Frequency Analysis of Healthy & Epileptic Seizure in EEG using Fast Fourier Transform

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Abstract— Analysis of EEG signals shows that the range of frequency for epileptic seizure in a neurological disorder which needs to be detected at an early stage to know their specific needs and to help them survive with the problem. In reference to the India population 0.6 to 0.8% is affected by seizure, which is the common neurological disease just after the knock, of which 3o% have not been able to gain any control over their seizure using current pharmacological treatment measure [1-2].KNN and Linear discriminate analysis are used to detect the discrete emotions (surprise, happy, fear, neutral and disgust) of human through EEG signals. We measure EEG signals frequency range relating to seizure, divide them into five different domain such as α, β, γ, δ and θ related to the total range, and eliminate frequency distribution through FFT of EEG signals to compare the difference between seizure and healthy subject. The resulting calculations are based on the selected frequency range.

Keywords— Epileptic seizure, EEG, Fast Fourier Transform, BCI, rhythms of the EEG signals.

INTRODUCTION

An EEG is the most used technique to capture brain signals due to its excellent temporal resolution, usability, noninvasiveness, and low set-up costs. The Supreme commander of the human body is the brain. It's the central part of the nervous system which governs the functions of a variety of organs in the body. The signals measured from the central nervous system will give the relationship between psychological change & emotions. An EEG can show what state a person is in, whether in sleep, anaesthetized, awake, because the characteristic patterns of the electrical potentials differ for each of these states. On the classification of EEG signals in the two most important areas, epilepsy and brain computer interface (BCI)[3]. Seizure is a transient abnormal behavior of neurons within one or several neural networks, which limits the patients' physical and mental activities. EEG plays an important role in nervous electro-physiology field such as using spike wave to discovering diagnose epilepsy, brain tumour early, sleep analysis and monitoring the depth of anesthesia etc.

Although theoretically there exist various signal analysis methods used in EEG analysis application[4-6], owing to the limitation of signal processing technique, the research on EEG by existing EEG instrument is not through, also the extracting of feature information of EEG, satisfied for clinical diagnosis. Virtual EEG instrument is based on the virtual instrument technology. The emergence of virtual instrument technology based on PC enabled us not only make full use of the resource of computer software and hardware, but also renew the functions and performance of the instrument in time. Because EEG signals is a stochastic complex non-stationary signal, it is difficult to extract the feature rhythms in EEG signals effectively only by some simple analysis methods in time domain or frequency domain. Furthermore, there are various different feature waveforms with different parameter feature contained in EEG signals, such as spike wave, slow wave, sharp wave sine wave, spindles and K-complex etc., which have relation with different pathological changes, so it is very difficult to extract all feature information only by a certain signal analysis method. Based on above consideration, for different feature information in EEG signals and the functions set of the EEG instrument, the concrete realization of several time-frequency analysis methods have been discussed and integrated into the virtual EEG instrument to extract adaptively feature information in EEG signals.

I. THE ALGORITHM REALIZATION FOR EXTRACTION OF BASIC RHYTHMS IN EEG SIGNALS

In clinical purpose, to evaluator if a basic rhythm of EEG signal is controlled, doctors usually develop some simple analysis methods in time methods or frequency domain and themselves' practice, which are of many suspicions. The function extracting the feature information of basic rhythms in EEG signals automatically integrated into the virtual EEG device, which is realized by Gabor transform with the definition of EEG signals basic rhythm frequency band relative intensity ratio (BRIR) [9].The Gabor transform of signal *x* (*t*) is expressed as

$$g_D(f,t) = \int_{-\infty}^{+\infty} x(t)_{g_D^*}(t' - t)e^{-j2\pi ft}\,dt' \text{……… (1)}$$

Where * represent complex conjugate. The window function *D g* is used for restricted the Fourier transform of the signal at time *t*. By discrete time and frequency, the discrete Gabor transform can be defined as

$$g_D(f,t) \rightarrow g_D(mF, nT) \text{.. (2)}$$

where *F* and *T* represent the sampling interval of frequency and time. Short interval *F* corresponds to big window width, while short interval *T* can be obtained by height overlapping of adjacent window. From the Gabor transform defined by eq. （1）, the spectrum can be defined as

$$I(f,t) = |g_D(f,t)|^2 = g_D^*(f,t)g_D(f,t) \text{……….……. (3)}$$

By employing recursive algorithm, slipping time window and output energy (I) as the functions of time and frequency, the time-frequency expression of the signal can be obtained. To quantize information, for the frequency band of each basic rhythm (**i=α, θ, δ,** β) in EEG signals, the frequency band power spectrum density is defined as

$$I^{(i)}(t) = \int_{f(i)min}^{f(i)max} I(f,t)\,df \quad \text{…….….(5)}, \ i = \boldsymbol{\alpha}, \theta, \delta, \beta$$

Where (*f* (*i*) min, *f* (*i*)) max) represents the upper and under limit of frequency band *i*. Note that the division of frequency bands in EEG is not arbitrary which correspond to different origin and function of brain activity. Where *i* =δ, θ, α, β denotes the different oscillation rhythms with different frequency [10].

Frequency range according to nature of rhythms of the EEG signals

Delta	0.5 to 4 Hz	It is primarily associated with deep sleep, serious brain disorder.
Theta	4 to 8 Hz	Theta wave arises from emotional stress or disappointment and unconscious material, creative inspiration and deep mediation.
Alpha	8 to 13 Hz	When the brain is in relaxation state.
Beta	13 to 30 Hz	When the brain is associated with active attention, mental activities.
Gamma	>30 Hz	It is associated with various cognitive and motor functions.

II. FAST FOURIER TRANSFORM

FFT is very important for many reasons that efficient computation of this has emerged as a well analyzed topic for decades. To determine the FFT algorithm have been developed which are generally known as FFT [7-8].

$$x^{(N)}(k) = \sum_{n=0}^{N-1} X(n)e^{-j2\pi kn/N} \quad , \text{ k=0, 1, ….. N-1}$$

Subscript (N) is to show length of DFT for each value of k, computation of $X(k)$ requires.N = Complex multiplications , N-1= Complex additions.

III.EEG DATA AND CHANNEL SELECTION

The EEG signals were recorded from 4 channels; C3, C4, P3 and P4 and filtered using band pass filter with frequency range 8 Hz to 30 Hz. The signal was analyzed using Fast Fourier Transform. The database is generated with 20 subjects in the age group of 22 to 40 years using 64 channels with a sampling frequency of 256 Hz.

EEG Hardware	Brain Amp Amplifier
Kind of electrode	Ag/Agcl
Hardware reference	Electrodes,Neurofeedback
Sampling Rate	256 Hz
Hardware filter	Hum notch filter
Software filter	Band pass filter
Other Hardware	None
Patient state during reading	Relax sitting on chair

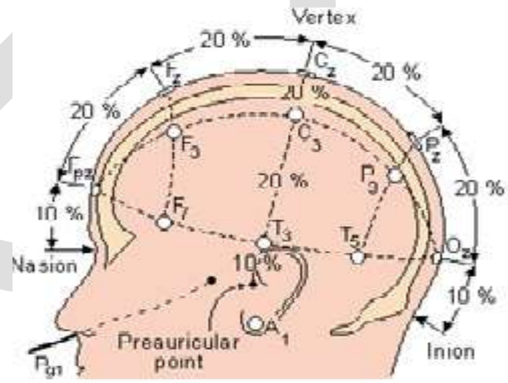
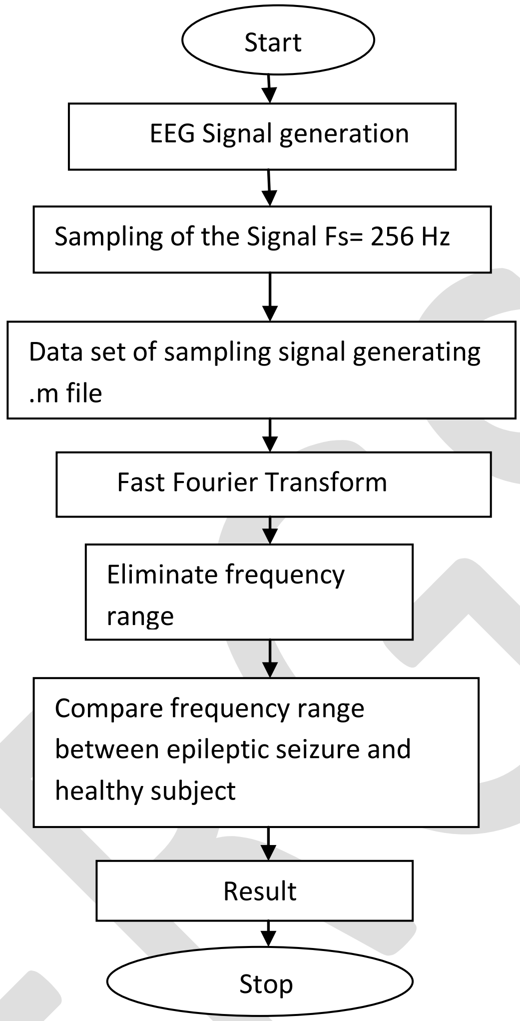


Figure 1. Channel placement

IV. PROPOSED METHOD

The main objective of this work is to compose the efficiency of classifying seizure & healthy subject using two fast Fourier transform based on their frequency range such as 0.5 to 4 Hz (delta), 8 to 13 Hz (alpha) 13 to 30 Hz (beta) and>30Hz (gamma)[11]. We measure EEG signals frequency range relating to seizure, divide them into five frequency range such as α, β, γ, δ and θ related to the total range, and eliminate frequency.

V. Flow chart of frequency analysis



VI. THE SYNTHESIS ANALYSIS METHOD FOR EXTRACTING FEATURE WAVEFORMS IN EPILEPTIC EEG

The EEG waves of epileptic consist of spike wave, slow wave sharp wave, and their combination like spike and slow wave, sharp and slow complex etc. What literatures mention mostly is the detection for spike wave and spike wave [12-14]. However, spike waves and sharp waves often emerge during the epileptic outbreak, while patients are in the diapauses at most of cases, in which the waves of spike and sharp will reduce greatly , even not emerge, although they are of significant clinical indication meaning for epileptic diagnosis. There will be slow waves and some complex waves with the background of slow wave more in the EEG signals of patients. The emergence status can prompt the vested pathogen for epileptic classification and focus localization. But the detection and analysis for slow wave has been mentioned rarely in the literature and product information of EEG instruments held by the authors, because the amplitude and frequency span of slow waves is wider and the difference of waveforms is great. At the same time, considering the multiformity of feature waveforms emerged in some pathology which cannot be extracted by using one or more signal analysis methods simply, multi signal analysis methods are synthesized in the virtual EEG instrument to detect the feature waveforms in the multi-channel EEG signals automatically[15,16].

VII. FEATURE EXTRACTION

The most important task here is to extract different features from the distributed frequency of FFT as shown in fig. (3), which directly dictate the finding & classification precision. In this work processing of FFT is obtained, there are two type of subject epileptic seizure and healthy subject, which frequency distribution colour are defined red and green respectively.

Seizure details of recording an patient Specification:

Source: record eegmmidb/S001/S001R01.edf Start: [16:15:00.000 12/08/2013] value has 1 row (signal) and 1600 columns (samples/signal)

Duration: 0:10

Sampling frequency: 160 Hz

Sampling interval: 0.00625 sec

Row	Signal	Gain	Base	Units
1	Fc2.	1	0	Uv

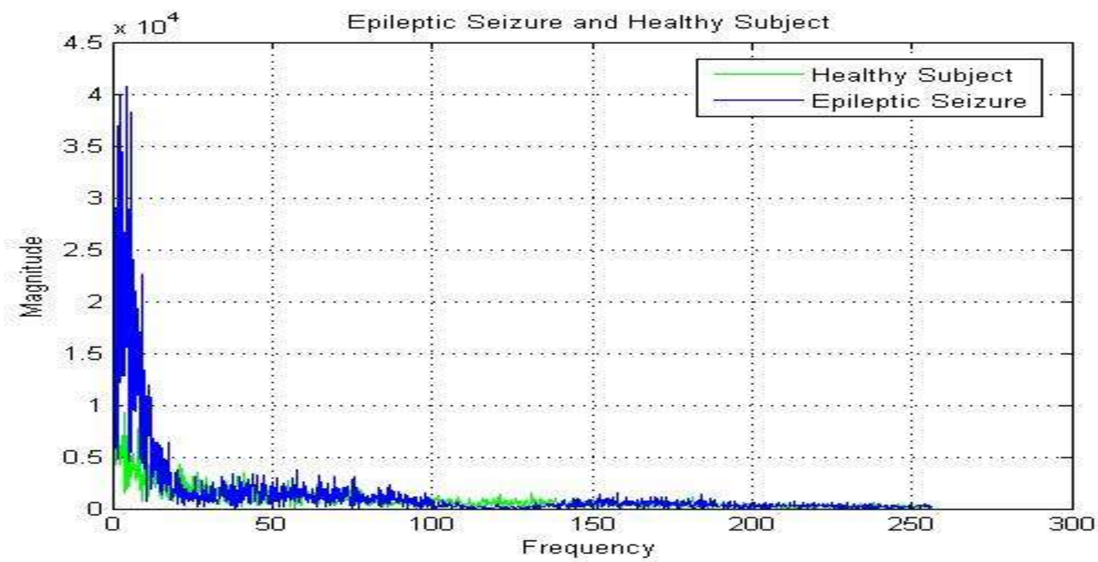


Fig.2 FFT of epileptic and healthy subject

VIII. Frequency Elimination

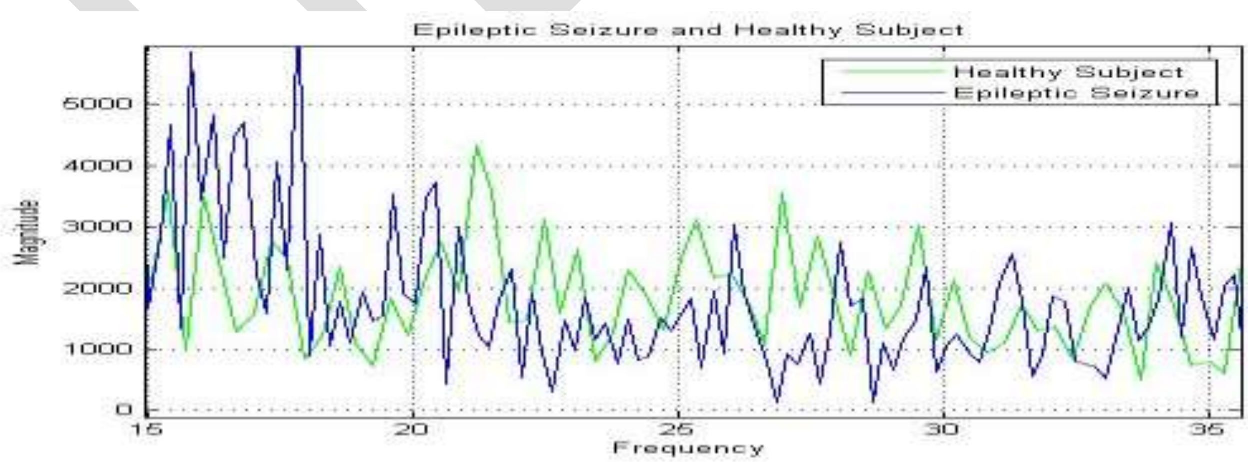


Fig.3 for Frequency (δ)

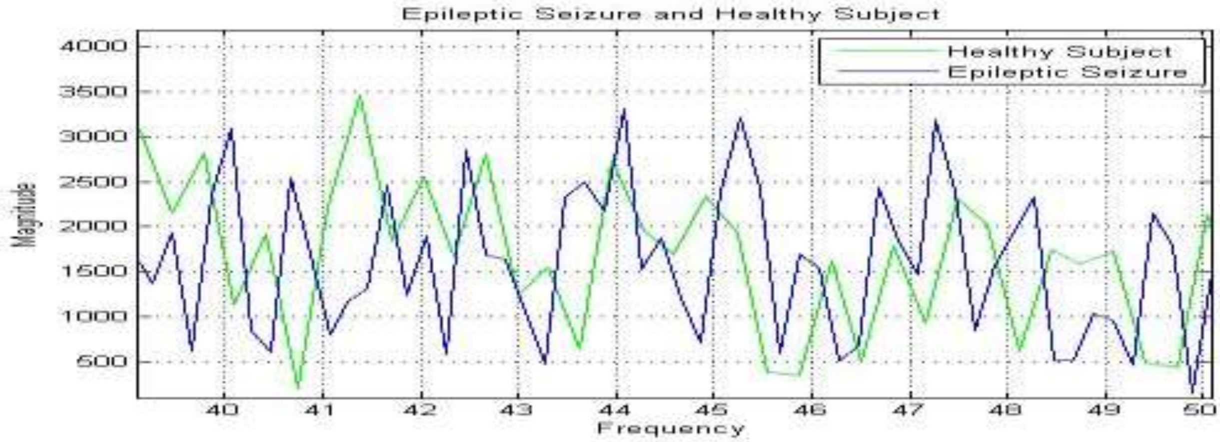


Fig.4 for frequency (α)

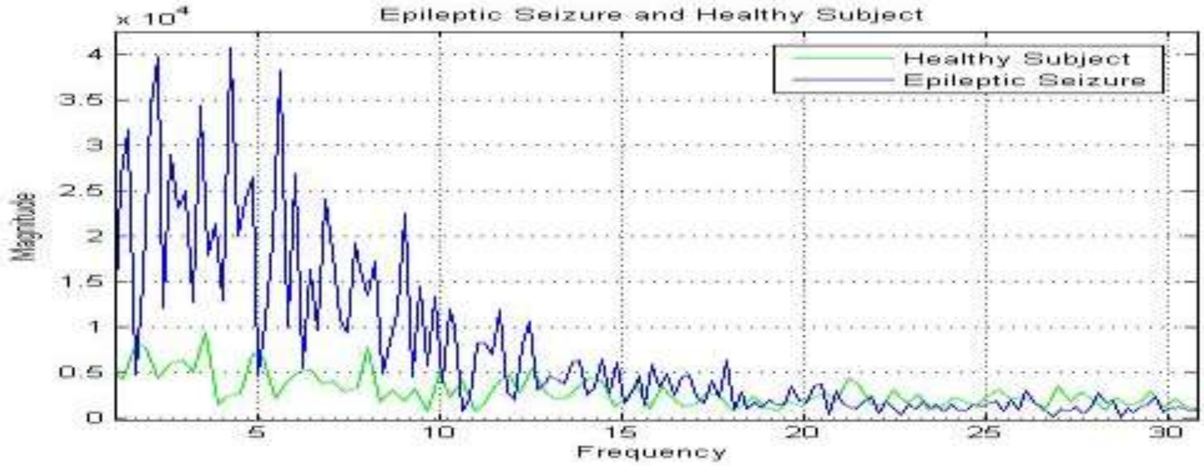


Fig.5 for frequency (ɣ)

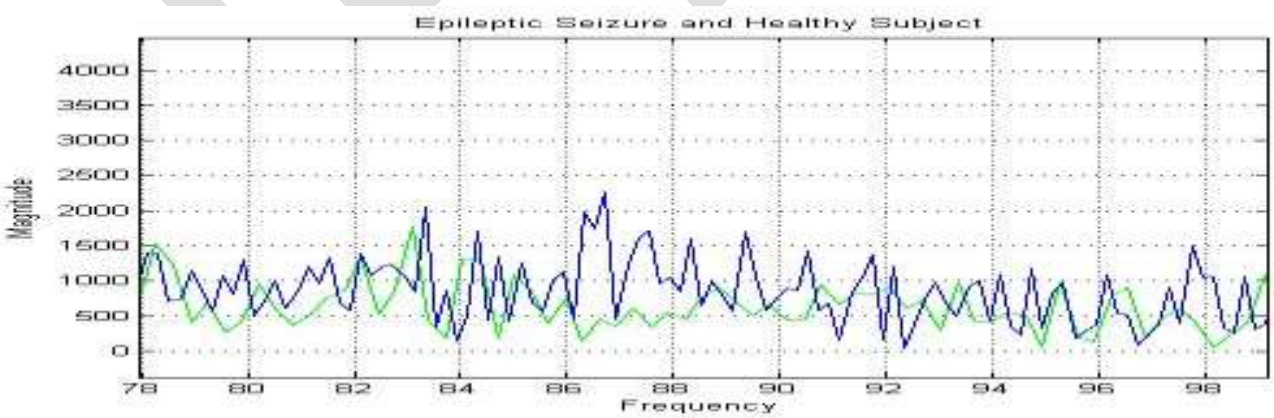


Fig.6 for frequency (θ)

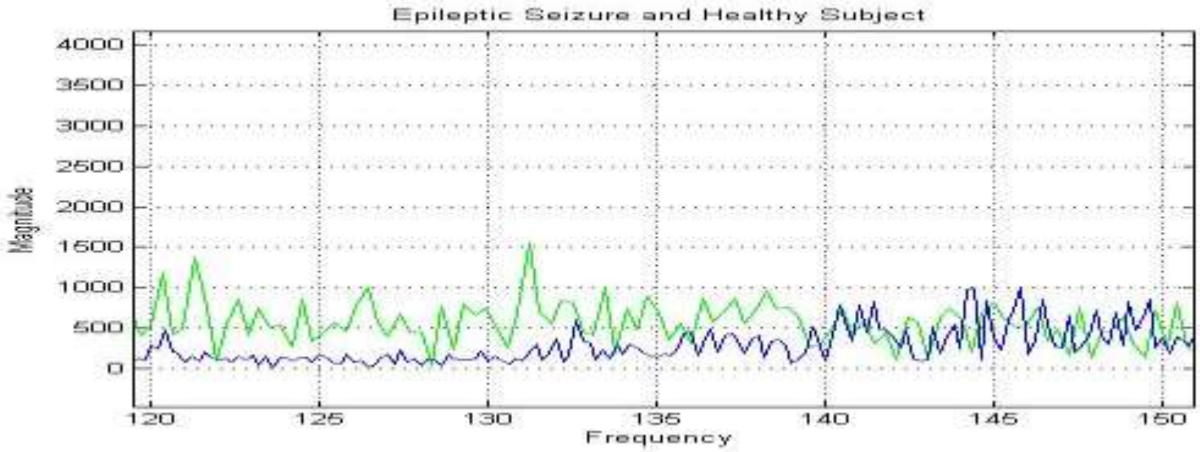


FIG.7 FREQUENCY MORE THAN (Θ)

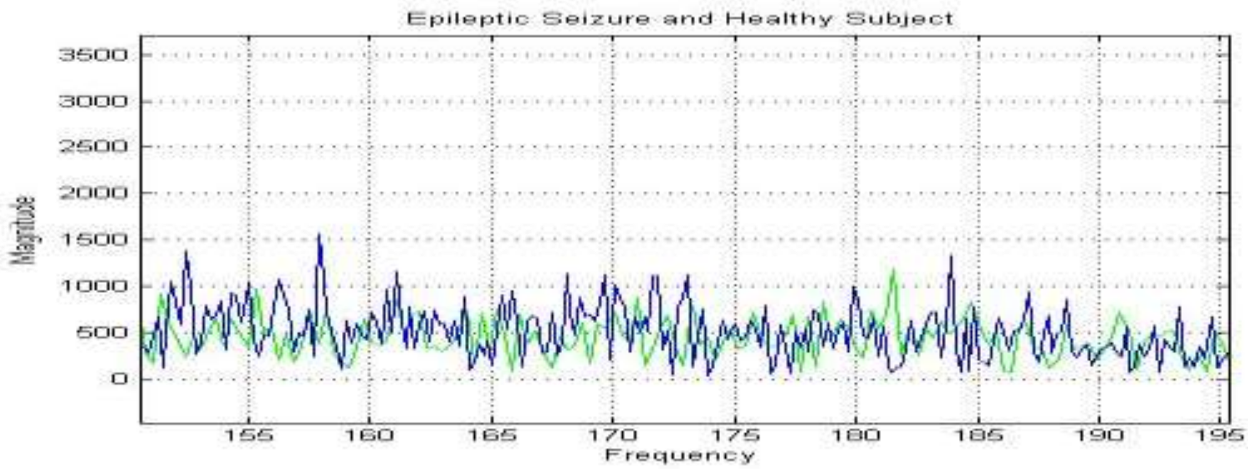


Fig.8 Frequency more than 30 Hz

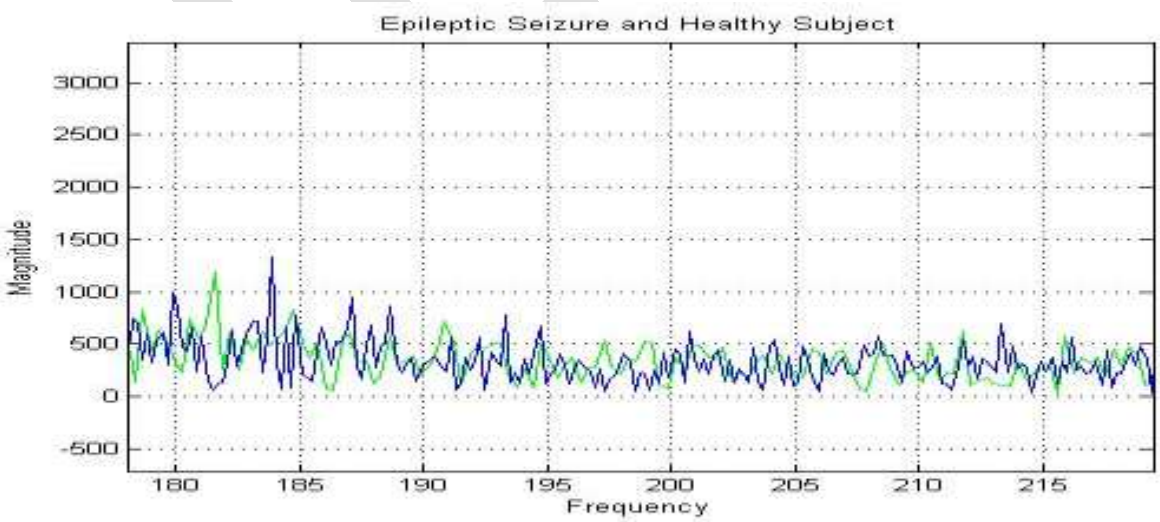


Fig.9 Frequency more than 40 Hz

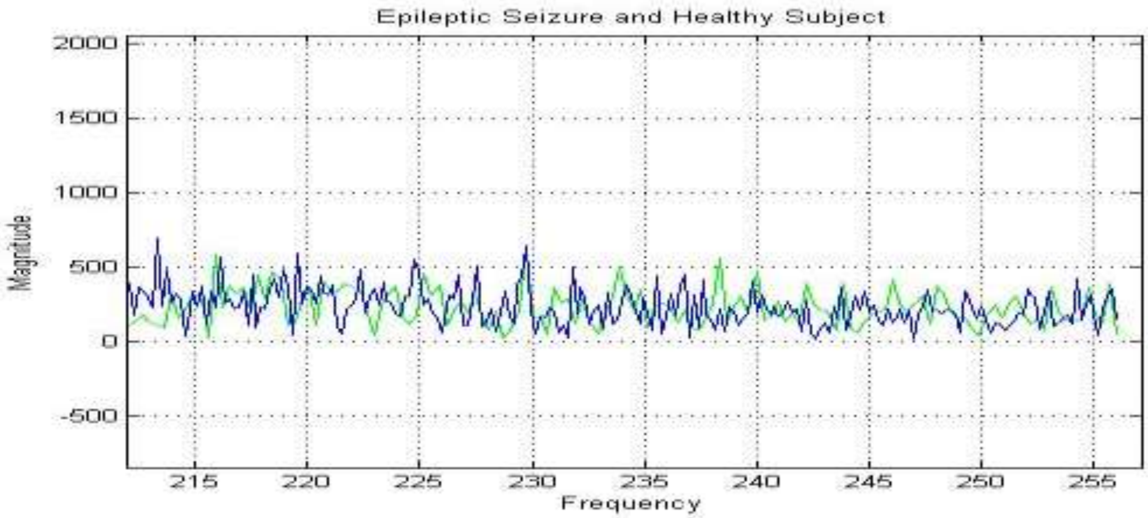


Fig.10 Frequency more than 50 Hz

IX. RESULT

The complexity of feature extraction and its implementation is another important criterion while developing a feature vector for multiclass epileptic seizure classification. It is found that frequency of spikes in epileptic seizure is less, in comparison to the healthy subject. . From the above analysis we can easily extract the features of EEGs signals for healthy and unhealthy signal. The results of this study confirm our hypothesis is that it is possible to prospectively predict an epileptic seizure and other patients.This frequency analysis algorithm of multichannel, except for the initialization stage after occurring of the first seizure in each patient. In the following plots we can analyze the repetition of frequency between healthy subject and epileptic seizure.

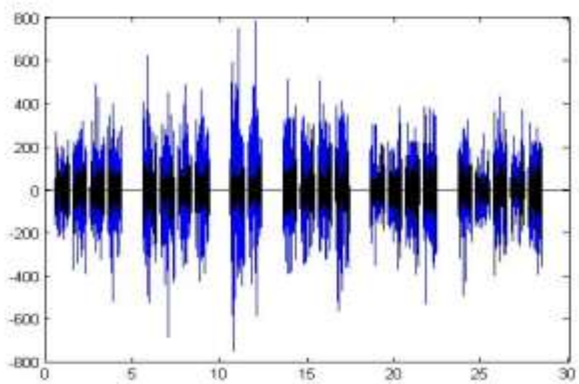


Fig.11 Overlapping Frequency of Healthy & Epileptic Seizure

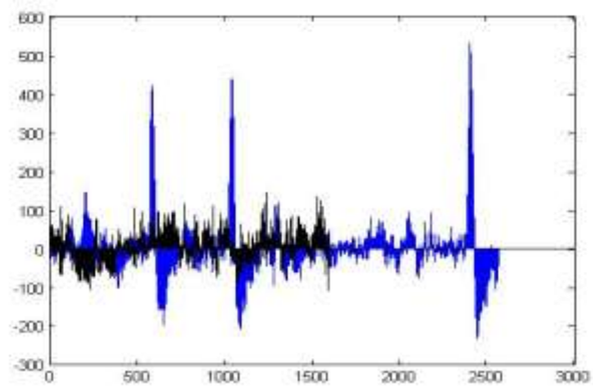


Fig.12. Overlapping Frequency of Healthy & Epileptic Seizur

CONCLUSION

Advantage of EEG Signal Extraction-Feature extraction and classification are used for investigation of the following clinical problems [18-20]. (i) Monitoring alertness, coma, and brain death. (ii) Locating areas of damage following head injury, tumour, and stroke. (iii) Testing afferent pathways (by evoked potentials).(iv) Monitoring cognitive engagement (alpha rhythm).(v) Producing biofeedback situations.(vi) Controlling anesthesia depth (servo an aesthesia).(vii) Investigating epilepsy and locating seizure origin. (viii) Testing epilepsy drug effects. (ix) Assisting in experimental cortical excision of epileptic focus. (x) Monitoring the brain development. (xi)

Testing drugs for convulsive effects. (xii) Investigating sleep disorders and physiology.(xiii) Investigating mental disorders. (xiv) Providing a hybrid data recording system together with other imaging modalities.

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