Brain and Body Interfaces: Designing for Meaningful Interaction

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Abstract
The brain and body provide a wealth of information about a person's physiological, cognitive and emotional states. There is an increasing trend to use physiological signals in computerised systems as an input control, and as entry level physiological sensors become more widespread, physiological interfaces are liable to become more pervasive in our society (e.g., through mobile phones). While these signals offer new and exciting means for controlling interactive systems, little questioning has been done whether or not these physiological interfaces are appropriate for applications and to what extent the end-user finds the interaction meaningful. This workshop sets out to bring together researchers working in the psychophysiological interaction field for discussing the nature of making physiological interactions meaningful for users.

Keywords
Physiological computing, BCI, biocybernetic adaption, ambulatory monitoring, meaningful interaction

ACM Classification Keywords
H.5.2 User Interfaces: Input devices and strategies;
B.4.2 Input/Output Devices: Channels and controllers;.

Introduction

Physiological interfaces are currently undergoing a boom in popularity as sensor technology is becoming cheaper and more convenient to use (i.e., wearable). Therefore, brain and body interactive systems are being experimented with in a wide range of different application domains, from health and fitness to entertainment and self-experimentation [4,6]. Physiological interaction has traditionally been used as medical tool, for example as an alternative form of input control for disabled persons or a form of psychological state management (i.e., biofeedback therapies). Of late physiological interfaces have focused on exploring what benefits these types of interactions offer healthy people. For example: in task performance [1] and entertainment [2,6]. Physiological interactive systems (or computers) are still in their explorative phase, as prior limitations in sensing technologies have limited the deployment of physiological computers (PC) to controlled environments [5]. However, since sensors become less of an issue, it is easier to explore what type of user experiences can be facilitated with physiological signals.

Categories of Physiological Computers

There is a broad range of different types of physiological computing systems. In Figure 1, an attempt to capture the different categories of how we understand PC systems has been made. The first category refers to conventional input devices, for example, a mouse and keyboard, and body tracking. The second category refers to muscle interfaces such as cursor control via gaze movement in eye tracking systems. Most of these interfaces use electromyography (EMG) to capture the electrical activity in a specific muscle, which is then translated into a system command.

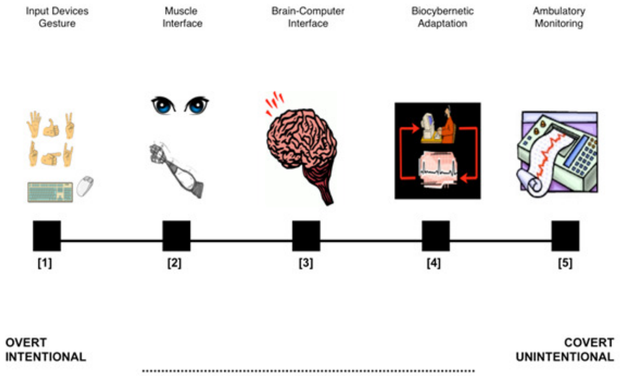

Figure 1. Categories of Physiological Computer Systems

The third category refers to brain-computer interfaces (BCI) where brain activity is used to drive a computer system. These three categories of system refer to overt and intentional control at the computer interface. The other two categories adopt a 'wiretapping' approach where physiology is monitored covertly in the absence of intentional control on the part of the user, sometimes for evaluating user experience facets such as emotion. The fourth category, biocybernetic adaptation, refers to those systems that passively monitor psychophysiological changes in the user related to cognition, emotion and motivation to inform real-time software adaptations. The final category, ambulatory monitoring, refers to the continuous collection physiological data via wearable sensors. Physiological data is inherently multidimensional, reflecting physical activity and health as well as psychological variables. Ambulatory monitoring based systems incorporate telemedicine applications and software designed for self-tracking and personal informatics. The fore mentioned categories of physiological computer are intended to describe an open continuum rather than an exclusive taxonomy of unique systems.

Designing for Meaningful Interaction

With any new technology, the drive to experiment is strong, and various physiological interaction types have been tested, though not all have been successful. Previously, we have been asking, can we adapt physiology signals into interactive systems and for what can we use them? However, as PC matures, we need to start asking what type of interaction is "actually" suitable for the user given a situation. To put it another way what brings meaning to the user experience of a physiological interface? For example, a physiological signal such as EEG could be used as a direct input control and thereby used to replace a conventional input device like a keyboard. For a person with limited hand motor control, this type of physiological interface would be ideal. However, for healthy users, an EEG interface will not provide them with the same fidelity of real-time control a keyboard would and subsequently would be a poor replacement. Nevertheless, such an interface is ideal for supporting multi-modal user experiences where the addition of a secondary control loop provides more control actions [3]. Discovering those relationships between a physiological signal and the control of an interactive system that provides a meaningful, user experience is going to be the next research challenge in PC.

Workshop Goals

This workshop will bring together researchers working on brain and body interactive systems. The goals of this workshop are as follows:

- Provide a platform to promote a shared understanding of the issues addressing physiological interaction between the various research strands, for example BCI and adaptive software.
- Provide a forum to discuss and exchange information on the technologies and techniques involved in developing physiological interfaces.
- Provide a forum to discuss the user experience in manipulating a physiological interface and how do we evaluate its effectiveness as an input control.
- Build upon the emerging online PC community[1], which provides current and new researchers a means to promote and exchange their ideas in a less formal setting.

We are inviting technical contributions from researchers working on physiological interaction in HCI. Submissions are welcome from all facets of PC. This workshop is aimed at defining common ground between the various strands of PC research in order to promote synergy and shared understanding. Through this, we hope that this shared information will lead to a deconstruction of the system concepts presented in Figure 1 in order to better promote mash-ups and novel forms of physiological interaction, such as muscle interfaces, biocybernetic adaptation, and avoid the community covering the same ground (e.g., tackling sensor design issues).

Workshop Submissions

This workshop is inviting technical contributions on the following three topics, relating to the research challenge outlined earlier on:

[1] e.g. http://physiologicalcomputing.net, http://groups.google.com/group/brain-body-interfaces

1. An Application Approach to Sensor Design

The design of a sensor at the hardware and software level defines the type of application for which the device is suitable. In medical and psychophysiological research, high-resolution data capture under laboratory conditions is the standard. However not every type of physiological computer requires such high-grade equipment and many of these systems must work in the field. Perhaps the physiological variable that needs to be captured to drive a system does not need to be very sensitive or requires a level of robustness to work outside of the laboratory. The application domain defines the requirements of the sensor and thereby the type of hardware and software support required. In submitting under this topic, we ask researchers to consider how the nature of the application influences the specification of the measures needed to infer a given user state and thereby to what extent an application can achieve its goals in a given environment. For example, a heart rate sensor combined with an accelerometer allows physical effort to be removed from changes in heart rate, allowing cognitive and emotional effects to be processed.

2. Meaningful Interactions with Physiology

A physiological computer can define the relationship between the changes in a physiological signal and a system command in any number of ways. However, certain relationships between the physical and virtual will be more usable if they are made meaningful for the user (i.e., a natural interaction). For example, increases and decreases in psychological activation should lead to changes that are both appropriate and intuitive at the interface. In submitting under this topic, we ask researchers to consider what defines a meaningful physiological interaction, types of meaningful interaction, the role of a measure's sensitivity in defining a meaningful interaction (e.g., what does a measure of average heartbeat rate provide or lose over a more sensitivity measure of heartbeat rate in lieu of a psychophysical variable being monitored) and methods to evaluate psychophysiological interactions.

3. Ethics and Privacy

Physiological data of users are a highly personalised and private source of information. The storage and/or manipulation of these data can pose certain ethical concerns. For example, the uploading of physiological statistics to an online forum outside a medical context may lead to unsubstantiated self-diagnosis. In submitting under this topics, we ask researchers to consider the ethics and privacy issues involved in the storage and/or manipulation of a users physiology (e.g., in biocybernetic adaptive systems) to what extent can the user's state be manipulated?

References

1. Pope, A., et al. (1995). "Biocybernetic system evaluates indices of operator engagement in automated task." *Biol Psychol* 40(1-2): 187-195.
2. Gilleade, K., et al. (2004). Using Frustration in the Design of Adaptive Videogames. *ACE 2004*, ACM.
3. Nijholt, A., et al. (2009). Turning shortcomings into challenges: Brain-computer interfaces for games. *Entertainment Computing* 1(2): 85-94.
4. Girouard, A., et al. (2010). Brain, body and bytes: psychophysiological user interaction. Proc. of CHI extended abstracts, ACM, 4433-4436.
5. Fairclough, S.H. (2009). Fundamentals of physiological computing. *Interact Comput*, 21(1-2): 133-145.
6. Kuikkaniemi, K., et al. (2010). BioS-Play: Workshop on Multiuser and Social Biosignal Adaptive Games and Playful Applications. Fun and Games 2010 Workshop. Leuven, Belgium. ACM.