Brain Computer Interface : The Present and Future Technology

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Abstract

This paper describes about the emerging technology Brain Computer Interface (BCI), the evolution of Brain Computer Interface from Human Computer Interface (HCI) technology and an overview about some of the applications developed using BCI technology, so far and some suggestions are made on what else can be developed in the near future. This technology is mainly developed in order to help the disabled peoples to overcome their daily basic needs without the help of their caretakers. The brain signals acquired from the subject using anyone of the brain acquisition technology acts as a control signal in operating an external application. Electroencephalography is one among themwhich is cost effective, portableand implementable and also the most used brain acquisition technology.

1. Introduction

Brain Computer Interface (BCI) is an interaction between a computer machine and a human brain. The human brain acts as an input and the computer system accepts it and operates the external application accordingly. Brain signals generated according to the users intent is extracted from the subject by means of a brain acquisition technology, these acquired signals are then converted into control signals by means of a controller system. These control signals operates the desired external application according to the corresponding users intent.

2. Evolution of BCI from HCI

Basically Human Computer Interface is an interaction between a human and a computer. A Personal computer can be considered for this case, in which the input devices like mouse and keyboard acts as an interface between the human and the computer [4]. But for the disabled people it is not possible to use these computer system, so in order to help these physically disabled people and to overcome the disadvantages in the HCI, the BCI technology has evolved by means of which without any physical muscular movements the external applications can be controlled.

3. Working of a Brain

The human brain consists of about 100 billion cells. Most of these cells contained in the brain are called neurons. A neuron basically acts an on/off switch. It may be either in a resting state (also called as an “off” state) or it shoots an electrical impulse (also called as an “on” state). It contains a cell body, whichresembles a long wire called an axon, and at the very end it has a little part that shoots out a chemical. This chemical goes across a gap (synapse) where it triggers another neuron to send a message. There are a lot of these neurons sending messages down a wire called as axon. Each of these billions of axons is generating a small amount of electrical charge. Measuring these electrical activity can tell how the brain is working. A device that measures electrical activity in the brain is called an EEG (electroencephalograph). Each of the billions of neurons "spit out" chemicals that trigger other neurons. Different neurons use different types of chemicals. These chemicals are named as "transmitters" and canalso be called as epinephrine, norepinephrine, or dopamine.[15]

4. BCI Technology

The initial process in the Brain Computer Interface (BCI) technology is the acquisition of brain signals, this can be generated by means of placing electrodes on the scalp of the brain [7]. When the communication takes place between the nerve cells in the brain, all the electrical signals are not transferred, in this process there are some leakage. These electrical potential transfers towards the scalp, by acquiring these escaped electric potential the users intent can be measured [2]. Thus the acquired signals are then processed and converted into control signals. The various process involved are:

1. Signal Acquisition

2. Pre-Processing

3. Feature Extraction

4. Signal Classification

5. External Application

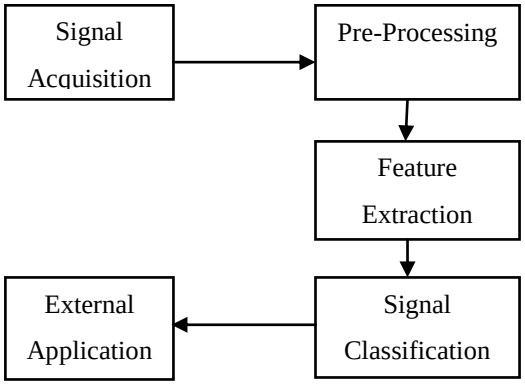

Figure 1.Block diagram of control flow in BCI process

4.1. Signal Acquisition

Signal Acquisition deals with the electrophysiological state of the brain. The electrical signals from the subject can be acquired by means of electrodes either by using invasive, partially invasive or non-invasive technique [9]. Brain waves are recorded from the motor pathway or sensory pathway of the human brain when it is performing some action, thoughts, and manipulationsor in excited state [8].

4.1.1. Invasive Acquisition. In this technique the brain signals are captured by implanting the electrodes deep into the grey matter of the brain. The electrodes are implanted by means of a surgical process called craniotomy. The electrodes once placed inside the grey matter of the subject generates the required signals. High risk is involved but the accuracy in this process is more when compared to the other two acquisition techniques[8] [9].

4.1.2. Partially Invasive Acquisition. Partially invasive devices are implanted inside the skull but rest outside the grey matter of the brain. The signals acquired by this technique is better than non-invasive but not when compared to invasive technique. In this case a partial surgery is required, so the risk involved is less when compared to invasive technique [8] [9].

4.1.3. Non- Invasive Acquisition. This technique is used to acquire the brain signals by placing a cap or an electrode over the scalp of the subject. The 10-20 International system of electrode placement method has to be followed in order to acquire the brain signals by means of non-invasive technique. EEG electrodes are placed over the scalp on the required region either by using EEG electrode cap or by using disposable electrodes. Two electrodes are placed in the subject's forehead, one acts as an active electrode and the other acts as a reference electrode the third electrode is placed at the backside of the ear lobe which acts a ground. [8] [9].

4.2. Pre-Processing

The signals thus acquired from the brain consists of artifacts. These artifacts has to be removed. The artifacts from the brain may be due to the following reasons:

1. Interference because of the muscular movements in the body.
2. Eye blinks at in appropriate moments.
3. Background noise from the environment.
4. Other user intent at a particular moment.

Initially the strength of the brain signal acquired from the subject is too low, so in order to increase the signal strength amplification has to be performed. The unwanted signals are removed by designing a band pass filter at the desired frequency range [1].

4.3. Feature Extraction

In Feature Extraction mechanism the raw information is converted into useful information, from the collective signals only the required signals are extracted and generated based on the actual user intent. Some feature extraction techniques such as Power Spectral Density (PSD), Adaptive Auto Regressive (AAR) parameter are performed in order to extract the desired signals from the raw signals. Features such as amplitude, time and frequency can be extracted from the brain signal of the subject [7].

4.4. Signal Classification

The signals acquired from the subject are classified based on the user's intent. Depending upon the mental state of the brain and the thoughts the signals are separated into various categories [5] [6].

4.4.1. Delta. The frequency range of the delta wave lies between 0-4 Hz. This signal represent that the adult is in slow wave sleep, can be found in babies and has been found in some continuous attention tasks. The electrodes should be placed in the frontally in adults.

4.4.2. Theta. The frequency range of the delta wave lies between 4-7 Hz. This signal represents that the adult is in drowsy state, can be found in young children and for elicited response. These signals are

found in locations which are not related to hand movements.

4.4.3. Alpha. The frequency range of the delta wave lies between 7-14 Hz. This signal represents that the person is in relaxed state, when the eyes are closed and also associated with inhibition control. In order to obtain this kind of signal the electrode has to be placed in the posterior regions of the head.

4.4.4. Beta. The frequency range of the delta wave lies between 15-30 Hz. This signal represents that the person isalert, active, busy, thinking or concentrating on something. This waves are most evident frontally and are low amplitude waves.

4.4.5. Gamma. The frequency range of the delta wave lies between 30-100 Hz. This signal represents that the person is trying to match some recognized objects, sounds or sensation. These waves can be acquired from the somatosensory cortex of the brain.

4.4.6. Mu. The frequency range of the delta wave lies between 8-13 Hz. This signal represents that the person is in rest-state. These waves can be acquired from the sensorimotor cortex of the brain.

The signals thus acquired lies between the above mentioned frequency ranges and denotes the various activities of the brain. Thus an analysis can be made on the subject and by using these generated signals the desired external application can be controlled and activated.

4.5. External Application

Brain Computer Interface is an emerging field, so more external applications are not available currently for the disabled people and is not used in practice. The research groups are increasing in this field to help the disabled people in expressing their needs. In the near future more number of applications will be developed and a cost effective BCI system can be developed so that people belonging to all category can use it. The applications available so far are Robot control, Vowel pronunciation, Shape differentiation, Object identification, games etc. [3] [14].

5.BCI: Present and Past technology

In this section let's have a look at the recent BCI applications and in the near future what kind of applications can be developed. Some of the BCI applications are listed out.

5.1. In-car brainwave scanning security system prevents carjacking, and drunk/tired driving

This system uses an EEG scanner for operating the vehicle. Some electrodes are attached to the brain waves in order to gain access to user's intent. The brain waves generates a pattern and from the brain waves the alpha and beta waves are generated. The subject should be trained by the driver. If the person has consumed alcohol or else if a hijacker has gained access over your vehicle then the system detects it and stops the vehicle [10].

5.2. First human brain-to-brain interface allows remote control over the internet

By this means a person's hand can be controlled remotely over the internet by another person. The person located at one place has to think of moving another person's hand remotely so accordingly brain signals are generated. They are looking at a two-way system, for allowing a more telepathic link between the two human brains [11].

5.3. Replace passwords with passthoughts by reading your mind using BCI

In the near future an application is yet to emerge, instead of typing the mixed passwords on a small screen, the passwords can be entered by thoughts. The brain thoughts are used as bio-metric identifier for authentication purpose [13].

5.4. Brain-to-Brain Interface, allows humans to control other animals with thoughts alone

Researchers at Havard University developed the first non-invasive brain to brain interface between the human and a rat. According to the humans thought the rat is controlled by fixing a controller in the rat's tail. Based on the thoughts the control signal is applied to the rat controller as a device command [12].

6. Conclusion and Future Enhancement

Numerous researches are going on in the field of Brain Computer Interface recently. It captures the electrical signal and blood flow from the brain in order to read the user's intent and to operate a wide variety of different applications, instruments, robots, cursors, wheel chairs accordingly. The accuracy and the data transfer rate has to be increased in order to make the system more realistic. Some alternatives can be provided in order to reduce the training period of the subject. No wonder even if the whole world is operated by human thoughts. Moreover BCI technology is user

friendly for the disabled people since it helps them to overcome their daily basic needs.

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