CAPTURING AUDIENCE EXPERIENCE VIA MOBILE BIOMETRICS

Yuan-Yi Fan

University of California Santa Barbara
Media Arts and Technology
3309 Phelps Hall Santa Barbara California 93106
dannyfan@mat.ucsb.edu

René Weber

University of California Santa Barbara
Department of Communication
4405 SS&MS Building Santa Barbara California 93106
renew@comm.ucsb.edu

ABSTRACT

Different from computer vision based approaches in audience participation research, such as in Glimmer [1] and in Flock [2], this paper presents a mobile approach to collecting and visualizing bodily responses from audience members. A mobile biometric application is designed as a novel medium that interfaces audience members to experienced content. To realize our goal on a mobile platform, a combination of video-imaging-based heart rate measurement and Zeroconf networking technology [3] (Bonjour) is implemented. As a proof of concept, we successfully collect continuous heart rate values from 3 mobile phones devices simultaneously and use the derived heart rate statistics to drive artistic audio and visual rendering. Preliminary results include two iOS applications and two mobile-biometric-enabled media arts installations.

1. INTRODUCTION

Similar to the use of biometrics in electronic art [4], a novel mobile biometrics system is designed and implemented in this paper. In designing public interactive interfaces in settings like theatres, galleries, theme park, and museums [5], our mobile biometrics provide a new design parameter that captures audience or spectators' bodily response. We first review the use of technology in audience participation and response research in the fields of affective computing [6], electronic arts [7], and collaborative musical experiences [1][2][8]. Then, we propose the use of a mobile biometric application as a probe to measure audiences bodily responses and demonstrate electronic artistic applications we implemented based on our mobile biometrics. Third, the design and implementation is described. Fourth, we present a preliminary evaluation of our mobile heart rate measurement implementation using a commercial Photoplethysmograph sensor (Biopac System Inc. [9]). Finally, future research directions and final thoughts are discussed.

2. CAPTURING AUDIENCE EXPERIENCE

Tools that allow participation of large audiences in electronic art applications have become an emergent field of research [8]. A real-time response device for collecting listeners' impressions on a temporal arts piece has been discussed in [10]. The type of biometrics we choose to implement in this study is a mobile heart rate monitor using the built-in camera of mobile phone devices. Our implementation is non-invasive because we are using an optical signal. Mobile biometrics and imaging-based biometrics, particularly heart rate measurement, have recently become emergent in both academic and in commercial circles due to recent advancement in software design and the miniaturization of the necessary hardware [6] [11]. The issue of scalability has been addressed in designing such a system for interactive audience participation [12]. We intend to introduce our mobile heart rate monitor as valid indicator of audience members arousal states. The main advantage of our mobile biometrics is its simple deployment and use in public interactive multimedia installations. This paper aims to explore the design and validity of such an unobtrusive, real-time audience participation system

2.1. Design

Existing biometrics-based electronic art installation have been restricted to either wired physiological data acquisition equipment [6] or limited to only one individual, as opposed to audience members in a real-time and aggregated fashion [25][26]. Application in the current affective computing field has personal heart rate monitoring devices on mobile platforms [10][11], which inspires us to extend such optical sensing approaches with network streaming capability. Our overall design objective is to create a tool that enables experiential design in the context of electronic art that takes into account the bodily responses of the audience members. The scenario we consider is a setting such as an interactive installation or an electronic art concert that uses audience participation or audience response technique as a design parameter. Specifically, the use of available mobile phone devices will provide a sense of feedback and control for audience members which is likely to increase the audiences participation in the event. To achieve such a design objective, a mobile biometric application that is easily deployable and measures the audience members' heart rate unobtrusively and in real-time is required.

2.2. Implementation

The system implementation consists of three parts. First, an iOS application utilizes the built-in camera of the mobile device in measuring the users heart rate. Second, Bonjour is implemented so that the network connection can be set up with minimal configuration steps. After network connection is set up, the heart rate value can be transmitted back to server via OpenSoundControl (OSC) [13] in real-time. Last, a server-side application capable of receiving heart rate values from audiences mobile device is implemented in a Max/MSP [14] environment. For the heart rate measurement, audience members have to place the index finger of their dominant hand on the mobile devices camera lens (see Figure 2). Thereafter, the iOS application accesses each video frame

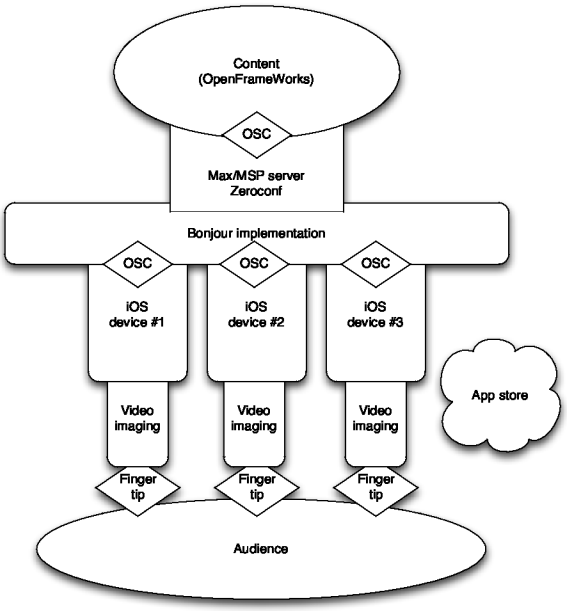

Figure 1: System design

from the built-in camera, and uses a finger-blood-volume-pulse signal in combination with a heart rate detection algorithm similar to that implemented in the Heartphone project [9] to compute the audience members heart rate. To enhance the performance of the heart rate measurement on a mobile device, we use the devices flashlight when acquiring the finger-blood-volume-pulse signal is in acquisition. To realize Zeroconf networking implementation on an iOS platform, Bonjour is implemented in our application. This makes it possible to connect to a server in a local area network with one-click on the user interface and it greatly reduces the configuration steps in setting up the server IP and port number. Finally, it uses our mobile biometrics to scale a 3D animation rendering as an example of the technologys capability. Intuitively, a 3D human heart model is animated based on the computed heart rate statistics. Visualization is done using OpenFrameWorks C++ Toolkits [15]. Our prototype system is implemented using a laptop that runs Max/MSP as server and three iOS mobile phone devices (iPhones) as clients. As our first prototype, the system is currently restricted to work within a Local Area Network (LAN), but later implementations will make it possible to deploy the system via an internet protocol.

3. PRELIMINARY RESULTS

As a working prototype of our system, the Max/MSP application running on the server successfully collects continuous heart rate values from 3 iPhones and uses the computed statistics for artistic graphics rendering. In Figure 3, we show an application that scales a human heart model based on incoming heart rate values from our mobile biometric application. So far, our mobile biometrics have been used in two iOS applications and two public media arts installations. The two iOS artistic applications are BioCymatics and HRclient, and the two public media arts installation are Ambient

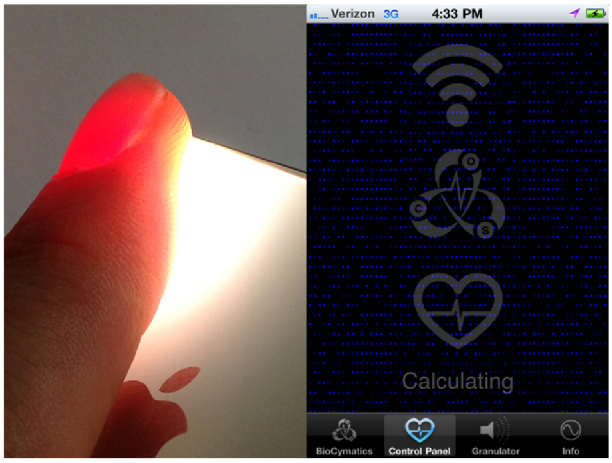

Figure 2: The image on the left illustrates where user should place his/her index finger for the heart rate measurement. The image on the right shows the user interface of our mobile biometric application.

Vision and Fight Or Flight.

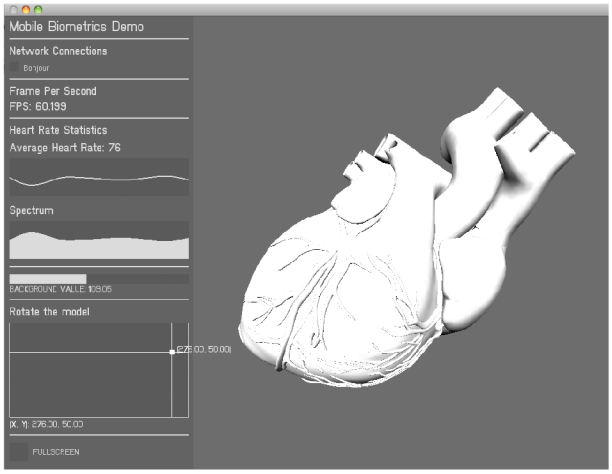

Figure 3: Intuitive 3D heart model is animated based on input signal from our mobile biometrics application. The control interface is implemented using OpenFrameWorks addon ofxUI [16]

The BioCymatics app explores the artistic use of biometric feedback signals (see Figure 2), such as using heart rate values to drive the graphical rendering of Cymatic patterns [17] and granular sound synthesis [18, 19]. In Figure 4, Ambient Vision [20] is an interactive audiovisual installation that addresses rippled mental images as the product of perceived stimulus and the internal bodily responses. The internal bodily responses refer to the heart rate collected using our mobile biometric iOS app HRclient while the external perceived stimulus is reconstructed based on information from Microsofts Kinect sensor. Throughout the installation, all software is configured remotely. During the exhibition, the spectator could easily participate in the exhibition by download-

ing the HRclient from app store freely. The above two examples demonstrate the design of our mobile biometrics application for both application designer and spectator participation in electronic art application. Fight Or Flight [21, 22] is another public installation that uses HRclient app. When the collected heart rate value from HRclient app exceeds certain threshold, it triggers a Boid swarming algorithm [23] to change between the calm state and chaotic state.

Figure 4: Interactive installation that uses the 3rd version of the mobile biometric application. Ambient Vision at Collider media arts series exhibition, Akron, Ohio, March 29-31, 2012 [20]

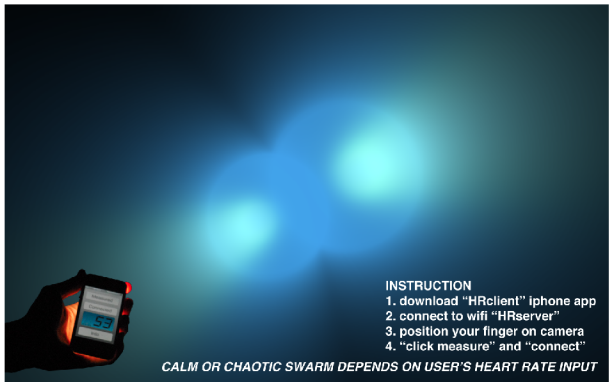

Figure 5: Interactive installation that uses the 3rd version of the mobile biometric application. Fight or Flight at UCSBs PRIMAVERA of Contemporary Arts and Digital Media, April 9-12, 2012 [21]

4. DISCUSSION AND FINAL THOUGHTS

Feedback from public installations that use our mobile biometric application is generally positive. In setting up Ambient Vision at Collider exhibition, we received good feedback from gallery staff for that we didn't have to ship bio-sensing equipment to the installation site. Since we deployed our mobile biometric application via the App Store, it reduced the potential complex software and hardware configuration as well as the equipment shipping insurance. One common negative feedback from user was our heart rate

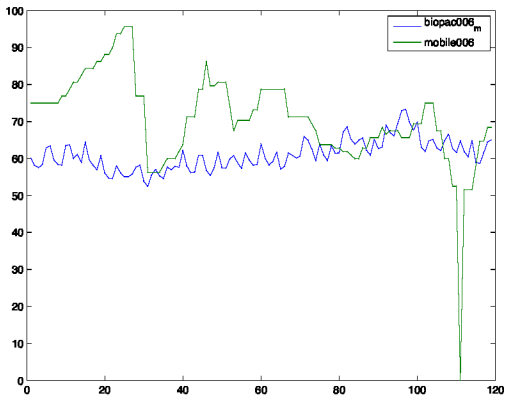

Figure 6: The blue line represents heart rate data collected using a commercial Photoplethysmograph sensor (Biopac System Inc. [9]), and the green line represents data collected using our mobile biometric application.

measurement is sensitive to motion artifact and background ambient light conditions. Although heart rate signal has long been used in the electronic art [7] and sonification field [24], our mobile biometric application is novel for its networking capability and ease of use in measuring heart rate. The system described in this paper enables research in techniques for aggregating audience input [12] and in other facets of the audience experience [5], such as interactive spectator and performer awareness. Future works involve the improvement of the heart rate measurements accuracy, large-scale installation based on our mobile biometric application, exploring the use of bodily responses in designing audience experience, and the use of mobile continuous self-reports in combination with our mobile heart rate monitor.

5. ACKNOWLEDGMENT

The author thanks Charlie Roberts for help with the iOS development.

6. REFERENCES

[1] J. Freeman, *Glimmer for chamber orchestra and audience*, PhD dissertation, Columbia University, 2005.

[2] J. Freeman, "Creative collaboration between audiences and musicians in Flock," *Digital Creativity*, Vol. 21, No.2 pp. 85-99, 2010.

[3] `http://en.wikipedia.org/wiki/Zero_configuration_networking`.

[4] R. McGee, Y.Y. Fan, and S.R. Ali, "BioRhythm: a Biologically-inspired Audio-Visual Installation," in *Proceedings of the International Conference on New Interfaces for Musical Expression*, University of Oslo and Norwegian Academy of Music, 2011, pp. 80-83.

[5] S. Reeves, S. Benford, C. OMalley, and M. Fraser, "Designing the Spectator Experience," in *Proceedings of the SIGCHI*

conference on Human factors in computing systems CHI 05, ACM Press, New York, 2010, pp. 741.

[6] M.Z. Poh, K. Kim, A.D. Goessling, N.C. Swenson, C. Nicholas, and R.W. Picard, "Heartphones: Sensor Earphones and Mobile Application for Non-obtrusive Health Monitoring," *2009 International Symposium on Wearable Computers*, pp.153-154, 2009

[7] http://www.lozano-hemmer.com/projects.php.

[8] J. Freeman, "Large Audience Participation, Technology, and Orchestral Performance," in *2005 International Computer Music Conference*, International Computer Music Association, 2005, pp. 757-760.

[9] http://www.biopac.com.

[10] M. Stephen, W.V. Bradley, V. Sandrine, K.S. Bennett, and R. Rogger "Influences of Large-Scale Form on Continuous Ratings in Response to a Contemporary Piece in a Live Concert Setting," *Music Perception*, 22(2), pp. 297-350, 2004.

[11] http://www.instantheartrate.com.

[12] D. Maynes-Aminzade, R. Pausch, and S. Seitz, "Techniques for Interactive Audience Participation," in *Proceedings Fourth IEEE International Conference on Multimodal Interfaces (IEEE Comput. Soc)*, pp. 15-20, 2002.

[13] http://opensoundcontrol.org/spec-1_0.

[14] http://cycling74.com.

[15] http://www.openframeworks.cc/.

[16] http://www.syedrezaali.com/blog/?tag=addon.

[17] J. Hans, *Cymatics: A Study of Wave Phenomenon and Vibration*, Newmarket, NH: MACROmedia, 2001.

[18] C. Roads, *Microsound*, MIT Press, Cambridge, Massachusetts, 2001.

[19] http://www.lifeorange.com/.

[20] http://collider.co/art/yuan-yi-fan-emily-davis-gallery/.

[21] http://www.ccs.ucsb.edu/primavera/FightOrFlight.

[22] http://en.wikipedia.org/wiki/Fight-or-flight_response.

[23] C.W. Reynolds, "Flocks, Herds and Schools: A Distributed Model," *Computer Graphics*, 21(4):25-34, 1987.

[24] Y. Nagashima, "Bio-sensing System and Bio-feedback System for Interactive Media Arts," in *Proceedings of the International Conference on New Interfaces for Musical Expression*, pp 48-53, 2003.