Time Giver: An Installation of Collective Expression using Mobile PPG and EEG in the AlloSphere

Yuan-Yi Fan, F. Myles Sciotto, Dr. JoAnn Kuchera-Morin

Abstract—Time Giver explores the multimodal representation of an audience’s physiological (PPG and EEG) temporal patterns, shifting each audience member from spectator to active participant within the work. Using our BioSync interface running on personal mobile devices, each member of the audience is engaged and contributing in a collective creative work. This synchronous interaction provides a shared visual and sonic experience, taking place within the immersive environment of the Allosphere, allowing for the dynamics of social and physiological triggers to relate to both the one and the many.

Index Terms—Audience, Biometrics, Mobile, Cybernetics, AlloSphere

1 INTRODUCTION

Time Giver is an artistic audio/visual installation that received its first public performance in the AlloSphere [3], a three-story immersive instrument and installation space at the University of California, Santa Barbara, on May 23rd, 2013. Time Giver is inspired by the German term Zeitgeber, which refers to “any external or environmental cue that entrains or synchronizes an organism’s biological rhythms to the earth’s 24-hour light/dark cycle and 12 month cycle [2].” Other common examples of Zeitgeber include light, temperature, social interactions, pharmacological manipulation, exercise, eating and drinking patterns. In designing Time Giver, we consider light, social interaction, and representation of temporal information as external cues to audience members within a dynamically evolving system generated using real-time data streams from the audience. Considering the Allosphere as a closed system, each individual in the audience has his or her own biological rhythm, for example, heart-rate and the ratio of Alpha/Theta bands from EEG data. As streaming physiological data is made simple by our BioSync mobile interface [7], we explore artistic multimodal representation of temporal information from the audience in the Allosphere. In addition to rhythmic information from individuals, social interaction is also a consideration, as Zeitgeber contributes to the dynamics within this closed system. To close the feedback loop, internal rhythmic information of the individual participant as well as the group’s aggregate response are used to create real-time stereoscopic visualization and spatial sonification in the Allosphere.

The important concepts in the Time Giver project include:

• audience participation in the making of feedback-based artwork,
• an interface that enables exploring an artistic conversation between heart-rate monitoring and brain-wave monitoring,
• and an evolving system based on initial conditions determined by the timing of audience participation, manipulated by real-time feedback during the unfolding of the artwork.

The novel contributions of this research can be summarized as follows:

• a new technique that allows the creation of feedback-based artwork using biometric data from a large group of participants,
• a novel way to meta tag each participant with a unique smartphone ID using OpenSoundControl,
• and an affordable and scalable audience apparatus of bi-channel and bi-directional communication for feedback-based visualization and sonification.

This is the first experiment of collective expression using the BioSync mobile interface in an immersive environment.
2 Audience as Constituents of a System and Collective Expression

The present idea of audience participation in the interactive arts can be traced back to the 1960s. An early example is found in Roy Ascott's "change-paintings" [22]. Over the years, audience interaction [16] in the context of interconnected musical networks [31] has been facilitated by mobile technologies [15, 32, 14, 8], computer vision techniques [10], web technologies [25, 24], ubiquitous sensing [9, 21], social networking [20, 6], and the trend of convergence of continuous rating and physiological sensing [5, 17, 13, 12, 4]. The AlloBrain project initiated "interface experiments proposing to explore how visualized and sonified fmri data can be integrated into a real-time interactive environment with biofeedback" [30]. The novel solution presented in this paper allows us to further explore real-time visualization and sonification using biometric data from a group of participants with convenient mobile biometrics.

To explore ways to collect information from the audience at a live performance or interactive installation, a modern mobile device like a smartphone has various built-in sensors and is convenient to program applications that can stream data to other applications. With real-time data from the audience, the composer starts to consider audience participation as a compositional technique [11]. In the Time Giver project, the same interaction technique is applied and it aims to explore ways to represent temporal information from a large group of participants in a conceptually enclosed feedback system. As a constituent of the system in Time Giver, each participant in the audience contributes to the dynamics of the system via a smartphone in real-time. There is a unique bi-directional communication in Time Giver, in that each individual is also informed by the group's aggregate response via network broadcasting in the same time as the user sends out rhythmic information.

Collaborative task performance has become a well-discussed topic in such journals and conferences as Computer Supported Cooperative Work and Social Computing (CSCW), and is an important aspect of Time Giver because it aims to explore artistic multimodal representation of real-time data streams from a large group of participants in an immersive environment. The participants work in collaboration in unfolding the artwork. In our first attempt, the experiment carries out an ecological system whose audio/visual representation evolves over time and depends on the dynamics of the crowd. The unique aspect of Time Giver is that it uses multiple types of biological information gathered from the participants as a group to realize the multimedia artwork.

3 Design Concept of Time Giver

The design of Time Giver consists of the audience, the AlloSphere, an audio/visual synthesis engine (AlloSystem C++ toolkit [23]), and mobile biometrics (BioSync iOS app [7] with MindWave Mobile [19]), and Max Msp [1] for data collection and broadcasting. The output of the system is a collective expression of 3D stereographic video projection and 54.1-channel 3D spatial sonification. The multimodal representation from the system output is a function of rhythmic information from audience biometrics as well as the dynamics of the crowd. Biometrics from the audience refers to heart-rate and ratio of Alpha/Theta bands from an EEG, and is captured using mobile devices in real-time.

3.1 Multiple Users in a Controlled Environment

In designing Time Giver, we explore the role of audience participation and biometrics as an interactive installation within the AlloSphere. Conceptually, we think of the audience as constituents of a dynamic system that generates artistic audio/visual content in a controlled immersive environment. The AlloSphere offered a controlled, closed performance space that facilitated a fully multi-user experience. The AlloSphere, a 30-foot diameter sphere built inside a 3-story near-to-anechoic (echo free) cube with a custom-built close-to-spherical screen, allows for synthesis, manipulation, exploration and analysis of large-scale data sets in an environment that can simulate virtually real sensorial perception [3]. Designed to accommodate a group of multiple users, it was an ideal test bed for the first audience-based performance of Time Giver.

3.2 BioSync Mobile Interface

The BioSync iOS app [7] enables convenient biometric data collection from the audience. The BioSync app merges the paradigms of heart-rate and brain-wave into one mobile unit which is scalable for large audience applications. It collects the user’s heart-rate via mobile device pulse oximetry and the EEG data via Bluetooth communication with the off-the-shelf Neurosky MindWave Mobile hardware. A mobile dual-channel pulse oximetry and EEG bi-directional interface for the iOS device (BioSync) was designed and developed for these purposes. Time Giver is the first experiment of collective expression using the BioSync mobile interface in a controlled immersive environment.

With our informed participatory biometric interface (BioSync), each individual contributes to audio/visual content creation while being informed of the crowd’s average response at the same time. Depending on the number of checked-in users, a running average is performed on both the incoming heart-rate and EEG signals. The average of the group’s response is then sent to all clients in OpenSoundControl format. The bi-directional communication in Time Giver is achieved via network broadcasting under a local area network.

3.3 Visualization and Sonification in Time Giver

Biometric data from each audience member is considered as an object that has its own aural and visual representation within the enclosed spherical environment. We consider rotation of objects and the enclosed spherical environment as metaphors that relate to the Zeitgeber idea of cycles and rhythms of time. The time tag of each checked-in audience member is collected and used to determine the initial condition of the audio/visual system as well as the unfolding structure of the artwork. For dramatic perceptual effects, rhythmic information from the audience was used to modulate the initial audio/visual representation during the unfolding of the artwork. The behaviors of these objects were determined by rhythmic information from the crowd and the audio/visual experience of Time Giver is unique to the audience dynamics of each performance.

3.3.1 Visualization

This section gives a description of parameters we used for real-time visualization, including number of connected users, the time tag of each user, and the running averages of both heart-rate and the EEG Alpha/Theta ratio for each user.

The visual design of Time Giver concerns itself with the sense of immersion within the AlloSphere and the connection of visual objects...
determined by audience participation. The number of connected users and the time tag of the checked-in user determines the initial conditions for the visual complexity in the artwork. To associate rhythmic information from the audience to the idea of a Zeitgeber cycle, we mapped heart-rate to the rotation of the object’s spherical texture. The sense of immersion is achieved by the use of a virtual camera in the center of the sphere so that the audience standing on the Allosphere’s 2nd story bridge perceives the cyclic movement of each visual object. With multiple participants, the overlay of transparent spherical textures rotate around the audience while the level of extrusion in the third axis is a perceivable effect of the group’s aggregate response.

Biometric data from each audience member is mapped to the motion and transformation of the spherical textures. The number of spherical textures depends on the number of clients connected, for example, the number of spherical textures increases whenever a new client checks in using the BioSync mobile app. The radius of the spherical texture also increases as the number of connected clients increases. In addition to transformations and rotations, the level of extrusion of the spherical textures is controlled by a running average of all checked-in users’ heart-rates. The eye separation for stereographic rendering is controlled by the ratio of EEG Alpha/Theta bands from all connected users. With stereographic video projection in the Allosphere, Time Giver presents a 3D visual system that evolves in synchronization with the rhythmic information from the audience’s biometrics.

3.3.2 Sonification

The Sonification of TimeGiver is designed around the temporal notions of the collected bio-signals and acts as a Zeitgeber cycle metaphor. The layers of sound synthesis are arranged by establishing a fundamental rhythm found within the lowest frequencies (normally 55-180 Hz) of the sampled data combined with the higher frequency harmonics (greater than 360 Hz) in cyclic motions. The lower frequencies are composed from a running average of the users’ heart-rates and are synthesized by a sine wave that represents the whole audience and unifies the space. This environmental ambient tone is supported by the running average of the user’s EEG data, which iterates through the respective frequencies of the Alpha/Theta ratio and is treated as a set from each user. Each set of EEG data is sonified using FM synthesis, where the fundamental frequency is the current running average of each user’s ratio, the modulation is determined by the signal peak and the magnitude is determined by the total number of users.

There are selected filters that trigger of certain events during the course of the interaction. These include the amount of reverb and delay within the given composition and selected meta-chords, which are made of the users’ EEG Alpha/Theta ratio, where Alpha is mapped to the delay time and Theta to the amount of reverb. A running average of all Alpha/Theta ratios is mapped to the amplitude index and the evolving composition is finally spatialized using 3rd-order Ambisonics through the Allosphere’s 54.1-channel Meyer sound system.

4 Artistic Contributions in Using EEG/PPG Data in Multimedia Artworks

Driven by our interest of using the bio-sensing paradigms of the heart and brain in the generation of multimedia art, Time Giver is our first experiment in creating an artistic conversation among the rhythmic information sources of multiple human bodies in a collective audience. Biometrics has been used for multimedia artworks such as Being Invisible [27], Music for a Solo Performer and Homuncular Homophony [26]. David Rosenboom’s work, along with the previously mentioned work of Roy Ascott, have provided a firm foundation in the generation and analysis of the electro-biological arts, which represents rational methods of these biological oscillators in the motivation, production, and connection of multimedia arts.

Time Giver builds upon this foundation by contributing a novel method for designing multimedia artworks utilizing multiple bi-directional bio-signals within one system; thus scaling the conversation from the one-to-one to the one-to-many in an efficient affordable way. By utilizing mobile biometric tools such as the BioSync interface, Time Giver allows the interaction of the user’s own biometric status within the entire sampled audience thus generating a real-time collaborative multimedia artwork.

5 Evaluation and Future Direction

Time Giver was part of the AlloSphere public exhibition “Shadows In Space” on May 23rd, 2013. It was shown twice, and each time, the size of the audience was roughly 20 to 25 people on the bridge of the AlloSphere. In terms of audience participation, the most challenging logistical problem was to instruct every participant to download our mobile app before coming into the AlloSphere. Instead of a native iOS application, such a problem might be able to be resolved using a browser-based application once an external accessory framework is also supported. This application is currently being developed.

Future research and evaluation of Time Giver will include experimentation in open public spaces where the environment is not closed and controlled as within the AlloSphere instrument. Understanding effects of various mapping strategies on audience perception and its consequence within feedback loops is of great interest to us. Various performance configurations will also be explored, as the sense of immersion will be less in a larger public space, however audience movement and grouping may be better explored as a performance mechanism in larger open environments which could include spatial tracking and movement patterns.

6 Visual Documentation from Shadows in Space 2013

The following visual documentation was taken from the first public showing of Time Giver at a one-night event called Shadows In Space that was held on May 13, 2013 at the California Nanosystems Institute at UCSB. Time Giver had two showings, each with a new audience that was briefed about the project and its components before beginning.

![Image](image_url)
Fig. 5. An audience member uses the BioSync iOS app to interface with Time Giver. The index finger is illuminated from the back of the device.

Fig. 6. Two users stand in the middle of Time Giver wearing active stereographic glasses and holding devices running the BioSync app.

ACKNOWLEDGMENTS

This work was supported by the Graduate Program in Media, Arts and Technology at the University of California, Santa Barbara. The AlloSphere infrastructure is based upon work supported by the National Science Foundation under Grant Numbers 0821858, 0855279, and IIS-1047678. Special thanks to NeuroSky for assisting in the iOS app publishing and Dihlung Kirat for visual documentation and Alan Macy with BioPac for the constant insightful support and feedback.

REFERENCES