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Unfolding the Dimensions of Brain-Computer Interface

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***Abstract*—**The proliferation of technologyis infiltrating all the aspects of life dramatically, as a result of which world is becoming dynamic and complex. Brain-Computer Interface (BCI) or Brain-Machine Interface (BMI) is an emerging field of technology whose goal is to make a real-time path between brain and electronic devices such as computers, robots, artificial limbs, self-driving cars and everything which can be connected with the internet. In BMI, brain or cerebral control these by transmitting and receiving electrical signals. This paper presents an idea of how with the help of technology we can control things.or this an example is explained where the system is based on steady-state evoked potential (SSVEP) is used, where it is made to give mobile number as an input. The buttons are typed on a virtual keypad similar to normal keypad. Each key or a button is assigned with a particular key and SSVEP is used to judge their frequencies.

***Keywords*—**BCI, BMI, SSVEP

I. Introduction

The great and mighty nervous system or the brain as most of call it, makes this organ unique is that within it lies the ability for humans to know oneself. This feature distinguishes and sets the human species apart from the rest of creation, this ability is known as consciousness or intelligence. And the field of study related to it is known as Neuroscience[1]. We all believe that our behaviour is controlled by brain, which is an ancient belief. In modern era with the help of tools, technologies and methods we can extract most of the details and structural complexityand function of the nervous system[1]. As per the researches our human brain houses approximately some hundred billion of neurons, and these neurons have one hundred trillion connections. And our brain is similar to cosmic web.

The sphere of brain computer interface depends on the ability of brain to generate certain kind of chemical and electrical signals in the form pulses which can be harnessed further by the computer and to be able to interpreted by computers. If we are able to harness some good amount of energy generated by our brain then we can do anything.

Rehabilitation effectiveness can be increased by integrating real-time brain activity assessment into individualized, adaptive training, and rehabilitation regimens.Technologies that help you focus and can achieve desired brain states[2]. Thisis one of the examples of potential brain–computer interface (BCI) technology. BCI is a technology which usesbrain–signal processing to influence human interactions with computers, their environment, and even other humans. There is massive advancement in the technologiesin wearable, mobile biosensors and data acquisition, chips, neuroscience, computational and analytical approaches and computing of mobile brain imaging, all of which are enabling potential BCI applications. Further, combining these technologies,with other technologies such as pervasive computing, will push applications beyond human–computer interfaces[2]. Soon with the help advancement of BCI and other computing technologies, we will able to control all the devices by our brain. One of the recent works in BCI is Hybrid Brain computer Interface[3]. As name says, it contains two or more brain systems connected together. The main aim of Hybrid Brain Computer Interface is to enhance the Information Rate (ITR) with respect to SSEVP and accuracy in terms of P300 [4]. In this paper I'm trying to explore some of the unexplored fields of Brain Computer Interface.

BMI has a major issue and its current decoder which uses recent data for manipulation, as it become ineffective when neural activity changes continuously [7]. There are some other issues like information transfer rate, BCIs which being used now a days, and they work on low bandwidth and offers maximum information rates which eventually take several minutes to input a word to a computer [6].

II. Related Work

There is so much of development in the field of brain computer interface. The major developments are restricted to help disabled people and some for research purpose also. For example, if a person is not able to move his/her arm which may be because of any injury or disease [5].Laboratories around the world have begun their work towards BCIs over the past few years [6]. Those all systems differ in their inputs, how they extract manipulation data, output and some other characteristics like accuracy, speed, rate of transmission. The block diagram shown below shows how this system work [4].

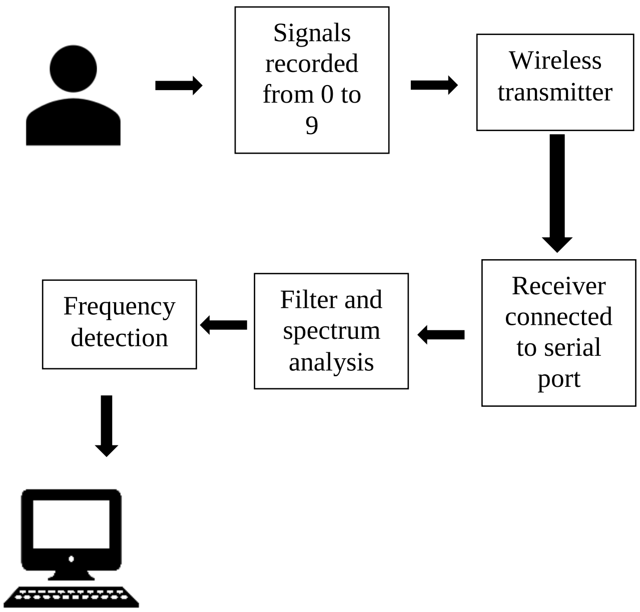

Figure1. Block diagram of calling system

The above diagram is an example of SSVEP based BCI system, where system designed in such and way that user can easily give the input for dialing a number.

There are two types of input signals of BCIs having slow cortical potentials [8], rhythms of μ and β over sensorimotor cortex [10], electroencephalography (EEG) patterns associated with different mental tasks [13], P300 potentials and visual evoked potentials (VEPs)[13]. Electrodes are placed on the scalp of a person. In every BCI systems, the key attribute isthe Degree of Freedom (DOF) or to say the number of independent control parameters derived from the signals generated by the brain and this is one of the functions that determines which whether BCI can execute it or not, which indeed will be used for rehabilitation [12]. There are various kinds of brain signals that are being harnessed by such BCIs for this purpose. But there are three major signals and they are EEG signals recorded over scalp [13], over the cortical surface [electroencephalography (ECoG)], and the third one is within the brain i.e., single-neuron action potentials (single units) and local field potentials (LFPs) [12].

Sensorimotor rhythm (SMR) based BCIs are used widely for improving human health as well as people having amyotrophic lateral sclerosis (ALS) [9] and people with spinal cord injuries [14]. If we modulate SMR signals, then user can acquire 2-D or 3-D movement [14], with DOF and performance comparable to assumed hypothesis. This is explained by Han Yuan et al. in their research [12], where they showed that human brain can fly a helicopter to any point by using EEG signal acquired through scalp of that person.

Brain generates signals which are response to the stimulus. Whether we think something or do any kind of activity, neurons in brain releases electrical signals [1]. A stimulus which are static in nature in the terms of view does not show any different effect in EEG activity [4]. The signals which are evoked by the visual input does show some properties of stimulus [15]. A difference in stimulus frequencies make sever distinction between VEP and SSVEP. Generally, stimulation frequency is less then 2 Hz. If the stimulus is responding at a rate of 6 Hz then such stimulus is behaving like SSVEP. A series of components whose frequencies are exact integer multiple of the repetition frequencies. In the diagram shown before, there are two EEG signals were generated and which was also recorded from 0 to 9 according to the international 10-20 system and they are termed as left or right ear lobes respectively.

III. METHODOLOGY

There are many stages of how BCIs work ranging from data acquisition to feature classification. The main aim of data acquisition is to extract required data from acquired signals and feature classification is used to classify the frequencies.

We generally call signal preprocessing as signal enhancement. In order to extract the data from extracted signal we need to first preprocess the acquired signal where it will remove all nuisance signals and give the useful signal.

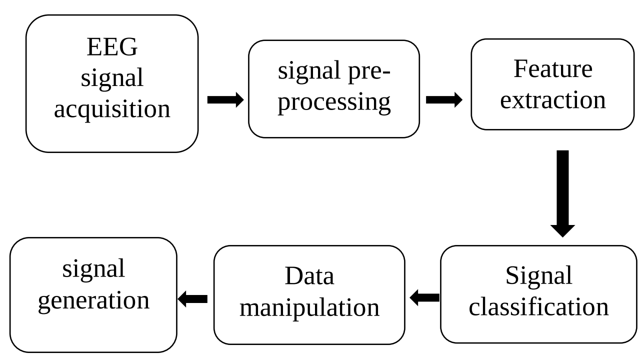

Figure 2. Block diagram of BCI system

The figure shown above gives an idea of how the signals from a BCI system will be converted into signals to be worked on. Data extraction usually amplifies the signal and upgrades the signal to a certain noise ratio (SNR). In signal preprocessing band pass filtering method is used where it separates the high frequency and low frequency.Data segments are collected and average filtering is applied for best performance. Different artifacts have different origins. These artifacts have utility frequency like noise, body and eye movement like if a person moves his/her limbs, bend his body or blinks. There are some approaches which can help us in handling these artifacts like avoidance, rejection and removal. By using avoidance, the user will try to not do a particular movement, whereas in rejection the user will not do that movement. Avoidance and rejection look similar, but actually they are not. If user uses removal method, then that particular part of data will be removed from the set of data which will be responsible for movement.

The goal here is to suitable data that subsequent detection of feature attempted to design BCI. Features of a signal can be extracted by using several methods like time or frequency analysis. The extracted data are classified based on classification algorithm. Since EEG signal non-stationary in nature, so its value or better to say spectrum changes with time. Algorithms used here are: Linear Discriminate Analysis (LDA) and Support Vector Machine (SVM).

Everything in this universe works in certain pattern so our brain activity also has certain pattern. Which indeed can be used to BCI as change in EEG values. After data is being extracted as per the requirement, this data is manipulated. Because a same data can be used to perform more then one task. So data is manipulated in such a way that it will perform a specific task. If the final task is to move an artificial limb, then signal will be generated for it.

IV. Results and Discussion

Present BCIs are designed to work on 2-D or 3-D objects and generally, and only two or four EEG patterns are enough for all of its tasks. Whenever, a frequency is repeated certain number of times continuously but more than 4 times, a tradeoff happens between machines which are connected to BCIs and selection is made. The efficiency of devices using present BCI technology is directly proportional to how strong concentration power of person is. And this selection criteria is the main reason for the less efficiency of BCIs.

BCI technology in future is going to be more advanced and sophisticated, with small amount of concentration user will able to complete a particular task with more efficiency. And the use of BCIs will not be limited for disabled people, anyone will be able to use.

V. Conclusion and Future Scope

BCI has several important steps for successful completion of a particular task and it ranges from signal processing, data extraction, to data manipulation. And signal processing being the most important step, it also has some sub-steps like signal acquisition, signal classification and signal generation. This paper tells us what are the most important factors which we should consider while deciding the accuracy of ITR in BCI. Since we know that neurons keep forming every second so the EEG signals generated are non-linear and non-static in nature. And this non-linear nature is good for EEG based BCIs.

Most of the recent research work related to BCIs are for disabled people or for some kind of experiment. But according to me the world is going to change soon. BCIs will be used to communicate with devices but without wearing any hardware devices on head. It will be simply based on a micro-chip, which will have its own network protocols. Such chips will not require any kind of pre-charging or anything like that, it will simply dynamically charged. As we know that, our body have some electric charge which is very less in amount, so this small amount of charge can be used for charging such chips.

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