Biomusic: the carrier

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Abstract

The present work investigates the concept of sound, in relation to the new means and sciences under different perspectives, ultimately providing an analysis of the newborn artistic movement of bioart. It deals with two parts. The first part of the study is based upon reference, investigating the interconnection between art and science. This mechanism is characterized by transformation processes in the interdisciplinary practices that are applied mainly by various artists and movements of the second post world war period. The expressive element seeks for an unworldly explanation through audio and visual conjunctions. This nature is obvious in Paul Klee's reflections of musical elements in his paintings, Rimington's attempts to marry audiovisual influences in his "colour organs", the experimentations of composers like Xenakis and Stockhausen at various locations with light and color proves the continuous quest to render sound by the use of new means. Technology is a vital component of transformation as it enhances the syncretic creativity for various art domains like the ones that Fluxus deployed. Nam Jun Paik and Dick Higgins introduce radical techniques in their performances as they detach their selves from the parameters that define composition and use the mind and power of sentiment in order to identify reality aurally and optically. Towards the end of the 20th century we witness the appearance of new art forms like bioart. The human body, host of material and immaterial functions comes to the forefront of art practice. Its relation to elements such as oscillations and vibrations that express the energy flow are analyzed through the model of spiritualism that came from eastern thought. The notion of digital embodiment is presented as a reminder, highlighting the importance of technology in biotechnology and genetics.

The second part of the study involves an experiment. This is how the concept of biomusic is applied with the use of ECG data from the MIT PhysioNet database. As sound penetrates the entire human body, it can be analyzed in all of its phasma. Using that information we attempt to translate/transform that biological sound phenomena into music. The sound produced by the elaboration of data which result from biological functions, can be described as Biomusic. It can be transformed into frequencies related to time and be expressed into music themes. Sonification plays an important role in this research as it constitutes a quick and precise rendering of the polymorphic information (in this case the E.C.G.) in musical notes. This modeling and musical attribution leads in two distinguished results each one of them concerning different clinical cases (all data belong to a normal heart function and a pathological one). The invention of this novel system is suggested for the scientific as well as for the music discipline. It has the ability to be implemented in an experimental form and obtain an educational character. The transformation process avoids compensation throughout the matching process in between E.C.G. functions and music, while focusing on the aesthetic factor at the same time. Sound meets art in the world of Biomusic as it takes shape through technology, constituting a new medium to further evolve the model of ''biology into art'' transformation.

keywords: Biomusic, Bioart, E.C.G. sonification

Introduction

The marriage in between audio and visual is a classic approach in the speech acts of artistic practice. Paul Klee, tried to reflect upon his paintings with musical elements (Hajo, 2004: 11-12). He used color being inspired from the movement of musical notes on the stave. He inevitably conveyed the spirit of a music performer on the canvas. The idea of motion is not a compositional component for Klee as he aims to the elimination of time. The polyphony in musical creation has responded to this demand to some extent. Klee wants to overcome music's periodical element by a conscious choice. He wants to escape from the programmatic style, which is dominant in classical music composition. He creates polyphonic structures, of higher provision that constitute free explanations of (virtual musical) scores. Such projects include "Fugue in Red" (Fugue in rot - 1921), and "Landscape in A major" (Landschaft in A dur) (Ibid., 28-29). Klee's musical paintings are a combination of scientific observation and artistic creation with strong abstraction elements just like the twentieth century defines.

The audiovisual connection in between the arts is dominant in various devices that host experimental application by composers and inventors alike. Alexander Rimmington first used the term «color organs» for his combinatory patent of musical/sonic elements with the art world. (Peacock, 1988: 397-406). Fifty years later Rimington's innovation led to the invention of the «Lumigrah» by abstract cinema animator Oskar Fischinger. It's function is based upon a collection of images that are projected with the touch of a rubberized screen. Depressing the screen would cause it to intersect with the light. In 1932 Fischinger researches the graphic composition of specific sounds through filmic practice. Thereby he introduces a new component to the conception of image, a contrapuntal mode (in this case one melody represents image and the other sound).

In our attempt to deliver a syncretic approach to creativity we focus on Fluxus (Rush, 1999: 24) movement. In Fluxus sound acquires energy substance. Vibration and sonification for and from the body are some of it's particular characteristics. Namely Nam Jun Paik and Dick Higgins, two artists from utterly different backgrounds were innovators in the field of sound art. The first transformed the video image from a literal representation of subjects and events into an expression of artistic view issues/events of the times. Television and the screen generally is one of the main tools / elements for Paik from the beginnings of 1960. That information (no matter it's content) is transferred to the world through the television or generally the screen. Paik comprises it in his work pointing out its domination on our senses and the control of attention. (Mc Luhan, 1966: 6.) On the other hand Dick Higgins belongs to the league of artists that approached sound as a real natural substance that sometimes has low intensity and durability. The natural substance of intense sounds that Higgins was keen on, could be perceived in different ways: a) like a sonic energy that is mass-perceived, b) a carrier of the material substance of sound that overturns the natural substance of sound, c) as a means that pervades and defines space and others.

The research on sound is part of the 'sonic art' legacy that composers like Xenakis and Stockhausen have left us. Karlheinz Stockhausen created entirely electronic music for his project "Contact" (Kontakte - 1958-60) signifying a new era in audio control. He gives a multidimensional approach to space issue and absorption of sound. The project is characterized by the composer's need to include all the sound elements (pitch, color, intensity, duration, etc.) with a single manipulation (Clarke, 1998: 222). The composition involves groups of classical and electronic instruments that contribute to a transformative process. A kind of contact in between groups separated by sound categories (metal, leather and wood) and electronic sound. The spatial distribution of four different speakers is the composer's attempt to bring the listener into contact with more than one dimension. A kind of contact with several aspects of reality.

Iannis Xenakis's quest to explore the idea of general morphology (combinatorial forms of various disciplines that meet in the field of arts), establishes the substantial application of mathematics. These disciplinary fields form two mechanisms: Theories from all the scientific fields belong to a compete theoretical mechanism which relates to the conclusion. Questions and verification of these theories are presented and investigated in an experimental apparatus. Nonetheless, art suggests a third mechanism revealing the link in between integrated and experimental methods, where the "art object" obtains

dimensions, following mysterious paths, combining the cores or elements from both mechanisms. (Xenakis, 1992: 4). The third mechanism that Xenakis refers to is evident in his projects, known as "Polytopes" (the term has a mathematical significance too, existing in Euclidian geometry). Polytopes are large-scale multimedia works that take place in specific locations (usually of historical archaeological significance) and involve music performance and light.

The human body, host and creator of energy have a special role in the multimedia combination of art-science. Digital embodiment is part of this process in the arts. Stelarc's main idea is that the human body is obsolete (Stelarc, 1994). The idea of interaction varies in between the two poles: the anthropomorphic machine from one side and the technological transfer of the organic element through digital technologies on the other. It could be argued that all the approaches that relate directly or indirectly to life and have some kind of application in the biotechnology laboratories are part of what it is named bioart.

Science has been moving in complementary ways to art for centuries now till lately with the introduction of biotechnology into the arts. The mix of eastern / western and holistic / analytical-technocratic thinking contributed to a multiangular approach to human nature. The informatics that supports biotechnology, became a craftsman's tool. According to Whitelaw, especially biotechnology involves technologies such as genetic engineering, tissue culture and cloning while it produces results, which are the base of inspiration for those occupied with the subject (Whitelaw, 2004: 12.) Bioart rather suggests that any future outcome for embodiment in the field of informatics should leave some space for the aesthetic processes of composition. The term bioart, an invention of artist Eduardo Kac for his work "Time Capsule" in 1997 (Kac, 2000: 243 - 249), and it's derivatives like biomusic belong to what could be described as the next level of syncretic creativity. It is about a technoetic evolution, where the self comes to the forefront through generative arrangements and processes. The self is shaped through new dimensions of consciousness. This transformative mechanism is the framework that our case study is taking place.

Case study

As part of our research we designed and conducted an experiment during which we applied the concept of biomusic on electrocardiography (E.C.G.) data. In our experiment we transformed data fetched from PhysioNet into music using simple computational procedures. We mainly focused on sonification of cardiac arrhythmia.

Arrhythmia is a medical term describing heart rythms that differ from normal sinus rhythm. The main difference is that in contrast to normal sinus rhythm, RR intervals show irregularities and variations of the heartbeat.

The dataset created for the purposes of 2001 Challenge of the conference " Computers in Cardiology" and it consists of recordings of 48 different subjects. This dataset was divided into learning set and testing test for the task of Atrial Fibrillation onset prediction using machine-learning methods.

Our main goal was to create a sonification process of Atrial Fibrillation (AF), which is one of the most common cardiac arrhythmia. Our hypothesis is that the aesthetic result of the final musical piece correlates with the health of the heart; thus, a normal heart will have a more pleasant result than an arrhythmic heart.

In our approach we use RR intervals and ΔRR intervals (difference of two successive RR intervals). In literature there do exist methods for prediction of Atrial Fibrillation using those features (Tateno, K. and Glass, L., 2000: 391-394). Thus, we strongly believe that our approach captures and sonifies statistical properties of normal and arrhythmic hearts.

The algorithm / method we used to produce biomusic is summarized in the following section.

Algorithm

Step 1.
We fetch data from PhysioNet.

Step 2.
For a given recording we fetch the corresponding RR intervals.

Step3. Note pitch computation

For the note pitch computation we use RR intervals that we map to integers of range $[0,n]$, (n is a parameter of our choose with which we control the note pitch range). Those integers then are mapped to MIDI notes and we audiofy them by using audio sequencers.

Step4. Note duration computation
We compute ΔRR with the following formula:

$$\Delta RR(t) = R(t) - R(t-1), t>1$$

we normalize ΔRR so as $0 \leq \Delta RR(t) \leq 1, \ \forall \ i$

$$\Delta RR(t) = \frac{RR(t)}{max \, \Delta RR}$$

We create 9 bins as follows:

no.bin	Note value	Range
1	64	$[0, 0.111)$
2	32	$[0.111, 0.222)$
3	16	$[0.222, 0.333)$
4	8	$[0.333, 0.444)$
5	4	$[0.444, 0.555)$
6	2	$[0.555, 0.666)$
7	1	$[0.666, 0.777)$
8	.5	$[0.777, 0.888)$
9	.25	$[0.888, 1]$

Table 1 Note value bins

Each bin corresponds to a note value. For example, the first correspond to sixty-fourth note and the 9nth to a longa. Then we map the scaled ΔRR to those bins in such way that values from 0 to 0.111 are mapped to bin1, from 0.111 to 0.222 to bin 2, etc. More formally the duration of note i is:

$$dur_i = dur_{i-1} + durations(floor(\Delta RR(i \cdot 8)) \cdot notelength$$

where $notelength$ is a parameter which we chose arbitrary and $floor(x)$ is the floor function (largest integer not grater than x).

Step5. Note dynamics

For the note dynamics we used the heart beat dynamics. The reason for that was that we wanted the transformation procedure to be as simple and bias free as possible.

Step6. Track tempo

The result of this process is a series of notes, which have duration, dynamic, and pitch assigned. The only part missing is the tempo of the track. For this we computed the mean value of RR intervals.

Conclusion

Although the sonic result is a series of notes that seem to obey rules, it surely takes the essence of contemporary composition a step further. The main feature of twelve-tone composition is that all twelve notes of the chromatic scale are of equal importance; so none of them is being given more or less importance in a music piece. The use of tone rows is significant as the target of twelve-tone composition is to avoid writing a piece in a specific key. Affiliations to our composition (that of having the composition made with note combinations that fall out from classic harmony rules) can be made to a certain extent. The listener is not prepared towards a compositional thought that relates to even and equal use of notes as well as tonal pitches. As a result we do not bias the listener towards an aesthetic judgment. For example by mapping the E.C.G. to western scales which are familiar to the listener we would restrict the musical outcome in a sense that we already maximize the possibilities of a familiar listening in it's traditional sense. E.C.G. is a biological signal, an imprint that carries data that can be sonified. Sound caries information that can be mapped/translated through the use of variable techniques. An E.C.G. is a very primal example of music. It refers to nature primarily. The pulse is energy, its presence is obvious from archaic shaman rituals to music/art and science practice encompassing the holistic-eastern and western thought at once.

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