BrainGain: BCI for 'Healthy Users'

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CHI 2008, April 5 – April 10, 2008, Florence, Italy+
ACM 1-xxxxxxxxxxxxxxxxxx.

Abstract
In this position paper we describe the Dutch BrainGain research project and our planned research in this project. We focus on Brain Computer Interfacing (BCI) research for healthy users. In the BrainGain project our task is to look at HCI aspects of BCI applications, to look at multimodal interactions that include BCI interactions, and to design games, game environments and game interfaces that allow BCI interactions.

Keywords
Brain-Computer Interfacing (BCI), Human–Computer Interaction (HCI), Multimodal Interaction, Game Design, Game Environments

ACM Classification Keywords
H5.2. Information interfaces and presentation (e.g., HCI): User Interfaces (D.2.2, H.1.2, I.3.6).

Introduction
BCI (Brain-Computer Interfacing) has become a research topic in computer science and, in particular, human-computer interaction. In 2007 a large scale BCI project has been approved in the Netherlands. This BrainGain project (http://www.nici.ru.nl/braingain/) started in September 2007 and is funded by the Dutch government with 14 million Euro. Part of this funding is assigned to BCI research for the 'healthy user'. That is, research that does not necessarily aim at results and

applications for disabled users (see also [4]). In the project description it is mentioned that:

- The psychiatric and neurological professionals in the consortium also want to investigate the use of modern methods of analysis of brain signals for specifically developed therapies. These developments could also be applied to the needs of healthy users, in terms of health, performance, or quality of life. The costs of stress to the society are high, and learning to relax, concentrate or meditate could provide a useful application of BCI for healthy users.

And there is an economical perspective too:

- In order to also create an economical impulse, the consortium will develop a broad range of applications, which will allow healthy users to also benefit from the newly developed technologies. Possible applications include entertainment, such as computer games driven by brain signals. Or, in more professional surroundings, to present information on a computer screen only when visual attention is detected, such as might be useful for air traffic controllers or customs officials checking scanned luggage.

BCI for Healthy Users: Introduction

From [1]: "Also, the elderly in general and the 100 million baby boomers in specific –in control of the largest concentration of funds than any other demographic group– will demand longer life, personalised health care, intelligence and memory support, and improvement of their senses and mobility." Future interfaces will allow us to communicate at an emotional and intentional level. Sensors and actuators will be integrated everywhere in our environment. They will capture verbal, nonverbal, physiological, and brain information and this information will be processed and interpreted in order to support the users in their daily activities.

Obviously, also in professional environments captured information can help the environment to support a user in performing his tasks. BCI can play a role in solving the threat of sensory and cognitive overload for, for example, pilots and crisis team members, but also for everyday life activities such as driving, controlling devices, gaming, etc. Especially in the latter applications the hardware must be designed for use in everyday life, i.e. unobtrusive, lightweight and wearable, preferably wireless, and with low power consumption. Moreover, often there is not a single task to be performed, as sometimes is the case for disabled persons, but there is information to be captured and fused from various input modalities and brain activity displayed in various brain regions with not always distinguishable functions.

BCI for Healthy Users: Research Topics

In the part of the BrainGain project that is devoted to BCI for abled users we have chosen the following topics to research [1]:

Attention Monitoring and Adaptation: To stay highly alert for extended periods of time is critical for flight controllers, truck drivers and security personnel scanning luggage or checking many video monitors. To detect visual alertness is an important prerequisite to warrant user performance. Experiments have shown that ongoing brain activity (posterior alpha activity) is a better detector of visual alertness than behavioural measures. These new findings could be used to create a BCI that determines the user's visual alertness and for example adjust the visual load in the interface or even advises the user to take a break. Such systems can be installed at airport traffic controllers, security inspectors etc. Fourthly, the combination with other physiological and ures used in man-machine interfaces is an important multi-dimensional challenge.

Classifying Images: The brain outperforms software tools when it comes to classifying images or the semantic understanding of images. In many areas, enormous amounts of images are available but very hard to access because they are not labeled. Automatic analysis of image contents is very difficult and despite the huge efforts put into machine algorithms, limited progress is made, while the brain does these kinds of tasks very easily. Using a BCI may provide us access to these very powerful brain mechanisms to interpret images. E.g., specific event related potentials may occur when a primed object is present in an image, even when many images are shown is in rapid serial presentation. By using this effect, observers may be able to reliably classify images at very high speeds.

Motion Control for Virtual or Remote Worlds: The general question here is "to what extent can brain signals be used for navigation in (relatively) fast in-the-loop applications for gaming, simulation, and remote control applications". In these areas, using our locomotion system as input device (e.g., walking on a treadmill) is cumbersome, complicated and expensive. Usually, motion control is accomplished by keyboard or joystick, though sometimes in combination with a head tracker to allow for a natural way of looking around. The drawback of these motion control devices is that they are unnatural, possibly disturbing the user's feeling of presence, and that they occupy the hands. The latter is undesirable when the hands are required to interact with the remote or virtual world. In this research hands-free (self-) motion control interfaces based on brain signals will be investigated.

Multimodal Measures of the User Experience: In this research we investigate the following topics. *(1) Brainsignals and user experience:* In the case of intelligent, adaptive interfaces the system tries to adapt itself to the way the user experiences the interaction. The brain signals contain information about this experience. In a series of controlled experiments it will be determined what brainsignals can tell us about the user experience*. (2) Correlations between brainsignals and other information from the body:* Measures of biosignals such as heart rate, respiration, perspiration, body temperature and muscle tension can point to factors of the user experience as well. In experiments brainsignals will be traced together with other physiological measures and information from voice, face and head. *(3) Expressivity and reliability:* For each modality and each combination of modalities it has to be determined what they can express and how reliably they express this. Combination of modalities reduces noise and can dissolve ambiguities. It is important to have a good indication of the reliability of the various measures. *(4) Interface:* The inferences about the cognitive and affective state of the user that can be made on the basis of the information from the various measures will be used in the development of adaptive interfaces for games.

Employing BCI in game environments: Currently there is a development from traditional videogames using keyboard, mouse or joystick, to games that use all kinds of sensors and algorithms that know about speech characteristics, about facial expressions, gestures, location and identity of the gamer and even physiological processes that can be used to adapt or control the game [3]. The next step in game development is input obtained from the measurement of brain activity. User-controlled brain activity has been used in games that involve moving a cursor on the screen or guiding the movements of an avatar in a virtual environment by imagining these movements. Relaxation games have been designed and also games that adapt to the affective state of the user [2]. For the design of game and training environments we need the integration of theoretical research on multimodal interaction, intention detection, affective state and visual attention monitoring, and on-line motion control. It also requires the the design of several prototypes of games. Some of these games will be elaborated into events for the general audience (as dissemination projects). Next to games for amusement we will explore (serious) games for educational, training and simulation purposes. Selection and design of BCI methods feasible for commercial computer games is still difficult. Here price, ease of fitting, required data rate, etc. put strict constraints on the technology. However, the computer game industry is ready to embrace these applications and can even drive some of the developments.

It should be mentioned that the development of (serious) brain games fits in many initiatives in the Netherlands to develop company-based game technology, such as the Benelux Game Initiative (BGIn) in which Dutch game development companies are the founding fathers and the GATE research project (2006) in which many Dutch game development companies are involved. The entertainment games market in the Netherlands was estimated (AGS) 200M in 2005 and is growing, with impact on education, care, sports and digital lifestyle. For serious gaming the market was estimated to be over 350M, with areas of interest that include care and safety & defense. Various initiatives to stimulate economic activity in these areas are taken by governmental organizations (Innovatieplatform, Informaticaonderzoek Platform Nederland, Ministry of Economic Affairs, and NWO).

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