A Study on EEG in Brain Computer Interface

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ABSTRACT
A brain-computer interface (BCI) is the hardware and software system for communications that directly link between computer and human brain also it is used to translate brain activity signals into control signals for external devices. BCI research is to give correspondences capabilities to extremely disabled people who are completely paralyzed or 'secured' by neurological neuromuscular issue, for example amyotrophic parallel sclerosis, brain stem stroke, or spinal cord injury. It has been studied the BCI system, looking at the different types of BCI.

General Terms
Documentation

Keywords
Brain computer interface; Invasive BCI; Non-invasive BCI

1. INTRODUCTION
Brain computer interface (BCI) is a technology that introduces an alternative means of connectivity between brains with computer or any other external devices. It is used as a communication channel for paralyzed people. The persons those who cannot speak or respond may use BCI to interact with each other, not necessarily the users need to be completely paralyzed or disabled.

Its function is to restore the damaged part of the brain and measure the signal of the central nervous system (CNS).It connects the brain with the computer hardware and converts the signal from CNS to artificial output by showing the results to interact with the other person.

BCI includes certain methods like Positron Emission Tomography (PET), functional Magnetic Resonance Imaging (fMRI), Magneto Encephalography (MEG), and Electroencephalograph (EEG) etc.

The rest of the paper is organized as section 2 presents the brain computer interface. Section 3 describes different types of signal. Section 4 depicts EEG in BCI.

2. BRAIN–COMPUTER INTERFACE
A Brain–Computer Interface (BCI), is called a Mind-Machine Interface (MMI), or at times can be termed as a direct neural interface or other way a Brain–Machine Interface (BMI) that is immediate connection among mind and outer gadget.

A BCI is a correspondence and control system that does not depend at all on the cerebrum (brain) neuromuscular yield channels. The client (user) screen and conveyed by cerebrum signal (such as EEG) rather than by fringe nerves and muscles and those mind signal don't depend their era on neuromuscular action. A BCI gives a continuous cooperation between the user and outside the world. The client get input mirroring the result of BCI's operation and the feedback can influence the user consequent purpose and expression in mind signals.

2.1 Applications of BCI

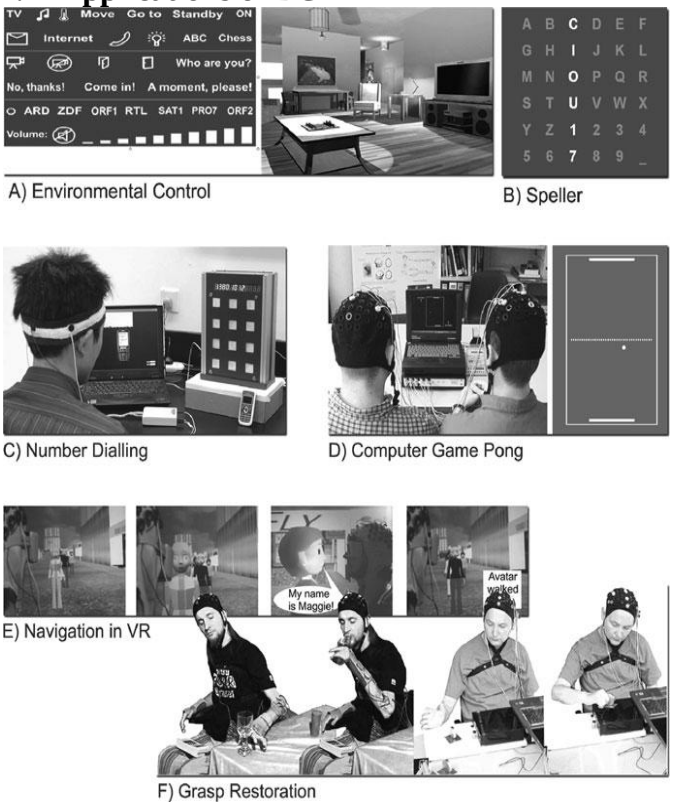


Fig.1: BCI Application [1]

2.2 Augmentative method
Augmentative method is used for paralyzed people or motor disorder people who are requiring some musical control for express their feeling. For musical control it required some musical group to supply the function regularly gave by another. (Example; use extra cellular muscles to drive a discourse synthesizer).it is not useful for total paralyzed people [2].

2.3 Functional diagram of BCI
In Signal obtaining process brain signal is measured and changing the subsequent signal into digital numeric values that can be controlled by a computer. Signal actualization process of BCI; include digital background process, digital foreground process and PC background process. BCI is seen as an example acknowledgment system that arranges every pattern into a class as indicated by its elements. BCI extricates a few elements from brain signals that reflect similarities to a specific class and additionally contrast from the classes. The

basic features are measured and/or derived from the properties of the signals which contain discriminate data needed to recognize their different class. Then it gives the visual in the computer.

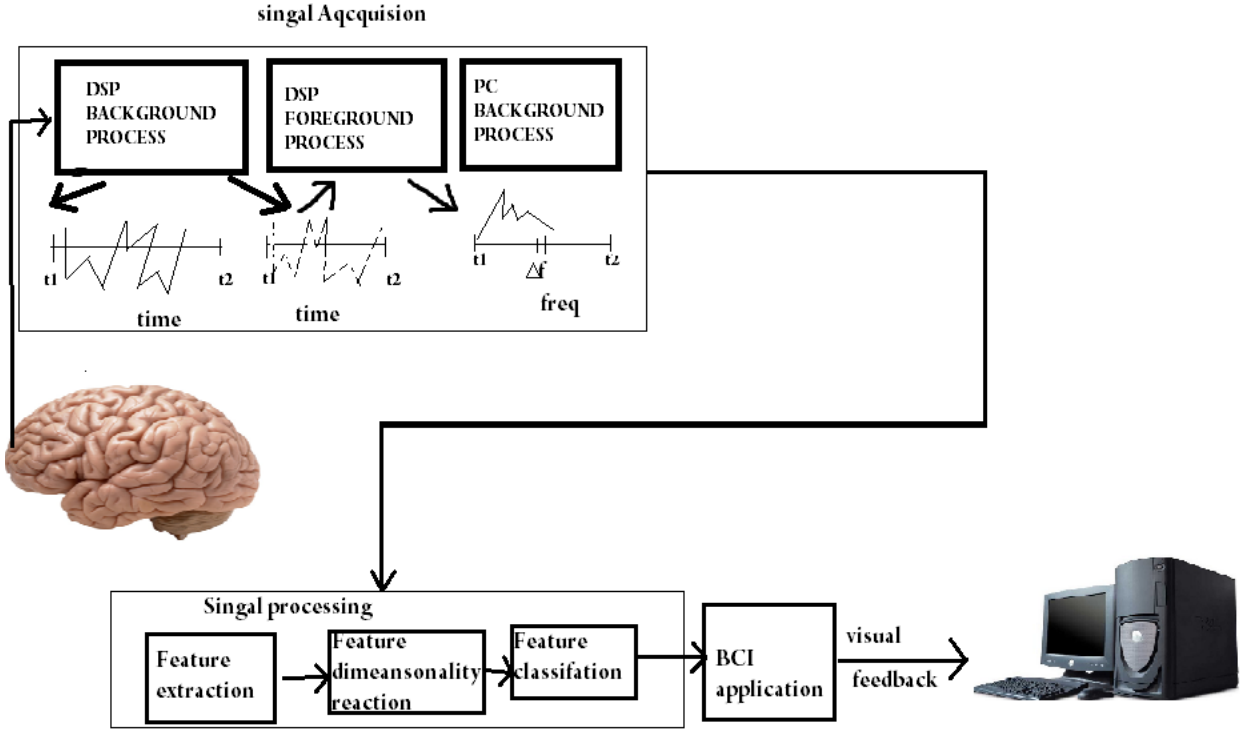
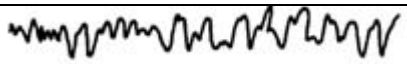
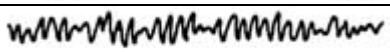


Fig.2: Brain Computer Interface Functional Diagram

2.4 Brain Signal Frequency Band

Cerebrum(brain) wave are symbolized by six distinct groups(bands) grounded on the frequency range between 1 to 100Hz considered as Alpha, Beta, Delta, Theta, Mu, and Gamma etc.

Table 1: Different types of frequency Band

Brain Rhythm	**Typical Frequency range (Hz)**	**Normal Amp. (µV)**	**characteristics**	**Signal**
Delta	**0.1 – 4**	**<100**	High emotional condition or in sleep stage	
Theta	**4 – 8**	**<100**	A calm and relaxed mood	
Alpha	**8 – 13**	**20-60**	Smooth pattern awaken ,calm and eye closed in relaxed mood	
mu	**10 – 12**	**<50**	Sensorimotor cortex	
Beta	**14 – 30**	**<20**	Desynchronized –normal awaken ,open eyes busy, concentrating	
Gamma	**> 30**	**<2**	Somatosensory cortex for touch-busy, concentrating or Active thought	

3. TYPES OF BRAIN COMPUTE R INTERFACE

BCI is divided into 3 parts. I.e. Invasive Brain Computer Interfaces, Noninvasive Brain Computer Interfaces, Partially Invasive Brain Computer Interfaces. The motivation behind various sorts of BCI is to interrupt the electrical signal that go among the neurons in the cerebrum and proselyte them to a signal that detected fringe gadget (system).

3.1 Invasive Brain Computer Interfaces

In invasive method the gadget is straightforwardly put over human mind and creates solid signal. It is essentially valuable for DOI (digital object identifier) people and paralyzed people. . It is useful to make tissue for paralyzed part of the body and alien the brain. In Invasive BCI the signal procurement strategy is separated into 2 units' i.e. single unit and multiple units.

Devices which are discovering signal from single areas of mind is called single unit and devices which are discovering signal from numerous zones of cerebrum cell is called multi-unit. Electrocorticography (ECOG) is an example of invasive BCI. It is an electrophysiological checking system in which electrodes are set straightforwardly on the unveiled surface of the mind further it can follow the electrical motion from the cortex of the cerebral.

3.2 Noninvasive Brain Computer Interfaces

In this strategy the gadget is set over scalp of human brain. It creates the most noteworthy nature of signal and gives new usefulness to incapacitated individuals (neuroprosynthetic) additionally forming scar tissue which is of lower danger. This strategy is used for brain monitoring incorporate EEG, MEG, fMRI, PET and so forth.

3.2.1 MEG

MEG is utilized for estimation of attractive fields brought about by electrical current dipoles that give by neural action. It creates signals with higher spaciotemporal resolution than EEG likewise it ameliorates the signal superiority and believers the signal into increased pace of BCI communication. MEG and EEG incorporate MU musicality whose recurrence extant is 8-12 Hz.

3.2.2 fMRI

fMRI is the non-invasive method to control the visuospatial attention. In this technology the BOLD fMRI (BOLD fMRI is the brain activation mapping method) is more grounded enough to base a dependable and proficient is control flag and is a closed loop system. It permits two users to play pong continuously by changing their hemodynamic response. fMRI is better than PET technology.

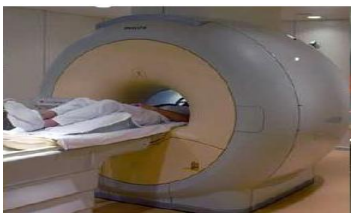


Fig 3: FMRI Scanner

3.2.3 PET

PET is an imaging methodology which creates a high motion spatial 3-dimensional picture. In clinical and research purpose PET is worn to precise the reasons of mind connected with different physiological assignments and to assess cortical reasons which are associated with different neurological issue.

PET delivers high quality of pictures that are homodynamic, compound, utilitarian or metabolic structure which finishes up the physiological variables that can be resolved. Before PET a scanning technique happens; the distinctive individual is injected with glucose or other chemical which contains radioactive atoms. At that point when examination (scanning) strategy happens the glucose or extra radioactive material started to label a positron is discharged and clashes into an electron that transmits two gamma rays going in right reverse direction.

3.3 Partially Invasive Brain Computer Interfaces

In this technique, devices are actualized inside the skull however rest are outer walls of the brains without adjoining the gray matter. It gives weaker nature of signal than invasive BCI. Likewise give less peril for making scar tissue. They need less preparing for leading. The function based on partially invasive BCI is categorized below:

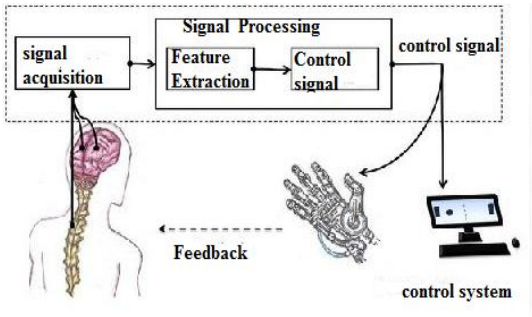


Fig 4: BCI System Configuration [3]

3.3.1 ECOG

ECOG utilizes the same innovation as non-invasive electroencephalography, yet the electrodes are fixed in a thin plastic cushion that is situated over the cortex, under the dura mater [3].

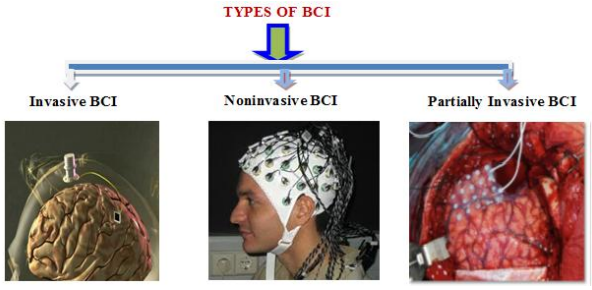


Fig 5: Types of BCI Head Set

4. EEG IN BCI

EEG is a complex and variable signal which reflect electric fields made by a billion of individual synaptic connection in the cortex. EEG is also a degraded signal because of its intricate anatomy and electrical characteristics of head .The electrical movement of EEG recorded at the scalp comprise of voltage changes of several microvolt at frequencies going

from underneath 1 Hz to 50Hz.It relies on a fruitful correspondence between 2 adaptive controller i.e. the system user who produce EEG control and the BCI system which interpret the controller in the device conrol. EEG produce rhythm like MU(8–12 Hz) and BETA(18–26 Hz) frequency band over left and/or right sensorimotor cortex to move a cursor on a video screen in one or two dimensions in words worth BCI[4].MU rhythms are focused near the midpoint of the center at the sulcus bilaterally.[2]

If a user is present at a certain target of right edge of screen and the cursor moves across the screen at a steady pace then the cursor move vertically to control the rhythm amplitude by sensorimotor. [4] On the off chance that a client is available at a specific focus of right edge of screen and the cursor moves over the screen at a relentless pace then the cursor move vertically to control the cadence adequacy by sensorimotor.[4]

$$V=b(s-a)$$

Where,

v is the cursor movement, S is control flag, a is the gain, and b is the mean control signal for the user's earlier performance. This is a linear equation to find the function of cursor movement. [4]

The EEG are measured on the scalp in microvolt (10-100 typically) but electrocardiogram measures in microvolt. As per the International Federation of Clinical Neurophysiology (IFCN) rules and the American Clinical Neurophysiology Society (ACNS) suggestions, before each recording electrodes impedance ought to be checked and that ought not surpass 5,000 Ω (=5 kΩ) (Ebneret al. 1999 ; American Clinical Neurophysiology 2008). [5]

4.1 Electrode Position

The IFCN proposes 10 -20 system EEG terminology for join electrode. It is made up of 21 electrodes for better scalp coverage. There are many types of EEG electrodes like cup electrodes, Pad electrodes, Ring electrodes, Needle electrodes etc.

The electrodes are named with a letter, speaking to the anatomical area (Fp = fronto polar, F = frontal, C = focal, T = temporal, P = parietal, and O = occipital), and a number (even numbers on the right and odd numbers on the left; midline electrode is called z (zero)).The electrodes are partitioned into (10 to 20) % in anatomical distance, so the system is called 10-20 [5].

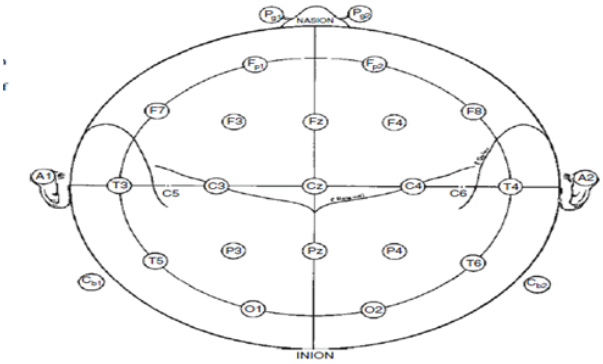
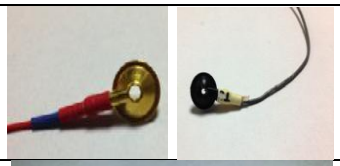
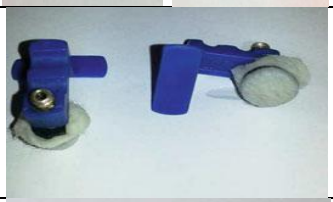
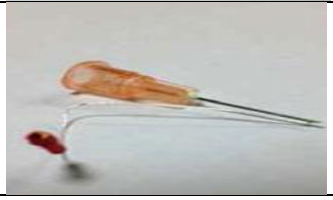
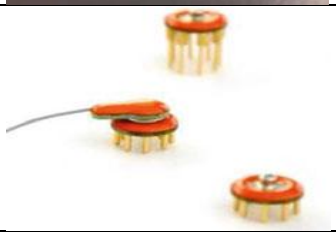


Fig. 6: Single plane projection of the head, showing all standard positions according to the 10–20 system [5]

Table 2 .Pros and cons for every type of EEG electrode [5]

Types of electrode	Figure of electrode	Pros	Cons
Cup electrodes		Good impedance CT-/MRI compatible electrode available	Time consuming Technician needed
Pad electrode		Good impedance Relatively fast setup	Only some hour of recording Not suitable for patent with significant skull defect Technician needed
Ring electrode		Good impedance Fast setup	Only some hour good recording Prone to bridge Not suitable for skull imperfect patent Technician needed
Subdermal or niddle electrode		Fast setup CT-/MRI well-matched electrode available	Only appropriate for comatose patents May be prone to skin infection Technician/nurse needed

Disposable & pad electrode		Fast setup No risk of cross contamination	complicated to use over hair so there is no full coverage of scalp possible Specialist needed
Dry electrode		Good impedance Fast setup No skin preparation	Cost Not broadly use in the clinical purpose

5. CONCLUSION

An in-depth survey of the presented literature speaks about the relevance of BCI which reads the 6 types of brainwaves, produced from the neural activity of brain and translate the brain signal into control signal. BCI is an interesting area for the research. Because it can solve many problems of paralyzed people also very much beneficial for environmental (ecological) monitoring as well as used in various applications of games especially after using EEG headset where the control on the game by thoughts. Also this study provides that how electrode is placed on the scalp of human brain and how it works. BCI techniques can be summed up as a section of neuro-modulation technology. Every individual can be figured out how to control a BCI with neuro-feedback involving self regulation of the neural activity. It may be helps to design and develop an automated device for driver and paralyzed people.

6. ACKNOWLEDGMENTS

My special thanks to Dr. Srinivas sethi to provide me a Lab facility funded by SERB (DST) New Delhi.

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