

Brain Computer Interface: Data Acquisition using non-invasive Emotiv EPOC Neuroheadset

Ms. Nidhi Vala

Department of IT
Shantilal Shah Engineering College
Bhavnagar

Mr. Kiran Trivedi

Associate Professor EC Department
Shantilal Shah Engineering College
Bhavnagar

ABSTRACT

Recent advances in human electroencephalogram systems featuring dry electrodes and wireless telemetry have promoted the applications of brain-computer interfaces (BCIs) in our daily life. Human brain's electronic signal acquisition and analysis of those signals can be used for extracting various expressive, cognitive and affective states of mind. Paper introduces different brain computer interface phases and it focus on the technique that is reading neural activity of the brain with use of multi-channel electroencephalograph (EEG). As the part of this paper we are introducing our experience with the low-cost commercially available equipment Emotiv EPOC Neuroheadset based on this technology.

Keywords

Electroencephalography (EEG), Brain Computer Interface (BCI)

1. INTRODUCTION

The aim of research into brain computer interface is to build communication and control systems that a person can use to interact with the environment and other electronic devices without the need for any muscular or peripheral neural activity.[1]

BCI can also be defined as a system which translates the human brain's intents or thoughts into technical command signals [3] for controlling different devices like virtual spelling boards or prosthetic arms[4] cell phone, wheelchair, etc. BCI aims to provide one-way or two-way communication interface direct between the human brain and the external devices.

Developing a robust BCI system is one of the main challenges of the twenty-first century.[2] But today's thought reading applications seem to be more innovative, thanks to the Researchers for developing such innovative applications using Brain Computer Interface as a means of interaction between human brain and a computer. A wireless neuroheadset placed on the human scalp is used to record the brain's electrical activity, as electroencephalographic activity (EEG) generated by the neurons.

Brain-computer interfaces (BCIs) use neural activity patterns to control external devices. Their success is tightly linked to the ability to extract rapidly and reliably detailed information based on the subject's recorded brain activity.[4]

BCI has several phases as described in section 2. But this paper mainly focus on its very first phase, Signal Acquisition which will include different acquisition techniques and the introduction of the low cost Emotiv EPOC Neuroheadset.

2. PHASES OF BRAIN COMPUTER INTERFACE

Major four phases of Brain Computer Interface are as follows:

- A. Signal Acquisition
- B. Signal Processing
- C. Computer Interaction

2.1 Signal Acquisition

Electromyography(EMG) signals, related to muscle activation or Electroencephalography(EEG) signals, related to brain activity are acquired from the user by means of electrodes.[6] One of the key component of Brain Computer Interface is the data acquisition hardware. Data acquisition can be done either invasively or non-invasively based on the requirement and accuracy need of the application.

Invasive signal acquisition requires surgery to implant the sensors or electrodes onto the brain cortex(See Figure 1). These electrodes are implanted by opening the skull through a proper surgical procedure called craniotomy. These techniques are able to provide best temporal and spatial resolution of signals.[3] Invasive signal acquisition techniques give excellent quality of signals[5].

Even though these Invasive signals provide fast and potentially rich information, there exist some cons of this technique.

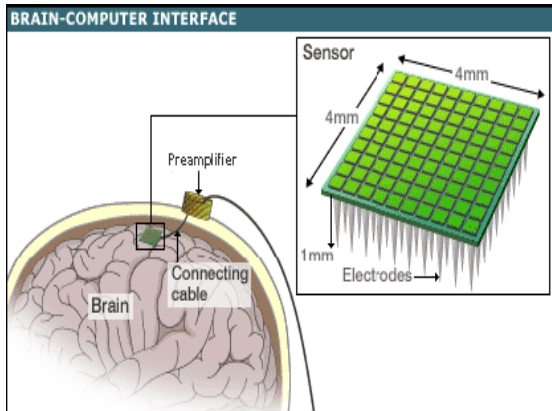


Figure 1: Invasive Signal Acquisition

Some of them requires implantation into gray matter of the brain which may lead to infection or permanent tissue damage. Along with that, Electrodes placed inside the brain are piece of wire or metal pins, they sometimes may not work properly in the brain.

While **Non-Invasive signal acquisition** techniques are used to capture the signals from the scalp (see figure 2), by using the technologies like electroencephalogram (EEG), functional magnetic resonance imaging (fMRI), magneto-encephalogram (MEG), P-300 based BCI etc.[3,5]



Figure 2: Non-Invasive Signal Acquisition

Although non-invasive technique provides lesser accuracy than the invasive one due to the deflection caused by the skull to acquire the signals generated by the neurons. It has several advantages like no modification is required in the scalp. And with minimal discomfort and in any naturalistic conditions user can wear the hardware for signal acquisition.

Among non-invasive Brain Computer Interfaces (BCIs), electroencephalogram (EEG) has been the most commonly used for them because EEG is advantageous in terms of its simplicity and ease of use which meets BCI specifications when considering practical use.[5]

2.2 Signal Processing

After the signals being acquired from the hardware they need to be pre-processed because whatever

technique we follow to capture these brain signals some irresistible signals like noise, interference from the electronic hardware or electromyography (EMG) signals evoked by muscular activity get involved with our desired signals. These unwanted signals may lead to the wrong conclusions of the analysis of EEG. So these signal must be pre-processed to remove the noise and for that several pre-processing techniques like basic filtering, adaptive filtering or blind source separation can be used.

The signal processing module converts signals from the brain into signals that control an external output device. This conversion has two stages: feature extraction and feature translation.

In the **Feature Extraction** stage, the digitized signal received from the BCI device is subjected to procedure in such a way that it extract signal features (e.g, firing rate of a cortical neuron, amplitude of an evoked potential, etc.). In the **Feature translation** stage, a translation algorithm translates these signal features into control signals that are sent directly to the user application.[7]

2.3 Computer Interaction

The last phase of the BCI system is to fire commands through brain for driving any developed application. And for that it will use the processed and analysed signals of the above two stages and translate them into command signals. The BCI system model supports any programming language, any development environment, and any operating system.[7]

The Emotiv EPOC is a low cost Human-Computer Interface (HCI) that is comprised of: (i) a neuroheadset hardware device to acquire and pre-process EEG and EMG user brainwaves, and (ii) the software development kit (SDK) to process and interpret these signals.

3. EMOTIV EPOC NEUROHEADSET

Our For developing any robust BCI application raw EEG data are very important and it can be captured by low cost commercially available Emotiv EPOC Neuroheadset. This 14-channel hardware is used to acquire signals from various electrodes placed on the human scalp at AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8 and AF4 positions, according to the international 10-20 system. Odd numbers of electrodes are reserved for left hemisphere of the brain; even numbers of electrodes are reserved for right hemisphere of the brain. Two referencing electrodes CMS (on the left side) and DRL (on the right side) are used for reduction of noise in signal. [3]

More importantly, the headset’s fixed sensor-array makes it easy to use and highly portable. Since it connects wirelessly to any PC via a USB dongle, the user maintains a full range of motion. Instead of gel or paste, Emotiv simply requires that the user wet its foam-tipped sensors with contact lens solution prior to each use[8].



Figure 3: Emotiv EPOC Neuroheadset

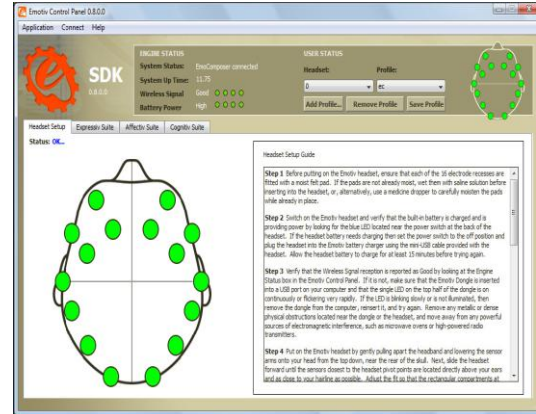


Figure 4: Emotiv Control Panel

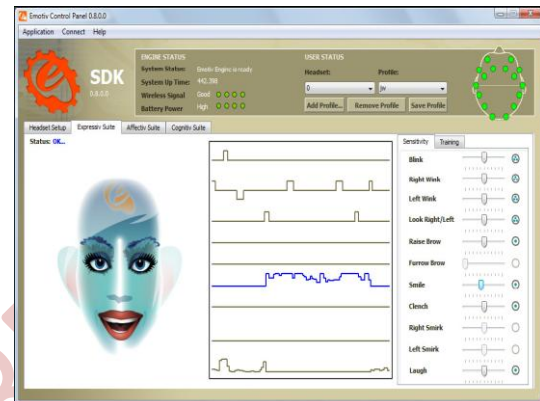


Figure 5: Emotiv Expressive Suite



Figure 6: Emotiv Affective Suite

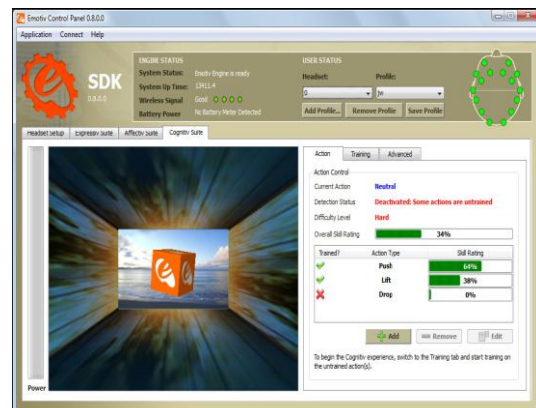
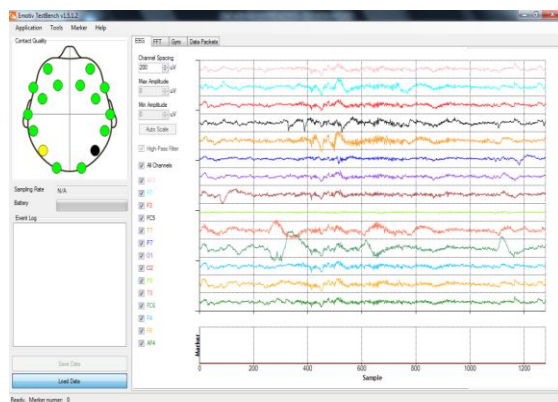


Figure 7: Emotiv Cognitive Suite

Any number of Emotiv headset can be attached with the PC. Figure 5 displays the control panel of this headset and other figures shows different suites of it through which various facial expressions, cognitive actions and affective tasks can be identified. Expressive suite through which various facial expressions like blink, smile, clench, raise brow, furrow brow, right smirk, left smirk, laugh, right wink, left wink, look left and look right can be measured. Along with that as shown in control panel's having affective suite which displays various states of mind like alertness, vigilance, concentration, stimulation, interest, boredom, engagement etc. Intentions of the subject to push, pull, move left, right, up and down and to rotate clockwise, counterclockwise, left, right, forward and backward are detectable through the cognitive suite.[3]

**Figure 8: Real Time Continuous EEG data being captured in Emotiv Test Bench**

And the real time EEG signals from all the 14 channels are being captured through the Emotiv Test Bench Software and are being used to find the various characteristic patterns from it which can be then used to develop any real time application.

4. CONCLUSION

This paper introduced brain computer interface as the communication pathway between the human brain and the external devices and it allows one-way or two-way communication. Also different phases of BCI has been described. And due to non-invasive technique's ease of use it is used in most of applications. Our experience with the low cost Emotiv Epoc has also been described within this paper.

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