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Data Analysis and Data Classification Techniques for Meditative and Non-Meditative Brain Rhythms using EEG Signals

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Abstract: ***This research aims new perceptions are obtained into the nature of EEG during meditation and non-meditation. Statistical comparison of the recorded signals. The paper covers the brain constituents, EEG patterns, EEG data acquisition equipment basics, essentials of classification techniques. This paper includes the effectiveness of signal processing and electroencephalography basics. It also includes the acquisition of the EEG signal in research at the time of implementation in Brain Computer Interfaces. The objective of this paper is EEG data acquisition of meditative and nonmeditative subjects and their statistical analysis field as well as building elementary perception for performing EEG data acquisition and analysis.***

Keywords: Meditation, Electroencephalograhy, EEG Capturing Devices, Classification techniques, EEG Data Acquisition.

I. INTRODUCTION

Nowadays, many advanced technologies, are available that is verified. The brain structure is very complicated and consists of many more processes. The brain processes perform complex tasks in preferably tiny, highly concentrated areas. Neurons are the most important part of the brain. In the prolonged processes neurons are interconnected to each other along lengthy processes.

DENDRITES and AXONS are used for receiving and delivering the information respectively between the neurons. Neurons are used for passing the electrical signals. [1]

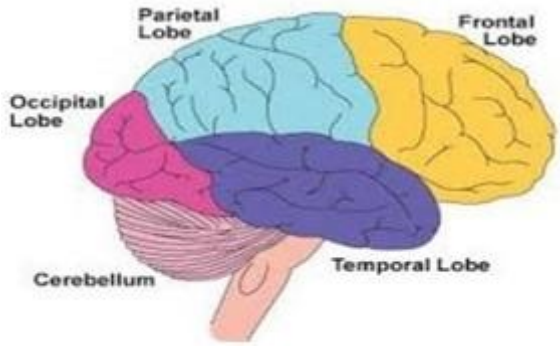

Fig. 1. Brain Structure [17]

A. Lobes of the Brain

- **Frontal Lobe:** Judgment, planning, problem solving, Intelligence, concentration.
- **Parietal lobe:** Sensation, Interpretation of language, words and signals.
- **Temporal lobe:** Understanding language, Memory, hearing
- **Occipital lobe:** Interpretation of color, light, and movement.[2][18]

Brain rhythms are the most leading part of the brain. Varied conditions can occur in the brain that can be linked with the four fundamental brain waves that are stated in TABLE I.

Table I. EEG Brain Rhythms [3]

EEG Rhythms	**Range**	
Beta	14-30Hz	Anxious Thinking
Alpha	8-12Hz	Vigilant State of Consciousness
Theta	4-8Hz	Drowsiness
Delta	0.5-4Hz	Deep Sleep

II. MEDITATION

Healthy body and brain are the two secrets of healthy life and the meditation is the best way of keeping that both healthy, their healthiness influences on brain activities by grabbing the highest attention level. [16] Meditation improves our emotions, calmness, psychological balance.

Mindfulness Meditation:

The fundamental building block of meditation is the mindfulness meditation. Mindfulness meditation techniques are planned to construct use of attention by hiring breath sensation to develop mental peace. It is observed that to enhance self-understanding by practicing mindfulness meditation.[15]

III. EEG

The electrical signals are produced by neurons. These electrical activities of the brain are exhibited by using EEG. There are different techniques are available for analyzing the human brain activities like Positron Emission Tomography (PET), functional Magnetic Resonance Imaging (fMRI), Electroencephalography (EEG). EEG is the non- invasive technique as

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compared to other techniques. In 1929, Hans Berger was first measured EEG in humans. EEG has been used to study brain physiology non-invasively. Firstly, an epileptic seizure is recorded by using EEG. In the starting days EEG is used only for medical purpose but now it is used in the meditation, emotion recognition research also for finding the mental states.[4]

Potential Measures of the EEG:

- Speed
- Lower Hardware Costs
- Non-Invasive
- Extreme temporal resolution
- EEG is a stronger tool for capturing brain changes during various phases of life. [13][5]

A. *Problem Area of the EEG*

- Little bit of spatial resolution on the scalp.
- EEG inadequately computes neural activity that occurs below the upper layers of the brain.
- Signal-to-noise ratio is inadequate. So huge numbers of subjects are required for getting functional data. [13]

IV. EEG CAPTURING DEVICES

Various equipments are obtainable for taking the EEG signals. Here, represent the overview of the Emotive Epoc and neurosky mindwave mobile device.

A. *Neurosky Mindwave Mobile:*

Fig. 2. NeuroSky Mindwave Mobile EEG headset [6]

The one parched electrode with a 512Hz sample rate and 3- 100Hz frequency span device called as the NeuroSky Mindwave Mobile EEG headset is used for measuring the EEG brain signals by positioning the electrode on the left brow at the FP1 location. This device required only one AAA battery for power supply. This is a very easy task to place this device on the actual place by using a ground clip.[6]

B. *Emotiv EPOC:*

Advanced Brain Computer Interface applications are done using two reference electrodes and 14 electrode EEG device with 128 or 256Hz sampling frequency. It is used in many research studies related to brain areas. Before using this device it is necessary to charge it and also the saline solution is used to wet the electrode pads for better fixation on a scalp. It has somewhat flexible plastic arms that are connected to each other and separately adjusted to ensure proper positioning. [8]

Fig. 3. Emotiv EPOC EEG headset [7]

V. DATA ACQUISITION WORK

In the proposed work EEG recorder (Neurosky Mindwave) device is used for collecting various types of tiny signals depending on the brain activity with the help of android mobile and would like to study these signals for analyzing the different brainwave rhythms during meditation. The meditator will do the meditation at that time we will collect EEG Data. Data from the mind wave is accessed using the Application Program Interface of NeuroSky Inc. for the mind wave headset. Data was then plotted using a Processing-based program. Data was recorded as the subjects in meditation for the meditator and the data is recorded for non-meditator also The EEG Data file is in the .csv file. This.csv file contains the fields like timestamp, poorSignal, eegRawValue, attention, meditation, blink strength, low Alpha, high Alpha, low Beta, high Beta, Delta, Theta, low gamma, high gamma, TagEvent, and location.

Fig. 4. Proficient Power

The Fig. 5 shows a comparison of power levels of different frequency bands for meditator and non-meditator subject.

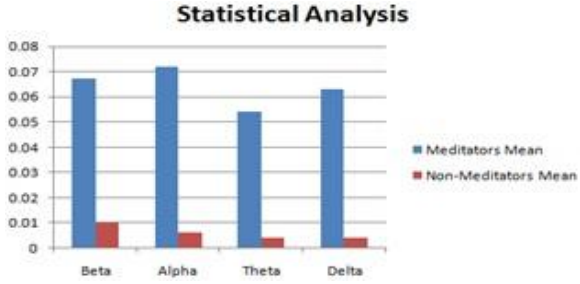

Fig. 5

It can be seen that the lower frequencies are dominant

while meditating as compared to the high frequencies which are more dominant in a non-meditating subject.

In this research, we select 5 normal males as the subjects with no experience of meditation and 5 normal males as performing meditation. This was mostly designed to trace the varying characteristics of EEG recorded with 1 electrode using Neurosky Mindwave Device system, with a sampling frequency of 512Hz**.** The recorded EEG signals are analyzed using MATLAB software.

Table II. Mean at Different Frequency Bands

Frequency Bands	Meditators	Non-Meditators
	Mean	Mean
Beta	0.067142	0.01
Alpha	0.071785	0.006364
Theta	0.054283	0.004343
Delta	0.063214	0.004343

Table II shows the statistical comparison by using mean method. Here we consider the 5 subject's data. It shows that the Alpha Frequency band is more superior in a meditating person as compared to a non-meditating person.

VI. CLASSIFICATION TECHNIQUES

A. Linear Discriminant Analysis:

Linear Discriminant Analysis is easy to use and it gives adequate results in both small and huge database. Linear Discriminant Analysis is easy to use and it gives adequate results in both small and huge database. Decision boundary is the main factor of the LDA performance identification. The LDA reconstruct the data from large volume to small. In decision making low volume is used. [14] This technique is generally utilized for finding out the linear features like in statistics, pattern recognition, and machine. [9]

B. Quadratic Discriminant Analysis:

In Quadratic Discriminant Analysis (QDA) the quantification from each class is usually scattered. The results of this technique are acceptable as well as encouraging. In this technique, quadratic surface is used to separate two or more events in machine learning and statistical classification. [10]

C. Support Vector Machine (SVM):

Classification, as well as prediction, is done by using Support Vector Machine. Support Vector Machine classification method is used for linear as well as non-linear data. It utilizes a mapping to modify the authentic training data into a higher dimension. In this technique using hyperplane data of two classes can be separated. This hyperplane is perceived using support vectors and margins. The hyperplane is nothing but the decision boundary. In EEG signal classification SVM is pertained [11][12][14]

VII. CONCLUSION

In medical and research areas EEG non-invasive devices are used. In EEG data acquisition different brain rhythms like Beta, Alpha, Theta, and Delta can be captured and after that, the statistical parameters are calculated at each level of the frequency band. The Alpha Frequency band is more superior in a meditating person as compared to a non-meditating person. Also the review of classification techniques used in BCI research.

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