

Space as an Evolution Strategy.

Sketch of a Generative Ecosystemic Structure of Sound

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Abstract — This paper discusses a generative, systemic approach on sound processing, touching topics like genetics, evolutionary programming, eco-systemic interaction of sound in space, and feedback, putting them in the context of the author's *Syntáxis(Acoustic Generative Sound Processing System, part 1)*: a sound installation for stereophonic speaker system and microphone. The main implications of the overall structure of the installation are analysed, focusing on the dynamics of it and its relationships with space. The paper also illustrates the main structure of the algorithm regulating the installation behavior, along with brief references to the software platform used to develop it (Max MSP 5).

I. INTRODUCTION

The concept of space has played a crucial role in the development of art during its history. Implications have been numerous, and while they fall mainly – and understandably – in the realm of visual arts, the full spectrum of their aesthetical, technical, conceptual and creative elements can be found in the framework of music as well. In this sense, the attitudes of visual art and music, regarding space, can be seen as similar in scope: with the dawn of the twentieth century's european avantgarde movements, both aimed at a progressive delinearization of the previous, standardized structures. Breaking down those elements, in music, which were considered obsolete meant, also, reconsidering the space of music itself – which had been up to then historically encased in a left-to-right linearity. The possibilities given by the electro-acoustic research, concrete and synthetic alike, permitted the investigation of space as a compositional element, offering peculiarities and potential to be experimented with, along with those offered by pitch and timbre. The relative implications became too numerous to list here, but they swiftly encompassed a wide range of different forms of electro-acoustic experimentation and research: one of them, the famous Soundscape scene, pioneered by canadian composers R. Murray Schafer and Barry Truax, insisted on a perspective on sound which is coherent with the environment in which is produced. A view which is ecologic in nature, where environment/space is treated as an eco-systemic source of sound, linked with the elements

which form and give influence to the system itself, regulating its dynamics. Elements which are the basis of the author's *Syntáxis(Acoustic Generative Sound Processing System, part 1)*, which will be illustrated here along with its design philosophy.

II. SPACE, ENVIRONMENT, ECOSYSTEM, AND THEIR POTENTIALS

Any environment in which sound occurs spins a complex web of relationships that are systemic in nature. A sound produced in a determinate environment is inevitably bound to interact with the system and the agents that generated it, carrying along informations about the space in which it occurs: an *acoustic* space, with precise physical characteristics (i.e. specific resonances, attenuations, size, reverberation and so on) which define the sound that propagates, evolving, through it[I]. The relationships between sound in space and the agents which produced it is, therefore, mutual and reciprocal, forming an ecosystemic structure of continuous energy movement, release, exchange, reception and self regulation – a feedback system of crucial importance and great complexity. As said, in the days before the contemporary era these dynamics were largely unknown: space had a role which was very much formal and symbolic in nature, ignoring the compositional and conceptual possibilities, almost excluding them from the creative process. Many subsequent avantgarde and experimental art movements, inspired by the investigations of the new science of sound, tried to use its potentials in an active – more than passive - way: one of these movements, installation art, came to prominence with the aim of integrating the space in which the work resides as a part of the work itself. Modification of the way with which space is experienced, along with possible interaction with the fruitors, can then occur. Sound art is a consequential expansion of it: sound happens into space and therefore is used as an active part of the installation, dialoguing with it. Crucial, in this sense, is the addition – when compared to visual-only installation art – of the time element: sound evolves in time, and its evolution represents history and behaviour of the installation itself. In accord with these elements, it can

be possible to trace and highlight the components and history of sound in space, through a systemic processing of its characteristics.

III.A SYSTEMIC PROCESSING OF SPACE: SYNTÁXIS

As said, space seen in the context of sound propagation – and under an ecological perspective - is a system of complex dynamics and relationships, where acoustic energy is produced, amplified or attenuated in its spectral characteristics, exchanged with the surrounding environment and received by the agents in it. Reaction can then occur, where the agents (e.g. living beings) produce sound in return and so on, in a feedback loop which is typical ecosystemic behaviour. An example worth of note is when exchange of spoken language happens: semantics aside, sound produced by a source propagates, is received and can provoke reaction with more production. The process of propagation, the second stage in this small but significant chain of events, carries with it a great amount of information: the energy moving through space is shaped and modelled by the particular physical characteristics of the environment – natural resonances, properties of absorption and reflection of the materials present in the environment, diffraction, and others - which constitute then a significant part of what is, in the end, perceived as sound. Consequently, it could be said that the whole moment of propagation, and the data contained thereof, represents the identity of the particular space in which sound occurs. An identity which the author's installation, *Syntáxis (Acoustic Generative Sound Processing System, part I)* investigates in a number of different ways. Sound as element of space was already used as the main aim of the author's previous work of installation art, *5x4: a Neapolitan Soundscape*: in it, sound was extracted from his natural urban environment and presented for listening to several different people, thus exploring the different meanings of it when separated from context. Here, sound continues to be a material, but also comes into being as a way to structure an evolutionary discourse on itself, and on the history and peculiarities of the space where it propagates as well.

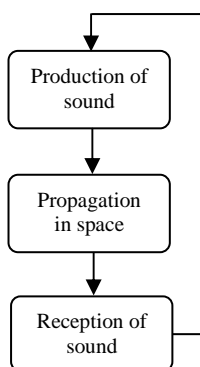


Fig. 1. Feedback loop of production – propagation – reception in an acoustic space.

The main backbone of *Syntáxis* is a systemic structure of sound reception, processing and reproduction, a chain composed of three elements.

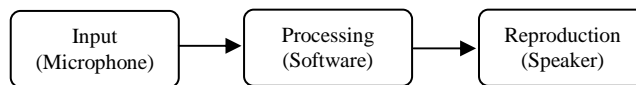


Fig. 2. Main structural design of *Syntáxis*.

Being an installation, *Syntáxis* occupies permanent space, working continuously in its process. Sound happening in its surroundings is feeded in the system by means of a microphone, and processed by a software algorithm, developed on the Max/MSP 5 platform. The result then returns back into the installation's space, by means of a speaker (or more than one). An element of great importance here is that the installation has a cycle of processing which is carefully structured, and which aims at a progressive highlight of that number of informations which the sound material happening in the installation's space contains, and which are linked to it. The time element thus plays a role of great importance, also taking into account history of sound and therefore, by the installation's point of view, history of the space thereof.

IV. SYNTÁXIS' CYCLE: AN EVOLUTIONARY DISCOURSE

At the start of the installation's cycle, sound received by the microphone is first analysed by means of a Fast Fourier Transform on the signal received, and the two strongest peaks in the frequency spectrum are recorded. These peaks represent the peculiarities of the sound material, modelled by the natural characteristics of space in which it propagates, at the moment of the cycle's first stage. After a twenty seconds delay, *Syntáxis* starts an history: sound is processed by means of a bank of resonant bandpass filters, in couples, which represent a population. Twenty couples of filters, twenty fourth order bandpass filters that is, with their center frequencies equally positioned in the frequency spectrum, bandwidths large enough to permit a sufficient recognition of the sound processed. This array of individuals constitutes two "populations" of sound, each composed of ten individuals, and contains the potential that will be optimized by a genetic algorithm, a *search space* [II] aimed at its main objectives: the identification of the resonant peaks contained in the sound at the beginning of its history, the identity of space in a particular moment in time. It's a formalisation which takes in account, for its evolution, the characteristics of sound and acoustic space: the whole collective of sound data regarding the space where it is evolving. The key element here is fitness, the propensity for each individual – and thus the filter's center frequencies – of achieving their objectives.

Genetic algorithms generally emphasize – for their structural processing – the presence of a genotype, the representation of a single individual's genetic code, to be evaluated. This genotype is typically represented by a simple data structure, in most cases – as in *Syntáxis* – by a string of bits. The algorithm develops its optimization in a series of stages formally known as generations: in each generation, the population's genetic codes are reviewed

and classified in a gerarchy based on fitness – typically an index ranging from 0 to 1 - towards a specific objective.

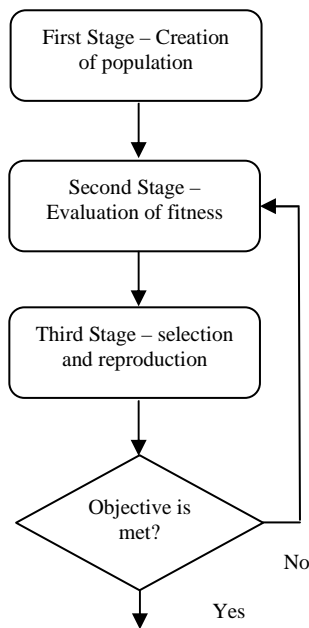


Fig. 3. Layout of a basic genetic algorithm.

As in the Darwinian model, survival of the fittest occurs, and individuals with greater fitness are selected for breeding and thus recombination of their genetic code: others with low fitness have greater chance of dying without reproduction. Offsprings are then inserted in the population, and the process starts again with another generation. History comes to an end when the objective is met. In *Syntaxis*, individuals – as said – are bandpass filter units, which act as instruments of investigation of sound, and genetic codes are represented by 32 bit strings equivalents of their center frequencies. At every generation, the individuals’ genetic codes are compared with the resonant peaks analysed at the first stage of the installation cycle, which represent the objectives. Individuals with center frequencies which are closer to the objectives have an higher chance of recombining themselves, by mixing their genetic code together, into new individuals with better center frequencies. The more the filters go towards their objectives, the more the bandwidths get narrow, until – when objectives are met and the resonant peaks are all centered – they center their bandwidth on a single frequency, thus highlighting the peaks in their single uniqueness. When the average fitness of all the individuals of the population is high enough so that the filters center on the peaks-objectives, the process completes and restarts from the beginning, with another analysis. With this series of generations, the system recombines itself in time, as said. It thus traces its history, the history of sound in its space, using the time element as a background for its evolution, and investigates the properties that shaped the sound detected and analysed at the beginning of the installation cycle.

The sound material which *Syntaxis* processes is not fixed, though. Space is an entity with dynamics which are complex and variable: energy is produced, transferred into space, repected and so on, as said. The installation applies its ongoing formalisation on an entity which is therefore dynamic, which changes, which is time-variant. An

investigation of the product of space and its history in its ongoing, direct manifestations.

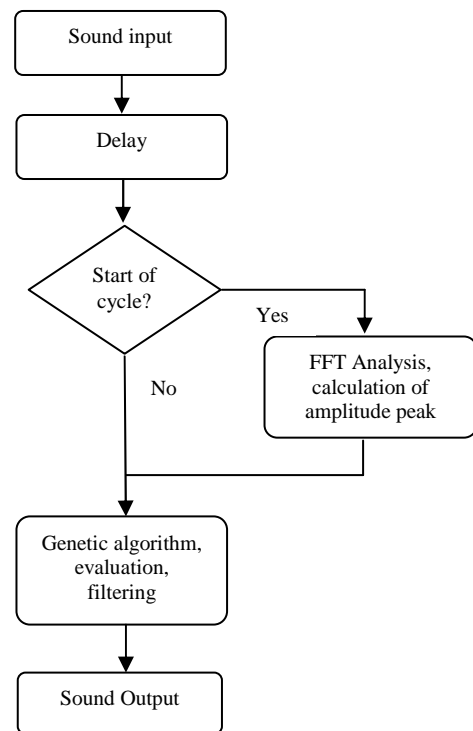


Fig. 4. Scheme of a single *Syntaxis* cycle.

It is worth noting that the *Syntaxis* chain implies a feedback loop. Sound is repected from the installation’s space, processed, diffused by speakers, and goes back into space, where it will eventually be repected again along with new acoustic energy present in the environment. The presence of a twenty seconds delay line is justified by the obvious need to delay accumulation, thus setting up a self-gating system which will be briefly discussed – in the overall context of the Max/MSP 5 patch - in the next section.

V.A BRIEF LOOK AT SYNTAXIS’ MAIN SOFTWARE STRUCTURE

The core of *Syntaxis*’ processing block consists of a Max/MSP 5.02 patch. It’s worth noting that - since the genetic algorithm and the FFT analysis and peak calculations are based on a great number of iterations processes – for simplicity’s sake the author has integrated the graphical object structure of Max/MSP with its javascript support. Thus, the whole DSP part is Max/MSP based, while the genetic algorithm and other elements are programmed in javascript and integrated in the patch. A thorough analysis of the software, in terms of specific references to code and the like, is way beyond the scope of this paper. But a couple of characteristics, vital to the overall design of *Syntaxis*, will be discussed.

It is of importance to note that *Syntaxis* comes in elements that could be called blocks. The chain of the installation has already been examined in this paper before: it consists

of a line made by a microphone, a processing unit (i.e. DSP algorithm, discussed earlier) and a speaker.

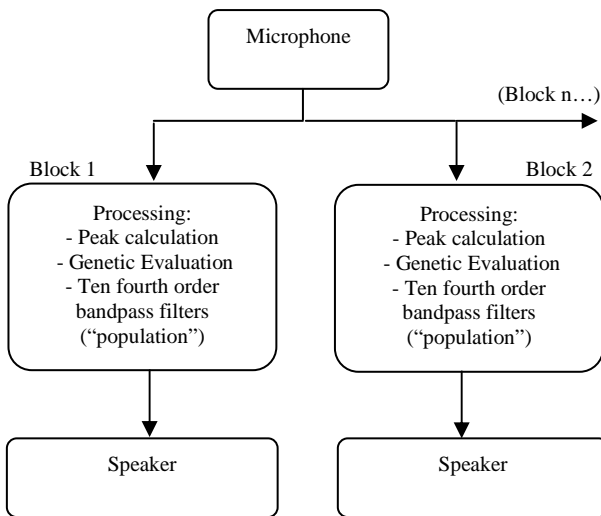


Fig. 5. *Syntaxis*' chain of processing blocks.

The processing and speaker elements constitute a single *Syntaxis* block. A single block has a population, array of fourth order resonant bandpass filters, of ten individuals: the whole process calculates a single peak-objective for its block, and genetic evaluation ensues. As of now, *Syntaxis* uses two speakers to reproduce back in its space its sound material, and therefore it means that it works on two blocks. That is, two populations, a total of twenty individuals (ten per population), a process of investigation of sound in space which will in time highlight the two strongest peaks in the spectrum analysed at the start of the cycle. This means that, in this way, we have two processes running at once, moving simultaneously towards two different aspects of the same sound: two independently processed but correlated sound sources. Multiple blocks and thus multiple peaks can be processed at the same time, e.g. setting up a quadrasonic or octophonic configuration, therefore working on more peaks of the received/analysed sound.

A second element of note is feedback, which is consistent with the whole behaviour of *Syntaxis*, and on different levels, as said: symbolic, systemic, ecological, acoustic and, strictly speaking, audio. The microphone – speaker chain, coupled with the time element and the continuous energy exchange, which is a central aspect of the installation, makes accumulation a possible and likely event, especially in case of slow evolution of a population. The dynamics of the installation space are also important: a great number of agents producing sound could minimize energy optimization in the environment, and thus negate feedback, while particular physical characteristics of the environmental space could instead strengthen certain frequencies more than others. A self – gating system, with the already mentioned delay unit, was created in the patch as a system of self regulation and response against saturation. The microphone input is multiplied by a gain factor, then goes through a twenty seconds delay line. Signal going out of the delay line is then both directed to the rest of the processing system and envelope followed. The resulting amplitude tracking, in inverse relation and as control signal, is low pass filtered with cutoff frequencies around 1 Hz (to smooth out ripples and low amp fluctuations) and sent back before the delay line, as

factor of control/attenuation. The whole process carries with it the element of homeostasis, where the system regulates itself in order to maintain a stable condition[III]. – in this case, as said, to avoid saturation and consequently distortion[IV].

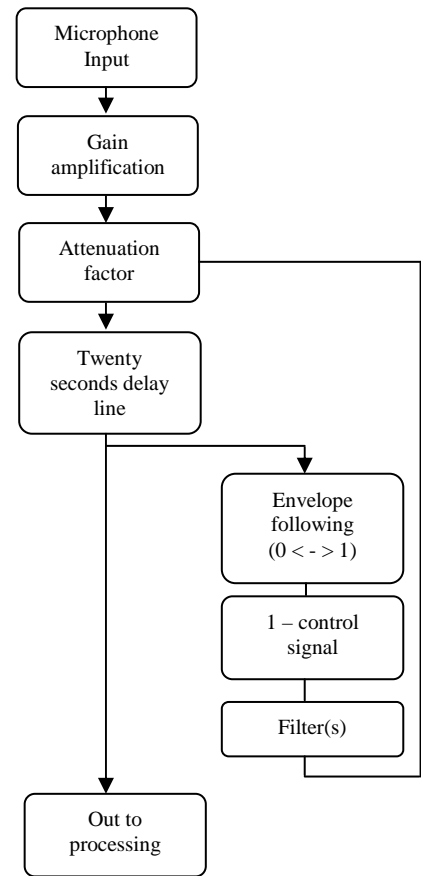


Fig. 6. *Syntaxis*' self-gating system.

VI. CONCLUSIONS, POSSIBLE OUTCOMES

Syntaxis is a work in progress. Its first incarnation, namely entitled *Part I*, explores only a small number of the whole possibilities of sound in its characteristics and relationships with acoustic space, although on a number of different levels. One of the main aspects of it is certainly investigation of space as a physical model of generating and shaping acoustic energy. Different, physical spaces can give very different results, not only through their dynamics of frequency amplification and attenuation but also through reflection, absorption and thus reverberation, and so on. More speakers could be used, thus having more peaks to be analysed and highlighted. Their placement in space could be adjusted in accord with specific characteristics of the environment where the installation takes place. The process could be reversed, aiming at investigating frequency regions which are attenuated instead. Implications are numerous, and represent inspiration for future research and experimentation. Another aspect of *Syntaxis* which has been stressed a number of times in this paper is its

recording and organic representation of history of sound in space. The concept of evolution in time has been represented in order to highlight this particular aspect. In the sense, the choice of using installation art to develop *Syntaxis* represent also the coherence of using space and sound in it, as a whole, in order to let it, in a way, to comment on itself.

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