BioSync: An Informed Participatory Interface for Audience Dynamics and Audiovisual Content Co-creation using Mobile PPG and EEG

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ABSTRACT

The BioSync interface presented in this paper merges the paradigms of heart-rate and brain-wave into one mobile unit which is scalable for large audience real-time applications. The goal of BioSync is to provide a hybrid interface, which uses audience biometric responses for audience participation techniques and methods. To provide an affordable and scalable solution, BioSync collects the user's heart rate via mobile device pulse oximetry and the EEG data via Bluetooth communication with the off-the-shelf MindWave Mobile hardware. Various interfaces have been designed and implemented in the development of audience participation techniques and systems. In the design and concept of BioSync, we first summarize recent interface research for audience participation within the NIME-related context, followed by the outline of the BioSync methodology and interface design. We then present a technique for dynamic tempo control based on the audience biometric responses and an early prototype of a mobile dual-channel pulse oximetry and EEG bi-directional interface for iOS device (BioSync). Finally, we present discussions and ideas for future applications, as well as plans for a series of experiments, which investigate if temporal parameters of an audience's physiological metrics encourage crowd synchronization during a live event or performance, a characteristic, which we see as having great potential in the creation of future live musical, audiovisual and performance applications.

Keywords

Mobile, Biometrics, Synchronous Interaction, Social, Audience, Experience

1. INTRODUCTION

Enabled by the technology, particularly mobile technology, audience research within the NIME context has been recently increasing. Previous literatures have indicated the importance of mobile technology in understanding interactive social experiences [23], and the need of using custom mobile interface to investigate concepts of emotional contagion, leadership, entrainment, and co-creation during a shared music experiences [13]. This ShEMP mobile framework is used to monitor the audience member's activities and biometrics with an external MobileMuse sensor board. With the network capability and various built-in sensors, the Smartphone is an ideal tool for collecting different types of audience responses and informing the performer's message to individuals within the crowd. Instead of audience participation technique using light-emitting or reflective object, mobile device tends to provide more engaging interactive experiences for software customization and external accessories. However, using mobile interfaces for audience research should take the network connection and the scalability issue into consideration. In Weinberg's categorization of interconnected musical networks [27], small-scale local system supports three to ten collaborators and the large-scale local system supports more than ten participants. With an appropriate choice of server implementation, for example, Node.js, it's possible to conduct a scale-able audience research. In audience perception of temporal art and performance, recent studies has shown a trend of convergence of continuous rating and physiological response [4, 13, 3]. As the continuous perception data stream becomes available on the server side, it's our interest to look into possible applications based on the dynamics between audience responses and the co-creation of audiovisual content. A relevant and inspiring study by Feldmeier and Paradiso [8] described a way of collecting activity information from the crowd and using it to "dynamically determine the musical structure or sonic events". Following the trend of audience participation interfaces, we present an affordable mobile interface that captures the user's heart and brain signals with the feature of bi-directional communication. In addition to analysis of audience perception data, this paper aims to explore ways of using the audience dynamics in collaboratively creating audiovisual content, which provides a more engaging shared experience.

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2. RELATED WORKS

As an overview, we summarize three aspects of audience participation research.

2.1 Interface for Audience Participation and Response

We categorize various interfaces used for audience participation into the following categories.

2.1.1 *Mobile Interface*

Bortz [3] described a series of studies using the ShEMP mobile framework to investigate concepts of emotional contagion, leadership, entrainment, and co-creation. Coupled with a MobileMuse external sensor board [13], ShEMP provides pulse oximetry, electrodermal activity, motion, and skin temperature. This concept of merging mobile interfaces and biometrics is consistent with our goal in designing the BioSync interface.

2.1.2 Computer-Vision Based Interface

Computer vision is an extremely low-cost method in gathering data over a large audience; however, the lighting conditions and illumination effects oftentimes influence the data. In Freeman's composition Glimmer [9], computer vision techniques were utilized to continuously track audience activities. The concepts of using continuous feedback of audience activities, and software algorithms to collaboratively create the musical content are consistent with our goal in designing a dynamic tempo control technique using BioSync.

2.1.3 Give-Away RF Interface

In Feldmeier and Paradiso's work [8], they addressed the problem of cost, data-communication bandwidth, and system responsiveness in designing" a system that enables large audience participation to collaboratively control a real-time, centralized interaction". With the low-cost RF motion sensors, they were able to "map the dominant tempo of the audience to the global tempo of the generated musical materials". Concepts of "dynamically determine musical structure and/or sonic events" and "a system as a tool for synchronization of the participants" are essential in our design for the use of mapping the biological rhythm of many individuals to the control of music tempo.

2.1.4 Biometric Interface

The use of biometrics for sound synthesis is commonly seen in the NIME community [22, 12, 1, 21]. While most of these biometric interfaces are limited to one or small-scale participants (usually due to the proprietary software and hardware), the BioSync interface aims to merge the mobile interface and biometric interface into one scalable client unit to facilitate large dynamic audience participation.

2.1.5 Bi-Directional Interface

The limitation of unidirectional communication has been addressed by Oh [23] and recent studies have presented bi-directional interface implementation in order to engage a large audience. The collaborative musical instrument in Lee's work [15] provides a shared music making experience among participants via mobile devices. Control, an interface by Roberts [25, 26] has recently been used over seventy five participants with a performance featuring bi-directional networked interactivity.

2.1.6 Infrastructure as Interface

Other projects have taken a different approach to designing the infrastructure for audience participation. The Magic Carpet project [24] was an audio installation, which used a sensor floor. Made of Doppler radar and a grid of piezoelectric wires under a carpet, This work encourages interactive environment for the audience through a common datum.

2.2 Audience Size

While the implementation of a small-scale local system is commonly seen in the NIME-related community, we summarize the number of participants in recent large audience applications. Golan Levin's Dialtones: Telesymphony (2001) supported up to 200 participants [17]. In Freeman's experiment, he used large computer vision system to track approximently one hundred participants [10]. Composition for Conductor and Audience, a piece by Roberts [26] performed for an audience of over seventy-five people.

2.3 Message from the Audience

We look at different types of messages collected from the audience. Text [6], motion [9], biometrics[16, 22, 12, 1, 21], continuous ratings[19, 4, 14] are commonly seen in audience participation and audience response projects. Recent studies [7, 20] also suggest mapping sensory inputs from the Smartphone for mobile music making. The later acted as inspiration in co-creating audiovisual content using the biological rhythm of the audience members.

2.4 Co-Creation of Audiovisual Content

This section gives a quick introduction to the ways of co-creating audiovisual content and the experiences of collective expression.

2.4.1 Audience Participation as a Composition Technique

The participants acted as performers in Freeman's Flock [10] piece by using computer vision techniques to track the participantsÕ locations in an open performance space.

2.4.2 Collective Expression

MoodMixer [16] is an EEG based installation where participants collaboratively navigate a 2-D musical space by their cognitive state. Blaine [2] gave a review on the dimensions of collaborative interface design and pointed out that it is more important to provide "an easy and intuitive access to music making experience than having a complex interface with the capability for virtuosic expression". Along this principle, BioSync aims to facilitate the collective expression experience with the goal of "instant music first, subtlety later [5]".

2.5 Prior Works and Summary

The prior works include iPhone pulse oximetry, heart rate based interactive installations, NeuroSky EEG based interactive installations. The BioSync interface presented here is a continuation of the prior works with the goal of merging the heart-rate and brain-wave paradigms into one mobile unit, scalable for facilitating intimate and wide audience participation. We present the BioSync interface and a technique for dynamic tempo control based on the audience biometrics response. The goal of the BioSync interface is to investigate if collective expression based on the temporal physiological parameters from the audience provides more engaging interactive experiences during a live event. With our interface, we take the idea of encouraging the synchronization of the crowd [8] further using our informed participatory interface.

3. METHODOLOGY

3.1 System Design

To explore ways to enhance the audience's quality of experience during interaction, we looked towards the research and projects of shared emotion, music, and physiology [23] and the design principles found in techniques for interactive audience participation [18]. In short, the design of BioSync interface addresses the following aspects. First, considering "presentation of collaborator's physiological data streams to the listener in real time [23]", BioSync uses the phone's built-in camera and LED to compute the user's heart rate and streams the user's EEG data from the off-the-shelf MindWave Mobile hardware($129.99) via Bluetooth. Secondly, with the functionality of Bonjour, BioSync interface can stream both channels of heart rate and EEG data to the server with minimum network setup within a standard LAN environment. Lastly, instead of pushing everyone's physiological metrics to each individual mobile device to keep the individual informed about the crowd's response ("you do not need to sense every audience member [18]"), we choose to have the audience focus on bringing the audience collectivity together and only display the mean response of the crowd alongside the relative user's data.

3.2 User Interface Design

The visual components of the BioSync interface include a major widget of comparison of self-versus-group and checkboxes on both sides for meta PPG/EEG biometric data streaming. The self-versus-group widget is designed in an intuitive way so the user may quickly compare how synchronized he or she is compared to the rest of the sampled audience.

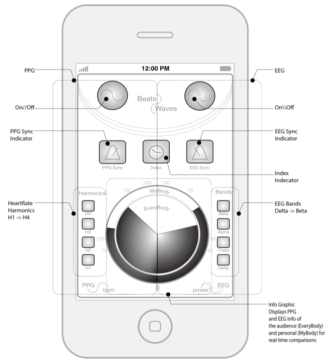

Figure 1: User Interface Mock Up.

3.3 Implementation of the BioSync Interface

The implementation of the BioSync interface includes video imaging techniques for heart rate measurement, NeuroSky's API with iOS external accessory framework for use with the MindWave Mobile hardware, Bonjour for network discovery, and OpenSoundControl for bi-directional network communication. The MindWave Mobile hardware communicates with the iPhone via Bluetooth. For a minimal setup, one iPhone, one MindWave Mobile headset and one laptop running a UDP client is required.

3.4 Prototype of BioSync Interface

Figure 3 shows the BioSync interface in action. Currently MaxMSP is used for server side implementation though we have a working server implementation using Node.js and have started testing its scalability with the hopes of developing many possible server side implementations for specific uses and purposes.

3.5 Temporal Physiological Index for Dynamic Tempo Control

Inspired by the idea of using the activity information of the crowd to dynamically determine events or content structure during a live event[8], we are particularly interested in using temporal physiological indexes derived from the PPG and EEG of the audience as a parameter for co-creation of audiovisual content in real time. Specifically, we are interested in heart rate variability and the EEG bands (Delta, Theta, Alpha, Beta, Gamma) as temporal indexes with the idea of a continuous feedback loop [9] and are currently working on a composition using this technique. Figure 4 presents use of the BioSync interface in the ongoing work Time Giver.

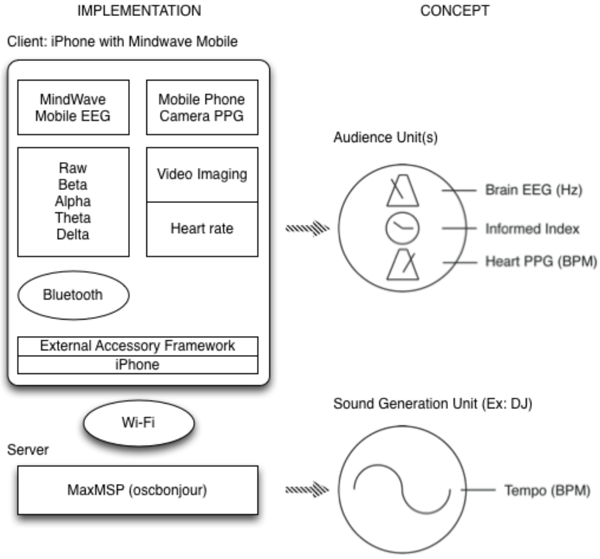

Figure 2: The components and concept of BioSync interface.

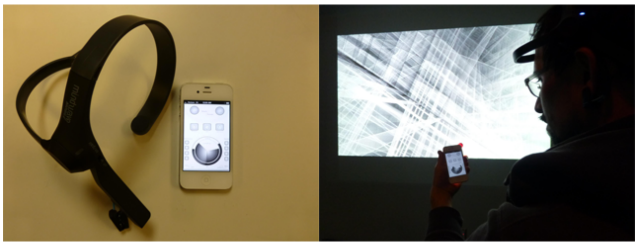

Figure 3: BioSync in Action.

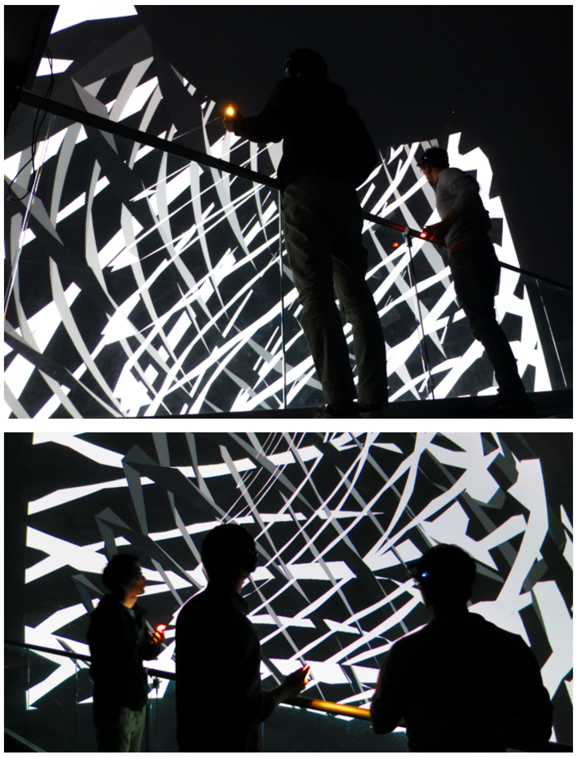

Figure 4: BioSync used in an ongoing project, Time Giver @ Allosphere.

4. DISCUSSIONS AND POSSIBLE APPLICATIONS

Following the trend of novel interfaces for audience participation; we provide an affordable client interface that features dual channel biometrics and bi-directional functionality in hopes of facilitating large audience participation. Instead of multi-channel bio-sensing of single user, BioSync interface enables multi-channel bio-sensing of many individuals in a low-cost and easy-to-distribute fashion. For possible applications, Gates [11] discussed the DJ's perspective on interaction and awareness in nightclubs, he looks into how DJs maintain awareness and adapt the music to the crowds energy level. In his paper, a system that provides the DJ with dynamic information about the audience without additional working load is one of future research directions. With BioSync, we are designing a series of experiments to investigate if the temporal physiological parameters of the audience encourages the synchronization of the crowd [8] during live events and performances.

5. REFERENCES

[1] C. Angel. Creating interactive multimedia works with bio-data. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 421–424.

[2] T. Blaine and S. Fels. Collaborative musical experiences for novices. *Journal of New Music Research*, 32(4):411–428, 2003.

[3] B. Bortz, S. Salazar, J. Jaimovich, R. Knapp, and G. Wang. Shemp: A mobile framework for shared emotion, music, and physiology. 2012.

[4] E. Carroll. Convergence of self-report and physiological responses for evaluating creativity support tools. In *Proceedings of the 8th ACM conference on Creativity and cognition*, pages 455–456. ACM, 2011.

[5] P. Cook. Principles for designing computer music controllers. In *Proceedings of the 2001 conference on New interfaces for musical expression*, pages 1–4. National University of Singapore, 2001.

[6] L. Dahl, J. Herrera, and C. Wilkerson. Tweetdreams: Making music with the audience and the world using real-time twitter data. In *Proceedings of the International Conference on New Interfaces for Musical Expression (NIME)*, 2011.

[7] G. Essl and A. Müller. Designing mobile musical instruments and environments with urmus. In *New Interfaces for Musical Expression*, pages 76–81, 2010.

[8] M. Feldmeier and J. Paradiso. An interactive music environment for large groups with giveaway wireless motion sensors. *Computer Music Journal*, 31(1):50–67, 2007.

[9] J. Freeman. Large audience participation, technology, and orchestral performance. In *Proceedings of the 2005 International Computer Music Conference*, pages 757–760, 2005.

[10] J. Freeman and M. Godfrey. Creative collaboration between audiences and musicians in flock. *Digital Creativity*, 21(2):85–99, 2010.

[11] C. Gates, S. Subramanian, and C. Gutwin. Djs' perspectives on interaction and awareness in nightclubs. In *Proceedings of the 6th conference on Designing Interactive systems*, pages 70–79. ACM, 2006.

[12] R. Hamilton. Bioinformatic feedback: performer bio-data as a driver for real-time composition. In *Proceedings of the 2006 conference on New interfaces for musical expression*, pages 338–341. IRCAMÑCentre Pompidou, 2006.

[13] R. Knapp and B. Bortz. Mobilemuse: Integral music control goes mobile. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 203–206.

[14] C. Latulipe, E. Carroll, and D. Lottridge. Love, hate, arousal and engagement: exploring audience responses to performing arts. In *Proceedings of the 2011 annual conference on Human factors in computing systems*, pages 1845–1854. ACM, 2011.

[15] S. Lee, A. Srinivasamurthy, G. Tronel, W. Shen, and J. Freeman. Tok!: A collaborative acoustic instrument using mobile phones.

[16] G. Leslie and T. Mullen. Moodmixer: Eeg-based collaborative sonification. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 296–299.

[17] G. Levin, S. Gibbons, and G. Shokar. *Dialtones: A Telesymphony*. Staalplaat, 2005.

[18] D. Maynes-Aminzade, R. Pausch, and S. Seitz. Techniques for interactive audience participation. In *Proceedings of the 4th IEEE International Conference on Multimodal Interfaces*, page 15. IEEE Computer Society, 2002.

[19] S. McAdams, B. Vines, S. Vieillard, B. Smith, and R. Reynolds. Influences of large-scale form on continuous ratings in response to a contemporary piece in a live concert setting. *Music Perception*, 22(2):297–350, 2004.

[20] R. McGee, D. Ashbrook, and S. White. Sensynth: a mobile application for dynamic sensor to sound mapping. 2011.

[21] R. McGee, Y. Fan, and R. Ali. Biorhythm: a biologically-inspired audio-visual installation. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 80–83, 2011.

[22] Y. Nagashima. Bio-sensing systems and bio-feedback systems for interactive media arts. In *Proceedings of the 2003 conference on New interfaces for musical expression*, pages 48–53. National University of Singapore, 2003.

[23] J. Oh and G. Wang. Audience-participation techniques based on social mobile computing. In *International Computer Music Conference, ICMC*, 2011.

[24] J. Paradiso, C. Abler, K. Hsiao, and M. Reynolds. The magic carpet: physical sensing for immersive environments. In *CHI'97 extended abstracts on Human factors in computing systems: looking to the future*, pages 277–278. ACM, 1997.

[25] C. Roberts. Control: Software for end-user interface programming and interactive performance. In *Proceedings of the International Computer Music Conference*, 2011.

[26] C. Roberts and T. Hollerer. Composition for conductor and audience: new uses for mobile devices in the concert hall. In *Proceedings of the 24th annual ACM symposium adjunct on User interface software and technology*, pages 65–66. ACM, 2011.

[27] G. Weinberg. Interconnected musical networks: Toward a theoretical framework. *Computer Music Journal*, 29(2):23–39, 2005.