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Review on Analysis of EEG Signals with the Effect of Meditation

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ABSTRACT
Meditation is proving out to be one of the most universally feasible solutions to the modern day stressful conditions. Varied positive physiological, psychological and spiritual benefits are known to be achieved through meditation. Many researchers previously investigated the effect of meditation on stress relief and disease improvement. The present study deals with the effect of meditation on human brain using electroencephalographic signals (EEG). To obtain new insights into the nature of EEG during meditation, the recorded signals are to be analyzed using wavelet transform.

Keywords **–** Daubechies, Electroencephalography, Meditation, Vipassana

I. INTRODUCTION

From thousands of years, Meditation has been practiced by the people. Originally it was meant to help deepen understanding of the sacred and mystical forces of life. 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 the past, many people doing research on meditation found out the effect of meditation on stress relief and disease improvement. This project is mainly designed to trace the varying spectral characteristics of EEG recorded during meditation and then the changes of EEGs during meditation are to be analyzed using Wavelet Transform. EEG signals are considered to be non-stationary, random, non-linear in nature. The important features of these signals can be determined by time-frequency analysis. In relation with the EEG signals, a lot of work has been done to find the significant changes between the signals and the mental states by using different advanced signal processing techniques.

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 [1]. For analyzing these EEG signal various Time- Frequency analysis methods are available in the stream of signal processing which are discussed in the later section.

The remaining of this work is organized as follows: The second section gives a brief introduction about Meditation and its effects, Electroencephalography (EEG), time frequency analysis of EEG signals and the problem definition. The third section talks about literature review on Meditation and its effects on EEG, different time-frequency analysis methods used in EEG signal analysis. The fourth section discusses the Real-time recording of EEG signals for meditating as well as non meditating subjects. The fifth section gives the stepwise implementation of proposed algorithm and wavelet transform and the wavelet family used explained in detail. Finally, sixth section offers the advantages of proposed Algorithm and suggested some improvements for future.

II. GENERAL OVERVIEW

Vipassana, oldest of the Buddhist meditation techniques is practiced primarily in south and south east Asia but now it is also a popular form of meditation in Western countries. "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."[2] The main goal of Vipassana is the understanding of the 3 characteristics of nature which are impermanence (anicca), sufferings (dhuka), and non-existence (anatta). Through the technique, 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 [2]. 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 function of electroencephalography is to detect and amplify the bioelectric potential of the brain by electrodes placed on the surface of the scalp. EEG has several strong points as a tool for exploring brain activity. EEG's can detect changes within a

millisecond timeframe, excellent considering an action potential takes approximately 0.5-130 milliseconds. The EEG measures brainwaves of different frequencies within the brain.

III. LITERATURE SURVEY

As discussed earlier [3], meditation have various effects on our human system, especially it acts as a stress-buster in our day-to-day stressful life. The brainwaves having different frequencies within our brain can be classified as shown in the following TABLE (1) with its respective frequency band and the mental state.

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, whereas delta activity is observed in deep sleep. Although theta-wave activity suggests dreaming, alpha, the predominant waveform in meditation, is most closely associated with wakeful alertness [4].

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 [5]. Hence, resolution is a problem in STFT and it can be resolved using Wavelet transform. Some researchers [6] found that wavelet analysis provides more effective way to study mental behavior in comparison with Fourier analysis.

IV. REAL-TIME RECORDING PROCESS

In this research, we select 10 normal adults as the subjects with no experience of meditation. The task 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 [7]. 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 electrodes placed on the scalp of the subject, pick up the EEG signal. This electrical parameter (EEG) is passed through a buffer. The buffer output is fed to a differential amplifier which is with high impedance, good Common Mode Rejection Ratio (CMRR), low gain and higher frequency response. The amplified EEG signal is then passed through High and Low cut-off filter passes higher frequencies above 0.5Hz. This block act as a band pass filter that passes filter frequencies from 0.5Hz to 40 Hz. This band passed signal is passed through a Gain stage block for amplification. The 50Hz notch filter cuts off 50 Hz signal that lies in the EEG signal. Again the signal is amplified by gain adjustment block and fed to the output to Digital Storage Oscilloscope (DSO). The stored signal in DSO is then transferred to the computer for further analysis purpose which is done in MATLAB software.

V. PROPOSED ALGORITHM

The proposed algorithm is as shown in the Fig.1 which gives the flow of work to be done. The EEG signal is analyzed using Time-Frequency Analysis method – Wavelet Transform. 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.

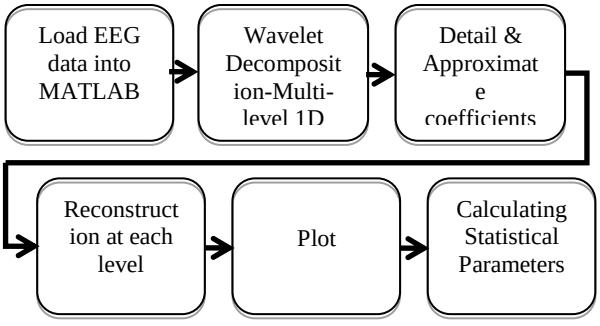

Fig. 1. Proposed Algorithm

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.

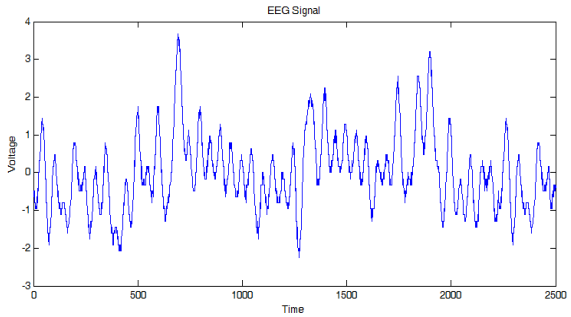

Fig. 2. EEG Signal

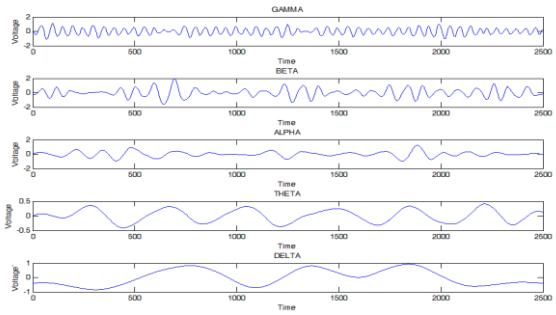

Fig. 3. Extracted Waves

VI. CONCLUSION AND FUTURE WORK

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

The future work focuses on comparing the results. Same way the signals for the meditating subjects will be recorded as recorded for non-meditating subjects, features will be extracted and statistical parameters will be calculated. Theses statistical parameters of the meditating and non-meditating subjects will be compared and the final results with conclusion will be obtained.

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