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Spectral analysis of EEG signal for detection of alpha rhythm with open and closed eyes

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Abstract: ***The Electroencephalography is a non invasive medical technique for monitoring and recording the electrical activity of brain. There are five frequency rhythms in EEG signals which among of them alpha rhythm is distinguished by quietness, daydreaming, unfocused thought, relaxed and meditative feelings. This rhythm is very useful in neurofeedback trapy for treatment of stress, depression, headache, ADHD and etc. In this paper we have used FFT function as a powerful tool in spectral analysis of EEG signals, for detection of alpha rhythm in subjects with open and closed eyes. Results have shown that alpha rhythm is the dominant rhythm on the back of the head in aware subjects with closed eyes. Our results are in support of other researcher's activity in identification of exact position of alpha rhythm over the scalp.***

Keywords: **Alpha rhythm, EEG, FFT, Spectral analysis.**

I. INTRODUCTION

The Electroencephalography is a non invasive medical technique for monitoring and recording the electrical activity of brain. This technique can be applicable again and again on infants, children and adults without any pain, for detection of their brain states and disorders. EEG signals are very low frequency and low amplitude signals. EEG's amplitude and frequency rhythms are listed in Table 1.

Table 1. Characteristics of EEG rhythms

Brain state	Unconscious		conscious		
EEG rhythm	Delta	Theta	Alpha	Beta	Gama
Frequency Hz	0.5-4	4-8	8-13	13-30	>30
Amplitude µV	20-200	10	20-200	5-10	5–10
Brain state	Instinct	Emotion	Consciousness	Thought	Will

As is shown in Table.1 amplitude of any rhythm has some ranges. Intensity or value of amplitude is depended to some factor such as state of patient as well as location of electrode on the scalp.

More recent papers have argued that alpha rhythm inhibit areas of the cortex not in use, or alternatively that they play an active role in network coordination and communication [1]. Historically, they were thought to represent the activity of the visual cortex in an idle state. Alpha wave biofeedback which is explained further, has gained interest for having some successes in humans for seizure suppression and for treatment of depression [2].

Two major applications of EEG is known as clinical application for diagnosis brain diseases and brain computer interface (BCI) technology in research application. In clinical application this signal can be helpful for diagnosis brain disorder such as epilepsy, tumors, stroke, brain death, sleep disorder, coma, drug intoxication, lesions of the brain, Alzheimer as well as in treatment of depresion, redusing of stress and improvement of behavior and intelligence scores in children with attention deficit hyperactivity disorder (ADHD) using neurofeedback techniques. Neuro feedback or neurotrapy that is commonly supplied using video or sound is a type of biofeedback which employs mostly EEG measurements. Generally biofeedback therapy involves training patients by help of biofeedback therapist**,** to control their involuntarily physiological processes that can be recorded by biomedical instruments such as electromyography (EMG), electrodermograph (EDG), electroencephalograph (EEG) and electrocardiogram (ECG). So by seeing these biopotential waves and training, patients can learn how to control these involuntarily process towards of improvement.

However EEG waves contain useful information of brain functions and states, but we cannot extract this information by observing only in time domain directly. Hence we have to analyze these waveforms by signal processing techniques. There are some methods for analyzing of EEG signals which can be applied in time domain, frequency domain and time-frequency domain. A well known method in biomedical signal analysis is spectrum analysis which referred to as frequency domain analysis or spectral density estimation. Spectral analysis is the technical procedure for decomposing a complex signal into simpler branches by quantifying the various amounts versus frequency. Those amounts can be in shape of amplitude, power, intensity or phase. The frequency spectrum of a time-domain signal is a representation of that signal in the frequency domain. The frequency spectrum can be generated via a Fourier transform of the signal, and the resulting values are

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usually presented as amplitude and phase, both plotted versus frequency [3]. EEG signals are best described as a sum of many individual frequency components. Many researchers have used fast Fourier transform (FFT) for spectral analysis of EEG signals in frequency domain. MD. Shahedul amin et al, have considered spectral analysis of human sleep EEG signals using EEGLAB. They have deduced that delta band more specifically, PSD at 1.8 ~ 2.0 Hz and at 2.7 ~ 2.9 Hz is good for finding whether a person is in sleeping or not. If the person is sleeping then there would be a sharp change at these positions [4]. S. Deivanayagi and her group have worked on spectral analysis of EEG Signals during Hypnosis. They have found the spectral analysis of EEG during hypnosis shows the frequency bands in theta and alpha ranges. From that analysis, they have derived that during hypnosis, the frequency bands acquired from the scalp falls in the higher theta and smaller alpha waves [5]. In this paper we have used FFT for detection of location of alpha rhythm in subjects with closed and open eyes.

II. FREQUENCY SPECTRUM

The Fourier transform (FT) converts time domain signals into frequency domain representations that is defined as Eqn.1 and similarly, the DFT converts discrete-time sequences into discrete-frequency versions which is derived by Eqn.2.

$$X(f) = F\{x(t)\} = \int_{-\infty} x(t)e^{-j2\pi ft}dt \qquad (1)$$

$$X_k = \sum_{i=0}^{n-1} x_i e^{-j2\pi ik/n} \quad \text{for k=0,1,…, n-1} \qquad (2)$$

Where in Eqn 1, x(t) is the time domain signal, and X(f) is its FT, and in Eqn. 2, x is the input sequence, X is its DFT, and n is the number of samples.

In 1965 J.W.Cooley and J.W.Tuckey reinvented the FFT for fast computation of the DFT. The Fast Fourier Transform (FFT) is an optimized implementation of a DFT that takes less computation to perform [6].

We can apply FFT to those signals with $N=2^n$ number (called radix-2-algorithm) of samples. Benefit of FFT algorithm is in reducing the computation time by a factor of the order $N/\log_2 N$, i.e. more than 100 times for a sample of 1024 samples [7]. FFT algorithm is available as a function fft () in MATLAB which is used in this paper.

III. EEG SIGNALS COLLECTION

The EEG signals were downloaded from the EEG motor Movement /imagery dataset (in European data format (EDF)) [8]. Subjects performed different motor task while 64 channels EEG as international 10-20 system were recorded using the BCI2000 system. Each subject performed 14 experimental runs. Two one-minute baseline runs as one with eyes open and one with eyes closed which are subject of this paper, and three two-minutes runs of each of the four tasks with motor movement. In this paper we will discuss on two tasks of subjects with open and closed eyes (without motor movement) in first 10 second. Sampling frequency of In these datasets, is 160 Hz.

IV. RESULT AND DISCUSSIONS

For considering that in which part of head and what states of patients alpha rhythm is dominant, some experiment is done in MATLAB software using FFT function. As an instance, time domain signal of P_Z channel for 10 second is shown in Fig. 1.

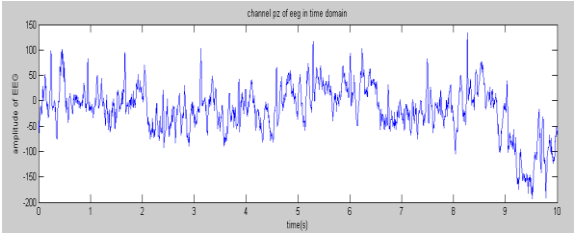

Fig.1. Time domain presentation of P_z channel

As it is clear from this figure, property of signal is not detectable by only observing on time domain signal. Hence, for feature extraction of EEG signals, FFT of some channels as P_Z, P_3, P_4, C_Z and F_Z for three subjects are derived. Results related to subject 2 as instance are presented in Fig. 2 to Fig.6.

By visual inspection on these figures we can say that there is no domination for alpha range in upper panel with open eyes, whereas in all the figures, in down panel which is related to closed eyes, alpha rhythm is as a dominant rhythm in these channels.

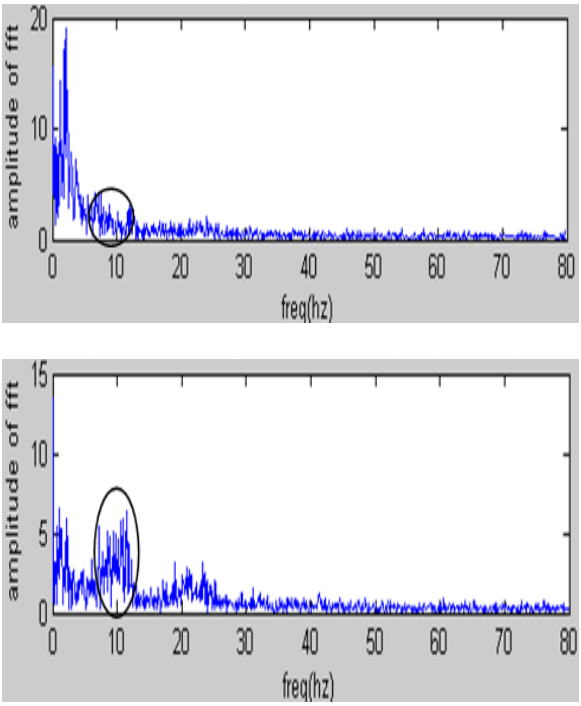

Fig.2 FFT of F_Z with open eyes in upper panel and closed eyes in down panel

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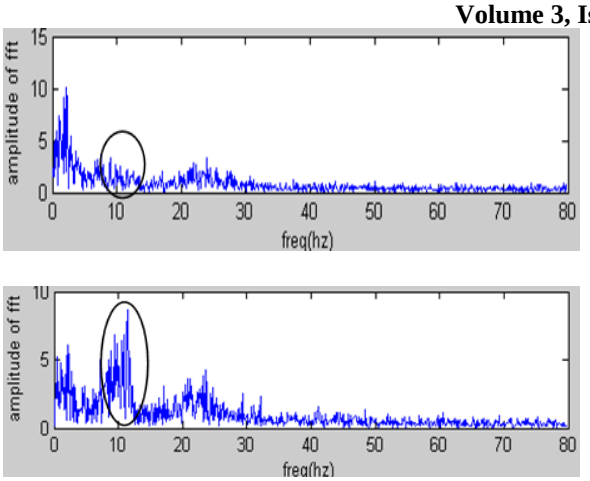

Fig.3 PSD of C_Z with open eyes in upper panel and closed eyes in down panel

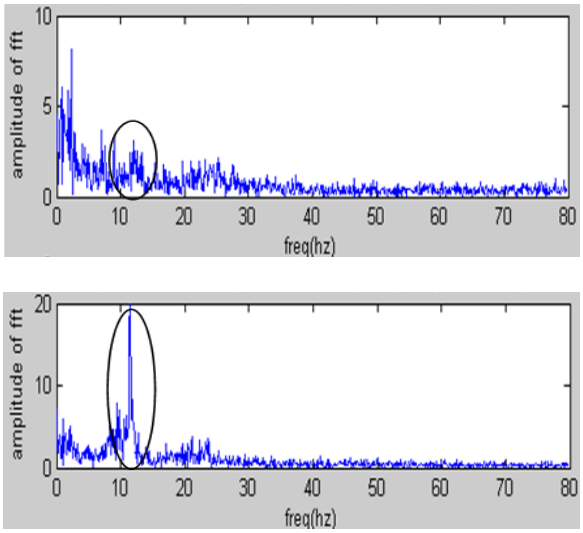

Fig.4 PSD of P_Z with open eyes in upper panel and closed eyes in down panel

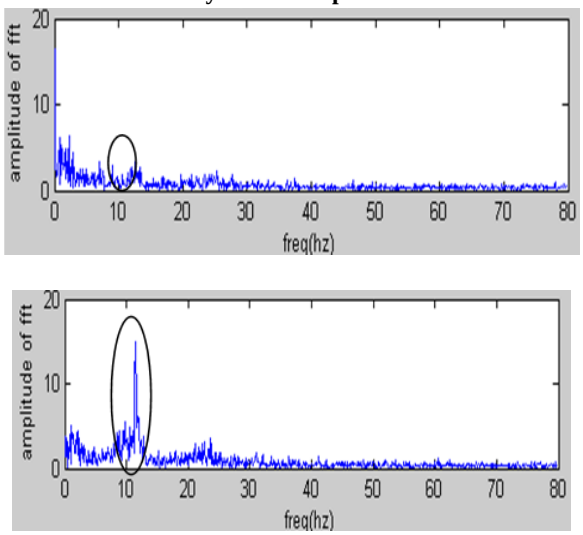

Fig.5 PSD of P3 with open eyes in top upper and closed eyes in down panel

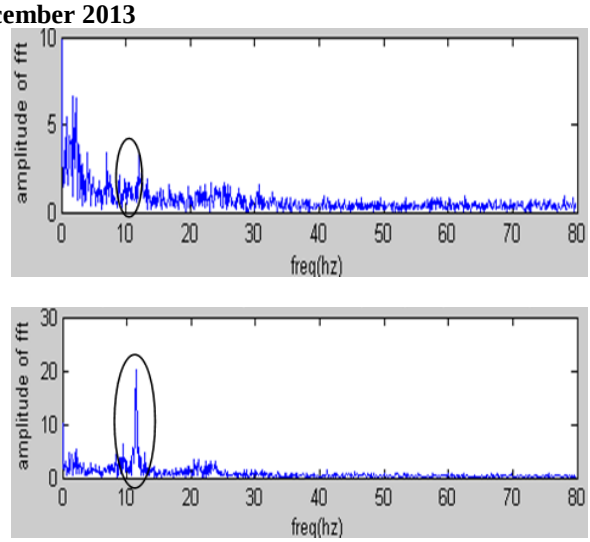

Fig.6 PSD of P4 with open eyes in upper panel and closed eyes in down panel

Another point that can be seen in these figures is that maximum peak of alpha rhythm with closed eyes is increasing by shifting the electrode from frontal to parietal lobe. For two more subjects similar results are observed. Hence we can conclude that back of head is good place for detection of alpha rhythm with closed eyes.

One more point in case of this subject which can be seen from these figures is that in all the channels, with open eyes delta rhythm is dominant rhythm and after closing the eyes this domination is attenuated or cancelled. This delta domination with open eyes is because of ocular artifacts (OAs) due to eye blink an eye movement. In down panel which is related to closed eyes, probability of existence of OAs is very less.

V. CONCLUSION

With analogy of FFT of different EEG channels on three subjects, it is achieved that alpha band is dominant in alert persons with closed eyes especially in channels over back of the head and with opening the eyes domination of this band will be attenuated. One more point also concluded from this paper that with closing the eyes we can reduce OAs.

So our future plan will be removing the OAs from EEG signals using advance digital signal processing techniques.

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