Organic Oscillator: Experiments using Natural Oscillation Sources from Audiences

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ABSTRACT

Our idea of Organic Oscillator is a combination of the mechanism of a table lookup oscillator and natural oscillation sources from audiences. Based on this idea, we conduct a series of audio and visual experiments, starting from using a single natural oscillation source in the human body to multiple ones from the audiences. Shifting from a single-participant paradigm to a group-participants paradigm, we summarize our development of audience sensing apparatuses and identify the need of an abstract audience representation to extend composition possibilities and interactive system design. Informed by our experiments, the absence of the abstract audience representation leads to a gap that limits us to express data relationships among multiple natural oscillation sources from the audiences. To advance our research, we present a novel symbolic audience model that abstracts audience members as objects and their responses as processes in a systematic perspective. We envision works created using this model may allow us to explore new forms built using this model's new conceptual strategies of inter-participant relationship, synchronization, and collective expression.

1. INTRODUCTION

The concept of unit generator, such as oscillators, is fundamental in digital sound synthesis languages [1]. In this paper, we extend the idea that "one could snip out a period of a recorded sound and load the table with it" [2] in our experiments. Instead of using a numerical representation generated by a computer program, we start by loading the table with samples recorded from a human cardiac cycle. In this paper, we categorize our works into asynchronous and synchronous experiments by nature of an experiment's final presentation format. The asynchronous experiments are electroacoustic studies that demonstrate our idea of Organic Oscillator using offline methods. The synchronous experiments are audience participation installations that extends our idea of Organic Oscillator through interactive system design. As it's critical for us to use multiple natural oscillation sources from the audiences as composition materials, we briefly summarize the development of our audience sensing apparatuses. This development has naturally led us to identify the need of an abstract audience representation in our works. Finally, informed by the results of our experiments, we present a novel symbolic audience model to extend our composition possibilities and to guide our interactive system design.

1.1 Related Works

Rhythmic signals from the human body are abundant resources for the electroacoustic composition [3], the extended musical interface [4], the data sonification research [5, 6], and the interactive sonification performance [7]. Using data from more than one human body for musical compositions [8, 9] or interactive installations [10, 11] requires an appropriate audience sensing apparatus, a wireless network communication infrastructure, and conceptual strategies for compositions, such as the idea of synchronization [9], the competitive mapping [8], and the interconnected musical network [12]. Lastly, our approach is data-driven, systematic, and inspired by research of collective behaviors in various fields [13]. The scope of this paper mainly concerns our choice of this data source, technologies required for this type of composition materials, and the necessity of a symbolic audience model that provides conceptual strategies to extend our future research.

1.2 Motivation

Characteristics of the rhythmic signals from the human body are unique and inspiring to our artistic practices. In a wavetable lookup synthesis, numerical values in the wavetable are generated by a computer program and stored in a memory. In most cases, the table length and the sampling frequency are fixed. Therefore, the frequency of the sound from an oscillator depends on the value of the increment. In a system like the human body, the table length of the cardiac cycle varies from time to time and from person to person. We are interested in what this variety from a single human body may provide us aesthetically and that from an audience collectively. The goal of our artistic experiments is to explore new forms informed and created by our idea of Organic Oscillator, which we introduce in the next section.

2. ORGANIC OSCILLATOR

Our idea of Organic Oscillator is a combination of the mechanism of a table lookup oscillator and natural oscillation sources from the audiences. To make a sound synthesis analogy, a wavetable for Organic Oscillator is one that is filled with samples recorded from one human cardiac cycle, illustrated in Figure 1. We started our first experiment by converting rhythmic signals from a natural oscillation source in the human body into sound using CSound in MAT 276IA [1]. Results of our first experiment became primary materials in our electroacoustic studies. Constraints of our first experiment has inspired us to extend our research by developing appropriate audience sensing apparatuses for experiments using multiple oscillation sources from the audiences. These experiments have naturally led to our attempt in creating a symbolic audience model that provides conceptual strategies to extend composition possibilities and interactive system design. In this paper, we first describe a series of experiments inspired by our idea of Organic Oscillator. Based on findings from these experiments, we identify the need of an abstract audience representation and create a novel symbolic audience model that provides conceptual strategies to guide our future research.

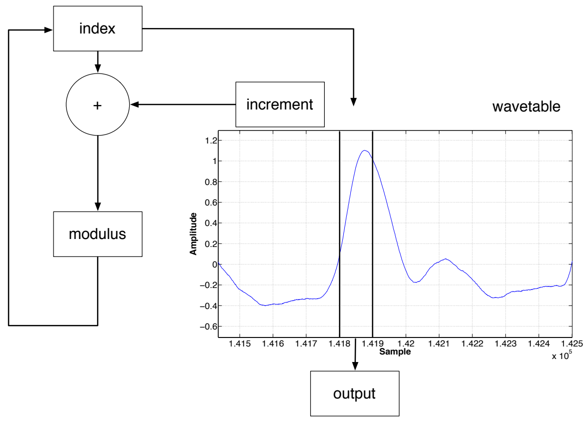

Figure 1. Elements of an Organic Oscillator are shown in this figure. Instead of a standard table lookup oscillator [14], we load the wavetable with samples recorded from one human cardiac cycle.

3. ASYNCHRONOUS EXPERIMENTS

As extended experiments of our CSound studies, we continued to use the materials converted from the human heart pulsation with recorded ambient sound for the following three electroacoustic studies. This series of asynchronous experiments include P.O.M. (4 minute and 37 seconds, 2010), a remix version of P.O.M. (4 minute and 3 seconds, 2011), and a short version of P.O.M. (1 minute, 2012). These experiments were presented as electroacoustic studies and hence called asynchronous experiments. The materials used in P.O.M. were recorded using a commercial Electrocardiogram sensor, a Photoplethysmogram sensor [2], and a Fostex FR-2 field recorder.

In creating P.O.M., we explored the subject of attention. By considering the human body as a black box, we recorded ambient sound from both outside the box and inside the box. At a conceptual level, the recorded ambient sound from outside the box are considered as sources of distraction. Sound objects generated using the samples recorded from inside the box are considered as states of the black box. In Logic Pro, relative positions of the sound objects in multiple tracks are critical in terms of causality, consequence, synchronicity, and the idea of now. We placed the sound objects in multiple layers so that ideally conversations among them may be perceived in different directions. With this multi-layer structure, we hope to express that the subject of attention is similar to a gaming experience where a listener chases and identifies sonic events throughout his or her listening experiences. To make a visual analogy, being able to continuously identify sonic events is consciously in focus.

3.1 P.O.M. 2010

P.O.M. was first presented at MAT 200B [3] and later received a Honorable Mention in the Electronic-Acoustic Category in the 2009-2010 Dorothy and Sherrill C. Corwin Awards for Excellence in Music Composition Competition, Music Department, University of California Santa Barbara, CA, USA.

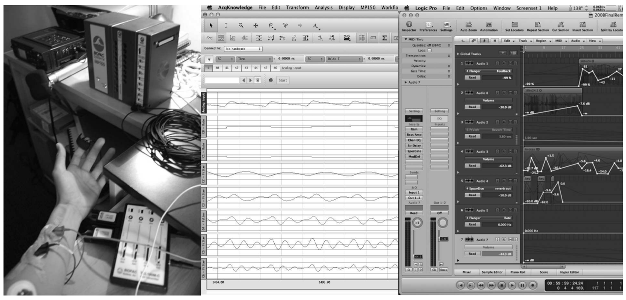

Figure 2. Our asynchronous processes in P.O.M. involve physiological data acquisition using AcqKnowledge software (the middle screenshot), signal processing in Matlab, and sound objects manipulation in Logic Pro (the right screenshot).

3.2 P.O.M. 2011

We continued using materials from P.O.M. in our eight-channel spatialization study in MAT 276N [4]. We converted the original stereo piece into an octophonic piece in the PluriLab. This 8-channel version was later selected to present at the CREATE [5] concert "Critical Point" [6] in Lotte Lehmann Hall at UCSB in 2011.

[1] MAT 276IA/IB Computer Music Synthesis and Composition, winter and spring, 2010
[2] http://www.biopac.com/
[3] MAT 200B Music and Technology, winter, 2010
[4] MAT 276N Special Topics in Electronic Music, fall, 2010
[5] Center for Research in Electronic Art Technology (CREATE), http://create.ucsb.edu/
[6] http://www.ucira.ucsb.edu/ucsbs-create-presents-critical-point/

Figure 3. P.O.M. is converted into an octophonic study in the PluriLab, Elings Hall, UCSB.

3.3 P.O.M. 2012

In 2012, we continued using materials from P.O.M. for a sound design study and submitted it to a call-for-work for MAT website sound design. To meet the submission requirements, we modified it into a one minute long piece. Our submission was selected and currently accessible at the UCSB's Media Arts and Technology website.

4. SYNCHRONOUS EXPERIMENTS

Shifting from asynchronous experiments to synchronous ones, we inevitably dealt with interactive system design. We started by creating an installation for a single participant to interact with and found that the number of participants was limited by the commercial physiological data acquisition equipment we used. This became a constraint in our conceptual development. To advance our research, we designed and implemented innovative audience sensing apparatuses that facilitate our experiment design using multiple natural oscillation sources from the audiences. After overcoming the limitation of the commercial physiological data acquisition equipment, we were able to shift from a single-participant paradigm to a group-participants paradigm in our experiment design. This was a critical progress as we are now able to create sonic and visual experiences using relationships of multiple natural oscillation sources from the audiences. To demonstrate, we summarize two studies according to the number of natural oscillation sources from an audience and their corresponding paradigms.

4.1 Single-Participant Paradigm: Using a Single Natural Oscillation Source from the Audience

In our early experiment [15], our custom interactive system was capable of using only one natural oscillation source from the audience due to the limitation of the commercial physiological data acquisition equipment. Our custom system renders artistic real-time graphic projection and 32 channel spatial sound based on the signal characteristics from a Photoplethysmograph sensor from a participant.

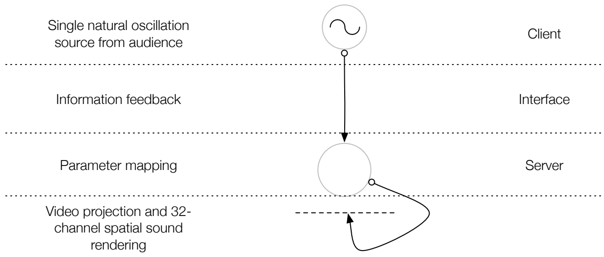

Figure 4. A conceptual illustration of our experiment using a single natural oscillation source from the audience.

Figure 5. Our biologically-inspired audiovisual installation creates interactive experiences using a single oscillation source from the audience.

4.2 Group-Participants Paradigm: Using Multiple Natural Oscillation Sources from the Audience

To use multiple natural oscillation sources in our work, we overcame the constraint of the commercial physiological data acquisition equipment by creating a custom mobile biometric interface that continuously collects data from the audiences. Our innovative audience sensing apparatuses were documented in detail [16, 17]. With our interface, we were able to invite large audience to collectively create sonic and visual experiences using both natural oscillation sources from the human body from a group of participants. We realized our composition idea of "audience as constituents of a system for collective expression [18]" in the Time Giver [7] audience-participation installation inside AlloSphere at MAT's End of Year Show, 2013 [8] . Our custom system renders artistic real-time stereographic video projection and 54.1 channel spatial sound based on both heart rates and brain waves from multiple participants.

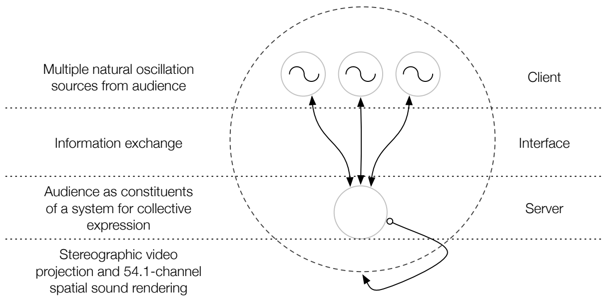

Figure 6. A conceptual illustration of our experiment using multiple natural oscillation sources from the audience.

[7] Time Giver, or zetigeber, refers to any external cue that influences an organism's internal biological clock.

[8] http://mat.ucsb.edu/show/2013/projects/time-giver/

Figure 7. Our audience participation installation creates interactive experiences using multiple natural oscillation sources from the audience.

5. DEVELOPMENT OF AUDIENCE SENSING APPARATUSES

The ability to use multiple natural oscillation sources from the audiences as composition materials is critical in our experiments. We have developed innovative audience sensing apparatuses that enable us to do so and promise the benefit to further explore our idea of Organic Oscillator. As a bottom-up approach example, an evolution of a system of two oscillators can already create a modular dialogue within a larger temporal structure.

In our asynchronous experiments, we started by recording data from a single natural oscillation source in the human body using the commercial physiological data acquisition equipment. We recorded and exported the desired data from the AcqKnowledge software application, and converted these data into sound objects offline in Matlab. These sound objects were saved individually as audio files. Finally, we organized these sound objects in various time scales and layers with effects in Logic Pro to create temporal forms.

In our synchronous experiments, we made the above offline methods into online ones for interactive system design. We began by creating intermediate software applications that query physiological data from the AcqKnowledge software application to other software environments for parameter mappings. These intermediate software applications we built include a Max/MSP external object and a plugin for the AlloSphere's Device Server [9] . Both allow us to query multi-channel physiological data streams from the AcqKnowledge software application to other software environments. However, we were limited by the commercial physiological data acquisition equipment in terms of the number of natural oscillation sources we can acquire from an audience. To overcome this limitation and advance our research, we designed and implemented two mobile biometric interfaces to replace the commercial physiological data acquisition equipment. The first mobile biometric interface [17] is a mobile application that captures a user's pulse via smarphone photoplethysmography, computes heart rate, and sends this data to a remote server in OpenSoundControl format. The second mobile biometric interface is an extension of the first interface that sends both heart rate and brain waves to a remote server. Both allow us to use multiple natural oscillation sources from an audience for creating artistic works.

Similar to the idea of "mouse for the masses" solution [10], our modular mobile biometric solution not only replaces the commercial physiological data acquisition equipment but opens up new composition possibilities, such as the idea of exchange, share, contagion, inter-participant relationship, synchronization, and collective expression. These innovative audience sensing apparatuses enable us to conduct audience participation experiments at a larger scale and naturally leads us to find the necessity of an abstract audience representation for systematic exploration of these new composition ideas.

We currently focus on using natural oscillation sources from the human body for our works. However, it's possible to leverage various user activity sensing engines and convert collective behaviors into collective expressions with modern smartphones.

To shift from a single-participant paradigm to a group-participants paradigm in our analysis-synthesis approach, we identify the need of a symbolic audience model to extend composition possibilities and to advance interactive system design.

6. A NOVEL SYMBOLIC AUDIENCE MODEL

Inspired by our idea of Organic Oscillator and informed by findings in our experiments, we find that the absence of an abstract audience representation leads to a gap that limits us to express data relationships among multiple natural oscillation sources from the audiences. To bridge this gap, we create a novel audience symbolic model that considers audience members as objects and their responses as processes in a systematic perspective.

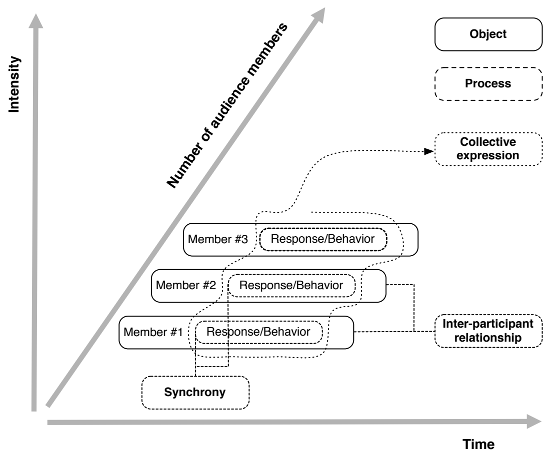

Figure 8. Illustration of our symbolic audience model.

Dimensions of this model are intensity, time, and number of audience members. Instead of building a model of a system for analysis and prediction, our intention is to assist creative processes and interactive system design. The goal of this model is to provide conceptual strategies to manage multiple data streams, express data relationships among these streams, explore permutations of these relationships, build structures using found relationships, and convert these structures into new forms.

[9] http://www.allosphere.ucsb.edu/DeviceServer/

6.1 Intensity

The intensity dimension of this model is a quantitative description of an audience's response. For example, having concepts such as a baseline and a threshold in mind may enrich creative processes via understanding the dynamics of a system of oscillators.

6.2 Time

The scale of the time dimension of this model depends on temporal characteristics of a system used in one's creative processes or interactive system design.

6.3 Number of Audience Members

The number of audience members indicate how many participants are there in an audience. Shifting from a single-participant paradigm to a group-participants paradigm, this dimension is critical in providing a systematic perspective to one's creative processes and interactive system design with the following three conceptual strategies.

7. CONCEPTUAL STRATEGIES

Our symbolic audience model provides three conceptual strategies to express data relationships for more composition possibilities and advanced interactive system design.

7.1 Synchrony

The synchrony is one of the three conceptual strategies this model provides. It is a quantitative description of how many identifiable events from an audience's response happen simultaneously. For example, it may enrich one's creative processes via having an additional parameter that describes the order of a system.

7.2 Inter-Participant Relationship

The inter-participant relationship is the second conceptual strategy that this model provides. It guides us to use more quantitative descriptions of relationships between two sets of data in creative processes. For example, we can examine the correlation between two sets of temporal data and use the result of this examination as a parameter to creative new forms. In a more advanced example, we can apply the same technique to two groups of temporal data and use the results as parameters to express data relationships in temporal forms.

7.3 Collective Expression

The collective expression is the third conceptual strategy that this model provides. It guides us to create new forms using relationships from more than two sets of data. For example, we can create temporal forms using the density of events computed based on the distribution of responses from an audience. Ultimately, it's possible to convert collective behaviors into collective expressions with advanced audience activity recognition engines.

8. FUTURE WORK

Both asynchronous and synchronous experiments presented in this paper are a preliminary exploration of our Organic Oscillator idea. Enabled by our innovative audience sensing apparatuses, we have shifted our focus from a single-participant paradigm to a group-participants paradigm in our experiments. In the latest experiment, we were able to conduct our first audience participation installation using multiple natural oscillation sources from the audience. The installation demonstrated our composition idea of "audience as constituents of a system for collective expression [18]". However, we didn't get to explore enough permutations of the data relationships for collective expression in this installation. With our novel symbolic audience model, we plan to apply the conceptual strategies to systematically expand our palette for future experiments. Further, we are very interested in looking into possibilities using principles from self-organization systems and synchronization networks to extend our model. Lastly, we consider interaction between contextual information and system dynamics an ultimate component to complete this model. We envision future works created using this model may allow us to explore new forms built using our conceptual strategies of inter-participant relationship, synchronization, and collective expression.

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