“Xenakis Alive!”
Explorations and extensions of Xenakis’ electroacoustic thought by selected artists

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This is a presentation of selected artists who extend Xenakis’ electroacoustic thinking. I concentrate on four aspects which I think are still radiating, or in some way only start to become virulent in our days: UPIC, GENDYN, Emergence, and Immersion. With this paper, I’d like to spread the virus a bit more.

“… In fact it is not a sound that is produced, but a whole music in macroscopic form. This form is the result of rhythmic transformations, giving a polyrhythm of events with variable timbre, changing pitches and intensities - in short, rhythmic strands of meeting and jostling sounds…”

(Xenakis 1985)

With my opening lecture to the session called “post-Xenakian applications”, I intended to give a very personal overview of some interesting results found by different artists over the last 20 years who became involved in some way or other into Xenakis’ electroacoustic thinking. These artists became “post-Xenakians” because they confronted themselves with his electroacoustic music, took up aspects of it but at the same time went beyond Xenakis. Certainly, this survey cannot be exhaustive. Many artists are not included because of lack of space, and many because of my ignorance. After my talk, Sharon Kanach pointed out that my selection was rather “euro-centric”. Yet I include 2 American, 1 Mexican, 3 Australians, 1 Turk (not yet in EU), and 1 Korean artist, so almost half of them are extra-European. In any case, I hope to present post-Xenakian applications which are new to the reader.

Certainly, I cannot do justice to any of my selected Xenakians, as I concentrate solely on the aspect of electroacoustics and even more so, on electroacoustic thought inspired by Xenakis. All these people do of course more in their lives than just being Xenakians. But their work teaches us that Xenakis’ electroacoustic thought is still topical and valid today. Certainly one life, namely that of Xenakis himself, was not enough not exhaust it.

Iannis Xenakis’ electroacoustic thought

First, I introduce five aspects of Xenakis’ electroacoustic thought which I think are essential: Graphic Sound, Stochastic Sound, Sonic Emergence, Sonic Immersion, and Sieved Sound.

Then, I’d like to show how some post-Xenakians built on and extended these aspects. One important aspect is missing here: that of Granular sound which Xenakis pioneered. But the application of Granular sound is such a vast field that I cannot cover it here, and what’s more, the granular post-Xenakians are so well known I would not convey anything new.
Graphic Sound

Xenakis was the first to design electroacoustic compositions by hand, like an architect, on a drawing board. The UPIC system was built from his ideas by the engineers of the CEMAMu, his research institute near Paris (1972-2001). Hundreds of composers have used UPIC, first in CEMAMu, then as visiting composers in Les Ateliers UPIC (from 1985), later (2000) rebaptized CCMIX, now (from 2010) CIX, but only a few like Wilfried Jentzsch (1995), Angelo Bello (1998) and Thierry Coduys (from 2004) have built upon the ideas of UPIC itself to extend it to alternate ways of composition. We will see examples for that.

Stochastic sound

Xenakis’ invention of Stochastic Sound, his GENDYN program and GENDY3 piece (1991) is unique. Unfortunately, he made only two pieces with it (the second being S709 from 1994). However, over the years, young composers have added more research and compositions to this idea of a true computer music, that is, a music which only a computer can make. Here, I refer to the work of Paul Doornbusch (1998), Jaeho Chang (1999), Alberto de Campo (2001), Andrew R. Brown (2005), Sergio Luque (2006), Luc Döbereiner (2008), Eric Bumstead (2009), and Nick Collins (2010).

Sonic emergence

The quote at the beginning of this article shows clearly that Xenakis had a conscious notion of emergence in his sonic design, namely that a music can be built from bottom up through the composition of its sound (micro-composition) instead of being built top-down through assembling sounds (macro-composition). Emergence is present in GENDYN, but one can do better and extend it to interactive performance (the aforementioned Angelo Bello and Andrew R. Brown) or even built systems of “pure” Emergence almost without human interaction like in the Audible Ecosystemics by Agostino DiScipio (from 2002).

Sonic immersion

Xenakis had a concept of a spatial setting of disparate sound sources in both his music for instruments and tape, from four up to several hundred sound sources, with a kind of mixing of these disparate sound sources in real time within each listener’s head, and thus drowning the listener into a bath of strong acoustic (as well as visual) stimuli. There are people who try to re-enact these immersive settings (like Daniel Teige, from 2004), and there are some who do it live on stage (like Reinhold Friedl, from 2007).

Sieved sound

There is one idea of Xenakis’ which he has left us without developing it further: the application of sieve theory to microsound. I had put this as a challenge to the audience at the end of my talk, and Nicolas Collins responded to it the next day by presenting me a couple of implementations in SuperCollider. Some weeks later, Nick wrote me an email stating that he had found an article by Christoph Ariza both of us hadn’t been aware of where Sieve Synthesis is covered in depth. We will see how both of them approached this new terrain.

But now let us study the different aspects of Xenakis’ electroacoustics in detail, and how they have been expanded by nowadays artists.
UPIC

UPIC is basically microcomposition and macrocomposition by graphical design. There is no emergence built into UPIC, at least not at first sight. This is particularly obvious in the tutorial example of UPIX, a software emulation of the last UPIC that CEMAMu had built. It is a chorale by J. S. Bach which shows very well how all these graphs within UPIC have to be combined in order to yield any music (even such a simple one as a chorale).

![Figure 1: The graphical user interface of the software version of UPIC 3 called upix, in a demo version as of 2001.](image)

UPIC means editing freehand graphs for frequency arcs, wavetables, amplitude envelopes, and frequency mappings. This can be done in real time. A user must assign to each frequency arc a combination of: wavetable, envelope, frequency mapping, amplitude mapping, and output channel. This configuration is then turned into sound by a bank of wavetable synthesis oscillators (hardware in UPIC, software in UPIX). Composing with UPIC is a very tedious work within a rigid user interface. On the one hand, with UPIC, one has 100% control over synthesis. On the other hand, complex sound is very difficult to obtain from UPIC because of the static wavetables.

UPIC has been conceived of by Xenakis as a means to abstract and generalize music to take shape within a continuum of frequency, time and timbre. We all know what Xenakis did with UPIC: Mycenae alpha, Taurhphanie, Voyage absolu, and maybe some also know UPIC works by composers visiting the Ateliers UPIC and CCMIX which are all such musical abstractions and generalizations. But what is less known is the work of the following people who generalized UPIC itself.
Algorithmic composition within UPIC: Angelo Bello

I met Angelo Bello (b. 1963) when he visited the summer course at Ateliers UPIC. While his composer colleagues would be producing pieces with the UPIC system right away, Angelo preferred to systematically research its capabilities especially in regard to frequency modulation. Every arc on a UPIC page can be modulated by any other arc, even in a recursive manner. So what Angelo did was excessively using this feature of the UPIC, and so he set up a complex feedback FM algorithm within the UPIC, sending UPIC hardware onto the road to chaotic oscillation. I was happy to assist a performance on the UPIC system in the studios of Ateliers UPIC in Nov. 1997 which was recorded under the title of Maya (13’50”). It sounded radically different from any other UPIC piece. The recording of Maya is taken directly out of the UPIC, without any post processing. Even the spatial effects are computer generated as an effect of the chaotic intermodulation of arcs (Bello 2000). UPIC’s playback cursor was in “freeze” position. As a consequence, in Maya there is no macrocomposition of pitch at all, all pitch movement comes about as a result of synthesis. This music is almost as immersive as La Légende d’Eer by Xenakis, but in contrast, is is not acousmatic but 100% algorithmically generated computer music. Angelo used the UPIC in a non-standard way, using the UPIC page as a FM patch cord panel, and bending the UPIC from its sequencer / synthesizer paradigm towards an Interactive Composition Instrument that can be performed in real time by altering e.g. frequency modulation gain settings. Maya is an example of interactively controlled automated composition of emergent microsound evolutions.

![UPIC score page of Maya](image)

Figure 2. The score page of Maya (1997) by Angelo Bello. Unlike a regular UPIC score, there is no movement of frequency, so the group of arcs look like empty note staffs. However, these arc groups are interconnected by frequency modulation in a way that feedback loops of modulation are established, changing the UPIC score page to a test bed for various FM algorithm setups. As a result, a whole music emerges with moving pitches, rhythmic pulses and a rich timbre content. Note that the UPIC playing curser (not represented here) is fixed in “freeze” position. Dragging it to different fixed positions on the page retriggers the FM modulations and changes the course of the sonic evolution, so this UPIC setup can be performed through live interaction. This picture is taken from Bello’s article (Bello 2000).

Maya is an example of an alternate use of the UPIC. Now let’s see how some people have altered the very idea of UPIC itself.
UPIC as a 2D-MIDI controller: Wilfried Jentzsch

Wilfried Jentzsch (b. 1941) belongs to the first composers who worked with the UPIC. He was visiting composer at CEMAMu from 1976-81 and later invented his own kind of UPIC system in order to turn graphics into sound: the GraphicComposer software developed at Hochschule für Musik, Dresden, in 1995 (Jentzsch 1995). The idea is to map the “pixels” of the graphics to MIDI values in order to command a bank of pre-processed sampled sounds, e.g. taken from sounding stone sculptures as in *Steinklänge* (stone music, 1995, 09'03”). Jentzsch’s graphics are partly induced by the wanted rhythmic and harmonic result he wanted to obtain, partly as surprising sonic realizations of shapes chosen for their associative character (as in *Kalligraphie*, where the graphics look like a mock Asian scripture roll).

In contrast to UPIC, the sonic control is discontinuous and limited by the MIDI protocol, but there are interesting sonic results like gamelan-like structures and fine-tuned microtonal scales which would have been very difficult if not impossible to obtain with the UPIC system. Some sonic effects recall Conlon Nancarrow’s Player Piano Pieces e.g. when a simultaneous cluster is acoustically rendered as a rapid arpeggio because the cluster notes have to be marshaled one after the other through the sequential MIDI interface.

![Figure 3](image)

**Figure 3.** The beginning of *Steinklänge* (1995) by Wilfried Jentzsch, composed by his alternate UPIC system called GraphicComposer. On can clearly recognize the superposed Gamelan-like rhythmic patterns. On the right end, there are scale patterns combined with cluster beats. These clusters do not sound synchronous but like rapid arpeggios, due to the MIDI protocol used. This picture is taken from a video recording of the piece played live from the GraphicComposer, kindly provided by the composer.

3D-UPIC: IanniX by Thierry Coduys

Thierry Coduys provides for a kind of higher-order UPIC in hyperspace: with as many cursors as one may wish, following curved spaces and controlling arbitrary synthesis engines and composition environments (Coduys 2004). IanniX could probably also be used to control a whole multimedia setup like e.g. a Xenakis Polytope. Xenakis would certainly have dreamt of controlling
his *Polytopes* with such an extended UPIC machine. I think that there is an interesting future of usage for IanniX, even if it departs a bit from the purity of a closed approach to graphical composition of microsound since IanniX “only” realizes a graphical control engine and no sound synthesis. On the other hand, the openness of IanniX is certainly a technical advantage over the monolithic design of the UPIC.

![Figure 4](image)

*Figure 4.* This picture is taken from the IanniX documentation, as downloaded in April 2011. One clearly sees the possibility of multiple cursor trajectories, both linear and circular, and in arbitrary directions.

This closes the first part of post-Xenakian applications, dedicated to UPIC. Let us now proceed to the second part: Stochastic Sound.

**GENDYN**

GENDYN is the acronym for “Génération Dynamique Stochastique” or in English “Dynamic Stochastic Synthesis”. It is really a “Music out of Nothing”, that is, it starts from complete silence by “blowing up” a waveform through probability fluctuations (like a sort of sonic Big Bang). The waveform is constantly changing and all initial shape is quickly lost. We learn from GENDYN that the shape of a waveform is less important than its change over time. This is also a lesson to be learned from UPIC, where the waveforms are repeated unchanged. In contrast to UPIC, Xenakis got with GENDYN all the interesting aspects of sound transients, modulation effects and so on built into sound synthesis, but at the same time he had to yield control of pitch, loudness and so on to the blind stochastic forces. So GENDYN is a struggle against the stochastic daemon. It is an experiment to wrest music from chaos.
Xenakis finished programming in 1991 (with a Quick Basic interpreter running for days on a PC 486DX-2 66 MHz), and created variants of his GENDYN program until 1994. He had no realtime sound control nor a graphic user interface. A GUI and realtime synthesis became available in 1996 through The New GENDYN Program (Hoffmann 2009), but unfortunately, Xenakis never used it (there are GENDYN sounds in EROD (1997), but this piece has been withdrawn by Xenakis). Real-time GENDYN can be a stochastic instrument which takes up much time to master because there is no deterministic relationship between parameter settings and acoustic result.

Figure 5. The 11 sequences (sections) of GENDY3 (1991) of Iannis Xenakis, along with a playing dialogue prompting for the real-time generation of the entire piece. This is a screen shot of the New GENDYN Program made by the author. The New GENDYN Program adds to Xenakis’ original algorithm of Dynamic Stochastic Synthesis a graphic user interface and real-time audio feedback.

New GENDYN’s beta-tester #1: Paul Doornbusch

Now I would like to give an overview of post-Xenakians who started developments in Stochastic Sound. The first was to compose a Stochastic piece after Xenakis at all since we know that Xenakis made only two of them: GENDY3 (1991) and S709 (1994), and I feel this is far from enough. Fortunately, after so many years, one starts to hear more stochastic sounds here and there, and Paul Doornbusch (b. 1959) is the one who is at the beginning of this. He simply did what Xenakis refused to do: he composed one more piece with the GENDYN program, not Xenakis’ original one but my New GENDYN Program (his piece G4 (11’35”), created in 1997). I am very happy about this because Paul verified for me that my design decisions for the New GENDYN Program, which I made having a usage by Xenakis in mind, were more or less correct and that it really worked for a composer. I for myself am not a composer, and so this verification was an important test to me.
Figure 6. A screen shot of the New GENDYN Program with Paul Doornbusch’s composition \emph{G4} (1997) loaded. In contrast to the 11 sequences of GENDY3, Paul’s piece consists of one sequence, so the duration structure of the entire piece can be seen in this window. The picture is taken from his PhD thesis (Doornbusch 2010).

What’s more and what made it even more precious for me is that Paul did not only compose with GENDYN but he also wrote how it feels to compose with GENDYN, that is, he provided a reflection which Xenakis never did, or at least Xenakis did not write about it. Paul shows in his PhD that my speculation of how it could have been for Xenakis to compose with GENDYN proved to be true at least in the case of Paul Doornbusch, and in his PhD he also adds more insights concerning the nature of the creative act when it comes to emergent, interactive, and algorithmic ways of composing, when “form emerges, or arises, secondarily from the rule-based generation of material or during the act of listening” (Doornbusch 2010).

I should add that Paul showed the same conceptual strength when he was undigging the World’s first computer generated sounds of Australia’s CSIRAC computer (1951): he researched the conditions and the results of this primeval stage of computer music (Doornbusch 2005) and thereby rewrote computer music history.

**GENDYN as a noise generator: Jaeho Chang**

Jaeho Chang (b. 1969), is a “Sonologist” like Paul Doornbush. I don’t think they have ever met there because they belong to different generations, but we see that Sonology somehow seems to lead its disciples towards non-standard microsound, and some of them end up as Xenakians. This is interesting because I do not know if Xenakis and Koenig ever met and both composers would probably never have acknowledged it, but they really share some same electroacoustic aesthetics. Jaeho Chang discovered Xenakis at Sonology (Chang 1999) and developed several algorithms which are inspired by Xenakis’ stochastic synthesis.
Figure 7. A chart of Jaeho Chang’s algorithm Random Sine Wave Shaping (RaiSin) which he developed as part of a series of noise generating algorithms, originally inspired by Xenakis’ Dynamic Stochastic Synthesis. This chart is taken from his studio report “Composing Noise” (Chang 1999).

He is one of the first to have re-implemented GENDYN (he called his implementation XENAK). Then, he went on to create his own stochastic synthesis algorithms once he had studied GENDYN. One new algorithm of his is Dynamic Random Waveshaping. One flavour of it is Random Sine wave shaping, or Raisin for short, and he has developed other ingenious sound synthesis methods since (for example by having a particle perform random walks in the complex plane).

The SuperCollider pioneer: Alberto de Campo

Figure 8. Beginning of the video *Octal Hatch* (2003) by Brian O’Reilly, where he successfully combines advanced abstract visual art with computer generated sound from UPIC and de Campo’s miniGENDY program (DeCampo 2000). The video can be watched at the author’s page http://squadral.com.au/ (last access June 2011).

Alberto De Campo (b. 1964) once gave me a CD-Rom with one of the first implementations of GENDYN after Xenakis (“miniGENDY”, DeCampo 2000). He did it in Super Collider which was at that times still a fairly new programming environment for composers. Unfortunately, these early SuperCollider versions only ran on Macintoshes and since I do not own a Macintosh, I was not able to try it out. But some others did, and I found a wonderful example on the Web by Australian multimedia artist Brian O’Reilly who once studied at Ateliers UPIC and therefore also includes UPIC sounds in his video *Octal_Hatch* (2003) which is conceived by him as “an abstract portrait” of Iannis Xenakis. (So actually Brian O’Reilly fits into my collection of post-Xenakians, too).
Interactive performance GENDYN: A.R. Brown

Andrew Brown is a very industrious man. He has the longest publication list of all people presented here. But he does not only write, his fun is to constantly develop interactive tools that support creativity. He even founded an institute for this (explodingart.com). When he took up the idea of Stochastic Synthesis from Xenakis, he immediately saw its potential for real time interaction and improvisation.

Therefore, he added to the pure GENDYN algorithm various extensions in order to turn GENDYN into a musical instrument called Interactive Dynamic Stochastic Synthesizer (Brown 2005), with all the typical features of a synthesizer: attack / sustain / release control allowing for percussive onsets and multisegment breakpoint envelopes, alternate breakpoint interpolations and customisable quantization, exponential scaling of parameter ranges and slider automation, interface to MIDI controllers and scripting of performances by recording control signals. One the Web, he published a recording of a session made with a colleague on two IDSS’s (check at www.explodingart.com, accessed in June 2011).

![Figure 9. Part of the control panel of Andrew R. Brown’s IDSS synthesizer workstation (2005). This picture is taken from his article (Brown 2005).](image)

Now we come to a somewhat younger generation born in the seventies, and we will see how they brought new ideas to the synthesis and application of Stochastic Sound.

Synthesis of synthesis (1): Sergio Luque

Sergio Luque (b.1976) has been researching GENDYN and its derivatives over the last 7 years and still finds many more things to explore. He implemented GENDYN in an early SuperCollider version and had later to redo it in C++ in order to plug it into current SuperCollider environments.
He is an intimate connoisseur of all the odds and edges of Stochastic Synthesis. He extended Stochastic Synthesis by techniques from the Sonology school (Luque 2009) and has more interesting plans to extend it even further in the near future. One very interesting such extension is to include the aspect of spatialization into synthesis, that is, the spatial effect of the stochastic sounds will also be a composed one – in a stochastic manner. Sergio has so far released 6 pieces with Stochastic Sounds: *to and fro* (adult male courtship song) (2003); *Y fue que le pareció convenible y necesario* (2005); *Happy Birthday* (2006); *Sex, Drugs and Rock ‘n’ Roll was never meant to be like this* (2007); *Brazil* (2009); *Daisy* (2011).

In my view, Sergio is doing a kind of “Synthesis of Synthesis”, because from his Sonology training, he takes a step back and brings together ideas from more than just one composer, e.g. by combining principles of Xenakis’ DSS and Koenig’s SSP. But Sergio is not the only one.

**Synthesis of synthesis (2): Luc Döbereiner**

Luc Döbereiner (b. 1984) is a young Sonologist who goes even a step further than Sergio in integrating synthesis methods of his forefathers. He does not only combine Xenakis’ DSS with Koenig’s SSP like Sergio does but he also puts in Herbert Brün’s SAWDUST. That means he creates a higher-order synthesis of three notorious non-standard synthesis methods.

So again we see that through the intermediation of a younger generation, composers like Xenakis, Koenig and Brün who hardly spoke to one another, can now be understood as having strived for a common, conceptual artistic goal which is the struggle against the ear’s cultural conditioning to known sounds and the opening up to new ways of perceiving, new ways of thinking, new ways of interacting in the society.
Figure 11. A graphic depicting the stochastic deformation of a waveform over time. This picture is taken from the article (Döbereiner 2009a).

Luc has composed several pieces with stochastic sound, e.g. *Piz Argient* (11’07’’). He has implemented DSS in a general synthesis language (Döbereiner 2008) and he even did DSS in the spectral domain (Döbereiner 2009a). He formulated his artistic credo in the article “Compositionally Motivated Sound Synthesis” (Döbereiner 2009b).

**Xenakis’ dream: Nick Collins’ iGENDYN**

![iGendyn](image)

Figure 12. A picture from Nick Collins’ web page featuring his iGendyn app for the iPhone (Collins 2011a). He exploits the various sensors of the iPhone for his real time multiparametric interaction with Dynamic Stochastic Synthesis.

Xenakis would have dreamt of this. A serious compositional tool, brought to the fingertips of the masses. His UPIC invention was a trial at making electroacoustic composition accessible to the people, even school children, and a lot of UPIC classes have been organised over the years. However, the spread of UPIC was limited, due to its size and its unintuitive interface. These times are over with the advent of Nicolas Collins (b. 1975) who by the way has not only put GENDYN into the app store (Collins 2011a) but has many more serious gadgets for the mobile electroacoustic composer.

He also explores tools for linking composing communities and many more inventive, non-standard software realizations. His implementation of GENDYN on the iPhone supports up to 5 stochastic oscillators with multiparametric control (5-finger touch and 4-fold tilting), something no GENDYN implementation has provided so far.
The one-man CEMAMu: Sinan Bökesoy

I met Sinan Bökesoy (b. 1971) in Athens on the 2nd International Xenakis conference in 2005. He held a workshop there on one of his composition programs, and I held a workshop on GENDYN. Sinan realized and extended various ideas of Xenakis’ when he was at residency at Ateliers UPIC.

![Figure 13. The GUI of Stochos, as described in (Bökesoy 2005). This picture is taken from the article, as downloaded from Sinan’s web page.](image)

If Xenakis had had such a prolific man to try out the many ideas of his, he would probably have created more electroacoustic and computer works. Sinan is, like Nick Collins and the others, a composer of a generation who are just fluent with modern programming languages and music programming environments. They try out in a few week’s time things that CEMAMu was not able to realize in years.

What I also very much like with Sinan Bökesoy is that he developed working models of Xenakis’ composition principles (Markovian Stochastic Music, Free Stochastic Music, Dynamic Stochastic Synthesis and Granulation Synthesis) and thereby did a kind of practical musicology. I have a friend who is a musicologist and who uses to say that musicologists are like vultures who live on dead works of art. Yet over the last few decades, there is a new kind of musicology emerging which brings artworks back to life through the principles they have found in them through analysis. For me this is very similar to the scientific practise of simulating physical systems or processes. If the simulation is right, the resulting artifact is something the composer could have created just as well. By comparing the composer’s artifact and the own result one can find out the specific way the composer has worked with his or her principles. In his way one enters the cosmos of possibilities within the framework of a composition. It is like looking into the composer’s workshop. So I hope that there will be more of the type of Sinan Bökesoy in the future.

Massive stochastic synthesis: Angelo Bello

And here he comes again, Angelo Bello. I already presented how he cracked the UPIC, now I present how he cracked the GENDYN. He is a true Xenakian: he uses non-standard tools in a non-
standard way, so he is a sort of higher-order non-standardist. Much in the same way as he programmed the UPIC for massive feedback Frequency Modulation, he is now programming my New GENDYN Program for massive parallel synthesis (up to 50 tracks in parallel, instead of 16 tracks as in the case of Xenakis). Since he had problems doing that from within the program, he generated GENDYN data files using a selfmade user interface, called “GenLab” (Bello 2011).

Figure 14. A picture of a GENDYN sequence with 50 tracks loaded. With this kind of massive parallel Stochastic Synthesis, Angelo creates sound textures which are at a time delicate and dense. I made this picture by loading a parameter file into the New GENDYN Program which Angelo had created using his GenLab user interface (Bello 2011).

**Stochastic strikes: Eric Bumstead**

I heard a piece with stochastic sounds called BlckWnd (2009, 9’53”) by Eric Bumstead (Bumstead 2009) in Berlin when the BEAST acousmonium (the loudspeaker orchestra of the Birmingham Electro-Acoustic Theatre) was setup there in a church. The church had been bombed to empty walls in World War II. So this church was reduced to a big empty space only filled with the sound of the loudspeakers.

Figure 15. The location of the Berlin premiere of *BlckWnd* by Eric Bumstead. One clearly sees that the public is seated within a cage of sound sources mounted all around and on top of them. In addition, a huge reverberation body being formed by the naked walls enforced the effects of the “Stochastic Strikes” in that piece.
Eric’s piece worked wonderfully well in that space. The noisy strikes came from the front and the rear and we were immersed into the stochastic roaring and sizzling textures all around us. To me it was a sign that stochastic sound has now been accepted by composers as a valid building material for their music, without all the conceptual stuff behind it. Stochastic sound has left the laboratory of the researchers and now starts to have its own life, just like frequency modulation in its time. So there is hope to hear more stochastic sound in the future.

**Emergence**

If we compare the two aspects of Xenakis’ electroacoustic thought discussed so far, UPIC and GENDYN, we see that they are in a way complementary. So one idea would be to combine the two. In fact, at times, CEMAMu thought about it but did not realize it (personal communication by Jean-Michel Razcinsky, hardware engineer at CEMAMu, in 1996). Nowadays, everybody could do that without CEMAMu, just by using IanniX for the graphics and, say, Sergio Luque’s stochastic oscillators for synthesis. So this is one picture of the story.

But now think about the example of *Maya* by Angelo Bello. For this piece the characterization of UPIC given here is no longer valid. When listening to *Maya*, we cannot really tell if these sounds are UPIC sounds or GENDYN sounds. So it seems to me that when it comes to a non-standard use of Xenakis’ tools, to sonic emergence and interactive composition, both paradigmata, Graphic Synthesis on the one hand and Stochastic Synthesis on the other, converge. There is no GENDYN vs. UPIC anymore, just Emergence and Interaction, and that is what leads us beyond Xenakis.

**The philosopher of EA music: Agostino Di Scipio**

Just before coming to the London conference, I had the chance of assisting a live performance of a sound installation *Condotte Pubbliche* (Public Conducts) by Agostino Di Scipio (b. 1962) in the Berlin gallery Mario Mazzoli (DiScipio 2011). In his setups of Audible Ecosystemics (environmental interactive installations), instead of composing sound, Di Scipio prefers composing conditions for the coming-into-existence of sound. *Condotte Pubbliche* consists of two long metal tubes side by side. On one end of each is a low-fi ear plug and on the other side a low-fi microphone. These are coupled by an amplifier, so as to create an acoustic feedback loop. In the installation setup there are more feedback loops, acoustic and electroacoustic ones, controlled by a sophisticated DSP setup, so that the system starts to resonate by itself, just by being fed with environmental noise. It is, like GENDYN, a music out of nothing. I find Di Scipio’s feedback setups reminiscent of Angelo Bello’s modulation system within UPIC, except that Agostino does it in physical space instead of inside a computer system. All these systems, GENDYN, Bello’s UPIC feedback system, and Di Scipio’s Ecosystemics, can be “played” through human interaction and thus gain a performance aspect which was more or less absent in Xenakis’ practise (except maybe the staging of *Taurhiphanie* in the arena of Arles back in 1988).

Agostino Di Scipio once coined the notion of *Sonological Emergence* (DiScipio 1994) which describes well the phenomenon of GENDYN’s sonic dynamics and its auto-organisation into e.g. non tempered scale patterns (Hoffmann 2009). However, Di Scipio developed the notion of musical emergence further. While Xenakis used a deterministic algorithm to create a work of art out of random numbers, Di Scipio transforms environmental randomness into a self-organizing sound world (DiScipio 2003). For me, just as important as Di Scipio’s sonic research is his strong philosophical attitude to be found in his numerous writings which distinguish him as one of the most brilliant thinkers of artistic creation today.
Figure 16. A picture of the ecosystemic installation *Condotte Pubbliche* (2011) by Agostino DiScipio. In addition to the visible wiring of microphones and earplugs with a DSP system under the black veil, there are more microphones and acoustic feedback loops within the room (floor and ceiling). This picture is taken from the web page of the gallery (DiScipio 2011).

**Immersion**

The aspect of immersion is present in all electroacoustic realizations that make use of spatialization, and couples well with complex emergent sound (think of the emergent effects of spatialization in e.g. Maya or Sergio Luque’s stochastic spatializations). In DiScipio’s Ecosystemics, immersion is even stronger since every listener is by definition part of the sonic ecosystem itself. In contrast to this more implicit kind of immersiveness, Xenakis’ *Polytopes* put immersion on stage, by performing larger architectural or natural sites through visual and acoustical enaction. This has been completed in more recent times by video art, which was absent in Xenakis’ times, and by technical means of control and synchronization that were unavailable for Xenakis.

**The Polytope man: Daniel Teige**

I met Daniel Teige (b. 1977) in Berlin when he directed a special kind of polytope, a sound and video installation of Kraanerg at the Kunstwerke gallery there. Daniel had cooperated with Daniel Kötter, a video artist, Heike Schuppeleis, an interior architect, Sasha Waltz, the then-choreographer of the Schaubühne ballet ensemble, Martin Rumori as an audio programmer, and Roland Kluttig conducting the Kammerensemble Neue Musik Berlin. It was a very impressive rendering of this piece of Xenakis, and as I learnt from the artists, a huge struggle against all odds. The struggle was won by joint effort of all the artists and cutting-edge technology.

Many projects later, Daniel joined the Center Iannis Xenakis (CIX) as a founding member and is currently researching the Xenakis archives to reconstruct optimal performance conditions for Xenakis’ *Polytopes*. He is currently doing a documentation of the *Polytope* material found in the Xenakis archives which helps him preparing new stage material that was used for staging *Persépolis L.A.* (2010) and will be used for hopefully many more *Polytope* stagings in the future (Teige forthcoming).
Figure 17. A performance score for *Persepolis* by Iannis Xenakis, created from a close study of Xenakis’ own sketches and tape material from the Xenakis archives (Teige forthcoming). This picture has been kindly provided by the author.

The music dissident: Reinhold Friedl

I met Reinhold Friedl (b. 1964) many years ago in the seminar “Music and Mathematics” at Freie Universität Berlin. This seminar served as a preparation to the cultural program of the World Congress of Mathematics 1998 in Berlin. What I did not know at that time is that Reinhold was not only a scholar but also an active musician and composer, doing avant-garde experimental music projects. One of these projects is re-enacting Xenakis’ acousmatic works live. From this project (and with his consent) I borrowed the title of my article.

Figure 18. Cover of Reinhold Friedl’s CD/DVD *Xenakis (A)Live*! with his ensemble Zeitkratzer. (DVD with video added by Lillevan, Asphodel Records).

For me, Reinhold’s project *Xenakis (A)Live*! with his ensemble *Zeitkratzer* is comparable to the project of Ensemble Modern live-performing Nancarrows Player Piano pieces. It is this sort of impossible projects which work out so well once they are attacked by people who are really decided in what they are doing. In both cases, mechanically fabricated music is brought back to the direct, spontaneous seizure of performing musicians (Friedl 2009). *Zeitkratzer* are performing a composition score in the spirit of Xenakis’ *Polytope* compositions as absolute music. They bring acousmatic sounds back to a real time, unacousmatic situation, by harnessing human randomness as a stochastic texture generator and by using special live electronic techniques.
Sieve synthesis

In my London talk, I had put the challenge of implementing Xenakis’ idea of sound synthesis using sieves as follows:

- Use Xenakis’ C-program (from Formalized Music) to generate a sieved number sequence
- Use these numbers to denote the time points (sample indexes) of a breakpoint waveform
- Use another sieved number sequence for the amplitude values of these samples (but HOW? Maybe with the help of a Cellular Automaton? How is the mapping?)
- Interpolate samples in between
- Send sample stream to DAC
- Listen to the resulting “Sounding Fractals” (I.X.)

That means, I had prompted for sieved waveform segment synthesis.

Sieve pioneers: Christoph Ariza and Nick Collins

2 years before my talk, and unbeknownst to me, Christoph Ariza had already published about his application of sieves to a variety of sound synthesis methods: not only waveform segment synthesis but also to additive, subtractive, frequency and amplitude modulation synthesis. In order to do so, he used C-Sound instruments controlled by Python objects. Here I shall only comment on his solution of the problem described above, namely that of the mapping of sieve values to breakpoint amplitudes.

![Diagram](image)

**Figure 19.** Chart taken from Christopher Ariza's paper (Ariza 2009) showing the algorithmic structure of his application of sieves to waveform segment synthesis. Thanks go to Nick Collins who made me aware of this paper.

If I understand right from his paper, in his documented example he linearly interpolates between 4 waveforms. These waveforms are contructed by half-cosine interpolation between breakpoints whose spacings and amplitudes are defined by finite segments of different sieves: one sieve segment for the time values (breakpoint spacings) and one sieve segment for the amplitude values. If I understand it right, he does not take the sieve values in ascending order but mixes...
them randomly, and then he rescales the amplitude values to fill the entire amplitude space from minus 16 to plus 16 bit, so he gets jagged waveforms instead of just ascending slopes.

Nick Collins, answering the challenge of my conference talk, started developing his own implementations of sieve synthesis in SuperCollider. His first solutions to my mapping problem were a) not to use sieve values for amplitudes at all but just generate unit pulses sieved in time; b) use sieve segments as bit vectors each representing the binary code of an amplitude value and round-shift the bits to get successive amplitude values and c) “fuzzy sieves”: to give each sieve number a probability value and/or to combine sieves by probabilistic operators. Nick has many more ideas that he will elaborate upon in a forthcoming paper of his (Collins 2011b).

What astonishes me with both Christopher’s and Nick’s implementations is that they only use very limited segments of sieves. My idea would have been to let the sieves go from 0 to “infinity” for the time values and from minus MAXINT to plus MAXINT for the amplitude values and then play on the periodicity and aperiodicity of the sieves and see how this translates to the resulting spectra. But this approach of mine is probably too naive, as there might be so many sieve values consumed up by the sampling rate that my sieves could not be aperiodic enough to get interesting sonic results. So we see here that a good mapping makes up really at least half of the composition.

**Conclusion**

I hope it has become clear that the ideas Xenakis has left us are still valid today. Even more so, they only seem to really unfold their full potential in our time, 10 years after Xenakis’ death. Xenakis lived too early to experience the full impact of his artistic thought onto art. Graphic control of sound is still researched and developed. Stochastic Synthesis has just begun its career in music production. Emergent Composition has a Golden Future. Immersive multimedia events are en vogue. Sieve Synthesis has just started. And there are more aspects to Xenakis’ artistic legacy which radiate into the present and future. I would even say that Xenakis’ ideas are virulent, Xenakis’ thought is contagious and prone to ever-spreading epidemics. It has already transgressed the genres and crossed over to the underground, industrial and noise scene, and is now part of the remix and clubbing culture. This propagation is unparalleled by any other avant-garde composer I know of.

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