

Chapter 13

A Review for Unobtrusive COTS EEG-Based Assistive Technology

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ABSTRACT

People with movement disabilities will not be able to move around as conveniently and easily as other people. One of the solutions that can help them is assistive technology based on Electroencephalography (EEG) signals. Brain Computer Interface (BCI) systems record EEG signals and perform interpretations that can capture the “thoughts” of their users. Two possible application domains are mobility and emotion detection. Besides this, it is also essential to develop these assistive technologies to be unobtrusive and intuitive to use. Therefore, the authors envision the use of Commercial-Off-The-Shelf (COTS) EEG devices as a feasible and affordable solution. In this chapter, recent work, which utilises COTS EEG-based devices to provide solutions for the two selected application domains, is presented and discussed.

INTRODUCTION

Motivation for the Proposal

For a person with disabilities, particularly those who are paralyzed or cannot move independently, it is a challenge to carry out everyday activities that are seemingly simple for normal healthy people. For example, it is not possible for them to drive

or move independently. They will face difficulties in giving input to devices, such as a computer or audio/visual devices. It is also a challenge to them to express their feeling or emotion to other people, when speech and expressions are obviously not as easy as people without similar disabilities.

Traditionally, among techniques applied and investigated in the past decades, newer approaches aim to enable hands-free control using various

human-machine interfaces (HMI). Examples of investigated HMI are such as techniques using muscle signals (Electromyography - EMG) (Felzer & Freisleben, 2002), eye movements (Electrooculography - EOG) (Barea, Boquete, Mazo & Elena, 2002) or video-based eye gaze tracking (Murata, 2006), human body movements (limited limb movements, head gestures, facial expression etc.) (Ju, Shin & Kim, 2008), voice command (Harada, Landay, Malkin, Li & Bilmes, 2008) and brain signals (Electroencephalography - EEG) (Iturrate, Antelis, Kubler & Minguez, 2009).

To provide a feasible and affordable solution to the targeted users, unobtrusive techniques based on commercial-off-the-shelf (COTS) devices can be an attractive option. The availability and cost of these products will be an advantage as compared to specialized, high-end and/or medical-grade devices. They are usually simpler and more intuitive than the high-end devices in terms of daily usage. Common shortcomings are the trade-off of accuracy and sometimes efficiency. However, there are situations where a fair trade-off is expected but patients may still accept the unobtrusive COTS devices, as long as the errors and loss of efficiency are not life threatening. For example, for self-initiated vital information monitoring and measurements at home, away from health care institutions and professionals, may be worth the above mentioned trade-off, because patients do not need to travel to their assigned health care institutions to perform periodical check-up (Lau et al., 2010). Patients may opt for in-home recuperation, as long as the monitoring procedures and reporting can be performed by medical experts with acceptable accuracy and efficiency.

One specific technology listed above is the usage of EEG devices to allow “mind-control”-based approaches to help patients to express themselves, control and move around. Particularly for patients with amyotrophic lateral sclerosis (ALS), cerebral palsy or spinal cord injury, this technology enables

them to capture their “thoughts” through the translation of their measured brain signals into usable commands or machine-comprehensible thoughts.

This chapter intends to present a survey of related work that applies EEG-devices for patients with movement disabilities. Focus will be given to the COTS devices and the techniques used for the respective solutions.

ASSISTIVE TECHNOLOGY FOR PATIENTS WITH MOVEMENT DISABILITIES

Electroencephalography: EEG

The existence of human EEG signal was first recorded by German neurologist named Hans Berger (1873-1941) (Berger, 1931). He was the first person who proved that an electrical signal can be recorded from the human scalp without opening the skull. This discovery enabled the investigation and usage of EEG signals for different purposes.

Early multi-electrode EEG system was mostly used in clinics and laboratories to diagnose epilepsy and monitor coma patients. Continuing research and development on EEG systems over the past decades has brought the opportunity to take this technology from the clinics and laboratories into informal environment such as homes and schools. Common approach to perform EEG-based research and development investigations is to apply an EEG cap that wraps the skull with electrodes at fixed positions. Electrodes are commonly connected to the measurement system via cables, hence making the EEG system non-flexible and non-practical for all day usages, especially when it comes to different factors such as mobility, outdoor and convenience (Stopczynski et al., 2014), (De Vos, Gandras & Debener, 2014). For laboratory applications, such set up and approaches

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