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REVIEW ARTICLE

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REVIEW ON: BRAIN COMPUTING INTERFACE

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ABSTRACT

A Brain Computing Interface (BCI) is only valuable method to communicate with the environment, is useful device that can read brain signals and convert these signals into control and communication signals. In basic BCI is communication path between the human brain and computer system. The most vital aim of BCI is to increase a system that allows disable people (e.g. A person who is cognitively intact but the body is paralyzed means people cannot move his arms, face and legs or control of muscles is lost) to communicate with other humans and interact with external environments. The BCI is broad area of do research that includes the components like comparisons of invasive and non-invasive techniques that measure the brain activity, gauge approximately of organize signals or brain activities used for communication, enhancement in algorithms that used for translation of brain signals in computer command and developing new BCI purposes. In this paper present a review on aspects of BCI, recent developments, applications and classification methods and output parameter.

INTRODUCTION

A Brain computer interface is a structure or organism that allows a human to control special computer applications like computer cursor or robotic limb by only using her/his thoughts.BCI are frequently directed at assisting, repairing human cognitive, augmenting, or sensory motor functions. BCI is also called mind-machine interface (MMI), synthetic telepathy interface (STI), directed neural interface (DNI) or brain-machine interface (BMI).BCI compute or gauge the brain activity of human, then process it, and generate control signals that reflect the user intent. To identify and recognize brain computing interface operations in additional detail, first has to recognize how brain activity can be measured and which signals of brain can be utilized.

The main preliminary aim of BCI research is to providing that BCI can effort with patients who need a BCI to communicate between patient brain and computer system. Suppose a person is cognitively intact but body is paralyzed means the person has lost control of muscles (cannot move legs, face and arms). Through BCI the patient communicate with the environment because BCI read the brain signals and convert these signals into communication and control signals.

The BCI have some components: A BCI records the activity frankly or openly from the brain may be invasively or non- invasively. BCI gives feedback to the user, must do so in real-time. BCI system must rely on intentional control.

History: The History of brain computer interface or mind machine interface started with Hans Berger's finding of the electrical activity of the human brain and the expansion of electroencephalography (ECG). Berger's was the first to records human brain activity by ECG in 1924. Berger was capable to identify oscillatory activity in the brain by analyze ECG traces. One wave he recognizes was the alpha wave (8-13 Hz) is also called as Berger's wave. Early studies on BCI began in 1970, they refers essentially to intonation and design algorithms that mimic the activity of motor area neurons. In 1980 scientists establish mathematical formula that interrelated or correlated electric signals that transmitted by the cerebral motor areas and the physical movements out by monkey.

Current and Future Applications: Some applications of BCI system may seem frivolous such as: Ability to control video games by thoughts. The device that would allows numerous disable people to function independent. BCI have been used to restore movement, access cognitive functioning and gives communication and environmental controls. If you consider a remote control is convenient, imagine you think about channel in your mind and channel changes. Mainly three major applications of BCI discussed below:

i. **Rehabilitation:** The Rehabilitation idealize to enhance life quality of human who are suffers with paralyzed completely or partially and suffers difficulties due to Amyotrophic Lateral Sclerosis (ALS), Cranium Traumatism, Locked in Syndrome, severe cerebral paralysis etc. after losing all facilities or potentials of voluntary movements, these patients go into state where communication is impossible. These human communicate with world and external devices.

ii. **Patient Treatments:** Neurofeedback (NFB) treatment is applied or utilizes the subject's neurophysiologic signals and displays them in a friendly interface like images, sounds and vibrations. The treatment is optimistic to control human brain activity, thus reasonable diseases like epilepsy and hyperactivity, since these pathologies constructor produce distinct features in the brain activity.

iii. **Entertainment:** More than a few investigation teams and companies are exhibit that it is fairly possible for a human to control her/his movements and gesticulation within virtual reality environment/games. some investigators was able to develop mobile phone systems that allows the user to send short mail system (SMS) or compose ring tones recurring to wireless BCI.

Types of Brain computing interface (BCI): There are many different types of BCI. But the main three types discussed below in detail:

I. Invasive Brain computing interface: Invasive strategies are surgically implanted directly into the brain and they are based on the use of array of microelectrodes implanted into visual cortex. The invasive BCI have highest quality signals and capable to give better spatial and temporal resolution of signals. The invasive BCI is mostly useful to gives functionality to paralyzed people. Invasive BCI very useful to restore vision by concerning or linking the brain with external cameras and restore the use of limbs by using brain controlled robotic legs and arms.

II. Partially Invasive Brain computing interface: The partially invasive mechanisms are implanted inside the skull but rest outside the brain slightly within the grey matter. When we compare it with Invasive BCI it is one bit weaker than Invasive. Electrocoticography (ECOG) is example of partially Invasive BCI technique.

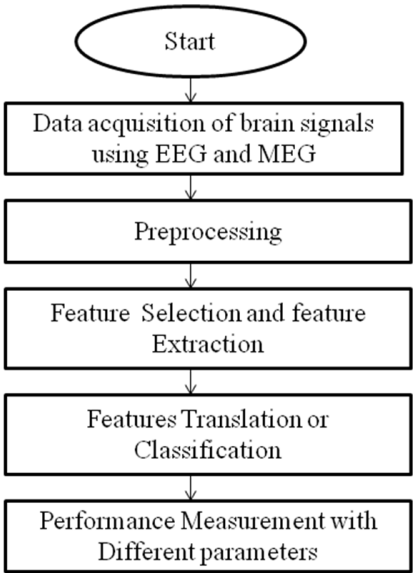
III. Non-Invasive Brain computing interface: Non-Invasive BCI has the slightest or least signal clarity when it communicating with skull distorts signals but it is well thought out to be very safest compared to other techniques. Electroencephalography (EEG), Computerized Tomography (CT), single-photon emission computed tomography and magnetoencephalography (MEG) and magnetic resonance imaging (MRI) are best examples of non-Invasive brain computing interface. Non-Invasive methods reduce ease risk for users

since they do not necessitate surgery or permanent attachments to device.

II Steps for Brain Computing Interface:

i. **Data acquisition:** The data acquisition is the first step in which many direct and indirect methods used for acquisition. The functional Magnetic resonance image (fMRI), position electron tomography, single photon emission computed tomography (SPECT) are indirect methods for data acquisition that only provide an atomically information, with minute temporal resolution, thus not present related or appropriate data to BCI system. The main supportive techniques for data attainment are MEG and EEG.

A) EEG: EEG is most widely used in BCI applications because it is non-invasive and less expensive method and corresponding to more than 80% of effectuated work. The EEG has highest temporal resolution that measuring every thousands of seconds. Recent EEG has a reasonable spatial resolution as signal from up to 256 electrode sites can be measured at the same time. The EEG is the portable device and has been standardized method.



B) MEG: MEG is also non- invasive device.MEG has good temporal and spatial resolution, due to necessitate of helium at very low temperature. But MEG is technically demanding and more expensive.

ii. **Preprocessing or Signal interference:** When the signals captured by invasive and non-invasive techniques and EEG contain a lot of noise, that noise is removed by preprocessing steps.

EEG deals with electrical signals and signal interferences signals have to with other electrical activity, whether produced by our body and our brain. The two type of source of the intrusion can be discussed here. First, the electric current from close things or objects with frequency ranging 50 to 60 Hz , and the noise is effortlessly removed with the proper isolation of the filtering of signals. Secondly, the signal interference can create or derives from the subjects muscular activities. If the activity is closed to brain then it can be traced by the electrodes and compromise with signals captured.

iii. **Feature extraction:** After the preprocessing the feature extraction is very important step. The feature selection and feature extraction algorithms as heuristic search methods that process huge and large amount of irrelevant data to find and extract few features. The spatial and temporal are two main features extraction types. The spatial method is useful for feature extraction and it utilize the alpha rhythms and the selection of spatial filter mostly affect the signal to noise ratio. In spatial method some high pass spatial filter use such as the bipolar derivatives compute, the first derivative and establish difference in voltage gradient in one direction. Another side temporal process is also helpful in maximizing the signal to noise ratio. Some characteristics or principals for feature extraction are discussed as: the first decisive factor is the definition of starting points that will conclude the direction of the search as well as the operators to decide the succeeding states. Second, is the initiation of the seek out because it is not competent search of entire feature space, stepwise adding and

removal and best search to select next features that develop the score over the current set. Third principal is the method used to evaluate all possible subsets of feature. Fourth and last is the terminate conditions for the search.

Some algorithms mostly used for feature extraction explain below:

a) **Embedded algorithm**: In the embedded algorithm the feature selection is part of translation. in this process the features selected, adds and removes features to counter prediction errors as new training data is introduced.

b) **Filter algorithm:** the filter algorithm select and extract features that independent of the translation process.

c) **Wrapper algorithm:** in this algorithm features selected by develop or utilize the translation algorithm to rate the quality of the feature set.

iv. Classification: some classification methods are used for train the specific features:

a) Linear discriminate analysis (LDA): LDA is mostly useful classifier because it is capable to create an output which is continuous in time as well as amplitude. LDA is also useful or successfully practical or applied to different EEG parameters like common spatial patterns (CSP), Adaptive autoregressive (AAR) parameters, band power values (ERD).

b) Support vector machine (SVM): SVM very useful in BCI because of the simplicity of SVM .the decision rule of SVM is very simple linear function in the kernel space which makes SVM stable and has low variance. SVM has the regulization, so the SVM may overcome the problems of noise and improve the generalization capabilities of classifier.SVM has immunity to the curse-of-dimensionality.

c) Neural Network (NN): the NN is a congregation or assembly of various artificial neurons which facilitate to create non-linear decision boundaries. The multilayer preceptron and learning vector quantization (LVQ) NN, Fuzzy ARTMAP Neural network algorithm is used. The MLP deficient or devoid of hidden layer is called preceptron. Interestingly enough, preceptron is the same as LDA has been sometimes used for BCI applications.

d) Hidden Markov Model (HMM): The HMM is the type of non-linear Bayesian classifier. It is popular algorithm or classifier in the field of speech recognition. HMM is not generative classifier but it is discriminative. HMM are not most widespread within the BCI society but these studies related that they were promising classifiers for BCI. HMM is useful to classification of temporal sequence of BCI features.

e) K- Nearest neighbors: it is not very useful in the BCI application because they are known very sensitive to the curse-of-dimensionality that made them fail in various BCI experiments. The main aim of the this method is to allocate an unseen point the dominant class among its k-nearest neighbors within the training set. For BCI system, these nearest neighbors are usually obtained using a metric distance.

v. Performance Metrics: In performance metrics if we define class labels of binary (two classes) prediction problem as positive and negative classifier has the following four possible outcomes:

True positive: TP is number of positive samples correctly predicted.

True negative: TN is number of negative samples correctly predicted.

False positive: FP is number of positive samples incorrectly predicated.

False negative: FN is number of negative samples incorrectly predicated.

Classification accuracy: Classification accuracy is defined as the percentage of number of trials classified correctly in the test set over the total trials. It is considered by

$$CA = \frac{\text{True positive} + \text{True Negative}}{\text{True positive} + \text{True negative} + \text{false positive} + \text{false negative}} \times 100$$

Specificity and Sensitivity: Sensitivity and specifying are calculated by
Following formula:

$$SE = \frac{\text{True Positive}}{\text{True positive+ false negative}} \times 100$$

$$SP = \frac{\text{True Negative}}{\text{True Negative+ False positive}} \times 100$$

Kappa: kappa statistical is defined as proposition of correctly classified samples after accuracy for probability of chance agreement.

$$\text{Kappa} = \frac{P(D) - P(E)}{1 - P(E)}$$

Computational Time: We compute the training and testing times of the classifiers.

Literature Review

The BCI is the most challenging area in the field of medical and research. More than a few such researchers and preceding work are summarized below:

Bishop C M [1] presents the MLP (Multi Layer Preceptron) algorithm that is most useful in Neural Network used for classification. MLP have been practical to BCI problems such as synchronous, multiclass and binary BCI. S. Mason, J. Kronegg, J. Huggins, M. Fatourechi, and A. Schloegl. [2] Introduce the Evaluating the performance of self-paced BCI technology. In this paper discuss about the number of linear and distributed inverse solutions that used for BCI such as ELECTRA. Rabiner L R [3] presents the tutorial on hidden markov models and selected applications in speech recognition. In this paper discuss the depth-weighted minimum norm techniques. F. Lotte, M. Congedo, A. Lécuyer, F. Lamarche, and B. Arnaldi [4]. Introduce A review of Classification algorithms for EEG-based brain-computer interfaces. In this paper they present the Band Power (BP) features are also identified to be efficient for motor imagery classification. The Linear Discriminant Analysis (LDA) has been used with success in an enormous number of BCI system such as motor imagery based BCI or asynchronous BCI [5][6]. Duda R O, Hart P E and Stork D G [7] introduce about two techniques linear Discriminant Analysis (LDA) and support vector machine (SVM).The Linear Discriminant Analysis (LDA) is also called fisher's LDA is used to hyper planes to separate the data representation in the different classes.[7] [8]. Anderson C W and Sijercic Z [9] present classification of EEG signals from four subjects during five mental task solving engineering problems with NN. In this paper describes about all classifiers like linear classifier, nearest neighbor classifier and neural network and non linear Bayesian classifier used for design BCI systems. The two techniques LDA and NN together for translation and to train the features [9] [10].

CONCLUSION

We have concluded that BCI is adolescent technology which previously promises to have a vast impact in the society of the future. This impact will be useful in two fronts: firstly the entertainment for people in general and secondly improving life quality of a miscellany of people which are in one-way or two way or another handicapped. This paper present the BCI as a technique that is able of building the communication bridge between external technical devices and central nervous system, and also allows one-way or two way communications. Various techniques and classifiers, especially the multi-channel inexpensive electroencephalography (EEG) hardware Emotive EPOC Neuroheadset was described.

REFERENCES

[1]. Bishop C M 1996 Neural Networks for Pattern Recognition (Oxford: Oxford University Press)

[2]. S. Mason, J. Kronegg, J. Huggins, M. Fatourechi, and A. Schloegl Evaluating The performance of self-paced BCI technology. Technical Report, Neil Squire Society, 2006.

[3]. Rabiner L R 1989 A tutorial on hidden Markov models and selected Applications In speech recognition Proc. IEEE.

[4]. F. Lotte, M. Congedo, A. Lécuyer, F. Lamarche, and B. Arnaldi. A review of

[5]. Classification algorithms for EEG-based brain-computer interfaces. Journalof Neural Engineering, 4:R1–R13, 2007.

[6]. Pfurtscheller G 1999 EEG event-related desynchronization (ERD) and Event- Related synchronization (ERS) Electroencephalography: Basic Principles, Clinical Applications and Related Fields 4th edn, Ed Niedermeyer and F H Lopes da Silva (Baltimore, MD: Williams and Wilkins) pp 958–967.

[7]. Scherer R, Muller G R, Neuper C, Graimann B and Pfurtscheller G 2004 An asynchronously controlled EEG-based virtual keyboard: Improvement Of the spelling rate IEEE Trans. Biomed. Eng.

[8]. Duda R O, Hart P E and Stork D G 2001 Pattern Recognition 2nd edn (New York: Wiley-Interscience).

[9]. Fukunaga K 1990 Statistical Pattern Recognition 2nd edn (New York: Academic).

[10]. Anderson C W and Sijercic Z 1996 Classification of EEG signals from Four subjects during five mental tasks Solving Engineering Problems With Neural Networks: Proc. Int. Conf. on Engineering Applications of Neural Networks (EANN'96)

[11]. Hiraiwa A, Shimohara K and Tokunaga Y 1990 EEG topography Recognition by neural networks IEEE Eng. Med.Biol. Mag.

[12]. A.Schlogl, C.Neuper, andG.Pfurtscheller.Estimating the mutual Information of a eeg-based brain-computer interface. Biomed Tech, 47(1-2):3{8, 2002.

[13]. B. Blankertz, R. Tomioka, S. Lemm, M. Kawanabe, and K.-R. Müller, "Optimizing Spatial filters for robust EEG single-trial analysis," IEEE Signal Processing Magazine, vol. 25, no. 1, pp. 41-56, Jan. 2008

[14]. I. Guler and E. D. Ubeyli, Multiclass support vector machines for EEG-signals Classication, IEEE Transactions on Information Technology in Biomedicine, vol.11, no.2, pp. 117-126, 2007.

[15]. M. Cheng, X. GAO, S. Gao and D. Xu, Design and implementation of a Brain-computer interface with high transfer rates, IEEE Trans. Biomed. Eng., vol.49, no.10, pp.1181-1186, 2002

[16]. J. R. Wolpaw, N. Birbaumer, D. J. McFarland, G. Pfurtscheller and T. M. Vaughan, Brain-computer interfaces for communication and control, Clin. Neurophysiology. , vol.113, pp.767-791, 2002

[17]. A. Furdea et al., A new (semantic) re exive brain-computer interface: In search for a suitable classier, Journal of Neuroscience Methods, vol.203, no.1, pp.233-240, 2012