Demonstration: Listen to Yourself and Others – Multiuser Mobile Biosignal Sonification Platform EMOListen

Ilkka Kosunen[1], Kai Kuikkaniemi[1], Toni Laitinen[1], Marko Turpeinen[1],

[1] Helsinki Institute for Information Technology (HIIT)
PO Box 19800, 00076 Aalto, Finland
{kai.kuikkaniemi,ilkka.kosunen,toni.laitinen,marko.turpeinen}@hiit.fi

ABSTRACT

EMOListen is a multiuser mobile biosignal sonification platform. Biosignal adaptation has gained a lot of recognition in recent years both in academia and within industry. However, experimentations rarely involve multiuser systems, and they do not consider audio as the adaptation target. Biosignal sonification is a relevant domain, because audio can be used in adaptation with high temporal accuracy, can be associated to several biosignals, and can be used as a secondary stimulus, enabling long term and out-of-laboratory experimentations. Multiuser mobile sonification system can be used for creating sense of telepresence and mediated body language.

General Terms

Design, Experimentation, Human Factors,

Keywords

Biosignal, multiuser, mobile platform, sonification, audio signals, biofeedback, adaptive system, playful interaction

INTRODUCTION

During the last ten years there has been phenomenal progress in the development of adaptive biosignal interfaces. For example, the work at the University of Pittsburg MotorLab by Andrew Schwarz [1] and his team that demonstrated a monkey self-feeding with a large BCI controlled robotic arm has gained much attention. Swartz demonstration is highly technical and requires laboratory condition. Then again companies like Emotiv[1] and NeuroSky[2] have been very visible with press releases and demonstrations related to their easily accessible BCI kits for fun and leisure applications. A few commercial products have used biosignal sensing as means of player-game interaction. Star Wars Force Trainer[3] was very popular Christmas presents in the United States in 2009. Nintendo has several times shown some material about their potential new interface called Nintento Wii Vitality sensor[4], which is probably a combination of heart rate (peek-to-peek via pulse oximeter) and GSR[5] sensor. Actually, a similar product called the Lightstone sensor bundled with the game "Journey to Wild Divine"[6] has been on the market since 2001.

Also in academia there has been quite significant amount of interest in this field. This is shown by the existence of several workshops such as Brainplay at ACE 2006 [2], Enterface [3], and Brain-computer interfaces for HCI and games in CHI 2008 [4]. Also, for example several large EU projects have explored the domain of biosignal adaptation (FUGA, CALLAS, TARGET, PRESENCE, PASION). Starting from a pioneering book by Picard [5] to fairly recent review article by Fairclough [6] we have seen several research statements and projections of the vast potential use of biosignals in HCI and games. As a summary, we can say that many companies and academia develop biosignal control or adaptive applications for several different purposes, they gain a lot of press attention, and people are already interested trying them also at home.

1. RESEARCH METHODOLOGY

Even though there has been quite much activity around biosignals, there are two elements that are mostly ignored in the commercial products as well as in academic experiments. First of all, social applications of biosignal adaptation are left yet relatively unexplored. Second, most of the biosignal adaptation targets are related to

Fun and Games 2010, September 15-17, 2010, Leuven, Belgium.

[1] Emotiv EPOC. http://emotiv.com

[2] NeuroSky Mindset. http://www.neurosky.com

[3] Star Wars Force Trainer is a toy device, which utilizes EEG interaction. System is developed by Uncle Milton

[4] Nintendo Wii Vitality sensor is a prototype presented by Nintendo Corporation for example in E3 conference.

[5] GSR = Galvanic Skin Response. Also known as EDA = Electrodermal Activity

[6] Wild Divine relaxation system. http://www.wilddivine.com

visualization or game interaction mechanisms. Sound is a powerful adaptation target, and useful in case of biosignals for several reasons: the temporal accuracy of sound is high, it is possible to deliver many simultaneous signals through sonification, and sound can be used as a secondary feedback channel parallel to other activities. For example, the sonification of biosignals can alert the user of increasing stress level or drowsiness. Furthermore, even though there is a lot of experimentation, there are only few experiments where subjects would have been exposed to biofeedback adaptive applications for longer periods than few hours in laboratory. For this reason we have developed a platform with the following properties:

- Capable of producing *simultaneous real-time sonification* of *multiple biosignals*;
- Both the sonification device and biosignal capturing systems are *mobile*;
- *Network connected* and capable of distributing biosignals among *multiple clients*;
- Configurability of sonification settings.

EMOListen is one of several biosignal adaptive prototypes that we have developed. Our earlier prototype experimentations have shown that the explicit biofeedback mechanisms are effective, they elicit positive responses to user, and users are able to learn to control the biofeedback [8]. On the other hand, we have realized that it is very hard to make definitive interpretation from biosignal readings even in laboratory conditions, not to mention in a real-world context. For this reason the longitudinal experiments are interesting. We plan to experiment how the sonification and other stimuli induce biosignal synchrony. The concept of biosignal synchrony can be used to understand social experience. In multi-user adaptive systems synchrony can be used as a group behavior measure and source for adaptation. In addition to the synchrony and biofeedback experimentations, we believe that multi-user biosignal sonification application can be an entertaining and social web system, and a valuable add-on to existing social media and presence systems. While developing entertaining sonification applications, we are not restricted in using only biosignals, but EMOListen platform supports easily other context signals such as location, movement and device use metrics.

2. SYSTEM

EMOListen platform is found from figure 1. The system includes basically four parts: biosignal sensors, biosignal processing software, multiuser architecture and sonification component.

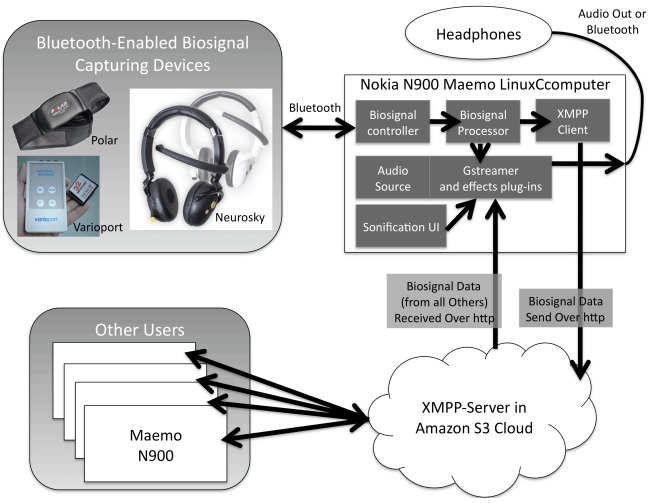

Figure. 1. EMOListen system illustration describes the overall system design, available biosignal capturing devices, and the internal system architecture in the Nokia N900 Maemo Linux computer.

2.1 Biosignal Sensors and Processing

Currently we have developed EMOListen system primarily for two hardware components: Varioport biosignal capturing device and Nokia N900 Maemo Linux mobile computer. Varioport is capable of capturing several different biosignals, such as EEG, ECG, GSR, EMG and Respiration[7]. Varioport and N900 communicate via specific protocol over Bluetooth. In addition we have implementations for NeuroSky MindSet[8] EEG sensor and Polar for Nokia Bluetooth[9] heart rate band. Each of these sensors is wireless and have unique affordances. Each sensor also requires dedicated software implementation and processing.

2.2 Biosignal Sonification

For Biosignal Sonification we use Gstreamer multimedia framework[10]. Basically we either compose sound by using sample files or sine-wave generators as a sound source. We can either change the original sound source based on biosignals or then the sonification parameters are connected to various audio effects plug-ins (echo, reverb, band-pass) implemented on top of Gsteamer. There can be several simultaneous audio sources, and each audio source can be connected to several effect plug-ins. We have implemented a graphical user interface (UI) for managing how biosignals are connected to audiosource, and what kind of

---

[7] Psychophysiological signals are usually measuring skin-related electrical activity

EMG = Electromyography , EEG = Electroencephalography, ECG = Electrocardiography

GSR = Galvanic Skin Response (also known as EDA = Electrodermal Activity)

[8] NeuroSky Mindset is a headphone mounted single electrode EEG sensor kit: http://www.neurosky.com

[9] Polar for Nokia is a Bluetooth band distributed together with Nokia N79. System is not commercially available.

[10] Gsteamer: http://www.gstreamer.net

sonification parameters are used. This way the user can tune the sonification parameters based on own preferences.

2.3 Mobile and multiuser platform

EMOListen platform can be used in two modes: listen to yourself (single user) or listen to others and yourself (multi user). The multiuser functionality is implemented by utilizing XMPP server system. XMPP is primarily designed for messaging and presence services, but due to easy scalability, robustness and performance, we have decided to use it also as a server back-end to the EMOListen. Alternative approach would have been developing traditional client-server architecture. XMPP allows easy extensibility to new types of signal sources and enables us to integrate EMOListen to our other prototypes that utilize the similar server setup.

3. REFERENCES

[1] Velliste M, Perel S, Spalding MC, Whitford AS and Schwartz AB. (2008) Cortical control of a prosthetic arm for self-feeding. Nature (2008) 453:1098-1101

[2] Nijholt, A. and Tan, D. (2007), Playing with your brain: brain-computer interfaces and games Proceedings of the international conference on Advances in computer entertainment technology, ACM, Salzburg, Austria, 2007.

[3] Camurri, A. et al (2009). Enterface workshop 2009. http://www.infomus.org/enterface09/. See also other Enterface workshop: http://www.enterface.net/

[4] Nijholt, A., Tan, D., Allison, B., Milan, J.d.R. and Graimann, B. Brain-computer. (2008), Interfaces for hci and games CHI '08 extended abstracts on Human factors in computing systems, ACM, Florence, Italy, 2008.

[5] Picard, R.W. (1997). Affective computing. MIT Press, Cambridge, MA.

[6] Fairclough, S.H. (2009) Fundamentals of physiological computing. Interacting with Computers, 21 (1-2). 2009, 133-145.

[7] Kuikkaniemi, K., Turpeinen, M., Laitinen, T., Saari, T., Kosunen, I,. Ravaja, N. (2010). Influence of Implicit and Explicit Biofeedback in First-Person Shooter Games. In Proc. CHI 2010, ACM Press.