Pulse - A Collective Biofeedback Project

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ABSTRACT

Pulse is a collective biofeedback installation aiming to synchronize the heartbeats of its participants, and to provide a direct, visual and aural, experience of the relationship and connection between individual participants and the entity, the body, they collectively form. Biofeedback, defined as "A training technique in which people are taught to adjust the functioning of their autonomic nervous system by using signals from their own bodies."[1] is now widely used in exercise equipment and for therapeutic purposes, and it has to a small extent been used in art (most notably in *Brainball*). Surprisingly, using it in a collective manner is still uncharted territory; this installation intends to explore the potentials of such use. One of the premises of the project is that people can modify functionalities of their autonomous nervous system by receiving direct visual, aural or tactile feedback. Another premise is that synchronization can take place between living organisms. Examples are the blinking of fireflies, women's hormonal cycles, and the cardiac systems of mothers and their fetuses. Pulse combines these in themselves fascinating phenomena into a collective biofeedback installation.

For visuals, sound samples and further explanations see the project web site at http://jevbratt.com/pulse/.

Categories and Subject Descriptors

J.5 [Computer Applications]: Arts and Humanities: Fine arts.

General Terms

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Keywords

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1. PROJECT DESCRIPTION AND CONTEXTUALIZATION

Inside the installation room, the heartbeat rate (BPM) is continuously collected from the participants, who are seated on cushions around the floor, wearing headphones equipped with pulse oximeters. The participants receive feedback through their headphones and an immersive four-wall projection. The aural feedback consists of the averaged heart rate of all participants played as a drum like sound, intending to lower or raise the heart rate of the participant in order to synchronize the group. Single beat sounds are very effective for changing states of minds (and are for that reason used extensively in various shamanistic traditions). Audience who are not participating by wearing the headphones will hear the heartbeats of all the participants played on loudspeakers around the room. Each of the participants heart rates is represented as one rhythm, and by overlaying all the different rhythms, a complex polyrhythmic pattern appear, which could be thought of as an aural moiré pattern.

We are currently investigating a couple of different methods for visualizing the heart rates (only one will be used in the final installation). Both methods create a pattern that will reveal, and potentially raise, the level of synchronization of the group. Since the participants' heart rates are continuously updated the pattern will appear as an animation. In the 'Moiré' visualization each participant's heart rate is visualized as a grid. All grids representing all participants are overlaid to compose one image. The grids will create moiré patterns as a result of thicker lines produced when the lines in two (or more) grids nearly overlap. The patterns that occur will reveal the combined frequencies of the different heartbeats, and in one glance allow us to see when the heart rates are closer to synchronization. In the 'line wrap' visualization, each participant's BPM is visualized as a line of dots spaced according to their BPM. By "wrapping" the line of dots patterns appear. The cutoff point is a multiple of the averaged heart rate. The BPM of participants whose heart rates are synchronized with the average BPM of the group, will appear as straight vertical lines. The ones that are getting close to a state of synchronization will appear as lines with various angles, while no discernible pattern will appear from heartbeats that are far from the average.

The project is a response to a growing interest in networks and other connecting principles in fields ranging from sociology to computer science and biology. As our technologies now allow us to truly experience macro and micro and ways of rapidly moving between these levels, we are becoming increasingly interested in how the details on the micro levels form a whole on the macro level. *Pulse* aims to create a tangible experience of the relationship between individual entities and the networks they form and act within.

While biofeedback is now commonplace in exercise equipment, stress relieving consumer products, and therapeutic contexts, it is typically not used in a collective fashion examining, and creating, connections between participants. *Pulse* intends to expand the use of biofeedback to enable its participants to experience connections to others. Most interactive art work involving sensor input from bodily functions uses the input more or less as an alternative mouse – as a way of intentionally maneuver a software. *Pulse* differ from "alternative-interface" sensor projects in that it is using aspects of our bodies that we cannot control intentionally, functions that are controlled by the autonomic nervous system. The cardiac system is specifically interesting to work with because it is highly interconnected with our whole organism and the environment in which it live. Its rhythm is the top of an iceberg of hormonal processes, environmental facts, metabolic rate, posture, stressful or delightful experiences. Apparently, the heart rate is such an intrinsic measurement of a being's "life-force" that the total amount of heart beats in a lifetime is almost the same for a vide range of species [2]. It is as if we all, humans, elephants and mice, have the same amount of "life-force" to use. There are also evidences of that the rhythms of our hearts are connected to the rhythms of other individuals. Studies of fetuses and their mothers indicate that couplings, synchronizations, of their cardiac systems take

place in the womb [3]. *Pulse* creates a situation where we might be able to experience such synchronization directly.

2. RELATED WORK

Brainball by The Interactive Institute in Sweden is one of the few art projects that utilize biofeedback in any way. In *Brainball* two opponents are competing in a ball game using only their brain, creating a "feedback loop" between the two participants. The opponents are hooked up to EEG equipment on opposite ends of a table. The ball moves towards the goal of the participant who is the least stressed, and the winner of the game is the person who manages to remain relaxed throughout the course of the game.

3. TECHNICAL DETAILS

The installation will consist of several interlinked subsystems that take care of gathering data from the participants, analyzing it, and generating visualizations and sonifications as described above. (Fig 1). Most of the needed bio-medical equipment has already been secured thanks to a generous donation from BIOPAC Systems, Inc. in Goleta [4]. This includes the necessary transducers, amplifiers, and interfaces to measure electrocardiogram responses from human subjects.

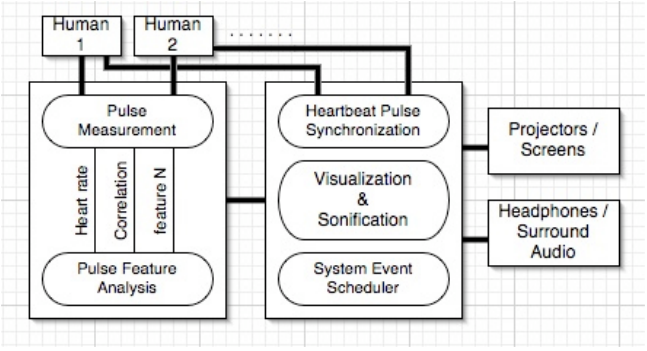

Figure 1: System block diagram for the Pulse collective biofeedback installation.

3.1 Pulse Measurement and Analysis

During our experimentation and evaluation of the various methods of detecting heart rates for this project, we first tried an electrocardiogram setup that used three electrodes placed on the arms. While this method proved very effective in providing detailed and accurate measurements of the wearer's hearbeat, it required an overly complex process of applying the electrodes that would be inappropriate in an installation setting.

Measurements provided by a photoelectric pulse oximeter plethysmograph proved to have somewhat less detail in the sensor acquisition, but the custom electronics provided by BIOPAC make the signal still quite useable. The transducer itself comes in two forms; one uses velcro to attach to the user's finger, and the other, which we most likely will use, is an ear-clip that attaches to the user's ear lobe. In both cases, the transducer consists of a matched infrared emitter and photo diode, which transmits changes in infrared reflectance resulting from varying blood flow. The signal is then sent to an amplifier to record the pulse pressure waveform. We will use eight of these pulse oximeter plethysmographs in our installation integrated into headphones for the participants.

The system will take the measurements from multiple participants and analyze the individual heart rates, averaging them for the sonic biofeedback and feed them to the overall visualization and sonification.

4. CONCLUSIONS& FUTURE WORK

A potential future development is to make the biofeedback system wireless and distributed. Small wearable devices equipped with electrodes would be used to record the heartbeats of the participants. Using a wireless network, the recorded heartbeat is transmitted from the device to a central computer. In an optimal version of the project the participants should be able to move around a large area, such as the downtown of a city. The participant receives feedback in their ipod or cell phone audio player. This system would allow people to create large distributed organisms together.

5. ACKNOWLEDGMENTS

Alan Macy of BIOPAC Systems, Inc. has provided equipment for the project.

6. REFERENCES

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