Analysis of EEG Signals with the Effect of Meditation

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ABSTRACT **- Meditation and ideas related to it are gaining popularity due to increasing stressful conditions. Many benefits are achieved through meditation such as physiological, psychological and spiritual benefits. Evidence for an influence of different meditation types on brain activity comes from electroencephalographic (EEG) studies. EEG signal processing provides the understanding of complex inner mechanisms of the brain. This research aims to obtain new insights into the nature of EEG during meditation. The recorded signals are analyzed using wavelet transform and are statistically compared.**

Keywords – Daubechies, Electroencephalography, Meditation, Vipassan

I. INTRODUCTION

Meditation arose from an ancient spiritual tradition centred in India. From thousands of years, it has achieved substantial popularity as a therapeutic tool as well as a method of self-development. It is widely perceived to have potent, specific effects on both the body and mind. In today's fast life, significant amount of mental stress due to hectic work schedules is leading to insomnia, negative emotions, depression and many other symptoms after an extended period. Previous researchers showed that meditation can significantly affect physical and mental relaxation. In general, meditation can be divided into two types: mindfulness and concentrative. Mindfulness based meditation is allowing all your thoughts, feelings and sensations to arise while staying aware of yourself and your location [1]. Recent research has found that mindfulness meditation is associated with an increase in psychological well-being and a decrease in stress and mood disturbance [1].

This project is mainly designed to trace the varying spectral characteristics of EEG recorded during meditation. The changes of EEGs during meditation and are to be analyzed using Wavelet Transform. Also the statistical parameters are compared.

The real time signals are characterized as non-stationary, random, non-linear in nature. Hence their both time and frequency information is equally important. In this research real time data is collected using Electroencephalography. Earlier, a lot of work has been done using different advanced signal processing techniques to find the significant changes between the mental states and these signals.

EEG studies have utilized these methods to portray the brainwave changes that occur in meditation. Although the meditative changes in EEG signals have not yet been firmly established, the preliminary findings have implicated increases in theta and alpha band power and decreases in overall frequency [2]. Various Time- Frequency analysis methods are available in the umbrella of signal processing which are discussed in the later section.

The remaining of this work is organized as follows: The second section gives literature review on Meditation and its effects on EEG, different time-frequency analysis methods used in EEG signal analysis. The third section discusses the Real-time recording of EEG signals for meditating as well as non-meditating subjects. The fourth section gives the stepwise implementation of proposed algorithm and wavelet transform and the wavelet family used explained in detail. The fifth section shows results and the statistical comparison. Finally, sixth section offers the advantages of proposed algorithm, conclusion and applications.

II. LITERATURE SURVEY

Meditation is a practice that self regulates the body and mind. Meditative styles can be classified into two types— mindfulness and concentrative— depending on how the processes are directed.

Mindfulness practices involve allowing any thoughts, feelings, or sensations to arise while maintaining a specific stance. Examples include Zen and Vipassana. Concentrative meditational techniques involve focusing on specific mental or sensory activity.

Vipassana is oldest of the Buddhist meditation technique. "Vipassana" is a Pali term though not directly translatable to English roughly means "looking into something with clarity and precision, seeing each component as distinct, and piercing all the way through so as to perceive the most fundamental reality of that thing."[3] The main goal of Vipassana is the understanding of the 3 characteristics of nature which are impermanence (anicca), sufferings (dhuka), and non-existence (anatta). Meditators are trained to notice more and more of their flowing life experience, becoming sensitive and more receptive to their perceptions and thoughts without becoming caught up in them [3]. Vipassana meditation teaches people how to examine their perceptual processes, to watch thoughts arise, and to react with calm detachment and clarity, reducing compulsive reaction, and allowing one to act in a more deliberate way.

The effects of meditation on the human brain can be categorized as: State Changes that are observed during meditation and Trait changes that are observed when person is practicing long-term meditation. These effects on the human brain can be analyzed using various techniques such as Electroencephalography (EEG), Functional magnetic resonance imaging (fMRI), Positron emission tomography (PET). Electroencephalography (EEG) is a non-invasive technique as compared to rest of the techniques. The function of electroencephalography is to detect and amplify the bioelectric potential of the brain by electrodes placed on the surface of the scalp. The EEG measures brainwaves of different frequencies within the brain as shown in Table (1).

TABLE 1. Classification of brainwaves.

Wave	Frequency	Mental State
Gamma	Above 40 Hz	High-level information processing
Beta	13-40 Hz	Normal waking consciousness
Alpha	8-12 Hz	Awake but relaxed
Theta	4-7 Hz	Light sleep or extreme relaxation
Delta	Less than 4 Hz	Deep dreamless sleep

Previous studies show that the activity of alpha-theta is predominant in meditation.

Time - Frequency analysis helps in characterizing EEG signals as they fall in different frequency bands. Fourier Transform is not suitable for analyzing non-stationary signal. Its fails to provide the exact location of the event along the time scale in frequency domain. Another technique is Short Time Fourier Transform (STFT) but the drawback is its finite window size. The narrow window offers poor frequency resolution whereas the wider window offers poor time resolution [6]. Hence, resolution is a problem in STFT and it can be resolved using Wavelet transform. Some researchers [7] found that wavelet analysis provides more effective way to study mental behavior in comparison with Fourier analysis.

III. REAL-TIME RECORDING PROCESS

In this research, we select 5 normal adults as the subjects with no experience of meditation and 5 normal adults performing meditation. This was mainly designed to trace the varying spectral characteristics of EEG recorded with 3 electrodes using a 10-20 system in which two were reference electrodes, with a sampling frequency of 250Hz**.** In clinical electroencephalography, 21 electrodes are applied to the head, it is known as 10-20 system [8]. The 10-20 system employs skull landmarks as reference points to locate the electrodes. In all, 19 scalp and 2 earlobe (auricular) electrodes are used to examine the electrical activity of the surface of the brain. So the three electrodes are used, one is Ground (G), other reference (R) and active (A). The recorded EEG signals are analyzed using MATLAB software.

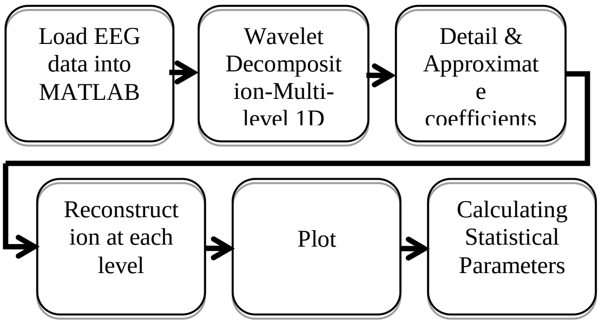

Fig. 1. Proposed Algorithm

IV. PROPOSED ALGORITHM

The proposed algorithm is as shown in the Fig.1. The EEG signal is analyzed using Time-Frequency Analysis method – Wavelet Transform. DWT analyzes the signal at different frequency bands by decomposing of signal into a coarse approximation and detail information. The Daubechies8 wavelet function ("db8") is used for extracting the features from the EEG signal. General characteristics of Daubechies are compactly supported wavelets with external phase, orthogonal, biorthogonal, wavelets with highest number of vanishing moments for a given support width. The number of decomposition levels was chosen to be 8 based on the dominant frequency components of EEG signal. Thus, the EEG signals were decomposed into the details $D1 - D8$ and one final approximation $A8$. Fig.2 shows the EEG signal for subject1 who is a non-meditator. Fig 3. shows the decomposition of the EEG signal into 5 different frequency bands.

V. RESULTS

The Gamma, Beta, Alpha, Theta, Delta frequencies are obtained in this process of feature extraction at different levels of decomposition. Once these features are extracted, the statistical parameters are calculated at each level of extracted frequency band.

Table2 shows a comparison of power levels of different frequency bands for meditating and non-meditating subject. 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.

Similarly data was calculated for 10 subjects and their Mean as well as Standard Deviation was calculated. It shows that the Alpha Frequency band is more dominant in a meditating person as compared to a non-meditating person. Table 3 below shows the statistics.

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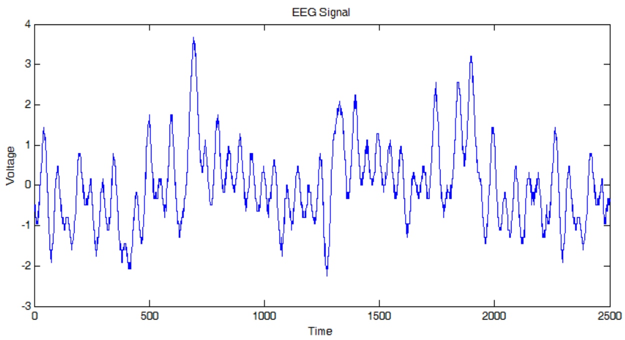

Fig. 2. EEG Signal

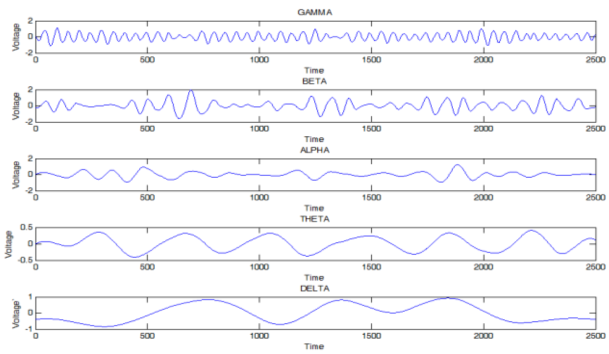

Fig. 3. Extracted Waves

Absolute Power		
Frequency Bands	Meditator	Non-Meditator
Delta	0.13	0.01
Theta	0.13	0.01
Alpha	0.17	0.01
Beta	0.1	0.03

TABLE 2 : Absolute Power at different frequency bands.

Frequency Bands	Meditator		Non-Meditator	
	Mean	Standard Deviation	Mean	Standard Deviation
Delta	0.063214	0.124277	0.004545	0.005096
Theta	0.064286	0.127379	0.004545	0.005096
Alpha	**0.081786**	**0.156774**	0.006364	0.007895
Beta	0.077143	0.115369	**0.01**	**0.006172**

TABLE 3 Mean and Standard Deviation at different frequency bands.

VI. CONCLUSION AND FUTURE WORK

Wavelet Transform helps in deriving more and more details of the signal at each level of decomposition. The time-frequency resolution problem which was there in Short- Time Fourier Transform is overcome by Wavelet Transform and features can easily be extracted.

The signals for the meditating and non-meditating subjects are recorded in real-time, features are extracted and statistical parameters are calculated. The comparison showed that the lower frequencies are more dominant in the meditating subjects as compared to non-meditating subjects.

This study can be applied in meditation training and the progress of the trainee can be tracked by real-time EEG analysis.

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