# A SURVEY ON BRAIN COMPUTER INTERFACE

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**Abstract**
This paper is about the analysis of different subdomains of Brain-Computer Interface (BCI) and its applications in day to day life. BCI allows for communication by brain activity without involving the muscular movement. This technology uses the signals from the brain and uses it to perform an outside activity like move wheelchair, robot arm, etc. If an individual wishes to do an activity like moving cursor then neurons capture the signal for this particular activity from the brain and then afterward, these signals are transferred to the finger, and now the individual can move the cursor. With the help of BCI, signals are directly transferred to a device where decoding is achieved, and one can quickly move the cursor. Thus it can be beneficial in case of physically challenged people. The day to day activities of a physically challenged individual will be at ease, which is the primary motivation to develop the particular BCI domain application. Brain-Computer Interface is achieved by invasive techniques like inserting electrode directly into one's brain by surgical methods. These surgical procedures are quite expensive, so there is a scope for future development in non- invasive domain so that everyone can take benefit of this technology. This paper also describes another subdomain of BCI Magnetoencephalography (MEG) which provides a signal with higher resolution than EEG, and thus the efficiency of the entire system can be increased exponentially.

**Keywords:** Brain-computer interface (BCI), invasive brain-computer interface, partially invasive brain-computer interface, non-invasive brain-computer interface, electroencephalography, electrocorticography.

## INTRODUCTION

Brain-Computer Interface is also called a Mind-machine interface which establishes the communication between external device and brain by passing signals. The signal reaches the computer from the brain directly rather than following a common neuromuscular way. Most of BCI applications provide a second option for communication medium for those who cannot use a keyboard or mouse. With the help of BCI applications, one can experience virtual world just by thinking about them. BCI provides communication methods that do not depend on nerves and muscles. BCI system takes and processes brain activity into a signal to which a computer can respond.

### 1.1 How was BCI evolved?

In 1924, Hans Berger discovered electrical activity of brain. At the same time, the development of electroencephalography (EEG) was going on. Hans Berger first recorded brain activity using EEG. When a person is doing some task, neurons are in action. Various Computer chips are programmed in such a way that, they convert these neural signals into action. This can be useful in case of physically challenged people. One can perform simple tasks like writing text using a cursor or writing a paragraph can be quickly done with the help of BCI. Even movement of the hand is possible via robot arm [14] [15]. From many years, researchers are developing applications using brain signals which communicate with the computer by using BCI. The systems which are based upon BCI measures brain activities and
Translate into signals which yield an output. BCI commonly uses electroencephalography (EEG)[4][5] recordings from the scalp and neuron recordings within the cortex. BCI recognizes specific patterns of signals in users' brain using five cognitive stages: signal acquisition, feature extraction, pre-processing or signal enhancement, classification, and the control interface. It also offers the measurement of intracellular currents flowing through dendrites. The magnetic fields produced by these currents can be measured outside of the head. So far, we have described the ECoG (Electrocorticography) of invasive type and MEG (Magnetoencephalography), fNIRS (functional Near Infrared Spectroscopy) of non-invasive type. Applications of Brain-Computer Interface base its functionality depends upon either observing the user state or allowing the user to express his\her ideas. The extent of BCI is too vast, so here we are trying to introduce some proposed result for application areas of BCI.

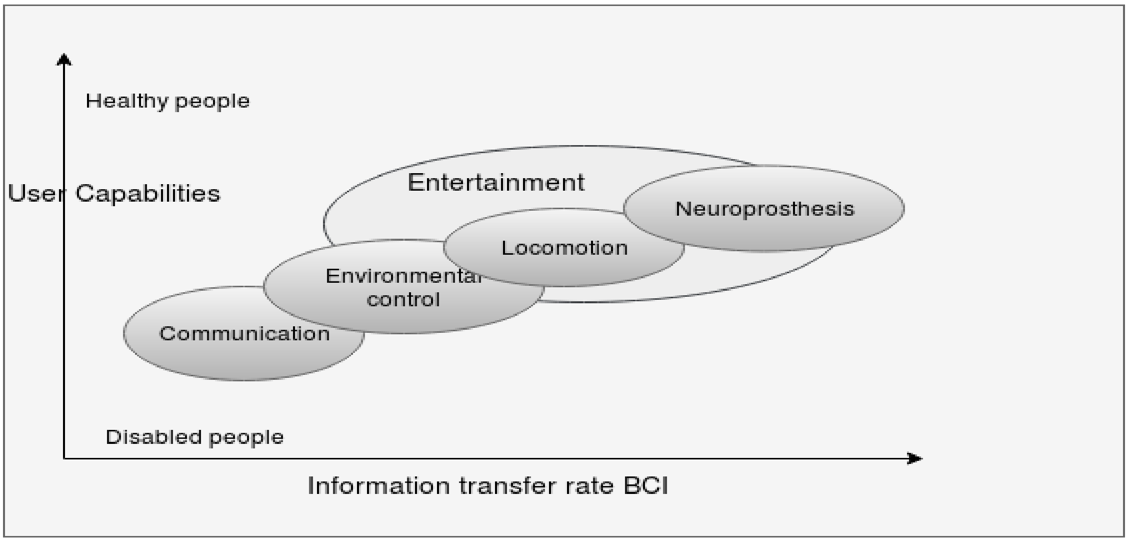
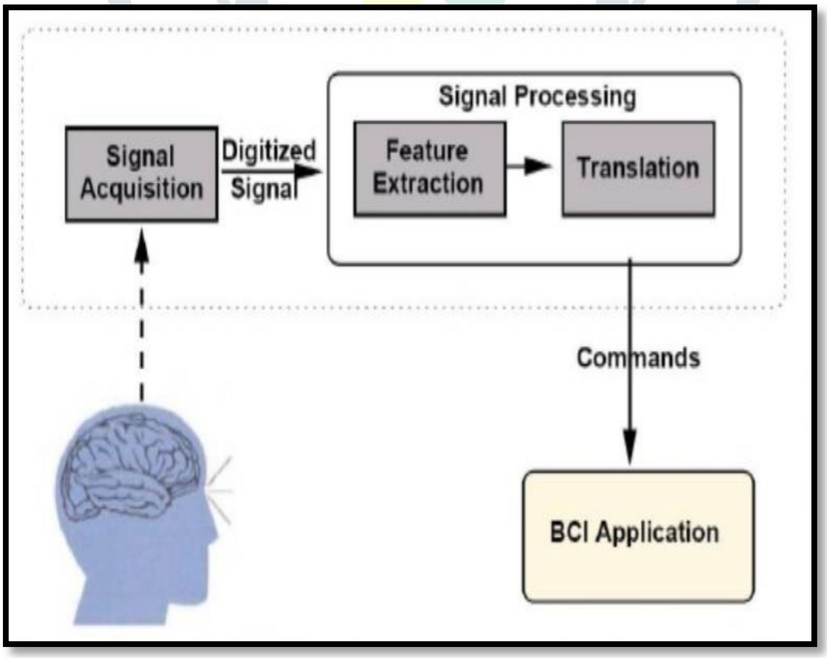



**Figure 1. Application areas of BCI**

## II.LITERATURE SURVEY

BCI provides an interface for providing EEG activity of brain function in a way such that it can have interaction with the surrounding world. BCI has become one of the new fields for research now a day. Spelling checking can be considered as the primary application of BCI. Variety of signals and classification algorithms are designed and tested in BCI. Also, studies have also noted some issues needed to be solved like merits and demerits of different signal acquisition methods. The latest advancement in BCI research involves multidisciplinary scientists like engineers, clinical rehabilitation specialists, neuroscientists, mathematicians, etc. The research has categorized the methods in BCI in 2 types, invasive and non-invasive. The devices (electrodes) are implanted inside the user's brain, or it can be implanted over the surface of the brain in the invasive method. While in non-invasive method sensors are placed on headbands or caps to read the signals. This is the safer way as compared to invasive one, but it has less signal clarity when the communication with brain signals is considered**.** The electrocorticography (ECoG) is one of the invasive methods which enables direct measurement and portability and uses electrical signals whereas MEG and fNIRS are the non-invasive types of methods. MEG uses magnetic signals, direct measurement but doesn't provide portability. fNIRS is portable, but there is no direct measurement for metabolic signal capturing.

## IMPLEMENTATION




**A fig.2 Block diagram of BCI[16]**

### 3.1 System Description

BCI system consists of various components but some are essential and extra components can be added to extend the functionality. Signal or data acquisition, their processing like feature extraction, feature translation, and output components. All these components are controlled by different protocols which define the timing for signal processing, nature of device commands, operation details and performance [6]. Each component is explained below briefly. [6]

### 3.2 Signal acquisition

Brain signal is captured using EEG acquisition device. The signal acquisition machine takes the signal from a 14 channel EEG based device which takes the signal from our brain in microvolts in the frequency range from 0.3Hz to 43Hz. These signals are given as input to the processor. Also, ECG artifact, electrode contact (salt bridge) artifact, pulse artifact are the unwanted superimpositions on the signals we acquire. Some of the signals are visual evoked potentials, slow cortical potentials, P300 evoked potentials and sensorimotor rhythms.[14]

### 3.3 Signal Processing

**3.3.1 Feature Extraction:** This part of signal processing extracts specific signal features. Activities, like encoding user's mental tasks, detecting an event related response, or reflecting subject's monitor intentions, are detected based on specific target patterns. This phase analyses the digital signals characteristics and presents them in a compact form which can be translated into output commands.

**3.3.2 Feature Translation:** The process of feature translation converts the selected features to the appropriate command to control the different devices. The various feature translation algorithms are categorized into linear and non-linear models which include Linear Discriminant Analysis, Support vector machine, K-nearest Neighbour Classifier, Artificial Neural Networks, etc. [15] This block translates the signal into such commands which are understandable by the BCI application.

### 3.4 BCI Application as system output

System output which is the user side application completes the closed loop of BCI. These external devices operate on commands from the feature translation algorithms which provide functions such as letter selection, robotic arm operation, cursor control, etc. Output devices can be any controllable machines for answering Yes/No questions, word processor, wheelchair, virtual reality, etc. Usually, the computer screen and the output is the selection of targets or cursor movement.

### BCI Applications

The control mechanism may be independent of the recording method such as invasive, non-invasive. Further clarification of recording and analysis techniques will apparently enhance the performance of both invasive and non-invasive methods. There are many emerging application areas in medical[2], communication fields. The project of "Controlling wheelchair for disabled people" is implemented in LDA class using electroencephalography where Commands are given by the disabled person deciphered by embedded algorithms and suitably executed[11]. Choice of control (manual or mind-controlled) provided. Regarding the application "decoding brain states from pre-specified cortical-regions," an efficient numerical solver is developed to find the solution of RDA with guaranteed global optimum. Compared to other traditional methods, RDA can efficiently extract the discriminant signals from the ROI and suppress the signals originating from the RON, as is demonstrated by the experimental results in [12].

**Table 2. Application areas of BCI**

| Application | Classifier | Method |
|---|---|---|
| Controlling a wheelchair for disabled people | Linear Discriminant Analysis | EEG |
| Subject identification with VEPs | Support vector machine | ECoG [3] |
| Detecting reading intentions | K-nearest Neighbour Classifier | ECoG |
| Towards Decoding Speech Production | Artificial Neural Networks | MEG [13] |
| Analysis of neuroimaging and biomedical signal processing human pain | Support Vector Machine | fNIRS |
| Emotion recognition | Linear Discriminant Analysis | fNIRS |
| The iterative reweighted Mixed-Norm Estimate for spatiotemporal MEG/EEG source reconstruction[16] | K-nearest Neighbour Classifier | MEG |
| Decoding Brain States Based on Magnetoencephalography from Pre-specified Cortical Regions[11] | Linear Discriminant Analysis | MEG |

**Future scope**

1. Access to the brain for performing read/write activity
2. The line between mind and the computer is blurred. Partial or full uploading is possible and unavoidable.
3. A person with disabilities could communicate easily.
4. Real-time gaming is also possible by using BCI.
5. The devices can be constructed which can detect the waves and using artificial intelligence derivate some conclusion on intensions of user. This technique can be used in criminal investigation.
6. Use of BCI barcode reader to activate BCI interface.

**Conclusion**

Brain signals depict the organized activities and controlling behaviour of the brain or the effect of the received information from other body parts either sensing or internal organs. Brain-Computer Interfacing provides a communication between the brain and external equipment. This paper presented various aspects of a BCI system. We have discussed the basic block diagram of BCI and its components. Furthermore, this paper discussed various signal acquisition methods which are cortical surface (ECoG), Magnetoencephalography (MEG) and functional Near-infrared Spectroscopy (fNIRS). Finally, we have produced our result and compare the result with the present paper which we showed with the help of graph and tables. Several studies have been presented regarding the exploration of BCI applications in the fields such as organizational, medical, transportation, games, entertainment, security, and authentication fields. The BCI field is rapidly approaching critical mass to develop the human-computer interaction methods of the future. [1]

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