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BRAIN MACHINE INTERFACE SYSTEM FOR PERSON WITH QUADRIPLEGIA DISEASE

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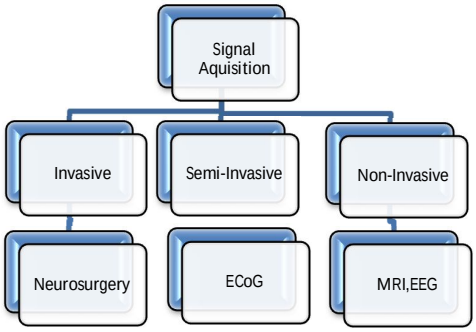
***Abstract*--** Brain Machine Interface (BMI) system is very helpful technique for the disabled and handicapped person to express their emotion and feeling to someone else with the help of EEG Signals coming out of our brain. As we know that, the human brain is made up of billions of interconnected neurons about the size of a pinhead. As neurons interact with each other, patterns manifest as singular thoughts such as a math calculation. As a by-product, every interaction between neurons creates a miniscule electrical discharge, measurable by EEG (electroencephalogram) machines. This system enables people with severe motor disabilities to send command to electronic devices by help of their brain waves. These signals can be used to control any electronic devices like mouse cursor of the computer, a wheel chair, a robotic arm etc. The research in this area of BCI system (or BMI) uses the sequence of 256 channel EEG data for the analysis of the EEG signals coming out of our brain by using tradition gel based multi sensor system, which is very bulky and not convenient to use in real time application. So this particular work proposes a convenient system to analyze the EEG signals, which uses few dry sensors as compared to the tradition gel based multi sensor system with wireless transmission technique for capturing the brain wave patterns and utilizing them for their application. The goal of this research is to improve quality of life for those with severe disabilities.

Keywords- Brain machine interface, BMI, machine –human interaction, EEG signals, BMI techniques, signal and brain wave simulation process.

I. INTRODUCTION

Brain-Machine Interface (BMI) asks user for brain signals instead of any muscular activities. This system enables people with severe motor disabilities to send command to electronic devices by help of their brain waves [1]. Signals should be identified, processed, and classified to specific command. Feature extraction and classification methods are playing the main role in any BMI systems; since any misclassification and error may cause a wrong command. In the past few years, many research groups focused their work on classifying EEG records to desired mental task classes [3]. Several algorithms have been investigated by purpose of increasing the classification rate and accuracy of evoked potential- based BCIs. Despite the improvements that have been achieved in this area, on-line BCI still poses some challenges. In this paper, we review the performances of different models for classification of BCI-based electroencephalogram signals regarding their real-time applications [4].

SIGNAL ACQUISITION METHOD



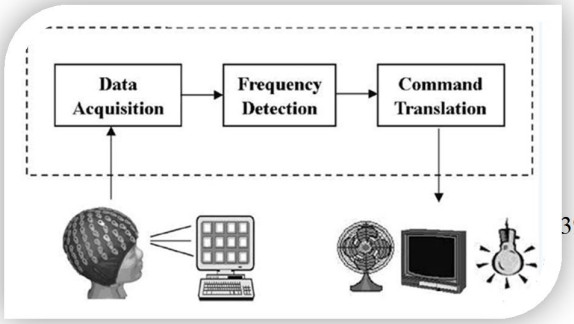
Classification of Brain Waves

Brain waves are recordings of fluctuating electrical changes in the brain. To obtain such a recording, electrodes are positioned on the surface of a surgically exposed brain (an electrocardiogram, ECoG) or on the outer surface of the head (an electroencephalogram, EEG). These electrodes detect electrical changes in the extracellular fluid of the brain in response to changes in potential among large groups of neurons. The resulting signals from the electrodes are amplified and recorded. Brain waves originate from the cerebral cortex, but also reflect activities in other parts of the brain that influence the cortex, such as the reticular formation. Because the intensity of electrical charges is directly related to the degree of neuronal activity, brain waves vary markedly in amplitude and frequency between sleep and wakefulness.

2. SYSTEM OVERVIEW

A. ARCHITECTURE

Brain-Machine interface (BMI) is a fast-growing emergent



technology, in which researchers aim to build a direct channel between the human brain and the computer. This system enables people with severe motor disabilities to send command to electronic devices by help of their brain waves. The first question arises in our mind is that what are brain waves?

Figure 2.1: **Block diagram of Proposed Architecture**

So, the brain waves are nothing but the electrical discharge generated by the interaction of neurons. As we know that the human head is made up of billions of interconnected neurons. As neurons interact, patterns manifest as singular thoughts such as watching movie. Every interaction between neurons creates a miniscule electrical discharge, measurable by EEG. These charges are impossible to measure from outside the skull. But in a dominant mental state, driven by hundreds of thousands concurrent discharges, can be measured.

B. INTRODUCTION TO EEG SIGNAL CLASSIFICATION

These brain waves are classified into four different categories according to the different mental states and frequency range.

Alpha Wave	7-13Hz
Beta Wave	13-40Hz
Theta Wave	4-7Hz
Delta Wave	0-4Hz

1. Alpha Wave

The alpha state is where meditation and relaxation begins. This is where we start to encounter the wealth of effortless creativity flowing just beneath our conscious state. In this state we are awake but deeply relaxed. Studies have shown the alpha state has been associated with “peak performance.” It has been found that Elite athletes produce alpha brainwaves prior to concentrated performance (shooting a free throw, hitting an important golf shot), whereas the amateur athletes produce more of the anxious beta brainwaves. In the alpha state we learn, process, memorize and recollect large sums of information fast and with peak effectiveness. Highly creative people have been shown to have “bursts” of alpha brainwaves when they have good ideas. Alpha brainwaves are thought to make the brain “act young” again. In the alpha state fears, habits and phobias begin to melt away. Alpha brainwaves bring an effortless sense of comfort, peace and harmony. Thus Alpha brain waves can be claimed as best for “super learning”. The alpha state is thus the first layer of our subconscious mind which can also be called as a gateway to deeper states of awareness.

2.Beta Wave

The beta brainwave is the predominant frequency when we are fully awake and alert. Beta brainwaves make up much of our conscious mind. The Active awareness is thus directed to the outer world. Beta brainwaves are present during stress, paranoia, worry, fear and anxiety. They are also present during hunger, depression, irritability and moodiness. Also, Insomnia is the result of producing excessive beta brainwaves. It can also be associated with excessive mental chatter and self-destructive impulses. But one has to take into account the fact that too much time in the beta state weakens the immune system. Beta Brain wave frequencies lie in the range of 13 to 40 Hz.

3.Theta Wave

Theta brainwaves become prominent when we go deeper into meditation and relaxation which can also be called as a state of trance. Here, brain activity decelerates to the threshold of the sleep stage. It can be described as a state where the indescribable and wonderful realms we can explore. The theta state produces flashes of creative visualization through vivid imagery. In this state we feel much more open and connected to other people. People often report a feeling of floating while producing theta brainwaves. Theta brainwaves are thought to bring out a person’s dormant extrasensory perception (ESP) skills. The theta state amplifies the problem-solving skills. A person equipped with dominant theta brainwaves are correlated with insight and intuition. Theta brainwaves bring forth the inspired thought and increased motivation. Sometimes long-forgotten memories come to the surface, which can be credited to theta waves. Children have strong theta brainwaves, which helps to explain their superior ability to learn. Theta is briefly experienced as we climb out of the depths of delta upon waking, or when falling asleep. The theta state can be said to lie in the deeper sub-conscious to super-conscious part of the mind.

4.Delta Wave

Delta brainwave is the deepest level of meditation. The delta state is associated with “no thinking” during deep, dreamless sleep. Delta brainwaves are very rewarding. Delta is said to be the entrance to non-physical states of reality. This is considered as a crucial state which is necessary for renewal, healing and rejuvenation.

The immune system is believed to strengthen in the delta state. The delta state is the unconscious/super-conscious part of our mind. Many scientists believe this state to be the most beneficial.

C. EEG SIGNAL CLASSIFICATION AND ARTIFACTS

Recorded brain electrical waveforms are associated with electrical potentials which are not originated in brain. The sources of these electrical potentials are eye blinking, eye movement, activity of heart and muscles in general. They also can be from EEG equipment’s or recording systems. These interference waveforms known as artifacts can often cause serious misclassifications. Hence, developing a practical real-time system to recognize and eliminate artifacts is essential.

3. CLASSIFICATION AND FEATURE EXTRACTION METHODS

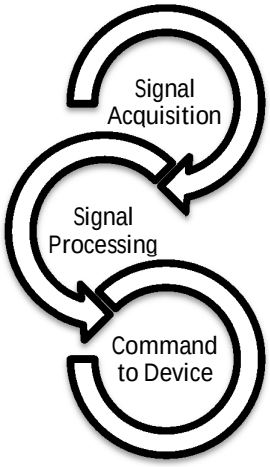


Fig3.1**: Process in the signal processing**

Classification algorithm can directly affect the BMI behavior. Therefore, any improvements have a significant impact on the real-time brain computer interface systems. In order to obtain excellent classification result, effective methods of feature extraction is necessary. To make decision about the classification method, it is essential to know what the features are, what is their application and in which way they may help classification. Feature extraction can be burden for BCI systems and make the classification process complicated and computationally costly. There are cases that some features are redundant or not enough discriminate to available data. Therefore, feature reduction helps for better result as classifier learn a robust solution and achieve a better performance. They have been introduced some classification models for EEG signals with capability of robust and accurate classification of raw EEG signal without feature extraction in prior step.

A. Underlying Neural Processes

All BCIs have to operate on observable effects of brain activity. EEG, MEG and ECoG can only detect large-scale neural dynamics. For example, 50.000 neurons firing in near-synchrony.

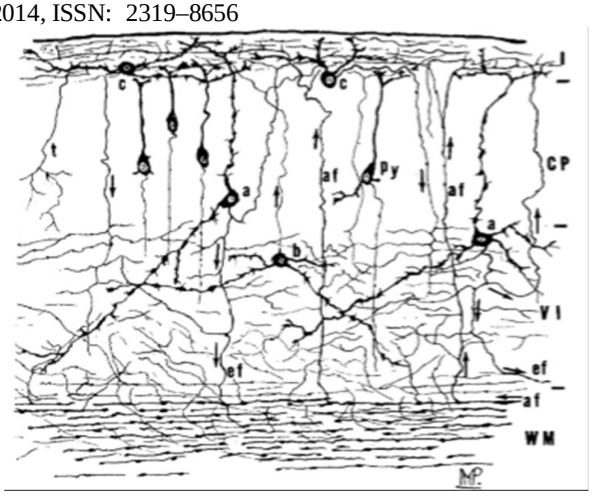


Figure 3.2: **Neuron Firing Process**

B. Signal Detectability

Root cause might not be directly observable (e.g., dopaminergic system, deep brain structures, and few neurons). Widely scattered neural populations are unlikely to exhibit synchrony (unless connected by fiber tracts). Spatially compact populations are more likely to have coordinated timing. Electromagnetic fields can cancel each other out (e.g., in the Amygdala).

i. Invasive Method

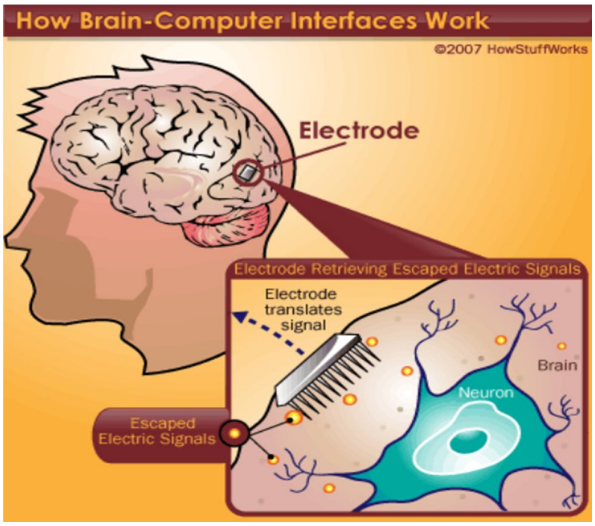


Figure 3.3: **Invasive method**

Invasive BCIs are implanted directly into the grey matter of the brain during neurosurgery. In invasive method obtained highest quality of signals.

ii. Semi-Invasive Method

Figure 3.4: **Semi-Invasive method**

SEMI-INVASIVE BCI devices are implanted inside the skull but rest outside the brain rather than amidst the grey matter. They produce better resolution signals than non-invasive BCIs where the bone tissue of the cranium deflects and deforms signals and have a lower risk of forming scar-tissue in the brain than fully-invasive BCIs.

iii. Non-Invasive Method

Figure 3.5: **Non-Invasive method**

Non-invasive implants produce poor signal resolution because the skull dampens signals, dispersing and blurring the electromagnetic waves created by the neurons.

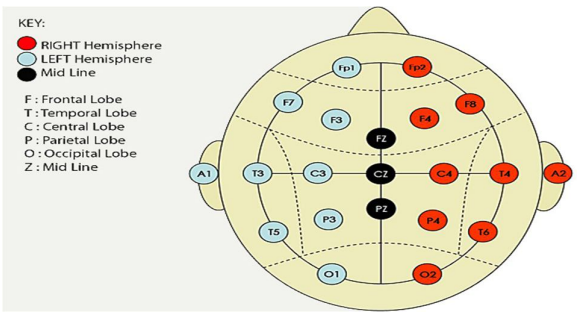


Figure 3.6: **Position of sensor on the basis of international standard 10-20 based system**

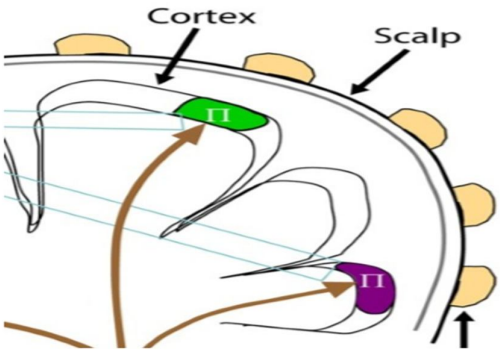
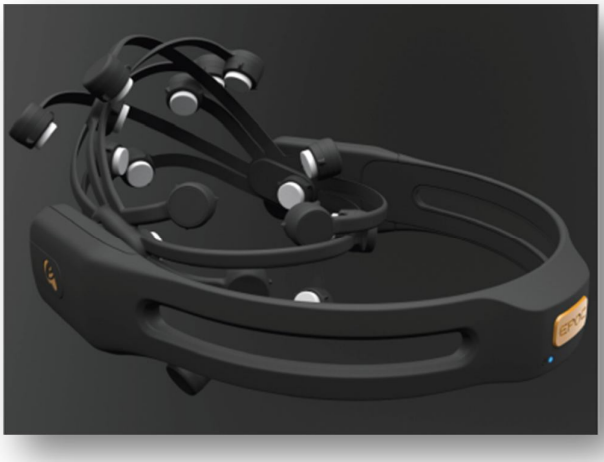


Figure 3.7: **Signal Detectability on Scalp**

We are working with Wireless Non Invasive technique of the data acquisition. For this purpose we are using EMOTIV EEG NEURO HEADSET which shown below in picture.

Figure 3.8: **Emotiv EEG Neuro Headset**



The Emotiv EEG Neuroheadset a 14 channel (plus CMS/DRL references, P3/P4 locations) high resolution, neuro-signal acquisition and processing wireless neuroheadset. Channel names based on the International 10-20 locations are: AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, and AF4.

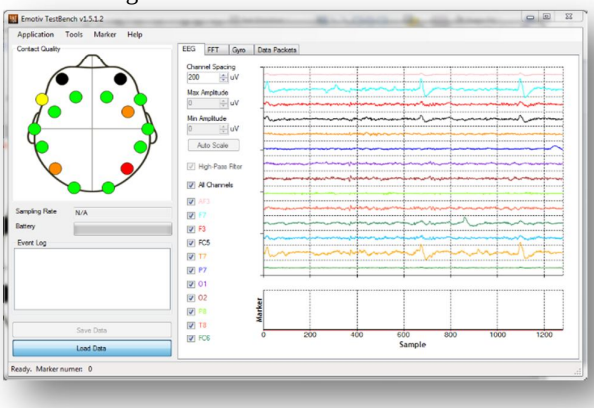
Fig3.9**: Practicing With Machinery**

4. WORKING PROCEDURE SYSTEM

The first step of my project is to capture the different EEG signals by the use of EMOTIV EEG NEUROHEADSET, and transmit these signals wirelessly to the system or laptop. A dongle is attached to the system which receives digital signal from headset and display these signals into the EMOTIV TestBench Software. After this we will have to analyze the raw EEG signals captured by the headset into the Test Bench software with respect to the different facial activity like eye blink, lip moment, teeth clench, smile, left/right wink etc. After detecting these activity on the waveform I'll have to use these signals to send different commands to the system.

The system looks like the picture shown below.
The snapshot of Test Bench software is shown below.

Fig 4.1: **Use of Test Bench Software**



II. APPLICATION DEVELOPED

Brain Machine Interface (BMI) system is very helpful technique for the disabled and handicapped person to express their emotion and feeling to someone else. This particular system can allow the person with motor disability to control any particular hardware, or mouse pointer on the computer screen.

1. Acolyte (A Friendly Interface for PwD)

This application is design for the entertainment of paralyzed or handicapped person which cannot operate computer with their hands. So, with the help of this application the person can control the mouse pointer by his head movement and can click with the help of blinking of eyes.

Fig 5.1:**Interface for Physically Handicapped**

2.Brain Controlled Wheel Chair

This chair is designed for to help the person who is crippled or Quadriplegic (i.e.; who is not able to move hands & legs). Who cannot control the electronic wheel chair by their hands, so by using this application he can control the motion of wheel chair by his facial expression only.

Fig 5.2: **Brain Wave Controlled Wheel Chair**

5. CONCLUSION

This project aims at developing BMI System using EEG based on same specific sensor which is controlled by uniform way, and it does depend on and analog signal. The study and implement EEG on NeuroSky Method based on non-invasive method has been done. The study and implement how to Detect Brain Wave signal on the CRO/DSO/Logic Analyzer is done. And also development of BMI on the above system based on EEG

Signal will get done in future. This helps in efficient use of Emotiv EEG Neuroheadset Module for developing any application based on real time system.

6. REFERENCES

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