STM JOURNALS

Journal of Artificial Intelligence Research & Advances
ISSN: 2395-6720(Online)
Volume 5, Issue 2
www.stmjournals.com

Cognitive Enhancement of the Brain: Removal of Artefacts

Yogesh R Kumar*
Information Technology, University School of Information, Communication and Technology, Guru Gobind Singh Indraprastha University, Delhi, India

Abstract

The study aims to investigate and explore the various methods to find psychological and physiological signals of any subjects. Their pre and post data recordings are studied as a part of this study. The study is named as the "Cognitive Enhancement of the Brain". Various features which are there in the physiological signals are actually processed to be extracted, then classified and then interrelated or correlated by using various tools and techniques. We have studied the steps involved in recording the data, both as pre and post by performing various tasks in the methodology. Some pre and post data were already given by performing some activities on the subjects previously like finding out the parts of the brain which are active while there are different emotions like happiness or sadness etc. We have studied the different ways and algorithms to check the brain activities on behalf of the data provided and the experiment done in order to get that data. In order to get that data, experimenters used MATLAB for filtering the EEG signals using ICA which is Independent Component Analysis.We have studied the way through which the comparison of the pre and post data of the subjects on whom the experiment has been done can be performed. ICA is one of a kind of conventional method useful to reduce the artefact issues of the pre-processing of the data. Some other important facts related to brain mapping and cognitive enhancement have also been discussed in this study.

Keywords: *ICA, EEG signals, artefacts, electrodes, feature extraction, pre-data, post data*

****Author for Correspondence*** E-mail: ryogesh1923@gmail.com

INTRODUCTION

Brain Computer Interface

There are many ways in which computers and we humans can converse by some kind of a language known to both of us or interact actively through the mixture of hardware and software compositions. Most of the times it is seen that people use peripheral devices like keyboards or mouse to give instructions to the computers which actually work in a desired manner. But this is not all, because to interact with computers, newer forms have been invented nowadays. And the research and development are still in process for this. For example, the quality of recognition of speech is convalescing day by day and strengthening itself among people. Another example of this is Nintendo's new game console which uses arm movement to play games. With these kinds of innovations and researches with the computer to interact, the brain activity usage is gradually becoming more popular and demanding nowadays.

This method of interacting with brain using computers is called as Brain Computer Interface. BCI was developed to be used as spelling device or for the video games. This can be used even for the replacement for the controlling a window computer. For this it has to be combined with electromyography. Apart from these examples of the real world, a list of various possible applications of the real world is there that can be controlled by this technique named BCI.

Which Areas of the Brain Control Emotions and How?

The deep limbic system in the brain is actually surrounded by the set of nuclei which is known as the basal ganglia. There are mainly three tasks that a brain carries: Thoughts, Feelings and Put Together Movements. How does anyone's brain work as when someone is scared, he or she gets a feeling or thought. This feeling or thought comes due to the emotions that a human being or a living thing has. The

electrical waves go to the brain and the brain reacts according to the feelings or thoughts that a person is getting. For example, if someone sees a snake and he or she is scared of it, he or she will automatically jump back. This disorder of movement of getting scared and jumping back is due to the low basal ganglia activity in the brain. Where in case, if it is high then it causes anxiety, muscle tension or symptoms like workaholic.Feelings or emotions like happiness and pleasure are countable in basal ganglia. The front half of the brain is occupied with the prefrontal cortex which is responsible for impulse control, empathy etc. In short, it is a low emotional part.So, it is important that this area of the brain should work in a healthy manner as it can increase and strengthen our conscientiousness and thoughtfulness etc. If this area suffers with anything negative or bad it can lead to disorganization and can be easily distracted. And if it high, the person will suffer from anxiety type emotions. Now, behind the eyes there are temporal lobes which are responsible for stability of mood, object rejection or language learning ability etc.If the left side lobe is being damaged, problems like severe depression or hypertension or loosing temper occur;whereas the right-side lobe gives symptoms of intense sense of intuitions if high.

The central area of the brain occupies the deep limbic system which plays the most important role when we talk about the emotional state of a person. It actually keeps or stores the emotional memories both, negative and positive, good and bad. Figure 1 shows the lobes of the cerebrum.

The physiological signals are obtained by various softwares interfaced with hardware and are analysed and studied with various techniques of signal processing.

INTRODUCTION TO EEG

EEG is basically the recording of the activity of the brain in an electrical form, which is recorded using electrodes. These electrodes are positioned on the scalp's surface which varies from subject to subject.This system has its applications in the clinical purpose, say, the epilepsy diagnostic and is also the only device which enables the neurologists to observe and check the abnormalities in the brain and in the human. The positions of the electrodes are codified by 10/20 system in which 20% of the brain area is fixed by 10-10 and 80% of the brain area is covered with 20-20 system.

Following are the EEG interests:

- High temporal resolution,
- Low cost,
- Low weight, and
- Entirely non-invasive.

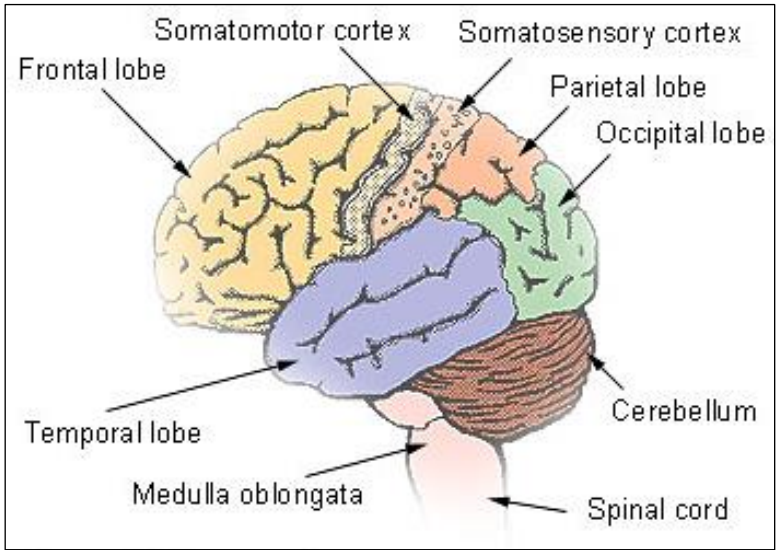

Fig. 1: *Lobes of the Cerebrum.*

These signals are complex and rhythmic and transient. The activities which are rhythmic are divided into frequency bands. If we consider the age and conditions then these EEG signals for a healthy person or an adult may vary in frequency and amplitude when we record in different states like when a person is in sleep or awake. Further, the wave's characteristics change with respect to age. There are basically five major waveforms when we talk about brain. These are differentiated according to the frequency range which is in accordance with the age too. These are alpha, theta, beta, delta and gamma in ascending order.

METHODOLOGY

Signal Processing

Signal processing is done by performing various tasks which includes the following steps shown in the Figure 2 given below:

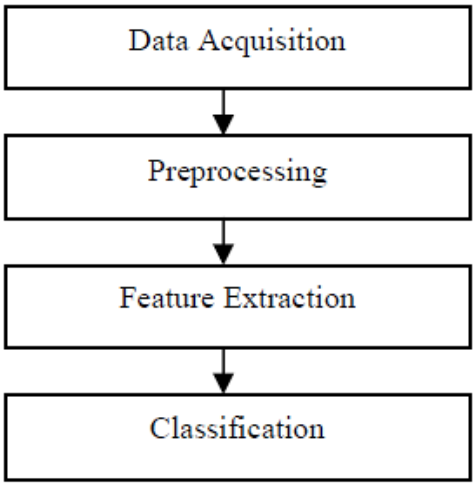

Fig. 2: *Flowchart of Signal Processing.*

Data Acquisition

EEG measurement actually gives the potential difference between the two electrodes. This is the principle of this measurement task. The system uses the reference electrodes as to determine the skull's background electric field. The placement of these electrodes is on the mastoids and ear lobes. We have to take care of the placement of the reference electrode because if we place the electrodes close to the brain, there might be a chance of getting affected by the activities of the brain. Not only the brain but any other parts of the body are responsible. It is likely to be affected by the muscle's electrical activity, especially from the heart. To remove the artefacts, we need to have the filtering system. To remove these unwanted frequencies, there are two pass filters, namely low pass filters and high pass filters, removing the EMG (Electromyography) and EKG (Electrocardiography).

Pre-processing

This phase is used to remove the artefacts which are present in the EEG. It uses digital filters like FIR and ICA techniques.

Artefact Removal by ICA by Blind Source Separation

Independent component analysis or another name, the blind signal separation, is a kind of mathematical tool which actually helps in solving the separation problems of the sources and helps in reducing the artefacts in EEG.

Artefact Removal by Digital Filters

In order to remove the eye ball movement, artefact or eye blink, we use a band pass FIR filter which is actually fixed by default, following eye blink threshold of a subject.

Feature Extraction

Feature extraction is a type of dimensionality reduction. When we are concerned with the data we have that input data which is actually large and each and every information that the data is consisting, is not important or required or relevant for our study. So we actually transform the given input data into a set of features. The feature set which we have opted gives the relevant data from input data so that further tasks can be performed.

Phase Locking Values and Coherence

PLV is a statistic which is used to find the changes in the induced tasks for the synchronization of neural activity in the long range from the EEG data. Coherence plays the role of measuring the synchronisation between the given channels.

Extracted Features of EEG Signals

Following are the features extracted from EEG signals:

- Power Spectral Density.
- Energy.
- Entropy.

Classification

Classification is nothing but the technique which we use or apply on the information or data which we have attained after the process

of feature extraction. Input is just a normal and a simple data whereas the output data is pretty similar to the class associated with that set of data. The comparison of pre and post data is done here in this section. There are various ways to perform the classification.

ANN

Artificial Neural Networks: The classification of the data is based on the neural network. Here the data gets converted to the classes and then it defines it.

Nprtool is used in MATLAB for ANN. It forms three processes:

(i) Training;
(ii) Validation; and
(iii) Testing.

- Training part is responsible for the training to the samples of data.
- Validation part takes on the responsibility for the validation of the samples of the data. The samples are checked for the validation in ANN technique.
- Testing part is responsible to test the samples for the training provided.

k-Nearest Neighbor

It classifies the data on the basis of the nearest neighbors. The basic method is provided as the instance nearest to the other in some or the other category.In general, the value of k is equal to 1.

kNN is a classifier which is based on the instances that workon the premises that the classification of the instances which are unknown can be performed by inter-relating the instances which are known in accordance with either the distance between them or any similarity between their functions. This is an intuition that any two instances which are relatively far in the instance space that has been defined by the distance functions are actually less likely than the two closely situated instances in comparison to be in the same class.

kNN is basically an instance-basedclassifier which actually runs and works on the grounds of classification of unknown instances which is done by relating the unknown instance to the known instance according to somedistance/similarity function. Here we have the hunch that in the instance space where there are many instances, then any pair of instance which are far apart in the space is actually defined by the appropriate function of distance that are actually less similar than the two instances which are situated close to each other belonging to the same class. In order to classify the samples into the groups, we have a syntax which is given as below:

Syntax

Class = knnclassify(Sample, Training, Group k)

CONCLUSION

ICA is a nice technique for the phenomena like brain and non-brain activities. It opens a functional and valuable doors and possibilities for these phenomena which are in the multichannel records by splitting up the recorded data at number of electrodes on the scalp into the sum of temporary independent components.

In most of the cases, this ICA is also independent functionally. But in specific, ICA can be said as the most effective and applicable method for eliminating a broad variety of artefacts from the records of EEG. This is because when there is time course and all the activities go in the time course, then their course of time is in general independent.

Also, the phase locking and coherence are the basic techniques which are used to study the brain signals patterns. The EEG of the brain in order to study has lots of jewel in its girth. After studying the pattern and which areas of the brains are active in different emotions we are now able to recognise the person is in which state. And to enhance that cognition, we can have various activities to perform.

The conclusion leads to the performance of the ICA as a perfect tool in order to remove the artefacts. The methodology gives the main process through which we can lead to the post data after extraction and classification of the pre-data.Given below are some advantages of using ICA:

1. The algorithm ICA is efficient and the mutable requirements are not large even if we go for the huge or heavy EEG data sets.

2. ICA is actually used to remove the artefacts of a broad variety of the EEG artefacts. But simultaneously it separates the EEG and its artefacts both in their own independent components based on the data given.
3. No random thresholds usually come across the tasks sessions that are needed to decide the time duration for the correction of artefacts.

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Cite this Article
Kumar Yogesh R Cognitive Enhancement of the Brain: Removal of Artefacts. *Journal of Artificial Intelligence Research & Advances*. 2018; 5(2): 21–25p.