Title: Brain Computer Interface using a low-cost 2-channels EEG amplifier for P300 and mu-rhythms detection

Student: Rafael Mendes Duarte

Supervisor: Jefferson Brum Marques

Alexandre Trofino

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Abstract:

Brain computer interfaces (BCIs) provide an alternative communication path between central nervous system (CNS) and motor system. In these systems, the brain signals (EEG) are measured using electrodes placed on the patient's scalp. The signal is then digitalized and processed by a computer which outputs a signal capable of controlling an external device. Hence, BCIs can be used to assist patients with neurodegenerative diseases or with nervous system injuries in which the communication between brain and motor system has been compromised.

EEG signals exhibits complex temporal characteristics due to low signal to noise ratio and presence of undesired biosignals such as muscle activity. It is possible, however, to extract specific features that can be more easily translated into the patient's intent to perform determined tasks. More specifically, due to easily detection, mu-rhythms and P300 evoked potentials have been widely studied as input signals for BCIs. The first consists in an oscillatory signal at around 10 Hz which appears over the motor cortex when the patient is not engaged in a motor task. The latter represents the user's response to an external stimulus and can be measured mainly over the parietal lobe.

This project aims to use motor imagery and associated oscillatory EEG signals from the sensorimotor cortex for device control. In addition, P300 evoked potentials will be used as an alternative path for outputting information from the brain, increasing the data transmission rate. In this scope, we will use a 2-channels low-cost EEG amplifier to measure EEG signals recorded from the scalp to generate a mental signal to control a computer interface.

1. Goal

To design a brain-computer interface system using a low cost amplifier. The acquired EEG signal will be measured and processed, yielding a signal for device control. The control signal will be used to select different applications in a menu containing home functions. The EEG signals explored in this work will be P300 evoked potentials and motor imagery oscillatory waves.

2. Motivation

According to the World Health Organization (WHO), as many as 500 thousand people suffer from spinal cord injuries every year, being most of them caused by road traffic crashes, falls or violence (physical traumas to the spinal cord). In general, this type of injury can cause severe motor function limitations, causing a considerable decrease in quality of life. In addition, other types of injuries that can affect communication between central nervous system and motor system can also cause mobility limitations. Brain-computer interfaces come as a solution for pacients affected by these traumas, providing an alternative channel for information processed by the brain.

Although a lot of research has been going on to increase portability of these kind of systems, the precision and accuracy requirements still demands a robust hardware to acquire and process the electroencephalography (EEG) data in real-time. Moreover, the high precision equipments used in BCIs are mainly sold for research purposes, increasing drastically the cost of the system. Therefore, a step towards a low-cost portable BCI system presents an important development to the BCI community.

3. Metodology

3.1 BCI System Overview

Figure 1 shows an overview schematic of a BCI system. The first stage includes the measurement and amplification of the EEG signal from the subject. The feature extraction stage is where the characteristics of the signals are extracted from the EEG raw signal. These features are selected according to the application and the classifier algorithm used in the following stage. The classifier will classify the incoming data into different classes. Supposing a switch application such as turning a light bulb on and off, the classes would correspond to the states “on” and “off”. The final stage is where the classifier output is used to perform the desired task, turning the light on and off, for example.

The first stage is critical due high sensibility to electrodes misplacement and very low signal-to-noise ratio (SNR) of EEG signals. The precision requirements at this stage lead to the high cost equipments used in BCI systems. In addition, as the number of channels used for acquisition at this stage the complexity of the signal processing stages decreases.

The signal processing stages, comprised by the feature extraction and the classifier, can be seen as the core of the BCI system. During these stages, the EEG signal is decoded into the user's desire to perform a task. The complexity of this processing is strongly related to the quality of the acquired signal. The detection of brain responses from very clean EEG signals tends to be easier then from EEG signals contamined with artefacts and noise.

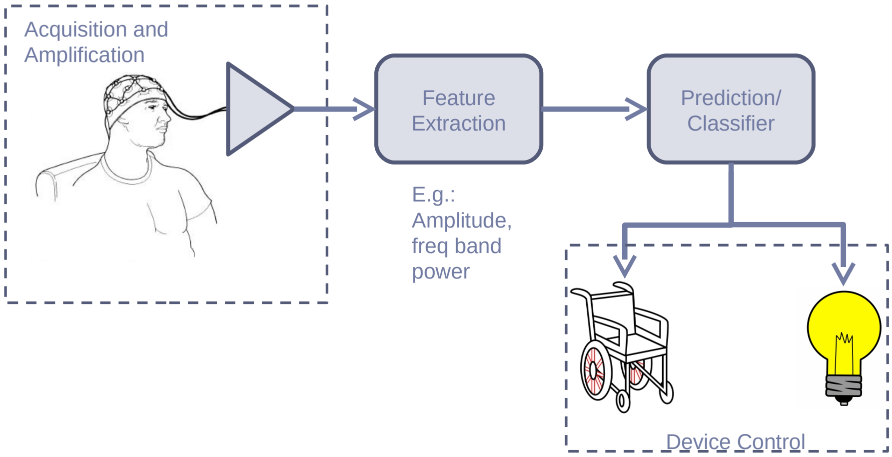

Figure 1: Overview of a BCI system

Work plan:

Period	Description
April, May	Bibliography and Literature Review, Software Review
June	Experiments with low-cost amplifier
July	Writing Partial Report (Official Thesis Proposal)
August, September	Experiments with low-cost amplifier, Data acquisition
October, November, December	Writing Final Bachelor Thesis