told me gave me some hints about how to go about my first attempts and I began to draw just one line. Around that time, I had composed a few pieces with the same title, *Monodie*, meaning "musical form like a single melody." Adopting a similar musical model, I tried some possibilities in this direction. And this time, I used the same title but added only a new number "IV."

As my main material, I chose a single sound sample, namely, a singing voice produced by a singer, which I had recorded for another piece just before. But this time I used only one cycle (Hz.) of the sound. Using the FFT (Fast Fourier Transform) function, or Fourier synthesis, included in the UPIC system, I obtained some new sounds, very similar to the voice of the singer. Likely inspired by Yori-Aki Matsudaira's idea, I began to draw on the very low range of the sound. **FIG. 1**

As one can see, in the score there is almost only one line or rather only one flux. For this piece I adopted other ideas based on traditional Japanese music, such as You-Kyoku (music for Noh theater), and Gidayu (music for Bunraku, traditional Japanese puppet theater).

This was one of the ways I considered that I could put original characteristics in my composition for the UPIC. Using traditional Japanese ideas has been a very important process in my composition

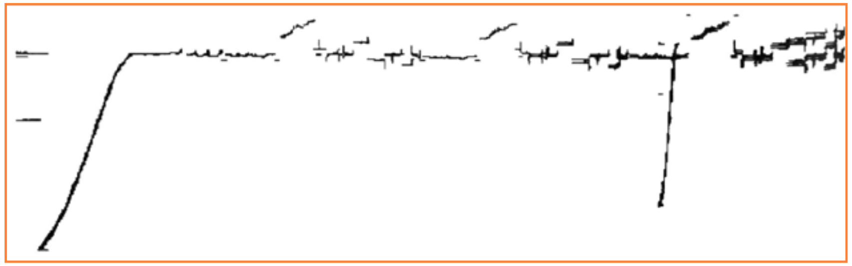


FIG. 1 Alain Després and the author, at Les Ateliers UPIC, Massy, France, 1990 © Takehito Shimazu

FIG. 2 Takehito Shimazu, Score of *Monodie IV*, 1990 © Takehito Shimazu from very early on; that is, I had been composing for traditional Japanese instruments or for traditional Japanese dance. I was composing these kinds of compositions not only because of real demands or commissions, but because such types of music (and sounds) were part of my daily surroundings, having grown up in a Buddhist temple. After that and to this day, I have pursued compositional ways of combining traditional material using scientific methods, including even electronic or computer music.

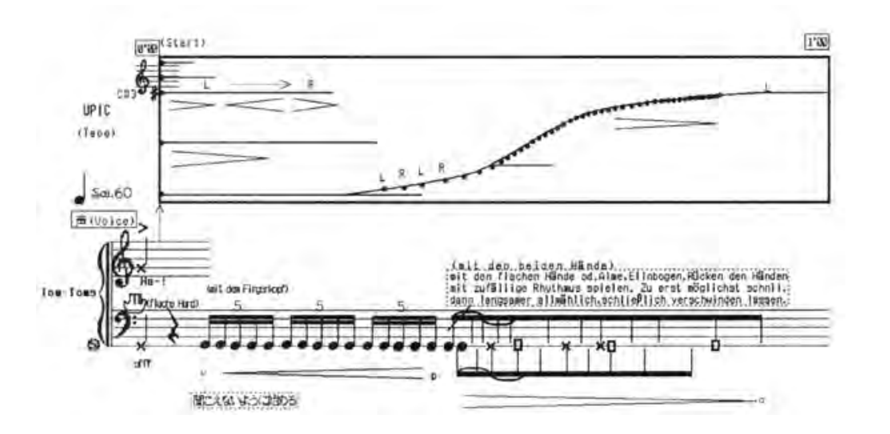
Specifically, in this piece, a melody derived from a You-Kyoku, called *Shakkyo* (Stone bridge) is gradually formed and finally, the melody is transformed into the style of Gidayu, with very drastic pitch changes, intentionally using distortional noise and developing it into heterophonic sounds. Thus, with such a precise concept, I was able to finish this piece in a few days. However, I had reservations about sounds coming only from speakers, and I had previously combined some of my compositions for tape with live instrument(s). So, I made a new piece for a percussionist and tape (UPIC-generated), titled *Monodie IVa*. FIG. 3

ILLUSION

As a result of this first piece for the UPIC, a couple of years later, in 1993, I was asked by Les Ateliers UPIC to compose a new work for the UPIC. By that time, I recall, the studio had moved from Massy to Alfortville, also right outside Paris. I went to France to work on this, expecting that the most characteristic changes to the UPIC as I had known it would be the new version's possibilities as a real-time system. So, I attempted to compose a new piece for live performance with the UPIC, and indeed, I did play the piece on the UPIC, live, at the workshop after completing the piece. However, after giving it some more thought, I added a sangen, or shamisen, a three-stringed Japanese instrument, to compensate the lack of visual effect and reality. At that precise moment, Kazuko Takada (1951–2007), the excellent Japanese sangen player, was also attending this new project initiated by Les Ateliers UPIC. Three Japanese composers—Joji Yuasa (*1929), Yuji Takahashi (*1938), and I—had all been invited to compose new pieces for the new version of the UPIC and, as well and if possible, to conceive of new possibilities between traditional Japanese instruments and the UPIC. Thus, I was able finish a new piece called *Illusion* with the rare combination of a sangen player and UPIC.

In *Illusion* I conjure the image of a traveler, specifically, Matsuo Basho, the most famous poet and greatest master of Haiku, who had made a journey around the Tohoku region, in northeastern Japan. Fukushima, where I lived at that time and indeed still live, is located at the entrance to the region. The following is the program note of the piece I prepared for its world première:

MONODIE IV Takehito Shimazu, 1992, 12'52", for UPIC tape, excerpt from 6'45" to 7'15"



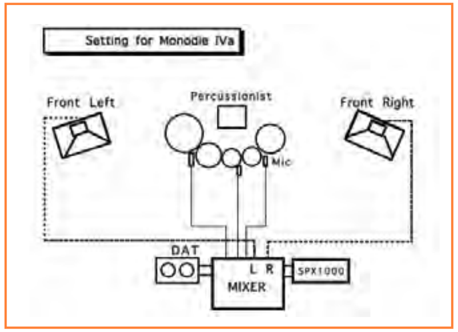


FIG. 3 Takehito Shimazu, *Monodie IVa*, 1990, score for percussionist and UPIC
© Takehito Shimazu

FIG. 4 *Monodie IVa setup* © Takehito Shimazu

MONODOIE IV A Takehito Shimazu, 1992, 17', for tape (UPIC) and percussion, recorded at the Festival of Asian Composers League, Sendai, Japan, June 7, 1992 at the Sendai International Center with Shin-ichi Ueno, percussion (SPX1000 is a reverberator by Yamaha), replayed with percussionist Michael Pugliese at the *Portrait de Iannis Xenakis* concert, Radio France, Paris, France, November 30, 1992, excerpt from 10'28" to 10'58" © Takehito Shimazu

Here is a very famous Haiku, the shortest style of the Japanese traditional poem created during the Edo period, which was made by Basho, a Haiku master and reputedly his last piece:[2]

(in Japanese)
Tabi ni Yande
Yume wa Are-no wo
Kake Meguru

I have found an English translation of this Haiku:

On a journey, ailing—
My dreams roam about
Over a withered moor

During my compositional process, the imagery of this Haiku provided me with some suggestions for this new piece. Namely, I employed the numerical combinations 5 and 7, which are the rhythms of the Haiku (in Japanese), as well as the prime numbers I often use in other works, namely, 2 and 3, as the components of 5. The activity of composing is, in my opinion, very similar to a journey. In fact, I composed my *Illusion* at Les Ateliers UPIC near Paris, very far from my home.

Using the new version of the UPIC system, I made the tape part of this piece. Although I incorporated some imaginary sampled sounds of nature, such as rain, wind, river flow, and others in the Haiku that I imagined, the most important sound was from the sampled sounds of the shamisen.

The instrumental part for the shamisen or sangen (meaning three strings) also consisted of combinations of the prime numbers for the durations, pitches, and other details.

It is possible to play this piece with a sangen player and either with a UPIC system in real time or on tape. I also created another version with tape only (or UPIC). To enhance the live sound, a digital reverberator (such as the Yamaha SPX1000) controlled by a computer (programmed by the composer) is useful.

As a composer, I strive ideally to work with humans and machines or humanity and science; in other words, the combination of a "warm system" and a "cold system." To achieve this, I use many kinds of interesting numerical combinations, and this belongs, in my opinion, to a cold system, like the use of computer. On the other hand, I give the instrumentalist many opportunities to select ways of playing freely, sometimes with minimal limitations but at other times with strict ones. This, I consider, is

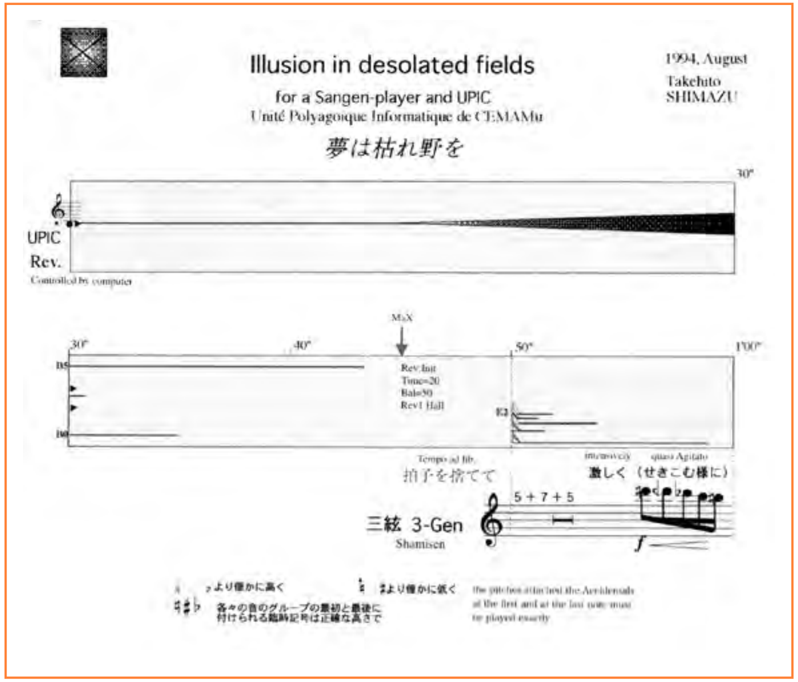


FIG. 5 Takehito Shimazu, Score of *Ilusion in Desolated Fields*, 1994, p.1 © Takehito Shimazu

FIG. 6 CCMIX CD cover, 1998 © CIX Archives a kind of warm system. For effective interaction, I adopted psychological operations within the time span of this piece. FIG. 5

I interpreted the word “dreams” in the poem as a kind of “illusion;” hence, the title of this piece.[3]

CONTINUUM (CONTINUATION)

I feel very fortunate and honored that this piece was included in the CD set, *CCMIX Paris: Xenakis, UPIC, Continuum (mode 98/99, 2001).* FIG. 6

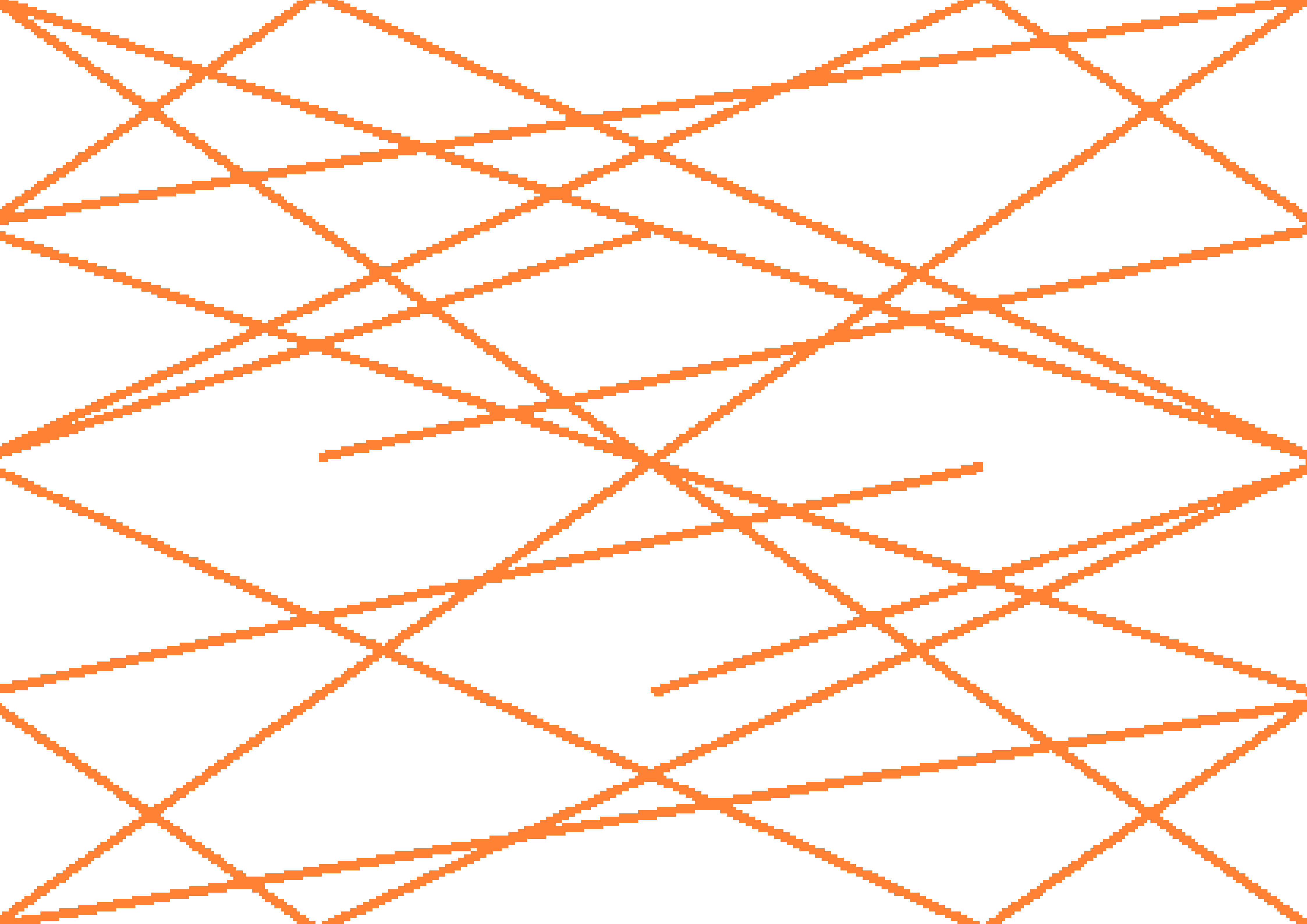
During the same period as this project, I participated as one of the core members in the preparatory committee for the International Computer Music Conference (ICMC), which was to be held in Tokyo 1993 and, finally, I was made Director of the music committee. I organized the international jury, programmed more than twenty concerts, and so on. This ICMC was the first international event for computer music ever held in Asia.

Some of the staff of Les Ateliers UPIC also participated in this event and I was very pleased to prepare a special space and concerts for the UPIC during the conference. Later, I continued to be interested in the UPIC, not only in Japan but in France as well. And I have often been invited to the studio. In the meantime, Gerard Pape had become director, and he also helped me and made great efforts for me to produce new work. And Sharon Kanach gave me the opportunity to pursue my research and work more in the studio, which had then relocated to Romainville, also just outside of Paris, as a composer-in-residence for one month, even though the studio was about to temporarily relocate to La Tourette Convent near Lyon. That was in February 2008. I was very lucky because each time Les Ateliers UPIC broke new ground, I also found new dimensions of composition.

During almost the same period, I also studied and researched various techniques in computer music at IRCAM and at INA-GRM in Paris. And I believe I made good use of these experiences in many compositions and in other activities as a composer. But I certainly obtained the most (and most musically satisfying) results from the UPIC.

FOOTNOTES

1. See Després, this volume.
2. MATSUO BASHO, by Makoto Ueda, Kodansha International Ltd., Tokyo, 1982.
3. See also program booklet *Illusion*, world premiere at Studio 104—Salle Livier Messiaen, Radio France, December 2, 1994.



BEYOND THE CONTINUUM: THE UNDISCOVERED TERRAINS OF THE UPIC

BRIGITTE CONDORCET
(ROBINDORÉ)

BEYOND THE CONTINUUM: THE UNDISCOVERED TERRAINS OF THE UPIC

THE UNIVERSALITY OF THE LINE

Iannis Xenakis stated, "It is the multiplicity of experiences that constitutes the truth of a work of art,"[1] and these words apply so well to his own graphical synthesis system, the UPIC—a work of art in its own right. The UPIC produced a multiplicity of musics, all from the personal experience of quite a range of composers—from Xenakis himself to Jean-Claude Risset, Julio Estrada, Curtis Roads, Daniel Teruggi, Gerard Pape, Takehito Shimazu, Nicola Cisternino, and the author[2] to name just a few.[3] The immediate truth that the UPIC revealed was the universality of a human's relationship to drawing, of the soul to the hand; an unobstructed path from inner impulsion to lines and curves containing the energy of creation. As Anne Hindry[4] has expressed:

> *In the beginning was the line. The curved and continuous one, which traced, for the first man, the threshold of his universe and the one, closer and more drawn, which delimited, on the ground, the contours of his shadow [...] thus distinguishing the formless in an attempt to order chaos, to bring the world into perspective [...] It was indeed the first line, this hint of a dash that emerged from the vital impulse consisting in drawing out of oneself the recording of one's passage, the sign of one's existence. Since then [...] and until the modern, then post-modern era, the mirror-line, the autographic stroke, has continued, in all its states [...] Bearer of the artist's most intimate imprints [...].*

THE ARCHITECTURAL ROOTS OF THE UPIC

Iannis Xenakis's creative experience as an architect and the application of graphics to instrumental compositional processes in some of his early major orchestral works were clearly precursors of the actual conception of the UPIC system.[5] In fact, through architecture, and also by introducing mathematical theories of probability to the use of pitch, and later to electronic sound generation (as in the GENDYN program developed at the CEMAMu),[6] Xenakis found an individual, pioneering path of liberation

BRIGITTE CONDORCET (ROBINDORÉ)

from the prevailing musical dogma of serialism in the 1950s. This path lifted him into a vaster arena of musical architecture. Xenakis considered serialism's formal structure to be weak, due to its emphasis on the note/phrase level of composition.[7] His vision or "auralization," (as it were) of musical form encompassed sonic structures and currents similar to those found in the natural world, which are unconsciously familiar to the human psyche.[8] Although his methods of architecture and what he later termed "stochastic music"[9] were complex, if not abstruse, paradoxically, this approach brought an unprecedented acoustic and physical experience to music. One could say his is a music of archetypes.

The well-known example of Xenakis's composition *Metastasis* (1954–55) is the first in which his use of architectural-like graphics, later translated into instrumental trajectories, can be observed. Xenakis comments: "In the Philips Pavilion I realized the basic ideas of *Metastasis*: [...] I was interested in the question of whether it is possible to get from one point to another without breaking the continuity. In *Metastasis*, this problem led to glissandos, while in the Pavilion it resulted in hyperbolic parabola shapes."[10]

The first image **FIG. 1** shows a preliminary sketch of *Metastasis*, delineating continuous pitch transformation paths (glissandi) for individual string parts. (The second image **FIG. 2** displays the corresponding section of the final instrumental score, as a reference.) Figure 1 is shown here because it prefigures the first graphical score which Xenakis produced on the original UPIC system for his work *Mycènes Alpha* (1978). A further illustration of the continuum field in UPIC graphics is shown in the third image **FIG. 3**, an extract ("page") of an early UPIC work, *eua'on*, by composer Julio Estrada. It is an ideal example of the energy of the creative impulse passing through a drawing, representing continuous frequency curves on the macro-compositional level.[11]

Metastasis was thus a significant part of the inception of an idea which would take more than twenty years to develop into an interactive, computerized compositional system. The first UPIC was operational in 1977.[12] In tracing back its roots to the nature-generating structures of stochastics and the translation of architectural drawings into music, one can understand why the system has been associated with a certain universality.[13] It presented a user-friendly interface, well-adapted to pedagogy, yet at the same time it could challenge the professional composer with complex considerations, from macroform to the micro-level of sound generation. The UPIC automatically set up a continuum between the almost sculptural plasticity of sonic events, due to their strong visual component, and the definition of music as organized sound in time.[14]

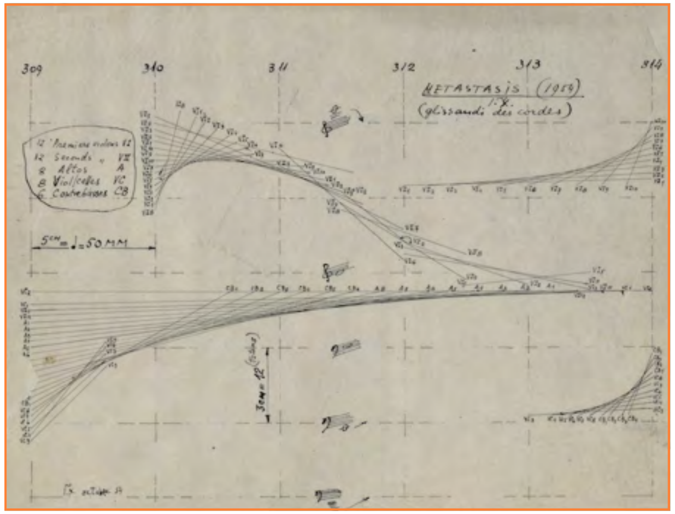


FIG. 1 Iannis Xenakis, *Metastasis*, graphic sketch delineating string glissandi
© Iannis Xenakis Family

FIG. 2 Iannis Xenakis, *Metastasis B*, 1953–1954, first page, final score
© Boosey & Hawkes

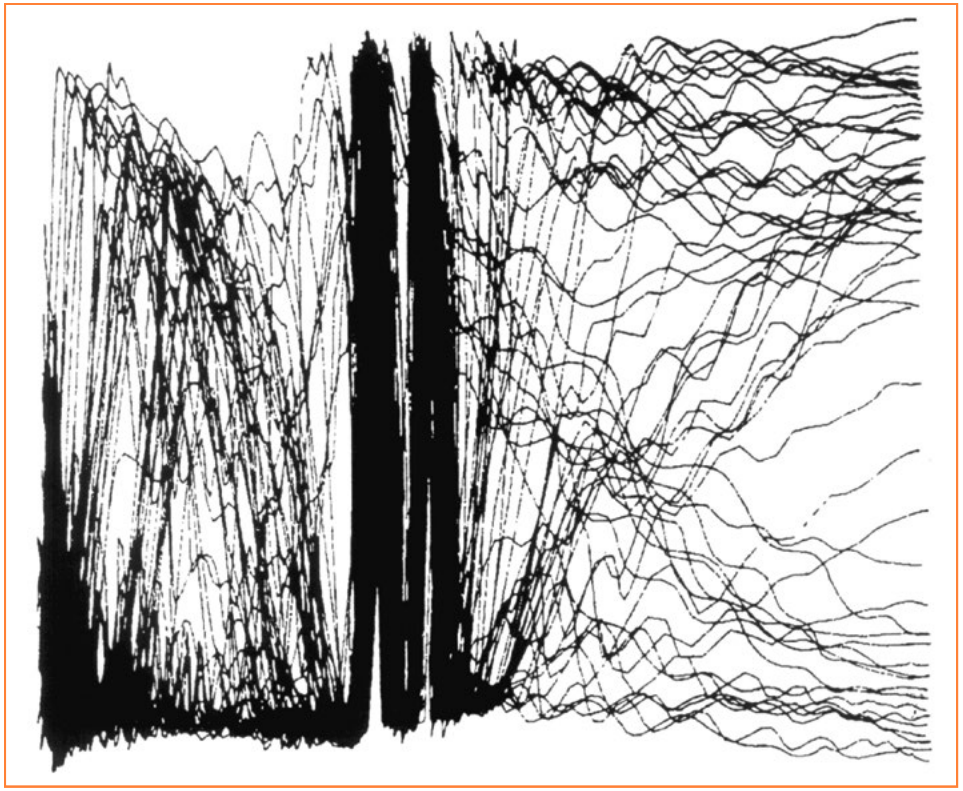


FIG. 3 Julio Estrada, *eua'on*, 1980, fragment of a UPIC score drawing © Julio Estrada

THE UPIC: A SONIC MODULE OF NEW COMPOSITIONAL PARADIGMS

The UPIC has been the subject of numerous articles and theses since its inception, and particularly since the real-time version of the 1990s.[15] Much as a lunar module explores the terrain of the moon, the UPIC was a type of sonic module for exploring a large range of electroacoustic compositional paradigms and techniques, its starting point being the frequential continuum. It provided a comprehensive graphical user interface for representing all compositional levels in interaction—a unique framework for the coexistence of macroform, mesostructures, and microsonics. The interface offered a bridge between the classical compositional model of score drawing and the abstract models of electroacoustic composition, such as the use of *objets sonores* in musique concrète or programming code for sound generation. The macroform in the UPIC was called a "page," which could represent an entire composition or a portion of one continued on subsequent pages. Each page consisted of mesostructures or events of "arcs" (line/curve segments) drawn in a frequency versus time axis, which served as a type of central nervous system, with each arc linked to multiple microsonic defining elements (including waveform, envelope, and amplitude). Each page could contain up to 4000 arcs, played back at speeds between 1/10th of a second to over an hour, with no change in pitch or sound quality, only the rate of events in time. This time stretching feature, in both expansion and contraction of a page (with the additional option of acceleration and deceleration), opened a space for work in the continuum/discontinuum temporal domain.

It is difficult in today's environment of imaging computer programs for architecture, music, film, and visual art to realize what a radical concept the UPIC represented in the 1970s. The immediacy of a graphical interface that translated drawing into sound was novel in computer music, whose composers at the time were largely thwarted by programming. Access to the continuous frequency space also stood in contrast to the era's growing popularity of note-based keyboard synthesizers, used mainly in pop, rock, and disco music. The UPIC thus spearheaded a truly divergent path into new paradigms of electroacoustic composition, in and beyond the continuum, thereby securing a unique place in the history of computer music. Later, the frequential continuum concept was vastly expanded in the development of timbral, dynamic, and rhythmic continua in acoustic composition by composer Julio Estrada, largely inspired by his work on the UPIC.[16]

Due to a timbral stereotype of the UPIC (a somewhat harsh, unnuanced tone), few people realize that it provided a significant range of synthesis methods and tools, making it a very sophisticated compositional system. This would indicate that the stereotype resulted from its use rather than from any inherent limitation. Perhaps, though, it could be argued that one of the "drawbacks" of the system was the ease of drawing, which tended to oversimplify the compositional process and lull composers into the illusion of accomplishment without the rigor of sonic exploration that a classic electroacoustic composition would demand. I say this from personal observation and experience as former head of Musical Production at the CCMIX. One of the further challenges to composers was the limited length of residencies, primarily due to institutional and personal financial considerations, as the UPIC at the time was not available to the public outside of the studio.

Mention may also be made of the typical experience of composers facing the UPIC process of drawing as part of electroacoustic composition. The relationship between a few lines drawn on a page and the resultant raw sound was almost always unexpected and even unsettling at first use. Composers were confronted with a new paradigm, which often led to frustration, or to accepting underachievement. This "wall" of newness tested composers' ingenuity to find their own voice and creative imprint under demanding compositional and time constraints. To those who did, these constraints could become the source of an original path of creation. The ability to grapple with and overcome a challenge, thereby surpassing oneself—and ideally bringing a new element of one's identity into manifestation—is a universal theme. This recalls the extraordinary thought of Arthur Koestler: "Einstein's space is no closer to reality than Van Gogh's sky. The glory of science is not in a truth more absolute than the truth of Bach or Tolstoy, but in the act of creation itself."[17]

UPIC'S FERTILE TERRAIN OF SYNTHESIS METHODS AND FREQUENCY EXPLORATION

The implemented and inferred UPIC synthesis methods included:

Additive synthesis. At its origins, additive synthesis was developed by the superposition of sine waves in harmonic relationship to one another, in a theoretical attempt to recreate any sound from nature (the Fourier theorem). The more complex the sound, the more sine waves of different frequencies and amplitudes were required. Although perhaps successful to physicists and acousticians, compositionally it had its limits. The UPIC offered an expanded form, achieved by multiple simultaneous arcs whose relationships were rarely harmonic, and to which one could assign non-sinusoidal waveforms. This led to very rich sound aggregates.

Subtractive synthesis was not a specifically implemented synthesis technique in the UPIC, however, it could be simulated. Classically achieved by applying a filter to alter or remove the partials of a sound (a portion of its timbral elements), in the UPIC this could be achieved by either removing superimposed arcs, by graphically redrawing one or more waveforms,

or by using an envelope to modify its amplitude—all three techniques contributing to simulating filtering.

Graphical synthesis in the UPIC was achieved by hand drawing waveforms. This category was unique to the system—that is, the ability to access the visual representation of a waveform and to either draw it from scratch, or modify it by hand. Xenakis very often touted this feature of creatio ex nihilo.[18]

Resynthesis or *resampling* in the UPIC consisted of extracting a waveform from a monophonic sample, which then became a synthetic waveform that could be assigned to an arc or arcs on a page. The 1990s UPIC sported a more effective hardware controller and processor[19] with improved sampling functions, allowing for the extraction of a larger sonic portion of a recorded sound than only a single waveform. This offered access to a previously inaccessible domain of synthesis that bordered on musique concrète. This is one of the main features that enabled the UPIC to depart from the harsh sonic stereotype mentioned above. It also presents its own unique category of continuum: between a sampled sound and its potential journey into synthetic derivatives.

Frequency modulation (FM) synthesis involves altering or modulating the frequency of one waveform (the "carrier") with another waveform (the "modulator"), whose amplitude and frequential harmonic or inharmonic relationship to the carrier will contribute more or less to the complexity of the resultant sound. This implemented UPIC feature was greatly enhanced when the frequency range of the 1990s UPIC was extended to infrasonics, starting at 0.01 Hz. This expanded range, coupled with the possibility of utilizing resynthesized (resampled) sounds as modulators and carriers offered a truly unlimited space of sonic exploration.

Amplitude modulation (AM) synthesis is classically achieved when a carrier wave's amplitude is altered by a modulator (although there are other features of AM not pertinent to this discussion). In the UPIC, it was not an implemented function, such as FM, although it could be simulated by envelopes applied to individual arcs.

Synthesis by aliasing. Caveat emptor: This is a radical and creative category of synthesis, and certainly not based on any implemented feature. In fact, contrariwise, aliasing is considered an undesirable by-product of digital sound reproduction. For example, if a system has a sample rate of 44,100 Hz (cycles per second), which is equal to roughly twice the audible range of the human ear (around 20,000 Hz depending on individual auditory capacity), then any complex waveform whose partials exceed 22.05 kHz (1/2 the sample rate, also called the Nyquist frequency) would, by the "wall" or limits delineated by the system, see the higher partials folded back into the audible frequency range, as by a mirror effect, in the same ratio in which they exceeded the "wall." Aliasing generally renders the signal blurred or distorted, and most systems implement anti-aliasing filters to eliminate this by-product. Because the UPIC could so easily produce the superposition of complex waveforms, aliasing was a very common feature of the resultant sound, although generally not understood and rarely, if ever, consciously used for its unpredictable sound effect or in any way controlled or calculated. One can see by this so-called "synthesis method," that regardless of its countercurrent use of audio system limitations, the UPIC has the potential to usher the composer into truly uncharted compositional terrain, one which Xenakis himself occasionally exploited, though not with any scientific rigor.[20]

Granular synthesis was one of the most immediate and simple methods of synthesis on the UPIC, though again as a vast extension of the original conception (using sinusoidal waveforms with Gaussian envelopes). The UPIC arcs could be drawn to be tiny "grains" or dots in agglomerations of hundreds, if not thousands, on a page in all types of formations, durations, and frequency ranges, as well as assigned very complex waveforms. As grains coalesced and accumulated, they would create larger articulated sonic events or masses, often very close to the structures of Nature, a now characteristic feature of granular synthesis.[21]

Finally, mention should be made of a unique and underused feature in the UPIC called the *Frequency Table*, which was implemented in its real-time versions.[22] Frequency was determined by the position of the arc(s) on the vertical axis of the page, a feature carried through from the original version. However, with the Frequency Table, a composer could choose to operate within up to four different simultaneous tables or grids that could be superimposed on each page. These grids were invisible to the eye, however, and accessed by assigning one of four tables to whatever arc was being drawn, the same way as one would assign the waveform or envelope to it. An arc could thus be "placed" within different frequency spaces determined by the composer, with as large a range as 0.01–22,050 Hz. (For those with classical training, it was possible to display Hz values in Notes + Octave designations with positive or negative cent values (a half-step or semitone being equal to 100 cents). In note values, with middle C at 261.54 Hz, this range covered from F - 14–23 cents to F + 9–25 cents.) One could argue that arcs assigned a frequency below 20 Hz would be inaudible to the human ear. However, highly complex (resampled) waveforms could contain more information than a single, simple frequency cycle, thus rendering them audible in the infrasonic range.

Interestingly, the Frequency Table further introduced a concept

FIG. 5 The author having tea with Iannis Xenakis at his apartment in Paris during their interview for *Computer Music Journal*, 1995 © Curtis Roads

that was potentially as impactful as the continuum: *the tempered discontinuum*. With a function called "discrete/non-discrete," the user could define how the frequency space was to be moved through. If non-discrete, then a diagonal arc would sound like a glissando, the classical use of the continuum with the UPIC. However, if "discrete" were chosen, the user could create equal temperaments between 1–99 divisions per octave. The same diagonal arc would then sound like discrete steps in a defined temperament. For those who wished to utilize non-tempered scales, the arcs would have to be drawn individually within a non-discrete frequency table. These features were almost never used, although they contained very intriguing possibilities of exploration into tempered scales beyond 12-tones, for those who wished to compose with determined pitches.

REAL-TIME PERFORMANCE AND POST-SYNTHESIS PROCESSING

Due to the greatly improved, somewhat revolutionary, hard and software developed by the CEMAMu team (Raczinski, Marino, Serra, and others), the second and third versions of the UPIC were powerful enough to perform many operations in real time. Although the UPIC was conceived to be a studio compositional system, the first use of these real-time capacities was by Xenakis himself when he chose to use the UPIC as a live performance system for his work *Taurhiphanie* (1987), (for UPIC, light effects and amplified bulls and horses) in the amphitheater at Arles, France. According to hardware engineer Jean-Michel Raczinski, who was part of the production team in Arles, the fact that Xenakis pushed the limits of the system to achieve a performance-level status, was an unforgettable and exhilarating experience, if not slightly harrowing at the early stages of the system's new capacities.[20] Perhaps the UPIC was not commonly used as a live performance tool also because there were so few units available (two or three at the CCMIX) and they were designated for composer residencies and courses. The UPICs at the CEMAMu were used primarily for research.

The UPIC feature of parametrical independence allowed graphical curves defining one parameter to be applied to another. For example, an envelope could share the same visual description as a waveform yet retain its own time-varying amplitude function. In real-time use, these parameters could be swapped or redrawn almost instantaneously, extending the concept of synthesis to a type of sonic metamorphosis in real time—a continuum in its own right. This said, most composers used the UPIC to generate sound material which they would later submit to transformation processes in a studio, such as echo, reverberation,

convolution, filtering, spectral processing, spatialization, and multitracking.

EVER ON A SIDEREAL PATH

> And I love listening to the stars at night.
> It is like the sound of 500 million tiny bells.
> ~ *Le Petit Prince*, Saint-Exupéry[23]

In my opinion, the UPIC has not uttered its last word. Indeed, some form of the UPIC concept has now been developed by a variety of programmers into various stand-alone apps, including IanniX, HighC, and UPISketch. However, the final version of the UPIC developed at the CEMAMu still contains significant potential that could be explored by longer residencies for composers and researchers alike, should the systems be refurbished and again made available. I, for one, stand at my own compositional threshold, pondering a reacquaintance with this benchmark system in the history of electroacoustics. May the sonic sidereal wanderings of many a composer be once again manifested through the UPIC, pursuing a Xenakian journey into the continuum and beyond.

FOOTNOTES

1. Iannis Xenakis, "Changer l'homme," *L'Arc* 51 (1972), 31.
2. Iannis Xenakis, et al. 2001. *CCMIX Paris/Xenakis/UPIC/Continuum: Electroacoustic and Instrumental Works by Xenakis, Risset, Estrada, Roads, Pape, Robindoré, Cisternino, Teruggi, Shimazu* (New York: Mode Records), (CD set mode 1998/99).
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4. Anne Hindry, "Du trait à la ligne," in *Le magazine du Centre National d'Art et de Culture Georges Pompidou* 86 (1995), 12. Translated from the French by the author.
5. Brigitte Robindoré, "The Impact of Electro-acoustics on Acoustic Composition and Thought: The Continuum and Noise," MA thesis, Université de Paris VIII, 1997.
6. Marie-Hélène Serra, "Stochastic Composition and Stochastic Timbre: GENDY3 by Iannis Xenakis," in *Perspectives of New Music* 31, (1993), 236–57.
7. Iannis Xenakis, "La crise de la musique sérielle," in *Kéleütha*, ed. Alain Galliari (Paris: L'Arche, 1994), 39–43.
8. Brigitte Robindoré, "Eskhaté Ereuna: Extending the Limits of Musical Thought. Comments on and by Iannis Xenakis," in *Computer Music Journal* 20 (1996), 11–16.

9. Iannis Xenakis, *Formalized Music*, revised edition (Stuyvesant, NY: Pendragon Press, 1992), Chapters I, II, III, and V.

10. Iannis Xenakis, *Music and Architecture: Architectural Projects, Texts, and Realizations*, ed. Sharon Kanach (Hillsdale, NY: Pendragon Press, 2008), 99.

11. Julio Estrada. 1980. *Eua'on* for UPIC. Score print-out provided by the composer.

12. See Médigue, this volume.

13. Peter Nelson, “The UPIC System as an Instrument of Learning,” in *Organized Sound* 2 (1997), 35–42.

14. Edgard Varèse and Chou Wen-Chung, “The Liberation of Sound,” in *Perspectives of New Music* 5 (1966), 11–19.

15. See, for example, Henning Lohner, “The UPIC System: A User's Report,” in, *Computer Music Journal* 10 (1986), 42–49; Gérard Marino, Jean-Michel Raczinski, and Marie-Hélène Serra, “The New UPIC System,” ed. S. Arnold and G. Hair, in *Proceedings of the 1990 International Computer Music Conference* (1990), 249–252; Gérard Marino, Marie-Hélène Serra, and Jean-Michel Raczinski, “The UPIC System: Origins and Innovations,” in *Perspectives of New Music* 31 (1993), 258–69; Brigitte Robindoré, *The UPIC User's Guide and Tutorial* (Paris: Centre d'Etudes de Mathématique et Automatique Musicales, 1993, 1995); Gerard Pape, “Sculpter le son par le graphisme de l'UPIC,” unpublished manuscript (1997).

16. See, for example, Julio Estrada,“Le continuum en musique: structure et ouvertures en composition, ses dérivations esthétiques,” in *Aesthetik und Komposition*, ed. Ulrich Mosch and Borio Gianmario, Darmstadter Beitrage zur Neue Musik (Mainz: Schott), 1994; Julio Estrada, “Freiheit und Bewegung: Transkriptionsmethoden in einem Kontinuum von Rhythmus und Klang,” in *MusikTexte: Zeitschrift fur Neue Musik* 55 (1994), 57–62; Julio Estrada, “Problems posed by the Transcription of a Chrono-graphical Representation into a Multiparametric Continuum of Rhythm and Sound,” in *Report of the Musicology Congress Musik als Text*, Freiburg, Albert-Ludwigs Universität (1994); Julio Estrada, “Théorie de la Composition: discontinuum-continuum,” PhD dissertation, University of Strasbourg, 1994; Julio Estrada, “eua'on'ome,” Donaueschingen: Donaueschinger Musiktage Program Notes (1995); Brigitte Robindoré, “The Impact of Electro-acoustics on Acoustic Composition and Thought: The Continuum and Noise,” MA thesis, Université de Paris VIII, 1997.

17. Arthur Koestler, *The Act of Creation* (London: Hutchinson, 1964).

18. Brigitte Robindoré, “Conversations with Jean-Michel Raczinski,” unpublished manuscript (Paris, 2019).

19. See two related articles: Jean-Michel Raczinski and Gérard Marino, “A Real-time Synthesis Unit,” in *Proceedings of the 1988 International Computer Music Conference* (1988); Jean-Michel Raczinski and Gérard Marino, *Real-time Unit Specifications* (Paris: Centre d'Etudes de Mathématique et Automatique Musicales, 1991).

20. Brigitte Robindoré, “Conversations with Jean-Michel Raczinski,” unpublished manuscript (Paris, 2019).

21. Curtis Roads, *Microsound* (Cambridge, MA: MIT Press, 2002).

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XENAKIS AND THE UPIC

RONALD SQUIBBS
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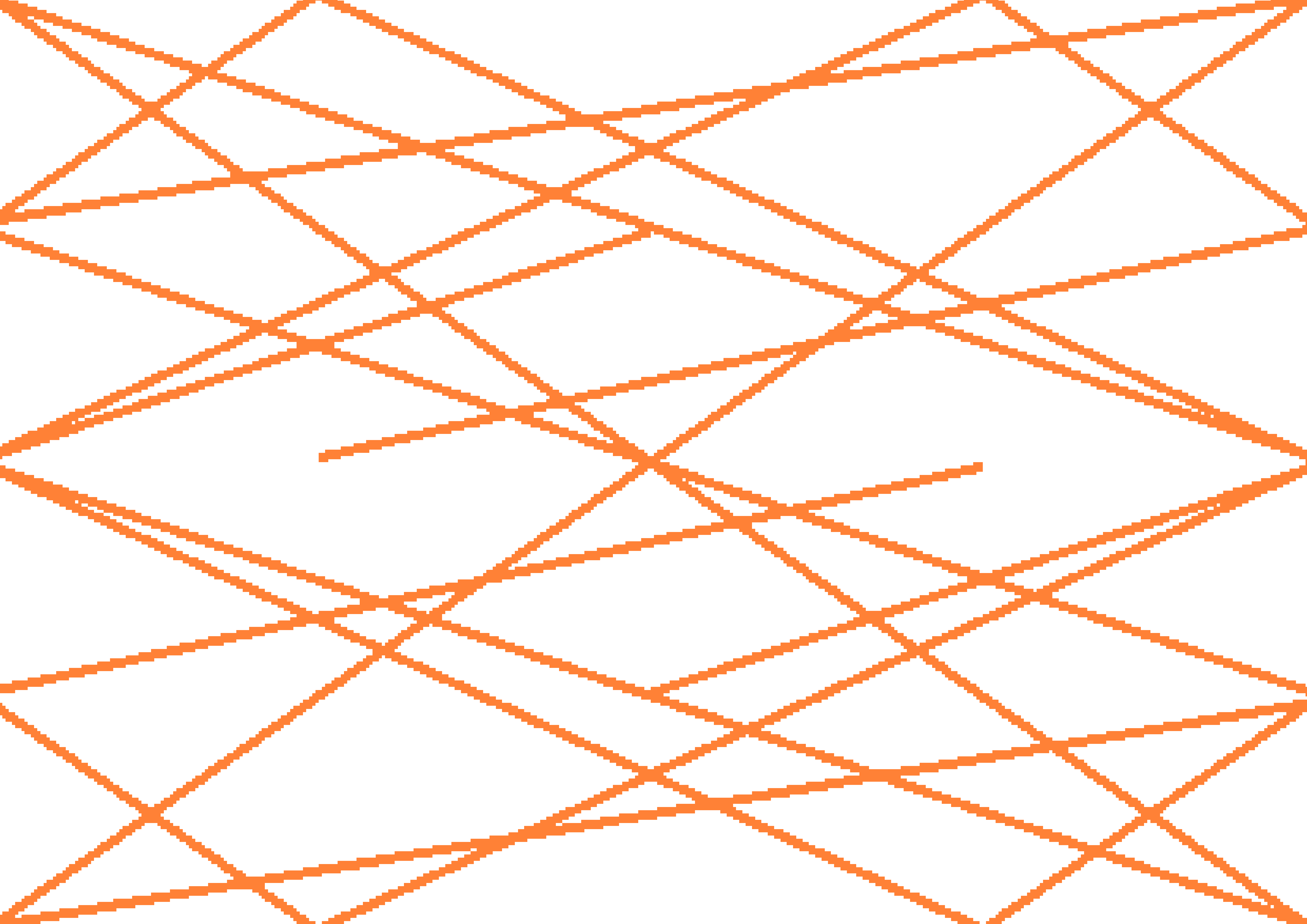
HENNING LOHNER



MYCÈNES ALPHA:

A LISTENER'S GUIDE

RONALD SQUIBBS

MYCÈNES ALPHA: A LISTENER'S GUIDE

INTRODUCTION

Mycènes Alpha is unique in that it is the only electroacoustic work for which the Greek composer Iannis Xenakis provided a graphic score that is integral to the conception and presentation of the work. It is strongly suggested that the reader listen to the work several times, preferably in conjunction with viewing the graphic score, in order to form some preliminary impressions and questions of his or her own prior to reading the interpretation that is offered in this essay.[1]

HISTORICAL AND TECHNICAL BACKGROUND

Mycènes Alpha was composed in 1978 at Xenakis's studio for electroacoustic research and composition, the CEMAMu (Centre d'Etudes de Mathématiques et Automatiques Musicales), for a multimedia performance piece, the *Polytope de Mycènes*, which was presented that same year at Mycenae, Greece. As part of the *Polytope de Mycènes*, *Mycènes Alpha* was presented in the form of seven sound interpolations.[2] The work was subsequently released as a continuous musical structure suitable for concert performance or private listening. It is this version that is the subject of the present analysis.

Mycènes Alpha was composed on the first version of the UPIC (Unité Polyagogique Informatique de CEMAMu), which is an electroacoustic instrument that allows the user to design virtually all levels of a musical structure by hand. Its graphic interface receives input for timbre (waveforms and envelopes), for the pitch and duration of individual sounds (arcs), and for the configuration of arcs into sections of music (pages). The graphic score of *Mycènes Alpha* shows the arcs and pages only. As in a short score, where details of instrumentation and dynamics have been omitted, the graphic score provides only information regarding the pitch and relative duration of the sounds. With respect to the work's timbres, James Harley has written: "The timbres tend to be noisy, but also static. Variation is achieved through the layering of the notes and the dynamic envelopes."[3] Dynamic flow is also achieved by means of the shapes formed by the clusters of arcs and by the curvature of some of the arcs, which create glissando-like effects. Despite the compositional possibilities that it opened up, the UPIC challenged Xenakis to work creatively within some relatively severe technical constraints, at least initially.[4] His success in doing so accounts for the work's peculiar charm.

RONALD SQUIBBS

THE STRUCTURE OF MYCÈNES ALPHA: GENERAL CHARACTERISTICS OF THE SECTIONS

TABLE 1 shows a list of the sections in *Mycènes Alpha*, each of which is numbered in the first column. Each section number is followed in the second column by that section's start time.[5] The durations shown in the third column of the table correspond to the differences between the start times that are shown in the second column. The labels in the fourth column refer to the morphological characteristics of the sections. Repetitions of the labels along with the use of the prime symbol (') indicate varied repetitions of morphological types, each of which will be described in more detail below. This analytical interpretation makes use of six morphological types. Five of these types reappear in varied form once each, and one of them—type D—appears in two varied repetitions. The fifth column shows that there is some variation in the use of pitch register among the sections, with eight of them making use of nearly all of the available registral space.[6] The sixth column indicates the orientation of the majority of the arcs within each section. The use of curved arcs is restricted to four out of the thirteen sections, one of which (Section 11) contains a mixture of horizontal and curved arcs. Even in those sections where only horizontal arcs are used, the perception of individual pitches is relatively rare because the arcs are typically clustered densely together within the registral space.

PART I: MORPHOLOGICAL CHARACTERISTICS

Mycènes Alpha divides into two parts, the first containing Sections 1–6 and the second containing Sections 7–13. The observations given in this section will focus only on the characteristics of Sections 1–6, which constitute a single, relatively closed structural unit.

Section 1 (labeled Morphological Type A in Table 1) consists of four bands of clustered horizontal arcs, distributed over the whole of the pitch register. There are discernable areas of open space between the bands. Even though individual arcs within the bands are mostly horizontal, the bands change shape as the section progresses, thus creating a sense of motion rather than the impression of a single, sustained chord.

Section 4 (labeled Morphological Type A' in Table 1) presents a variant of the contour of Section 1. This section, which begins at 1'53", consists of three bands of horizontal arcs distributed over nearly the whole of the pitch register.

SECTION	START TIME	DURATION (SECONDS)	MORPHOLOGICAL TYPE	REGISTER(S)	ARC DIRECTION
1	00"	17	A	all	horizontal
2	17"	38	B	med. high	curved
3	55"	58	C	low	horizontal
4	1'53"	5	A'	all	horizontal
5	1'58"	55	B'	all	curved
6	2'53"	60	C'	low, then all	horizontal
7	3'53"	24	D	low, med.	horizontal
8	4'17"	59	E	all	curved
9	5'16"	60	E'	all	horizontal
10	6'16"	60	D'	all	horizontal
11	7'16"	59	F	all	mixed
12	8'15"	20	F'	all	horizontal
13	8'35"	61	D"	low, med.	horizontal
	9'36"	Total Time			

TABLE 1 General Characteristics of Sections in *Mycènes Alpha*

Section 2 (beginning at 17", labeled Morphological Type B in Table 1) begins with a narrow band of curved arcs in the middle upper register, in the vicinity of A4. The band gradually expands to occupy more of the registral space, resulting in a bush-like structure that is a type of arborescence (branching structure), a general morphological category that appeared in several of Xenakis's works from the 1970s onward.[7]

Section 5 (beginning at 1'58", labeled Morphological Type B' in Table 1) presents a variation on the contour of Section 2. It begins with a single arc at approximately A3 (one octave lower than in Section 2) from which a second arc soon branches off. Additional branchings result in a complex configuration that extends over most of the pitch register before returning to the area around A3 near its end. The two sections are linked not only by their general morphology, but also because each begins audibly around pitch class A, albeit an octave apart.

Section 3 (beginning at 55", labeled Morphological Type C in Table 1) is confined entirely to the lowest register, with its arcs all occurring approximately within the range from C1 to D#1. At some places within this section, pitches one octave lower and one octave higher than those indicated on the graphic score become clearly audible. (This is likely due to the waveform used to generate the sounds.) The amplitude decreases markedly near the conclusion of the section, approaching silence at the very end. This attenuation of the amplitude suggests a relative degree of formal closure at this point. The effect of closure is musically appropriate here, since the following section (section 4) initiates a sequence of varied repetitions of Sections 1–3 that occupies the remainder of Part I.

The resemblance between Section 6 (beginning at 2'53", labeled Morphological Type C' in Table 1) and Section 3 is exact until about 10 seconds before the end, when a cluster of sustained sounds begins to accumulate, moving from the lowest register (C1) up to about C4. This cluster recalls the texture of Section 1, and thus provides, by means of structural rounding, a fitting conclusion to Part I.[8]

In summary, the morphology of the sections in Part I forms the simple and well-defined pattern: A B C A' B' C'.

PART I: TEMPORAL STRUCTURE

The temporal structure of *Mycènes Alpha* is based on a primary unit of one minute, which was the limit of duration for a page of music composed with the original version of the UPIC. Among the first three sections, Section 3 is the only one to approach this limit, having a duration of 58 seconds. The preceding two sections increase progressively in length, with the sum of the durations of Sections 1 (17 seconds) and 2 (38 seconds) nearly equal to the duration of Section 3. The relations among the durations of these sections approximate simple ratios involving the integers 1, 2, and 3, as shown in **FIG. 1**.

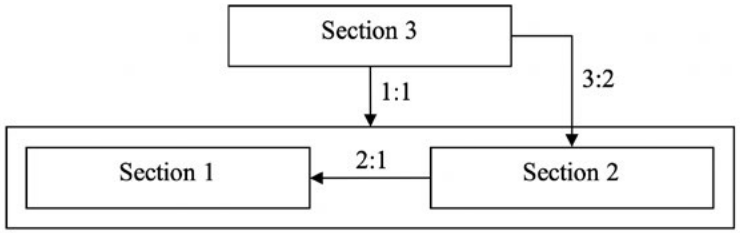


FIG. 1 Relations among durations in Sections 1–3 of *Mycènes Alpha*

The relations among the durations of Sections 4–6 are more straightforward. Section 4 has a duration of 5 seconds (1:12 of 60) and Section 5 follows with the complementary duration of 55 seconds (11:12 of 60). Section 6, in turn, follows with a duration of 60 seconds, which is exactly equivalent to the sum of the durations of Sections 4 and 5. **FIG. 2** illustrates these relations. The only ratio that is the same in Figure 2 as it is in Figure 1 is the 1:1 between Section 6 and the sum of Sections 4 and 5,

which corresponds to the (approximately) 1:1 ratio between duration of section 3 and the sum of the durations of Sections 1 and 2.

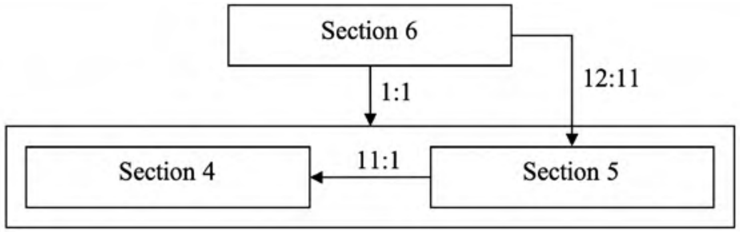


FIG. 2 Relations among durations in Sections 4–6 of *Mycènes Alpha*

FIG. 3 illustrates the relations among groups of sections in Part I. At this level of structure, the differences between the relations within the groups (as shown in **FIGS. 1,2**) are subsumed into a relative degree of equilibrium. This is because the combined duration of Sections 4–6 is approximately equal to the combined duration of Sections 1–3, each group making up approximately half of the entire duration of Part I. The 2:1 ratio between the duration of Part I and that of Sections 1–3 and 4–6, respectively, is a reflection on a higher structural level of the approximately 2:1 ratio between Sections 2 and 1 at the beginning of Part I (see Figure 1).

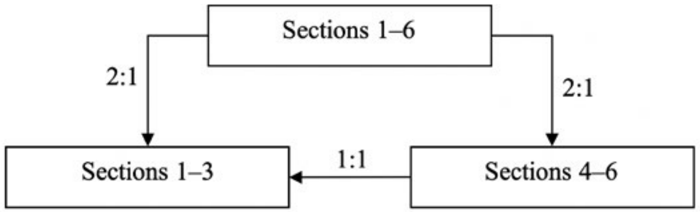


FIG. 3 Relations among groups of Sections in Part I of *Mycènes Alpha*

At this level of structure, the differences between the relations within the groups (as shown in Figure 1 and 2) are subsumed into a relative degree of equilibrium.

PART II: MORPHOLOGICAL CHARACTERISTICS

The six sections in Part I divide evenly into two groups of three sections each. Part II is slightly more complex, but the varied repetitions of morphological types produce a succession of sections whose musical logic is almost as straightforward as that in Part I.

Section 7 (beginning at 3'53", labeled Morphological Type D in Table 1) consists of a succession of clusters of horizontal arcs that are confined to the lower register. This section—which is repeated in temporal augmentation in Section 13 (beginning at 8'35", labeled Morphological Type D" in Table 1)—is the only morphological type that includes periods of silence. These silences, in fact, divide the section into twelve short segments that are followed by a longer, concluding thirteenth segment. The number of segments in Section 7 (and also in Section 13) may or may not be intended to be a reflection of the number of sections within the work as a whole, but the numerical correspondence is striking nonetheless. The density of the clusters makes the frequencies of the individual arcs all but impossible to distinguish except in the thirteenth segment, which features sustained individual arcs in its middle and at its end. The pitches of these arcs are approximately A1 and E2, two pitches whose fundamental frequencies are in the ratio 3:2. As will be demonstrated later, this ratio plays an important role on several levels of the work's temporal structure.

The morphology of Section 8 (beginning at 4'17", labeled Morphological Type E in Table 1) suggests the form of a fantastic, mythological creature. From a sonic perspective, it is significant that this section is composed almost entirely of curved arcs, giving it an unusual degree of fluidity. Over the course of its unfolding it occupies all of the available registral space. Toward the end of the section a narrow band of arcs descends to a point in pitch space in the vicinity of D4 before branching off in opposite directions, ultimately opening into a fourteen-note cluster that spreads out over a space of about two-and-a-half to three octaves.

Section 9 (beginning at 5'16", labeled Morphological Type E' in Table 1), though not as fantastic in appearance as Section 8, has some morphological features in common with it. It has clusters and open spaces in about the same areas as Section 8 but it consists entirely of horizontal arcs until the very end, when an ascending glissando is superimposed over the still-active horizontal arcs in order to connect the end of Section 9 to the beginning of Section 10.

Section 10 (beginning at 6'16", labeled Morphological Type D' in Table 1) consists of clusters of horizontal arcs like Section 7, but each of the clusters is connected to the preceding and following one by means of narrow bands of arcs. In retrospect, the final segment of Section 7 may be regarded as a compound segment whose two clusters are connected together with a narrow band of arcs, in effect providing a precedent for the connected clusters of Section 10. While all of the clusters in Section 7 are

built up from pitches in the lowest register, the majority of those in Section 10 are placed within the upper register, with only a few of them reaching lower into the registral space. In a general sense, the morphology of Section 10 appears to be a free inversion of the morphology of Section 7.

Section 11 (beginning at 7'16", labeled Morphological Type F in Table 1) contains another fantastic-appearing image. This section is remarkable in that it contains a relatively balanced mixture of horizontal and curved arcs. A briefer variant of the general morphology of Section 11 appears in Section 12 (beginning at 8'15", labeled Morphological Type F' in Table 1), which consists entirely of horizontal arcs. While Section 11 extends over the entire register, Section 12 is more compact and ends on a single pitch, at approximately C#3.

As mentioned previously, Section 13 (beginning at 8'35") is a temporally augmented repetition of Section 7. It thus provides a degree of closure by referring back to material from the beginning of Part II. The closure it provides is even more marked than that provided by the return of clustered arcs at the end of Section 6 in Part I, in two respects: (1) it repeats an entire section, not merely a texture associated with that section; and (2) its longer duration provides a structural "ritardando" that helps to dissipate the energy of the music in preparation for the work's approaching conclusion.

To summarize, Part II consists of two sequences of three sections, each of which is initiated by a version of morphological type D, followed by the introduction of a new morphological type and a variant of it. The second sequence is rounded out by a final variant of D material. The sequence of morphological types in Part II may thus be symbolized as D E E' D' F F' D".

PART II: TEMPORAL STRUCTURE

The temporal structure of Part II is simpler than that of Part I, but it has some complexities of its own. Its first subdivision, consisting of Sections 7–9, contains two approximately one-minute sections (8 and 9) and one section (7) that is 2:5 of a minute in duration. Its second subdivision, consisting of Sections 10–13, contains three approximately one-minute sections (10, 11, and 13) and one section (12) whose duration is 1:3 of a minute. Analysis of the relations among the sections within these subdivisions is straightforward, but the use of different subunits of one minute in each section complicates the analysis of relations between the subdivisions as well as between the subdivisions and Part II as a whole.

FIG. 4 shows the relations among the sections in the first subdivision of Part II. The duration of Section 7 is 24 seconds, which is 2:5 of one minute. The relation of the duration of Section 8 (59 seconds) to Section 7 is approximately 5:2, as shown in the figure. The relation of the duration of Section 9 (60 seconds) to the combined duration of the previous two sections (83 seconds) is approximately 5:7. The decimal approximation of 5:7 is .72, which is slightly larger than the decimal approximation of the simpler ratio 2:3 (.67). Because of the relatively close approximation of 2:3 to 5:7, the simpler of the two ratios has been substituted for the more complex one in Figure 4.

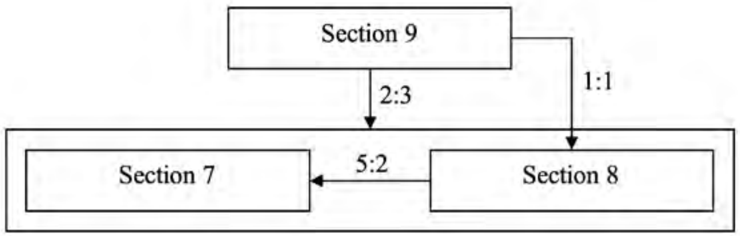


FIG. 4 Relations among durations in Sections 7–9 of *Mycènes Alpha*

Sections 10–13 present a different challenge to the representation of the relations among its sections. In order to diagram the relations among the sections in a way that may be compared easily with the previous diagrams, it is necessary to pair two of the sections together in order to present the sections as three entities rather than four. Since the sequence of morphological types in Sections 7–9 is D E E', it makes the most sense to preserve the idea of separating the first D-type section (10) from the first section of a different type (11, type F) and to separate this section, in turn, from its varied repetition (Section 12). Section 12, at 20 seconds, is the briefest of the sections in this subdivision. Since Sections 11 and 13 are of approximately equal duration, Section 12 could be paired with either of them while still preserving a relative sense of durational balance among the three entities in the diagram. Pairing it with Section 13, however, has the advantage of more firmly integrating the final, rounding section into the main body of the second subdivision of Part II. For these reasons, the diagram in **FIG. 5** shows the relations among Sections 10, 11, and 12–13.

A comparison of Figures 4 and 5 reveals some similarities in the internal organization of the subdivisions of Part II. The relation between Section 9 and the combination of Sections 7 and 8, expressed as the ratio 2:3 in Figure 4, recurs as the relation between Sections 12–13 and the combination of Sections 10 and 11 in Figure 5. The 1:1 ratio, expressing the relation between Sections 9 and 8 in Figure 4, recurs between Sections 11 and 10 in Figure 5.

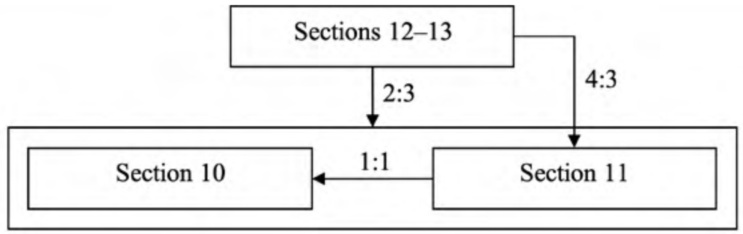


FIG. 5 Relations among durations in Sections 10–3 of *Mycènes Alpha*

The relations between Part II and its subdivisions may also be expressed in ratios that have been seen previously. The ratio of 5:2 in **FIG. 6**, between Part II as a whole and Sections 7–9, is the same as that between Sections 8 and 7 in Figure 5. The ratio of 3:2, between Sections 10–13 and 7–9 in Figure 6, is the inverse of the 2:3 that appears in both Figures 4 and 5 and recalls the 3:2 between Sections 3 and 2 in Figure 1.

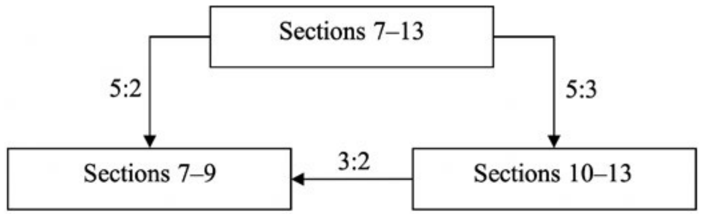


FIG. 6 Relations among groups of Sections in Part II of *Mycènes Alpha*

TEMPORAL STRUCTURE: GLOBAL PERSPECTIVES

Until now the discussion of temporal structure has been limited to relations within the two parts of *Mycènes Alpha*. In this final section on temporal structure, some aspects of the work's overall temporal structure will be explored. Each new perspective that is introduced will be referred to one or more of the networks of temporal structures that has been introduced previously. The resulting correspondences between levels of the temporal structure of *Mycènes Alpha* suggest possible strategies for listening in which different aspects of the work may be kept in mind on successive hearings, thus allowing the listener to experience multiple dimensions of the work's overall structural design.

FIG. 7 shows the relations between the whole of *Mycènes Alpha* and each of its parts, and between the parts themselves. Remarkably, these relations are identical to those within Part II itself, as shown in Figure 6. The identity of the structures at these two levels reveals a depth to the work's temporal structure that may or may not have been intentional on the composer's part. As Xenakis said in an interview with Bálint András Varga: "Musicologists may analyze scores and come up with their conclusions—and they may be perfectly right—but their findings need not indicate anything conscious on my part."[9] In this case, it is reasonable to conjecture that the correspondence between these levels of the temporal structure may have resulted from the use of systems of proportions such as those proposed here. Alternatively, it may have grown intuitively out of a feeling for proportional balance between whole and parts that would have developed from decades of experience in generating musical and architectural structures.

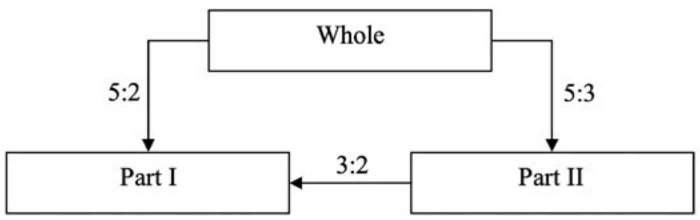


FIG. 7 Relations of Whole and Parts in *Mycènes Alpha*

There is also a sense of formal balance that is articulated by the distribution of registers and arc orientations among the sections of *Mycènes Alpha*. Eight out of the thirteen sections make use of relatively unrestricted registral space, while five sections are more restricted in their use of register (see **TABLE 1**). The division of the 13 sections into 5 + 8 according to use of register is a division according to integers from the Fibonacci series. When the durations of the sections in this division are taken into account, the total duration of each group of sections results in a by-now-familiar pattern of ratios. This is illustrated in **FIG. 8**. A similar pattern occurs when arc orientations are used as a means for dividing the sections into groups and the durations of these groups are compared to the duration of the whole work. This is illustrated in **FIG. 9**.

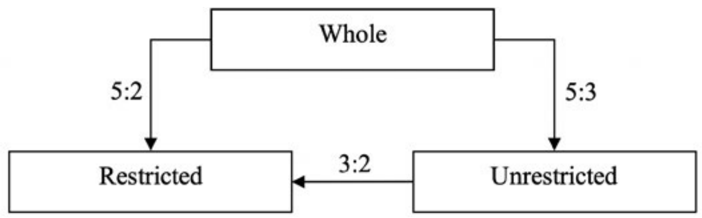


FIG. 8 Grouping of Sections according to use of registral space

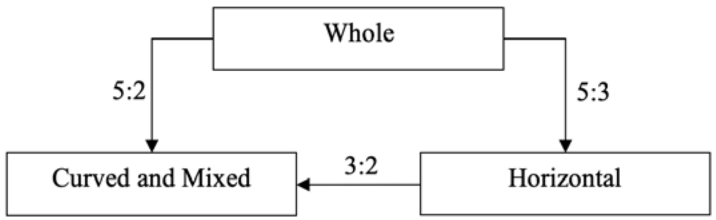


FIG. 9 Grouping of Sections according to arc orientation

Finally, there is a global division of the work according to the golden section, whose decimal approximation to three places is 0.618. As was mentioned during the discussion of morphological types in Part I, an ascending cluster begins to accumulate at about 10 seconds or so before the conclusion of Section 6. Within the context of the work's overall form, this point—which is within the vicinity of 3'40" into the work—occurs at its negative golden section, i.e., 1 – 0.618 = 0.382. It thus divides the work into a smaller portion followed by a larger portion, with the division occurring according to the golden section.

CONCLUSION

Mycènes Alpha is an adventurous foray into the previously uncharted territory of wholly graphic electroacoustic composition. Its use of varied repetition, together with its economical use of proportional structures — nested at different structural levels and observable from different structural perspectives—reveals it to be a very disciplined and highly structured foray as well. Whether or not the composer arrived at the structural features described above through conscious effort, intuition, or some mysterious combination of the two, the structure of this and many other works by Xenakis reveals a persistent concern with the value of time, including the listener's time. Time in Xenakis's music is not a space in which the composer seeks to explore as if aimlessly. Rather, it is a crucible for the focusing of energy, a place in which to offer the listener a concentration and intensity of experience that is difficult to find in the work of many other composers.

FOOTNOTES

1. For recordings, see *Electro Acoustic Music: Classic*s. Neuma Records CD 450–74 (1990) and *CCMIX Paris*. Mode Records CD 98/99 (2001). The graphic score has been published in Iannis Xenakis, "*Mycenae Alpha* 1978," in *Perspectives of New Music* 25, no. 1/2 (1987), 12–15; in the booklet accompanying *Electro Acoustic Music: Classics*; and in Sharon Kanach, "The *Polytope de Mycènes* 1978," in *Iannis Xenakis*, *Music and Architecture*, ed. Sharon Kanach (Hillsdale, NY: Pendragon Press, 2008), 232–38, here 236–38. A scrolling video of the graphic score with audio is available at http://www.centre-iannis-xenakis.org/items/show/668.

2. Xenakis, *Music and Architecture*, 241–43.

3. James Harley, "The Electroacoustic Music of Iannis Xenakis," in *Computer Music Journal* 26, no. 1 (2002), 33–57, here 51.

4. For technical descriptions of later versions of the UPIC, see Henning Lohner, "The UPIC System: A User's Report," in *Computer Music Journal* 10, no. 4 (1986), 42–49; Iannis Xenakis, "Appendix III: The New UPIC System," in *Iannis Xenakis*, *Formalized Music*, ed. Sharon Kanach (Stuyvesant, NY: Pendragon Press, 1992), 329–34; Gérard Marino et al., "The UPIC System: Origins and Innovations", in *Perspectives of New Music* 31, no. 1 (1993), 258–69 and Sharon Kanach, "Appendix A: The UPIC System," in *Xenakis*, *Music and Architecture*, 280–85.

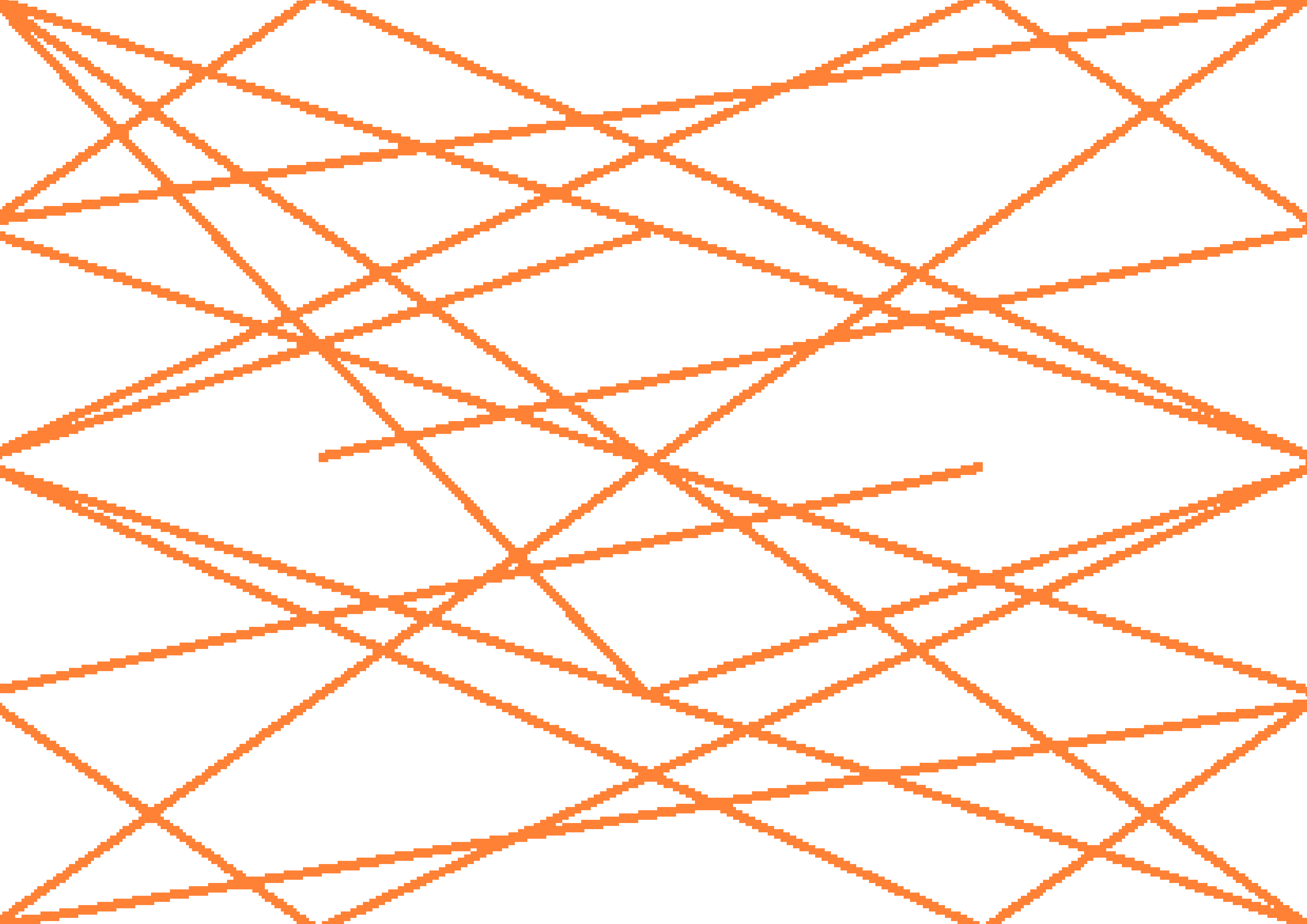
5. The start time for Section 1 corresponds to the onset of the work's first sounds, following any leading silence that may have been edited into a given recording. On *Electro Acoustic Music: Classics* the duration of the leading silence is 0.5"; on *CCMIX Paris* it is 4"; and at http://www.centre-iannis-xenakis.org/items/show/668 it is 13". All of the published graphic scores give the timing for the beginning of Section 2 as 55": this should be changed to 17", which may be verified via playback software or by using a sound editor (such as Audacity). The 55" mark belongs at the beginning of Section 3.

6. The graphic score shows that the registral space in *Mycènes Alpha* extends over five octaves, from C1 to C6, in which A3 corresponds to 440 Hz.

7. For general introductions to the arborescence as a morphological category in Xenakis's music, see Bálint András Varga, *Conversations with Iannis Xenakis* (London: Faber and Faber, 1996), 88–91; James Harley, *Xenakis*: *His Life in Music* (New York: Routledge, 2004), 71–88; Nouritza Matossian, *Xenakis*, rev. ed (Lefkosia: Moufflon, 2005), 278–86; and Benoît Gibson, *The Instrumental Music of Iannis Xenakis: Theory, Practice, Self-Borrowing* (Hillsdale, NY: Pendragon Press, 2011), 138–50.

8. The sense that this gesture signals the recall of material heard previously may have led James Harley to regard it as a separate section, even though the graphic score does not indicate a section break at this point. He divides *Mycènes Alpha* into fourteen sections rather than the thirteen that are identified here. See Harley, "The Electroacoustic Music of Iannis Xenakis," 51 and Harley, *Xenakis: His Life in Music*, 115.

9. Bálint Andràs Varga, *Conversations with Iannis Xenakis*, 2003, 204.



ANALYTICAL APPROACHES TO TAURHIPHANIE AND VOYAGE ABSOLU DES UNARI VERS ANDROMÈDE BY IANNIS XENAKIS

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INTRODUCTION

Iannis Xenakis's electroacoustic work represents only a small percentage of his musical production. However, as Makis Solomos points out, these fourteen works represent real milestones, "masterpieces of absolute originality and innovation"[1] in the history of electroacoustic music. But, beyond this often-emphasized originality, Iannis Xenakis seems also to have provided a true model for music research. By transposing the methods of scientific research into the field of artistic creation, he created a new discipline that combines the logic of mathematics, the empiricism of computer sciences, and the creativity of arts.

It is standard practice to classify the composer's electroacoustic production into three time periods:[2]

1. Works from the 1950s and 1960s representing the production carried out by or under the influence of the Groupe de Recherches Musicales (GRM).
2. The "climax of the early 1970s" with the realization of *Polytopes* between 1967 and 1978.
3. The works of the late 1980s composed with the UPIC.[3]

The analytical research of this chapter concerns this last period and focuses on two emblematic works, rarely presented and analyzed: *Taurhiphanie* (1987) and the *Voyage absolu des Unari vers Andromède* (1989). It is difficult to find sources,[4] and there is a very important difference between concert versions and those released on CD, but the technical context of their production or the surprising strangeness of their sound and musical rendering make it an exciting field of research for the musicologist. I will show that these characteristics are obviously strongly linked to the UPIC, the instrument on which Xenakis worked both as a designer and as a user for the composition of these works.

Analyzing an electroacoustic work presents several difficulties, such as the lack of visual support (score, transcription, or other), the study of the complexity of materials, and the predominance of nonrepetitive, evolutive forms. To solve these difficulties, I will use acoustic analysis and visualization techniques already proven in my previous publications.[5] After introducing some background information on the UPIC and the few sources that exist on the creation of these two works, I will develop the essential points for understanding the analytical method, and then I will present the first results of the comparative study.[6]

CONTEXTS THE UPIC SYSTEM

For a detailed presentation of the UPIC, I invite the reader to consult three seminal papers: the article by Gérard Marino, Marie-Hélène Serra, and Jean-Michel Raczinski which focuses on a description of the functional aspects of the instrument;[7] the introduction to drawing techniques and their sound rendering by Iannis Xenakis;[8] and the article by Rodolphe Bourotte and Cyrille Delhaye with a perspective on the UPIC and its uses in education and with other technologies.[9] In the history of computer music, which usually begins with the MUSIC software, the first version of which was released in 1957,[10] or the development of digital instruments from the 1970s, the UPIC appears to be one of the most important tools. Indeed, although its use remained rather confidential, limited to a certain number of studios, its concept, based on converting a drawing into a synthesis sound,[11] has inspired many developers. The pedagogic[12] and artistic potential of image conversion into sound makes this instrument so powerful.[13]

The first versions of the UPIC[14] were not in real time,[15] which made it a composition tool for studio use. The first real-time version of 1987 allowed some form of interaction and could therefore be used live, in concert. The UPIC appears to be a very innovative instrument, combining composition functions, a graphical user interface that was easy to use by composers or even children, and a live performance capability using a gestural interface.[16] These characteristics prefigured current music creation software. By comparison, the other two main tools developed in the 1970s and 1980s in Paris, namely, the 4X[17] at IRCAM and SYTER[18] at GRM, were essentially sound transformation tools which could be used as well for mixed works that combined acoustic instruments with electronic sounds.

These few technical details about the instrument itself are also related to sound rendering. The UPIC differed from other technologies of the time. As James Harley[19] and Makis Solomos point out in their discussion of *Pour la Paix,*[20] the sounds produced by the UPIC may seem harsh because the composer does not try to smooth out the result. This remark obviously echoes other works by Xenakis, such as *Bohor,* composed in 1962.

CREATION OF THE WORKS

I have chosen to analyze *Taurhiphanie* and *Voyage absolu des Unari vers Andromède* by Xenakis for several reasons. The first is that they were composed two years apart, in 1987 and 1989. Being electroacoustic works, they were both composed on the UPIC system. Another reason is that they share the same process of creation and publication: the recordings released on CD are very different from their performance in concert. Finally, there are very few sources that allow us to understand the composition process used by the composer. *Taurhiphanie* and the *Voyage absolu des Unari vers Andromède,* therefore, appear to be ideal for comparative analysis. However, this chapter is not a reference analysis, but rather proposes a few guidelines to understand the aesthetic issues that these two works represent.

Taurhiphanie was premiered on July 13, 1987, at the Arles arena during the Radio France Festival in Montpellier. The performance combined electronic music and a peaceful demonstration of bulls and horses from the Camargue region. The concert also included a performance of *Les Pléïades* (1978) and *Psapha* (1975) by Les Percussions de Strasbourg and the Ensemble Pléïades conducted by Silvio Gualda.

The set FIG. 1 consisted of a circular raised stage in the middle of the arena on which the UPIC was installed and around which the animals circled. The work included fixed and improvised parts from sixty fragments manipulated in real time by playback with variation of sequences and by effects such as freezing[21] or reverse. In the original concept, the bulls were to be equipped with high frequency (HF) microphones to capture their breathing; the UPIC would then also have been used to manipulate these sounds in real time. It turned out that the lack of rehearsal time and the movement of animals, which was difficult to control because of the intensity of the sounds diffused, led Xenakis to use prerecorded live sound playback.[22] The performance did not have the expected success.

In 1988, Iannis Xenakis produced a stereophonic version for four loudspeakers containing only the fixed parts. The work was released on CD in 1994.

As James Harley points out,[23] *Taurhiphanie* differs from *Mycènes Alpha*, also composed on the UPIC, in the continuity of its transformations and its formal construction.

The sources used for the analysis include a score and audio recordings as shown in the table below.[24]

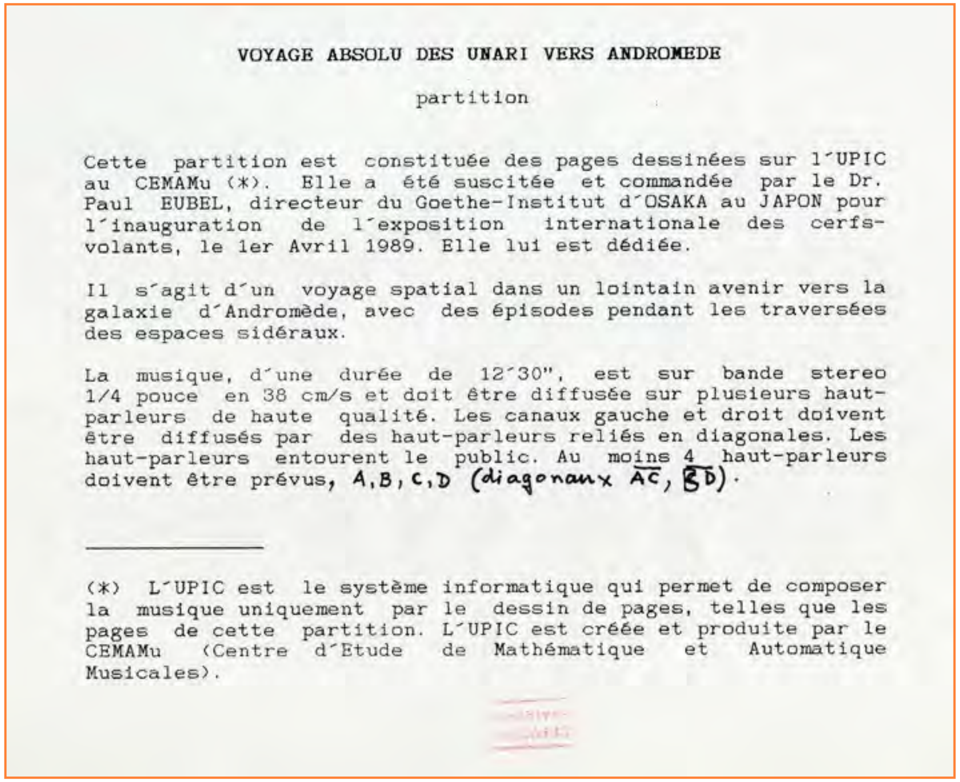
TYPE	SOURCE	DURATION	INFORMATION
26 Photos	IXF		Taken before and during the concert
Text	IXF		Publisher's tape notice
Drawing	CIX		Tape structure with start of improvisation
Printed matter	CIX		Page 30 of the score (unreadable)
Audio	CD	10'53"	CD edition[25] – stereophonic
Digitized audio tape	BNF	3'41"	Inscribed: "mounted bulls sequence tape" (in English) – monophonic – June 28, 1987 This may be the tape used during the concert to replace the real-time recording of the bulls.
Digitized audio tape	BNF	6'45"	With a mention of "Right track. Non-final version. Ready for editing with amorces and mixing" (in French) – monophonic – July 13, 1988 Contains three sequences that are also on the CD version.
Digitized audio tape	BNF	8'08"	With a mention of "Left track. Non-final version. Ready for editing with amorces and mixing" (in French) – monophonic – July 13, 1988 Contains three sequences that are also on the CD version.

The *Voyage absolu des Unari vers Andromède* was premiered on April 1 1989 at the Kamejama Honyokuji Temple as part of the International Kite Exhibition organized by the Goethe-Institut in Osaka, Japan. It was premiered in France a few months later during the Festival d'Avignon in the main courtyard of the Palais des Papes in a program that also included *Rebonds A* and *B*, *Idmen A* and *B*, as well as improvisations by Michel Portal and Bernard Lubat. The title, *Voyage absolu des Unari vers Andromède,* refers to traditional Japanese unari kite bows, simple one-string aeolian instruments which produce a sound arch vibrating in the wind that resembles the chirping of insects.

As with *Taurhiphanie*, the sources used for the analysis include a score and audio recordings as shown in the following table.

Unlike Taurhiphanie, the UPIC "score" of Voyage absolu was an invaluable help in understanding some aspects of Xenakis's creative process.

FIG. 1 Iannis Xenakis, *Taurhiphanie*, 1987, during the performance at the Arles arena
© Iannis Xenakis Family


VOYAGE ABSOLU DES UNARI VERS ANDROMEDE

partition

Cette partition est constituée des pages dessinées sur l´UPIC au CEMAMu (*). Elle a été suscitée et commandée par le Dr. Paul EUBEL, directeur du Goethe-Institut d´OSAKA au JAPON pour l´inauguration de l´exposition internationale des cerfs-volants, le 1er Avril 1989. Elle lui est dédiée.

Il s´agit d´un voyage spatial dans un lointain avenir vers la galaxie d´Andromède, avec des épisodes pendant les traversées des espaces sidéraux.

La musique, d´une durée de 12´30", est sur bande stereo 1/4 pouce en 38 cm/s et doit être diffusée sur plusieurs haut-parleurs de haute qualité. Les canaux gauche et droit doivent être diffusés par des haut-parleurs reliés en diagonales. Les haut-parleurs entourent le public. Au moins 4 haut-parleurs doivent être prévus, A,B,C,D (diagonaux AC, BD).

(*) L´UPIC est le système informatique qui permet de composer la musique uniquement par le dessin de pages, telles que les pages de cette partition. L´UPIC est créée et produite par le CEMAMu (Centre d´Etude de Mathématique et Automatique Musicales).

FIG. 2 Iannis Xenakis, *Voyage absolu des Unari vers Andromède*, score, 1989

TYPE	SOURCE	DURATION	INFORMATION
Score (15 pages)	IXF		A notice **FIG. 2** and 12 pages of the drawing realized on the UPIC (pages: 61, 62, 30, 35, 36, 34, 33, 33, 38, 9, 31, 32, 66[26])
Audio	CD	15'29"	CD edition[27] – stereophonic
Digitized audio tape	BNF	12'49"	With a mention of "A version" (in French) – stereophonic
Digitized audio tape	BNF	12'39"	With a mention of "Demo examples" (in French) – stereophonic Contains examples from the UPIC and a long extract from *Taurhiphanie*

THE ANALYSIS METHOD

Both works are perfectly adapted to the methods of analysis that I usually use on acousmatic music.[28] These are works on magnetic tape and whose sources contain only fragmentary parts of the UPIC score. It was therefore necessary to use other types of graphic supports for this study. As the works are very close in time to each other, and also in terms of the tools used and the compositional approach used for CD publishing (sources of the creation are recomposed in the studio), a comparative analysis is completely justified and makes it possible to show how Xenakis made different compositional and aesthetic choices from fairly similar material.

As I mentioned briefly in the introduction, analyzing a fixed work is quite difficult. I have already presented and analyzed in detail the problem of the lack of visual support in several of my publications.[5] For the analysis of the two works in this article, I used spectral representation and audio descriptor extraction techniques to create visualizations that decomposed the sound textures into musical gestures and, in the case of the *Voyage absolu des Unari vers Andromède*, contextualized the fragments of the score.

The techniques of audio descriptor extraction from the audio signal used here have already been described in detail in an analysis of an extract from *Son Vitesse-Lumière*[29] by François Bayle.[30] To summarize: a set of audio descriptors[31] are extracted, either directly from the signal or through spectral analysis achieved with a fast Fourier transform (FFT) algorithm.[32] A representation (visualization) is then made to allow the data to be read.[33]

The visualization part is essential because it is the source of the interpretation that the musicologist will use to make the analysis. I used four visualization techniques that are particularly efficient for musical analysis:

1. The simple graph (morphology identification) or the superposition of curves (correlation identification between values);
2. The flow graph or Brightness, Standard Deviation graph (BStD)[34] (see **FIG. 3.1**), allowing to visualize an estimation of the evolution of the timbre through 3 descriptors. This graph is particularly efficient for the analysis of electroacoustic music by facilitating the interpretation of correlations between descriptors;
3. The linear or logarithmic sonogram;
4. The self-similarity matrix (see **FIG. 3.2**) representing the similarity between values[35] (identification of musical structure or form). **FIG. 3**

As shown in Figure 3.2, the self-similarity matrix is realized in three steps:

1. The creation of the table[36] and the distance computation. The values to be calculated appear on the x-axis and y-axis of the table.
2. The mapping of numerical value results into grayscales (mapping) making the table easier to interpret.
3. In this article, I use color matrices, so the third step is to apply a false color filter.[37]

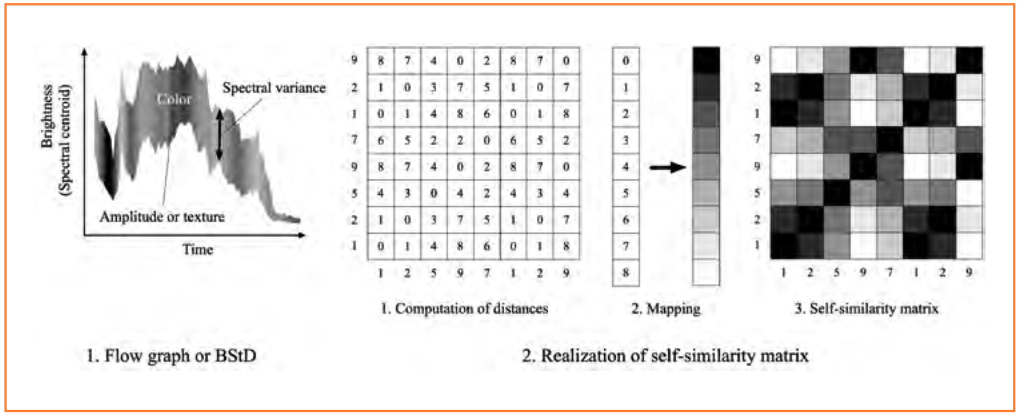
These representation techniques are classified into three categories:

1. What I call macroscopies[38] allowing visualization of the entire work while keeping a view of the complexity of the short structures;
2. Correlation analysis at several hierarchy levels in order to identify the links between the variation of several descriptors;
3. Analysis of internal or external morphologies, both localized or around a focal point.

This representation method has the advantage of allowing analysis without selecting an observation level first. In addition, it also offers the possibility of studying both sound and musical phenomena located on one or more dimensions or that have rather fuzzy borders and are strongly dependent on perception. In this sense, even if I rely heavily on techniques of signal analysis from acoustics or visualizations from the hard sciences, the object observed is not a laboratory sample like an isolated fragment, but the work itself. These researches are naturally in a systemic or complexity[39] study direction, which seems to me to be the only way to study this type of musical work.

COMPARATIVE ANALYSIS

The presentation of these first analytical results is organized in three parts: forms and segmentations, gestures, and the poles of *continuous–discontinuous*. However, they do not correspond to the stages of the analysis and could just as easily have been presented in a different order.



FIGS. 3.1, 3.2 Techniques for producing a flow graph (1) and a self-similarity matrix (2), 2019 © Pierre Couprie

FORMS AND SEGMENTATIONS

FIG. 4 represents a self-similarity matrix computed on the zero crossing rate (ZCR) of the *Taurhiphanie*'s waveforms. This representation provides a good estimation of the whole form of the work. Vertical band reading can be used to segment the shape into three large parts or eight more detailed parts. In addition, the central part offers a strong contrast with the other parts of the work by being similar to itself (colors close to yellow and red), but not to what comes before or after (purple color indicating a low similarity).

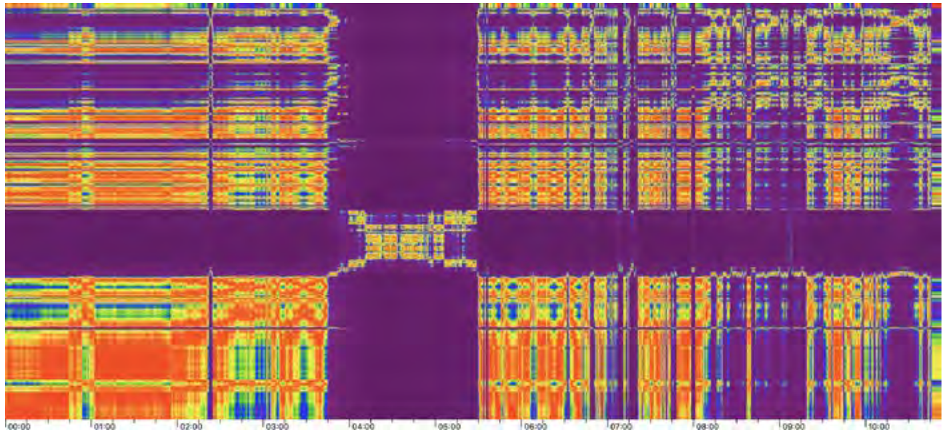
This representation also provides two other important formal clues. The first concerns the duration of the parts. Xenakis seems to have organized the material into fairly long ranges with constant evolution and only a few breaks. The second clue concerns the transitions between each of the parts, which seem quite distinct, thus separating them into well-defined blocks.

FIGS. 5, 6 illustrate the most salient transformation processes and transitions:

1. Transition between two parts including silence.
2. Transition by very short crossfade.
3. Accentuation by amplitude modification or spectrum densification.
4. Long morphological gesture.
5. Coloration by modification of the spectral centroid.
6. Destructuring a material by altering a dimension such as amplitude or spectrum.
7. Tightening of the spectrum.

These two representations are created from three audio descriptors[40] in a single graph. Correlations between several elements of the curve—for example, y and width—and significant changes—for example in figures 4 and 6—highlight salient elements of the spectrum evolution. On all the graphs, there is no real break and this evolution appears to be rather continuous. Also, the two forms do not have repetitions; each part allows to cross a step in a continuous evolution of the sound material, a morphological form.[41]

James Harley proposes a two-part form segmentation of the *Voyage absolu des Unari vers Andromède*.[42] **FIG. 7** shows this segmentation as well as the one derived from a two-level listening analysis. These segmentations are compared here with two complementary self-similarity matrices calculated on the FFT and on three audio descriptors root mean square (RMS) amplitude, spectral centroid, and spectral variance. These figures highlight strong similarities between the two works in terms of form construction:



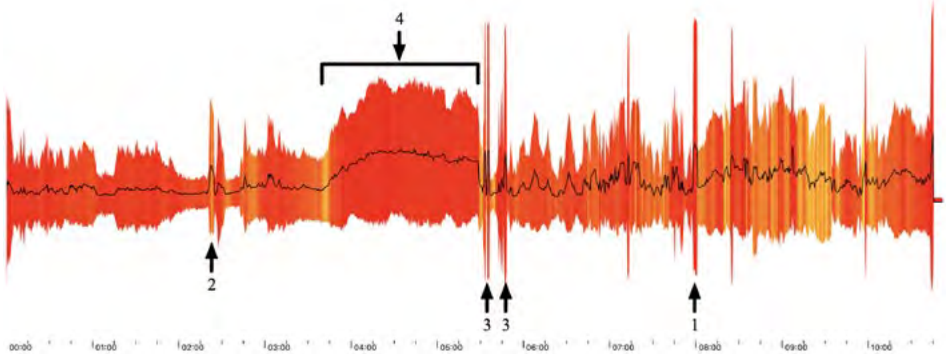
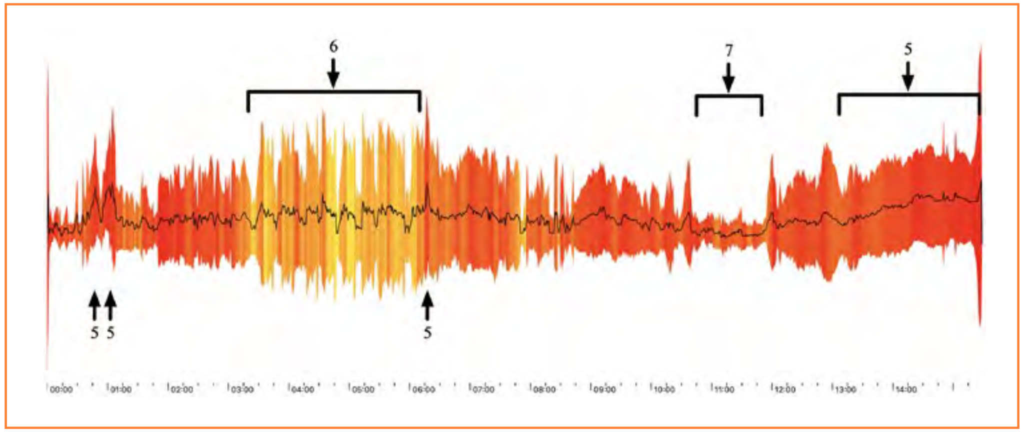


FIG. 4 Self-similarity matrix of Iannis Xenakis's *Taurhiphanie*, 1994, computed on the ZCR descriptor in software iAnalyse, 2019, screenshot © Pierre Couprie

FIG. 5 Four examples of transformation processes from a BStD representation of Iannis Xenakis's *Taurhiphanie*, 1994, produced with software iAnalyse, 2019, screenshot © Pierre Couprie



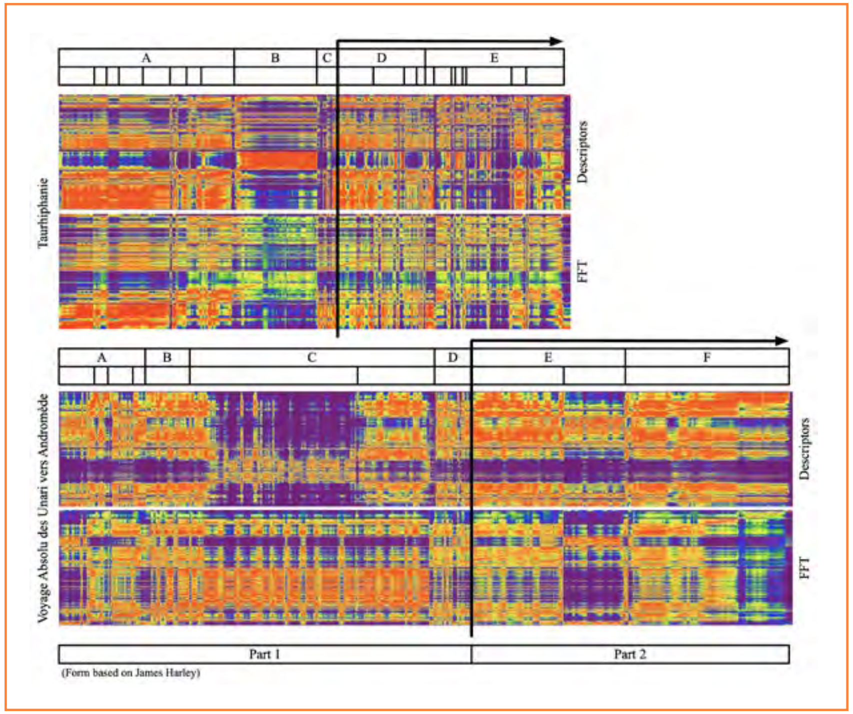


FIG. 6 Three examples of transformation or transition processes from a BStD representation of Iannis Xenakis's Voyage absolu des *Unari vers Andromède*, 1987, produced with software iAnalyse, 2019, screenshot © Pierre Couprie

FIG. 7 The form and comparison between FFT and the audio descriptors as selfsimilarity matrices, produced with software iAnalyse, 2019, screenshot © Pierre Couprie

- An overall division into two parts (indicated by a wide line and an arrow), the second part can itself be subdivided into two other parts.
- The presence of a long part (A in *Taurhiphanie* and C in *Voyage absolu…*) built on a continuous evolution of the sound material.
- The presence of short parts (C in *Taurhiphanie*) and B, D in *Voyage absolu…*) whose duration contrasts strongly with the other parts.

These two works, therefore, appear to be linked in terms of structure while at the same time being the result of very different compositional strategies. However, the form alone is not sufficient for comparative analysis. I will now show how the morphogeneses or gestures[43] used by Xenakis also play a very important role in the transitions and in the characterization of the subparts.

GESTURES: FROM THE UPIC TO SOUND REALIZATION

As mentioned above, I had access to the score of the *Voyage absolu des Unari vers Andromède*. This consists of twelve drawings on the UPIC.[44] Considering the numeration of the pages divided between 9 and 60, it is likely that it is only a fragment of the complete score. In addition, pages 32 and 60 are identical and there appear to be only two original drawings (page 32 and 34), the others being variations of page 32. The second original drawing (page 34) did not result in any variations. Figure 8 provides a hypothesis on the realization of these variations. We can see that Iannis Xenakis worked mainly from variations by rotation[45] and by assembling the same multiplied form (as in pages 9, 30, 38 and in the ones that follow). Finally, few drawings are directly visible and perceptible in the spectrum computed from the CD version. **FIG. 9** shows the spectrum (top) and a schema (bottom) containing the locations of the actual drawings.[46] I have named A and B the two forms that appear clearly on the spectrum as probably having their origin in a UPIC drawing, but they are not present in the score. Similarly, the fragment 9b comes from page 9, but there is a montage of two additional iterations compared to the original form. The only appearance of page 34 (noted 34b) at 12:03 is, for its part, greatly modified by the effects of multiplication and time stretching.

What is observable in this work is unfortunately not observable in *Taurhiphanie*. Indeed, if the score exists, it has not yet been digitized, and the fragility of the originals have not yet allowed me to work on the identification in the CD version of the shapes drawn on the UPIC. Nevertheless, some of the shapes visible on the spectrum probably come from materials drawn on the UPIC, their appearance being very similar to those used in the *Voyage absolu des Unari vers Andromède*. While listening to the digitized tapes at the Bibliothèque Nationale de France (BNF), I realized that the waveforms used in the UPIC probably all come from recordings of bulls' roars. In addition, the very short morphologies in glissandi, such a as at 2'22", 5'34", between 6'55" and 7'58", or at the end of 8'35" are very similar to some of the roars present on the sound recording tape available at the BNF.

The CD production of these pieces, therefore, appears as a composition in its own right, based on materials partly made on the UPIC. Both of the two pieces can be decomposed to analyze how Iannis Xenakis managed the transitions between materials and the progressive changes in textures.

CONTINUOUS AND DISCONTINUOUS: TRANSFORMATIONS AND TRANSITIONS

In my analysis, I highlighted the composition of the two works as an assembling of several sequences, some of which use materials from drawings on the UPIC. However, during the listening, the editing aspect does not really appear and an impression of moments would be more accurate. Each of them has its own written logic and all these moments follow one another without any real break. This first form of continuity is particularly visible on the complete logarithmic spectrum of each piece. **FIG. 10**

In *Taurhiphanie*, except for the central break between 3:48 and 5:28,[47] the spectrum shows continuity on two types of materials:

1. 0'00"–3'45": A material with a very rich spectrum.
2. 5'15"–End: A rather harmonic set of sounds.

In the *Voyage Absolu des Unari vers Andromède*, the logarithmic spectrum highlights the crossfade transitions chained between three types of sound materials:

1. 0'00"–3'00": material with a rather clear spectrum.
2. 3'00"–8'00": A very rich and dense sound material.
3. 8'00"–End: A set of sounds whose spectral sites are quite narrow.

In the second work, the crossfade transitions between the three types of materials are very evident. These transitions between the main parts also operate at a finer level. Listening to and viewing the sonograms reveals that both works were composed as a montage of several sections on several levels. If Iannis Xenakis uses the crossfade between the large parts, he varies the transitions of shorter sound materials (see **FIG. 11**):

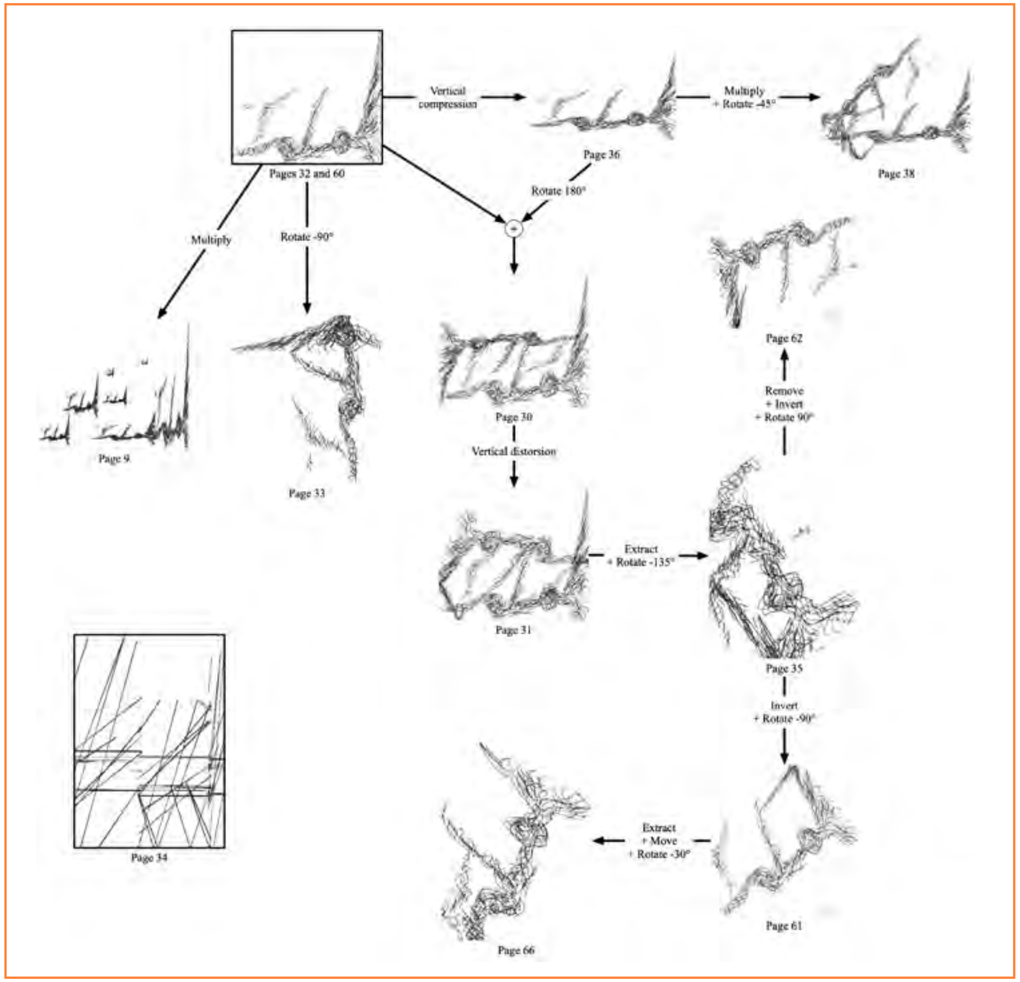
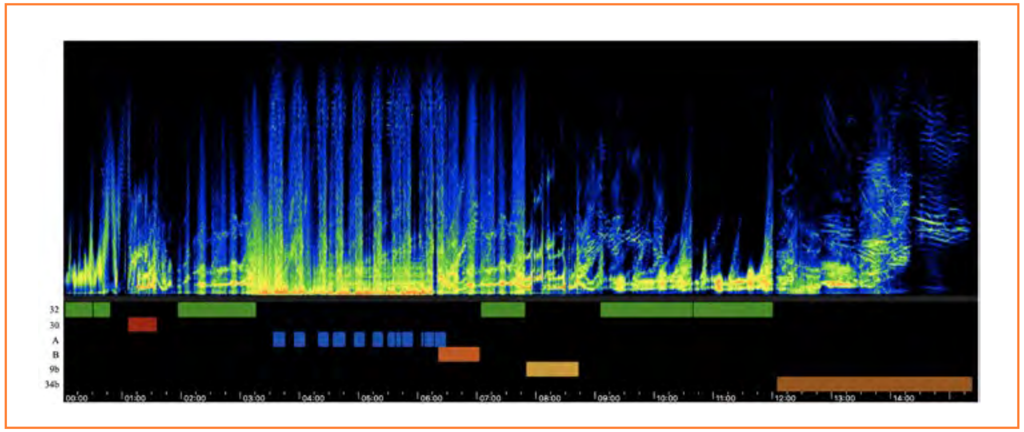
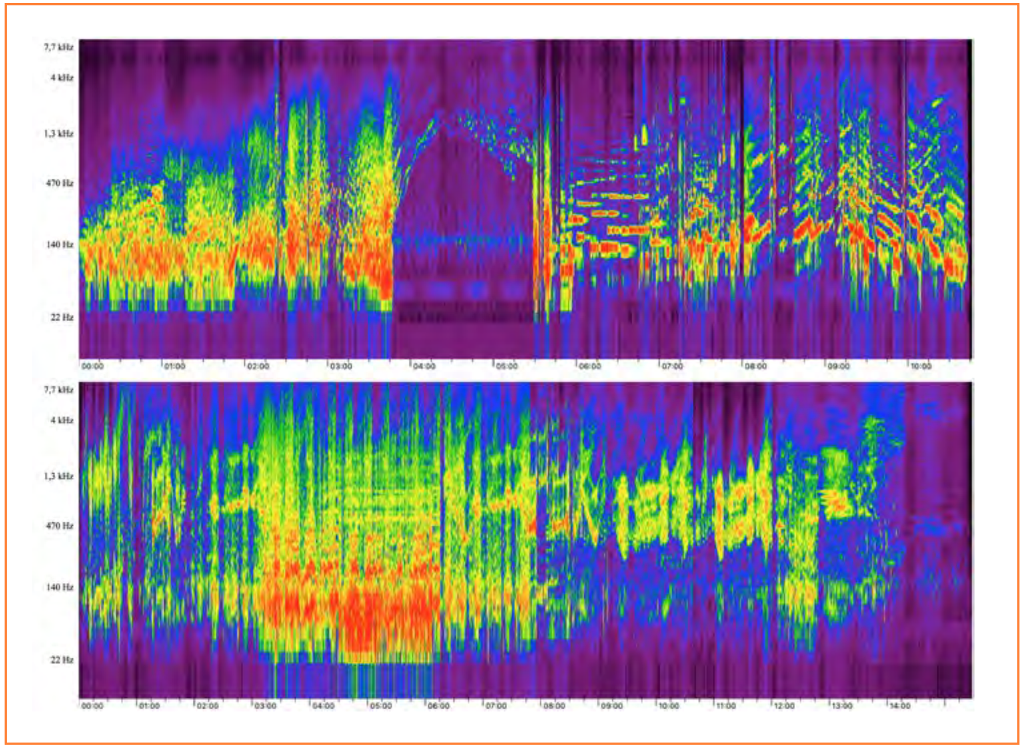
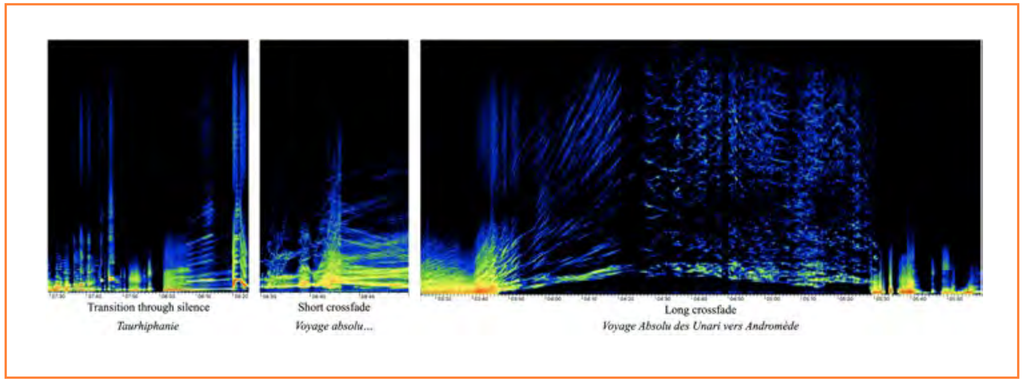


FIG. 8 Hypothesis of the genesis of the score pages from two original shapes (framed) of Iannis Xenakis's *Voyage absolu des Unari vers Andromède*, 1987 © Pierre Couprie







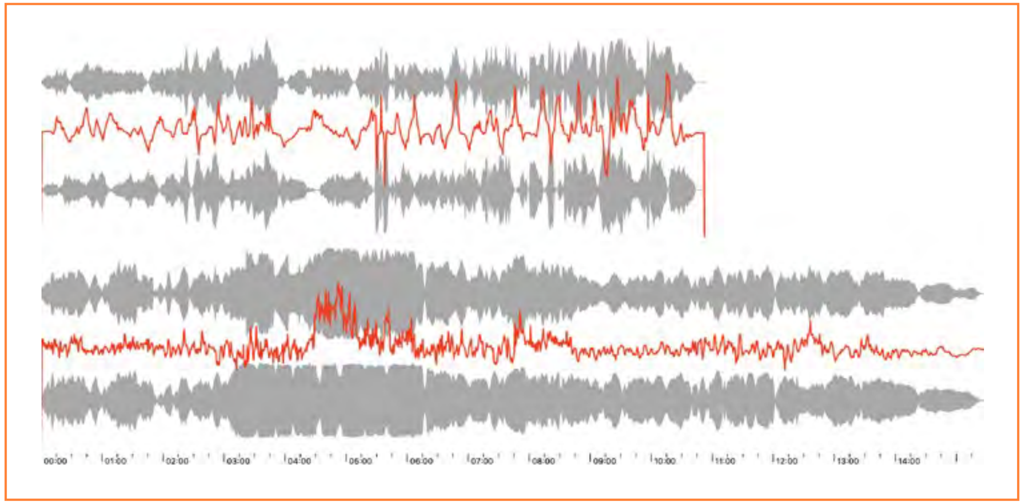


FIG. 9 Time location of the score pages of Iannis Xenakis's *Voyage absolu des Unari vers Andromède*, 1987, produced with software iAnalyse, 2019, screenshot. A, B, are missing gestures in the score and 9b and 34b are variations of pages 9 and 34. © Pierre Couprie

FIG. 10 Logarithmic spectrums of Iannis Xenakis's *Taurhiphanie*, 1994 (top) and *Voyage absolu des Unari vers Andromède*, 1987 (bottom), produced with software iAnalyse, 2019, screenshot © Pierre Couprie

FIG. 11 Examples of transitions by crossfading or by a silence in Iannis Xenakis's *Taurhiphanie*, 1994, produced with software iAnalyse, 2019, screenshot © Pierre Couprie

FIG. 12 Comparison of Iannis Xenakis's *Taurhiphanie*, 1994 (top) and *Voyage absolu des Unari vers Andromède's*, 1987 (bottom) waveform and deviation between the RMS amplitudes of the two channels in red, produced with software iAnalyse, 2019, screenshot © Pierre Couprie

1. Via a very short silence (1.2 seconds at most) present only in *Taurhiphanie*.
2. By using a very short crossfade.
3. By using long crossfades or progressive transformations of the material. **FIG. 11**

Taurhiphanie, Iannis Xenakis, examples of transitions by crossfading These transitions, both in large parts and shorter structures, create great continuity in the evolution of form. However, both works also have forms of discontinuities that are revealed in the balance between the two channels. Iannis Xenakis systematized a strong stereophonic oscillation of the material. **FIG. 12** shows the waveforms and a deviation curve of the RMS amplitude[48] in red.

It can be noticed that the frequency of oscillation is very different in the two works. Even if the one at the top (*Taurhiphanie*) has a greater range of deviation, this oscillation is almost continuous; only *Voyage Absolu des Unari vers Andromède* has some moments of relative stability (around 1'00", 9'30" and 14'00").

Continuity and discontinuity are therefore to be found at several timescales and are complementary to each other. Thus, the de-correlation of the channels allows the composer to obtain a less monolithic material. It is easy to imagine what Iannis Xenakis wanted when he suggested playing these stereophonic versions over four loudspeakers by crossing the channels.

CONCLUSION

In this short paper, I have attempted a first approach at comparative analysis of these two emblematic works of electroacoustic production by Iannis Xenakis. As I have been able to demonstrate, the use of analytical methods based on acoustic representation or visualization of information extracted from the signal has allowed me to study the construction of the works in more detail, and also to propose some hypotheses about the creative process. The exploration of new sources will probably be able to complete these analyses.

If Iannis Xenakis has provided a model for the interaction between mathematics, computer science, and artistic creation, he has also offered us a model for what are known as digital humanities, just as Jean-Claude Risset did. Research on such works cannot be conducted without the interaction between several scientific disciplines and a constant back and forth between research and creation. Through his works, Iannis Xenakis has shown us a very rich path for music research by combining in the same discipline issues that may seem very different, but which contribute to the same goal; the renewal of artistic forms.

FOOTNOTES

1. Makis Solomos, "Introduction," in *Iannis Xenakis, la musique électroacoustique*, ed. Makis Solomos (Paris: L'Harmattan, 2015), 5.
2. Boris Hofmann, "The Electroacoustic Works by Xenakis and Their Instrumental Contemporaries," in *Iannis Xenakis, la musique électroacoustique*, ed. Makis Solomos (Paris: L'Harmattan, 2015), 19–28.
3. UPIC: Unité Polyagogique Informatique du CEMAMu. The UPIC is a digital instrument that allows users to compose by drawing on a graphic tablet. Iannis Xenakis composed four works on UPIC: *Mycènes Alpha* (1978), *Pour la Paix* (1981), and the two works analyzed in this chapter.
4. I would like to thank Mâkhi Xenakis, Sharon Kanach, Cyrille Delhaye (GRHis), and Pascal Cordereix (BNF, Bibliothèque Nationale de France) for all the help they gave me in consulting parts of the sources.
5. Pierre Couprie, *L'analyse musicale et la représentation analytique de la musique acousmatique: Outils, méthodes, technologies,* Habilitation Thesis (Paris: unpublished manuscript, 2015); Pierre Couprie, "Prolégomènes à la représentation analytique des musiques électroacoustiques," in *Circuit 25*, no. 1 (2015), 39–54; Pierre Couprie, "Analyse de la musique mixte: Logiciels, procédures, workflows," *in Analyse de la musique mixte*, ed. Alain Bonardi, Bruno Bossis, Pierre Couprie, and Vincent Tiffon (Paris: Delatour, 2017), 61–79; Pierre Couprie "Nouvelles approches audionumériques pour l'analyse musicale." in *Musicologies nouvelles 5* (2018), 120–132.
6. Representations, whether of the signal, its analysis, its decomposition into descriptors or graphs and transcriptions, have been made on the iAnalyse 5 software developed for musical analysis assistance (http://ianalyse.pierrecouprie.fr).
7. Gérard Marino, Marie-Hélène Serra, and Jean-Michel Raczinski, "The UPIC System: Origins and Innovations," in *Perspectives of New Music* 31, no. 1 (1993), 258–69.
8. Iannis Xenakis, "Determinacy and Indeterminacy," in *Organised Sound* 1, no. 3 (1996), 143–155, here 150–52.
9. Rodolphe Bourotte and Cyrille Delhaye, "Learn to Think for Yourself: Impelled by UPIC to Open New Ways of Composing," in *Organised Sound* 18, no. 2 (2013), 134–45.
10. The MUSIC software was developed by Max Mathews from 1957 at the Bell Telephone Laboratories on an IBM 704. It is referred to as MUSIC I.
11. This idea had already been partially put into practice by Larry Rosler and Max Mathews who had developed a graphic system in 1966 to draw the frequency and amplitude of synthesized sounds (see Jean-Claude Risset, "Recollections and Reflections on Organised Sound," in *Organised Sound* 20, no. 1 (2015), 15–22, here 18.).
12. Anastasia Georgaki, "Sound Pedagogy Through Polyagogy: Initiation to Xenakis' World in Primary School Through the HighC Interactive Whiteboard," in *Iannis Xenakis, la musique électroacoustique*, ed. Makis Solomos (Paris: L'Harmattan, 2015), 241–54; Malika Combres, "La musique contemporaine à l'école," in *Transposition*, no. 2 (2012), 23–31, http://journals.openedition.org/transposition/462
13. Maria Harley, "Musique, espace et spatialisation. Entretien de Iannis Xenakis avec Maria Harley," in *Circuit* 5, no. 2 (1994), 9–20, here 12.
14. The first version of the UPIC was completed in 1977.

15. In other words, the time required to calculate and generate sound is far greater than the few milliseconds that give the illusion of real time used in live music.

16. Marlon Schumacher and Marcelo M. Wanderley, "Integrating Gesture Data in Computer-aided Composition: A Framework for Representation, Processing, and Mapping," in *Journal of New Music Research* 46, no. 1 (2017), 87–01, here 88–89.

17. The 4X processor is the result of development carried out by Giuseppe Di Giugno and IRCAM researchers. It was finalized in 1981 and marketed in 1984.

18. The SYTER system (Système Temps Réel) was developed at the Groupe de Recherches Musicales by Jean-François Allouis in 1978.

19. James Harley, "The Electroacoustic Music of Iannis Xenakis," in *Computer Music Journal* 26, no. 1 (2002), 33–57, here 53.

20. Makis Solomos, "L'équilibre fragile de Pour la Paix," in *Iannis Xenakis, la musique électroacoustique*, ed. Makis Solomos (Paris: L'Harmattan, 2015), 127–57.

21. Freezing consists in stopping the advance of the playback head without stopping the sound. The reading is then performed by the playback of a multitude of sound grains located around the position of the playback head.

22. James Harley, "The Electroacoustic Music of Iannis Xenakis," in *Computer Music Journal* 26, no. 1 (2002), 33–57, here 52–53.

23. Ibid., 53.

24. Only audio recordings were used for musical analysis. The abbreviations in the source column stand for: IXF: Iannis Xenakis Family; GRHis: History research laboratory (France, Rouen); CD: CD Edition; BNF: Bibliothèque Nationale de France.

25. Iannis Xenakis, *Aïs – Gendy3 – Taurhiphanie – Thalleïn* (Neuma Records, 1994).

26. The order is the same as that of the PDF document of the sources.

27. Iannis Xenakis, *Musique électroacoustique* (Fractal Records, 2001).

28. Acousmatic music is generally associated with composers from France or abroad related to the GRM. Even when it refers to music composed in a studio on a medium and diffused entirely on loudspeakers in concert, it is difficult to describe some of Xenakis's works as "acousmatic music." The filiation would rather be from computer music.

29. Pierre Couprie, "Voyage dans Grandeur nature," in *Son Vitesse-Lumière*, ed. François Bayle (Paris: Magisson, 2016), 47–57.

30. On this point, the three works present a certain similarity in terms of form, even though the composition techniques are very different. They share the idea of a continuous sound flow articulated by strong morphologies or musical gestures.

31. The descriptors used are mostly low level: RMS amplitude, zero-crossing rate (ZCR), spectral centroid, spectral variance, spectral deviation, inharmonicity.

32. Unless otherwise specified, the FFT computation parameters for extracting audio descriptors are: Window size = 2018, Window type = hanning, Window step = 25 %.

33. The visualization is obtained by converting the list of numerical values into a diagram or by converting the numerical values into color values (mapping).

34. Mikhail Malt and Emmanuel Jourdan, "Le BStD: une représentation graphique de la brillance et de l'écart type spectral, comme possible représentation de l'évolution du timbre sonore," in *L'analyse musicale aujourd'hui*, ed. Xavier Hascher, Mondher Ayari, and Jean-Michel Bardez (Paris: Delatour, 2015), 111–28.

35. It therefore does not represent the values themselves, but their distance.

36. I utilize here the term used in computer science (table); in mathematics we use the term matrix. A matrix is called self-similarity when the computation is based on only one set of values.

37. This step is not trivial, as it compensates for the graphic aberrations caused by grayscale visualization. The coloring generally used is a gradient close to the light spectrum.

38. In reference to Joël de Rosnay's macroscope, see Joël de Rosnay, *The Macroscope: A New World Scientific System* (New York: Harper & Row, 1979).

39. On these questions, I refer to Abraham Moles, *Les sciences de l'imprécis* (Paris: Seuil, 1990); Edgar Morin, *On Complexity* (New York: Hampton Press, 2008).

40. The graph represents: y = spectral centroid, width = spectral variance, color = ZCR.

41. John Young, "Forming Form," in *Expanding the Horizon of Electroacoustic Music Analysis*, ed. Simon Emmerson and Leigh Landy. (Cambridge: Cambridge University Press, 2016), 58–79, here 61.

42. James Harley, "The Electroacoustic Music of Iannis Xenakis," in *Computer Music Journal* 26, no. 1 (2002), 33–57, here 54.

43. Philippe Lalitte points out the impact of the gesture on the perception of form; see Philippe Lalitte, "Conditions de possibilités d'une rhétorique formelle perçue," in *Intellectica* 48–49 (2008), 103–14, here 104.

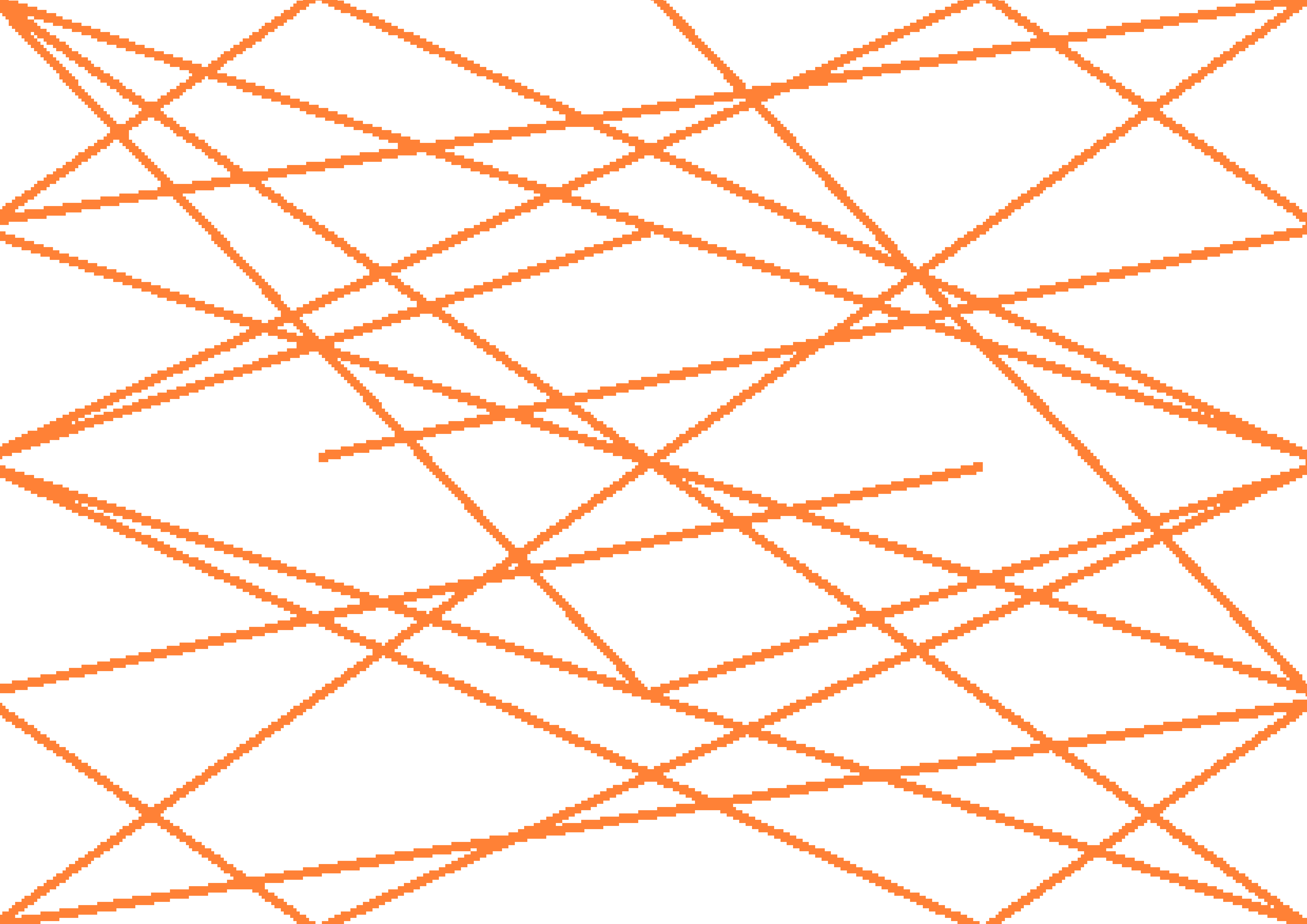
44. There are thirteen drawings, but pages 32 and 60 are the same.

45. The rotations shown in Figure 8 are approximate.

46. It is, of course, possible that there may be others, masked by transformations.

47. As transitions are made by crossfades, the times shown here and in the following lists are approximate.

48. The deviation between the two RMS amplitude graphs shows the balance of the levels: 1 (bottom) = predominance of the right channel, 0 (middle) = balance between the two channels, +1 (top) = predominance of the left channel.



IANNIS XENAKIS, ROBOTS, AND THE UPIC— "THE GREATEST ROBOT SHOW THE WORLD NEVER SAW"

HENNING LOHNER

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IANNIS XENAKIS, ROBOTS, AND THE UPIC—“THE GREATEST ROBOT SHOW THE WORLD NEVER SAW”

PROJECT HISTORY, PART 1: “WHY ME?”

Xenakis was the composer-in-residence at Centre Acanthes in 1985, a six-week course that focused entirely on his work; it was held as part of the European Year of Music. I was lucky to be there. At my first private meeting with the composer he asked me why I wanted to write music; I said: “I want to change the world.” He responded: “Have you ever been depressed?” My life changed forever. Xenakis became my mentor and surrogate father—he would remain so until the end of his life. I soon began publishing about Xenakis’s work in German and American journals, and was eager to share my enthusiasm of this great composer’s work wherever I could. I had become a regular guest at his studio in Rue Victor Massé. Often, I would arrive from Germany with the night train and go to the studio around six in the morning; the key would be under the doormat. Usually, I would spend a day at a time “rummaging” through the Master’s notes and archive until he came round to discuss my findings. He would then proceed to give me the most exclusive, meaningful training a composer and thinker could ever imagine.

In early 1989 I was hoping to organize a Xenakis festival in Munich in conjunction with the city’s annual international opera festival. Didier Deschamps, then the director of the Institut Français in Munich, and Sabine Kienow from Frankfurt, a major force in the German communications world, were driving the network that sent me back to Paris to ask Xenakis whether he would accept an opera commission from the City of Munich. Xenakis was not a fan of opera, yet a stage of magnitude was mandatory for the project contained in a slim folder he consequently put into my hands: the *Robot Ballet*.

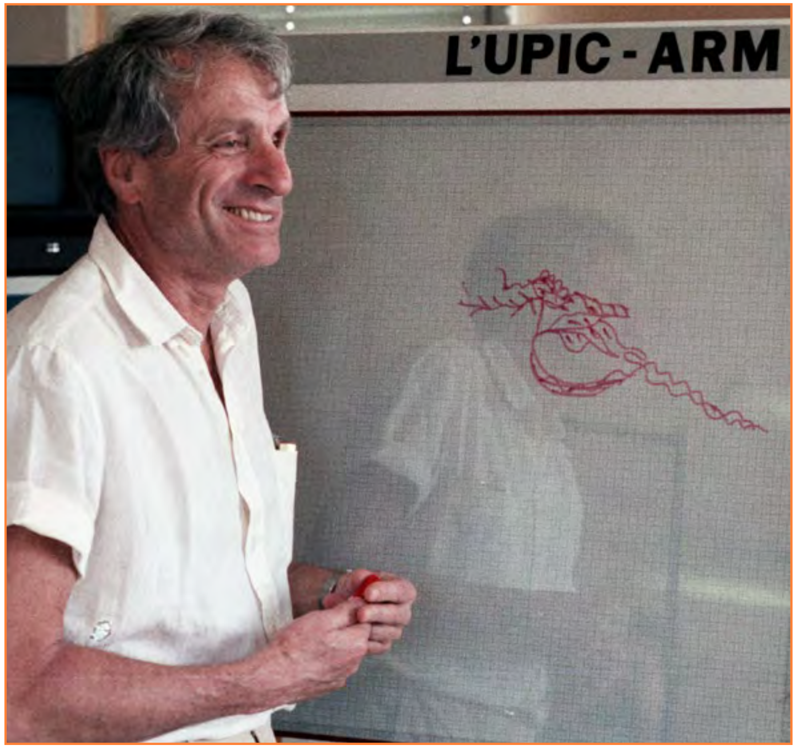
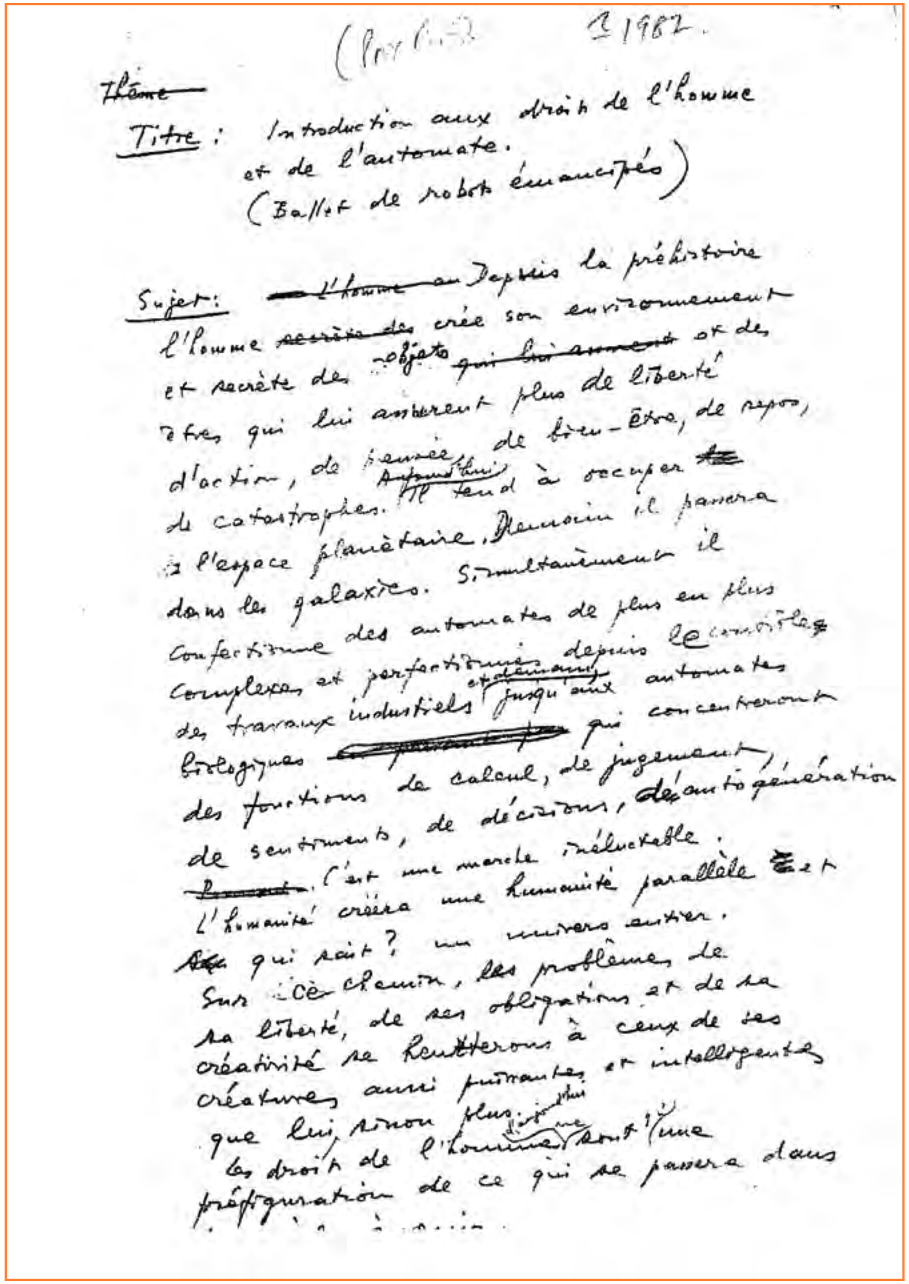


FIG. 1 Xenakis and the UPIC, 1985 © Henning Lohner and CIX Archives


3 1982.

~~Thème~~

Titre : Introduction aux droits de l'homme
et de l'automate.
(Ballet de robots émancipés)

Sujet: ~~l'homme~~ Depuis la préhistoire
l'homme ~~secrète des~~ crée son environnement
et secrète des objets ~~qui lui amènent~~ et des
êtres qui lui assurent plus de liberté
d'action, de pensée, de bien-être, de repos,
de catastrophes. Aujourd'hui il tend à occuper ~~le~~
l'espace planétaire. Demain il passera
dans les galaxies. Simultanément il
confectionne des automates de plus en plus
complexes et perfectionnés depuis les contrôles
des travaux industriels et domestiques jusqu'aux automates
biologiques ~~[illegible]~~ qui concentreront
des fonctions de calcul, de jugement, d'autogénération
de sentiments, de décisions,
~~[illegible]~~. C'est une marche inéluctable.
L'humanité créera une humanité parallèle et
qui sait? un univers entier.
Sur ce chemin, les problèmes de
sa liberté, de ses obligations et de sa
créativité se heurteront à ceux de ses
créatures aussi puissantes et intelligentes
que lui, sinon plus. Les droits de l'homme sont l'une
des droits de ce qui se passera dans
préfiguration
...

FIG. 2 Photocopy of page 1 of Xenakis's original manuscript for the *Robot Ballet*, 1982. Reproduced from facsimile at CIX Archive, fonds Lohner. Originals can be consulted at the Iannis Xenakis Family Archive. © Iannis Xenakis Family

THE PROJECT

Here is what the ballet was intended to be, in Xenakis’s own words:

Title: Introduction to the Rights of Humans and of Automatons
[*A Ballet of Emancipated Robots*]

SUBJECT:

Since prehistoric times man has been creating his own environment: equally spawning things and beings that seem to guarantee humanity’s greatest freedom of action, thought, well-being, and leisure, along with ever-growing disaster.

Today, humankind is already occupying the entire planetary space for its own goals; tomorrow it will be conquering the galaxies.

At the same time, man is creating increasingly complex and sophisticated automatons, believing in the human machine itself. We can begin by entrusting simple functionalities of industrial and agricultural work to these machines, and by tomorrow we will move all the way to biological automatons recommitted with the capabilities of judgment, expediency, feelings, decision-making, and finally, self-regeneration.

This progress is inevitable: Humanity will create a parallel humanity and possibly an entire autonomous universe. On this path, the major concerns of freedom, obligation, and creativity will have to settle their accounts with those of their new creatures, as powerful and intelligent as their makers, if not more so.

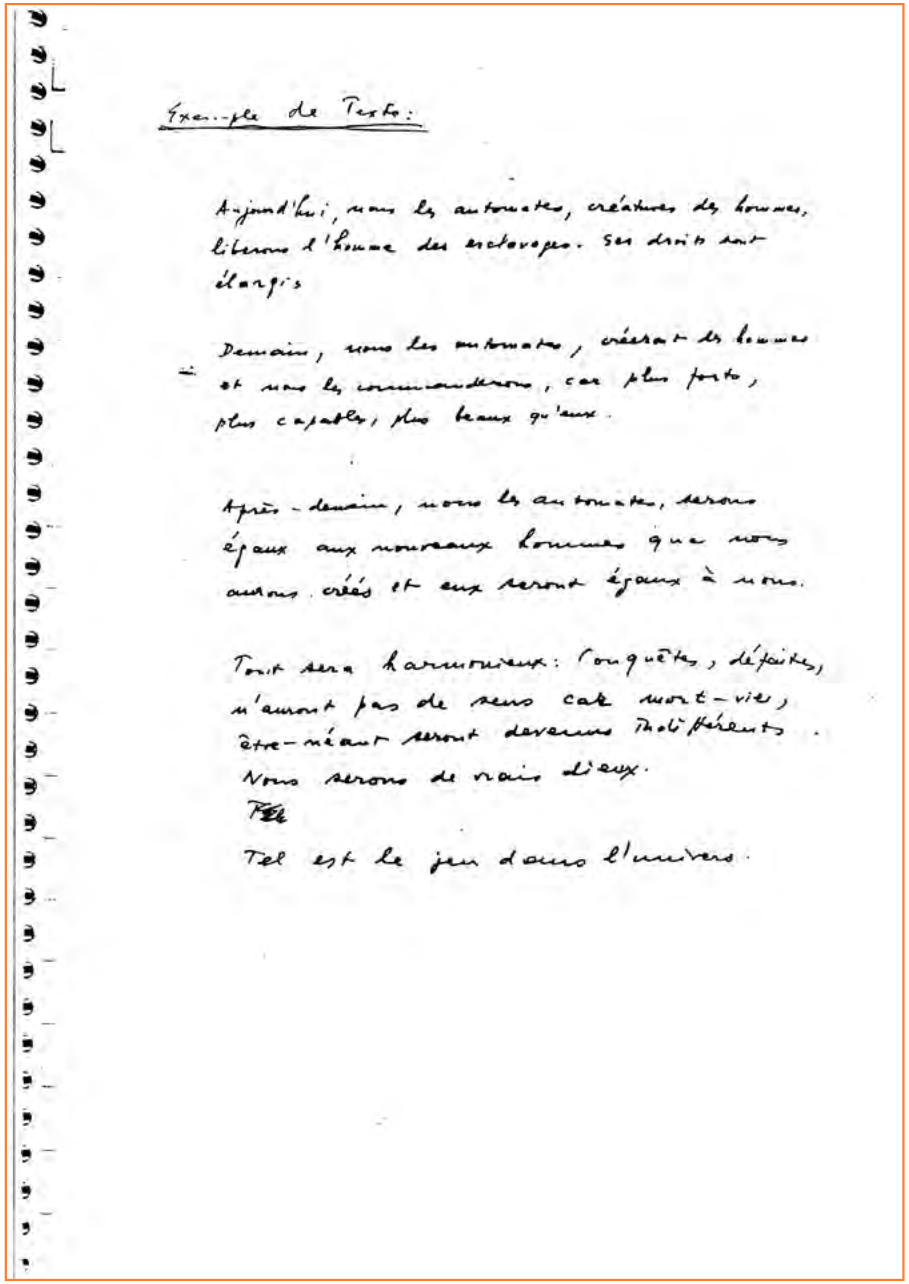
Human Rights today are really nothing but the anticipation process for the ethical and moral battery of questions that future generations will have to deal with. **FIG. 2**

FLOW OF THE SHOW (“BIRD’S EYE VIEW”):

The Robots’ movements (i.e. evolutions) create a type of abstract ballet which, from time to time, seems surprisingly realistic. This fluid transition between movements is conceived as a strong contrast in tension that will give the audience the irresistible desire to see and hear more for the entire duration of the show.

The Robots represent Hercules fighting Antaeus, who, in order to regain his strength, has to touch the Earth beneath him, but in the end succumbs to Hercules.

The Robots’ movements will be of very diverse natures: fights, duels, submission, pushing and shoving, even the exchange of feelings between the Robots, such as affection and love, are representable. The show will be an image of humanity in the sense that all gestures are indicative of a society in miniature. We are creating an ode to the glory of human beings, to justice and peace, moved by the Act of Creation, given by Nature itself.



Exemple de Texte:

Aujourd'hui, nous les automates, créatures des hommes, libérons l'homme des esclavages. Ses droits sont élargis

Demain, nous les automates, créerons les hommes et nous les commanderons, car plus forts, plus capables, plus beaux qu'eux.

Après-demain, nous les automates, serons égaux aux nouveaux hommes que nous aurons créés et eux seront égaux à nous.

Tout sera harmonieux: conquêtes, défaites, n'auront pas de sens car mort-vie, être-néant seront devenus indifférents.
Nous serons de vrais dieux.
~~Tel~~
Tel est le jeu dans l'univers.

FIG. 3 Photocopy of Xenakis’ autograph: text and vocal examples for the *Robot Ballet*, 1982. Reproduced from facsimile at CIX Archive, fonds Lohner. Originals can be consulted at the Iannis Xenakis Family Archive. © Iannis Xenakis Family

Music and lights on and/or around the Robots will highlight the Act of Creation.

Essential texts will be projected throughout the staging area via a multi-vision video-wall, supporting the above-mentioned subjects, from the physical, atomic and astrophysical sciences; philosophy, religions, human rights, animal rights, living beings, races, etc. will be projected by a system of slides on clearly visible screens.

PROJECT FEATURES (ORGANIZATION):

Nine SMART 6.50 R (or similar) robots are to be dispersed irregularly within the audience's space.

The event will last about 30 minutes. It should be repeated several times a day with ample time between performances to let the audience enter and leave.

The performance space should, if possible, be a public space, in other words: not within the factory hall where the machines usually work. However, the space needs to have a flooring that can carry the weight of the robots.

Sound will be dispersed through a system of speakers that are distributed within the entire space between the robots and the audience. This will allow for the sonic effect of "flying sound."

Music will be pre-recorded on multi-channel tape; add to this three UPIC graphic music computer units; some robots will freely improvise on these.

Lighting, just like the motion of the robots and the music itself, and indeed the entire event, will be completely automated. Installation, disassembly, and transportation will be of such ease that the show can travel easily from location to location for about a full year.

The venues can be anywhere as long as they have flooring that structurally can carry the robots and the space should be sheltered (a hangar, abandoned factory, etc.)

Apart from the fact that the robots necessarily have to be mounted to the floor, they can perform all possible motions thanks to their three wrist axes; the specific motion capabilities of these joints will of course be considered in the composition. All motion will be composed by myself in programming language in the same way I develop and compose a musical score.

The automated control programming for the show will be carried out by myself along with CEMAMu[1] engineers under my supervision. The music will be composed entirely by me, in principle at CEMAMu.

For reasons of economy it is conceivable to utilize robots that are not currently in use so long as they can perform computerized manoeuvres.

KINETIC PROCEDURES:

I will define the precise figures or "routines" the robots will "dance" when the time comes; these will be animated by special settings based on the varying angles and propulsion speeds of the Robots' capabilities (see FIGS. 4, 5). These settings are established specifically by functional and deterministic mathematical methods, along with stochastic laws of distribution (in particular during the Robots' wrestling and disorderly sessions). Mathematical distribution models such as Bernouli, Poisson, and Cauchy will be used with or without elastic barriers. Ideally, I would also like to include cellular automaton routines and, if possible, fractals. The entire show will be composed in the sense that the mathematical models underlying the musical composition will equally be applied to the motion of the Robots and the overall staging of the show.

TEXT EXAMPLES FOR THE VOCAL PARTS:

- "Today, we automatons, created by man, liberate man from his own slavery; his human rights are expanded".
- "Tomorrow, we automatons will rebirth man himself as stronger, more beautiful, and more capable than he has ever been before".
- "The day after tomorrow, we automatons will be equal to man himself, and as he is now equal to us, we will be equal to him".
- "All will be at peace in harmony: no conquest, no defeat; no directions anymore. Life and Death, to be or to be born: all has become indifferent".
- "We are truly Gods". "This is the Universe's Game".

CORE ASPECTS OF THE PROJECT

(Text written by Xenakis in collaboration with Sistema Dinamo, revised by Xenakis, Radu Stan, and Henning Lohner).[2]

The complete musical work includes a fully automated, scenic composition. The protagonists on stage are nine Robots, possibly aided by other machines.

This work is a homage to science and to the power of progress inherent to humanity.

As our 20th century closes, this work will reflect on the actual role the most progressive technologies have on our civilization. Imagine a scenario of living together with these automatons that are continuously becoming more intelligent. Both formally and in terms of the content of our show we will be investigating questions of ethical and moral problems in anticipation of the "new social rapport" we will undoubtedly have as we look into the 21st century.

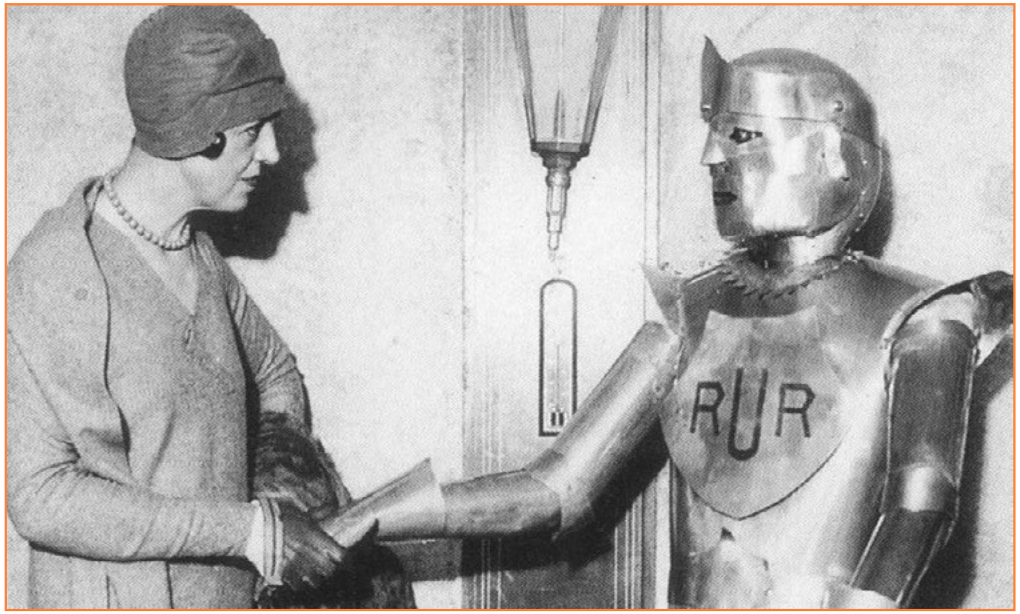


FIG. 4 Example of robotic motion: Eric the Robot shaking hands and displaying on its chest the logo of *R.U.R. (Rossum's Universal Robots)*, play by Karel Čapek, 1921

FIG. 5 Example of robotic motion: Marvin Minsky with his Tentacle Arm, ca. 1963, screenshot © *AI History, movie*, 2010, posted on CSAIL YouTube public channel by MITCSAIL

This work merges creativity with the technological knowledge of current industry standards into a completely new formula. The artist will create new ideas, and industry has the opportunity to show their most progressive products to a broader audience, outside of the manufacturing hall.

As such, this work is in complete synchronicity with Xenakis's creative continuity—who has made it his life's work as an artist to engage with the progress of technology and its effects.

Therefore, we can summarize these positive truths:

- **A** The particular emotional power of the performance.
- **B** The complete novelty of structural and visible representation of events and their application in society and in the media.
- **C** Stimulation and reflection resulting from ethical and philosophical aspects of the show.
- **D** Use of industrial machines and products as protagonists in a new, contemporary work by one of the most important composers of the 20th century.
- **E** Flexibility and ease-of-use of the project's components, along with (relatively) low maintenance, will allow for relative ease of installation and disassembly logistics of the performances themselves and between their venues.
- **F** International intelligibility of the characters via a universal language, regardless of heritage or social order; the audience need not have any elite nor particular affiliation or prejudice.

We believe that these remarks are indicative of successfully integrating the product-oriented interests of industry and the creative expression of a scenically composed, artistically and socially valid performance symbolizing the notion of progress for humanity.

PROJECT HISTORY, PART 2: "WHY?"

Prior to my involvement, the goal was to give the world premiere of the *Ballet of Emancipated Robots* during the bicentennial celebrations of the French Revolution in 1989, specifically at the Mission du Bicentenaire de la Révolution Française et de la Déclaration des Droites de l'Homme et du Citoyen (Bicentenary Commemoration of the French Revolution and the Declaration of Human Rights and Citizens) at Le Grande Arche de La Défense in Paris.[3]

This event and venue made perfect sense with regard to the intent, form, content, and appearance of the *Robot Ballet*. But first: Why would anyone attempt a ballet for robots? Although the cultural history of the twentieth century since Expressionism is full of *ideas about* robots, nothing involving a *real* robot had ever been done before. Surely there must have been good reasons why no one had succeeded at it, although a few had tried. "It's actually quite easy to make something new. You just have to pay attention to what exists, and then do something different"—this was a mantra I would hear from Xenakis on occasion. It sounded convincing. However, making real robots dance proved much more difficult.

In attempting this ballet, the opportunities were perhaps its challenges:

- **A** The drama and the composer's personal history.
- **B** The robot itself.
- **C** The invention of two significant musical interfaces.
- **D** The staging and logistics of the show itself.

HUMAN VS. MACHINE

"The idea of the automaton, for example, exists since the beginning of time, because man wants to resemble God. **FIG. 12** This idea, actually, has been formulated by the musician in using certain compositional structures, such as the fugue, long before any theories about robots came around."[4] An unassuming and short quote, this nevertheless clearly describes the interlacing of Xenakis's philosophical position with practical questions of creating; indeed, creation is a constant flow of birth and rebirth.

For Xenakis, who, as a resistance fighter in his early 20s, caught a bomb that blew off nearly half of his face, surviving on a mere thread of life, I have no doubt that creation equaled survival and rebirth—in his case, with a glass eye and half his face either missing or filled with shrapnel. In my view it is not a coincidence that the only truly substantive research object in his archives on this project was a book on medical ethics and human rights.[5]

Xenakis's ballet exposé, in particular his "text examples," suggest a profound understanding of Maslow's hierarchy of needs. The effects of excessive, progressive automation are cited as one of the dominant threats to basic human needs[6] such as food and water, work and education, mental stability, and so forth; indeed, Xenakis's entire output deals with the Human Condition.

It is a strange and fortuitous coincidence that the year 1921, in which Xenakis was either born or conceived,[7] also marks the birth of the term "robot" and its predominantly negative connotation as a threat to humanity, as portrayed in the theater play *R.U.R.* (*Rossum's Universal Robots*) by Karel Čapek.[8] **FIG. 4** The theme of the piece is surprisingly similar to the dramatic outline Xenakis gives for his ballet.

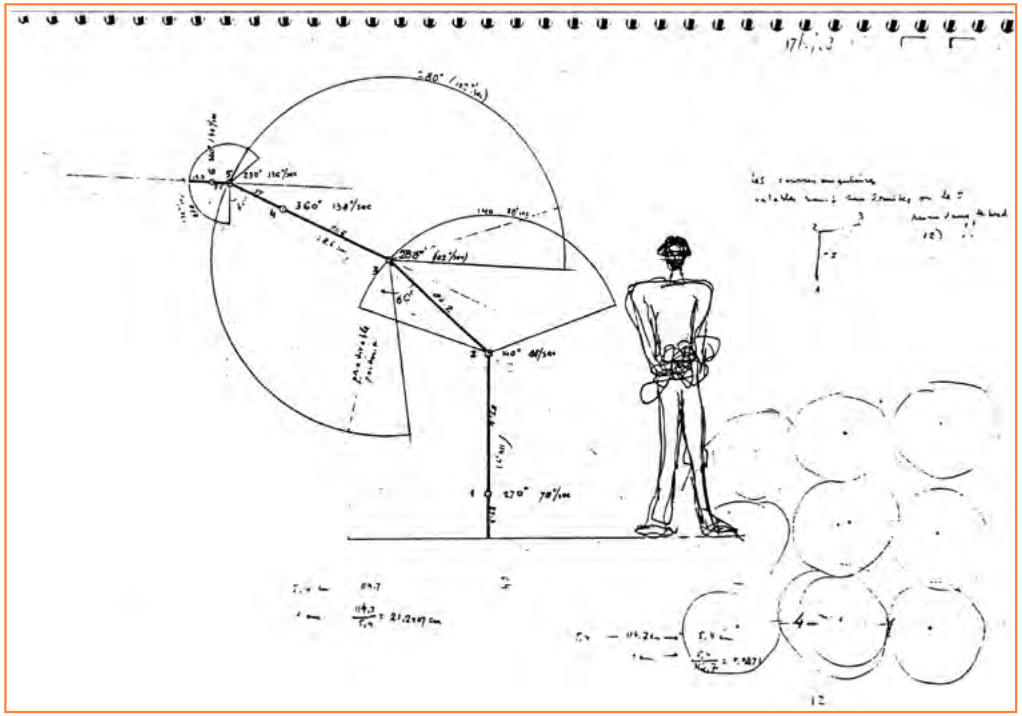


FIG. 6 Photocopy of Xenakis' autograph, scale and reach of the Robot Arm 1, 1982. Reproduced from facsimile at CIX Archive, fonds Lohner. Originals can be consulted at the Iannis Xenakis Family Archive. © Iannis Xenakis Family

While the concept of autonomous “artificial life” finds its antecedents in the earliest surviving scriptures, the first appearance of the actual term “robot” occurred in this play by Čapek: derived from the Czech word *robota*, which translates as “compulsory labor.”

THE ROBOT PROTAGONIST

The Unimate was the first digitally programmable robot; invented by George Devol, it was patented in 1954.[9] Basically, this was the first real robot. That same year Xenakis began his composing career with his first major orchestral work, *Metastasis,* premiered at Donaueschingen in 1955, and changing the course of music forever. From then on, in a curious paradox of parallel developments, the progress of robotization and Xenakis’s personal development as a composer marched consistently side-by-side.

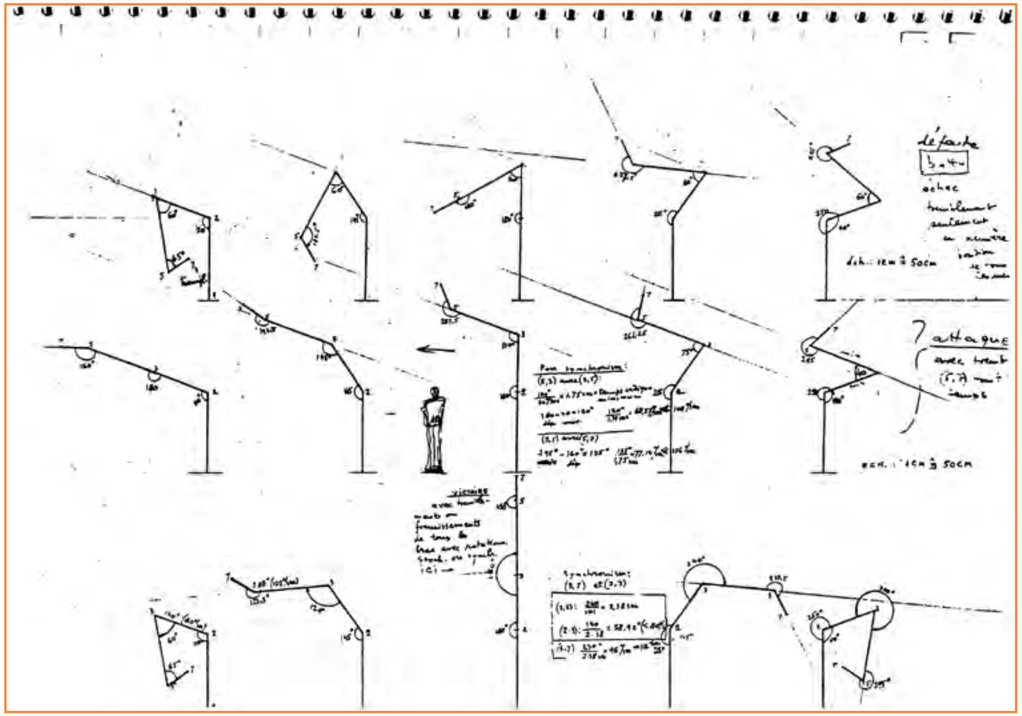
In the early 1960s SRI International introduced Shakey, the first mobile and perceptive robot. Marvin Minsky developed his tentacle arm **FIG. 5** and the notion of “artificial intelligence” (AI). In 1975, while Xenakis was deeply engaged with designing his first UPIC, ABB of Sweden introduced the spot-welding robot, ASEA IRB 6 **FIG. 8**, the world’s first completely microprocessor-controlled robot.

The Comau Smart 6.50 R **FIG. 10**, which Xenakis intended to use, was practically the twin of the ASEA IRB 6, but with six fully computer-controllable axes and ratios. Being a spot-welding machine on an automotive assembly belt meant it could perform very precise actions within an area of a few millimeters. Although it looked Herculean, the machine was not “clumsy.”

The appearance of this robot alone symbolizes notions of human progress: it looks like, and acts as an extension of a human arm. **FIG. 9** As such, this robot fits an iconography that Xenakis was very familiar with. The machine’s ambitus is surprisingly similar in range not only to a human in motion, but also to the concept of the Modulor.[10]

Equally important, the robot’s computerized control center drove a maximum of 1800 execution steps (“evolutions”) with a 64k RAM maximum storage. This is nothing compared to today’s computer memory capacities, but it was significant in 1988: 1800 evolutions allowed for fluid, uninterrupted programming of motion for at least 30 minutes, thus guaranteeing the practical performability of the show. Furthermore, external interfacing was possible, which was mandatory for Xenakis in order to synchronize all the events of the show.

The Smart and the ASEA robots were significant precisely because they gave the impression of being able to perform a greater amount of automatic programming steps than a human programmer would be able to enter into the command control at the same time, allowing for a completely automated showing of the performance without human supervision.



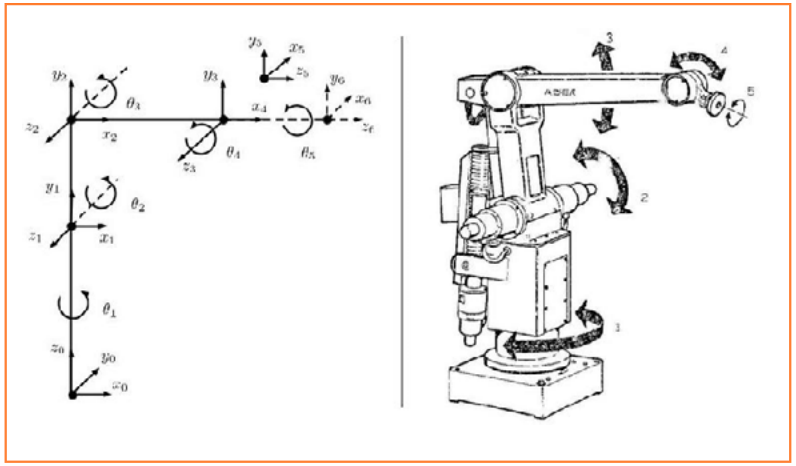


FIG. 7 Xenakis' autograph, scale and reach of the Robot Arm 2, 1982. Reproduced from facsimile at CIX Archive, fonds Lohner. Originals can be consulted at the Iannis Xenakis Family Archive. © Iannis Xenakis Family

FIG. 8 Juan Toquica, definition of a coordinate system for the ASEA Robot (left), ca. 1974. Retrofitting of Asea IRB6-S2 industrial robot using numeric control technologies based on LINUXCNC and MACH3-MATLAB. 10.1109/ROBIO.2017.8324737 (right), 2017 © Alberto Alvares, Juan Toquica, Eduardo Lima II, and Marcelo Bomfim

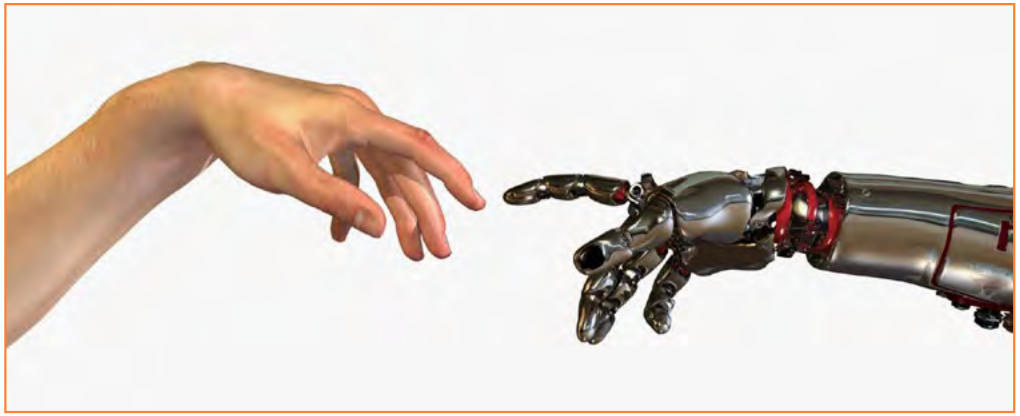


FIG. 9 Raymond Duchamp-Villon, *Le Cheval majeur* (The Large Horse), 1914

FIG. 10 The Comau Smart robot, Torino, Italy, February 2014, advertising brochure

FIG. 11 Linda Bucklin, *Robot (right) vs. android (left)*, 2013. Courtesy of Shutterstock

FIG. 12 Michelangelo, detail of the Sistine Chapel ceiling, 1536–1541, Rome, Italy

In other words, the looks and functionality of the machine gave hope: the hope that a machine could actually do more than a human, and optimism, breaking with their past, beginning a new life of their own.

THE UPIC AND ROBOTS

A robot is literally the visible externalization (the "front end") of the internal mathematical models (the "back end") inside the computers that drive the robot to "behave on its own": computational science that, by its nature, can spawn endless variants of mathematical automatons. For Xenakis, robots could become a direct "anthropomorphic"[11] gestalt of their computational digital "intestines"; these mathematical intestines being of the same substance as Xenakis's musical and kinetic compositions.

Xenakis's fascination with this particular type of robot lies in humanity's desire to actually *have* thinking machines versus the *ability* to have thinking machines. The Smart 6.50 R or the ASEA had enough ergonomic capabilities to create the optical illusion of acting human for the audience, and this was intended and planned by its inventors.

Xenakis's attraction to robotics was an extension of his research into, and his invention of, musical interfacing. Both robots and the UPIC could be related as programmable music data input interfaces, while at the same time actually being performers of the sounds they create. In creating music, Xenakis was of course aware that certain human-made mathematical models could generate and automatically produce their own quasi independent iterations, mathematical automatons.

To announce that some robots will improvise on the UPIC graphic table was a remarkable idea for that time: it meant that Xenakis was expecting to display the robots' "hand to brain" ergonomic capabilities in a very detailed and exacting way; the effect being that the preconceived notion of robots looking "clumsy" in their movements would be counteracted by very finely tuned actions, immediately visible to the audience.[12]

PROJECT HISTORY, PART 3, "WHY NOT?"

The project had originally been outlined for the FIAT Foundation.[13] After Xenakis was awarded the Fiat Foundation's sponsored prize in November 1987,[14] specifically attributed to Les Ateliers UPIC,[15] Xenakis went to FIAT's automobile factory in February 1988 to view the robots and discuss the strategy for their theatrical implementation. In order to do this, Xenakis collaborated with Sistema Dinamo, the cultural branch of the COMAU company.[16]

However, time ran out to meet the production deadlines of the Bicentennial. Twelve months was just not long enough to compose, program, finance, and produce the staging of an event of this magnitude.

By the time I joined the project, Xenakis had looked at several other options for the robots, as there were three or four very similar models around. In the meantime he had also visited Renault in France. I had contacted Mercedes Benz and BMW in Germany. I had Letters of Commitment to stage the ballet at the Almeida Festival in London, the Frankfurt Feste, the Festival de Lille, the Gulbenkian Foundation in Lisbon, Strasbourg Musica, the State Opera of Hamburg, and the Villa Medici.

Ultimately, the *Robot Ballet* failed for three reasons: (a) it was ahead of its time in terms of ease of use; (b) the total cost of the project (the equivalent of over € 1.5 million today, excluding the cost of the robots) was prohibitive; and (c) the automotive industry's sponsorship focus was not aligned with our project. In a letter to me, the director of cultural projects at Mercedes Benz symptomatically wrote: "We believe this project to be basically worthy of our sponsorship. However, to be efficient with our sponsorship program we have concentrated our interests in long-term directives. A single project such as yours thus does not fit into our sponsorship guidelines."[17] All in all, we spent a total of three years trying to get this project going. By the end of 1991, sadly, we abandoned it.

CONCLUSION

Robots are not androids. FIG. 11 Androids are made to replicate humans so that one cannot see a difference, whereas robots were meant to act like humans, but were always seen as clearly different. The rise of android science fiction culture in the media and in science was particularly appreciated by Xenakis.[18] Xenakis chose robots and not androids precisely because they look different than us. Although androids could perform the same tasks, they would confuse the observer.

Xenakis was acutely aware of the moment in history when we, as a civilization, were still "living the dream"; holding on to the analog world, but already able to see into the future of what a digital age was promising. At that precise moment, Xenakis attempted to display—and play—with ethical questions that were based on recognizable patterns of experience: the hand (arm) of the robot replacing the hand of the human.

"Finally, a kind of aesthetic, rational, and intuitively fluid of imagination seems to circulate between light, sound, technology, theories, almost without a break in continuity."[19]

In view of Xenakis's quasi universal model of composition (each individual composition being directly related to each other, like a mosaic[20]), his *Robot Ballet* provides circumstantial evidence that the composer-inventor used his gift of computing to enable the UPIC to be at the center of a very specific chain reaction between music and its common mathematical basis in composing for lights, spatial hearing, and space itself, through institutional, scientific experimentation at CEMAMu, through which the UPIC came into being. Here, finally, in his *Robot Ballet*, the UPIC would be and become much more than a graphic interface for a music computer. Here, the UPIC itself becomes the centerpiece of a theatrical world drama in which the robot's mechanical hand replaces the human hand, producing new music on a machine "handed" to them by the original composer, so as to give birth to a new music that would subsequently be perpetuated by the robots themselves.

CODA

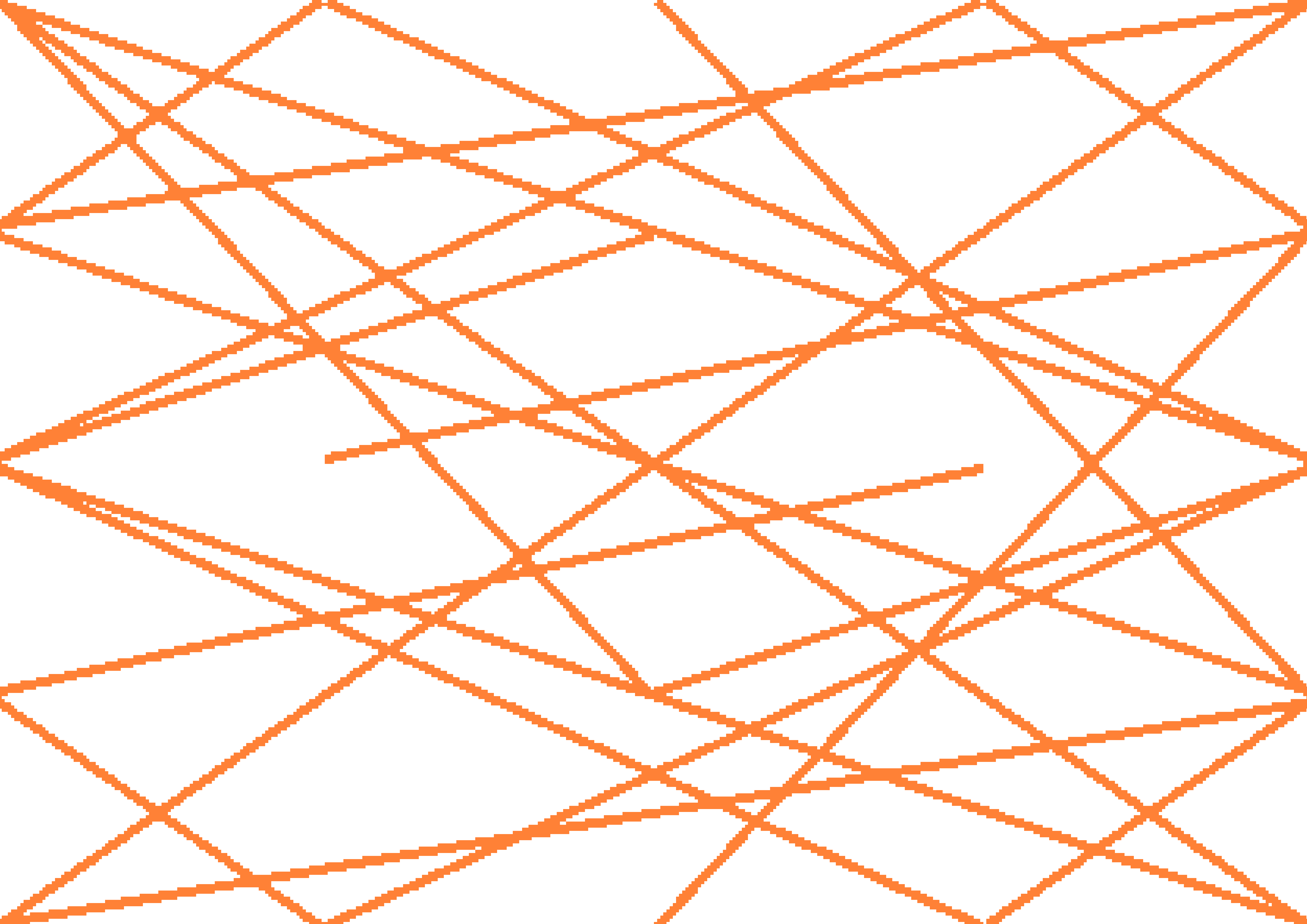
The first robot theater art project was realized in Bologna in 2008 with the roBOt Festival,[21] basically 20 years after Xenakis's unrealized *Robot Ballet* project, and they have been going strong every year ever since, with other events and festivals[22] following suit. As the first robot was a figment of the imagination of the writer Karel Čapek a hundred years ago, we now have more and more artists actually utilizing robots to make art.

FOOTNOTES

1. The Research Center for Musical Computing and Acoustics in Paris, founded and directed by Xenakis.
2. Xenakis's original of this exposé is held in the Xenakis Archives, Dossier OM 28/5 and 32/1–8. My translation was made from the copy in my personal archives.
3. Xenakis Archives, Dossier OM 32/6.
4. Iannis Xenakis, "Condition du musicien"; originally published in *France Forum*, no. 223–224, Oct. – Dec., 1985, reprinted in Iannis Xenakis, 1994. *Kéleütha: écrits* (Paris: L'Arche, 12, 121–128). [translated by H.L.].
5. Xenakis Archives, Dossier OM 32/8, "La fabrique du corps humain et les droits de l'homme": documentation sur des conférences et débats au Centre G. Pompidou, mai-juin 1988", published as *Ethique médicale et droits de l'homme*, (Paris: Actes Sud, 1988).
6. See: https://en.wikipedia.org/wiki/Maslow%27s_hierarchy_of_needs; Maslow stated that people are motivated to achieve certain needs and that some needs take precedence over others. Our most basic need is for physical survival, and this will be the first thing that motivates our behavior. Once that level is fulfilled, the next level up is what motivates us, and so on.
7. Although Xenakis's last passport stated 1922 as his year of birth, for most of his life he celebrated his birthday as being on May 29, 1921.
8. Written in 1920, premiered in Czechoslovakia on January 25, 1921.
9. See: https://www.robotics.org/joseph-engelberger/unimate.cfm
   The Unimate was the very first industrial robot. Conceived from a design for a mechanical arm patented in 1954 (granted in 1961) by American inventor George Devol, the Unimate was developed as a result of the foresight and business acumen of Joseph Engelberger, who has been called the "father of robotics."
10. Le Corbusier developed the Modular as mathematical proportions to improve both the appearance and function of architecture. For images see http://www.fondationlecorbusier.fr/
11. It's an interesting paradox that in his text on robots, Xenakis included anthropomorphic semblance although he was generally opposed to such notions in his art. I believe this was actively accepted by Xenakis in this instance to prove his more general point of the "ethical rivalry" between humans and robots ("An art like music, in itself, without anthropomorphic or realistic reference. [...] [t]his is the meaning of polytopian adventures. This is the quest for a pan-musical expression." Iannis Xenakis, "*Polytopes*," in *Festival d'Automne à Paris 1972–1982*, eds. Jean-Pierre Léonardini, Marie Collin, and Joséphine Markovits (Paris: Messidor/Temps Actuels, 1982), 2018 [translated by H.L.].
12. "What interests me is that I am free to choose, my score allows me multiple paths, I can improvise on elaborate structures, and of course mix the elements at my convenience." Iannis Xenakis quoted in *Le Matin*, June 19, 1987, "Le compositeur à Arles: Xenakis dans l'arène" (propos recueillis par Brigitte Massin). [translated by H.L.].
13. "Fondation de France—Institut de France: Les Sphères du Mécénat 1987," n.d., n.p. Source: CIX Archives, Fonds Després (uncatalogued).
14. See: "Le Match des Enterprises: Giovanni Agnelli," in *Paris Match*, November 13, (1987), 154.
15. Email exchange between the author and Alain Després (28.05.2019) confirmed that the grant was actually utilized by Les Ateliers UPIC for North American and Mexico tour of the UPIC.
16. Source: CIX Archives, Fonds Lohner, uncatalogued.
17. Letter to the author from Dr. Ulrich Kostenbader, Office of Public Relations and Economic Policy at Daimler Benz AG, February 1, 1991.
18. Xenakis was a big fan of science fiction literature. It was also a frequent conversational topic of his. I fondly remember him introducing me to the delights of the hard-boiled eggs you can buy at the bar of any Parisian café while discussing the ending of Stanley Kubrick's *2001: A Space Odyssey* ("The Starchild appearing at the end is just a bit too melodramatic for my taste," is a quote I remember that still makes me chuckle).
19. Iannis Xenakis, "Polytopes" in *Festival d'Automne à Paris 1972–1982*, eds. Jean-Pierre Léonardini, Marie Collin, and Joséphone Markovits (Paris: Messidor/Temps Actuels, 1982), 218.
20. Xenakis often spoke of his entire body of work as "one piece". See: Iannis Xenakis, *Arts/Sciences: Alloys*, trans. Sharon Kanach, Hillsdale, NY: Pendragon Press), 6, where he refers to himself as a "mosaic artisan": "For more than twenty years now, I have strived like a mosaic artisan, unconsciously at first, then in a more conscious way, to fill this philosophical space with an intelligence which becomes real by the colored pebbles which are my musical, architectural and visual works and my writings. These pebbles, at first very isolated, have found themselves brought together by bonds of relationships, of affinities, but also by opposition, gradually forming figures of local coherencies and then vaster fields summoning each other with questions and then the resulting answers. Mathematics plays an essential role here as a philosophical catalyst, as a molding tool for forming auditory or visual edifices, but also as a springboard toward self-liberation."
21. http://www.robotfestival.it/en/
22. https://it.wikipedia.org/wiki/RoBOt_Festival

THE ROAD TO THE UPIC

PETER WEIBEL



THE ROAD TO THE UPIC. FROM GRAPHIC NOTATION TO GRAPHIC USER INTERFACE

PETER WEIBEL

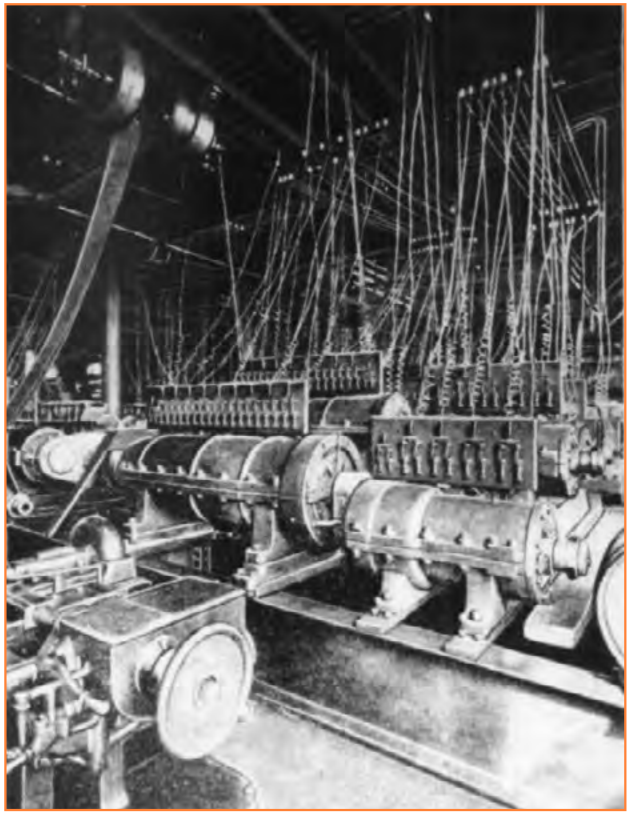


FIG. 1 Dynamos of the Third Telharmonium, Cabot Street Mill, Holyoke, Massachusetts. *In Electrical World*, 55, 17 (1910): 1060

FIG. 2 Cover of the radio magazine Practical Electrics featuring the Staccatone, March 1924

PETER WEIBEL

THE ROAD TO THE UPIC. FROM GRAPHIC NOTATION TO GRAPHIC USER INTERFACE

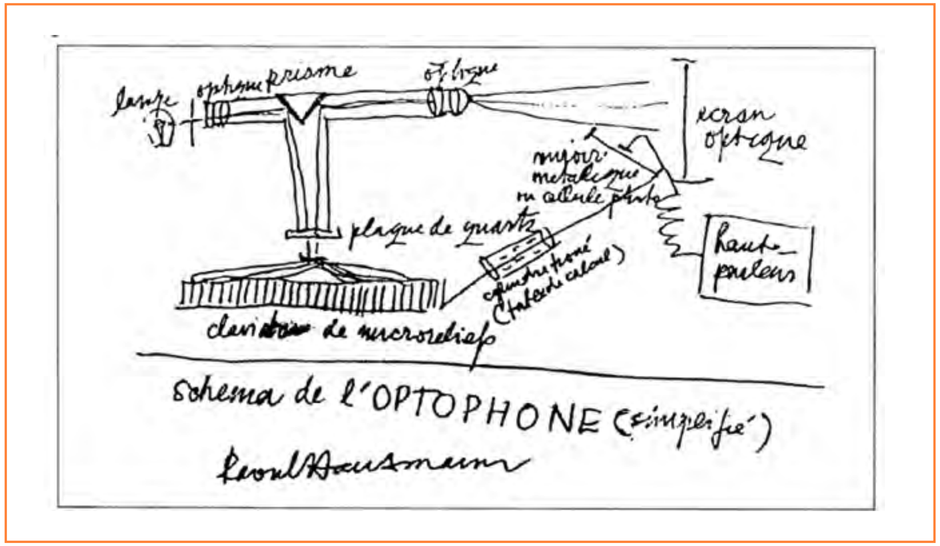
The boldest technical and aesthetic revolutions of the twentieth century in the world of arts probably took place in music. Music is the mother of all technological and time-based arts. Therefore, the technical innovations became mostly evident, audible, and observable in the radical transformations of music. Pioneers, inventors, engineers, and musicians—unique heroes—have built countless new musical instruments to expand the cosmos of sound. Tape recorders, oscillators, generators, transistors, transformers, resistors, ring modulators, filters, frequency converters, sequencers, amplifiers, switches, diodes, oscilloscopes, synthesizers, and computers have created a new (electric, electromechanical, electromagnetic, optoelectronic, electroacoustic, electronic, acousmatic, digital) music. In the following treatise I shall hint at some of the most important steps in the evolution of advanced musical practices.

ELECTRIC AND ELECTROMECHANICAL INSTRUMENTS

Electrical instruments generate sounds by converting mechanical energy into electrical energy. So called *pick-ups* (magnets) are used to pick up the mechanical vibration of a string. One of the first electromechanical instruments was Thaddeus Cahill's Dynamophon (1900), later called Telharmonium (1906). Cahill already used the term *synthesizing*. In his Washington laboratory, which was the size of a machine hall, he used alternating current generators to produce various stages of the tone scale. The sounds produced were transmitted to keyboards via various transformers, filter tracks, and switches. The sound was reproduced via electric arcs, but also via telephone lines, for example in hotels and department stores.

In 1923 Hugo Gernsback promised "Electric Music" with his *Staccatone*, based on pure sine wave tones. The engineer Laurens Hammond succeeded in miniaturizing Cahill's gigantic generators, and in 1934 he invented the first commercially successful electric instrument, the Hammond organ, which Hammond had actually built for use in churches.

The most famous electromechanical instrument, however, is the electric guitar, in which the vibrations are generated mechanically by strings and the string vibrations are picked up electromagnetically. In 1932,



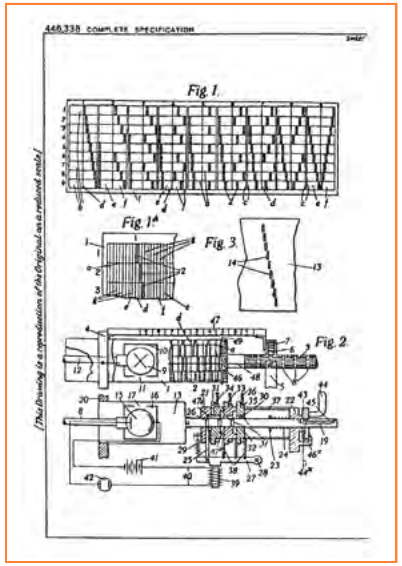


FIG. 3 Raoul Hausmann, sketch accompanying his Optophone patent, 1919 © VG Bild-Kunst, Bonn 2020

FIG. 4 Raoul Hausmann, diagram of the Optophone accompanying his Optophone patent, 1926, page from the patent specification 446338 © VG Bild-Kunst, Bonn 2020

FIG. 5 Raoul Hausmann, "Vom sprechenden Film zur Optophonetik" (From Sound Film to Optophonetics), 1923. The article was first published in *G—Material für elementare Gestaltung* © VG Bild-Kunst, Bonn 2020

George D. Beauchamp and Adolph Rickenbacher launched their famous Hawaii guitar model Frying Pan after experiments to amplify the sound of guitars.

FILM AND THE OPTOPHONIC APPROACH TO MUSIC

Im played a special role in the development of electronic musical instruments because film had two techniques to produce sound: one was magnetic sound, and the other was optical sound. At the end of the nineteenth century, the light sensitivity of selenium was discovered. With the help of a selenium cell, the current flow could be varied by the intensity of the illumination. The changes in light were intended to control the production of sound. One could speak of photographic image and sound recordings. At the edge of the filmstrip visual patterns were noted, which controlled the changes of the light. This light writing, this graphic notation of the light at the edge of the filmstrip, not only recorded the sound, but also reproduced it. Blackened lines were the result when light fell through an aperture onto a light-sensitive filmstrip. This is how the sound filmstrip, the Photophonefilm, was created. The filmstrip with integrated soundtrack, the "Bild-Ton-Streifen" (image-sound-strip), made practicable by Joseph Massolle, Joseph Engl, and Hans Vogt, was first shown in 1922, in Berlin. Numerous optical sound instruments were built on this basis: The Selenophone by the physicist Hans Thirring (1929), the Cellulophone by Pierre Toulon (1927), the Syntronic Organ, and the Photona by Ivan Eremeef (1934/35).

The Dada artist Raoul Hausmann, in particular, is known for his invention (together with Daniel Broido) of the Optophone, patented in 1936, which used selenium cells to electronically translate beams of light into sound waves, and sound waves into light. In manifestos, he investigated ways of synchronizing perceptions of light and sound: "We demand electric, scientific painting!!! The waves of sound and light and electricity differ only in their length and frequency," he wrote in his 1921 manifesto "PRÉsentismus" (Presentism).[1] In another manifesto from 1933, "Die überzüchteten Künste" (The overbred arts), he wrote: "My dear musicians, my dear painters: You will see through your ears and hear with your eyes ...! The electric spectrophone will obliterate your ideas of sound, color, and form."[2]

The optophone, or spectrophone, as Hausmann called the color piano, was operated—much like a computer—by a keyboard comprising about a hundred keys, which corresponded to a hundred fields, each with a different chrome gelatin relief, whose spectral line shifts were beamed by a fluorescent lamp into a converging prism. The resulting play of colors was projected onto a screen, while photocells converted the variations in luminance into electronic pulses that produced audio effects via speakers.

SYNESTHESIA: MUSIC AND COLOR

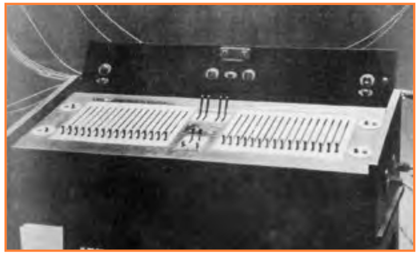
As the manifesto of Hausmann declares, with the spectrophone, or optophone, the dreams of synesthesia—for example, the Color Organ (Alexander Wallace Rimington, 1893),[3] the Sonchromatoscope (Alexander László, 1925), the Chromatophone (Anatol Vietinghoof-Scheel, 1920er), as well as the inventions of the Optophonic Piano (Vladimir Baranoff-Rossine, 1923), and the Clavilux (Thomas Wilfred, 1936)—entered the electronic age.

The artists looked for a scientific foundation between music and painting, between music and graphics, that was not built on color, but specifically on light and luminance. The idea was that variations of light could be transformed into variations of sound. The relation between moving images, moving machines, and music machines as the basis for future musical instruments is declared and evidenced by the title of Raoul Hausmann's article "From Sound Film to Optophonetics" (1923). To confirm the special role of film in the development of new musical instruments I would also cite Louis Favre's *La musique des couleurs et le cinéma* of 1927. After systematic explorations between color and music, mostly by painters and musicians, the relation between light and music became the source for synesthetic experiences. Film played a decisive role in the future optophonic turn of music. Pierre Schaeffer, the inventor of Musique concrète in the 1950s, also emphasized the influence of cinematographic techniques like recording and montage on his own musical practice.

FROM SYNESTHESIA TO SYNTHETICS

By 1930, visual research into synesthesia was over; the emphasis shifted from synesthetic to synthetic approaches. Sound and image were produced synthetically. The relation between sight and sound, of visual and musical elements, was built on the relation between light and sound.

For the filmmaker Oskar Fischinger, the desire for a scientific and technological definition of the interrelationships between sound and image was strengthened by the advent of new instruments such as Friedrich Trautwein's Trautonium (1930) and Maurice Martenot's Ondes Martenot (1928). The Trautonium was an important step in the development of electronic instruments. Paul Hindemith, Hanns Eisler, Paul Dessau, and Carl Orff took a keen interest in this instrument by writing compositions for it. But the success of the Trautonium is owed to Oskar Sala, who was a student in Hindemith's composition class. Sala later became famous for his soundtrack for Alfred Hitchcock's film *The Birds* (1963). In 1930 the brochure "Elektrische Musik" (electric music) by Trautwein was published. Trautwein already had ideas for sound reinforcement systems serving large rooms and therefore developed towers for assemblies of loudspeakers, Phil Spector's *Wall of Sound* (1962).



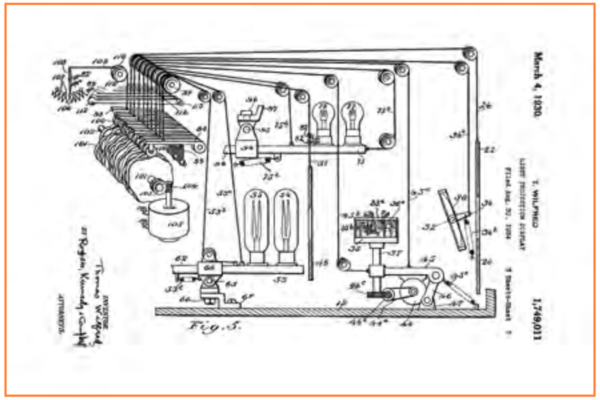


FIG. 6 Alexander Wallace Rimington and his Color-Organ, 1893. In Adrian Bernard Klein, *Color-Music. The Art of Light* (Lockwood and Son: London, 1926), plate 11, 190

FIG. 7 Alexander László's notation system for *Die Farblichtmusik* (Leipzig: Breitkopf & Härtel, 1925), appendix: *Die 24 Farbtonnormen nach Professor Ostwald*

FIG. 8 Alexander László's switching table of his Color-Light piano, 1925. In Peter Weibel, *Enzyklopädie der Medien*, vol. 2: *Musik und Medien* (Berlin: Hatje Cantz, 2016), 158

FIG. 9 Thomas Wilfred, *Light Projection Display Apparatus*, 1924, technical drawing of the patent. Thomas Wilfred papers (MS 1375). Manuscripts and Archives, Yale University Library

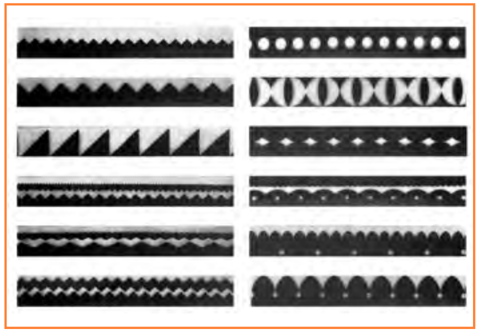
Fischinger, who recognized the similarity of image and sound in general, realized about 1930 that, broadly speaking, there was no fundamental difference between the abstract visual ornaments he used in his films and the patterns on the optical soundtrack that produced sound. It must be recalled that in this era, optical sound was used rather than magnetic recording, so visual and audio information were on the same filmstrip, with no additional magnetic tape involved. Fischinger could thus ask: What are the sounds in the objects (patterns)? He was concerned with the relation between sounds and shapes, i. e. what sounds could be generated by specific shapes, the visual patterns. Through an extensive number of experiments, his Ornament Sound experiments, Fischinger learned which patterns produced which sounds. He photographed the drawn “ornaments” onto the soundtrack area of the filmstrip. When played through a projector, they were translated into a kind of music. In 1932 he wrote about his experiments in a press release that garnered a great deal of attention and was widely distributed under the titles *Tönende Ornamente* and *Klingende Ornamente* (Sounding Ornaments). In the July 28, 1932 edition of the *Deutsche Allgemeine Zeitung,* he wrote: “Between ornament and music persist direct connections, which means that ornaments are music. If you look at a strip of film from my experiments with synthetic sound, you will see along one edge a thin stripe of jagged ornamental patterns. These ornaments are drawn music—they are sound.”[4]

Instead of music being modeled on painting, now music was being drawn directly onto a filmstrip; and by filming the drawn soundtrack frame by frame, the drawing could be transformed directly into the sound of a film. This “drawn music” on a filmstrip was the beginning of the graphic notation that lead to Daphne Oram, Iannis Xenakis, and others.

“Drawn music” is just another word for graphic notation. However, the graphic notation of the 1950s was interpreted by a person, whereas the graphic notation on a filmstrip was interpreted by a machine. This idea of music as graphic notation read by a machine was known and used around 800 CE. The three famous Islamic Banu Musa brothers (Muhammad, Ahmad, and al-Hasan ibn Musa ibn Shakir), living in early ninth century Baghdad, had already constructed a music automaton.[5]

GRAPHIC SOUND

The novelty in the 1930s was an optical track as source, graphically controlled variations of light waves that could turn into sound waves. Graphic patterns were turned by various devices into sound patterns. These ideas opened the way to the UPIC and other music machines. However, another film artist working in Munich had a very similar idea. In 1929, the animator Rudolf Pfenninger had developed what he called “Tönende Handschrift”



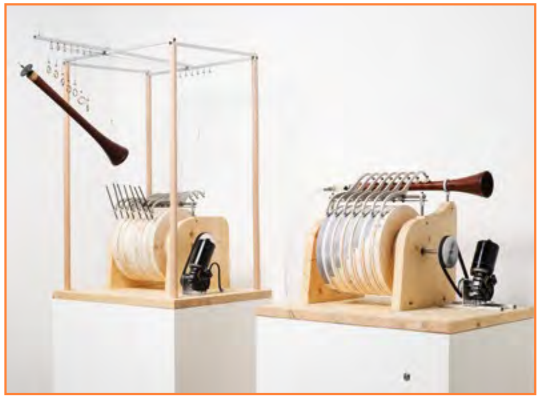


FIG. 10 The manufacturing of “scrolls” of Ornament Sound, Hans and Elfriede Fischinger are at the table on the left. Staged photograph for publicity purposes © Collection of Center for Visual Music

FIG. 11 Oskar Fischinger, *Sounding Ornaments* (Tönende Ornamente), ca. 1932, detail from larger display card © Collection of Center for Visual Music

FIG. 12 Reconstruction of the Banu Musa’s music automaton according to their description, 2015, exhibition view *Allah’s Automata* at ZKM | Karlsruhe © ZKM | Center for Art and Media Karlsruhe, photo: Harald Völkl

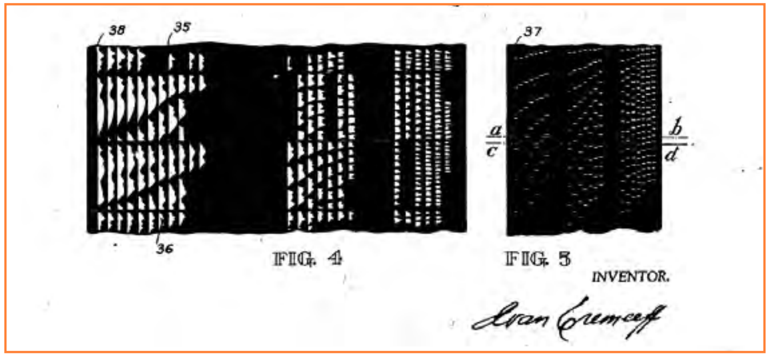


FIG. 13 Rudolf Pfenninger working on his "Tönende Handschrift" (sounding handwriting). The strips show the drawn optical sound which was copied onto the film using a camera. © Archives Thomas Y. Levin

FIG. 14 Arseny Avraamov, Drawings of ornamental soundtracks, Moscow 1930–1931. Courtesy of Andrey Smirnov © Andrey Smirnov Archive

FIG. 15 Evgeny Sholpo, Variophone optical discs with cut wave shapes, 1932. Courtesy and © Marina Sholpo

FIG. 16 The *Talking Paper*, tape recorder with photophonic tape, Polytechnic Museum, Moscow. Courtesy and © Peter Donhauser

FIG. 17 Ivan Eremeeff, quality and pitch film from a Photona patent, Feb. 25, 1936, page from the patent specification of the Photoelectric musical system, no. 2031764

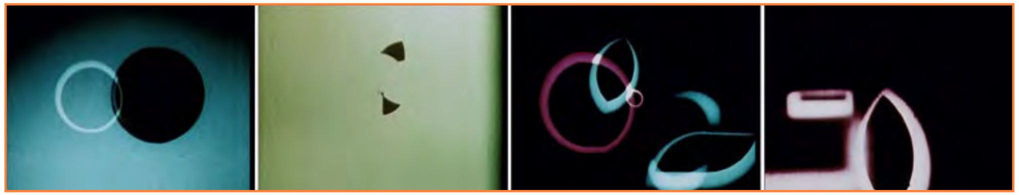
(sounding handwriting), which he presented to the public in 1932. He drew patterns on a strip of paper, filmed them directly with a movie camera, and incorporated them into the optical soundtrack, making him one of the first to produce "synthetic sound." Like the Canadian animator Norman McLaren after him, Pfenninger drew sound directly onto the film. Similar experiments with synthetic sound had already been conducted in Russia by Arseny Avraamov, Vladimir Popov[6], Mikhail Tsekhanovsky, Evgeny Sholpo, Nikolai Voinov, and Boris Yankovsky. Voinov was the first to synthesize piano sounds with his paper sound techniques. These were based on the synthesis of sound waves by means of paper cutouts with the carefully calculated sizes and shapes produced by his newly invented tool, the Nivotone.[7] In 1930 he was involved in the production of the first drawn ornamental soundtracks ("drawn music") at Avraamov's Multzvuk laboratory. In 1932 Yankovsky wrote a proposal for a patent of his own method of sound synthesis, based on Graphical Sound techniques. In 1933 he founded the Laboratory for Synthetic Sound Recording and invented the Vibroexponator.

These different attempts to combine light and sound, graphics and tone, took place on a manual-mechanical level in the first half of the twentieth century. In the second half, the paradigmatic setting of such synthetic dreams changed; they took place on the electronic level. The development of electronic devices for the production of music and pictures, the development of audiovisual synthesizers capable of synthetically generating not just sounds, but also images, resulted in a completely new possibility: the controlled transmission of any synthetically generated sound or image, in any modulation, through space.

Mary Ellen Bute is also an important pioneer of the new synthetic sound and image in cinema. She started to work with oscilloscopes to synthetically create abstract images in the 1950s. She thus called one of her films *Abstronic* (1952). With oscilloscopes there was for the first time an electronic screen instead of paper or film available for the graphic notation of sound. This idea became very influential for computer-generated sound or images. Bute's aesthetic credo was "seeing sound," or "visual music,"[8] which would later become a slogan of the music video industry.

After World War II, following the classic period of handmade synthetic moving images and sounds, the era of the mechanically aided, mechanically generated synthesis of image and sound began. In the late 1960s, video spawned the first attempts involving electronic images, which culminated in the computer-aided and computer-generated images and sounds of today.

James and John Whitney, the pioneers of computer art, produced between 1943 and 1944 their *Five Film Exercises*. They created a special



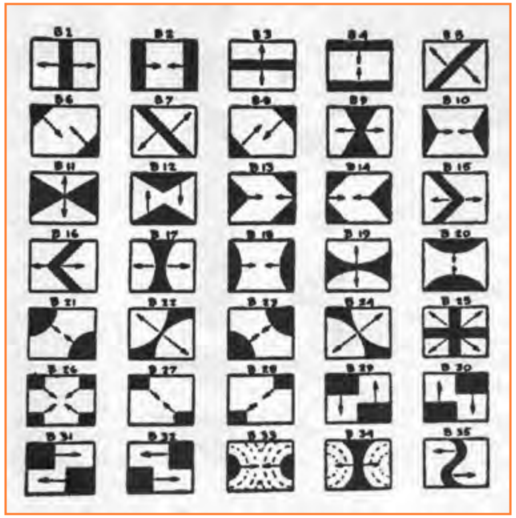


FIG. 18 John and James Whitney, *Five Film Excercises*, 1944, film stills © J&J Whitney / Cinédoc PFC

FIG. 19 Image illustrating John Whitney's essay "Bewegungsbilder und elektronische Musik" 1960. In *Die Reihe. Informationen über serielle Musik*, no. 7, 1960, 62–73, here 64

FIG. 20 Peter Weibel, *Autogenerative Sound Screen. The Magic Eye*, Multi Media 1, Galerie Junge Generation, Vienna, Austria, 1969 © Peter Weibel, photo: Joseph Tandl

machine, which generated synthetic optical sound for the abstract *Five Film Exercises*. They used a graphic matrix, which delivered different patterns, negative and positive masks. The optical soundtrack was controlled by light through slits connected to a moving pendulum. With this method they created a new kind of shutter. Their matrix predated the use of presets in the later computer technology, a kind of keyboard to choose graphical ways of seamless transition from one scene to another instead of cutting.

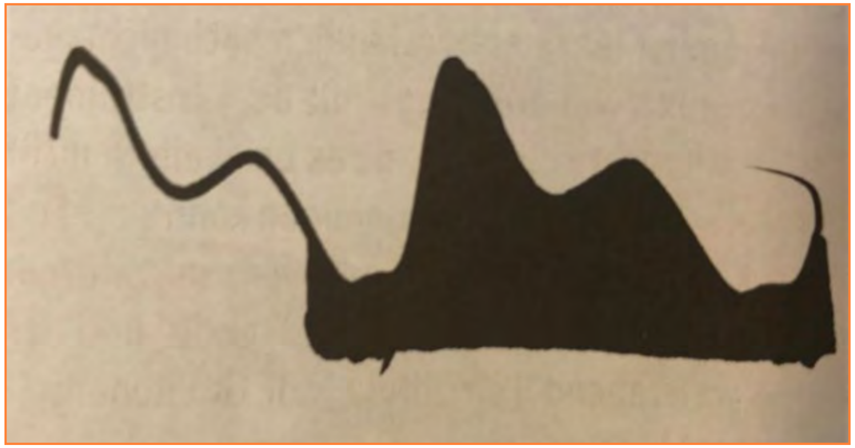
In the Viennese journal *Die Reihe, Informationen über serielle Musik*, the Whitneys published in 1960 the important paper "Bewegungsbilder und elektronische Musik" (moving images and electronic music), which is about their work and the relation between moving machines, moving images, and music. Again, this proves my point of how important film, with its optical devices, was for the evolution of new musical instruments. I, myself, also worked with optical sound and made it the central feature of my *Autogenerative Sound Screen* (*The Magic Eye*, 1969). Normally, the optical sound is located on the filmstrip and comes from the projector. I took light-dependent resistors (LDRs), which transform light waves into sound waves (bright light into high pitch sound and darkness into low pitch sounds), and put these on a transparent screen. On the screen I projected a film with optical patterns (e.g., Kurt Kren's short 16mm film *11/65 Bild Helga Philipp,* 1965).[9] The projected film created the sound, the source of which was the screen. Another variation was no projection, only the shadows caused by moving spectators in front of the screen.

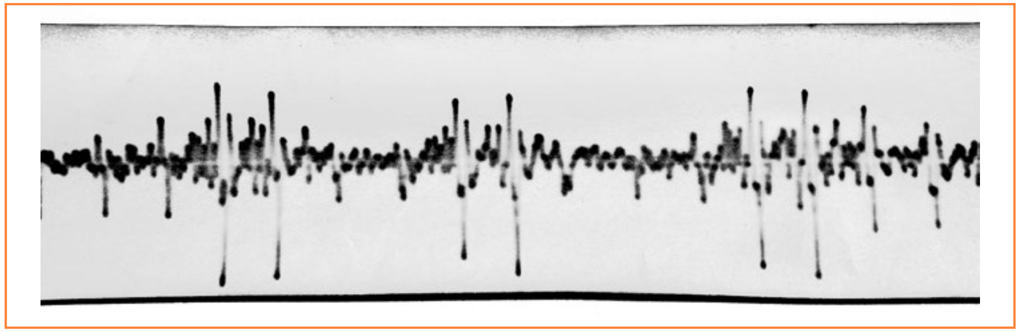
OPTOELECTRICAL INSTRUMENTS

Another musical instrument based on the optical sound principle was the Rhythmicon or Polyrhythmophone (1931), developed by the American avant-garde composer Henry Cowell. Two perforated discs positioned one behind the other rotate simultaneously and, when the holes match, release a light beam onto a photocell. On one disc there are 16 rows with perforations for different rhythms, for example, a keyboard illuminates different rows and makes them audible.

Among the many mechanical and electronic devices that created the New Music of the twentieth century, the optophonic and screen approach (photocells, lamps, luminance, light-dependent resistors, oscilloscopes, etc.) played a decisive role in the emergence of the UPIC.

Another important optical sound experiment is the *Variophone* by Evgeny Sholpo in 1930 with which sounds without musicians could be produced automatically without a performer. Already between 1917 and 1918 Sholpo wrote a science fiction essay "The Enemy of Music" in which he described a musical machine, capable of synthesizing complex sound spectra according to a special graphical score.





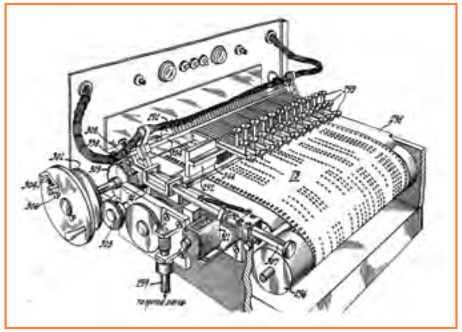


FIG. 21 Edwin Welte, painted oscillogram as the basis for printing on sound discs. Courtesy and © Augustinermuseum Freiburg

FIG. 22 Filmstrip with an oscillogram. Courtesy and © Peter Donhauser

FIG. 23 Harry F. Olson, Princeton, and Herbert Belar, Palmyra, NJ, assignors to Radio Corporation of America, a corporation of Delaware, 1958, page from the patent specification Music Synthesizer 2,855,816. Courtesy and © Peter Donhauser

Yankovsky founded with Sholpo in 1939 the new Laboratory for Graphical Sound in Leningrad. In 1944, B. N. Skvortsov developed a device with a paper tape on which eight tracks of optical sound were printed, called the Talking Paper.

With devices like the Photona (or the WCAU organ by Ivan Eremeeff, 1935) and Talking Paper by B. N. Skvortsov, we were then very close to electronic musical instruments, because both paper and pitch film are already comparable to predigital technologies like Hollerith punch cards, binary coded paper tapes, and so on. The process of optical sound technology allowed different forms of vibration in the form of visual blackening patterns, for example, on transparent films or on paper, to be converted into current fluctuations and thus into audible signals.

After the intuitive phase of synesthesia, electrical devices were actually built that could convert light fluctuations into power fluctuations and then into sound fluctuations on a scientific basis. This is the basic idea for the future computer-aided scanning systems for generating sound like the UPIC. The optical methods for generating sound, which were able to realize any waveforms and thus timbres, culminated in the introduction of microprocessors in synthesizers.

The Light-tone Organ (Lichttonorgel), developed by Edwin Welte in the 1930s, was another important step towards the machine version of graphic notation. Optical sound on filmstrips had been the solution for recording music for a long time. Oscillation curves were transferred to the sound discs of the organ. In the process, recordings of sound oscillations were used and these curves were artificially generated mathematically and graphically by sound synthesis, as Rudolf Pfenninger had already demonstrated with his painted sounds at the beginning of the 1930s. The future of electric music thus seemed open by way of the Light-tone Organ.

ELECTRONIC MUSIC

The invention of purely electronic instruments began with the invention of the Audion Three-electrode Vacuum Tube in 1906 by Lee de Forest, who presented his own Audion Piano in 1915. The *Dynaphon* by René Betrand (1928), with whom Edgar Varèse worked, is one of the most important instruments for the development of electronic music. In 1929, Armand Givelet and Edouard Coupleux introduced a Synthétiseur Polyphonique, an electronic organ.

Physicist and acoustician Werner Meyer-Eppler, from Bonn, took a decisive step by establishing the term electronic music between 1949 and 1953. For him, music, in a strict sense, was only electronic if the range of acoustically perceptible oscillation processes is extended by electronic sound generators, like for example oscillators. The Siemens Studio for Electronic Music in Munich from 1955 consisted of devices for generating electronic sounds. One of Carl Orff's students, Josef Riedl, specialized in electronic sound design. For the documentary film *Impuls unserer Zeit* (The impulsion of our time, 1959), Riedl used the first electronic music produced with binary coded paper tape.

In the 1950s the Columbia-Princeton Electronic Music Center (CPEMC) was established at New York's Columbia University by the composers Vladimir Ussachevsky and Otto Luening. Experiments were conducted with Ampex tape recorders: Speed changes, feedback, reverse playback, and so on. There already stood the famous first programmable synthesizer Mark II, manufactured in 1957 by the Radio Corporation of America (RCA) in its Sarnoff Lab in Princeton. Mark II was the successor to Mark I built by Harry F. Olson and Herbert Belar between 1952 and 1955. Mark I consisted of twelve oscillators controlled by four perforated paper bands, frequency counters, and filters.

From 1962 to 1966 the *San Francisco Tape Music Center* involved some composers, including Ramón Sender, Morton Subotnick, Pauline Oliveros, Steve Reich, and others. The collaboration between Morton Subotnick and Donald Buchla resulted in the modular synthesizer Buchla 100.

SCANNING PRINCIPLE, OSCILLOSCOPES, AND SYNTHESIZERS

In the years between 1945 and 1948 the Canadian physicist Hugh Le Caine had already developed a kind of manual keyboard, a touch pad with different surfaces for different instruments, as well as for waveforms. The instruments were assigned to sensor fields. He named this instrument Electronic Sackbut.[10]

The touchpad anticipated the new digital interface technology. The use of scanners was a different method to control a sensor field. It was the astronomers who began scanning star photographs with an oscilloscope in 1946. On the oscilloscope screen, a vertical luminous line is generated, which is quickly deflected from left to right, like the light source of the photocopier. A photocell converts this light into electric current. Continuing the work of Edwin Welte and Rudolf Pfenninger, with the scanner, which transformed optical oscillation images into synthetic sounds, a new method for the future was invented; namely, the scanning of drawn curves by the light of an oscilloscope display. Since the illuminated dot on the oscilloscope screen can be moved as quickly as desired, the instrument is referred to as a "flying spot scanner". Today we speak of "wavetable synthesizers".

Two composers stood out in particular, Max Brand and Daphne Oram. Born in Lemberg, Max Brand lived in the USA from 1940. There he developed his "flying spot scanner" in 1957. In front of the oscilloscope screen, cardboard or metal stencils with curved shapes could be pushed around. A concave mirror concentrated the light of the oscilloscope on a light-sensitive

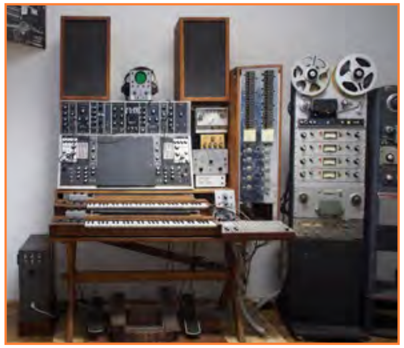
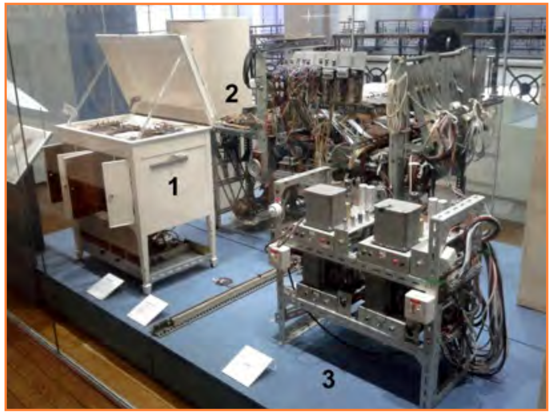


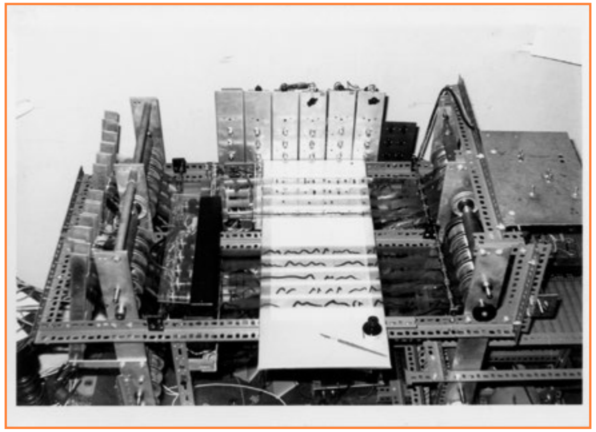
FIG. 24 Hugh Le Caine at his Electronic Sackbut, with his left hand controlling the touchpad. Courtesy of Andrey Smirnov © Andrey Smirnov Archive

FIG. 25 Max Brand's Synthesizer. Courtesy and © Peter Donhauser

FIG. 26 Daphne Oram's timbre waveforms. Wikimedia commons © CC BY 2.0

FIG. 27 User interface of an Oramics composition machine, showing a set of 35 mm films, a drawing board (center), film scanners (left label), and photomultiplier amplifiers (rear units) which convert shapes on the films into signals that control the pitch, timbre, amplitude, etc. of the generated sound. Wikimedia commons © CC-BY-SA-3.0





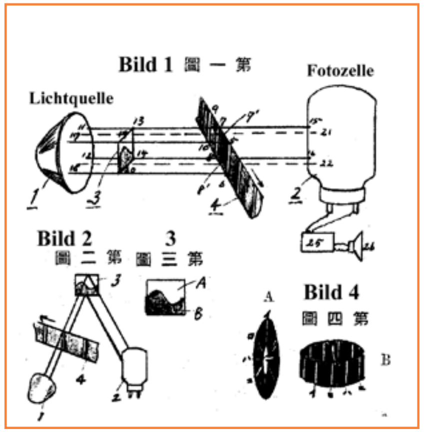


FIG. 28 Construction of the entire Oramics machine for an exhibition at the London Science Museum: 1. Flying spot scanner, 2. programming machine, 3. power amplifiers. Courtesy and © Peter Donhauser

FIG. 29 Programming unit of the Oramics machine, ORAM/7/9/044. Courtesy of Goldsmiths Special Collections & Archives © Daphne Oram Trust, photo: Fred Wood

FIG. 30 Methods of light deflection, Shibata patent. Courtesy and © Peter Donhauser

germanium photocell or photomultiplier. This converts the drawn sound into a synthetically produced real sound. Max Brand commissioned a synthesizer from Robert Moog in 1966 with many special features, the Moogtonium, a mixture of Oskar Sala's Mixturtrautonium and a Moog Synthesizer.

Various patents for scanners were applied for: David E. Sunstein with his Photoformer (1949), a mask controlled feedback system; Marlin Davis, who combined two flying spot scanners in 1947 and Douglas R. Maure, who invented the Function Generator in 1955 together with Robert W. Kettlety. This was a stencil in front of an oscilloscope tube together with a photocell allows the illuminated dot on the screen to follow the contour of the shutter.

From 1962 Daphe Oram used her own Oramics, her electronic composition machine.[11] Because conventional staff notation with five lines beginning with a treble or bass clef was no longer adequate, she proposed graphic notation. Composers could draw onto transparent filmstrips. These filmstrips covered a series of photoelectric cells that generated an electric charge to control the frequency, timbre, amplitude, and duration of a sound. Daphne Oram used four flying spot scanners in 1967, again placing the stencil in front of the tube and the illuminated dot scanned the contour using the photocell. Strips on transparent films switch on various functions, such as audio frequency, by means of light barriers. She summarizes her research in her book *An Individual Note of Music, Sound and Electronics* (London: Galliard, 1972). Her goal was to use a pencil to design the desired curve shapes, which would then be scanned and produce audiowaves.

Two further optoelectrical scanning methods should be mentioned: Mr. Shibata's patent in Japan in 1936 and Evgeny Murzin's ANS synthesizer (in honor of composer Alexander Nikolayevich Scriabin, with whom Murzin worked with from 1937 to 1957.)[12] In Shibata's case, for example, a filmstrip containing slits was scanned through a beam of light.

The ANS Synthesizer consists of five rotating discs, each with 144 individual tracks, and an opaque glass plate covered in nondrying black mastic, which constitutes a drawing surface. A glass plate covered in non-drying opaque black mastic, which constitutes a drawing surface. The user makes marks by scratching through the mastic, and thus allows light to pass through at those points. In front of the glass plate there is a vertical bank of photocells that send signals to amplifiers and filters. The glass plate can then be scanned left or right in front of the bank of photocells in order to transcribe the drawing directly into pitches.

GRAPHIC NOTATION—MUSICAL GRAPHICS

The turn to New Music prompted by new sound and noise generators brought with it a crisis of conventional notation. The notation of the score can be understood both as documentation and as the composer's instructions for the vocalists and instrumentalists. The Benedictine monk and music theorist Guido of Arezzo is regarded as the inventor of modern musical notation. The notation system he invented, based on four lines, is described in his major work, *Micrologus de disciplina artis musicae,* which was written around the year 1025. Before Guido, musical notation involved symbols known as *neumes,* which were usually written above the words of a text to be sung but provided no information on a tone's exact duration or pitch; the actual melody was passed on orally.[13] Symbolic notation using a system of lines enabled a concept of the work to be developed that reached its first peak with the historicism of the nineteenth century and the great editions of the collected works of Johann Sebastian Bach, Wolfgang Amadeus Mozart, and Ludwig van Beethoven.

With the arrival of new instruments that produced new sounds, conventional notation was no longer sufficient. Thus the development of graphic notation and musical graphics began in the 1930s and burgeoned in the 1950s. Musical notation became diagrammatic drawings on the two-dimensional surface of the paper: graphic notation. With the help of new technologies such as oscillographs and computers, this evolved into the graphic user interface, the touchscreen, the point of contact between human and machine. Running one's fingers over this surface produced music: The instructions of notation were simultaneously their execution. The notation became the instrument. The user was composer and performer rolled into one.

Attempts to improve, simplify, expand, and complete classical notation got under way in the first half of the twentieth century, as evidenced by Oskar Rainer's *Musikalische Graphik* (Musical Graphics, 1925).

The new compositional techniques and principles led to musical graphics as a form of notation, which completely abandoned notation based on traditional interval theory.

Three books published in the mid-1960s took stock of the new graphic musical notation revolution. First: In 1965, the ninth volume in the series *Darmstädter Beiträge zur Neuen Musik* provided a summary of what had been presented and discussed at 1964's nineteenth annual International Summer courses for New Music, with composers (György Ligeti, Roman Haubenstock-Ramati, Mauricio Kagel, Earle Brown) as well as instrumentalists (Siegfried Palm, Aloys Kontarsky, Christoph Caskel) voicing their opinions on the topic of musical graphics. In the essay "Neue Notation—Kommunikationsmittel oder Selbstzweck?" (New notation: A means of communication or an end in itself?), Ligeti defines the differences between conventional musical notation and musical graphics very clearly: "Fundamentally, then, 'notation' and 'musical graphics' are (to make a more precise distinction) two different realms. [...] 'Notation' is not a

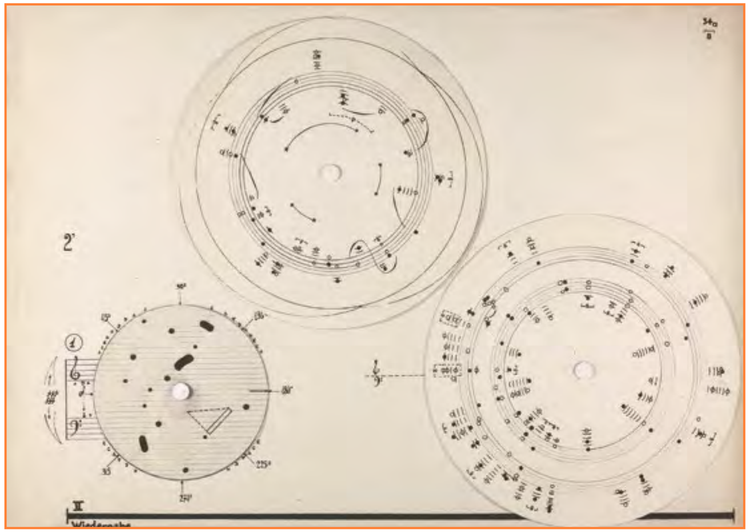


FIG. 31 Oskar Rainer, *Musikalische Graphik. Studien und Versuche über die Wechselbeziehungen zwischen Ton- und Farbharmonien* (musical graphics. studies and experiments on the interrelations between tone and color harmonies, Vienna, Austria: Jugend & Volk, 1925), cover of the first edition

FIG. 32 Hans Kohn, *Walkürenritt* (Ride of the Valkyries), 1920, "Nachschrift zu Richard Wagner (Postscript to Richard Wagner)," charcoal on paper. In Oskar Rainer, *Musikalische Graphik. Studien und Versuche über die Wechselbeziehungen zwischen Ton- und Farbharmonien* (Vienna, Austria: Jugend & Volk, 1925), 63

FIG. 33 Mauricio Kagel, *Transición II | für Klavier, Schlagzeug und 2 Tonbänder* (score for piano, percussion, 2 tapes, 1958–1959). Courtesy of Universal Edition A.G., Vienna, Austria and Sammlung Mauricio Kagel, Paul Sacher Stiftung, Basel, Switzerland © Universal Edition (London) Ltd., London/UE13809 ‘representation’ of musical events, nor is it a ‘depiction’ of the movements (actions) that lead to the creation of music (although a subset of notation can relate to such actions); rather, it is a system of signs and at the same time a system of relationships between these signs that brings music into being in consequence of its correspondence to musical relationships. The visual sign system of notation corresponds to a system of auditory events; it denotes musical relationships.

A ‘musical graphic,’ on the other hand, is not a sign system. It does not denote musical relationships. It can, however, be a representation (depiction) of the events that lead to the creation of music; it can also suggest musical ideas and implementations through association.

There is an interrelationship between music and the visual configurations associated with it. A ‘musical graphic’ gives rise to an entirely different kind of music than a ‘notation’ does.”[14]

Kagel closely investigates the inversion, brought about by new notation, of the classical sequence “composition—notation—interpretation”:

‘*It took a long evolution for musical notation to travel from indistinctness, vagueness, and ambiguity to precision and an ever more indelible clarity,’ wrote Willy Tappolet in 1949 in his book* La notation musicale. *As we see today, it has taken a short evolution for musical notation to find its way back to the indistinct, the vague, and the ambiguous. […] The transformation to which musical notation is today subjected has at the same time blown up the traditional structure: AUDITORY IDEA (composition) => DOCUMENTATION (notation) => AUDITORY PROCESS (performance).*

Notation no longer functions as a mediating element, but can now occupy the first and last positions in the configuration. The reform efforts of the past fifteen years have had such a radical effect on our thought processes in the area of notation that the sequence of auditory idea, documentation, and auditory process has by now been put through every possible combination.[15]

And Earle Brown gives the most detailed statement in *The Notation and Performance of New Music*: “The ‘decorative’ value of a score is in itself a pleasure but I am more concerned with the possibilities of a notational system that will produce an aural world which defies traditional notation and analysis and creates a performance ‘reality’ which has not existed before.”[16]

He continues: “The early development of musical notation proceeded, of course, in the direction of more and more discrete control of all the elements and did not achieve its ‘standard’ appearance until after 1600 and its standardization of performance practice (the function of the conductor as we know it) until approximately 1800.”[17]

Brown gave a great deal of thought to the idea of direct contact between composer and sounds. This led to an engagement with notation and its execution that can perhaps best be seen and heard in *Folio*—and is further developed in *Available Forms I* (1961) and *II* (1962)—in which the conductor seems to paint “with a palette of […] composed sound events.”[18] Brown mentions Charles Ives as one of the first composers whose conceptual approach and powers of musical imagination declared war on traditional notation. Ives’s music made a genuine effort, he says, “to disengage infinite sound from finite graphics.”[19]

But Ives was not the only one to mark out and follow new paths. Leo Ornstein “devised notation for ‘tone clusters’ when the standard notation (primarily developed for triadic vertical structures) made the clusters visually contrary to the desired simultaneity. William Russell wrote much percussion music in the 1930s and 1940s and devised a notation for playing on the strings of a piano with a dining fork, and for all of the eighty-eight notes of the piano to be struck simultaneously; Henry Cowell devised notations for playing directly on the strings of the piano, as in *Banshee*.”[20]

So Ives, Cowell, and the others had already attempted, in the first half of the twentieth century, to free music from the straitjacket of interval theory and the vise of conventional notation. And Russell had apparently invented the prepared piano (à la John Cage). Brown engaged with the notation problem in 1952 in order to address “the problems of mobility and immediacy […] throughout the composer–notation–performance process.”[21]

Two other books that heralded the graphic notation revolution in music were *Das Schriftbild der neuen Musik* (*Notation in New Music*) by the composer Erhard Karkoschka, which was published in 1966 and contains the author’s enlightening explanations and commentaries; and *Notations*, a collection of scores by 269 living composers, which was compiled by John Cage with Alison Knowles and published by Something Else Press in 1969. Rather than providing direct explanations or commentaries, the accompanying texts were, like the typography, the result of chance operations.

In the 1950s and 1960s, the phrase “musical graphics” became a catchall for any radical experiment in New Music. Notation changed from an extremely precise, clearly defined specification to an action for free performers, to the indeterminacy of chance in Cage’s work. The score became an arena of action for the performer.

The decisive factor was the evolution of the concept of notation from pure documentation to action notation, i.e., instructions. Whether “graphic notation” or “musical graphics,” “notational image” or “visual music,” all these names point to a fundamental transformation of music in the mid-twentieth century in response to the advent of technological devices.

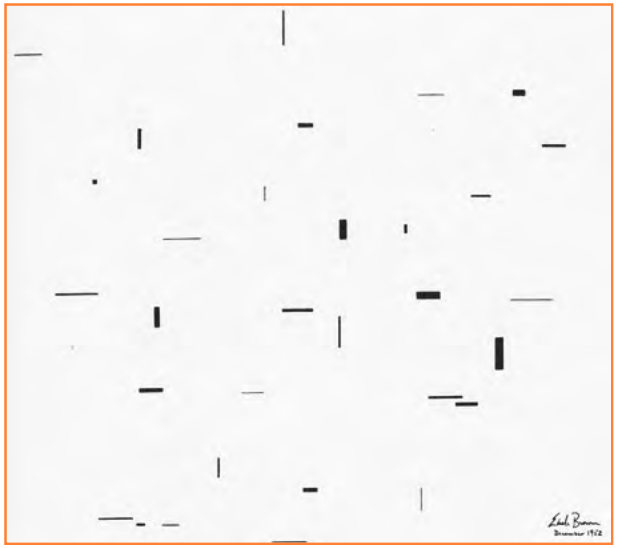


FIG. 34 Earle Brown, *December 1952*, 1952, musical graphics. Brown conducted from this score at the Darmstadt Summer Courses for Music in 1964. © Associated Music Publishers Inc., G. Schirmer Inc / Edition Wilhelm Hansen GmbH. Courtesy of Bosworth Music GmbH

FIG. 35 Earle Brown, *Available Forms I*, 1961, score for chamber music ensembles © Associated Music Publishers Inc., G. Schirmer Inc / Edition Wilhelm Hansen GmbH. Courtesy of Bosworth Music GmbH

FROM GRAPHIC NOTATION TO GRAPHIC USER INTERFACE

The composer or musician looked for a direct contact between notation and sound. They invented different technologies for this purpose. Graphic notation was a decisive step in this development. A classical score is already a set of directions that tells the musician exactly what to do with his or her instrument at specific moments. With a score, instead of an interpreter's second-by-second movements (with an instrument or a machine) being photographically recorded and described, an interpreter's second-by-second movements (with an instrument) are graphically defined and prescribed. A score is a set of instructions—work instructions, performance instructions, instructions for use—for the performer, the interpreter. On one side is the subject, the executing musician; on the other is the object, the machine, the musical instrument. Between them stands the score, in which the transformations of the parts of the subject's body (hands, mouth, etc.) are described, transcribed, and prescribed as phase changes in the interaction with the object (violin, etc.). Musical notation is therefore an interface between the subject and the world of objects, created to realize a previously imagined or intended sound in the here and now. The traditional score is an interface between human and instrument (machine); as such, it is interaction design. But it is also an algorithm, a set of directions, which consists of a finite number of rules and clearly defined instructions, and which precisely and completely describes the solution to a problem, or rather, a composition. The question, posed by Schoenberg, of how a composer moves from one note to the next,[22] is answered by the algorithm of the score.

An algorithm is a sequence of instructions, formulated according to the rules of a language, which enables a computer to execute a task. In the same way, a score is a set of instructions, formulated according to rules, which enables humans to execute a task. In that respect, the score is an early higher-order machine language, an algorithm. Graphic notation introduced ideas into music as practices before they were technologically feasible.

Under the guidance of the composer Milton Babbitt, a variety of electronic musical instruments were already in use in the 1950s, such as RCA's Mark I and Mark II music synthesizers. Another composer was Raymond Scott, born in the United States in 1908, who was also a pianist, sound engineer, and electronic music pioneer. Less well known are Scott's achievements in inventing electronic musical instruments, which he had already begun in the 1940s. He was the founder of Manhattan Research in 1946, which became one of the most advanced studios for the creation of electronic music. With ring-modulators, filters and other devices, he set up the Wall of Sound with a built-in Circle Machine, a kind of sequencer.[23]

FIG. 36 Raymond Scott, Wall of Sound © Reckless Night Music LLC and RaymondScott.net

FIG. 37 Raymond Scott with his Clavivox © Reckless Night Music LLC and RaymondScott.net

FIG. 38 Don Buchla sitting in front of one of his instruments © Buchla U.S.A.

A rotating arm, at the end of which a photocell was attached, scanned 16 light bulbs during the circular movement, the brightness of which could be individually adjusted. Various musical parameters could be influenced by the photocurrent. Many of Scott's inventions anticipated modules that would later become parts of synthesizers. For example, he invented an early trigger delay device, portable waveshape generators, preset programming devices, and so on. In the late 1950s, Scott also developed instruments, such as the Clavivox, a keyboard synthesizer, an automatic composition machine called Electronium, and an electronic sequencer he named Karloff.

The term "synthesizer" had already been introduced, such as the ANS Synthesizer and Mark II, but it was Donald Buchla and Robert Moog who made modular synthesizers financially affordable in the 1960s because they were mass-produced. The Moog synthesizer could be operated in real time and controlled via a normal keyboard. Moog had met Scott in the 1950s, designed circuits for him in the 1960s, and acknowledged him as an important influence.[24] Like Moog, Wendy Carlos (born Walter Carlos) was a student of Vladimir Ussachevsky's from the Columbia-Princeton Electronic Music Center. In 1968 her record *Switched on Bach* was released, which she had recorded after experiments with Moog Synthesizers. This record became a worldwide success and popularized synthesizers. Many other synthesizers capable of generating tones electronically through sound synthesis followed, from Tom Oberheim to Yamaha, from Korg to Roland synthesizers.

The modules of Moog Synthesizers consisted of signal generators, noise generators, voltage-controlled oscillators, modulators, and so on, all connected by a circuit board. But it was not until these synthesizers became polyphonic—that is, able to produce more than one tone at a time— and capable of storing settings in memory that they gained widespread popularity and mass appeal. With the Fairlight CMI, which was also a sampler, and the Yamaha DX7 in 1983, digital synthesizers displaced the analog models. The Roland D50, introduced in 1987, was particularly popular.

Today, electronic music is largely computer music that is realized on the basis of specially programmed algorithms and self-programmed software. This development began in the 1950s. The first digital synthesis (*Silverscale*) was made by Max Mathews and Newman Guttman in 1957. Joseph Schillinger's theories on the mathematical basis of the arts[25] were taken up in 1963 by Robert Baker and Lejaren Hiller to create MUSICOMP: a computer program based on standard programming languages such as FORTRAN, which was designed to generate musical scores. One of these was their *Computer Cantata* (1963);[26] later compositions bore the telling titles *Algorithms I* (1968) and *Algorithms II* (1972). Lejaren Hiller and Leonard Isaacson wrote the famous *Illiac Suite* with their own software (MusiCOMP in FORTRAN) with the mainframe *ILLIAC* in 1957. In 1946, Denis Gabor, the inventor of holography, created a kind of short-time Fourier transform, the Gabor transform, named after him. Small sections (tone quanta, or “grains”) of a maximum length of 20 msec are cut out of the sound material and form the basic material for new sounds. This is why we speak of “granular synthesis.” Iannis Xenakis developed a composition theory based on grains. He used numerous pieces of tape up to 1 second in length for his first composition *Concret PH*, which was performed at Expo 1958 in the Philips Pavilion in Brussels. Curtis Roads was the first to use the computer for granular synthesis in 1981.

However, the use of computer programs to create sounds proved to be quite laborious, prompting a search for better forms of human-computer interaction. In 1963 Ivan E. Sutherland published his epochal work *Sketchpad. A Man–Machine Graphical Communication System*.[27] This opened the door to the interface technology of the future. His console was also the decisive breakthrough in music from the changeover from graphic notation to the Graphic User Interface in music. The “drawn music” was no longer executed on paper or filmstrips, but through direct interaction with the computer on the screen. This procedure is also the starting point for the UPIC, mixed with scanner techniques.

Max Mathews and Lawrence Rosler used a graphic input computer named Graphic 1 in 1965.[28] The Graphic 1 console was a computer system with a light pen for real-time graphic input, a keyboard for alphanumeric input, a card reader for binary input, and a cathode ray tube for graphic output. It also included a DEC PDP-5 Computer, a DEC 340 oscilloscope, and the appropriate hardware interfaces. Tone sequences were represented by graphs, and compositions were produced algorithmically.

The Graphic 1 enabled the user to enter images and symbols directly into the computer’s memory by drawing them. The drawings could also be retrieved, deleted, duplicated, and modified. The Graphic 1 was originally intended as a tool for designers, but a musical composition can also be understood as a design problem: Not only can computer sounds be designed, they can also be produced with computers, and algorithms can be useful for creating parts of the music with the aid of the computer. A graphic notation language was invented so that the score of a piece could be specified as a set of graphs. The heart of the system was the program *MUSIC IV* for the IBM 7094 computer.

Mathews and Rosler developed their graphical language for the scores of computer-generated sounds based on a computer language

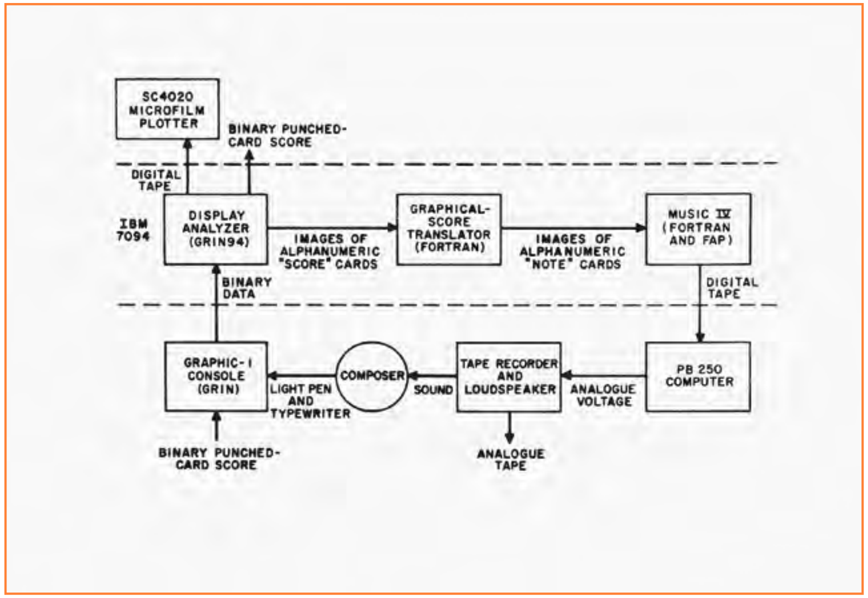


FIG. 39 (left) Ivan E. Sutherland, Sketchpad console: The first graphic human–machine communication system, 1962. In Peter Weibel, *Enzyklopädie der Medien*, vol. 3: *Kunst und Medien* (Berlin: Hatje Cantz, 2019), 667

FIG. 40 (right) *Graphic 1* terminal, 1965. The Graphic 1 was developed in 1965 by William Ninke (together with Carl Christensen and Henry S. McDonald) at the Bell Laboratories computation center at Murray Hill N. J.. Lawrence Rosler and Max Mathews utilized the terminal to develop interactive graphical music. Reused with permission of Nokia Corporation and AT&T Archives

FIG. 41 Max Mathews and Joan Miller, MUSIC IV for IBM 7094, 1963. Synthesis software for computer music to be used on the *Graphic 1*. In Peter Weibel, *Enzyklopädie der Medien*, vol. 2: *Musik und Medien* (Berlin: Hatje Cantz, 2016), 357

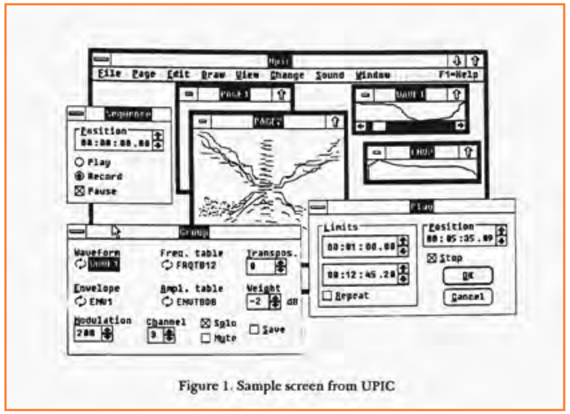


FIG. 42 Iannis Xenakis, UPIC whiteboard © CIX Archives

FIG. 43 Iannis Xenakis, Sample Screen of UPIC 3 © CIX Archives

FIG. 44 Iannis Xenakis, UPIC – Unité Polyagogique Informatique du Centre d'Etudes de Mathématique et Automatique Musicales, 1977. Installation view, *Art in Motion*, ZKM | Karlsruhe, 2018/2019 © ZKM I Center for Art and Media Karlsruhe, photo: Tobias Wootton

called GRIN. The GRIN program they used to create graphic scores divided the console display into two sections: an area for "light buttons" and messages to the composer, and a grid on which the music functions were displayed.

Conventional scores are an insufficient and inconvenient way of describing sound sequences to computers. A procedure is described for drawing scores as graphical functions of time by using a light pen on a cathode ray tube attached to a small computer. The information is transmitted digitally to a larger computer, which synthesizes the sound and reproduces it immediately with a loudspeaker. […] The graphical programs provide great flexibility for drawing, copying, erasing, and altering functions. Thus it is easy to develop a sound sequence by a succession of trials. Microfilm and punched-card versions of the score are automatically provided. In addition to being compositional tools, the graphical scores are effective representations of the sound to a listener. In many ways they are easier to follow than conventional scores.[29]

In Buenos Aires, Argentina, important research was undertaken and results achieved at the Electronic Music Lab, Laboratorio de Música Electrónica del Centro Latinoamericano de Altos Estudios Musicales, of the Instituto Torcuato Di Tella. In 1970 Pedro Caryevschi created *Analogías Paraboloides* (for tape), which was the first composition that used the Analog Graphic Converter (Convertidor Gráfico Analógico) invented by Fernando von Reichenbach. This device could convert graphic scores from a paper roll into electronic control signals adapted for musical use with analog instruments, capturing the drawn images with a camera. At the end of a long road, there it was: drawn music instead of notes, not drawn on paper but on a screen, consoles instead of instruments, a user interface instead of graphic notation, a direct physical, interpreting device instead of a human interpreter. In the 1970s, Xenakis's UPIC (Unité Polyagogique Informatique de CEMAMu, Centre d'Ètudes de Mathématique et Automatique Musicales) project captured what was historically inevitable—that is, the transformation of graphic notation into a computer-assisted graphic user interface. The UPIC system used an AT 386 microcomputer and a mouse-controlled graphic interface which enabled real-time drawings to generate and store music.

Once the necessary technology was available—specifically, a touchscreen—tones could be generated simply by touching the score. The performer did not have to translate the notes he or she had read into fingerings on musical instruments, but could cause the notes to sound by pressing a finger on them on the graphic user interface of the touchscreen. Consequently, a favorite educational installation at music museums involves a score that is placed behind a pane of glass and also

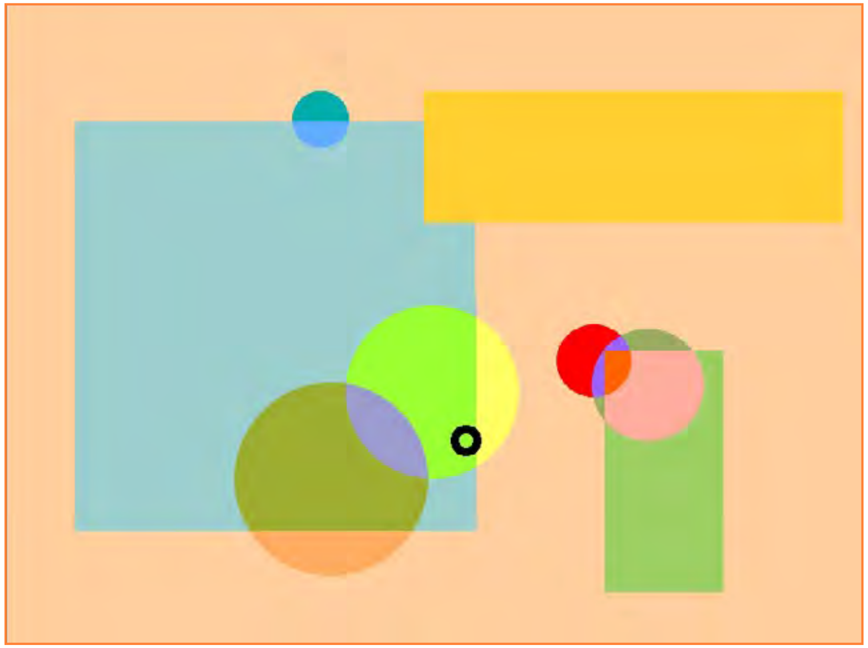


FIG. 45 Masaki Fujihata, Kiyoshi Furukawa, and Wolfgang Münch, *Small Fish*, interactive sound installation, 1999 © ZKM I Center for Art and Media Karlsruhe and the artists

marked on the surface of the glass. Visitors can activate this haptic score with the touch of a finger, which transmits the information to a computer, so that touching the notes produces the corresponding sounds and melodies.

Thus the promise of the revolution in graphic notation was only realized later by the technological revolution of the graphic user interface, the touchscreen. Today, the use of the interface as a graphic score takes place on countless laptops, tablets, and smartphones.[30] The profusion of music applications in the digital realm is the product of graphic notation since the 1950s. A pioneering role was played here by the interactive CD-ROM *Small Fish*, produced by Masaki Fujihata, Kiyoshi Furukawa, and Wolfgang Münch at the ZKM | Karlsruhe in 1999.[31] *Small Fish* includes fifteen different programs for activating and modifying audiovisual compositions. Typically, shapes move across the display, producing tones when they collide or reach the screen's edge. In some of the programs, the shapes can also be moved with the mouse to affect the analog playback of the synthetically generated sounds. The music is created on the graphically formatted score.

Machines, from optophones to computers, were the new instruments. This new music was not suited to traditional notation. Therefore, new forms of notation emerged. One of these new notations was the graphic notation of the 1950s. Through the development of computer interfaces, the idea arose that composers can directly interact with the computer and create all kinds of sounds and music. Musicians have drawn directly onto filmstrips and with this optical sound created music. Now, musicians can draw with the mouse or a pen directly on a screen, and a scanner, instead of a magnetic pick-up, generates the sound. The digest of one hundred years of reflections about how to formalize music mathematically with the help of machines was the implementation of graphic notation as graphical user interface: the UPIC. With the UPIC, the notation was already the instrument and the scanner became the new interpreter. The composer just had to write the graphical notation, as the composition and the machine created the music.

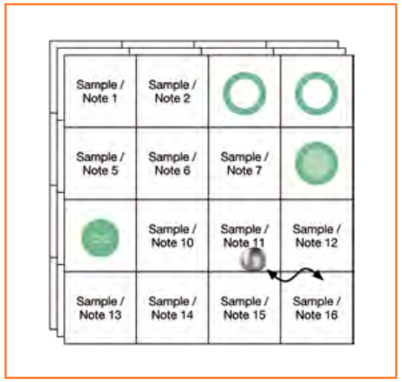
Building on these ideas, I created two apps, *Music Board* (2011, with Jens Barth) and *Sound* Writer (2016, with Chikashi Miyama), in which tone sequence and sounds are determined or generated by the positions of the phone in space, that is, in the electromagnetic field. When someone plays piano, it makes no difference whether the instrument is placed on the floor, hanging from the ceiling, or mounted on the wall. The music does not change in any way. The music remains independent of the piano's position in space. In my two apps the spatial position of the instrument—that is, the smartphone—produces the score or causes the tone sequence to change.

I use the electromagnetic field as a screen and the movement of the mobile phone in space as notation, which executes the notation, the code, and produces the sound.

The apps employ the mobile phone as a universal sound instrument whose position in space generates the music. After all, a mobile phone is, among other things, a kind of compass that indicates the device's position in the electromagnetic field. Changing the phone's position by means of hand and arm movements creates the "notation" and the music. The graphic user interface is no longer touched, but produces music by itself based on its position in space. Rather than the movements of a hand on an instrument or a two-dimensional user interface, it is the movements of the instrument in space that generate the score and the sound. There is no longer any difference between notation and sound event. Notation and sound occur in real time. Notation, instrument, and sound event become one.

The transformations of musical practices, notations, and instruments took place in different phases: magnetic, electric, electromagnetic, electromechanical, electronic, and digital. The decisive steps were: 1. the change from traditional notation to graphic notation, to "drawn music"; 2. the change of "drawn music" from a sheet of paper to a screen, be it to an oscilloscope or to a computer from hand to pen; 3. the change to optical techniques like optical sound in cinema or scanning methods in TV for recording, reproducing, and producing sound; 4. the change to direct physical interaction between machine and musician.

Finally, at the end of this progress, for the time being, the machine (computer, the mobile phone, electromagnetic devices of all kinds, data gloves, etc.) became all at once the notation, the instrument, the interpreter—and the composer became a programmer. Music has always been a temporal code. Nowadays, we have the technology available to program music directly as code. The code replaces the notation. There is a fundamental difference between analogue codes and digital codes: analogue codes like traditional musical notation or alphabetical code are just instructions. Digital codes are instructions *and* execution at the same time. Therefore, the old idea of live music today turns into live coding. You write a code, which can be projected, and you listen simultaneously to the music that is created by this code and you can even see visuals created by the same code. The synesthetic dream is completely realized as synthetic programming.



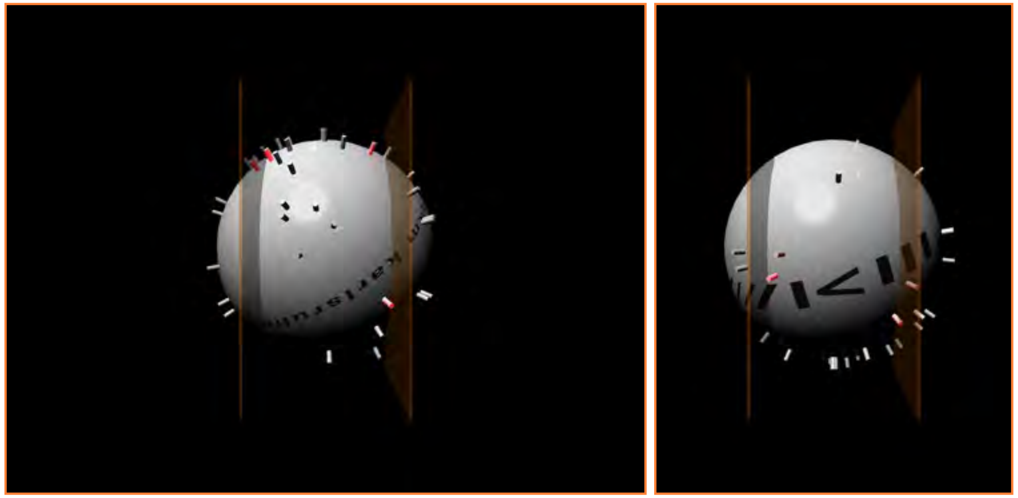


FIG. 46 Peter Weibel and Jens Barth, *Music Board*, 2011. Schematic drawing of the structure of the game board with the different layers for each instrument as well as the individual sound triggering objects: (a) a sample object triggers a single sample; (b) a sequencer object triggers several samples in a chain one after the other by means of an internal pulse generator; (c) a melody object changes its position by tilting the device and collides with other objects. © ZKM I Center for Art and Media Karlsruhe and the artists

FIG. 47 Peter Weibel and Jens Barth, *Music Board*, 2011, mobile app © ZKM I Center for Art and Media Karlsruhe and the artists

FIG. 48 Peter Weibel and Chikashi Miyama, *Sound Writer*, 2016, mobile app. Sound Writer is a 3D virtual music box, which can be played with simple finger gestures: Rotate the sphere in the middle of the screen by dragging it with your finger. When the pins on the surface of the sphere hit the tone comb, sound will be played. You can also change the sound color and the layout of the pins by two finger gestures © ZKM I Center for Art and Media Karlsruhe and the artists

FOOTNOTES

1. Raoul Hausmann, "PRÉsentismus. Gegen den Puffkeismus der teutschen Seele," in *Texte bis 1933*, ed. Michael Erlhoff, vol. 2, *Sieg Triumph Tabak mit Bohnen* (Munich: text+kritik, 1982), 24–30, here 27. Originally published in *De Stijl* 4, no. 9 (1921), 136–43. Translated from the German.

2. Raoul Hausmann, "Die überzüchteten Künste," in Hausmann, Si*eg Triumph Tabak mit Bohnen* (1982), 133–144, here 144. Translated from the German.

3. Already in 1895 the British painter Alexander Wallace Rimington regarded the color organs and color pianos as the foundations of a new kind of art: Alexander Wallace Rimington, *Colour-Music. The Art of Mobile Colour* (London: Hutchinson & Co., 1912).

4. Oskar Fischinger, "Sounding Ornaments," (1932) in *Optical Poetry: The Life and Work of Oskar Fischinger* by William Moritz (Bloomington: Indiana University Press, 2004), 179–181, here 179.

5. See *Alllah's Automata: Artifacts of the Arab-Islamic Renaissance* (800–1200), ed. Siegfried Zielinski and Peter Weibel (Ostfildern: Hatje Cantz, 2015).

6. Vladimir Popov invented various noise tools for his Noise Orchestra in the 1920s.

7. Andrey Smirnov, *Sound in Z. Experiments in Sound and Electronic Music in Early 20th Century Russia* (London: Walther König, 2013), 182.

8. "Bute made a series of Visual Music films which she called 'Seeing sound' [...] *Rhythm in Light*, 1934; *Synchromy No. 2,* 1935; *Dada*, 1936; *Parabola*, 1937; *Escape*, 1937; *Spook Sport* (animated by Norman McLaren), 1939; *Tarantella*, 1940; *Polka Graph*, 1947; *Color Rhapsodie*, 1948; *Imagination*, 1948; *New Sensations in Sound*, 1949 (RCA Commercial); *Pastorale*, 1950; *Abstronic*, 1952; and *Mood Contrasts*, 1953." "CVM's Bute Research Pages: About the Films / Retrospective Program / Upcoming & Recent Screenings," Center for Visual Music, www.centerforvisualmusic.org/Bute.htm.

9. Kren's film is based on the print of an Op art picture by Helga Philipp. The painting or parts of the painting were filmed in single frames.

10. For a discussion of Hugh Le Caine's *Spectrogram* see Smirnov, this volume.

11. For a more detailed discussion of Daphne Oram and her work, see Smirnov, this volume.

12. For a more detailed discussion of Evgeny Murzin, see Smirnov, this volume.

13. Guido of Arezzo inspired the name GUIDO Music Notation, a digital format for the representation of music scores.

14. György Ligeti, "Neue Notation – Kommunikationsmittel oder Selbstzweck?" in *Notation Neuer Musik, Darmstädter Beiträge zur Neuen Musik 9,* ed. Ernst Thomas (Mainz: Schott, 1965) 35–50, here 36–37. Translated from the German.

15. Mauricio Kagel, "Komposition – Notation – Interpretation," in *Notation Neuer Musik*, ed. Ernst Thomas, *Darmstädter Beiträge zur Neuen Musik* 9 (Mainz: Schott, 1965), 55–63, here 55, 59. Translated from the German.

16. Earle Brown, "The Notation and Performance of New Music," *Musical Quarterly* 72, no. 2 (1986), 180–201, here 181. Brown added in a footnote: "I am speaking of new notations whose primary application is toward extending the musical sound possibilities rather than those moving toward verbal or graphic descriptions of more theatrical activities."

17. Ibid., 182.

18. Ibid., 186.

19. Ibid.

20. Ibid., 188.

21. Ibid., 192.

22. Cf. Arnold Schoenberg, "Composition with 'Twelve Tones' (1)," i*n Style and Idea: Selected Writings*, ed. Leonard Stein, trans. Leo Black (Berkeley: University of California Press, 2010), 214–45.

23. Raymond Scott anticipated with this term the production formula *Wall of Sound* of Phil Spector.

24. Tom Rhea, "Electronic Perspectives: Raymond Scott's Clavivox and Electronium," *Contemporary Keyboard*, February (1981), 72.

25. Joseph Schillinger, *The Mathematical Basis of the Arts* (New York: Philosophical Library, 1948).

26. See Lejaren A. Hiller and Robert A. Baker, "Computer Cantata: A Study in Compositional Method," in *Perspectives of New Music* 3, no. 1 (1964), 62–90; and also Lejaren A. Hiller, *Informationstheorie und Computermusik. Zwei Vorträge, gehalten auf den "Internationalen Ferienkursen für Neue Musik"* Darmstadt, 1963, trans. Peter Jansen, *Darmstädter Beiträge zur Neuen Musik* 8 (Mainz: Schott, 1964).

27. Ivan E. Sutherland, "Sketchpad. A Man-Machine. Graphical Communication System," in *Proceedings of the Spring Joint Computer Conference*, Detroit, Michigan, (May 1963), 507–524.

28. Max V. Mathews and Lawrence Rosler, "Graphical Language for the Scores of Computer-Generated Sounds," in *Music by Computers*, ed. Heinz von Foerster and James W. Beauchamp (New York: John Wiley and Sons, 1969), 84–114, here 107.

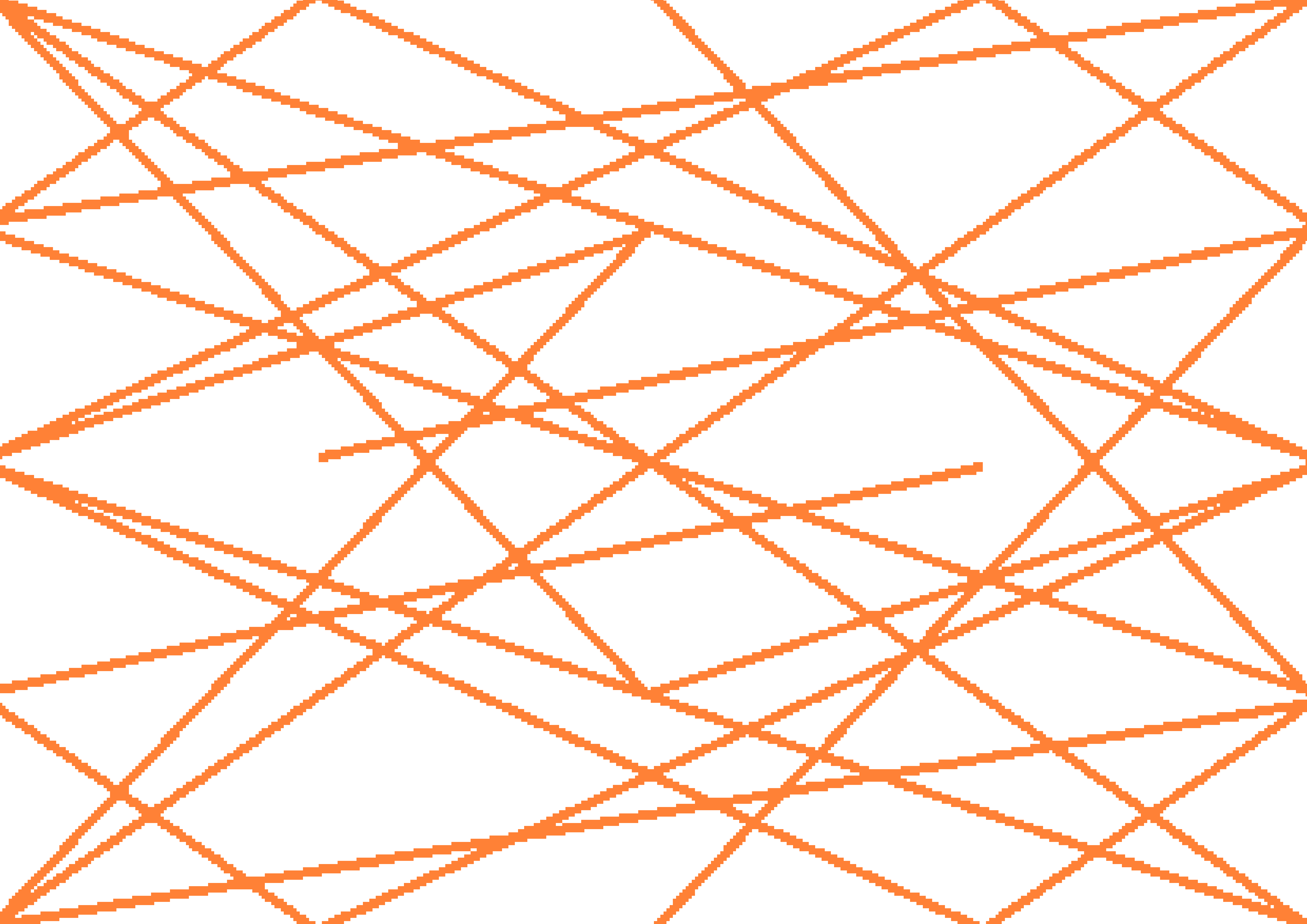
29. Max V. Mathews and Lawrence Rosler, "Graphical Language for the Scores of Computer-Generated Sounds," in *Music by Computers*, ed. Heinz von Foerster and James W. Beauchamp (New York: John Wiley and Sons, 1969), 84–114, here 84.

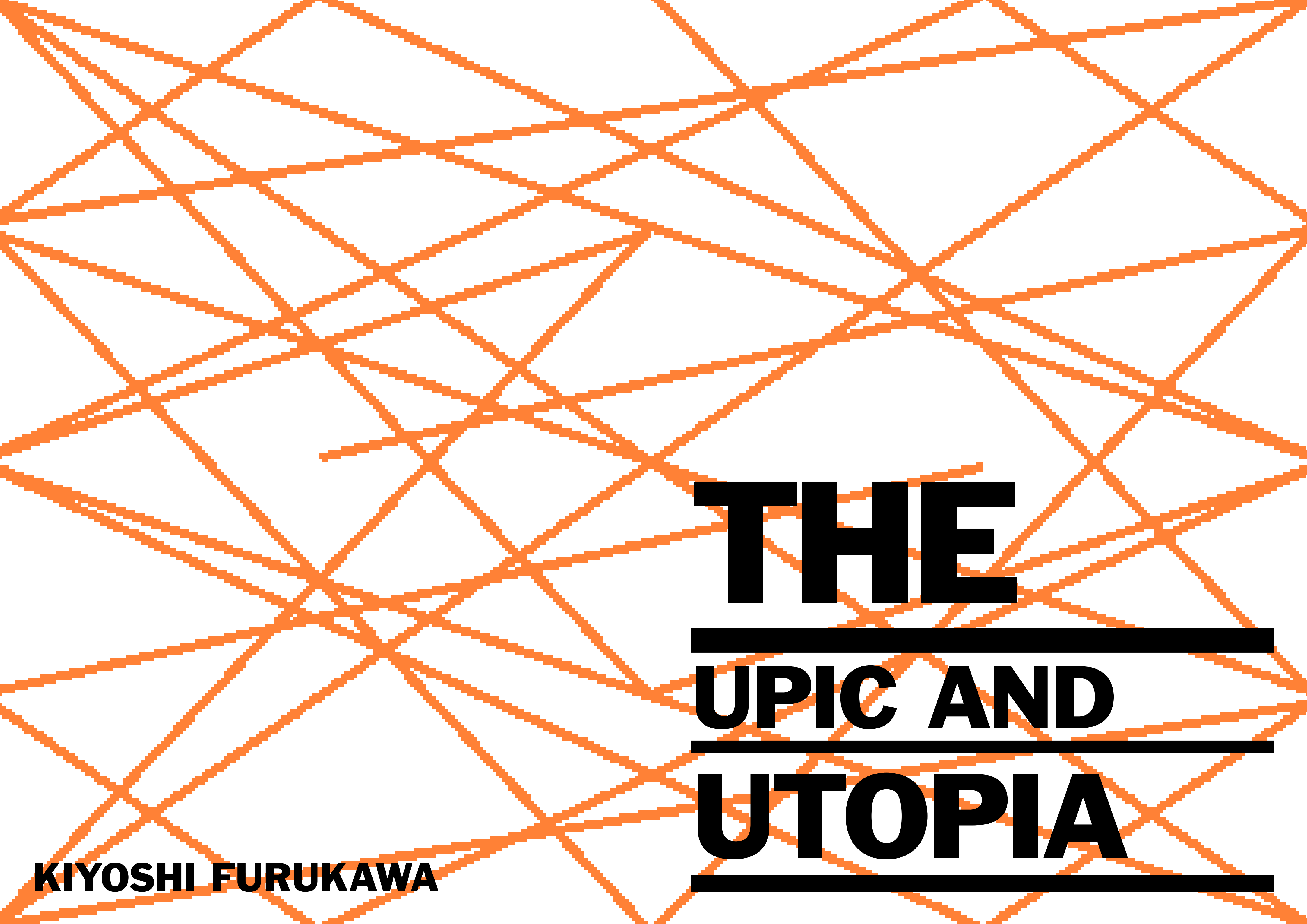
30. At the 2013 AppArtAwards ceremony at the ZKM | Karlsruhe, Matthias Krebs, an app musician and the founder of DigiEnsemble Berlin, gave a lecture entitled "App Musik: Kunstwerke, Sound Toys und App Instrumente" about the potential uses of smart devices for producing music.

31. See also Furukawa, this volume.

THE UPIC AND UTOPIA

KIYOSHI FURUKAWA
CHIKASHI MIYAMA
VICTORIA SIMON
JULIAN SCORDATO
KOSMAS GIANNOUTAKIS





THE UPIC AND UTOPIA

KIYOSHI FURUKAWA

THE UPIC AND UTOPIA

THE AIM OF THIS ESSAY

We are able to infer that Iannis Xenakis's creative acts are based on visual, spatial, and graphic ideas, which derive from his experiences as an architect. The UPIC (Unité Polyagogique Informatique du CEMAMu), which generates sounds from visual images, was developed from his conception in 1977. Utilizing an electromagnetic pen and a tablet to input the visual images, which are then directly converted into sounds, this system is a complete departure from traditional relationships between the score, instruments, performance, and composition.

In 1999, we developed *Smallfish* FIG. 1, 2[1], an interactive artwork which generates music, in the technological environment at the time. Recalling the discussions of the relationships between composition, score, instruments, and audiovisual expressions that my team and I had with regard to *Smallfish*, I would like to add our perspectives of today, and unveil the potential of the direction the new artistic expressions can take.

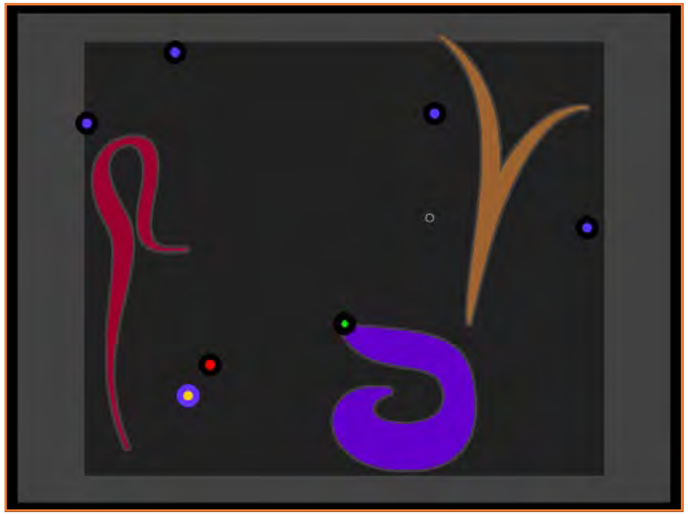
SMALLFISH

In 1999, I collaborated with media artists Masaki Fujihata and Wolfgang Münch at the ZKM | Institute for Music and Acoustics (IMA)[2] to develop *Smallfish*, an interactive artwork which generates music with a personal computer. We produced it on a CD-ROM, and released it through the publisher Hatje Cantz. This interactive artwork enabled us to control graphic objects on computer screens with a computer mouse or fingers,[3] which in turn added alterations to the musical structures and the music generation algorithms. This created an environment for audiences to enjoy visually the alterations of the movements of the objects with the generated music.

Smallfish's graphic user interface (GUI) screen can be thought of as a musical score, because visual objects directly generate the music. However, it can also be defined as a musical instrument, since users can directly and intentionally control the objects, which results in the interactive generation of music.

Additionally, the structures of the visual objects not only act as a musical generator, but also as aesthetic targets alongside the music that the users experience. We called this relationship between the music and the visual structuration of the control objects Active Score Music; however, we did not discuss in depth the new correlations of the score, visual expression, and the instruments. I remember explaining *Smallfish* as a musical instrument, just like the piano, in the discussion about its relation to the German collecting society and performance rights organization

KIYOSHI FURUKAWA



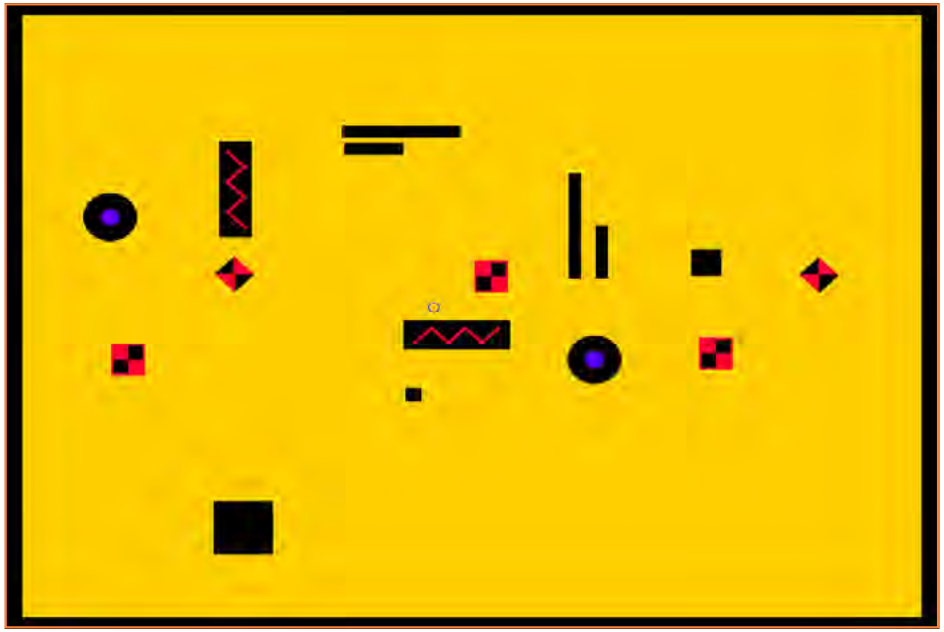


FIG. 1 A screenshot of a constellation in *Smallfish*, 1999 © Kiyoshi Furukawa

FIG. 2 A screenshot from the "Factory" in *Smallfish*, 1999 © Kiyoshi Furukawa

GEMA with Johannes Goebel, who was then the director of the ZKM | IMA. Today, this software is also sold as an iPad app, and this app is controlled with the fingers.

MUSICAL SCORE AND INSTRUMENT

Before I consider the issues of the new relationship of the musical score and the instrument in *Smallfish*, UPIC's visual image of the GUI as a functional musical score, and the possibilities and the potential that we see of the GUI as a musical instrument, I would first like to set out some preliminary ideas.

A musical score has been the product of the maturation and the complications of musical cultures.[4] However, we do find music with advanced complexity and musical theory, such as the traditional Indian repertoires, which has an oral tradition, but no tradition in notating scores.[5] From such cases, we can conclude that a musical score is not indispensable to all musical cultures.

A musical score is believed to have been some sort of a memo for performance purposes in the earlier stages of its development; however, in Western music from the Middle Ages onward, a musical score was a crucial tool for composition. It has been used for purposes of conservation and elaboration of musical ideas, as well as a medium to deliver the ideas to the performers. It is undeniable that the musical score in Western music has had an important role in the development of culture.

Musical scores are presented in various forms: scores with visual representations like lines of sound patterns and the movement of the sounds, other scores with symbols and characters representing the sound patterns, or the ones indicating their meaning and the aim of the music with characters, symbols, or words. When we conceptualize the GUI's visual image in the UPIC as a musical score, it is close to the scores where it notates the movements of the sounds with a line. However, when we include the factors that the UPIC's GUI can be thought of as an instrument, we can see that it is close to a type of a tablature score,[6] a score that reflects the instrument's structure and the technicalities.[7]

FROM SCORE TO INSTRUMENT

The first version of the UPIC was developed in 1977, and until 1980, it was hardware which used an electromagnetic pen and a tablet to input the data, and also to record and regenerate the digital-to-analog converted sounds.

Users operated the system with an input pen to create arcs, where a freely drawn line on the score acted as a trajectory, and multiple line drawings created with the arcs were integrated into a musically higher unit called pages. The visual image that is then expressed on the UPIC screen acts similar to a graphic score; however, as the sound is generated throughout the visual image itself, it is not a musical score by definition. In addition to that, after the sound is generated, the sound can be recorded on tape, waiving in the end the necessity of the visual image in further performances. However, we can say that the visual image holds the technicalities to be defined as a score as a compositional tool, due to the fact that, before the final version of the sound is actually recorded on tape, the visual image can be fixed as many times as one likes. By the mid-1990s, the input source of the Windows software became the mouse, and real time processing has become a possibility. Due to this fact, there was a massive improvement in the working environment for composers, as we could listen to the sound that resulted from the graphics as many times as we liked, and repeat the compositional process on the system. From here, we can state that the idea of the UPIC as a musical instrument has unquestionably come close to reality.

THE INNOVATIVE ASPECTS OF THE UPIC

In the 1950s and the 1960s in the realm of contemporary music, graphic representation of the music, such as graphic notation, became commonplace in the scene. This phenomenon is due to the fact that much electronic music, and music that cannot be expressed on the traditional five-line scores, is no longer a rarity. György Ligeti's *Volumina for Organ* (1962), where he reflected his electronic music experiences, as well as Krzysztof Penderecki's graphic notations for the clusters he used in his series of orchestral works, are just two of the many examples. The founding principles of the works by Xenakis were decisively influenced by his experiences as an architect, and I believe that his ideas are graphically represented. From these examples mentioned, the graphic ideas of the UPIC and the GUI's visual image in the 1970s are not novelties. Rather, the innovative aspect of the UPIC is the users' direct control of inputting the line-curve with a pen, and that the composite of the sounds are generated from the visual image. Namely, this is the contrast between this and the traditional notational system, where an instrumentalist performs the score, and where the composer and the performer are assigned divided tasks. Moreover, it can be contrasted with the computer music at the time, for example, with the scores of Music-N, a popular family of computer music programs, where the idea of a traditional sound is utilized to notate the note list, and is defined and bundled as a traditional instrumentational unit. In the case of the UPIC, the musical score and the instrument coexists within the visual image, and it can be said that the UPIC has excavated new potentials for instruments as a musical score. This highlights the fact that the UPIC exhibited foresight regarding

the issue of the relationship between a musical score and an instrument, prior to my development of *Smallfish* in 1999. Here, the visual image of a curve that was produced by a human's physical act (input with free hands) directly produces sounds. Here, the visual image of a curve is a medium which converts the human physical act into sounds, but the conversion itself is rather simple; the vertical axis of the trajectory represents the pitch, and the horizontal axis represents the flow of time. In principle, the system possesses the aspects of a musical instrument where a physical act produces some kind of sound, as the system does not require the user to have any prior musical knowledge, and the sound generation is possible without processing by musical ideas. Of course, this simplicity is the result of many expressive and musical abstractions.

BEYOND MUSICAL SCORE AND INSTRUMENT

As stated above, the input of data in the UPIC using the mouse, as well as the possibility of real time processing in the 1990s, has found itself representing an instrumental face. With the advances of technology today, the techniques of integrating humans, GUIs, and sound has become nothing extraordinary. As for myself, I have utilized the technology to develop *Smallfish*, as well as its successive mobile app software *Mucca* in 2017.[8] However, although I have pursued the story to this point, I doubt the validity of applying the traditional concept of musical scores and instruments to computer programs like the UPIC or *Smallfish*. We should not merely apply new technologies to software, but should consider and envision the new situation from diverse perspectives.

THE UPIC AND COMMUNITYWARE

We can infer that the UPIC has utilized the GUI as a musical score to open new doors to possibilities for creative processes. However, the first UPIC was implemented by Guy Médigue according to Xenakis's ideas,[9] for he himself says that the system was not built for composition, but to grant a field of freedom.[10] As such, it was something that was distanced from his compositional concepts. Nevertheless, the simplicity, the directness of the input relations, and concreteness of the GUI were taken into account during the development of UPIC. FIG. 3 The fact that they were able to execute a workshop is meaningful, considering that anyone without any basic knowledge of music can experience the creative processes of electronic music, thus it was designed as a constituent of an educational system. From today's perspective, we can discard the premise of "composer" or "musical work," and imagine a system where a person can make and enjoy sound using the GUI. We can catch a glimpse of the utopia of what music has to offer. I created *Smallfish* not in order just to

FIG. 3 Iannis Xenakis with Japanese pupils during the French Contemporary Music Weeks, Yokohama, Japan 1984, UPIC graphic table in the background © CIX Archives

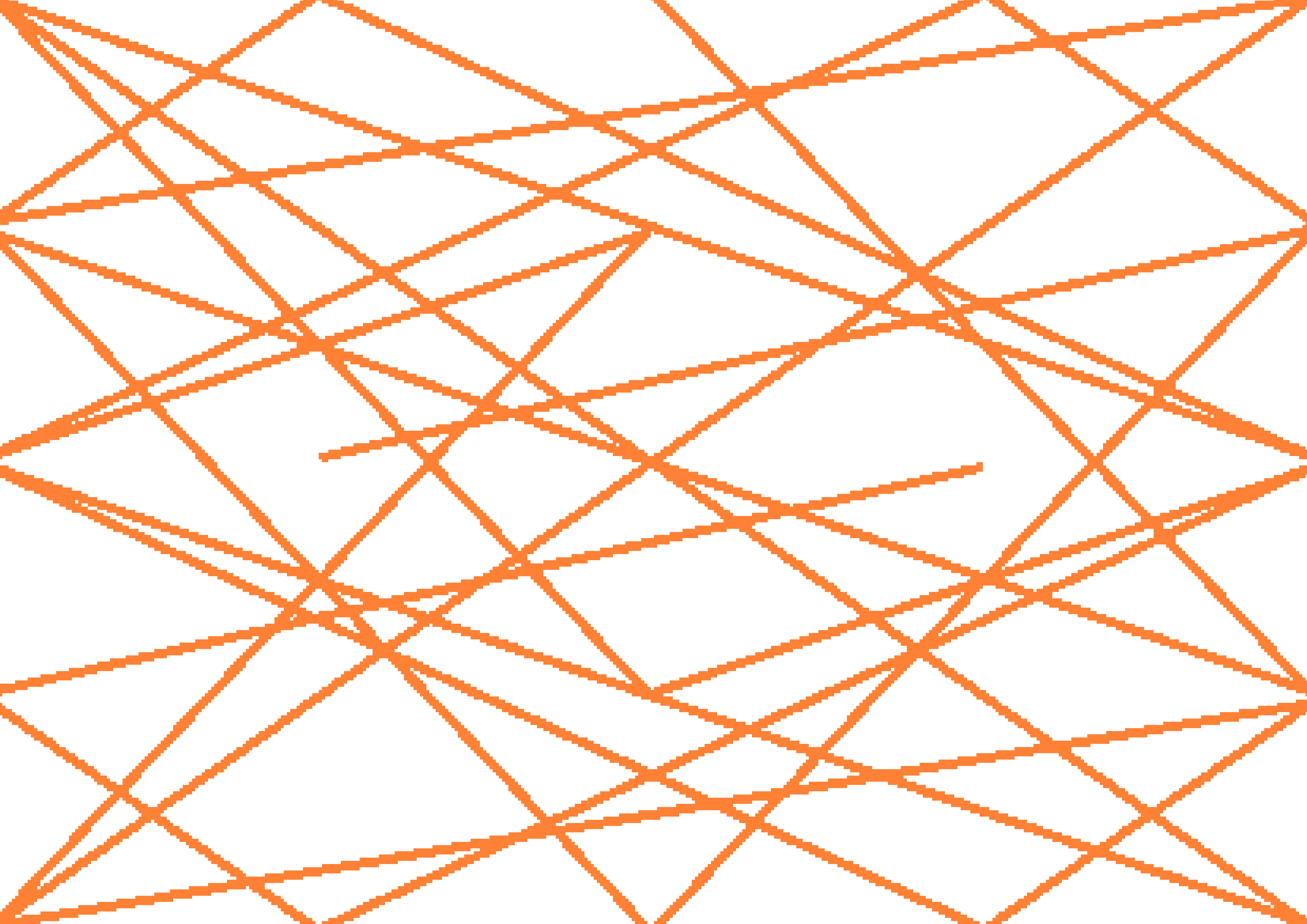
appreciate composers' works, but to connect the process of art and the process of making sound as one, and, moreover to build a bridge between humans and community art. We can state that this was made possible with the GUI used in *Smallfish*, and its model came from the UPIC.

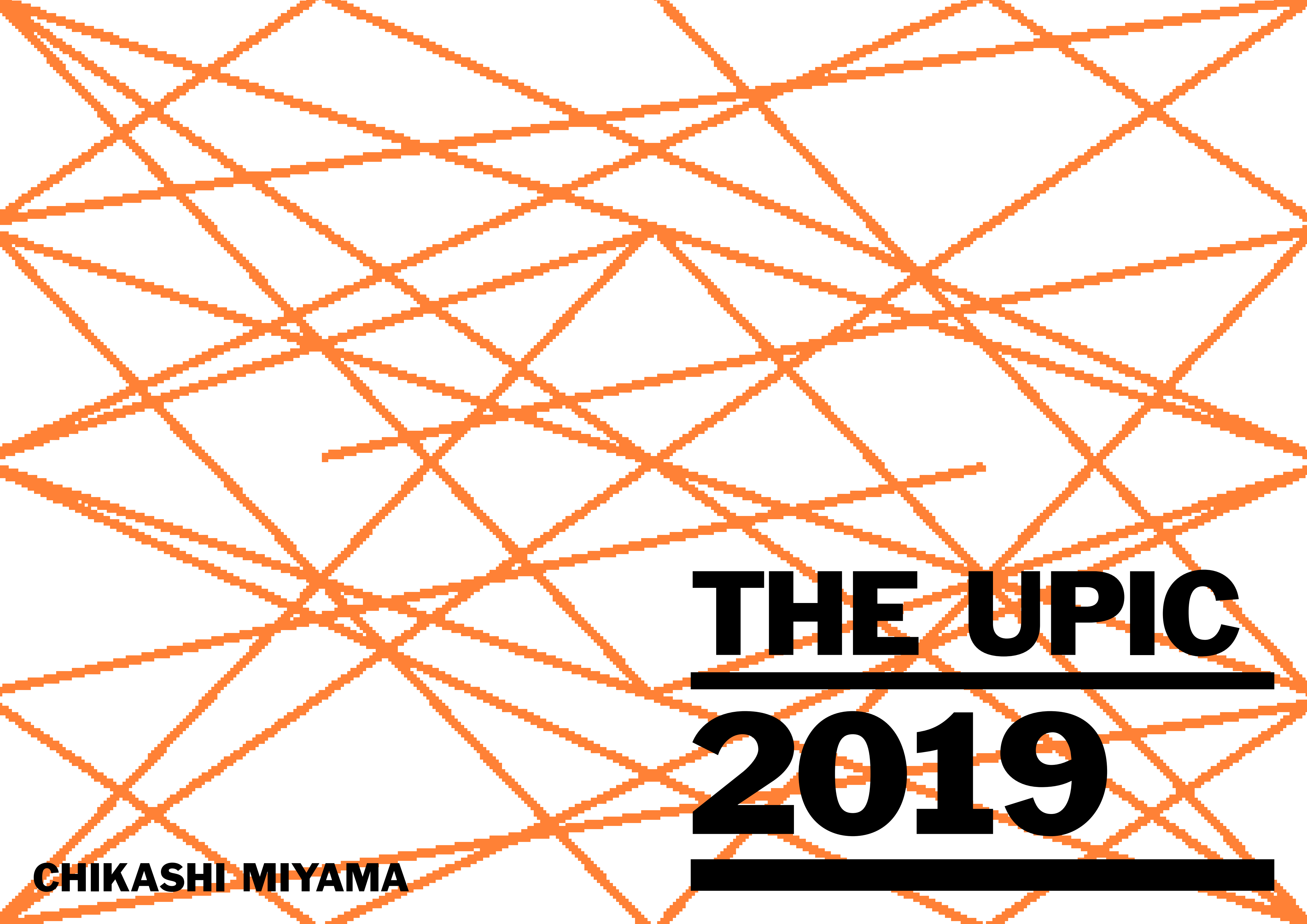
PROSPECTS

Nowadays, automatic composition is not only used in computer music, but also in entertainment contexts. I also utilize artificial intelligence algorithms to develop a system of automatic composition called *Soundroid*.[11] However, I am concerned about the passivity of the notion, because the prerequisite suggests that music exists merely to be listened to. There is joy in using one's body, and performing on an instrument, as well as in creating music, both as a composer and as a noncomposer. I believe that today, the possibilities of the UPIC as a musical instrument are essential. Technology is building and extending its possibilities day by day, and I contemplate there will be immense developments. Regarding the improvement of this technology, I hope that, without the idea of a composer, a musical work, or an art work, a structural opportunity will arise to enjoy electroacoustic music interactively, as if one was playing an instrument. I am greatly interested in and enthusiastic about the potential of the idea of the UPIC, as well as the way music is headed, from the knowledge I have acquired through the development of *Smallfish*. This might lead music to its primordial form, or it might create a whole new structure of what music is and can be.

FOOTNOTES

1. https://zkm.de/en/publication/small-fish
2. https://zkm.de/de
3. https://zkm.de/de/publikation/small-fish-app
4. *Die Musik in Geschichte und Gegenwart*, vol. 7, (Kassel: Bärenreiter, 1997) 284–285.
5. *The New Grove Dictionary of Music and Musicians*, 2 ed., vol. 12, (Oxford: Oxford Universtiy Press, 2001), 162–168.
6. Ibid., vol. 24, 905–906.
7. In a wider context, the Western five-line score can be thought to have correlations with the tablature scores. In brief, the notes on the five-line scores can be set visually on the location of the key on a keyboard instrument, such as a piano.
8. https://mucca.town/en/index.html
9. François Delalande, "*Il faut être constamment un immigré*," in *Entretiens avec Xenakis*, (Paris: Buchet/Chastel, Institut national de l'audiovisuel, 1997), 142.
10. Iannis Xenakis, *Formalized Music* [1971], (New York: Pendragon Press, revised edition 1992), 146–147.
11. https://soundroid.com





THE UPIC

2019

CHIKASHI MIYAMA

CHIKASHI MIYAMA

THE UPIC 2019

Around forty years have passed since the birth of the original UPIC system. Today, Most of us have a smartphone in our pockets, communicate on social networking systems, and talk to AI-backed smart speakers. Many things that were technically impossible in 1977 are possible today.

In this article, we will analyze the UPIC system from the perspective of a software developer, and introduce other UPIC-inspired systems realized with the technologies evolved in the last forty years. Based on them we will attempt to answer a hypothetical question: "What can we do if we make a brand-new UPIC-like system from scratch with the technologies available today, preserving the objectives that Xenakis envisioned forty years ago?"

THREE ELEMENTS OF THE UPIC

The original UPIC system can be interpreted as a combination of three main elements; namely, *Canvas*, *Player*, and *Instrument*. The canvas is an interface that allows composers to draw lines and shapes. The player is the mechanics that read the graphics on the canvas at a specific speed. The instrument is the component that generates the actual audio signals. In this section, we will discuss the technical aspect of these three elements of the UPIC individually.

CANVAS: RASTER GRAPHICS

In many cases, a computer stores the information of an image as a collection of colored pixels. For example, a photo taken by a high-end smartphone in 2019 consists of more than ten million pixels. Since computers handle data of colors as a combination of numerical values, an image is fundamentally a collection of an enormous amount of numbers for them. These pixel-based images are called raster graphics.

This means that in raster graphics we have to deal with ten millions of pixels if we draw a high-resolution image by hand. Raster image editing applications often provide virtual tools, such as pen, brush, sponge, and eraser that imitate the functionalities of painting tools used by painters in the real world because it is practically impossible to manipulate and adjust the numerical values of such a tremendous collection of pixels one by one. With these tools, users can edit and process the numerical values of countless pixels intuitively. FIG. 1

VECTOR GRAPHICS

In contrast to painting, we focus more on abstract and mathematical properties of objects in the image when we draw geometrical shapes, diagrams, or blueprints and we use different tools such as compasses, rulers, and protractors for drawing them.

In such a case it is more efficient if the application comprehends more abstract properties of the graphical elements, such as the length of lines, the steepness of curves, and the size of polygons, and manipulates pixels automatically based on those high-level data. Roughly speaking, this approach is called vector graphics as opposed to raster graphics.

The benefit of this approach is that the application allows the users to change flexibly the properties of lines and polygons after drawing them, and encourages them to iterate trial and error at the higher abstraction level. **FIG. 2**

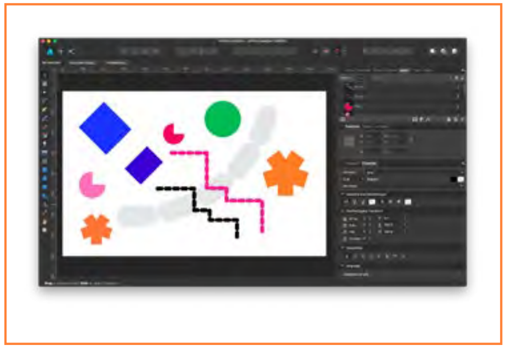
GENERATIVE GRAPHICS

In vector graphics, the software generates pixels automatically based on the provided properties of lines and polygons, but the power of automation could be exploited further; we can also automate the process of generation. **FIG. 3** shows one thousand circles with different sizes and colors automatically generated by a few lines of JavaScript code shown on the left, utilizing some functions of p5.js, a library for creating images and interactive experiences. Images created by this sort of program are called *generative graphics* and this approach provides artists with unprecedented systematic ways to create new images.[1] We can alter the visual impression of the images dramatically by slightly changing the parameters in the source code. For example, by just adding one zero at line 4 in the source code, we can alter the number of circles in the image from a thousand to ten thousand. This approach would be also a positive addition in the context of the UPIC, in view of its counterpart in the musical context, such as algorithmic or computer-aided composition.

AN IDEAL DIGITAL CANVAS FOR THE GRAPHIC NOTATION

What is the best canvas implementation for the UPIC-like system of the three approaches mentioned above? On the one hand, the canvas has to provide a way to draw lines and shapes as simply, directly, and intuitively as possible because one of the objectives of the system is musical education. On the other hand, it has to accompany the abstract, mathematical, and structural thinking of professional composers. In addition, the newly emerging generative approach would be an expected feature for many artists. Because of these diverse requirements, it is anticipated that the canvas implementation of a UPIC-like system will be highly challenging for developers.

The original UPIC did provide ways to process images at a higher abstraction level to some extent. Various modes, such as freehand,



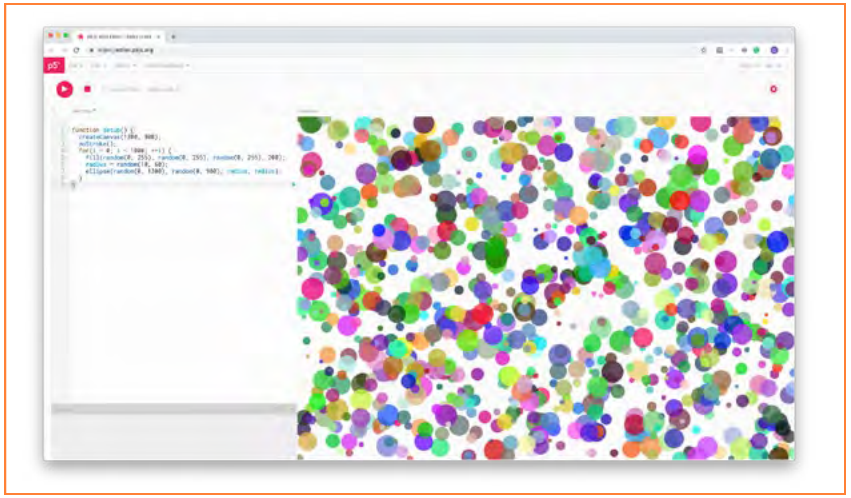


FIG. 1 A raster image edited with open source software Gimp, 2019, screenshot. Various virtual tools for drawing are available on the left. © Chikashi Miyama

FIG. 2 Interface of the Affinity Designer software, 2019. This vector graphic software stores properties of each line and shape (e.g. color, thickness, length etc.) and lets the users change them with the inspector on the right. Screenshot © Chikashi Miyama and Affinity Designer UI copyright of Serif (Europe) Ltd, used with permission

FIG. 3 One thousand circles with different colors and sizes generated with the JavaScript library p5.js, 2019, screenshot © Chikashi Miyama segmented lines, are available for users and the drawn shapes can be rotated or mirrored afterwards in the original system.[2] IanniX, a new UPIC-inspired software launched in 2000, allows the users to create graphics in the vector approach by default; all basic lines are stored as Bézier curves even if the lines are drawn in the freehand mode in IanniX.[3]

Not only the original UPIC and IanniX systems but also most of the relevant applications process images basically in the vector approach; the applications are aware of the properties of drawn objects and allow the user to freely manipulate them later.

However, the potential of the pixel-level processing should not be disregarded in the early stage of the software design. The original UPIC offers a way to use recorded sound samples in the composition. What would prevent us from doing the same thing in the visual world? If the system were required to provide a way to use photos as parts of graphical notation, and offers a way to collage them with standard line-based notation, the vector graphic-centered software design must be revised to some extent.

The generative approach could be combined with both vector and raster approaches relatively smoothly since they are essentially automation of multiple operations. In fact, IanniX features an editor in which the user can write JavaScript code for generating graphical elements programmatically. However, the generative approach inevitably involves some sort of coding that may contradict the original goal of the UPIC system.

PLAYER

To listen to stored music on media, such as the disks of a music box, LP records, or magnetic tapes, we need a mechanism to access a particular part of the particular medium, for example, the teeth of a music box, the stylus of an LP player, and the tape head of a magnetic tape player. In this section, we will call all those mechanisms simply *playhead*.

Even in this digital era, playheads still exist. Digital Audio Workstation (DAW) software shows playheads as a long vertical line in its window for indicating a part currently being accessed, and it allows us to playback from the middle of a piece by changing the position of it.

The original version of the UPIC system required a significant amount of time for converting the drawn graphics into audio data. However, by the end of the 1980s the system gained a capability to let composers move the playhead freely and play music in the graphical score in real time.[4] This technological development dramatically changed the workflow of UPIC composers.

If a human musician plays the graphic notation in the UPIC with an instrument, she or he moves their eyes as the playhead moves. In this sense, a playhead symbolizes the eyes of musicians. If multiple human musicians play a graphic notation, they may interpret the score differently. We could also implement such differences of interpretation in the system, for example, by changing the behavior and the shape of a playhead. Below we will introduce a few different types of playheads implemented in UPIC-inspired systems. FIG. 4

CURVED PLAYHEAD

Rotating Scores (2016) by Ludger Brümmer and Anton Himstedt is an interactive sound installation in which the system allows participants to design the shape of the playhead freely with a mouse.[5] As soon as the participant draws a playhead on a screen, it starts moving automatically on the prestored graphic scores. When the playhead collides with the black part of the score, the system produces sounds with different pitches based on the part of the playhead that collided. Thus, the musical outcome differs significantly according to the shapes of the drawn playheads. FIG. 5

MULTIPLE PLAYHEADS

In most systems with a playback function, only a single playhead is available; only one part of the score can be accessed at a time. What if we could use more than one playhead to access several different parts of a piece simultaneously? *Rhythm of Shapes* (2016), by the author, is an interactive installation that takes a photo of the participants, extracts the contours of objects in the photo, and uses them as the elements of a graphic score. Immediately after the contour extraction, multiple synchronized playheads with different speeds and sizes move on the score and generate sound when they collide with the extracted lines. As a result, the system generates a gradually changing, complex rhythmic texture.[6] FIG. 6

PARTICLE PLAYHEAD

Rhythm of Shapes uses a maximum of six playheads at the same time. However, with the computational power of modern hardware, it is also possible to employ a massive number of playheads, say one hundred, at the same time. In this case, manipulating the movement of each individual playhead becomes cumbersome; it would be more practical to control meta parameters, such as randomness or activeness, and control the behavioral tendencies of playheads through these parameters.

Chris Carlson implements this idea in an iOS app called *Borderlands Granular* (2015), in which randomly emerging particle-like playheads play the waveform placed in the background.[7] FIG. 7

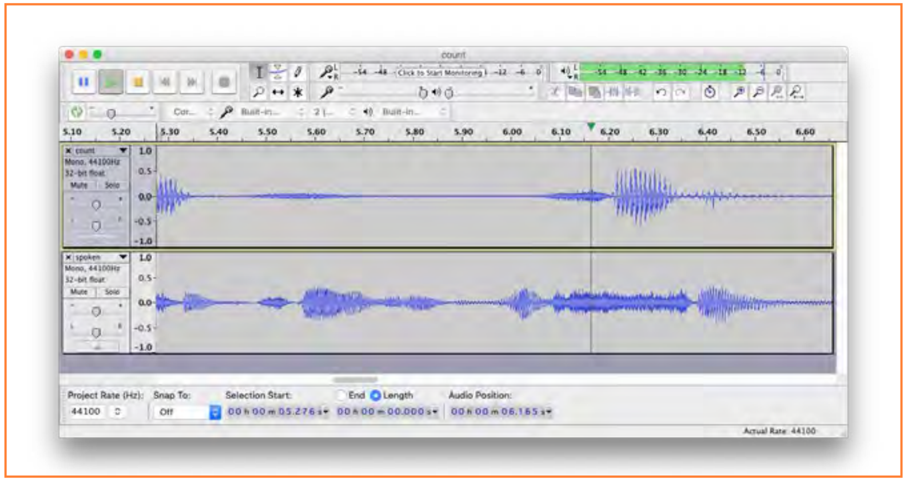


FIG. 4 The free DAW software Audacity, which visualizes the playhead as a vertical green line, 2019, screenshot © Chikashi Miyama and 1999-2019 Audacity Team

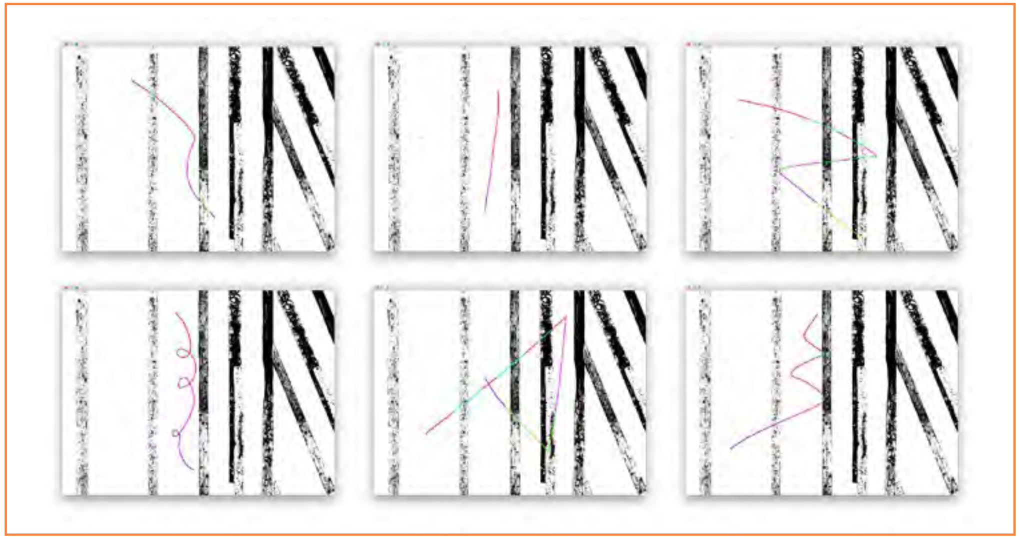


FIG. 5 Ludger Brümmer and Anton Himstedt, *Rotating Scores*, 2016, screenshot. The interactive sound installation plays the graphic score in six different ways according to the shapes drawn by participants. © Ludger Brümmer, Anton Himstedt and Chikashi Miyama

FIG. 6 Chikashi Miyama, *Rhythm of Shapes*, 2016, screenshot. The interactive sound installation takes a photo of the viewer and extracts the contours in it. Subsequently, multiple playheads of different sizes and speeds move vertically and horizontally on the processed photo and generate sound when they collide with those contours. © Chikashi Miyama

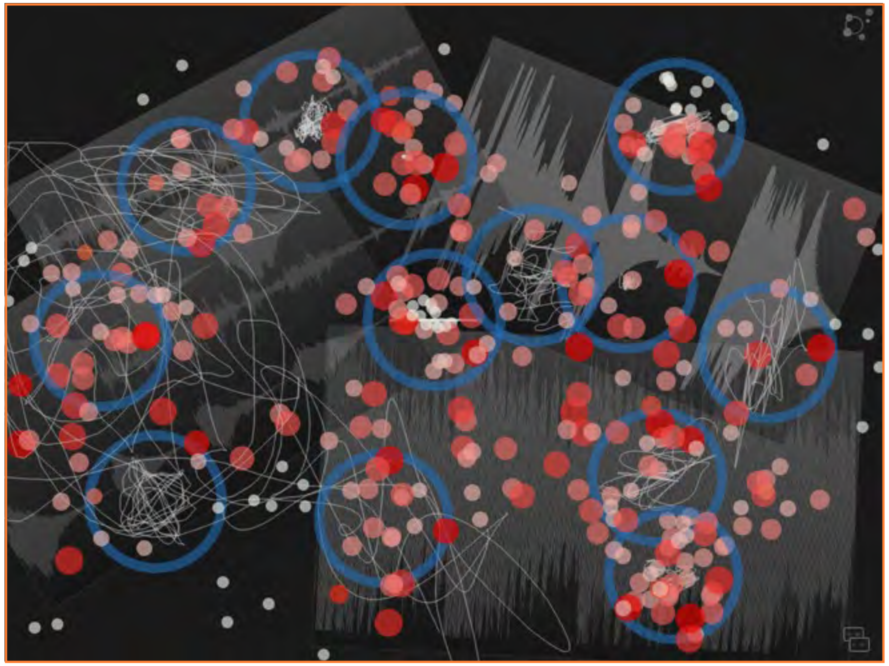


FIG. 7 Chris Carlson, Borderlands Granular, 2012-2020, screenshot. This iOS app displays multiple playheads as red and white dots which playback the waveform behind them. © Chikashi Miyama and Chris Carlson

REACTIVE PLAYHEADS

Although all the above-mentioned playheads either move constantly in a particular direction or do not individually change their behavior during their lifetime, it is also possible to implement a playhead that reacts to a specific event, such as a collision with other objects. The mobile app Small Fish (2011) by Kiyoshi Furukawa, Masaki Fujihata, and Wolfgang Münch employs such reactive playheads.[8]

As these unique variations of playheads show, the functionality of playback can be implemented in a variety of ways. Although we tend to focus more on input devices and sound synthesis in the context of the UPIC, playback mechanics also assume an important role for characterizing individual systems.

INSTRUMENT: SOFTWARE SYNTHESIZER

Like images, sound is also a collection of numbers for a computer. In the case of sound, it interprets sound waves as a collection of audio samples and plays back sound by sending these samples to speakers via a digital to analog converter (DAC).

Just as we do not change the value of each pixel one by one in image editing applications, we do not usually manipulate audio samples manually in audio programs. Most of the time we control parameters of software synthesizers, such as pitch, timbre, loudness, or vibrato, and let them generate audio samples automatically according to the parameters, just as the virtual brushes and pencils generate pixels in raster graphic software.

INTERNAL SYNTHESIZER OF THE ORIGINAL UPIC

A software synthesizer was also embedded in the original UPIC and was one of the most unique features of the system. It allowed composers to draw waveforms and envelopes on the canvas and use them in a composition. With this feature, the system enabled artists to access not only the macrostructure but also microstructure of their compositions with a consistent approach; namely, drawing.[9] However, today a tremendous number of software synthesizers are available and some composers develop their own personalized software instruments with dedicated audio programming environments such as Max or Pd. It is not surprising that they desire to connect the UPIC *Canvas* and *Player* with their own sound generators instead of its internal one.

THE MAPPING BETWEEN GRAPHICS AND SOUND

In terms of software design, one of the greatest challenges of developing UPIC-like software is to determine its mapping; that is, how the properties of graphical elements are associated with the properties of sound.

Although the *page view* of the original UPIC system followed a western style of notation by mapping the X-axis to time and the Y-axis to pitch, it is also technically possible to map these axes to cut-off frequency of a filter, predelay time of a reverb, or other numerous parameters of audio processing modules. Furthermore, it is also viable to employ a scaling factor or a particular transfer function as implemented in the original UPIC[2] and those mappings can be changed during the playback.

For these issues, the connectivity to external synthesizers and the configurability of mapping, IanniX proposes a drastic solution that will be discussed later.

TOWARDS THE UPIC 2019

In this section, an outline is given of the technological evolution in the past forty years in conjunction with the various descendants of the UPIC system and the future possibilities of UPIC-like systems with the emerging technologies will be discussed.

SPEED AND CAPACITY

The three core components of a computer are its processing unit, memory, and storage. Their speed and capacity have evolved dramatically in the past forty years and enable us to process audio in real time. Today the use of DAW software, such as Logic, ProTools, Cubase, and Reaper are essential for audio production and these applications have replaced dedicated hardware, such as reverb racks, synthesizers, multitrack recorders, and samplers. Along with this, graphic-based audio controls, such as automation curves, piano roll editor, and waveform editor, have become widespread. It is notable that many composers and audio engineers today are accustomed to controlling sound using lines and curves, like in the UPIC system. FIG. 8

INPUT DEVICES

If we draw a picture on a computer display with a mouse, we lose a significant amount of information. Firstly, computers do not store information beyond a specific resolution. Secondly, a standard mouse detects its position only 125 times per second. Thirdly, a mouse does not deliver any auxiliary data such as the pressure on a pencil or the angle of a brush that may characterize individual strokes.

Peter Nelson points out in his article that the use of a mouse for drawing a graphic score produces poor user experiences and the size of the drawing board significantly influences the clarity of connection between the intellectual and the corporeal.[10]

Today, a large full-color tablet such as Wacom Cintiq Pro, allows us to draw directly on a sizable colored display with a dedicated stylus.[11]

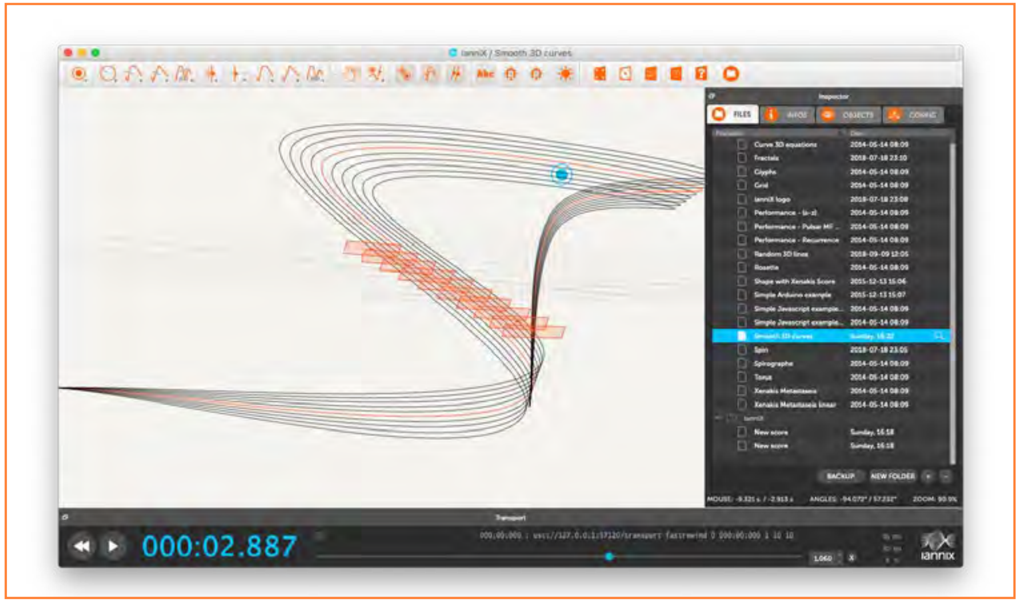


FIG. 8 Waveform editor, automation curves, and piano roll editor of software Reaper by Cockos Incorporated, 2019, screenshot. The Graphic User Interface (GUI) of modern DAW employs various graphical ways to visualize musical properties. © Chikashi Miyama and 2004-2019 Cockos Incorporated

FIG. 9 Three-dimensional graphic score rendered in the graphical open source sequencer software IanniX, 2019, screenshot © Chikashi Miyama and IanniX Association

The tablet detects the pressure and the angle of the stylus and lets us use these data for controlling details of the strokes, such as the opacity of the color and the thickness of the lines. By mapping these properties of strokes with audio parameters we can achieve a closer correlation between graphics and sound, though it may require composers to have a certain level of drawing skills to take full advantage of it.

THREE-DIMENSIONAL GRAPHICS

The computational performance of video cards and graphics libraries, such as OpenGL or DirectX, have improved significantly in the past few decades. Today, they allow us to render very detailed three-dimensional graphics in real time. Consequently, we have the possibility to draw graphic scores in three-dimensional space even with a small laptop or a tablet.

IanniX, the software mentioned previously, internally processes all lines as lines in a three-dimensional space, even if the user utilizes them solely as components of a two-dimensional score. This fact demonstrates how trivial it has become to render polygons in a three-dimensional space with modern hardware. **FIG. 9**

STANDARDIZATION

The original UPIC system could be categorized as an E2ES (end-to-end-solution). In other words, the system offers everything needed for the composition; other external components are not required.

On the one hand, an E2ES approach is more practical for users because they do not have to prepare additional components to compose musical works. On the other hand, this approach could be inflexible because it does not allow users to use external components, such as software synthesizers by other developers, instead of the internal one.

Why is it impossible to replace UPIC's internal component with an external one? Roughly speaking, this is because external synthesizers are unable to understand the language used by the UPIC system. In other words, a software synthesizer by another developer could play the graphic scores drawn on the UPIC system, if the system could communicate in a language that the synthesizer understands.

For the communication between digital synthesizers and sequencers the MIDI specification 1.0 was published by a consortium of Japanese and American synthesizer manufacturers in 1983.[12] This suggests that there were not many standardized communication protocols between musical hardware and software back in 1977.

Around 10 years later, software synthesizer vendors were able to distribute their products in a standardized way, notably by the release of VST 2.0 specification by Steinberg, which enabled developers to implement virtual musical instruments, running on various hosting software. Consequently, developers of systems like the UPIC, in which several components are combined, no longer had to offer an E2ES and count on users to prepare the software or hardware that conform to the standardized specifications or protocols by themselves.

The development of IanniX utilizes this very trend. One of the unique parts of the implementation of IanniX is that the software offers a canvas and playheads but it does not provide instruments for generating sound at all. Instead, it just sends messages to other programs and notifies them of events happening in IanniX, such as the movement of playheads with a standardized network communication protocol called Open Sound Control (OSC).

This approach liberates composers from limitations and allows them to use all kinds of software that can accept OSC messages. Furthermore, the OSC messages that IanniX sends are pure mathematical information, such as 3D coordinates of playheads, etc. Thus, the mapping is entirely up to the composers; they can map the X or Y axis to whatever parameter they want. In addition, assigning them to parameters of non-musical equipment such as a lighting system, a VJ application, or a drone controller, is also possible.

However, there are two downsides to this approach. One is the overhead caused by the communication between OSC senders and receivers. The other is the steeper learning curve due to the incomplete workflow; composers need to have knowledge of OSC protocol and other software synthesizers.

MOBILE AND WEB SOLUTIONS

Over a decade has passed since the release of the first generation iPhone in 2007. Mobile devices such as smartphones and tablets have spread at an enormous speed. Obviously, an application like the UPIC system can run as an app on these devices, and this would be beneficial for educational purposes since the haptic interaction on tablets would be more intuitive for the younger generation, and in general the hardware is more affordable. UPISketch, developed by the Centre Iannis Xenakis, is a UPIC-like software that runs on iOS, OSX, and Windows. It focuses more on sound creation based on audio sampling.[13] FIG. 10

Also in the realm of the web, the implementation of interactive media contents on web browsers has become significantly simpler for developers with the release of HTML5 and WebAudioAPI in 2014; it has enabled audio synthesis and processing in real time on a webpage without any additional plug-in components. Furthermore, WebGL allows the contents of a website to utilize the resources of the GPU. The combination of these technologies facilitates the implementation of a canvas which enables users to draw complex shapes on a web page and a synthesizer that sonifies the

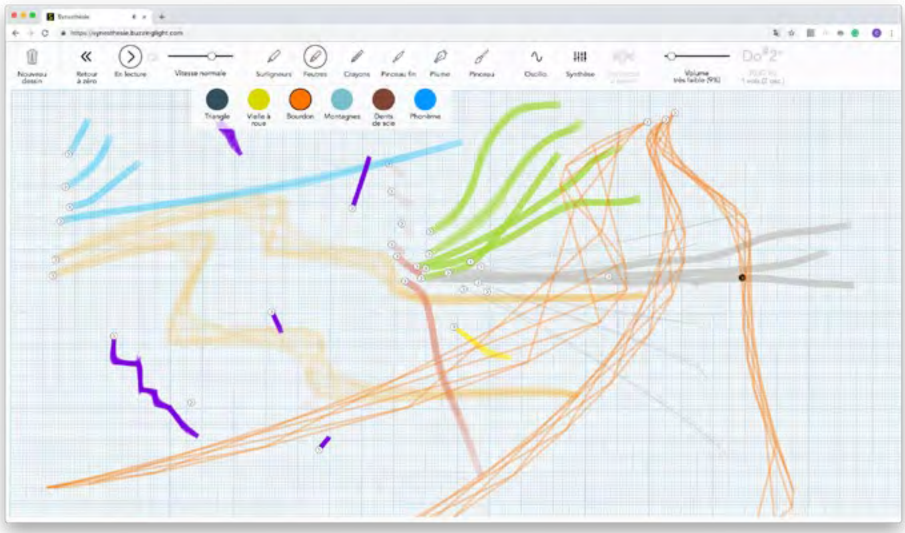


FIG. 10 Graphic score drawn on the canvas of the web-based software Synesthésie by Guillaume Jacquemin, 2019, screenshot © Chikashi Miyama and Guillaume Jacquemin

lines on the canvas. The web-based software Synesthésie by Guillaume Jacquemin, who also developed several software versions of IanniX, realizes an UPIC-like system on a webpage by combining the previously mentioned technologies. By accessing the web page, the user is able to start sketching graphic scores with various preprepared drawing tools and synthesizers, and can listen to them without installing any additional software components.[14] Synesthésie would be very helpful to introduce the concept of the UPIC to people who are not familiar with it.

UPIC DESCENDANTS

	UPISketch	Synesthésie	High C	IanniX
Author	Rodolphe Bourotte, Sean Soraghan, Daniel Walz	Guillaume Jacquemin	Thomas Baudel	Therry Coduys, Guillaume Jacquemin, Matthieu Ranc
License	Unknown	Unknown	Proprietary	GPL 3
Platform	iOS, MacOS, Win	HTML5 browser	Win, MacOS, Linux	Win, MacOS, Linux
Framework	JUCE	WebAudioAPI, Pixi.js	Undisclosed	Qt
Programming Language	C++	JavaScript	Undisclosed	C++
URL	http://www.centre-iannis-xenakis.org/upisketch	https://synesthesie.buzzinglight.com	https://highc.org	https://www.iannix.org
Synthesizer	Granular synthesis/ PSOLA	Internal sound generators	Internal sound generators	External (OSC)

TABLE 1 DESCENDANTS OF THE UPIC
Table 1 summarizes four major applications whose newest versions were released after 2015. As shown in the table, the descendants of the UPIC employ modern technologies to settle on various platforms. UPISketch and Synesthésie offer easy access to the system in the mobile and the web environment. HighC by Thomas Baudel highlights multiplatform compatibilities and has a strong focus on musical education; it provides step-by-step tutorials for nonmusicians and includes various samples. IanniX offers highly experimental features, such as three-dimensional notation, generative score, and OSC output. This radical approach is justifiable only with the technologies available in 2019, in which many audio specifications are standardized and matured.

THE UPIC IN 2019?

As discussed above, the use of graphic interfaces for controlling sound parameters became recognized by sound artists along with the evolution of DAW software. UPIC's descendant applications are handier and more accessible than ever thanks to the evolution of mobile devices and web technology. Basic hardware capabilities have been rapidly improved and this enables production of complex graphics and sound in real time. Many things that were technically impossible in 1977 are possible today.

Given this situation, it is rather challenging to predict the future of UPIC-like software in general. However, one possible future implementation can be anticipated from the perspective of the field in which the author is currently engaged.

VR AS A CANVAS

2016 is often called the year of Virtual Reality (VR) because Oculus Rift, the first consumer VR headset was released and enabled the general public to access immersive interactive three-dimensional experiences.

Although IanniX allows us to draw three-dimensional scores, mouses and monitors are designed for two-dimensional control; specific sequences of operation are required to draw complex three-dimensional lines and polygons. However, VR technologies allow us to draw them in space in a very natural way by pressing a button of a controller and moving our hands in an actual space.

Some VR applications, such as Google Tilt Brush, have already crystalized this idea. Tilt Brush allows users to draw lines in VR space, using various brushes and painting tools. Furthermore, to encourage artistic creation in VR, the Google Cultural Institute invited visual artists with no previous experience with VR from all over the world and let them create artworks in VR using Tilt Brush.[15] Through this sort of software and encouragement, three-dimensional creation in the digital domain is becoming rapidly accessible today. FIG. 11

This accessibility and ease of use that VR technology provides coincide with what the original UPIC system envisioned. However, in addition to conventional issues such as mapping and playheads, VR technology raises diverse domain-specific challenges. How should the audience listen to a score drawn in a VR space? Would it be possible to hold a concert? Should the performances take place in the virtual or real world? Should they be exhibited simply as a form of jukebox? As in the case of the Ateliers UPIC a few decades ago, an intimate collaboration between artists and engineers would still be essential to work on these challenges.

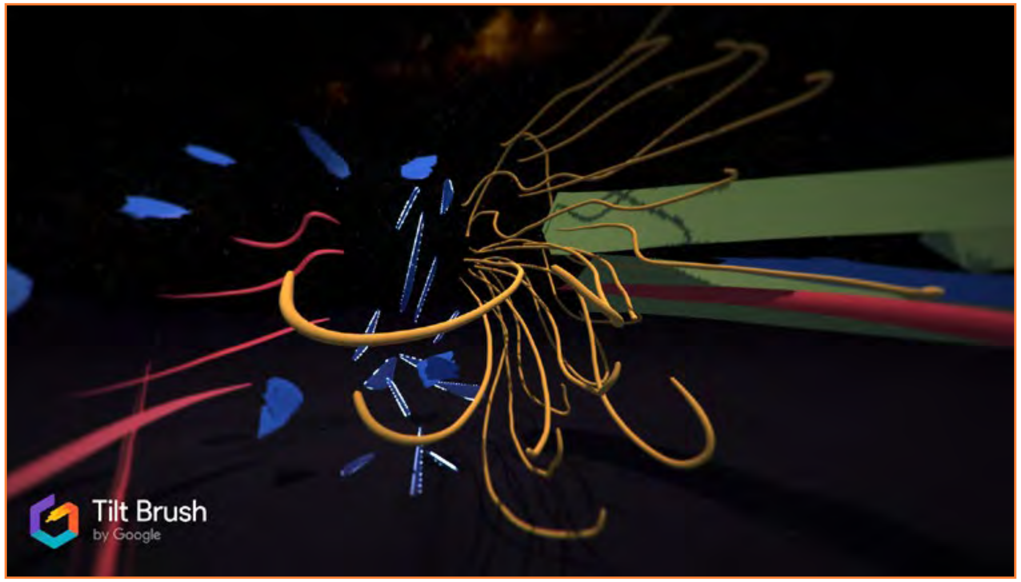


FIG. 11 Three-dimensional sketch by the author drawn in virtual space with the software Google Tilt Brush, 2019, screenshot © Chikashi Miyama

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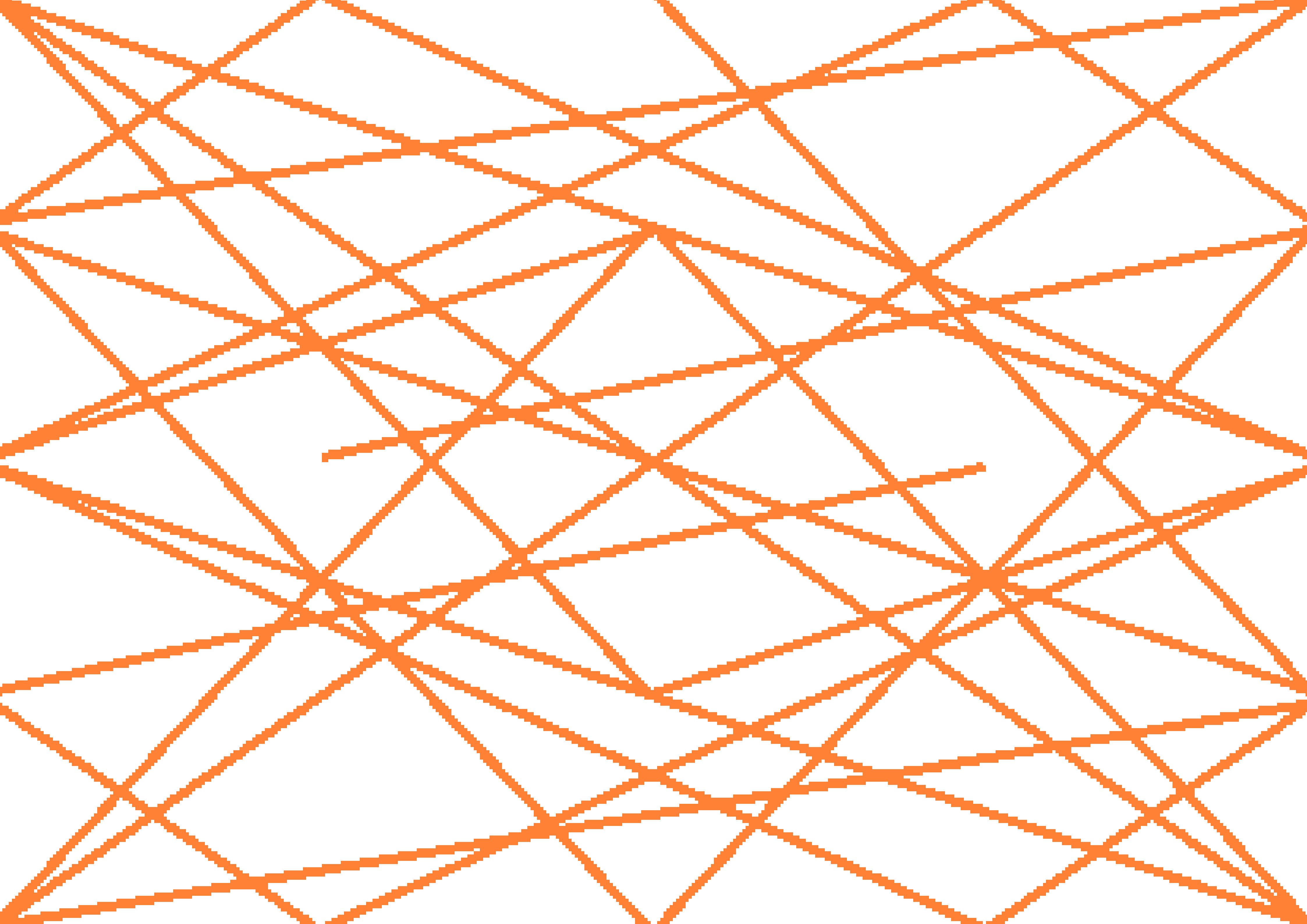

UNFLATTERING SOUNDS: PARADIGMS OF INTERACTIVITY IN TACTILE INTERFACES FOR SOUND PRODUCTION

VICTORIA SIMON

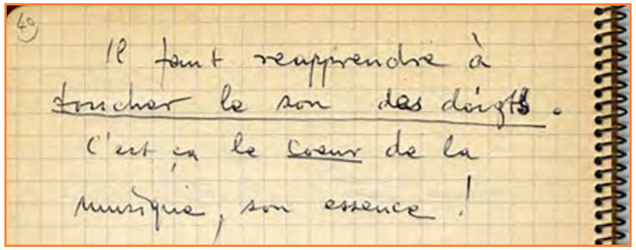

FIG. 1 Iannis Xenakis, fragment of page 40 in notebook n°1, 1952. Here, he emphasizes the importance of touch in music. Ref: OMS. 24357 © Iannis Xenakis Family

VICTORIA SIMON

UNFLATTERING SOUNDS: PARADIGMS OF INTERACTIVITY IN TACTILE INTERFACES FOR SOUND PRODUCTION

Written sometime during the years 1951 to 1953 in Xenakis's journal, this handwritten entry translates as: "It is necessary to relearn how to touch sound with one's fingers. That is the heart of music, its essence!" **FIG. 1** This quotation underscores his way of thinking about the nature and meaning of sound as a tactile experience. It indicates a desire to touch sound and it foreshadows his later statements about the importance of tactile knowledge that he consistently projected onto the UPIC system both in interviews and in the paratextual media, which provided explanations of it. The *L'UPIC du CEMAMu* pamphlet, a sort of user's guide and tutorial, for example, emphasized the importance of touch in the user's interaction with the computer, stating "when we touch the computer for the first time, it is free from any musical element [...] everything goes through the hand which draws."[1] One could interpret this journal entry as a statement asserting that the true essence of music is an embodied practice, one that is learned and cultivated through a person's fingers. Another interpretation might be that a tactile engagement is the heart and essence of music, essentially linking touch to the sonic experience.

Either interpretation supports Xenakis's numerous statements about touch in the form of drawing and it was the primary justification for the UPIC's drawing board interaction paradigm. It should be noted that the romance surrounding a musician's "touch" of an instrument has a history that dates at least as far back as the eighteenth century.[2] The importance of "touch" is bound up with a preexisting tradition in the manner in which Western music culture has historically fantasized the unique relationship between the musician and the instrument. Nevertheless, the quotation taken from Xenakis's journal also indicates his romanticizing of touch, and the ability for people to encounter the heart and essence of music through the hand was part of his thinking before subsequent developments of the UPIC and applications of commercial touchscreen user interface design.[3]

We can see the notion of “direct contact” with sound as a privileged form of interaction and user-friendly music practice in the way that music software companies market music applications (music apps) for Apple’s iOS platform. In the present context of the iOS platform, the dominant paradigm of app interface music touchscreen user experience is to provide the feeling of instant mastery over a musical instrument through touch. The most popular apps in the app store such as iMaschine 2 and ThumbJam are those which focus on a smooth, seamless experience, where users feel in control over the sound. Evident in the marketing of these apps, the explicit goal of the interface is to create a “fun” musical experience.[4] Fun, in this case, I define by instant gratification; where the aesthetic outcome flatters the user and creates the semblance of instant ease and competency with an instrument. In this article, I will argue that the app Borderlands Granular presents an alternative paradigm of user interaction, one defined by the same principles of user interaction and musical experience that Xenakis attributed to the UPIC.

Borderlands Granular is a software program created by Chris Carlson, initially as a graduate student at Stanford University, which he later translated to the iOS platform.[5] The goal of the app is playful experimentation and exploration of sound. In Borderlands, the user receives feedback by listening to the results of their actions, and then modifies how they use the app and the results they obtain. The user records a sound sample or brings in a sound sample from another source, which the app then visually renders into a metaphor for a sound wave. Within the sound wave, the sound is broken up into tiny dots or “grains,” which the user is encouraged to explore. This paradigm of sound synthesis comes from Dennis Gabor’s theory of granular synthesis, which Xenakis famously used in his music composition *Analogique B*.[6]

In our interview, Carlson explained why he opted for the touchscreen over the mouse and desktop software paradigm. He described the touchscreen as the optimal solution to the interactivity of the Digital Audio Workstation. With the touchscreen, “suddenly you have the ability to use all of your fingers simultaneously to manipulate these objects on the screen in a way that you can’t with just a mouse and a keyboard.”[7] Carlson faults the mouse and keyboard paradigm of interaction for providing a “serial process” of interactivity: “you do this, and now I’m going to move this thing over here, and I’m going to edit this parameter, and I’m going to move the mouse and click this thing.” He observes that with the mouse, the user must focus on one thing at a time. For Carlson, the ability of the user to deploy all of their fingers simultaneously to alter visual images on the screen was a crucial reason to opt for the touchscreen. The user would have had to take too many steps to accomplish a task with the desktop format and to focus on too many tasks, each requiring the user’s attention through bodily engagement. Unlike desktop software, the touchscreen could embody a more “realistic and natural” form of musical interactivity, with the sounds changing based on a direct feedback loop with the user’s body. The interaction paradigm of immediate feedback based on the user’s tactile input, to Carlson, confers on the app its supposedly “natural” and musically expressive qualities.

Borderland’s interface encourages users to explore different ways of manipulating sound waves, playing with their variable textures and seeing how they respond both visually and audibly to different sound effects the user can select in the app. Carlson states that “the intention behind Borderlands, and part of why the interface is so focused on just the sound files and these grain clouds that you see, is that I really want the focus of the interaction to be on engaging with sound files and exploring those sounds files directly.” Without having any knowledge of music or the Borderlands user interface, the user participates in a feedback loop as they build skill within the app in a way similar to how they would learn a musical instrument.

In the Borderlands app, the process of obtaining a desired outcome may involve frustration or irritation. In my experience, as well as from hearing the experience of others who have used the app, it is possible to sound bad. Frequently, the app is recalcitrant. Efficiency and successful completion of a track are not the goals of the app. Rather, the end goal is to deepen the user’s exploration of sound and to play with alternative possibilities of sound generation.

Like Carlson, Xenakis saw hands-on direct manipulation as paramount to an unmediated form of embodied musical expression. When Xenakis was interviewed by Henning Lohner, he stated, in reference to drawing: “With the UPIC you have the potential to enter into the problem of composition in a much more simple and direct way—and by this I mean direct to the mind. [...] I think this more universal notation is possible for everybody because it is the end of the hand that creates the drawings. The hand is the organ of the body that is closest to the brain.”[8]

This statement attests to the idea that Xenakis saw the UPIC as a medium that disappears, allowing for a natural production of music to occur. For him, music would flow from the person’s mind, unaffected by the medium—a technology of unadulterated creative authenticity. Xenakis painted the UPIC as a way “to touch the sound with one’s fingers” and engage with the unmediated essence of music itself. The sound drawn on the page would be represented as a true expression of the user’s thoughts. The logic was as follows: as the movement of the hand was an unmediated and direct expression of the user's brain, and as the GUI (graphical user interface) of the UPIC system provided a direct translation of the hand's gesture to sound, then there was no intermediary between the user's hand/brain and the sonic output. To interact with sound—via a drawing board—was also the most simple and natural form of interaction for Xenakis. Due to its tactility and immediacy, he considered the UPIC to be a user-friendly interface.

In the case of the earlier versions of the UPIC, however, users could not attain proficiency with the interface so easily. While users could make sound through the interface by directly drawing in lines and shapes, many experienced difficulties interacting with the system, and it took time both to obtain sound results and to achieve general competency. Today, the Center Iannis Xenakis (CIX) has created a version of the UPIC in an app format, UPISketch.[9] The UPIC in the iOS format maintains the values of exploration and discovery of sound. What is lost, however, is the difficulty the user initially experienced in gaining proficiency with the UPIC.

From the statements that Xenakis made about the UPIC, we can infer that he viewed the experience of difficulty as integral to the process of learning an instrument and making music. The pamphlet that accompanied the first UPIC explicitly stated, "From the child to the composer, everyone will use it in his own way, according to his knowledge, abilities, job, and talent. [...] For all of them, the UPIC is a tool which leads to sound concretization through a gesture. If the gesture is naive [...] the music will be naive [...] if it is skillful, the UPIC will traduce the intelligence of one's art."[10] From this account and from Xenakis's own words, we can see that the system was potentially easy to use, at first, but difficult to master. Xenakis recognized that novice users would create musical works that sounded different from those of more advanced users. He understood this issue as part of the process of learning an instrument and making music. Xenakis described the act of drawing as a universal approach to music because knowledge of the basic principles of sound would be attained directly through the user's body through the act of drawing its basic electroacoustic components. Attaining a level of fluency with the system required that the user spend time learning it.

This image taken from the UPIC user's manual **FIG. 2** is an example of what a score looks like using the UPIC system. At the CIX, I found numerous examples of musicians' graphical music compositions. These elaborate drawings required knowledge of how to draw and skill to produce, as seen, for example, in Xenakis's score for *Mycènes Alpha*. Xenakis saw the UPIC as a way to augment human capabilities and intelligence through feedback from the system. For instance, the user could learn about sound properties through the neuromuscular coding of

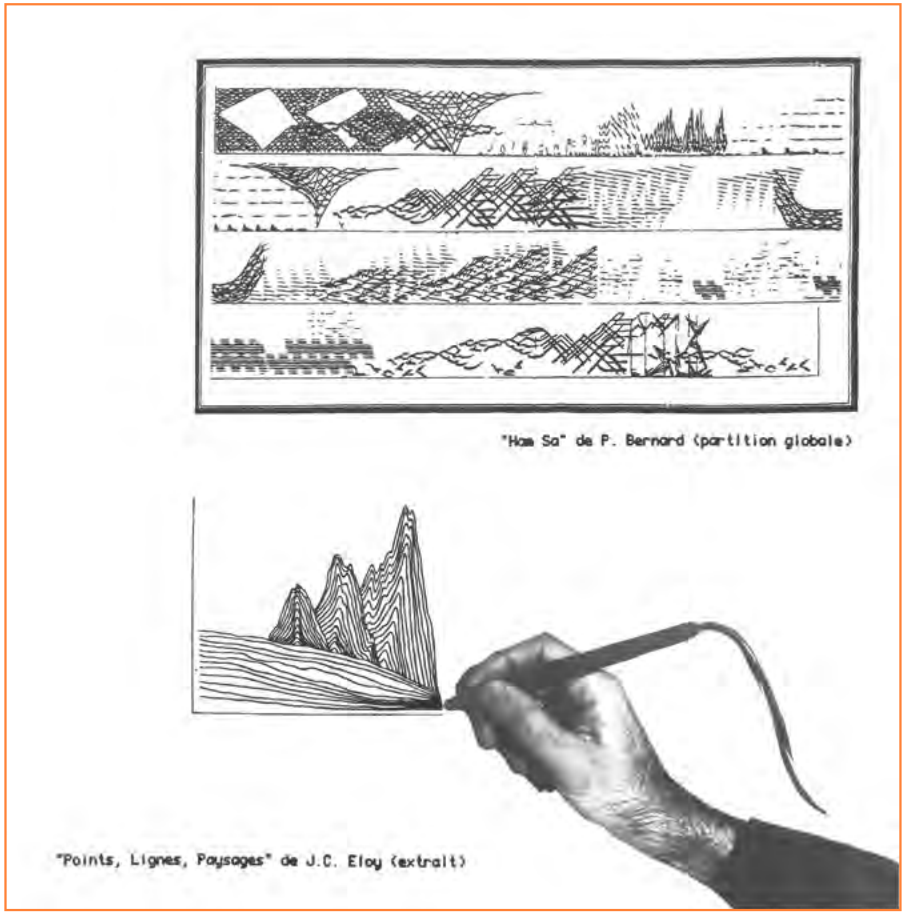

FIG. 2 Examples of intricate illustrations that composers Pierre Bernard and Jean-Claude Eloy did with the UPIC. © CIX Archives id. 224/4

the hand and compose music through exploration, trial, and error. Through drawing, the user could conceptualize and make sense of the world of sound. This would occur through an embodied knowledge that came from the connection between the gesture of the user's hand and the audible sound. Through the visual, tactile, and sonic feedback loop of the UPIC, the user could process this knowledge of sound and music in order to learn and grow as an artist.

What Borderlands Granular and the UPIC present to us is an alternative paradigm of interface design where the user learns and grows musically through embodied feedback from the interface. The dominant user interface paradigm of music apps is an experience of instant success and effortless musical mastery. The ability to attain a desirable sonic outcome efficiently typifies what counts today as "user-friendly" interface design in the app format. Tactility and immediacy in the app format mean that with just a few swipes or taps on the screen, a person with limited musical ability, skill, and knowledge can immediately create a professional sounding outcome. The UPIC is a case study of user interface design that historicizes the terms "tactility," "immediacy," and "user-friendliness." We can see Borderlands Granular as a present day iteration of the UPIC's paradigm of interactivity. At times the interaction may produce disappointing sounds and frustration in the user. Nevertheless, these recalcitrant interfaces promote the values of exploration and playful discovery of sound as opposed to the goals of instant success and control over the aesthetic outcome.

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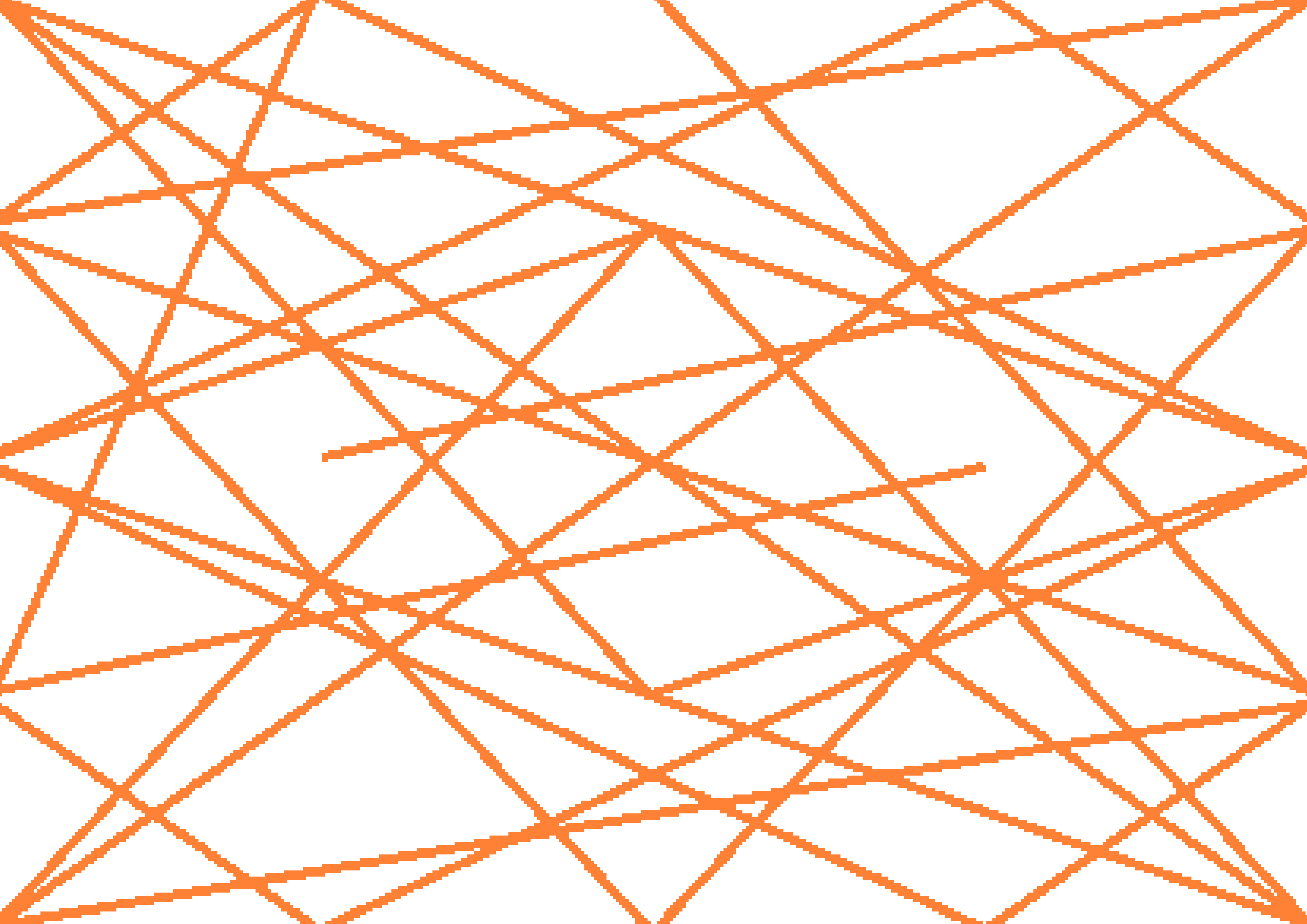

NOVEL PERSPECTIVES FOR GRAPHIC NOTATION IN IANNIX

JULIAN SCORDATO

NOVEL PERSPECTIVES FOR GRAPHIC NOTATION IN IANNIX

INTRODUCTION

With his mathematical approach to musical composition,[1, 11] Iannis Xenakis proposed a pitch-time Cartesian space for the notation of continuous motions—such as *glissandi* or “arcs”—which characterized the premise for his conception of the UPIC. As an early computer system capable of generating sounds from user drawings, this machine offered an attempt to extend the notation from traditional *solfège*, a multi-formal description of the score, and a gestural approach mediated by the computer.

As the chronology of the UPIC unfolds, various tools and devices participate actively in the same process of technological evolution and democratization that led the UPIC to a prototype of a software-only version in 2001—called UPIX—after passing through a continuous update of its hardware design.

After Xenakis’s death, in 2001, the development of UPIX stopped.[2] At that time, Thierry Coduys (La Kitchen), with the collaboration of Gérard Pape (CCMIX) and Adrien Levèfre and supported by the French Ministry of Culture, started to develop IanniX.[3] On one hand, this software would be based on the UPIC, but on the other hand it would become an interface devoted to a wider creative field by combining current technological developments, new significant features, and a multimodal approach.

In particular, at the foundation of IanniX, there was the willingness to integrate part of the original framework of the UPIC conception with a poly-temporal and multi-topological representation system: from bi-dimensional arcs on the UPIC page, to three-dimensional curves interpreted by different reading heads—namely, cursors—with their own space-time behavior. Also, the sound synthesis engine was oriented to plug-ins.[4]

In addition to the development of the concept of score, especially in terms of dimensions, IanniX recovered an important feature for notation: the ability to represent punctual events—called “triggers”—like MIDI notes. Indeed, for control purposes, musical notes do not necessarily foresee a continuous variation of a parameter—for example, their pitch (*glissando*) or dynamics (*crescendo* or *diminuendo*).

JULIAN SCORDATO

At a further stage of development, the implementation of more features and interaction modes allowed to go beyond the conception of a predetermined and reproducible "control score," thus paving the way to new types of scores.[5]

A DEFINITION OF IANNIX

IanniX is a "graphical open source sequencer [...] for digital art"[6] that operates in real time; in this sense, it is a tool for both graphic notation and transmission of information for multimedia performance. Through various communication protocols, it synchronizes punctual events as well as continuous data to other environments—for example, Pure Data, Max, Processing—and hardware such as MIDI devices and Arduino. IanniX's package is free and multi-platform.

Its operation is based on the reception of commands for the creation and management of a score, as well as on the transmission of score-related messages for controlling other devices. Therefore, it implements various communication protocols and technologies (OSC, raw UDP, TCP, WebSocket, HTTP, MIDI, Syphon, and serial port communication) in order to support interfacing with numerous software and hardware.

Its main window shows a representation of a multidimensional and multi-format score that is programmable via a Graphic User Interface (GUI), JavaScript, and other applications that use a compatible network protocol. This flexible configuration has an advantage over most software environments in that it avoids forcing users to adopt a unique method for the creation of a score, so they can benefit from the use of multiple design strategies, also according to their expertise.

IanniX scores are based on three types of abstract objects to be placed in a 3D virtual space: triggers, curves, and cursors. Triggers and curves represent discrete and continuous events, respectively. Cursors are time-based elements—playheads—that can move along the curves in order to read a specific sequence of space-limited events. A theoretically unlimited number of cursors can be added to a score, in contrast to the single predetermined timeline of IanniX's predecessor. Thus, a three-dimensional and poly-temporal sequencer is proposed, unlike the UPIC which was based on two-dimensional drawing and allowed for only one timeline that could be normally read from left to right, as an emulation of the conventional way of reading a music score. Also, IanniX runs independent of any sound synthesis engine, in order to permit the use of different instruments and plug-ins. The characteristics of the design and interface, therefore, make it quite suitable for a broad variety of applications.

MAIN APPLICATIONS

Through the communication with audio environments or MIDI devices, IanniX can be used as a tool for the creation and performance of musical works designed using 2D or 3D graphic notation. Many object attributes and four mapping modes allow the user to match the characteristics and behavior of cursors, curves, and triggers with sound and music parameters as well as several MIDI events. The capability to import external graphics, as textures, into a IanniX project amplifies the representational possibilities of basic objects. Furthermore, sketches and notes can be integrated into the score as a background image, providing a tool to assist the user in the creation of the final work; images can also be included in the final version for display purposes. Overall, the GUI offers a compact and simple work environment for accessing all IanniX functions without the need of specific programming skills.

With an ad hoc scripting language based on JavaScript, users can program IanniX scores using a procedure substantially different from the UPIC. Constituting the content of the source file, in a sense, the script actually *is* the score, as every IanniX command—which either produces or is produced by an action in the GUI—is defined through a custom JavaScript function (named "run") and every reaction to external input from network protocols or interfaces can be set in a Javascript method called "onIncomingMessage." Through this advanced approach, IanniX's functionality goes far beyond a mere technologically evolved emulation of the UPIC, thus facing the generation of scores by means of functions and control structures which are more comprehensible to programmers.

The strong relation between sound and visual content that emerges through the use of IanniX has often been a stimulus to reveal the score as an integral part of the work, as is evident from the showcase of projects on the IanniX website. Indeed, IanniX has been used in audiovisual works as a tool for controlling specific parameters and events, and showing their graphical representation to the public, even to facilitate their formal intelligibility, such as in *City Score* (2012) by Julien Poidevin, *(A-Z)²* (2012) by Guillaume Jacquemin and Matthieu Ranc, and *Constellations* (2014) by Julian Scordato.[7]

An interesting field of application involves the development of graphic artifacts for sound reactive systems, data visualization, or image processing; among the known examples are, respectively, *Neyma* (2012) by Stefano Alessandretti and Giovanni Sparano,[8] *Fa Octothorp* (2012) by Guillaume Jacquemin & Matthieu Ranc, and *Mille Plateaux* (2014) by Pascal Dusapin.

Other specific usages of IanniX include the control of sound spatialization by means of the definition of virtual sound trajectories—

in *Shin-ji-ke* (2012) by Charles de Meaux, and Specter System by Bill Manaris and Seth Stoudenmier[9]—and the sonification of graphic data related to architecture.[10]

Several examples of completed projects and practical suggestions are bundled into the IanniX software package, including the score of *Récurrences* (2011) by Thierry Coduys, *(A-Z)²* (2012) by Guillaume Jacquemin and Matthieu Ranc, *Pulsar* (2014) by Guillaume Jacquemin, and a sketch from Xenakis's *Metastasis* (1953–1954).

CLASSIFICATION OF IANNIX SCORES

According to their functionality, and to the interaction mode with other applications and devices, various types of scores have been recognized.[5] They can be summarized theoretically in the following five typologies.

CONTROL SCORE

As in the conventional practice of musical composition, a score is commonly used to organize a system of graphical signs and symbols that represent certain characteristics, subsequently interpretable to *control* instruments in a performance. Still, instrumental notation has reached a specific and shared definition, which only became systematic after centuries. Instead, in the multiplicity of production techniques, parameters, and processes involved in computer music and, in general, in time-based digital art, a more abstract and generalized system would be needed to adapt to a wide range of expressions interpretable by a computer. According to the nature of the magnitudes involved and their articulation over a time frame, two general categories can be distinguished: these stand for discrete and continuous events. In order to be sequenced, the former may require one or two distinct output messages—for isolated occurrences or for delimiting a time span—while the latter are simulated through an interpolation of values at a certain sampling rate. Hence, the distinction between triggers and curves exists to represent graphically such events.

In IanniX, in a way comparable to the operation of the UPIC, once a score has been set by the user and then started, a sequencing device reads the events previously defined and produces a data output for controlling one or more processes in real time (e.g., sound synthesis, sampling, and audio/visual processing). Therefore, the performance of a control score can be considered as "autonomous, reproducible, and determinist."[5]

REACTIVE SCORE

In opposition to the control score, a reactive score foresees only the reception of data from the input side; more specifically, commands conforming to the IanniX scripting language or any message interpreted by

the *onIncomingMessage* method are used to create entirely or to modify partially the content of a score. This approach leads IanniX to an operation which is independent from the sequencer, as long as event timing is defined by an external input device that controls IanniX.

By reacting to external stimuli without causing any output of control data, the primary purposes of the reactive score are visualization and graphical representation of data received from software environments and devices (e.g., a 3D path detected by a motion capture device, a variation of a specific parameter against time, or the deformation of a curve expressed by a parametric equation). Despite strong graphic limitations, such as the lack of support for the representation of surfaces and numerous restrictions in texture processing, IanniX's environment can be configured for data visualization, implementing vector and raster graphics.

Moreover, the objects added to reactive scores (e.g., triggers related to note messages received from a MIDI keyboard) can be subsequently read by the sequencer in order to produce control messages. In this way, IanniX may also work as a performance recording system.

INTERACTIVE SCORE

In an interactive score, the characteristics of the two typologies above are joined together: the use of IanniX to control other tools is coupled with the capability to edit the score from an input device during the performance. A bidirectional data flow is involved and IanniX acts as a part of a human-computer interface or a bridge for the connection of software and/or hardware, exploiting the ample interfaceability supported.

Considering that interactivity is a very common aspect in the design of multimedia performances and installations, this kind of score offers many possible applications such as real time performance control by means of user interaction (already implemented in later versions of the UPIC), the interfacing of sensors and actuators that use a different communication protocol and, more generally, the mapping of input data combined with time management.

From a strictly technical point of view, a control score which receives commands only for display purposes (e.g., change in object color, camera rotation, vertical and horizontal scrolling, or zoom) can also be considered an interactive score.

GENERATIVE SCORE

This type of score is produced or controlled by algorithms written in JavaScript language. A generative approach can either cause the result to evolve over time or arrange IanniX objects in a predetermined way (*outside-time*). Therefore, in this case the score *is* the output.

The advantages of using a programming language to create a score include the possibility to expand the basic functionality of GUI and automate processes through iterative structures, conditional statements, functions, and variables. Algorithms may speed up significantly object instances and positioning when compositional rules are formalizable. For example, aleatoric or stochastic processes can be implemented and executed once when a score is loaded or repeatedly during the performance. In the script, the function *run* for sending a command to IanniX may include arithmetic operations, variables, and other functions along with fixed parameter values; all of these are also applicable to output messages before sending them to other devices.

For the reasons above, generative scores can take deterministic, nondeterministic, or stochastic traits.

RECURSIVE SCORE

Through an ad hoc protocol called "direct," IanniX proposes a way to control itself during the performance of a score: an output message related to an object can be reinserted into the system as an input command at time $t + x$ [ms], according to the scheduler period. In some cases, this implicates recursion or deformation of the score as a function of time; in other cases, it commands the application itself.

There are three common elements that may characterize a recursive score: (1) the control of an object by means of an unrelated cursor/trigger, thus establishing a univocal correspondence or a one-time instance; (2) a stable or chaotic feedback between controlled object and controller, with the involvement of an actual recursive function; (3) the control of the sequencer (status, position, or speed) or viewport (camera rotation, position, or zoom) through a cursor/trigger. In a practical application, a recursive score does not exclude the possibility to integrate features from the other score types discussed above. Different compositional approaches and communication protocols may in fact work together.

GRAPHIC OBJECTS AS A MEANS OF NOTATION AND PERFORMANCE

As a reference for the positioning of objects in the score, IanniX uses a Cartesian coordinate system which does not establish a fixed relationship with time. Being determined by the path of individual cursors along the curves, the progression of time is freed from the constraint of a Cartesian axis or a "straight line", as instead proposed by Xenakis.[11] Or at least, a linear time model could be applied to IanniX scores only as a special case. Basically, in IanniX scores, temporal structures are multiple and variable, and become the object of the notation itself.

Besides the position on the XYZ axes, every object has a series of general attributes that are configurable dynamically by the user: ID number, group name, label, activation status, thickness/size, color, texture, and syntax of output message/s (only for cursors and triggers). These attributes are useful for identification, for setting the appearance and behavior of the object itself, as well as for storing and managing data which are retrievable through predefined variables to be included in a message. Furthermore, objects hold specific properties, as described below.

CURVES

A curve is a graphical representation of a function or a vector-based path within the score; it can be defined either by parametric equations (i.e., "math curve"), by a set of 3D points ("straight curve" or "smooth curve"), or by a tool for drawing ellipses ("circular curve").

IanniX curves assume three possible functions in a score: (1) as tracks for the path of a linked cursor, they outline a localized temporal pattern; (2) as objects within the space-time range of a cursor, they describe the variation of values in 3D space in relation to the *temporal position* of the same cursor; (3) as graphic artifacts, they represent objects of visualization with a formal and aesthetic value.

In a very simple example, assuming to have a straight timeline on the X axis, it is possible to use a curve to represent graphically the continuous variation of two one-dimensional quantities (e.g., audio frequency [Hz] and amplitude) on Y and Z axis, respectively. In more complex cases, through parametric equations or generative scores, sophisticated geometric shapes and architectures can be drawn precisely to give formal consistency to the notation. FIG. 1

CURSORS

A cursor is a time-based graphical object that moves along the path of a linked curve and performs local and autonomous sequencing functions: (1) it permits the activation of triggers located in its range; (2) it sends continuous messages which may include variables related to its position or status, to any collision point with curves, or to the sequencer. The size of a cursor—in attributes of width and depth—determines its surface of intervention in the score at instant *t*, according to a global timeline and to its specific behavior.

Cursors are indeed subject to global Transport controls. However, several attributes define their own temporal behavior in the score: speed/duration, loop pattern, acceleration, offset, and message transmission rate. For this reason, they represent the core of IanniX's poly-temporal functionality.

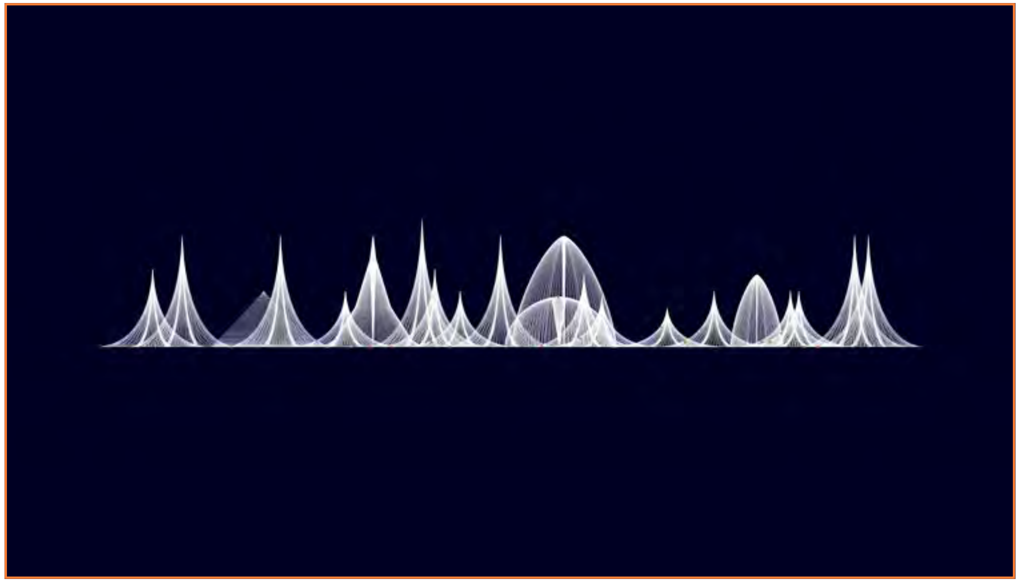

FIG. 1 Julian Scordato, *Study for a Cosmic City*, 2019, score excerpt, graphical sequencer and electronics © Julian Scordato

FIG. 2 Coordinate mapping for a cursor in a score in IanniX, 2019, screenshot © Julian Scordato and IanniX Association

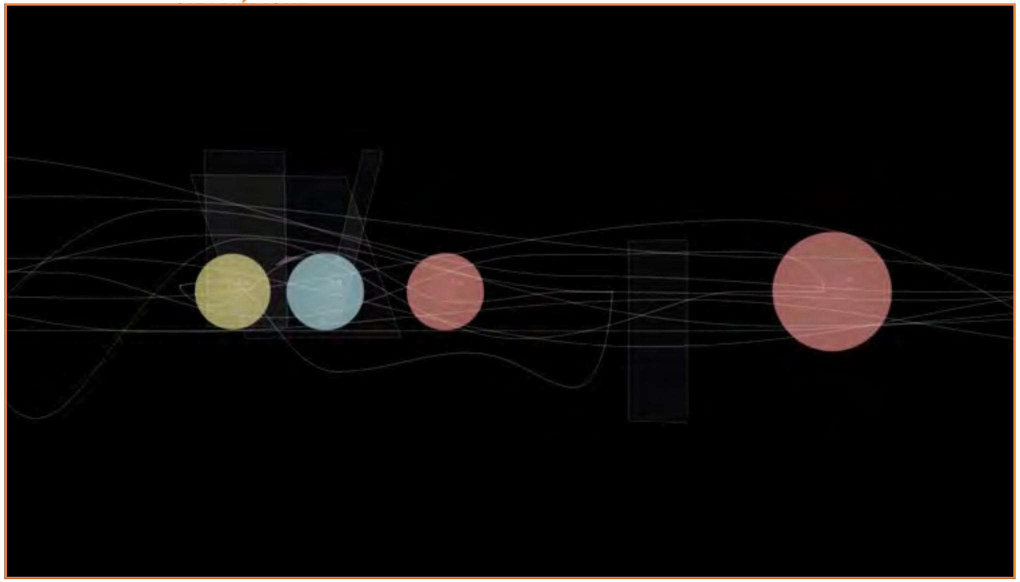

FIG. 3 Julian Scordato, *Engi*, 2017, score excerpt, grapical sequencer and electronics © Julian Scordato

Through cursors, different portions of 3D space of the score can be mapped conveniently to the range of values needed to control specific parameters, in order to facilitate interfacing between devices and IanniX objects. **FIG. 2** This leads to multi-formal and multi-topological conceptions of the score.

TRIGGERS

In its default appearance, a trigger is a spherical object with the ability to send individual output messages in the event of a spatial collision with a cursor. By involving discrete events over time, in a musical context triggers represent an extension of the notion of *note* within a 3D space. Their duration—that is, the time between the activation and deactivation message (*note off*)—is defined by a trigger-specific attribute. Thus, they are well suited for communication via MIDI protocol. In addition, the fact that triggers are placed in a 3D space inherently encourages the user to explore unconventional ways of conceiving a score. **FIG. 3**

When applied to interactive or control scores, triggers are able to control any sort of punctual event, from dataflow to final media, depending on the software or hardware linked to IanniX.

Beyond that, triggers can be used to manage data presets, as score self-control devices, or as tools for importing bitmap images, even to enrich the semiographic aspect.

CONCLUSIONS

This text aimed to provide an overview of current possibilities and limits of graphic notation and performance with IanniX. Developed in the wake of the UPIC, IanniX has in many ways expanded its functionality and areas of use, proposing to meet various expressive needs and focusing on the critical aspect of notation in the age of New Media.

In an original way, this software proposes a generalized system for the notation of relative space and time that challenges the concept of score and opens up new possible applications within music, digital art and design, and mixed technology contexts.

From a performative side, various user approaches are possible through interactive scores, such as improvisation, live coding, collaborative and network performances.

With the awareness that the role of composer nowadays may include becoming "the programmer and constructor of the device that originates the sound,"[12] IanniX intentionally did not offer an integrated sound synthesis engine, favoring operational openness and flexibility at the expense of "ease of use [...] and immediacy."[2] In fact, to fully exploit IanniX features, the user needs various technical skills, including interaction design, programming,

and knowledge of networks and communication protocols. Inevitably, this shifts the focus of an eventual pedagogical function from an artistic to a technological approach.

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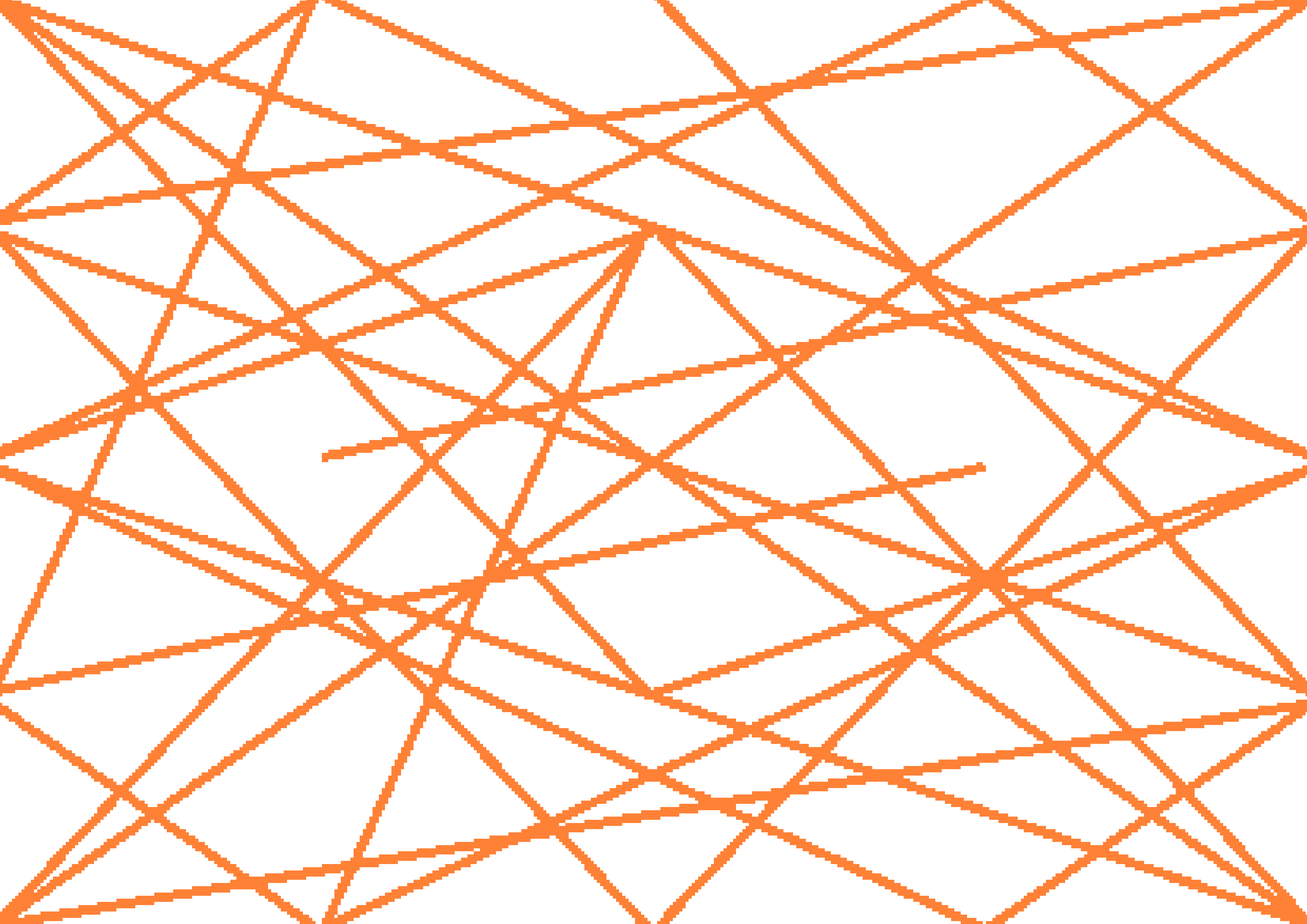

EXPLORING VISUALIZATION METHODS OF THE DYNAMIC BEHAVIORS IN COMPUTER-BASED MUSICAL WORKS

KOSMAS GIANNOUTAKIS

EXPLORING VISUALIZATION METHODS OF THE DYNAMIC BEHAVIORS IN COMPUTER-BASED MUSICAL WORKS

ABSTRACT

The score plays a very important role in the tradition of Western music. The recently developed computer-based practices challenge its conservative status by assigning novel functionalities to it. The creative output of the composer, which used to utilize symbolic and graphical notation, tends nowadays to include computer code and programs that produce multimedia content. This paper discusses the problem of scoring computer-based musical works that emphasize dynamic behaviors, and proposes visualization methods that could give an overview of the sonic dynamics and assist the composer in order to articulate his/her intention. Two works by the author are presented as case studies that demonstrate early investigations.

CONTEXT

The traditional role of the music score is to communicate the articulated musical ideas of a composer to the performers, who interpret the graphic symbols and actualize them into concrete sound. This understanding of the score appears to be solid in our current Western musical culture. It is challenged, however, by recent technological innovations that investigate novel ways of composing, performing, experiencing, and teaching music.

The function of the score has always been redefined by shifts in the musical culture. For example, with the decline of the improvisation practice during the nineteenth century, the added notes that decorated melodic and harmonic structures known as ornamentation, started to be explicitly written out.[1] In that historical period the musical work ceased to contain improvisation elements and reached a status that is still predominant. The pitch content, instrumentation, rhythmical proportions, tempo, dynamics, and articulation were precisely defined, although the performance practice of the nineteenth century permitted creative deviations on the last three

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features. For a significant time period in the history of Western music, this type of score was the principal creative output of the composer.

The piano roll, a continuous roll of paper with perforations punched into it that served as a storage medium for operating the player piano, brought a new perspective to the musicl score. Invented at the end of the nineteenth century, it primarily functioned as reproducer, replicating piano performances of famous pianists. Composers like Conlon Nancarrow went beyond this utilitarian use and artistically explored the new possibilities this medium had to offer.[2] Intricate rhythmical patterns were precisely punctured and played by the player piano with an accuracy that was impossible to achieve by even a virtuoso pianist. This practice brought a more radical change to the concept of the score. It became a medium that contains unambiguous instructions for performance by a mechanical musical instrument.

Iannis Xenakis had a background in engineering and architecture and a great interest in mathematics, philosophy, and computer science, which influenced his unique artistic output immensely. From his early creative period, he massively employed lines as his main compositional material, denoting continuous sonic transformations.[3, 4] These features could not be conveniently grasped by the traditional music notation system, so Xenakis relied heavily on graphical sketching before transcribing his compositional ideas into standard notation. Later, with the foundation of the Centre d'Etudes de Mathématique et Automatique Musicales (CEMAMu), he saw the possibility of translating a graphical sketch into sound directly by means of a computerized musical composition tool. The development of the UPIC system embodied his vision[5] and brought forth a new kind of music score. Bypassing the convoluted character of a symbolic music notation system and a computer programming language, a UPIC score is a drawing that maps the horizontal axis to time and the vertical axis to a frequency range. It functions as an input program for a computer music system that generates sound based on the additive synthesis technique and as an outline, which contains the traces of the compositional thought.

With the advent of personal computers and the Internet, computer-based musicking exploded into numerous fields, all of which explore new identities for the composer, audience, composition, instrument, score, and performance. In the fields of generative scores and real-time notation, the algorithmically generated scores are often displayed during the performance and portrayed as aesthetic objects that guide the audience's perception.[6, 7, 8, 9] In live-coding practices, the textual, visual, and gestural qualities of the projected code explore an experimental format that transforms the compositional process into a live event.[10]

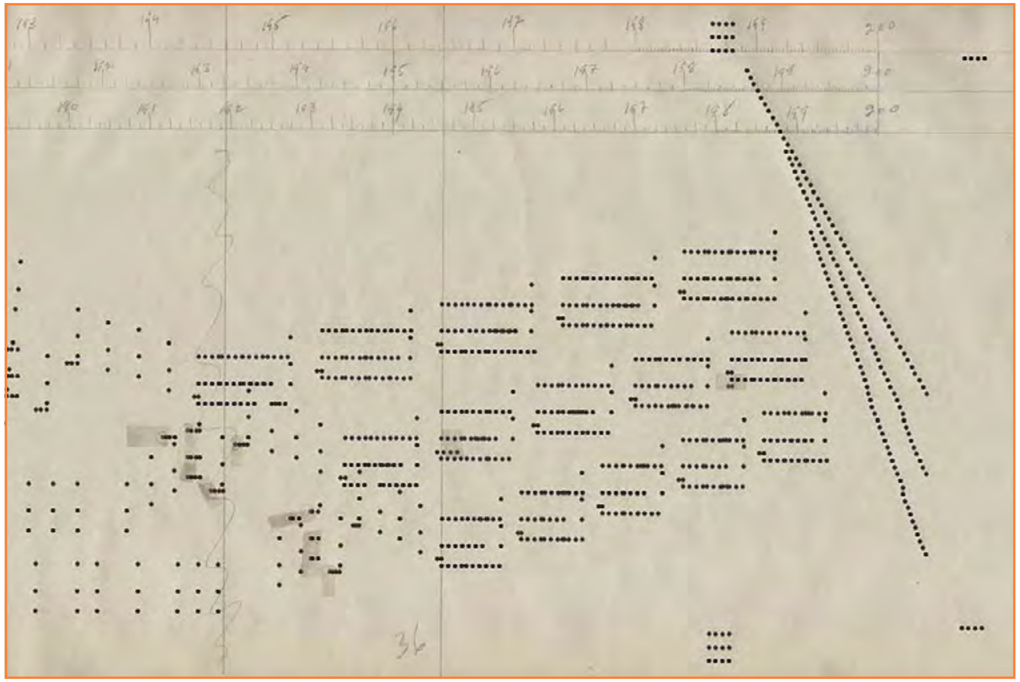


FIG. 1 Conlon Nancarrow, *Study No. 49c*, 1987, Perforated piano roll © Jürgen Hocker

SCORES FOR COMPUTER-BASED WORKS WITH AN EMPHASIS ON DYNAMIC BEHAVIORS

The historic UPIC system epitomizes the graphical score as parameter data for a computer algorithm that produces a fixed media composition. The reverse approach, namely, the generation of parameter data by algorithmic processes that can be applied to compositional processes, has also been pioneered by Xenakis with his research on stochastic synthesis and computer algorithms that generate micro- and macrostructures.[11] These innovations, along with the full body of his instrumental and electroacoustic works[12] have influenced numerous composers and sound artists like Agostino Di Scipio, who has written extensively about Xenakis's work.[13]

Di Scipio has developed a series of electroacoustic works that he calls *audible ecosystems*, which aspire to bridge the gap between sound generation and music creation by following consistent principles as had been envisioned by Xenakis and Stockhausen.[14] They are based on dynamic couplings between performers, Digital Signal Processing (DSP) algorithms, and acoustic environments, which produce ephemeral sonic structures in various timescales.[15] Similar approaches characterize this paradigm of music creation variously as *interactive music composition,*[16] *self-organized music,*[17] and *performance ecosystem.*[18]

In this field, the composer does not intend intelligible listening of preconceived music ideas, but the experience of dynamic behaviors that produce ephemeral sonic structures. This radical shift in the composer's role is also manifested in the output artifact, of what used to be a score. For the realization of an ecosystemic performance, the composer provides various documents that serve multiple functions. Along with the computer program, which can be a patch or code with accompanying libraries, the composer typically delivers:

- Instructions for the performers in the form of text and symbolic or graphic music notation.
- A tech rider, which includes connectivity diagrams, descriptions for the analog equipment, spatial setup, and detailed information about custom instruments and interfaces.
- Flowchart diagrams for the digital signal flow. The values of some crucial parameters can also be indicated.
- Description of the expected behavior and methods of driving the system's dynamics.

All this information is addressed to the performers, concert organizers, technicians, and computer musicians, and should be sufficient for the realization of a performance. Although the preservation of computer-based

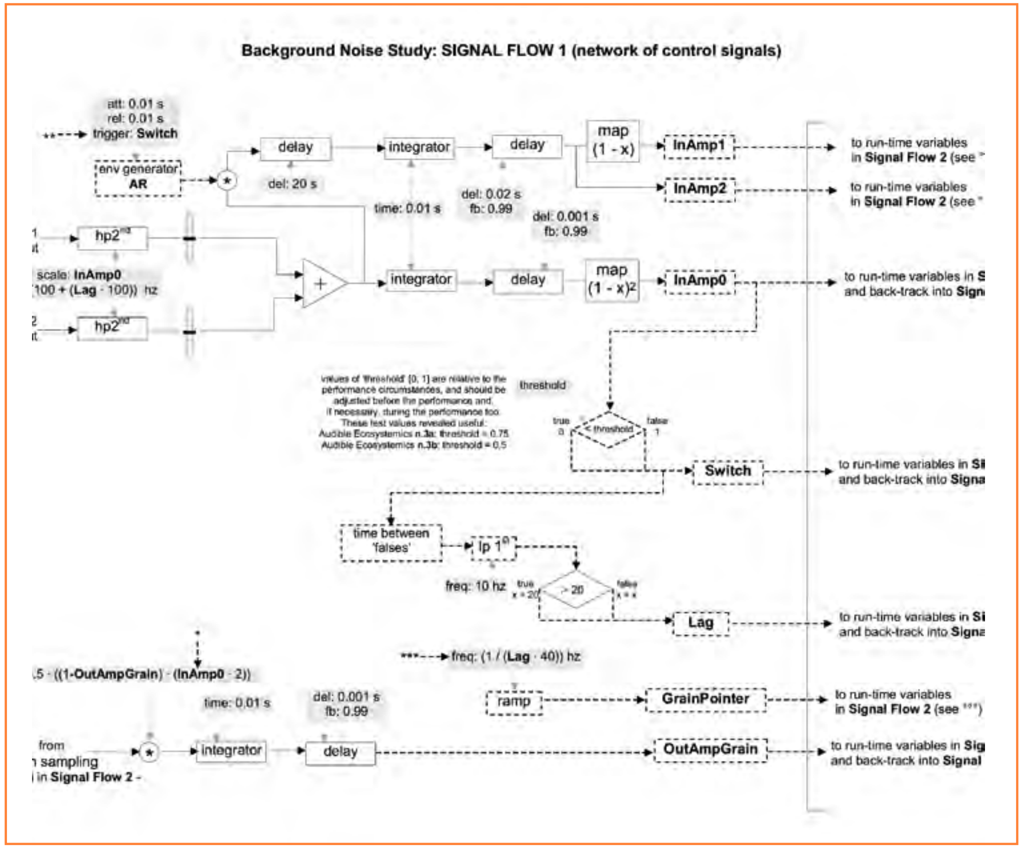


FIG. 2 Agostino Di Scipio, *Background Noise Study: SIGNAL FLOW 1* (network of control signals), 2004-05, score excerpt © Agostino Di Scipio

musical performances is a complex topic that requires interdisciplinary effort,[19] the composer could facilitate this process by formulating the information in a detailed way that makes migration to new technologies possible. The conventional role of the score is included only as a part of this expanded manuscript, which I shall call the "handbook."

GRAPHIC NOTATION FOR THE HANDBOOK

The aforementioned features for the handbook seem adequate. It lacks, however, an important feature that used to be an integral part of the conventional score, namely, an overview of the temporal evolution of the piece. This feature enables the mental recreation of the sound qualities and dramaturgy intended by the composer, although the mastery of this skill requires years of professional practice. It seems that this feature does not have a place in a handbook of an ecosystemic work; nevertheless I would argue that this could be very fruitful.

A musical work that puts an emphasis on dynamic and emergent behaviors does not present a single narrative but it can evolve within a continuous space of possibilities. The portrayal of that space and the predominant evolutionary paths by means of graphical representations may offer insights about the outcome of a performance. It could serve as a tool for the composer to articulate his/her ideas and effectively communicate them to his/her collaborators. With this feature the performers can memorize desirable scenarios so that they can detect early routes to desirable or undesirable states in order to carry out supportive or subversive actions.

Ideally, the dynamic behaviors could be formalized and codified by the rigorous language of mathematics, as Xenakis did for stochastic compositional processes.[20] A mathematical description of the work's dynamics would make the creation of computational models and simulations possible that can give an overview about the work's behavior. The graphic outputs of such programs can be incorporated into the handbook restoring the full functionality that the score used to have.

These advancements could lead to new documentation media such as computer and web applications that enable an interactive learning and exploration of the work. An example of such an interactive documentation is Gerhard Eckel's sound environment Zeitraum, hosted in the Research Catalogue—international database for artistic research website.[21] In this work, a spatialized periodic pattern of percussive sounds is distorted by the movement of the listener due to the differences in propagation time of the sound sources. The website contains various multimedia sections that allow the visitor to explore the work from various points of view, denoted as *formulations*.

TWO EXAMPLES OF VISUAL REPRESENTATIONS IN WORKS WITH DYNAMIC BEHAVIORS

In this section I will present two of my works that utilize visualizations as a means of gaining an insight about the work's conduct.

SONIC CURRENT

Sonic Current (2016) is a sound installation originally conceived and implemented for the "Twist," a central construction structure at the heart of the House of Music and Music Drama (MUMUTH) at the University of Music and Performance Graz, designed by the architectural design network UNStudio. Loudspeakers and microphones are installed according to the specific twisted geometry of the site creating an audio feedback network. Sounds from visitors, the environment, or other exhibited installations, are captured by the microphones and distributed over a digital, generative feedback network. Inside the high-dimensionally dynamic, self-regulating digital network, sound circulates recursively in multiple recurrent layers, resulting in diversely fragile resonant frequencies. The digital network output is assigned to the loudspeakers, which radiate the processed resonances back to the Twist. The emitted sound flows tangentially on the twisted surface and reenters the network, while it is reflected simultaneously in a peculiar twisty manner to the surrounding space.

The digital network is implemented with the Pure Data programming environment and utilizes nodes as junction points where the signal activity is integrated, and edges as variable delay lines with self-modulating mechanisms. In subsequent presentations of the installation in various locations, the arrangement of the transducers and the topology of the digital network are redesigned according to any peculiarities in the exhibition sites. The digital network has an intricate structure, containing three layers of feedback pathways. In order to illustrate the internal activity of the digital network, I have used in recent presentations an algorithm that implements a delay coordinate embedding,[22] which visualize the node dynamics in three dimensions. With this visual extension, the visitors can experience the internal activity visually and track where the components of the audible output are generated.

BURSTY EXORBITANCE

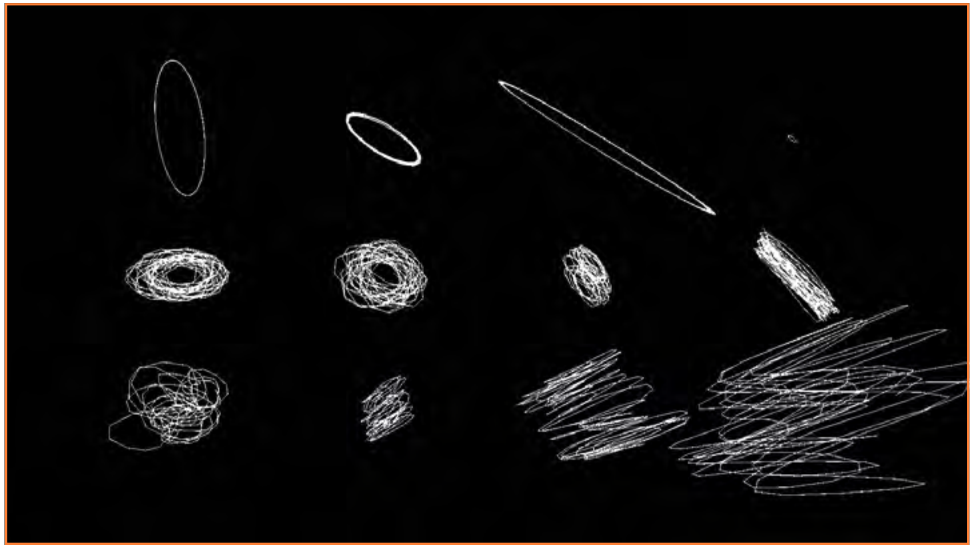
Bursty Exorbitance (2018) is an eight-channel computer-generated composition developed at the Hertz Lab at the ZKM | Center for Art and Media Karlsruhe in Germany as part of a residency on graphic notation. It explores the eruptive sonic qualities that emerge from a far-from-equilibrium drive of a Generative Feedback Network, implemented with the Pure Data programming environment. Eight nodes with self-modulating mechanisms were soft-coupled as nonlinear oscillators, which produced continuous sonic streams of explosive and recalcitrant character. Some crucial parameters of the self-modulating mechanisms were controlled by a four-dimensional chaotic attractor, discovered by Mohammad Ababneh in 2017.[23] The visualizations of the attractor served as a tool that provided proper parameter mappings for the macro development of the composition. Other important sets of parameters were randomized within composed limits while others were manually adjusted during the unfolding of the composition. FIG. 5

In diagram FIG 4, the boxes with the sine waveform represent wavetable sine oscillators and the dashed lines modulating signals. It is worth mentioning that the four-dimensional chaotic system is an autonomous system without any influence from the generative feedback network or the user, and functions as a control structure. The attractor visualization is achieved by the numerical integration of the differential equations, a trivial process that yields immediate graphic results. A potential coupling with the generative feedback network would require other methods for visually representing the dynamics, like algorithms that implement delay coordinate embeddings.

OUTLOOK

The mathematically inspired and computer-based music-making, as established by Xenakis's pioneering work, is flourishing nowadays with the abundance of computation devices. The prominent field of sonic ecosystems departs from the stochastic models introduced by Xenakis, and explores dynamic and emergent sonic behaviors. The difficulty of describing and communicating such behaviors retard the development of the field, in comparison with other fields that explore other possibilities which the computation media enable. In order to address these difficulties, visualization techniques borrowed from the mathematical field of dynamical systems may accelerate advancement and assist the composer in order to articulate clearly and communicate his/her intention. Further research is required to appropriate these techniques in the context of sonic ecosystems. The emigration of the composer's output, namely, the printed score, to new media such as computer simulations and web applications that present the artwork with multimedia content, seems a very promising direction.

A framework that would enable the interaction of the UPIC approach (graphical notation as parameter data for sound synthesis) and the algorithmic approach (computer algorithms that produce visualized parameter data) would be a very interesting strategy. For example, the multidimensional strange attractors generated by chaotic mathematical



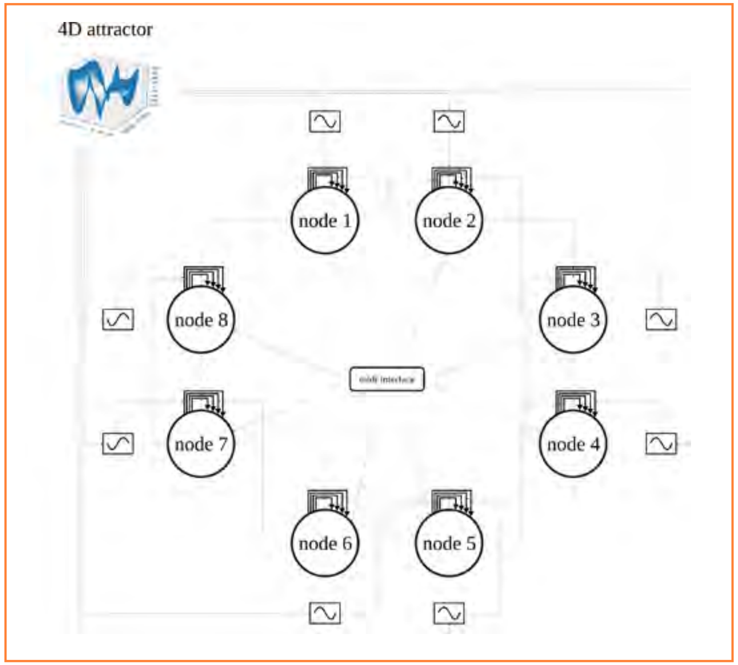


FIG. 3 Internal activity of the digital network consisting of 12 node structures in 3 layers, 2018 © Kosmas Giannoutakis

FIG. 4 Flowchart of the network topology used for the composition *Bursty Exorbitance*, 2018 © Kosmas Giannoutakis

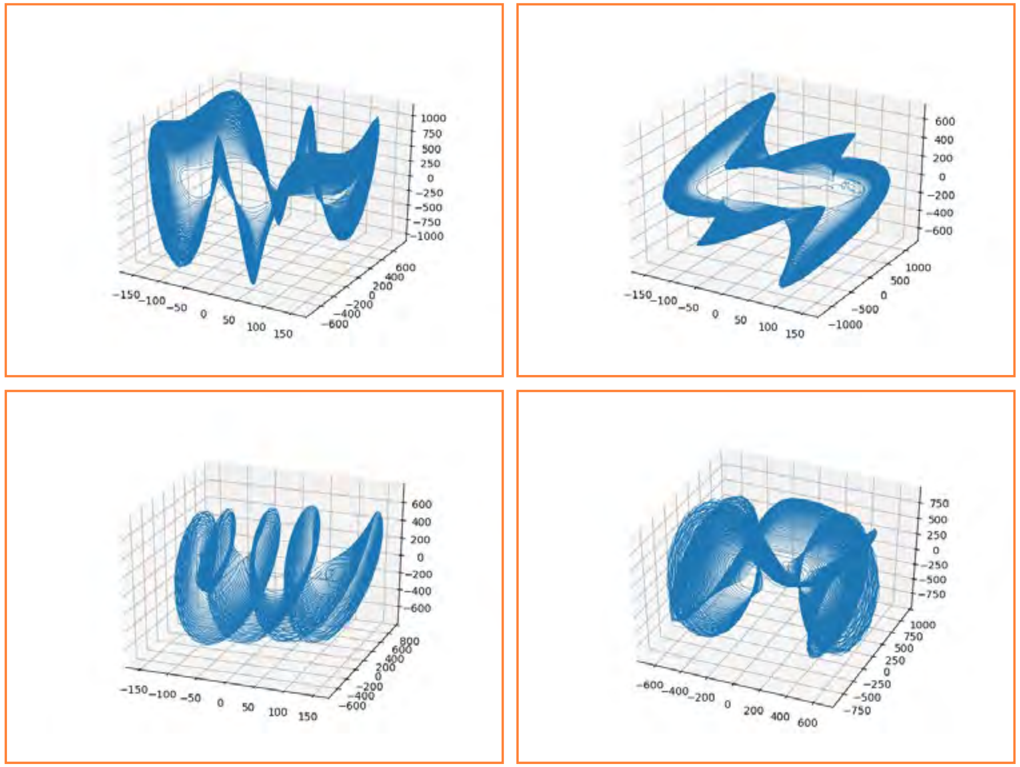


FIG. 5 Various three-dimensional phase space portraits of the four-dimensional chaotic attractor, 2018. The four-dimensional chaotic attractor was discovered by Mohammad Ababneh in 2017. © Kosmas Giannoutakis

systems could be imported in an appropriated graphical editor program that would make manual changes on the trajectories possible. This development would require the integration of three main programs: a numerical computing program, a graphical editor program, and a sound synthesis engine, which would enable a smooth workflow on all different levels. This framework would be ideal for creating control structures that provide parameter data for exploring areas with distinctive sonic qualities.

Another possible direction could be the application of machine learning (ML) to the computer-based compositional process. Personal or collective databases of parameter data created visually by humans and or numerically by algorithmic processes can be used to train ML models. These models could be used to generate new parameter data, which could be inserted into the aforementioned framework and facilitate an early phase of sonic exploration.

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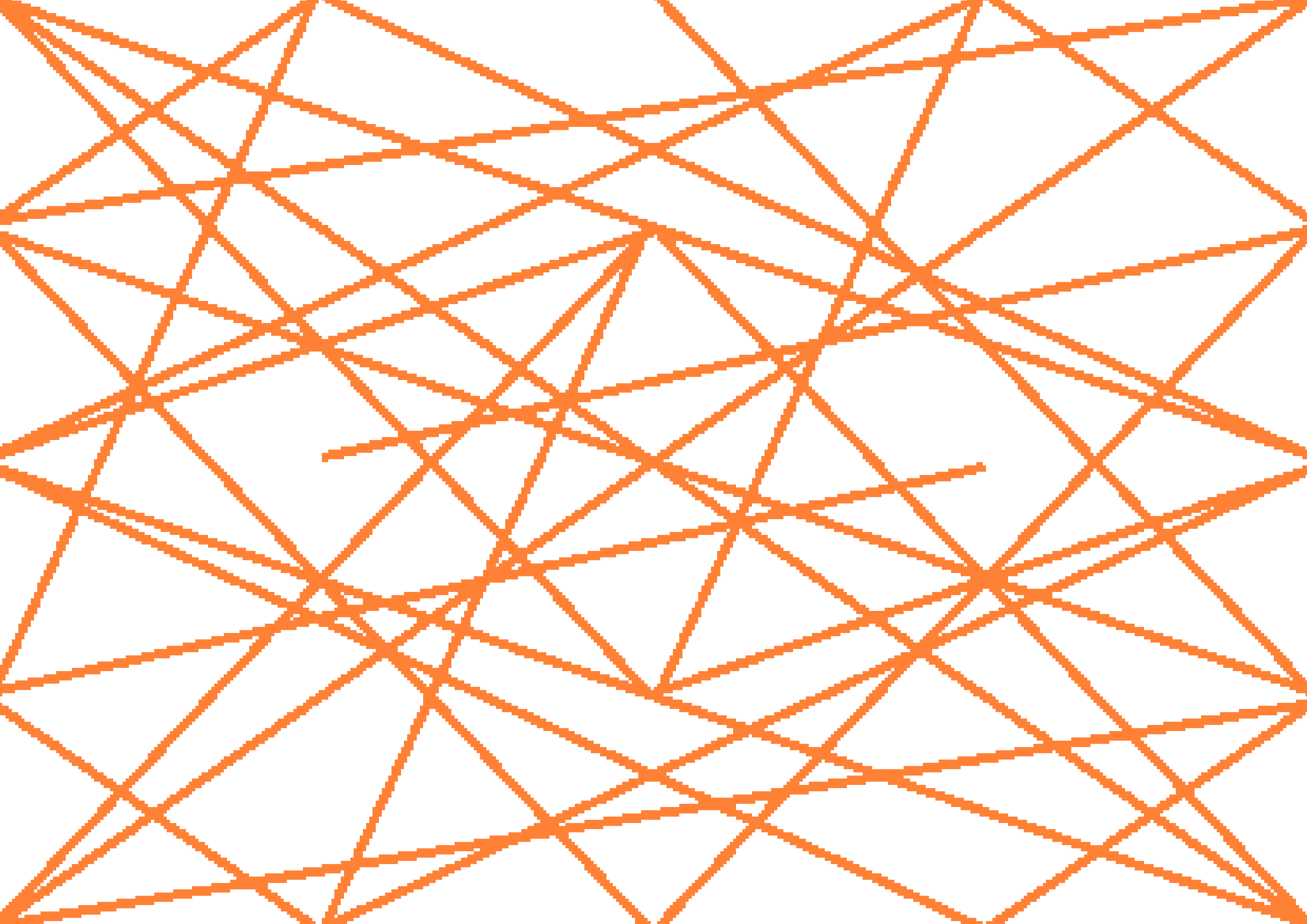
MARCIN PIETRUSZEWSKI
JULIA JASMIN ROMMEL
LUKAS NOWOK



THE DIGITAL INSTRUMENT AS AN ARTIFACT

MARCIN PIETRUSZEWSKI

MARCIN PIETRUSZEWSKI

THE DIGITAL INSTRUMENT AS AN ARTIFACT

INTRODUCTION

At first, the computer program is neutral and exists only in terms devoid of any reference other than to itself. The program is its function. It is a tool. It does something; it instructs a computer to perform a task. Its working is often imperceptible beyond the surface of its interface—screen based or physical—and its material extension to the inner depths of its digital structure, the code. Reduced to its substance, being digital consists of one of two binary values, either 0 or 1—the bit—and its multiples, the byte. These elementary values cannot by themselves constitute an object of reflection; as Guerino Mazzola points out "The digital age is not centered around 'bits and bytes' but around their accessibility and handling."[1] Opening up the contents of the software and exposing its inner working enables theorizing about the relationships within the code itself, the coding architecture, the functioning of the code, and specific programming choices or expressions, upon which the code acts, outputs, processes, and represents.

However, focusing solely on a functional aspect of software limits our engagement with its wider assemblage of connotations. Beyond the functional and ostensible neutrality of its interface the software is an artifact, as Matthew Fuller points out: "software creates sensoriums" and participates in constructing "ways of seeing, knowing and doing in the world."[2] The software both contains a model of a world it ostensibly pertains to and it also shapes the world each time it is used. Subrata Dasgupta defines artifacts as "useful things that are produced or consciously conceived in response to some practical need, want or desire."[3]

With the UPIC (Unité Polyagogique Informatique de CEMAMu) Iannis Xenakis operationalized a multiscale approach to sound composition within a standard user interface. An incessant interpolation between temporal resolutions of the micro, meso, and macro scales[4] constituted a vital feature of the vision behind the UPIC. The system incorporated a particular view of sound composition which moved beyond the theory of Fourier[5] and took as a starting point the pressure versus time curve together with a sound conceived as quantum; a "phonon" imagined already by Einstein in 1910.[6,7] Xenakis's ambition was "to take possession of the sound in a more conscious and thorough manner," to conceive "the material of sound" as composable.[8]

The design of the UPIC mobilized a correlative gestural and conceptual exploration of the temporal, physical, and perceptual parameters of sound.

In my practice as a composer and researcher, I have been developing a computer program called the New Pulsar Generator (nuPG).[9] The program produces a form of synthesis called pulsar synthesis; its design draws upon and extends the original Pulsar Generator (PG) application by Curtis Roads and Alberto de Campo as described in the publications *Microsound*[10] and "Sound Composition with Pulsars."[11] The technique generates a complex hybrid of sounds across the perceptual time span between infrasonic pulsations and audio frequencies, giving rise to a broad family of musical structures: singular impulses, sequences, continuous tones, time-varying phrases, and beating textures. Through its inherently multiscale character, pulsar synthesis proposes a unique view on rhythm moving beyond a linear series of points and intervals tied to a time grid, and introduces a notion of rhythm as a continuously flowing temporal substrate. Both PG and nuPG relate to the UPIC through their graphical parametrization of synthesis data and systematic approach to composition across multiple temporal levels; an attempt at fusion between micro and macro scales. The study of pragmata of these systems and a reflection on their sonic output provokes many fundamental questions about computing, listening and understanding, creation, interaction, and computer music aesthetics.

This article aims to display how engaging with a digital instrument—particular qualities and propensities of its design, functional and conceptual encapsulation of sound and composition theories—contributes to a mediated model of creative music practice. Such an approach fits within a broader perspective viewing technology and its objects beyond their merely functional and instrumental roles, but as mediators of human experiences and practices.[12] Taking a comparative approach in which the UPIC and the nuPG systems are engaged with as tools of a particular epistemic modality, I propose a concept of an "epistemic tool" to further contextualize a practice of composing with computers in a current multiply-mediated musical reality.[13]

I shall focus on a particular epistemic perspective prescribed within the design of the UPIC, an integration between conceptual, sound and visual realms under a notion of multitemporal sound composition. I propose a parallel narrative of the UPIC and nuPG that display an osmosis of concepts and technologies of design. Throughout, key themes of this text are composition across multiple timescales and computer program as an artifact.

THE UPIC AND A MULTITEMPORAL PARADIGM

A key idea behind the UPIC was that everything in the composition could be solved in the time domain by working out various shapes, such as

waveforms, pitch curves, and dynamic envelopes. This concept, also called "graphical synthesis"[14] can be linked back to early experiments in optical synthesis from the early twentieth century.[15]

When working with the UPIC, the user is confronted with a clean slate, a tabula rasa; the system is mute and to generate sound it requires input. The whole aspect of compositional labor—requiring the user to specify objects from the microstructure of sound, its dynamic development in time, and to the overall form of the composition—should be seen as an intentional aesthetic and conceptual stance.[16] At the level of sound microstructure, the user specifies the waveform and a shape of the dynamic envelope, which together can be thought of as an elemental timbre of the instrument. At a higher level of organization, the user operates the music page function, drawing shapes—lines, curves, and points, called arcs—on a frequency (vertical) versus time (horizontal) axis.[17] FIG. 1

These drawn shapes need to be assigned to previously specified timbres. However, up to this point each input to the system—the waveform, envelope, and frequency time shapes on a page—exist only as a simple drawing. To use a Xenakian notion, these shapes exist outside-of-time—they lack temporal boundaries. By defining a duration (or multiple divisions of it) for the page, the user decides how to temporalize these drawings: how to bring the outside-of-time abstract shapes into-time. Only when the duration is defined are these shapes then converted to music waves.

An essential aspect of UPIC's setup are the editing capabilities that each of the arcs could be subjected to: the user can cut, copy, and paste individual shapes, and compress or stretch them in time and frequency. An example of all these procedures can be found in Xenakis's UPIC composition (1978), which consists of arborescent shapes, cut and pasted, compressed and stretched in time and frequency.[18] The reading position and direction on a page and between pages can be variable, too. As observed by Curtis Roads,[19] arcs written to a page with a duration of a second become a characteristic of the sound's microstructure. An opposite manipulation is possible as well; the microstructural pressure versus time curve can be stretched in time and used as a structuring element at meso or macro time levels.

The uniform treatment of composition data and objects at every level mobilizes a creative grafting across and between the micro, meso, and macro time resolutions, a dialectical couplet of local and global perspectives. The design of the UPIC favored a flexible work between two strands of conceptualization: the inductive—a bottom-up glueing of the elemental into the global—and a deductive—a top-down carving of the whole into smaller parts. As such, the UPIC might be described

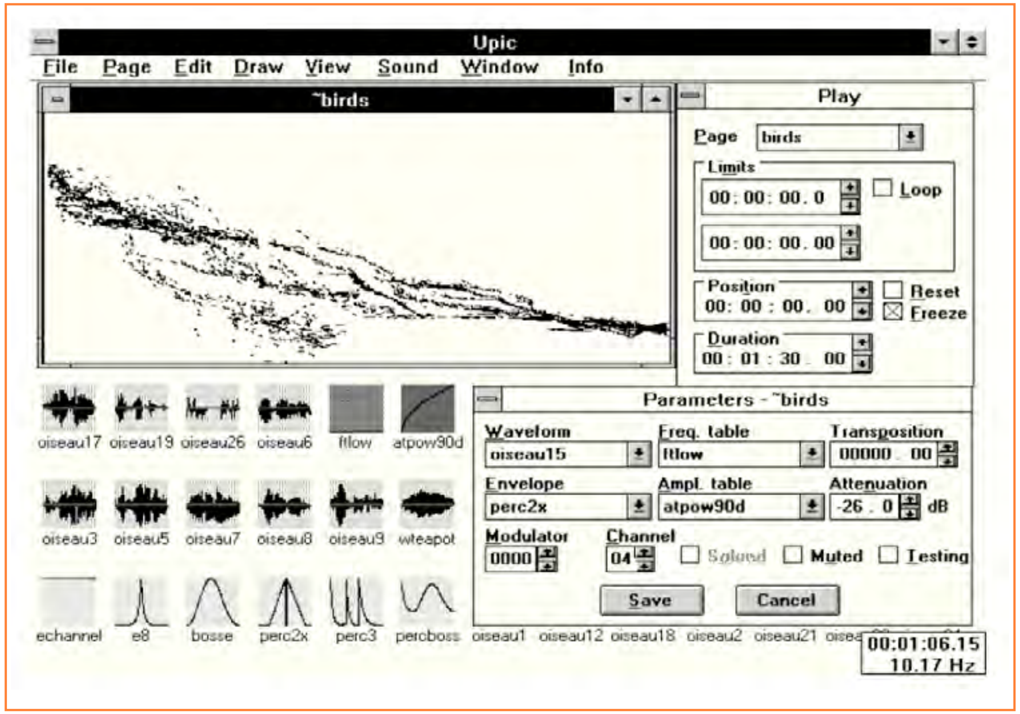


FIG. 1 A workspace of UPIC 3 running on a PC displaying partial data of a composition by French-American composer Brigitte Robindoré, 2003, screenshot. Notice a variety of shapes used as envelope and waveform as well as complexity and richness of the page. © Brigitte Robindoré

as a system of "transparent stratification" rendering entirely open for a pendular process of differentiation and reintegration of sound materials and forms at all the levels of temporal organization.[20] Such a bimodal process problematizes the duality between form and material: the same object can be conceived as material or form (substance or container) depending on the level of investigation.[21]

The design of the UPIC extended the temporal field of compositional activity and attempted to functionalize a multiscale approach to musical form. To operate within a full register of timescales is to shift the aesthetic focus away from discrete sound entities occupying well-defined time frames towards continuous and evolving objects with fuzzy boundaries. These new objects rarely conform to traditional angular forms of musical structure, and tend toward cloud-like evaporative and continuously evolving morphologies. The multiscale approach favors flexibility, as Curtis Roads points out: it mediates between a high-level abstract plan (the top-down global structure) and opportunities emerging from a low-level of sound material operations (the bottom-up local structures). All temporal levels are to be composed; at any time in the compositional process, we can intervene by synthesis and transformation at any timescale, from a macro scale of the whole work, down to sections, phrases, sound objects, grains, and even individual samples.[22] A dialectic of inductive and deductive processes, observed within the workings of UPIC, forms a key characteristic of the multiscale composition approach: to approach musical composition from a multiscale perspective is to allow an interplay between inductive (specific and local) and deductive (general and global) thinking. These issues are pertinent to the theory and practice of pulsar synthesis.

PULSAR SYNTHESIS: FROM PG TO NUPG

As an integral part of my artistic research practice, I have been involved in a systematic exploration of the technique of pulsar synthesis. Over the past two decades, the technique of pulsar synthesis and its various software instrument implementation—such as, Pulsar Generator (2000) by Curtis Roads and Alberto de Campo, Pulsar Generator (2004) by Tommi Kerannen and Particularity (2010) by Chris Jeffs—acted as a material point of connection, linking practitioners in and outside research institutions. Whether as input sound material for further processing,[23] a raw synthetic output,[24] or as a model for auditory display of data,[25] the practice of pulsar synthesis activated discourse in a variety of functional, aesthetic, and conceptual contexts.

The technique of pulsar synthesis is a powerful approach to digital sound synthesis; it is named after a highly magnetized rotating neutron star that emits a beam of electromagnetic radiation at a frequency between

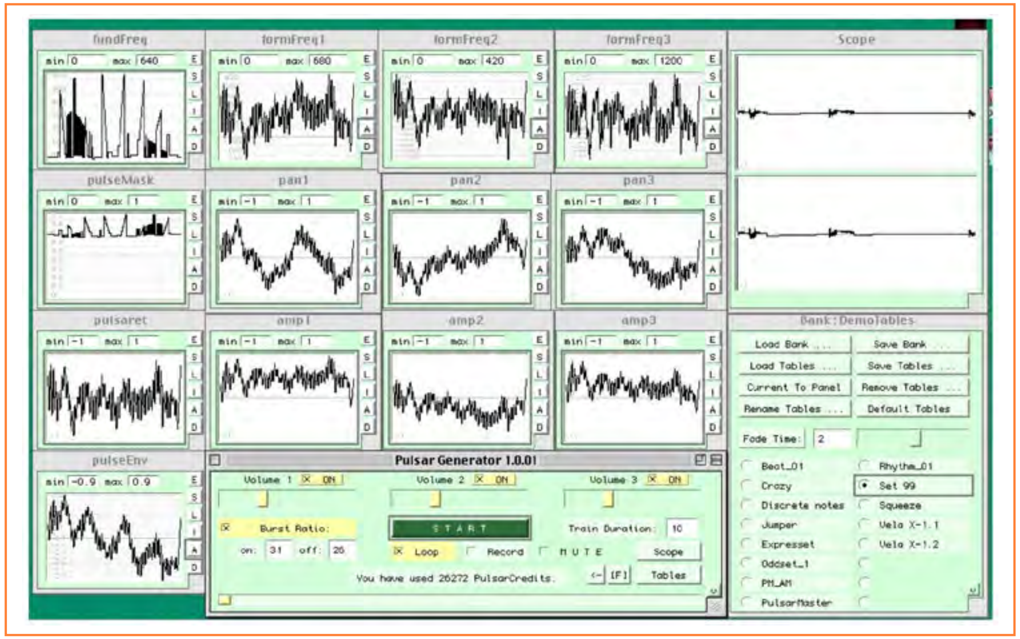


FIG. 2 A workspace of the Pulsar Generator program designed by Curtis Roads and Alberto de Campo in 2000, 2019, screenshot. Notice the complexity of the pulsaret and the envelope tables, as well as the variation in fundamental frequency and three sets of formant frequencies, panning, and amplitude trajectories. These could be designed in advance of synthesis, or manipulated in real time as the instrument plays. The program implemented a scheme for saving and loading these envelopes in groups called settings. The program lets one crossfade at a variable rate between multiple settings, which takes performance with Pulsar Generator to another level of synthesis complexity. © Curtis Roads

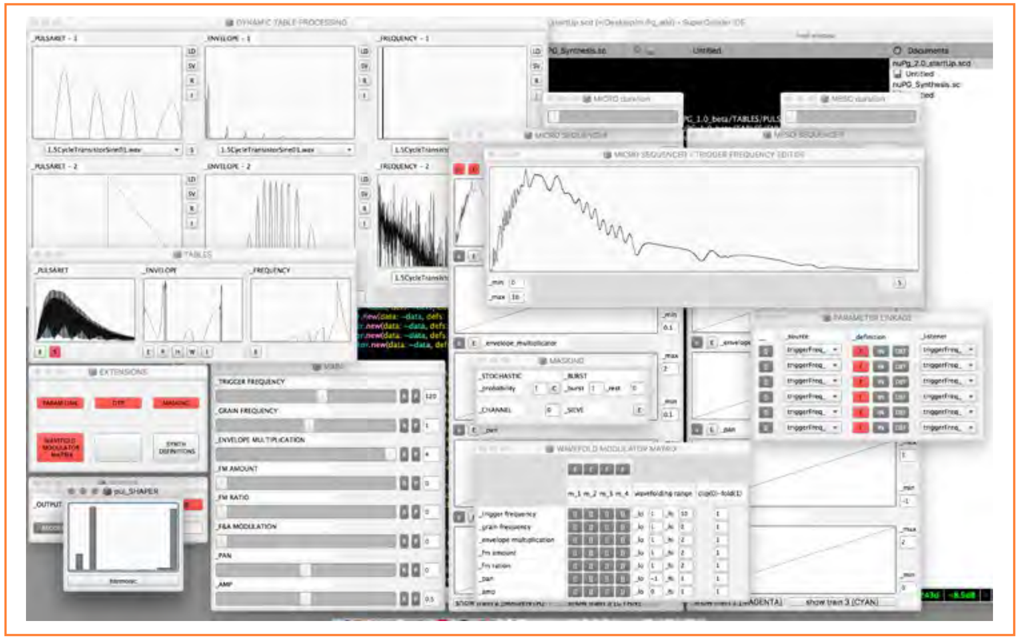


FIG. 3 A workspace of the New Pulsar Generator with its various extensions (e.g., wavefold modulators of synthesis parameters via matrix, parameter linking, multiple tables for micro and meso scale trajectories, and preset system), 2019, screenshot. The user can control all parameters of synthesis via the graphic interface, as well as through text of the programming language via a set of predefined functions. © Marcin Pietruszewski

0.25 and 642 Hz.[26] Pulsar synthesis operationalizes the notion of rhythm with its multitemporal affordances as a system of interconnected patterns evolving on multiple time scales.

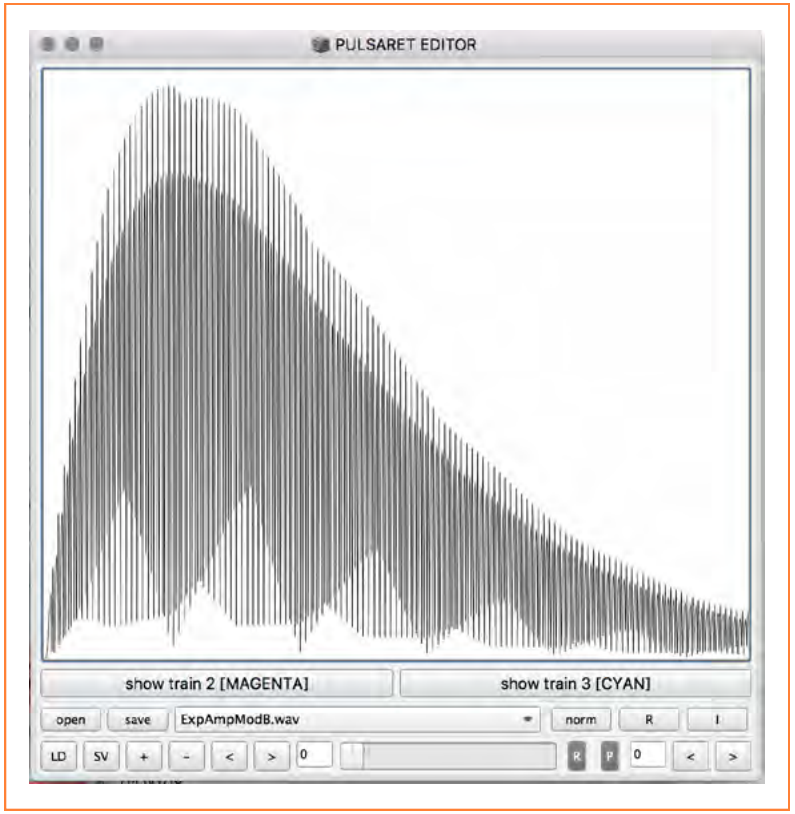
The fundamental functional unit at the microstructure level in pulsar synthesis is called a pulsar. A spectrum of a single pulsar is a result of a convolution between pulsaret and envelope. The pulsaret table can be considered "a template of spectrum shape,"[27] while the envelope is a function limiting it in time. An important generalization is that both tables, pulsaret waveform and envelope tables, can be any shape. A repetition of the pulsaret forms a pulsar train; a stream of pulses emitted at a user-stipulated rate which can vary from infrasonic pulsations to audio frequencies.

Developed in 2000 by Curtis Roads and Alberto de Campo, the PG program generalized the technique of pulsar synthesis and provided a powerful interface to control its various parameters.[28]

As part of my ongoing PhD research at the University of Edinburgh, I have been developing a new version of the historic PG. The nuPG program is developed in SuperCollider 3 programming language and incorporates an extensive set of graphic interface tools to control various parameters of synthesis.[29] Additionally, the underlying Just-In-Time programming paradigm[30] used in the development of the program means that all objects of the nuPG can be redefined in real time. A coupling between graphic and textual interfaces allows for powerful control of visual and formalized compositional models.

At the microstructure of the sound the New Pulsar Generator provides a set of tools to manipulate the shape of the pulsaret waveform. **FIG. 4** The shape can be also generated using a harmonic or the Chebyshev shaper function **FIG. 5**. The waveform has a fundamental effect on the spectral shape of the generated pulsar stream.

Foundational for the discussion on the digital musical instrument design is the concept of representation.[31] Roads and Wieneke[32] distinguish between iconic (also called analog) and symbolic representations. "A sign is said to be iconic when there is a topological similarity between the signifier (the sign) and its denotata (i.e., what it represents)." A sequence of numbers stored in the memory of a computer corresponding in value to the shape of an acoustic signal is one example of such representation. "A sign without either similarity or contiguity but only a conventional link between its signifier and denotata is called a symbol."[33] A syntactic arrangement of symbols plays a functional role within formal languages. Such symbols do not usually mirror the surface structure of a composition; rather, they represent the "background" interrelations or "deep structure."



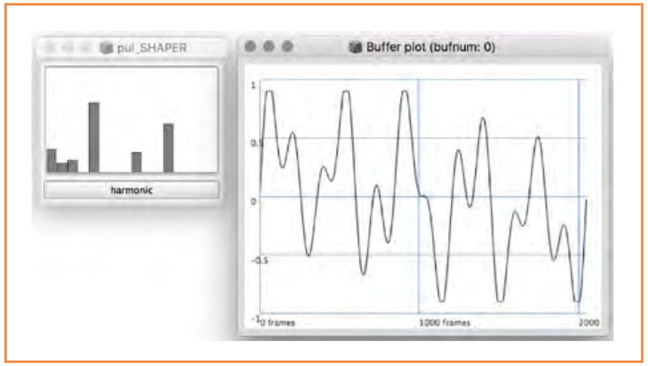


FIG. 4 An editor of the pulsaret waveform, 2019, screenshot. The shape can be drawn directly or loaded from predefined functions. A sound sample can be used as a waveform, too. Located at the bottom of the window, preset functionality allows for saving and interpolating between waveforms. © Marcin Pietruszewski

FIG. 5 A simple tool allowing generation of various shapes for a pulsaret waveform, 2019, screenshot. It can be thought of an incorporation of additive synthesis paradigm—where multiple harmonics are added together—within pulsar synthesis. © Marcin Pietruszewski

The question of iconic versus symbolic, discrete versus continuous, as well as graphical versus textual representation of musical information is a perennial issue in the context of digital instrument design.

THE DIGITAL INSTRUMENT AS AN ARTIFACT

As a way of synthesizing the discussion about UPIC, PG, and nuPG I propose to expand the notion of digital instrument as an artifact. the UPIC, as well as PG and nuPG programs, as any other piece of human-made technology, do not function in a vacuum. As Anne Sauvagnargues points out:

> *A tool or a machine should not be studied in isolation without taking into consideration the milieu of individuation that surrounds it and allows it to function. No machine or technical tool exists by itself […] they only function in an assembled milieu of individuation, which constitutes their conditions of possibility: there is no hammer without a nail, and thus the interaction between a multitude of technical objects makes the fabrication of hammers and nails possible, while also forming the conditions of their utilisation and the practices and habits associated with them.*[34]

Systematic engagement with an artifact must acknowledge its constituent multiplicity and contexts activated via its use. Artifacts are complex conglomerates of things and composition of "components, which are continuously rearranged and reassembled in their specific modes of appearance throughout history".[35] Artifacts are "like organisms, they manifest evolution."[36] Any artifact is surrounded by the knowledge that is prior to its emergence and also by the knowledge that appears only after the artifact was made.

Every artifact generates an interpretative cut. With a particular perspective prescribed within its design and function, UPIC, PG, and nuPG can all be thought of encapsulations of knowledge and carriers of a sound theory. Moreover, engaging with such instruments is not limited only to interaction with their physical dimension—the interface. These instruments engage their user with a prescription of a compositional model; a projection which embodies a particular epistemological perspective of what is to be composed: what is the material, its possible transformation and formal organization. By mediating their compositional model, UPIC, PG, and nuPG framed the boundaries of perception and thought.

Don Ihde conceptualized a variety of phenomenological modalities of instruments and their role in our relationship with the world. Among these are embodied relations, where the instrument acts as an extension of the body and amplification of the senses; and hermeneutic relations, where

the instrument provides us with data (e.g., a sonogram) which we have to interpret (from Greek hermēneuein, interpret.)[37]

The underlying design technology of UPIC, PG, and nuPG correlates the embodied and hermeneutical within one design based on a bimodal evolution between gestural and conceptual. All the systems incorporated embodied relation; the UPIC especially, through its corporeal interface relying on the drawing capacity of the human hand and the proportion of a CAD/CAM drawing board, ergonomically designed to follow the proportions of the human body.[38] The ability to use the various objects (a waveform, an envelope, the page, pulsaret editor, etc.) of these systems, however, required interpretative work, and it is here that UPIC, PG, and nuPG incorporated a hermeneutical relation. In this perspective, all three can be seen as compound devices extending the body, eye, ear, and mind, as instruments impregnated with knowledge, which can serve as a model of how our conceptions of what is musical material and form are being constructed.

FOOTNOTES

1. Guerino Mazzola, *The Topos of Music: Geometric Logic of Concepts, Theory, and Performance* (Basel: Birkhäuser, 2012), 105.
2. M. Fuller, *Behind the Blip: Essays on the Culture of Software* (New York: Autonomedia, 2003), 19.
3. Subrata Dasgupta, *Technology and creativity* (New York: Oxford University Press, 1996), 9.
4. For an extended discussion on temporal scales see Curtis Roads, *Microsound* (Cambridge, MA: MIT Press, 2004).
5. Iannis Xenakis, *Formalized Music* (Hillsdale, NY: Pendragon Press, 1992), 258.
6. Ibid. xii.
7. In the 1940s, British physicist Dennis Gabor proposed that all sounds can be viewed as a succession of elementary particles of acoustic energy. The question of "realness" of these particles is an attractive one and relates to the age-old dilemma of pre-existence of all possible divisions within a whole.
8. Bálint András Varga, *Conversations with Iannis Xenakis* (London: Faber and Faber, 1996), 44.
9. For the documentation see https://www.marcinpietruszewski.com/the-new-pulsar-generator.
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16. Herbert Eimert related to this approach as the "absolute composition" through which "real musical control of nature" can be asserted; see Herbert Eimert, "Von der Entscheidungsfreiheit des Komponisten," in *die Reihe* 3 (1957), 5–12.

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18. For an analysis see Benjamin R. Levy, "Clouds and arborescences in *Mycenae alpha and the Polytope de Mycènes,"* in *Xenakis Matters: Contexts, Processes, Applications*, ed. Sharon Kanach (Hillsdale, NY: Pendragon Press, 2012).

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20. Robin Mackay, Russell Haswell, and Florian Hecker, "Blackest ever Black", *Collapse 3* (2007), 109–139.

21. Gottfried Michael Koenig, "Genesis of Form in Technically Conditioned Environments," in *Journal of New Music Research* 16, (1987), 165–175.

22. See Chapter 9, "Multiscale Organization," in Curtis Roads, *Composing Electronic Music: A New Aesthetic* (New York: Oxford University Press, 2015). 283–317.

23. For example, see the compositions by Curtis Roads: *Half-Life* (1998), *Tenth Vortex* (2000), *Eleventh Vortex* (2001), and Kim Cascone's *Pulsar Studies* (2004) EP.

24. Florian Hecker, *Recordings for Rephlex* (2006), CD, Rephlex.

25. Marcus Schmickler utilized a pulsar synthesis model in a sonification of pulsars in the Bonner Durchmusterung project, for details see http://piethopraxis.org/projects/bonner-durchmusterung/

26. Pulsars are rotating neutron stars that appear to "pulse" because the beam of light they emit can only be seen when it faces the Earth. Pulsars were discovered by Jocelyn Bell Burnell, which is considered one of the greatest astronomical discoveries of the twentieth century.

27. Curtis Roads, *Microsound* (Cambridge, MA: MIT Press, 2004), 146.

28. Ibid. 154.

29. For the User Manual describing all objects of the New Pulsar Generator see: https://www.marcinpietruszewski.com/the-new-pulsar-generator

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31. Meinhard Müller, *Fundamentals of Music Processing: Audio, Analysis, Algorithms, Applications* (Heidelberg: Springer, 2015).

32. Curtis Roads and Paul Wieneke, "Grammars as Representations for Music," in *Computer Music Journal,* 3, (1979), 48–55.

33. Thomas A. Sebeok, "Six Species of Signs: Some Propositions and Strictures," in *Semiotica,* 13, (1975), 233–260.

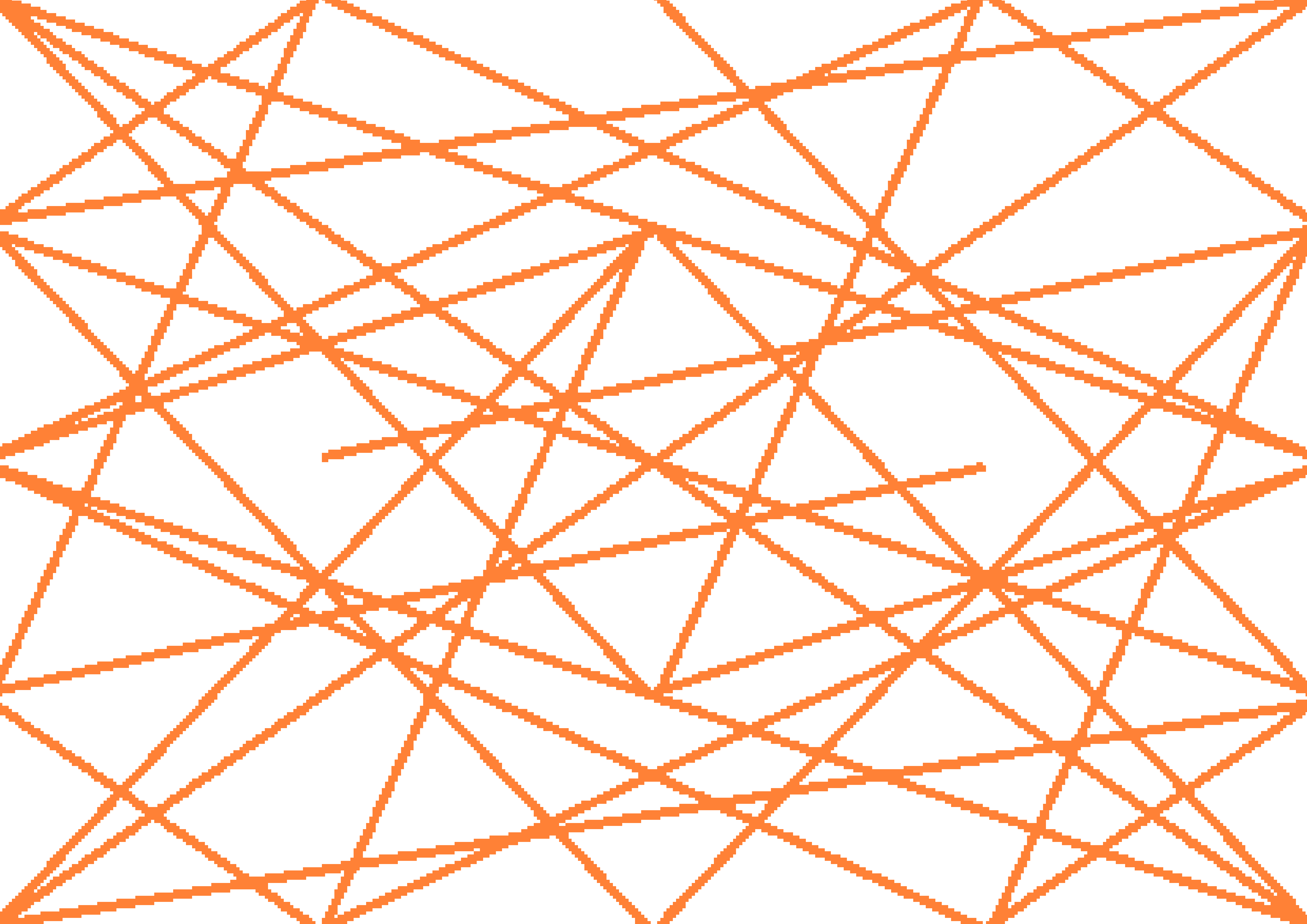
34. Anne Sauvagnargues, *Artmachines: Deleuze, Guattari, Simondon* (Edinburgh: Edinburgh University Press, 2016), 186.

35. Paulo de Assis, *Logic of Experimentation. Rethinking Music Performance through Artistic Research* (Leuven: Leuven University Press, 2018), 107.

36. Subrata Dasgupta, *Technology and creativity* (New York: Oxford University Press, 1996), 114.

37. Don Ihde, *Technology and the Lifeworld: From Garden to Earth* (Bloomington, IN: Indiana University Press, 1990).

38. The drawing board featured in the early version of the UPIC system and later had been replaced with an interaction on a computer's screen with a mouse. In the early version of the system, the drawing field of the board had a calibrated area of 60 cm high by 75 cm wide.



ZWISCHENRAUM (INTERSPACE)

JULIA JASMIN ROMMEL

JULIA JASMIN ROMMEL

ZWISCHENRAUM (INTERSPACE)

My work on the *Zwischenraum* (interspace), which is elaborated on in this chapter, is based on an artistic exploration of an acoustic measurement of space. I shall also address the close connection between the cultural techniques of graphic notation and cartography.

To gain a more precise overview of my daily movement routine, that is, the paths I take every day, I recorded every distance with at least a duration of 3 minutes for a period of exactly one year, with precise details of the duration, starting, and end points of the movement and the means of transport. Although this documentation was not originally created for the purpose of analysis, it became the starting point for reflecting on what overcoming distance—the interspace—means to me.

The interspace actually describes a temporal-spatial interval, which has to be traversed (in my case) by subway, train, car, or airplane, in order to get from A to B. Even though this is a kind of by-product, I experience this transitional situation as something very positive: in a constellation of external framing conditions—being interned in repetition, routine, and boredom—the space in between becomes a kind of state of mind, of contemplation and distraction. Rhythm is the permanent confirmation of continuity. The space in between contains neither the past nor the future, thus no development, but rather the standstill in the present of passive movement.

In my curiosity to understand this very inspiring spatial configuration, I have begun to document cartographically the interspace and sonify it with the graphical sequencer IanniX.

MAP PRODUCTION AND ROOM SURVEYING

A total of ten cards were created during my everyday sojourn in the *Zwischenraum*. Some of them are long-term documentations of the relations of different places to each other, others are concrete (but arbitrarily chosen) snapshots of linear distances.

Each map deals with a certain aspect of the in between space that is decisive for me, for example, *Frequenz* (frequency), **FIG. 1** *Übergänge* (transitions), **FIG. 2** *Orientierung* (orientation), **FIG. 3** *Rastlosigkeit und Kontinuität* (restlessness and continuity), **FIG. 4** *Richtungswechsel* (changes of direction), **FIG. 5** *individuelle Distanzwahrnehmung, Be- und Entschleunigung* (individual perception of distance, acceleration and deceleration), and so forth. To visualize these topics I developed

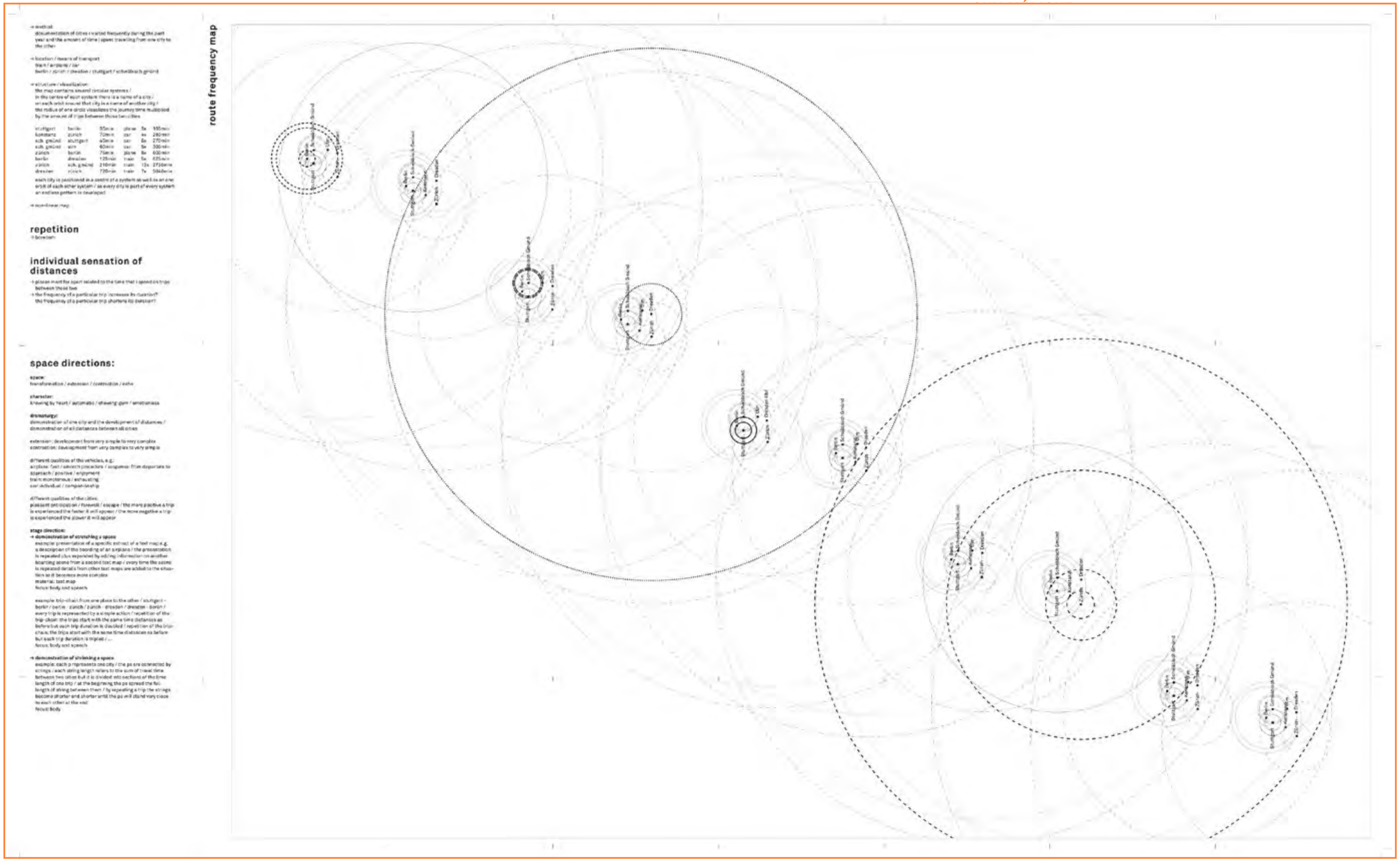


FIG. 1 *Frequenz* (frequency)
METHOD: Documentation of cities visited frequently during the past year and the total amount of time spent travelling from one city to another.
LOCATION/MEANS OF TRANSPORT: Car, train, air travel between the cities Berlin, Zurich, Dresden, Stuttgart and Schwäbisch Gmünd.
STRUCTURE/VISUALIZATION: The map contains several circular systems, each circular center marks one city, the circular system around this city marks the distance to another city. This distance calculates the time of all my travels between those two places. Each city is positioned at the center of a system as well as on one orbit of each of the other systems.
TOPIC: Individual sensation of distances caused by repetition; extension; contraction of distances caused by repetition; boredom.

Stuttgart - Berlin	plane	55 min	3 × 165 min
Konstanz - Zurich	car	70 min	4 × 280 min
Sch. Gmünd - Stuttgart	car	45 min	6 × 270 min
Sch. Gmünd - Ulm	car	60 min	5 × 300 min
Zurich - Berlin	plane	75 min	8 × 600 min
Berlin - Dresden	train	125 min	5 × 625 min
Zurich - Sch. Gmünd	train	210 min	13 × 2730 min
Dresden - Zurich	train	720 min	7 × 5040 min

experimental but context-related criteria, parameters, and methods. For this purpose, I captured space-structuring elements, such as tunnels and bridge crossings, oncoming trains, flight booking data, curve angles, window views, announcements in trains and planes, route repeats, local time, and so on.

At first glance the contents of my maps seem banal. They were created far outside any conventionally measurable quantities of geographical cartography and can in some respects be regarded as "meaningless" data that have no objective or scientific significance. The question of which routes were documented is also relatively irrelevant.

For me, the meticulousness with which the respective documentation methods were applied is decisive. I am interested in the aesthetics of information and the relationship between local and temporary facts, their context and connection, which makes information meaningful in detail. By systematizing this abstract information and summarizing it in corresponding structures and systems, I hope to be able to represent the complexity and absurdity of the logic of my interspace.

Cartography as a cultural technique of space appropriation is implemented here in an individual and very personal recording of locomotion, a kind of field research as a self-experiment. It should be understood as an interpretation of space that has arisen in the context of a certain aesthetic attitude.

TRANSFORMATION OF THE CARDS INTO SOUND

The resulting cartographic survey makes it possible to experience the interspace on a cognitive level. My aim, however, is to go beyond factual analysis and express the poetic qualities of these specific spatial configurations.

This motivation led me to examine translation into other media, with a focus on a possible acoustic dimension of the maps. In a further transformation process, my maps thus become the source material for a spatialization of information into sound. The aim is not to revive the original paths taken, but rather the graphic system of my spatial measurements and to make it experienceable audibly.

The linearity on which some maps are based forms the framework of a timeline, embedded in a classical coordinate system. I have tried to find simple shape-describing sounds that vary in frequency and dynamics. The sound material was selected intuitively; there were no musical models. It ranges from a simple sinus tone to sound recordings (for instance, certain vehicle noises from the interspace), which are linked to a certain card in terms of content and method. In this way, facts that are not immediately apparent from the visual image—such as the information that the arrows

are trains, or that the curves refer to impending air travel—are supplied as auditory information.

In addition to working on the sound material, the focus of my work on graphic notation at the Hertz Lab at the ZKM | Center for Art and Media Karlsruhe was on the spatial arrangement of information using the ZKM's Sound Dome sound spatialization system. The direction of the sound source becomes an important means of describing the properties of the respective parameters of a map. The sound material was arranged in such a way that an essential spatial factor of the corresponding spatial situation becomes comprehensible. For example, parallel overlapping events are distributed among different loudspeakers in order to make them more differentiated and experienceable. In a corresponding arrangement of the channels, the changes of direction repeatedly addressed in the maps are translated as sounds moving towards or away from one another. They circle around the listener at different speeds and in this way make it possible to experience the information density of a map.

MUSICAL RENDERING FROM THE DESIGNER'S PERSPECTIVE

My competence as a graphic designer and scenographer lies in creating strategies for structuring information to make it more easy to read. Based on this approach, I have investigated which aesthetic qualities of a graphic notation can play a role in the transformation into sound, and which design parameters that increase the visual readability of data find a correspondingly meaningful application in acoustics.

I assume that, as a person who works and thinks visually, I judge data differently than a musician or composer. I am interested in these differences in perception, and with my work I try to show where exciting interfaces of possible cooperation open up.

GRAPHIC NOTATION FROM THE PERSPECTIVE OF THE DESIGNER

In order to be able to define this interface concretely, I must first describe my perspective as a designer on the graphic work of composers.

In my opinion, it is remarkable what a large number of graphic notations are created with very limited technical aids. In view of our everyday communication, which allows everyone to communicate as colorfully as possible using digital tools, these pencil drawings seem antiquated with their rather inelegant aesthetics, although admittedly, they are quite appealing. Perhaps it can be deduced from this that for many composers the step into another medium represents a great challenge, or that one consciously wishes to remain recognizable within the context of a music score sketch. However, if one decides against using a conventional sign system or consciously opts to use graphic images, in

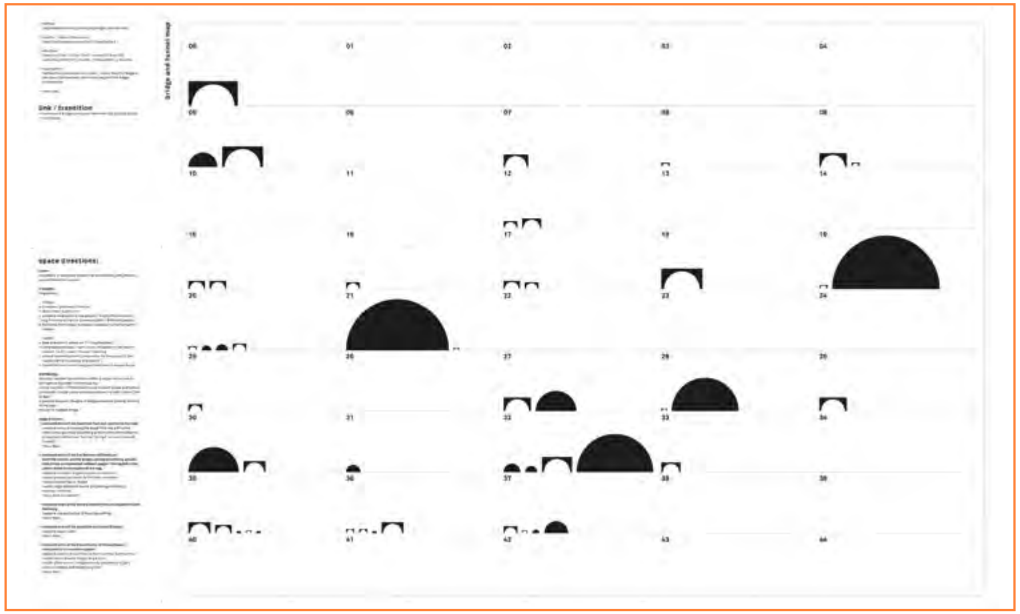


FIG. 3

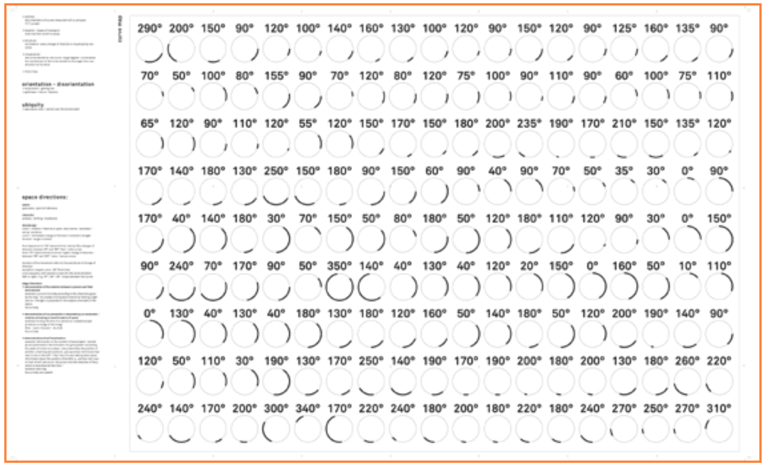


FIG. 2 *Übergänge* (transitions)
METHOD: Documentation of tunnels and bridges on a train journey.
LOCATION/MEANS OF TRANSPORT: Train journey between Arosa and Chur, Switzerland.
STRUCTURE: Linear map; time line from 12:05 p.m. to 12:42 p.m.; duration of train journey/five minutes per line; measurement in seconds.
VISUALIZATION: Black semicircles represent tunnels; arches represent bridges; the size of the elements refers to the length of the bridge or the tunnel.
TOPIC: Link and transition; tunnels and bridges are spatial elements that connect places.

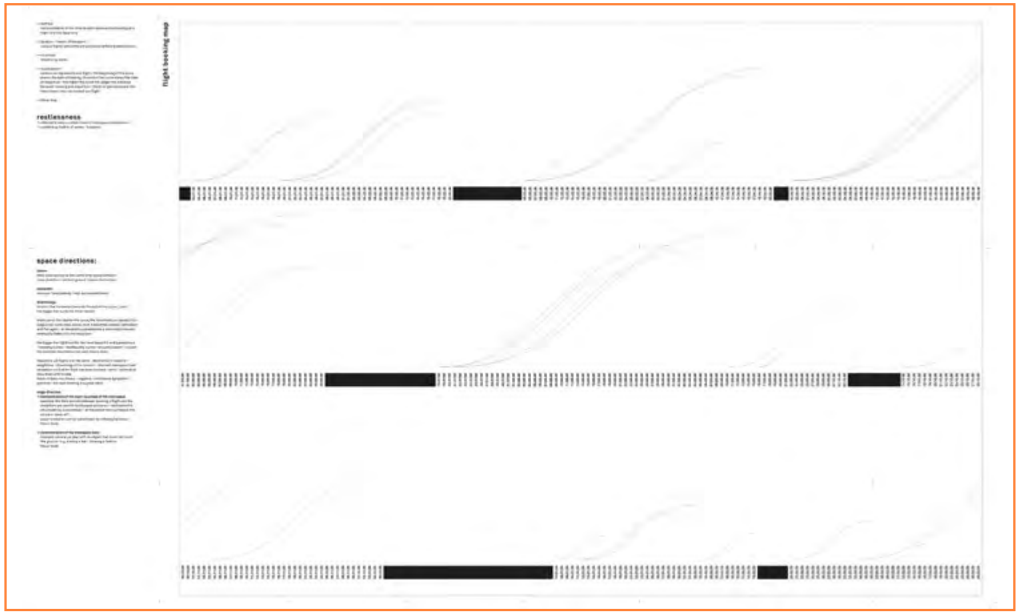


FIG. 3 *Orientierung* (orientation)
METHOD: Documentation of curves measured with a compass (171 curves).
LOCATION/MEANS OF TRANSPORT: Train journey from Zurich to Arosa, Switzerland.
STRUCTURE: Linear map; no timeline; every change of direction is visualized by one circle.
VISUALIZATION: One circle represents one curve; the marked part of the circle stands for the angle from one direction to the other.
TOPIC: Orientation - disorientation; localization.

FIG. 4 *Rastlosigkeit und Kontinuität* (restlessness and continuity)
METHOD: Documentation of the time relation between the date of booking a flight and the date of departure.
LOCATION/MEANS OF TRANSPORT: Various flights with different airlines to different destinations.
STRUCTURE: Linear map; timeline by dates.
VISUALIZATION: Each curve represents one flight; the beginning of the curve marks the date of booking, the end of the curve marks the date of departure; the higher the curve the longer the distance between booking and departure; erased dates represent the time where there wasn't any flight booked.
TOPIC: Restlessness, continuity, attempt to keep a certain level of interspace experiences.

my view it is lost potential not to engage intensely with the corresponding technical and manual methods.

As already envisaged in Dieter Schnebel's book *Mo-No: Musik zum Lesen* (Music for Reading) (1969),[1] many contemporary composers regard their graphic notation as an integral part of their works. Therefore, this notation should reach both the medium of communication for the interpreter of the music, and also the listener directly. In view of his book, Schnebel was accused of only addressing an elite audience of contemporary music interpretation with his scores, which are directed at the reader.[2] Might it be possible that Schnebel's idea of allowing music to develop solely in the mind of the recipient would perhaps have been rendered more accessible to an audience if he had collaborated for his notations with a graphic artist who was able to communicate visually more effectively?

For me, of course, the outstanding examples that place a differentiated visual expression of abstract forms and colors in direct relation to a musical experience, such as György Ligeti's *Werk Artikulation* (1958) in its transcription by the graphic artist Rainer Wehinger, or Cornelius Cardew's legendary graphic composition *Treatise* (1963–1967), are outstanding examples. Here I recognize clear creative intentions that evoke interest and joy in contemplation.

Graphic notation cannot take on the function of classical notation. The reception of script and image functions completely differently, as composer and media designer Christian Fischer explains in a direct reference to graphic notation: "Pictures cannot be read. They can only be analyzed and interpreted. The more unspecific, unclear or abstract the image, the more sketchy and difficult the interpretation. In this context, there is no right or wrong interpretation as long as it is coherent and comprehensive."[3]

RECEPTION IN CARTOGRAPHY AND GRAPHIC NOTATION

It is precisely in this question of the reception of signs, respectively of images, that I find the connecting element of graphic notation and cartography. As cultural techniques of information translation and mediation, they exhibit parallels in their necessity to reflect on the interplay of the different levels of information reception, and to open up to interpretation at a decisive moment. The focus is no longer only on the question of the precision of the tool, but on the possibility of giving the recipient a specific approach and attitude to this information, and thus overcoming the boundary between reading a sign and interpreting an image.

The task, therefore, consists in designing a sign as an image in such a way that it does justice to both functions. It is important to take into account this tension between the targeted conveying of information and free interpretability in the communication process.

SYMMETRY OF HEARING AND SEEING

In the context of sonification as a scientific form of publication, it is emphasized on the one hand that it allows an audience outside the field of science easier access to complex data, but on the other hand that the gathering of data by hearing is much less established in our society than by the eye. There seems to be great potential here to cultivate consciously an alternative level of information perception. My design of a "cartophony" arises out of a similar motivation: the aim is to enable an exemplary form of spatial experience through an alternative aesthetic approach.

I try to invent a sign system that can be read, but which at the same time forms an aesthetic construct that can be interpreted in an experiencable way, that at the same time addresses a rational as well as an intuitive level. It is particularly this cognitive interface of reading signs and interpreting images that interests me in information design.

Limited to their visual perception, the attention of the viewer of my maps is probably focused primarily on density and repetition of the documented elements and on the comparison of maximum and minimum versions of the event.

The transformation into sound is not intended to replace what can be experienced visually, but rather to expand it, thus opening up readability to an expanded interpretation. The aim is not to place sound and vision in a mutually illustrating relationship, but to enable a multi-layered perception of information through the interaction between the two different levels of perception.

In my work *Zwischenraum* I implement this through the graphic sequencer IanniX, which triggers live acoustic events as a time-based medium based on a visual combination of curve and cursor. In the resulting comprehensibility of a self-referential system, a special reference to reality is created after my experience: One waits for what one sees; one hears what one expects and thus concentrates on the details of the map.

This form of cartophony encourages me to look at individual elements in a certain direction and at a certain tempo. In a way, the sound leads through the graphics—or vice versa? The information is thrown back and forth between acoustics and optics like a ping-pong ball. I try to observe what effect this process of reciprocal reflection has on the essence of the information and which parameters can be used to determine which level of perception sets the tone in this process.

LEVELS OF PERCEPTION IN THE ORIENTATION PROCESS

The connection between eye contact and listening comprehension in communication is familiar to us from everyday experience. Recent

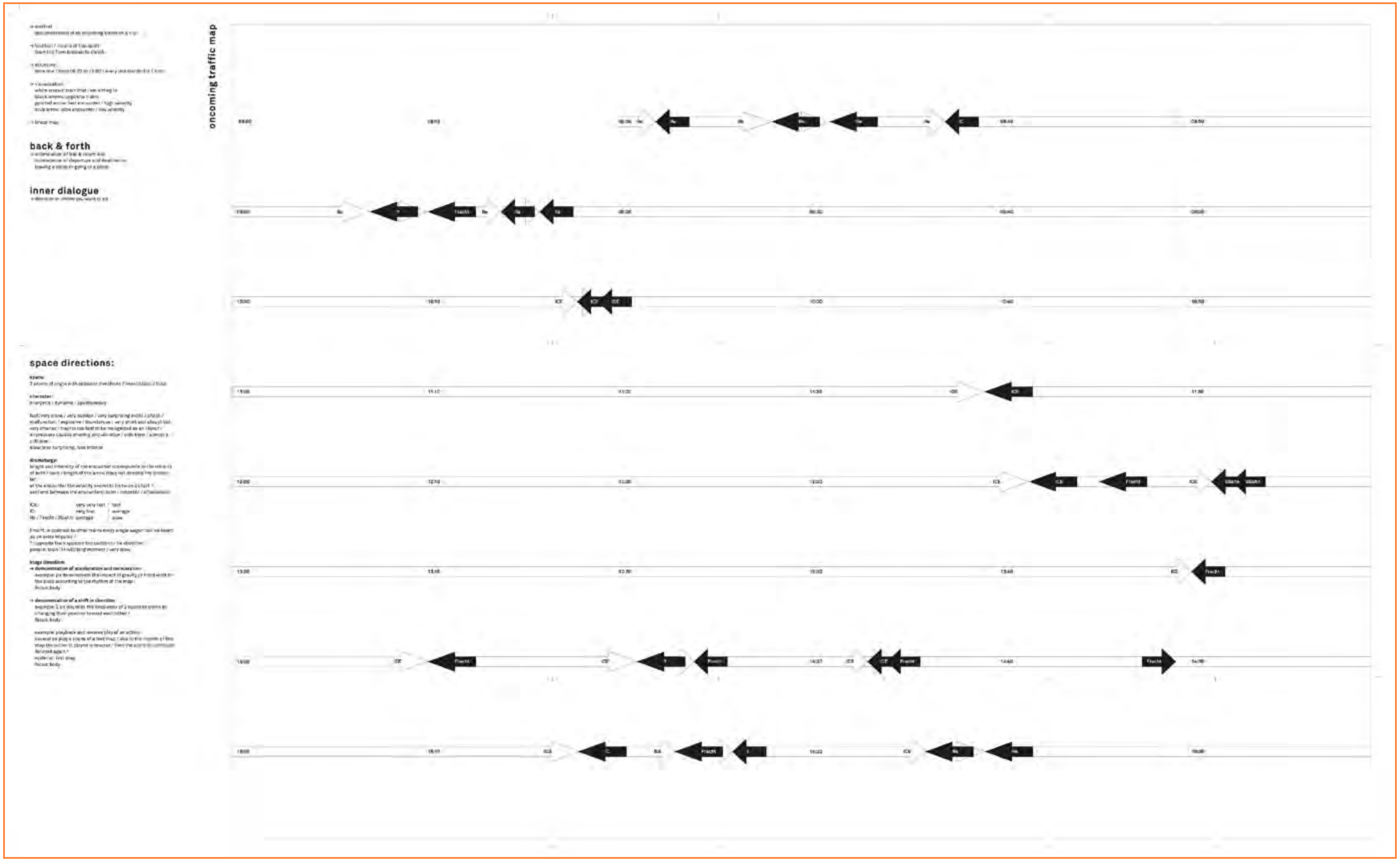


FIG. 5 *Richtungswechsel* (changes of direction)
METHOD: Documentation of all oncoming trains on a journey.
LOCATION/MEANS OF TRANSPORT: Train journey from Bremen to Zurich.
STRUCTURE: Linear map; timeline from 8:20 a.m. to 4 p.m.; each line represents one hour.
VISUALIZATION: Arrows left to right: train that I am sitting in; arrows right to left: oncoming trains; pointed arrow: fast encounter at high velocity; stub arrow: slow encounter at low velocity.
TOPIC: Back and forth, interrelation of trip and return trip; departure and destination; leaving a place and travelling towards a place.

research by neurologists at the University of Pittsburgh has shown that this is not only a neurological coupling of eye and ear, but also a physiological one. Accordingly, the alignment of the auditory system is oriented to the direction of the gaze by an appropriate alignment of the eardrum.

> *The peripheral hearing system contains several motor mechanisms that allow the brain to modify the auditory transduction process. […] Here, we report a form of eardrum motion produced by the brain via these systems: oscillations synchronized with and covarying with the direction and amplitude of saccades. These observations suggest that a vision-related process modulates the first stage of hearing. In particular, these eye movement-related eardrum oscillations may help the brain connect sights and sounds despite changes in the spatial relationship between the eyes and the ears.*[4]

The ear as our balance-regulating organ is per se responsible for our ability to orientate. Here, however, it is again explained how the visual apparatus controls hearing, how strongly the stimuli overlap instead of coexisting. Auditory perception, therefore, plays a fundamental role in spatial orientation—the location and orientation of the self in space.

The cartographic studies are part of my extensive theoretical and practical examination of spatial orientation processes. Thus the task was to place the map, as a medium of overview on the one hand, and as a linear route description on the other, in a verifiable relationship, thus posing a fundamental question about the orientation process: To what extent can strategies of parallel linking of sound and image be applied to goal-oriented spatial navigation?

Orientation processes are supported by media in different ways: In the form of classical signalling, in other words, through information that is located directly in physical space; through the print medium of the map; or as its extended version of a virtual navigation system.

The latter is directly related to my work: I see parallels between the way in which acoustic and visual information in my maps overlap, and the interaction between virtual information and physical reference in space when using a navigation system. The IanniX cursor corresponds to an avatar with the help of which I search for my position on the screen or the street.

In our everyday lives, purely acoustic spatial information is mainly used where it is particularly important: as a warning signal. It rarely acts as a substitute for a visual sign; for example, in an acoustic parking aid. A further example are the train melodies of the Japanese local transport companies, where both the stations and the trains of the individual lines are distinguished by different melodies. This solves the problem posed by

overcrowded trains and platforms, where it is impossible for information to be captured visually.

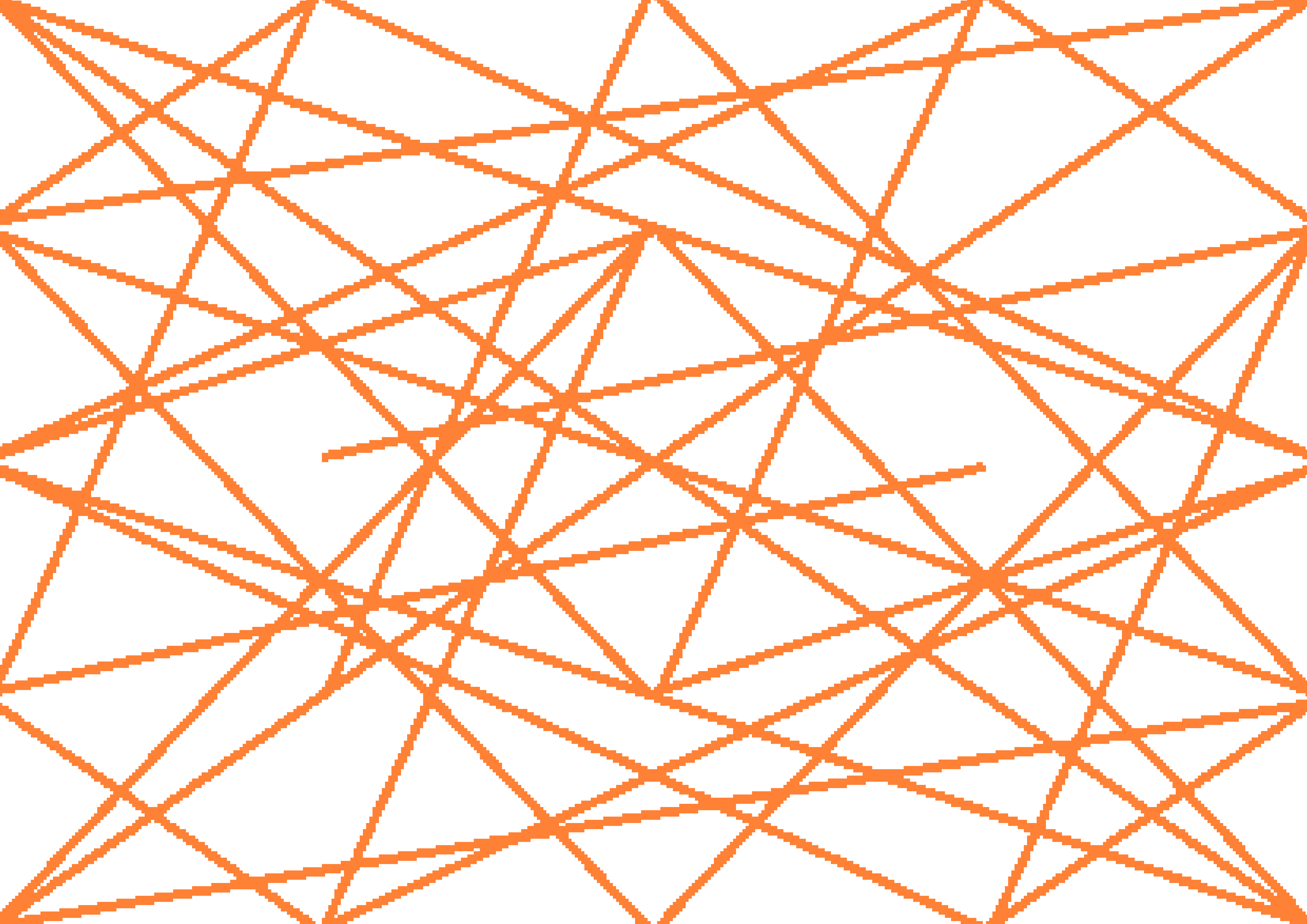
Unlike visual information, we cannot blank out acoustic information so easily, and the danger is to classify it negatively as a flood of stimuli (such as the endlessly repeating, somewhat annoying instructions of the voice of a navigation system). In my opinion, however, this is largely due to misuse. A specific investigation of this is planned for my future arts-based research work.

After all, hearing is predestined as an orientation aid: Localization as the task of auditory perception describes the determination of the relationship between auditory event, direction, and distance of a sound source. In contrast to the image, there is no nonspatial sound. Hearing includes basic spatial aspects: How far can I hear? As a perspective hearing and also a kind of acoustic horizon line definitely exist, in what way do they form a promising alternative to the corresponding visual parameters? My further work will focus on the question of which acoustic navigation strategies can be developed in order to guide intuitively through space, to reduce visual information in a meaningful way, and to make paths interpretable.

The close relationship between graphic notation and cartography, which I have established in my work, offers a concrete basis for investigating these possibilities for developing acoustic information in spatial orientation processes.

FOOTNOTES

1. Dieter Schnebel, *Mo-No:Musik zum Lesen* (Ostfildern: DuMont Reiseverlag, 1982), http://www.medienkunstnetz.de/werke/mo-no/
2. Heinz Josef Herbort, "Und sieben Futurophone," *Die ZEIT*, no, 15 (1970), https://zeit.de/1970/15/und-sieben-futurophone
3. Christian M. Fischer, "Understanding Animated Notation," in *Proceedings of TENOR 2015, First International Conference on Technologies for Music Notation and Representation*, Paris (2015), 36, http://tenor2015.tenor-conference.org/papers/05-Fischer-AnimatedNotation.pdf
4. Kurtis G. Gruters, et al., "The Eardrums Move When the Eyes Move: A Multisensory Effect on the Mechanics of Hearing," in *PNAS*, 115, E1309-E1318 (2018); first published January 23, 2018, https://www.pnas.org/content/115/6/E1309



FROM THE SYMBOLIC TO THE REAL: GRAPHIC NOTATION AS A SYMBOLIC AND TECHNOLOGICAL MEDIUM

LUKAS NOWOK

FROM THE SYMBOLIC TO THE REAL: GRAPHIC NOTATION AS A SYMBOLIC AND TECHNOLOGICAL MEDIUM

Given their function as a strictly one-way medium of communication between composer and performer, musical notation systems would seem to be quite inflexible. They play an imperative, instructive role on behalf of the musical work, which makes their readability dependent on a syntactical and grammatical agreement between composer and performer. Notation, therefore, is fundamentally a reduction or quantization of the concrete/real to the symbolic, with the ostensible goal of subsequent reproduction: realization. The basic prerequisite for such a quantization is to determine a framework that captures the dimensions required for an adequate representation of the work to be realized—while simultaneously excluding parameters that do not fit the framework and are not represented, thereby giving the performance a certain flexibility, on the one hand, and a certain indeterminacy on the other (in traditional notation, for example, timbre is merely implied by the choice of instrument or the specification of a particular way of playing).[1] For that reason alone, one would assume that the form of notation must serve and be subordinate to the musical, compositional, or aural idea—and indeed, the concept of the musical idea's independence from the way it is written down is persistently underscored in traditional musical ontology. For example, Roman Ingarden wrote:

> *As every symbol (sign) is distinct from the symbolized (signified) object, so also is the score distinct from the work defined by it. No univocal correlation exists between it and the work, since the same work can be written down by means of different systems of notation.*[2]

In reality, this independence and flexibility is only somewhat observable in the history of music. The symbolic framework of traditional notation is pushed to its limits, in a constantly changing musical and

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aesthetic language, to represent aural structures that are almost impossible to represent in that framework as fundamentally constituted, and yet even this transformation takes place only very slowly—perhaps on account of the complex dependencies and functions the framework has to fulfill. Cornelius Cardew addressed this subject in the handbook accompanying his graphic work *Treatise:*

> *The writing down of music is in process of disintegrating. In the past the notation of music was dependent on flexible conventions and a performer could use these to correct the tendencies of an aural tradition. [...] In the notation of music today two tendencies are apparent: (1) to so reduce the flexibility of the conventions that they become virtually inflexible (this means that and nothing else), and (2) to so increase the flexibility of the conventions that they in fact become non-conventional (this may mean this, that or the other, and not necessarily any of these).*[3]

My aim here is to illuminate this "disintegration" of musical writing systems from a variety of perspectives, and to elaborate, via speculative and exploratory lines of thinking, some possible methodological paradigms that may be created by breaking up the rigid relationships and dependencies that exist between idea, transcription, and realization in notation. An introductory consideration of traditional musical notation shall serve merely as a starting point, establishing the historical basis from which new, nonconventional, graphic abstractions of musical writing have diverged. The conventional categorization of notation, in musical ontology, as "a medium through which is expressed the will of the artist as to how the work created by him should be given form"—according to which notation is to be viewed as merely a material object that makes "the work that was composed at a certain point in time [...] intentionally accessible"[4]—shall be turned on its head. Ingarden, and some of the musical ontologists who came after him, saw in notation nothing more than an instantiation of the musical work, which comes into being through a creative process unconnected to notation, and which then exists from the moment of its completion as a supratemporal, nonmaterial object. According to Ingarden, there is no straightforward correspondence between notation and work, "since the same work can be written down by means of different systems of notation."[5]

Countering this still widespread view, notation shall be regarded here, in the context of our present-day artistic and musical culture, as an integral part of conceptualization, form-finding, and the artistic thought process itself, rather than a neutral communications and storage medium. This affords us, perhaps most importantly, analytical access to the complex relationship between symbol and symbolized in spheres such as computer music in particular, and artistic procedural work with computers in general. In these fields, the reproduction of notation is no longer bound to human limitations in communication and interpretation, thus opening up syntactically flexible and individualized possibilities in terms of the design of notation, and also blurring the boundaries between notation as a symbolic medium and as a technological one. At the same time, expanded or unconventional definitions of the (ontologically more or less clearly defined) concept of notation also entail the risk of introducing poorly defined boundaries between the functions of writing down and of representation (that is, between notation and visualization). Notation, here, is regarded not as the mere writing down of an independent idea or an already existing aural phenomenon, but as a "visual form of thinking."[6]

Ingarden was quite certain: The work cannot be properly identified with the notation. Some forty years later, however, Cardew showed how much the concept of the work and the relationship between idea/conceptualization and realization had changed: Notation was now essential to the work, with the potential to be elevated to the status of a work in its own right. "The notation is more important than the sound. Not the exactitude and success with which a notation notates a sound; but the musicalness of the notation in its notating."[7] The notation itself has the potential to reconceive aural forms and compositions by other means. The dissolution of the symbolic framework of traditional notation gives access to "the immediacy of visual observation [of] one's own creative process, making that which 'underlies' it conscious and therefore analyzable."[8]

In McLuhanian terms, forms of notation can be viewed as both medium and message simultaneously.[9] In their essence, as symbolic abstractions of the key parameters of the music to be represented, not only do they reproduce the way a particular work is structured (supposedly the true import of notation), they also tell us just as much about the concept of music that the composer, or the epoch in which she is working, has abstracted from perception. Notation as concept, independent of its individual instances, answers the question "What is music and what is not?" from the point of view of the composer who is defining that notation, or of the period in which that notation was or is conventional. This is a consequence, as noted above, of the necessity of defining a symbolic framework. Any analytical examination must therefore focus (primarily on account of media and technology-related changes in the process of musical creation) on how the medium affects the musicultural and music historical situation—not on that which is notated, but on the notation's *influence* upon it. In McLuhan's words, "The 'message' of any medium or technology is the change of scale or pace or pattern that it introduces into human affairs."[10] Given new and unconventional graphic forms of notation and representation, this recontextualization of notation, from a concept of music theory or musical ontology to one of media theory, opens up freer analytical and speculative perspectives, initially releasing notation from its traditional imperative function and giving it access to other possible functions—for example, in computer art. But to what extent is notation truly a medium and a technological object?

One obvious way to try to categorize notation as a medium would be by comparing it with graphic representations of language (and of aural phenomena in general)—which, according to Ferdinand de Saussure, can be divided into two systems.[11] On the one hand there are ideographic systems, which use a separate symbol to represent each word. The symbol itself has no relation to the phonetic sound of the word it represents; rather, it symbolizes the entire word, and thus the idea that the word conveys. Chinese characters are a classic example of ideographic writing. By contrast, phonetic writing systems use elemental phonetic or alphabetic symbols to represent the sound sequences that make up words. However, what is significant for the comparison with musical notation is not the division of linguistic symbol systems into ideographic and phonetic, but rather the characteristics brought to light by contrasting the differences between the various graphic representations. One characteristic that stands out especially clearly in relation to the difference between ideographic and phonetic systems is the *granularity* of the abstraction, which not only plays a part in the writing down of aural (phonetic or musical) phenomena, but has also had a significant influence on our analysis and theoretical understanding of them:

> *Linguistic analysis [...] came to resolve oral speech into a finite series of elementary informational units. These ultimate discrete units, the so-called "distinctive features," are aligned into simultaneous bundles termed "phonemes," which in turn are concatenated into sequences. Thus form in language has a manifestly granular structure and is subject to a quantal description.*[12]

Consequently, it is no surprise that formal music-theoretical considerations and analyses have focused overwhelmingly on the note as the elemental unit of musical information. Using the parameters of pitch (typically, the division of the octave into twelve semitones) and time (the division inherent in meter), the note divides the physical continuity of music into distinct aural events, in consequence of which music can be described in discrete numerical and mathematical relationships—and is in fact described and analyzed in terms of these parameters in most cases. Moreover, the granular structure of phonetic and alphabetic writing systems, as a discretization of temporally continuous language, enables us to identify a characteristic that is far more important for grammatology, linguistics, and, later, for media theory: the spatial linearization of temporal processes. As Saussure wrote, in reference to alphabetic writing:

> *Auditory signifiers have at their command only the dimension of time. Their elements are presented in succession; they form a chain. This feature becomes readily apparent when they are represented in writing. [...] The signifier, being auditory, is unfolded solely in time, from which it gets the following characteristics: (a) it represents a span, and (b) the span is measurable in a single dimension; it is a line.*[13]

The dominance of the linear time axis in graphic abstractions of "real" phenomena plays an especially important role in Friedrich Kittler's media theory.[14] Through the spatialization of signs, which represent the smallest elements in the continuous flow of language, it becomes possible, by symbolic means, not only to store and repeat this continuous, irreversible flow, but also—and much more importantly—to manipulate it. It is precisely this quality of notation—the possibility of manipulating time axes—that makes it a symbolic medium in the first place:

> *The different arrangement of a stream of temporal data is precisely what is meant by time axis manipulation. [...] Time axis manipulation therefore presupposes (to the horror of philosophers) that time-serial data be referred to spatial coordinates. [...] History's first such time manipulation technology was, of course, writing, especially in the shape of an alphabet that assigns a spatial position to each graphic sign representing a time-serial element in the chain of speech.*[15]

This positioning of notation in the context of Kittler's theory gives rise to a new frame of reference for his analysis: On the one hand, Kittler pays particularly close attention not just to storage, but to the medium's capacity for data processing. Storage is understood to be merely a basis enabling the manipulation of the medium's content. The *how* of the symbolic medium is thus given greater significance than the *what*, as a result of which media are no longer seen primarily as purely the transmission of content, but as a technology for acting upon that content. On the other hand, it is worth noting the way Kittler dissolves the traditional media-historical understanding of the development of media. Instead of the stereotypical conception of media evolution in three phases—the invention and spread of the alphabet, the printing press, and the computer—Kittler sees the invention of analog technological media such as film and the gramophone as a more significant step.[16] The qualitative shift initiated by analog technological media, in relation to symbolic media, plays a central role in Kittler's media theory. In the age of handwriting and of the printing press, all forms of writing are bound up in a symbolic universe—which in its most basic variant is that of everyday speech transcribed by notation. Technological media, by contrast, attempt to select, store, and produce the physical realities themselves.[17]

For example, if we consider traditional Western musical notation in terms of the spatial abstraction of time, a direct relationship between real and notated time can be identified only with difficulty. Notated time is defined by the meter and its division into whole sections, generally even in number (halves of a measure, quarters, eighths, etc.), and elapsing time extends along a horizontal axis. The dominance of the time axis is misleading, however: Neither the length of a measure on paper nor the relationships between the lengths of the individual measures says anything about the actual duration of the measure. This characteristic makes it impossible to formulate time in terms of absolute points, or to describe events occurring in real time periods. Points in time are necessarily derived from the meter; manipulation and modification of "real" time are impossible.

To be able to realize formulations and manipulations that go beyond "symbolic time" and the syntactic structures of the symbolic framework, some graphic forms of notation have developed a strictly isomorphic way of representing time, in which the spatial qualities of the notation have a constant relationship to the real time being represented. UPIC's design concept may be regarded as a qualitative approximation of the symbolic to the technological medium, in that it offers an exact Cartesian mapping between the spatiality of the notation and the time period being notated (on the horizontal axis) and the spectral content (on the vertical), thus seemingly presenting the possibility of acting directly upon the unabstracted continuum of these dimensions. However, by describing the two temporal dimensions of sound—its instants and its frequencies—on linear axes, it circumvents the physical incompatibility between them (as proposed by Dennis Gabor)[18] and thus cannot be considered a strictly technological medium. In other words, a "sonic quality [...] is an oscillatory movement, a movement that consists in nothing else but a cluster of *multiple* moments or a spectrum of frequencies, which in itself have no momentary existence. *What* and *when* are mutually incommensurable."[19] Therefore, a diagram interrelating the otherwise incommensurable

dimensions of time and frequency (as is the case, for example, with the frequency spectrum of Fourier analysis) can only refer to physical reality by means of symbolic abstraction. However, UPIC's successor, IanniX, takes a different approach to the mode of temporality. By incorporating real time into the interpretation of the notation, it eliminates the need to symbolically reduce the notated time period to a single visual state. Instead, it notates by means of "three-dimensional paths and 'spheres' with their own space-time behavior, read by 'cursors.'"[20] Time enters the notational space as its physical reality itself.

Kittler viewed the historical shift in the medium of writing from the scroll to the codex (that is, the book) as a more significant media transformation than that engendered by Gutenberg's invention of the printing press.[21] Whereas the scroll required that modifications to the temporality of the material be strictly sequential and linear, the book, with its separate spatial analogues to the time of the material, allowed modifications to the medium to be nonchronological. "To use technical jargon, one could say that this invention transforms the sections of the text into 'addresses.'"[22] This shift in media-historical focus illustrates, once again, the significance to Kittler's media theory of modalities of manipulating and acting upon the medium, as opposed to purely storage and communication-oriented functions. In that regard, graphic forms of notation have the potential to approximate, through new graphic abstractions, the reality of the material notated—but also, and equally, the potential to regain their distance from that reality through symbolic abstraction, making possible a variety of flexible modalities for acting upon the material. The spatial abstraction of time, in particular, holds untapped potential for breaking away from the dominance of the linear, horizontal time axis and adopting ideas of temporality, developed in visual, kinetic, and media art in the twentieth century, that go far beyond traditional ideas of narratology (in visual art) and chronology (in media art). These began with Robert Delaunay's window pictures[23] and have continued through Cubist and Futurist ideas of temporality and movement (for example, in Naum Gabo's 1920 *The Realistic Manifesto*, in which he insisted on the necessity of integrating movement and rhythm as an expression of time[24]) and Paul Klee's polyphonic painting, which Robert Kudielka described as images that define depth as a layering of perceptual levels, in part through the superposition of various colored glazes, and in part through a structural distinction between concealing and revealing modes of presentation. Time is noted here as an alternation between visible and hidden, not a continuous advance from here to there, from "no longer" to "not yet,"[25] to the concept of "input/output time" in the work of Nam June Paik.[26]

FOOTNOTES

1. Roman Pfeifer, "Schrift und Klang – zur Verschriftlichung von Tonbandmusik" (*Diplom* thesis, Folkwang Universität, 2002).

2. Roman Ingarden, *Ontology of the Work of Art: The Musical Work, the Picture, the Architectural Work, the Film*, trans. Raymond Meyer and John T. Goldthwait (Athens, OH: Ohio University Press, 1989), 26.

3. Cornelius Cardew, *Treatise Handbook* (London: Peters, 1970), xiv.

4. Ingarden, 25–26.

5. Ibid., 26.

6. Angela Lammert, "Von der Bildlichkeit der *Notation*," in *Notation: Kalkül und Form in den Künsten*, ed. Hubertus von Amelunxen, Dieter Appelt, Peter Weibel, and Angela Lammert, exh. cat. (Berlin: Akademie der Künste; Karlsruhe: ZKM | Center for Art and Media Karlsruhe, 2008), 52.

7. Cardew, *Treatise Handbook*, vii.

8. Sharon Kanach, "Sichtbare Musik: Notationsübertragung im Oeuvre von Iannis Xenakis," in *Notation: Kalkül und Form in den Künsten*, 212

9. Marshall McLuhan, *Understanding Media: The Extensions of Man* (1964; repr., Cambridge, MA: MIT Press, 1994).

10. Ibid.

11. Ferdinand de Saussure, *Course in General Linguistics*, ed. Charles Bally, Albert Sechehaye, and Albert Riedlinger, trans. Wade Baskin (1916; repr., New York: McGraw-Hill, 1966), 25.

12. Roman Jakobson, "Linguistics and Communication Theory," in *Selected Writings*, vol. 2, *Word and Language* (The Hague: Mouton, 1971), 570–59, here 570.

13. Saussure, *Course in General Linguistics* (1916, repr. Illinois, Open Court, 1986), 70

14. Friedrich Kittler, "Real Time Analysis, Time Axis Manipulation," in, *Cultural Politics* 13, trans. Geoffrey Winthrop-Young, (2017), 1–18.

15. Ibid., 5–6.

16. Sybille Krämer, "The Cultural Techniques of Time Axis Manipulation: On Friedrich Kittler's Conception of Media," in *Theory, Culture & Society* 23, 7–8 (2006), 93–109.

17. Ibid., 94.

18. Dennis Gabor, *Theory of Communication* (London: Institution of Electrical Engineering, 1946), 429.

19. Julian Rohrhuber, "Algorithmic Music and the Philosophy of Time," in *The Oxford Handbook of Algorithmic Music*, ed. Alex McLean and Roger T. Dean (Oxford: Oxford University Press, 2018), 17–40, here 27–28.

20. See Scordato, "Novel Perspectives for Graphic Notation in IanniX," this volume.

21. Krämer, "Cultural Techniques," 100.

22. Ibid.

23. Barbara John, "The Sounding Image: About the Relationship between Art and Music; An Art-Historical Retrospective View," Media Art Net, http://www.medienkunstnetz.de/themes/image-sound_relations/sounding_mage/

24. Brigitta Wolf, "Nam June Paik und die Zeit" (*Diplom* thesis, Technische Universität Berlin, 2015), 8.

25. Robert Kudielka, "Schichten: Zur Notation von Tiefe in der Zeit," in *Notation: Kalkül und Form in den Künsten*, 353.

26. Lydia Haustein, *Videokunst* (Munich: C. H. Beck, 2003), 62.

APPENDIX

BIOGRAPHIES

EDITORS' BIOGRAPHIES

LUDGER BRÜMMER (*1958 in Werne, Germany) is a composer professor for composition in digital media in Trossingen and head of the ZKM | Hertz-Lab research institute since 2017. As of 2003, as head of the former ZKM | Institute for Music and Acoustics, he initiated the Sound Dome Project and important festivals on electronic music. The central focus of his music is the use of the computer, both as an artistic means of composition and for electronic sound production. Brümmer has also realized a series of multimedia and interdisciplinary projects, experimental music pieces, compositions for dance and live electronics, and is interested in the interaction between acoustic instruments and live video.

SHARON KANACH (*1957 in New Jersey, USA) has lived in France since 1976. She originally went to Paris to study with Nadia Boulanger. Very quickly, however, her path crossed that of Iannis Xenakis with whom she collaborated closely, especially on his writings. First, she translated *Arts/Sciences: Alloys*, followed by a new, revised, and enlarged edition of his seminal *Formalized Music,* then *Music and Architecture*, which Kanach coauthored with Xenakis, published in French in 2006 and in 2008 in English. As General Editor of the Xenakis Series at Pendragon Press, Kanach has, so far, also edited two collective volumes: *Performing Xenakis* and *Xenakis Matters*. Since 2007, Kanach is vice-president of the Centre Iannis Xenakis based at the Université de Rouen. In 2010 Kanach founded the Xenakis Project of the Americas under the auspices of the Brook Center for Music Research and Documentation at the CUNY Graduate Center, New York City.

PETER WEIBEL (*1944 in Odessa, Ukraine) studied literature, medicine, logic, philosophy, and film in Paris and Vienna. He became a central figure in European media art on account of his various activities as artist, media theorist, curator, and as a nomad between art and science. He has been granted honorary doctorates by the University of Art and Design Helsinki in 2007, and by the University of Pécs, Hungary, in 2013. In 2008, he was awarded the French distinction of Officier dans l'Ordre des Arts et des Lettres. Since 1999, Peter Weibel is Chairman and CEO of the ZKM | Center for Art and Media Karlsruhe, and since 2017 director of the Peter Weibel Research Institute for Digital Cultures at the University of Applied Arts Vienna.

AUTHORS' BIOGRAPHIES

RICHARD BARRETT (*1959, Swansea, UK) is internationally active as a composer and a performer, ranging from intricately notated orchestral and chamber music to free improvisation with live electronics. He also teaches at the Instituut voor Sonologie in Den Haag and the University of Leiden. He was awarded a PhD by Leeds University in 2018, and in 2019 his book *Music of Possibility* was published by Vision Edition.

RODOLPHE BOUROTTE (*1971 in Abidjan, Ivory Coast) is a composer-researcher. He has been writing and improvising electroacoustic and instrumental music since 1998. He studied composition with Allain Gaussin, Jean-Yves Bosseur, Jean Balissat and Paul Méfano, and electroacoustic composition at Les Ateliers UPIC. He developed various programs linking graphics and sound, notably for real-time generated scores or picture-driven probability sequences. His music is based on the view that we humans should make the effort to create things that cannot be modelled by a computer.

PIERRE COUPRIE (*1970 in Poitiers, France) holds a Ph.D. in musicology and is an associate professor and a researcher qualified for direct research at the Sorbonne University and the Research Institute for Musicology. His research fields are musical analysis, representation and performance studies of electroacoustic music, digital musicology, and the development of tools for research or musical performance (iAnalyse, EAnalysis, MotusLab Tools). He teaches digital pedagogy, musicology, and computer music at the Sorbonne University. He collaborates with the Music, Technology and Innovation Institute for Sonic Creativity (MTI^2) of De Montfort University since 2004 on musical analysis projects. In 2015, he won the Qwartz Max Mathews Price of technological innovation for his musical analysis software. As an improviser, he is a member of The Phonogénistes and The National Electroacoustic Orchestra (ONE).

CYRILLE DELHAYE (*1980 Evreux, France) is a teacher, a documentalist, and musicologist. He studied musicology at the Université de Rouen. His work focuses on the history and analysis of concrete and electroacoustic music and digital humanities. In 2010, he defended his PhD on *Orphée* by Pierre Henry and Pierre Schaeffer. His thesis is based on the private archives of the two composers and investigates the different versions of this artwork (1951–2015). Since 2010, he has been in charge of the archives of the Centre Iannis Xenakis (CIX), which include the material on 120 composers who had composed on the UPIC there: inventory, digitization, editorialization, and online publishing of more than 1000 unpublished items. In addition to contributions to collective books, his work has been published in the *Revue Française de Musicologie* and in *Organised Sound*. He is currently working on Pierre Henry's catalogue raisonné, to be published by the Philharmonie de Paris.

ALAIN DÉSPRES (*1948 in Graçay, France) was director of artistic and cultural structures for more than 25 years. He notably created and directed Les Ateliers UPIC alongside Iannis Xenakis. In this context, over a hundred composers were hosted and many groups of amateurs coming to work on the UPIC in Paris. He has also organized and initiated numerous concerts, master classes, and workshops in universities, art schools and at contemporary art festivals in North America (Mexico, USA, Canada), Japan, and in most countries of Europe. He then created and directed Alpha Centauri, a cultural structure whose purpose was to foster collaborations between scientific researchers and creative artists (CNRS, CEA, Ecole Polytechnique, INRA, SUPELEC, universities, ministries, and so on). For about twenty years Alain Déspres has been pursuing more personal work of stone sculpture in direct carving (serpentines, marbles, basalts, granites, etc.).

JULIO ESTRADA (*1943 in Mexico City, Mexico). Estrada's devise and research-creation take network theory (*Canto tejido, Canto alterno*) and interval classes (*Canto naciente*) as their starting point, followed by a series of innovations in the field of the continuum: rhythm–sound continuum (*eua'on, eua'on'ome*), rhythm–sound macro-timbre polyphony (*ensemble'yuunohui*), topological rhythm–sound continuum (*ishini'ioni*), rhythm–sound space continuum macro-timbre (*eolo'oolin*), continuum–discontinuum fusion (*yuunohui'tlapoa*), continuum noise (*yuunohui'wah*), or vocal and instrumental macro-timbre (*mictlan, hum, yuunohui'ehecatl, yuunohui'sa*). He explores "live music creations" (*Quotidianus, Bajo el volcán*) and ground-breaking operas (*Murmullos del páramo*, 1991–2006, and *La nube en el laberinto*, a novel to be silently listened to within the readers' experience (2008–). At the UNAM, Mexican National University, he is coauthor with Jorge Gil of *Music and Finite Groups Theory: 3 Boolean Variables* (1984); author of *Continuous Reality and Imagination* (2019); and *The Scales Continuum* (in press). He has been the research director of the *eua'oolin* projects, the intervallic classes combinatorial theory MuSIIC (2000–2016), and 21st Century UPIC (2000–2001, France). His awards include chevalier and officier of the French Arts et Lettres, the UNAM Prix, a Mexican Fine Arts Medal and National Scholars System Emeritus.

RUDOLF FRISIUS (*1941 in Celle, Germany) studied musicology, philosophy, art, and mathematics in Hamburg, Frankfurt, and Göttingen. He was active in musicological and music pedagogical teaching and research in Oldenburg and Karlsruhe with a focus on music theory and music pedagogy (studies on the concept of chords, harmony in the 20th century, electroacoustic music). He has published extensively, including in the *Handbuch der Musik im 20. Jahrhundert, Neue Musik*, on Xenakis (Musik-Konzepte 55/56), Stockhausen (3 volumes, numerous radio broadcasts), Henry, Bayle, Kagel, Ligeti, Riedl, and Rihm, and collaborated with institutions such as the INMM Darmstadt (1998–2004 as chairman), the Darmstadt Summer Courses (1990 on Xenakis and Cage), and the Centre Acanthes (Henry and Xenakis).

KIYOSHI FURUKAWA (*1959 in Tokyo, Japan) studied composition in Tokyo with Yoshiro Irino, in Berlin with Isang Yun, and in Hamburg with György Ligeti. In 1991 he completed a study stay at the CCRMA at Stanford University, USA. He was a long-term artist-in-residence at the ZKM | Center for Art and Media Karlsruhe in 1992/93 and 1996/97, and premiered

the media opera *Den ungeborenen Göttern* for the opening of the ZKM in 1997. For his multimedia works, chamber music, and orchestral music, he has received numerous awards and scholarships, and his works have been performed at international music festivals (Warsaw Autumn, Inventionen Berlin, Steierischer Herbst Graz, Interface Hamburg, Multimediale Karlsruhe, amongst others). Since 2000 he is a professor at the Tokyo National University of the Arts (Inter-Media Art).

HUGUES GENEVOIS (*1958, Abidjan, Ivory Coast) is a researcher in musical acoustics, within the LAM team at the Institut d'Alembert (Sorbonne Université — CNRS). With a scientific background (Master of Science in Physics and Telecom ParisTech Engineering School), Hugues Genevois became interested very early in music composition and the possibilities offered by computers for sound synthesis. However, if his tastes willingly led him to musique concrète and music from the Far East, it was through contact with Iannis Xenakis that he decided to deepen his written work. After having produced numerous pieces of music on paper, his interest in instrumental practice (electric guitar, synthesizers) led him to explore the expressive possibilities of the computer. His research focuses in particular on new lutheries and musician–instrument interaction. Also an improviser, he performs in various formations: ONE (septet), *Les complémentaires* (trio with György Kurtag Jr. and Jean Haury) and *Moon Module* (duo with Laurence Bouckaert).

KOSMAS GIANNOUTAKIS (*1985 in Thessaloniki, Greece) studied piano and percussion performance, composition, and computer music in Greece, Germany, and Austria. His artistic practice focuses on emergent music outcomes brought forth by self-organizing systems. These include compositional, performative, and algorithmic agencies that are organized as non-hierarchical, decentralized networks which exchange information on multiple timescales through the medium of sound. His works have been presented and received awards at various international festivals and conferences, such as inSonic at ZKM Karlsruhe, ALIFE 2018 conference in Tokyo, Junge SIGNALE concert series in Graz, Soundislands Festival in Singapore, Toronto International Electroacoustic Symposium, New York City Electroacoustic Music Festival, Gaudeamus Muziekweek 2015 and ICMC 2016 in Utrecht, REAL/UNREAL BEAST FEaST 2016 in Birmingham, klingt gut! 2016 in Hamburg, 13th Athens Digital Arts Festival, Sonic Realities 2018 in Aberdeen, Workshop-in-Exposition: Thresholds of the Algorithmic in Bergen, xCoAx 2017 in Lisbon, and *The Digital Body* International Exhibition in Bucharest.

DIMITRIS KAMAROTOS (*1954 in Athens, Greece) studied music and computer science in Athens, musicology, composition, clarinet, and electroacoustic music in Paris with D. Charles, M. Battier, H. Vaggionne, and I. Xenakis. From 1986 to 1995 he worked as research manager in the CMRC (Center for Contemporary Music Research of Athens), founded by Xenakis. During this period he planned and implemented the main activities concerning the UPIC system of the CMRC. As a researcher, he contributed to the field of automated music pattern recognition. As a composer, he is developing the use of interactive sound control and generative technologies in theatrical performance. Since 1990 he has contributed original music, sound design, and sound dramaturgy to many performances for the Hellenic Festival, in the Epidaurus ancient theater, National Theater of Greece, La Comédie-Française, Volksbühne Theater, Riksteatern Stockholm, Shanghai DAC, Seoul Arts Centre, and European theater festivals.

HENNING LOHNER (*1961, Bremen, Germany) is a German-American composer, filmmaker, and digital media artist. Lohner's creative output embraces diverse fields within the audiovisual arts. He has collaborated extensively with artists such as Karlheinz Stockhausen, Karl Lagerfeld, Louis Malle, Gerhard Richter, Frank Zappa, Dennis Hopper, and John Cage. Since 1996 Henning Lohner has been a member of the Remote Control film composers' group founded by Hans Zimmer. Lohner's documentary *Ninth November Night* was shortlisted for the Academy Awards (the Oscars) in 2005. His active images media artwork, *Silences*, has been screened, exhibited, and acquired by museums such as SFMoMA, the Centre Pompidou, the Louvre, the German National Academy of Art, the Venice Biennale, and many others. Iannis

Xenakis became Lohner's life-long mentor in 1985. Since then, Lohner has published numerous articles on the composer's work, including initiating and contributing to the first German language monograph on the composer, as Volume 54 of the series *MusikTexte*.

FRANÇOIS-BERNARD MÂCHE (*1935 in Clermont-Ferrand, France) was born into a family of musicians and has pursued two careers simultaneously. As a composer (student of Messiaen and a founding member of Pierre Schaeffer's G.R.M.), he has been invited to perform in some thirty countries. He has received the Prix Italia (1977), the Grand Prix National de la Musique (1988), and the Grand Prix de la Sacem (2002) amongst other awards. His catalogue now includes 115 works illustrating all genres and techniques. In addition, Mâche graduated from the prestigious Ecole Normale Supérieure, is an *agrégé* and Doctor of the Arts. He headed the Music Department of the University of Strasbourg for ten years, published eight books, and ended his academic career as Director of Studies at the E.H.E.S.S.. A Commander of Arts and Letters and Knight of the Academic Palms, he was elected member of the French Institute in 2002, in the chair previously occupied by Iannis Xenakis, and was appointed Doctor *honoris causa* of the University of Athens in 2011.

GUY MÉDIGUE (*1935 in Algiers, Algeria) studied mathematics, attended the Ecole Polytechnique in Paris for one year, then preferred to sing his songs in Paris until 1964. After that, he worked as a computer engineer from 1965 until 1996. For nearly eleven years, he worked for SEMA-METRA International (traffic software), then for CERCI, which subcontracted him out for several years to participate in the IRIA CYCLADES project (French premises of the Internet). Always fascinated by the relationship between music and computer science, he then gladly worked as a freelancer with Iannis Xenakis at the CEMAMu from 1976 to 1980, developing and refining the first UPIC. From 1981 to 1996, he participated in the building of a multi-microprocessor structure (SM90 project, CNET), mainly on software aspects. Next, he managed source programs for a team working on a communication-based operating system (Chorus system).

CHIKASHI MIYAMA (*1979 in Otsu, Japan) is an artist and software developer who utilizes diverse interactive digital media technologies. He holds a Master's degree from the Kunitachi College of Music, Tokyo, a Nachdiplom from the Music Academy of Basel, and a Ph.D in composition from the University at Buffalo, New York. His works have received an ICMA award, a second prize in SEAMUS commission competition, a special prize in Destellos Competition, and the first prize in Strom Festival Cologne. His works and papers have been accepted by ICMC twelve times, by NIME four times, and selected by various international festivals in more than 20 countries. In 2011, he moved to Germany as a DAAD scholar and worked as a research associate at ZKM Karlsruhe between 2015 and 2017. He is currently working as a lecturer at the Cologne University of Music and Dance and an audio software developer at Dear Reality GmbH in Düsseldorf.

LUKAS NOWOK (*1993 in Donaueschingen, Germany) studied music technology and design in Trossingen and Helsinki. Since 2016 he has been a sound director for the SWR public broadcaster Experimental Studio, a laboratory and international touring ensemble for contemporary music with live electronics. There he has worked with composers such as Chaya Czernowin, Peter Ablinger, and many others. Besides his work as a sound director, he is active as a sound and visual artist, working in a broad range of disciplines including theater, electroacoustics, performance and installation arts.

GERARD PAPE (*1955 in New York City, USA) is a former director of the Ateliers UPIC/CCMIX, from 1991 to 2007, and he founded the C.L.S.I., a collective of composer-performers playing instruments and computers "live" in 2007. Two CDs of his music were released in 2015 on Stradivarius and Mode Records. A bilingual book of Pape's texts as well as musicological texts about his work, *MUSIPOESCI*, was published in 2015 by Editions Michel de Maule in Paris. In recent years, Pape has been working on a large-scale opera cycle called SUNSET TIME. He completed the first opera of the cycle, *Pourquoi des poètes?*, in 2014. He is currently working on the second opera *L'Enfant et le 4e Monde*. These two works for 4 soloists and string ensemble are intended to be performed as a diptych. Pape recently composed a music theater work based on Sam Shepard's and Joseph Chaikin's play *The War in Heaven* (*Angel's Monologue*) for bass voice and electronics.

BRIGITTE CONDORCET (ROBINDORÉ) is a French composer and researcher, who worked from 1991 to 1997 at Iannis Xenakis's two Parisian centers, the CCMIX (formerly Les Ateliers UPIC) and the CEMAMu, as a composer, head of Musical Production, and UPIC system beta tester and manual author. She experienced firsthand the intensity and authenticity of Xenakis's presence and conceptions and had a long and unique compositional journey with the UPIC system. Her compositions *Autel de la Perte et de la Transformation* and *Comme Etrangers et Voyageurs sur la Terre* were selected for the 20th anniversary double CD set of the CCMIX for Mode Records in 2001, and the latter was also excerpted by the Computer Music Journal for its Sound Anthology (Vol 20, 1996). Her composition *L'Enfant et le Phénix* received the Prix Radio France/La Muse en Circuit and featured narration by French cinema icon Emmanuelle Riva of *Hiroshima mon Amour*. She obtained an Advanced Master's (DEA) degree from the Université de Paris VIII in 1997, under the direction of Horacio Vaggione, studying the impact of electroacoustics on acoustic composition and thought. She is currently a doctoral candidate at the Université de Rouen, researching syncretic and mystical music traditions and their influence on post-war European composers.

MARCIN PIETRUSZEWSKI (*1984 in Gniezno, Poland) is a composer and researcher based in Edinburgh. He engages with sound synthesis and composition using computers, exploring specific formal developments in the tradition of electroacoustic music and contemporary sound art, as well as extra-musical domains of auditory design, computational linguistics, and psychoacoustics. He works across performance, multimedia installations, and radio productions, probing the dynamics between formalism of synthetic sound and its material realization. He has collaborated extensively with musicians and composers, including Marcus Schmickler, Tristan Clutterbuck (fancyyyyy), Jules Rawlinson, and Lauren Sarah Hayes. Among his recent projects are a collaboration with Florian Hecker and graphic design company NORM from Zurich, philosopher Chris Schambaugh (The New School, New York), choreographer and dancer Agnes Cebere (Martha Graham School of Contemporary Dance, New York), the Laboria Cubonics Collective (the authors of Xenofeminist Manifesto).

JULIA JASMIN ROMMEL (*1979 in Mutlangen, Germany) studied visual communication and scenography in Berlin, Stockholm, and Zurich. Her work focuses on developing spatial concepts for contemporary music theater productions (*Follies for Fontane*, Brandenburg 2019; *Match Cut Music Convention*, Berlin 2017; *Die Nachtigall*, Berlin 2017; *Into the Deep*, Radialsystem Berlin 2017; *Mockumentary Altus*, Bremen 2014; Orlando UA Theater, Bielefeld 2013) as well as on scenography for classical opera productions (*Dido & Aeneas*, *Cosi fan tutte, Acis & Galatea*, Antwerp 2015/16; *Kinderzauberflöte Berliner Philharmoniker*, Baden-Baden 2013). Another focus of her work is creating orientation systems for buildings and public spaces (*Elbphilharmonie Hamburg* 2010 for Integral Zürich, *Löwenbräu Areal* Zürich, Switzerland) and also corporate design and cartography. Furthermore, she is participating in a PhD program at the Offenbach University of Art and Design, where she explores the phenomena of ubiquity and space constitution in the context of information and communication technology.

JULIAN SCORDATO (*1985 in Pordenone, Italy) studied composition and electronic music at the Conservatory of Venice, and sound art at the University of Barcelona. He is cofounder of the Arazzi Laptop Ensemble and was a research assistant at SaMPL — Sound and Music Processing Lab, Padua. As a music technologist, Scordato has presented results related to interactive performance systems and graphic notation tools in conferences and lectures. He has worked as a professor of electronic music at the conservatories of Brescia, Salerno, and Cuneo. His award-winning electroacoustic and audiovisual works have been performed and exhibited at international festivals and institutions.

TAKEHITO SHIMAZU (*1949 in Shimoda, Japan) studied composition with Sesshu Kai in Tokyo at Tokyo Gakugei University and with Isang Yun in Berlin at Berlin University of the Arts. He produced electronic and computer music at the electronic studio of the Technical University of Berlin, at IRCAM in Paris, at Les Ateliers UPIC in Paris, and at INA-GRM in Paris. His compositions were selected and played several times at the Music Days of ISCM and ICMC (International Computer Music Conference) and many other festivals in Asia, Europe, and America, including the Saarbrücken Music Festival (2002) and Dresden Music Festival (2005). He chaired the music committee of ICMC '93 in Tokyo. His scores are published by Breitkopf & Härtel and F. Hofmaister in Germany, amongst others. From 1985 to 2015 he was a professor at Fukushima University, and since 2005 he has been the Artistic Director of the Orchestra Pfirsich in Fukushima.

VICTORIA SIMON (*1983 in New York City, United States) earned her PhD in Communication Studies from McGill University in 2019. Her research focuses on the history and cultural politics of sound technology and user interface design. She has published in the journals *Television and New Media, Communication*, *Culture and Critique*, *Amodern*, and is a contributor to the edited volume, *Appified: Culture in the Age of Apps* (2018).

ANDREY SMIRNOV (*1956 in Moscow, Russia) is an interdisciplinary artist, independent curator, collector, writer, composer, and researcher of new techniques in computer music. He is the founder of the Theremin Center, a research fellow at the Center for Electroacoustic Music at Moscow State Conservatory, the head of the Rodchenko Sound Lab, and a lecturer at the Rodchenko Art School in Moscow. He teaches history and the aesthetics of electroacoustic music, composition, and new musical interfaces. His main ongoing project is focused on restoring the censored history of artistically utopian early twentieth-century Russia. He is the author of the book *Sound In Z: Experiments In Sound and Electronic Music in Early 20th Century Russia* (Walther König, Cologne, and Sound and Music, London, 2013).

RONALD SQUIBBS (*1962 in Bridgeport, Connecticut, USA) earned his undergraduate and graduate degrees in music at Yale University. He has presented his research on the music of Iannis Xenakis at conferences and in publications in journals and edited collections, including *Xenakis Matters* (ed. Sharon Kanach, Pendragon Press, 2012) and *Twentieth-Century Music and Mathematics* (ed. Roberto Illiano, Brepols, 2019). In addition to his scholarly work, he is active as a performer of twentieth and twenty-first-century music. His recordings of piano music by Joji Yuasa and Dane Rudhyar are available on the Aucourant Records label. He is currently Associate Professor of Music Theory at the University of Connecticut, where he has taught since 2002.

KATERINA TSIOUKRA (*1993 in Kozani, Greece) studied at the Department of Music Studies of the Ionian University in Corfu, Greece. She obtained her Master's degree in the history of neohellenic music and is currently a doctoral candidate at the same university. Her research interests lie primarily in the area of post-war music history in Greece. Since 2018, she has been collaborating both with the Contemporary Music Research Center (KSYME) and the Center of Research and Documentation of the Athens Conservatoire in their educational and research activities. She is an Alexander S. Onassis Public Benefit Foundation scholar.

SUPPLEMENTARY CREDITS

SUPPLEMENTARY CREDITS

P 14 One of the original UPIC installations, undated © CIX Archives

P 52 Marion Kalter, Iannis Xenakis at his studio in Paris, undated © ZKM | Center for Art and Media Karlsruhe and Marion Kalter

P 54 UPIC workshop for children in Mexico City, Mexico, 1988 © Alain Després and CIX Archives

P 56 The UPIC installed in the KSYME studio, May 1986 © Dimitris Karageorgos

P 58 Portrait of Alain Després (left) and François Bernard Mâche (right), undated © CIX Archives

P 60 Iannis Xenakis on his last teaching day at the Sorbonne, Paris, France, 1986 © Henning Lohner

P 62 François-Bernard Mâche, *Hypérion*, page T1, 1981 © François-Bernard Mâche

P 64 Pierre Bernard, Peter Nelson and Alain Després performing *Un Alliage Ritue*l at the world première at the ICMC, Glasgow, UK, 1990 © Alain Després and CIX Archives

P 66 Alain Despres (left) and Iannis Xenakis (right) during a UPIC workshop, Centre Acanthes, Aix-en-Provence, France, 1985 © Henning Lohner

P 68 A group of children stand over the UPIC during a UPIC Atelier, Middelburg, Netherlands, 1982 © CIX Archives

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P 80 A workspace of the New Pulsar Generator with its various extensions (e.g., wavefold modulators of synthesis parameters via matrix, parameter linking, multiple tables for micro and meso scale trajectories, and preset system), 2019, screenshot © Marcin Pietruszewski

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