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Brain Computer Interface issues on hand movement

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Non invasive;
Feature extraction;
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Abstract This paper focuses on the Brain Computer Interface (BCI) application and its issues. Further the attempt was made to implement left and right hand movement classification after removal of the artifacts in the acquired signals of the various hand movements.

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1. Introduction

The Brain Computer Interface (BCI) involves a combination of the brain and device both sharing an interface to enable communication channel between the brain and an object that have to be controlled externally. The human brain has innumerable neurons which are connected to each other for transmission of impulses. As an electrode chip is implemented into the brain via surgical methodology the electrical signals produced by the neurons are transmitted to the computer which then translates the signals into data. These data are interpreted

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to control a computer device. In 2013, Lebedev successfully coupled the brains of two rats making use of an interface to enable direct sharing of information (Pais-Vieira et al., 2013). Minute fluctuations in voltages between neurons are measured and signals are amplified to produce graphs. While the Invasive BCIs focus on direct implementation into the grey matter of the brain to produce the highest quality of signals by neurosurgery, Non Invasive BCIs make use of techniques like Electroencephalography (EEG), Magneto Encephalography (MEG) and function Magnetic Resonance Imaging (fMRI). EEG techniques experience placing of electrodes on the scalp accompanied by a conductive gel or paste. Many systems are known to use electrodes which are attached to separate wires. Over the years, BCI has been instrumental in developing intelligent relaxation devices, providing enhanced control of devices like wheelchairs and vehicles, controlling robots and computer cursors and providing an additional channel of control in computer games. Bionic eyes have been known to restore sight for people having vision loss (Krishnaveni et al., 2012).

Considering the case of a motor imagery which refers to a mental process wherein an individual replicates an action. Thus, a mental representation of movement prevails without an actual body movement. Imagination efficiency is hard to control. Hence controlling EEG enables an individual to communicate despite the inability to control voluntary muscles. Interface substitute for nerves and muscles and the signals are incorporated into the hardware and software to be translated into physical actions. EEG based BCIs can record and classify EEG changes through different types of motor imagery like imagination of right and left hand and activity, consequently motor imagery as means to enhance motor function and motor learning. It has made a significant contribution in the field of neurological rehabilitation, cognitive neuroscience and cognitive psychology. Clinical applications have procured a great deal of aid from motor imagery ranging from enhancing mobility and locomotion to reduce neuropathic pain (Malouin and Richards, 2013). Analysis and interception of data are challenging as EEG signals are vulnerable to varying fluctuations often termed as noise. Various strategies have been devised for prevention and removal of noise. In this paper, we apply Butterworth filter mechanism to eliminate noise from the signals to enhance the data quality. Besides we concentrate on feature extraction to transform raw signals into informative signals. We make use of Support Vector Machine for the same. Feature extraction contributes significantly in image processing.

A step by step process involved in Brain Computer Interface system is shown in the Fig. 1. Signal is acquired through various means such as invasive (ECog, Neurosurgery) and Non-invasive (EEG, fMRI, MEG) techniques. The channel selection is one of the important considerations since most of the EEG channel represent redundant information (Sleight et al., 2009).

Fig. 2 shows the EEG channel placement on the human scalp. Each scalp electrode is located at the brain centres. In 2001 Pfurtscheller (Wolpaw, 2002) identified that many of the neural activity related to fist movements are found in channels C3, C4 and Cz as shown in Fig. 2 B. F7 is for rational activities, Fz is for intentional and motivational data, P3, P4 and Pz contain perception and differentiation, T3, T4 is for emotional processes, T5, T6 has memory functions and O1 and O2 contain visualization data.

In order to remove the noise from the obtained signal, any of the suitable filtering techniques may be adopted. Further the extracted data may move for classification phase.

1.1. Applications

Some of the popular applications of the BCI system are shown in Fig. 3 and each of them are discussed below:

The applications shown in Fig. 3 have been mentioned below:

i. BCI for communication and control: BCI for communication for and control mainly incorporate applications like spelling devices, environmental control and Functional Electric Stimulation (FES) or prosthetic devices. Non-muscular communication and control are not only limited to guesswork. It has been reported in Graimann et al. (2007) that a direct contact between the brain and external world is attainable and can be used for several useful purposes. BCIs are yet to achieve the ability to fly airplanes and most likely not anytime soon. Currently implemented BCIs at most are capable of reaching 25 bits/min. This modest capacity may be valuable for those who lack voluntary muscle control or for those in whom the remaining control is weak, easily fatigued, or unreliable. Patients with immobile condition (e.g. by ALS, brainstem stroke, or severe polyneuropathy) or lack any 778 J.R. Wolpaw et al./Clinical Neurophysiology 113 (2002) 767–791 useful muscle control (e.g. due to severe cerebral palsy), a BCI aids in giving the ability to answer simple questions and control the environment (e.g. lights, temperature, television, etc.). It may also be instrumental in performing slow word processing (i.e. with a predictive program, 25 bits/min could produce 2 words/min. It is possible for an intelligent wheelchair to automatically avoid collisions and hazardous events or a robot arm to independently manage specific movement scenarios and identify and rectify safety issues which may be suitably

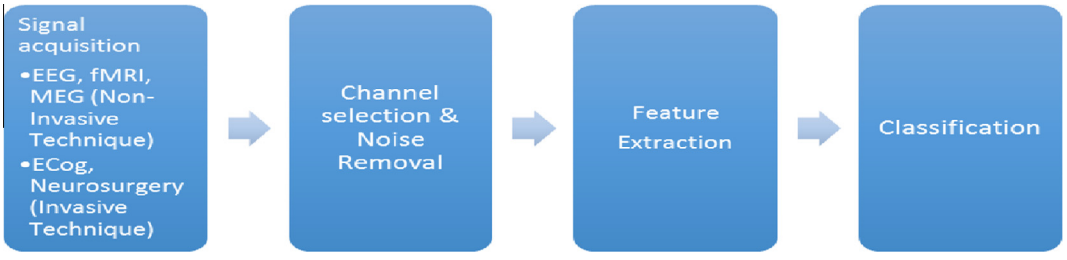

Figure 1 Process involved in brain computing interface system.