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Analysis of EEG Signals for Epilepsy and Seizure by decomposition with Wavelet Transform

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Abstract— ***The Electroencephalogram (EEG) is a complex signal that indicates the electrical activity of brain. EEG is a signal that represents that effect of the superimposition of diverse processes in the brain. Epilepsy is a common brain disorder. Out of hundred one person is suffering from this problem. Here we study a novel scheme for detecting epileptic seizure from EEG data recorded for healthy subjects and Epileptic patients. EEG is obtained by International 10-20 electrodes system. Wavelet transform is used for feature extraction. Wavelet Transform (WT) provides a flexible way of time-frequency representation of a signal.***

Index Terms— ***EEG (Electro Encephalo Graph), Epilepsy, Seizure, Wavelet Transform.***

I. Introduction

The EEG signals indicates the electrical activity of brain. The Electrical activity of brain that is EEG, exhibit significant complex behavior with strong non-linear, random and non-stationary properties . A typical EEG signal is measured from scalp of the subject will have amplitude of about 10µV to 100µV and frequency roughly range of 0.25Hz to about 100 Hz. EEG traces are different for different brain activities.However it is very difficult to get useful information from these signals directly in time domain just by observing them. EEG signals are highly non-Gaussian, non-stationary and have a non-linear nature. EEG signals are random in nature. Hence their important features can be extracted using advanced signal processing techniques. A number of signal processing techniques are available for the analysis of EEG signals (like - Fast Fourier Transform, Wavelet Transform etc.)The frequency range of EEG extends from ultra slow to ultra fast frequency components that play no significant role in clinical EEG. Clinically meaning frequency lies between 0.1Hz to 100Hz. In more convenient way to say, the frequency range is classified into several frequency components as: Delta rhythm (Δ: 0.5 to 4 Hz), Theta rhythm (ϴ : 4 to 8 Hz), Alpha rhythm (α: 8 to 13 Hz), Beta rhythm (β: 13 to 30 Hz) and Gamma rhythm (γ: 30 to 60 Hz) .

In a normal adult person the slow ranges (0.3 to 7 Hz) and very fast ranges (>30 Hz) are sparsely represented, and medium (8 to 13 Hz) and fast (14 to 30 Hz) components predominate.

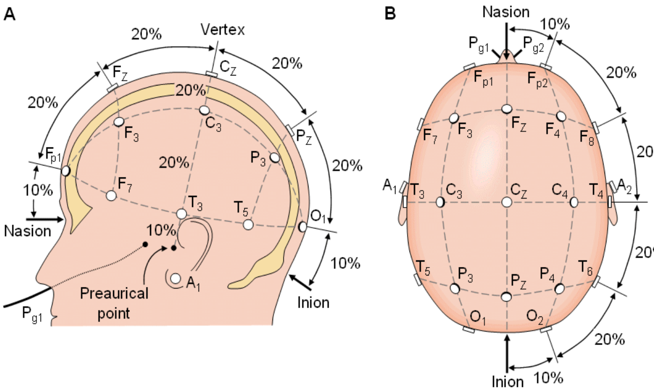

Fig. 1. Internationally used 10-20 Electrode system for EEG measurement

A. Epilepsy and Seizure : A seizure (from the latin sacire, “to take possession of”) is a paroxysmal event due to abnormal, excessive, hyper synchronous discharges from an aggregate of central nervous system (CNS) Neurons. A Seizure is the result of sudden burst of electrical activity in the brain. This cause the brain messages to entire body, temporarily halted or mixed up. The symptoms are vary with each seizure type, and may include muscle jerking, convulsions, memory loss, eye blinking, muscle stiffening or loosing, a blank state or loss of consciousness. I a person experience single seizure, it does not mean he has epilepsy. Epilepsy is condition characterized by recurrent seizures.

Epilepsy describes a condition in which a person has recurrent seizure due to a chronic, underlying process. This definition implies that a person with a single seizure, or recurrent seizure due to correctable or avoidable circumstance, does not necessarily have epilepsy. Epilepsy is a recurrent seizure disorder caused by abnormal electrical discharges from brain cells, often in the cerebral cortex. It is not a distinct disease; it is a group of disorders for which recurrent seizures are the main symptom. So, epileptic seizures are the result of the transient and unexpected electrical disturbance of the brain. Approximately one in every hundred persons will experience a seizure at some time in their life.

The detection of epilepsy,

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which includes visual scanning of EEG recordings for the spikes and seizures, is very time consuming, especially in the case of long recordings. In addition, bio-signals are highly subjective so disagreement on the same record is possible, so the EEG signal parameters extracted and analyzed using computers, are highly useful in diagnostics. A powerful method used for time-scale analysis of signal is wavelet transform. One of the efficient property of wavelet transform is that it is appropriate for analysis of non stationary signals as EEG signals.

B. *Wavelet Transform:* The wavelet transform has become a useful computational tool for a variety of signal and image processing applications. For example, the wavelet transform is useful for the compression of digital image flies smaller files are important for storing images using less memory and for transmitting images faster and more reliably.

The WT can be consider as an extension of the classic Fourier Transform, except that instead of working on a single scale (time or frequency), it works on multi scale basis. The multi-scale feature of wavelet transform allow the decomposition of signal in to a number of scales, and each scale representing a particular coarseness of signal under study. All wavelet transforms may be considered forms of time-frequency representation for continuous-time (analog) signals and so are related to harmonic analysis. There are classified into different type- 1) Continuous wavelet transforms. 2) Discrete wavelet transforms. 3) Multi resolution discrete wavelet transforms.

Here we consider the discrete wavelet transform (DWT). DWT analyzes the signal at different frequency bands, with different resolutions by decomposing the signal in to a coarse approximation and detail information. DWT employs two set of functions called scaling functions and wavelet functions, which are associated with low pass and high pass filtering of time domain signal.

II. WAVELET TRANSFORM ANALYSIS

A. *Continuous Wavelet Transform :*

The continuous wavelet transform (CWT) of an analog signal f(t) with analyzing wavelet function ψ(t). In continuous wavelet transform the given signal of finite energy is projected on a continuous family of frequency bands. For instance the signal may be represented on every frequency band of the form [f, 2f] for all positive frequencies f > 0. Then, the original signal can be reconstructed by a suitable integration over all the resulting frequency components. Discrete wavelet Transform : *It is computationally impossible to analyze a signal using all wavelet coefficients, so one may wonder if it is sufficient to pick a discrete subset of the upper half plane to be able to reconstruct a signal from the corresponding wavelet coefficients. One such system is the_ system for some real parameters a > 1, b > 0.*

$$\psi_{m,n}(t) = a^{-m/2}\psi(a^{-m}t - n\,b).$$

Above is the equation of corresponding baby wavelet.

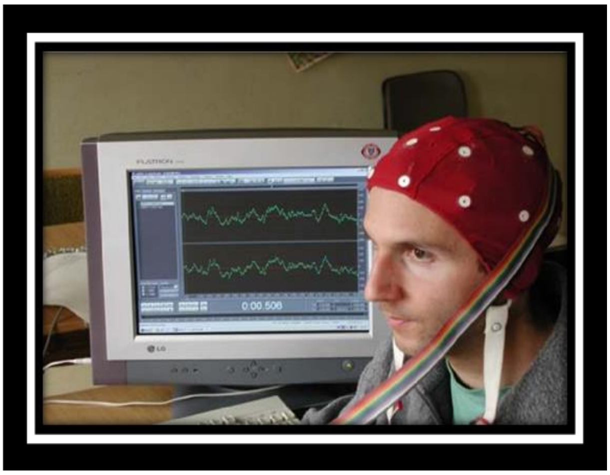

Fig 2- 10-20 EEG electrodes international system based cap for acquiring signals

III. DATA ACQUISITION

Epileptic seizure is an abnormality in EEG recordings an it is characterized by the brief and episodic neuronal synchronous discharges with dramatically increased amplitude. This increasing amplitude synchronization may occur in the brain locally (that is in some parts of brain partially, called partial seizure) So, it is seen only in few channels of EEG signal, or involving the whole brain (called generalized seizures) which is seen in every channel of the EEG signal. Twenty channel for normal persons and for typical epileptic EEG records were measured according to the international 10-20 electrodes arrangement.

Wavelet transform is a spectral estimation technique in which any general function can be expressed as an infinite series of wavelets. The basic idea underlying wavelet analysis consists of expressing a signal as a linear combination of a particular set of functions (wavelet transform, WT), obtained by shifting and dilating one single function called a mother wavelet. The decomposition of the signal leads to a set of coefficients called wavelet coefficients. Therefore the signal can be reconstructed as a linear combination of the wavelet functions weighted by the wavelet coefficients. In order to obtain an exact reconstruction of the signal, adequate number of coefficients must be computed. The key feature of wavelets is the time-frequency localization.

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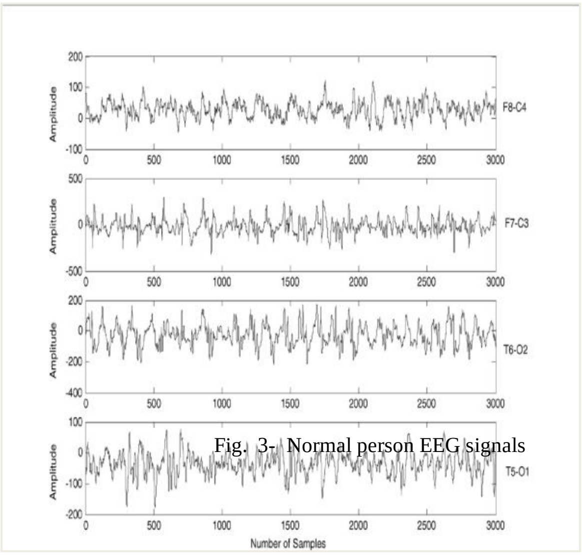

Fig. 3- Normal person EEG signals

Table I- 1st detailed coefficients of normal subjects by Wavelet Transform

No. of Subject	Mean (volt)	Max (volt)	Min (volt)	Std dev. (volt)
N1	-0.0334	8.1664	-6.4155	2.0537
N2	-0.0320	8.1665	-6.4157	2.0537
N3	-0.0807	8.933	-9.6887	2.8188
N4	-0.0334	8.1671	-6.4154	2.0536
N5	0.0900	19.7430	-11.171	3.193

Table II- 2nd detailed coefficients of normal subjects by Wavelet Transform

No. of Subject	Mean (volt)	Max (volt)	Min (volt)	Std dev. (volt)
N1	-1.4843	85.8707	-77.3773	26.8400
N2	1.4841	85.8709	-77.3772	26.8399
N3	-0.9272	106.7530	-87.5871	30.9097
N4	-1.4848	85.8810	-77.3771	26.8398
N5	-0.9450	123.5970	-96.2584	24.1431

Table III- 3rd detailed coefficients of normal subjects by Wavelet transform

No. of Subject	Mean (volt)	Max (volt)	Min (volt)	Std dev. (volt)
N1	-0.0979	30.568	21.6995	6.9056
N2	-0.0978	30.569	21.6993	6.9056
N3	-0.0902	36.039	39.9556	9 .9397
N4	-0.0979	30.569	21.6994	6.9057
N5	-0.2318	48.131	40.7132	9.109

Table IV- 4th detailed coefficients of normal subjects by Wavelet transform

No. of Subject	Mean (volt)	Max (volt)	Min (volt)	Std dev. (volt)
N1	6.2497	234.3669	-186.849	87.7532
N2	6.2497	234.367	-186.843	87.753
N3	8.3013	310.099	-152.429	81.8029
N4	6.2499	234.367	-186.843	87.7532
N5	-1.2032	164.069	-189.199	65.827

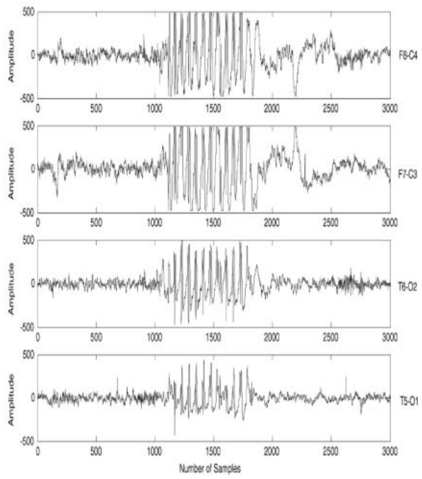

Fig. 4- EEG of Epileptic person

Table V- 1st detailed coefficients of Epileptic subjects by Wavelet transform

No. of Subject	Mean (volt)	Max (volt)	Min (volt)	Std dev. (volt)
E1	0.0478	55.128	-52.810	16.3626
E2	-0.032	62.8023	-63.985	234167
E3	-0.0330	75.0797	-67.673	19.2450
E4	-0.032	62.8023	-63.985	234169
E5	-0.1102	93.2310	-86.365	28.0438

Table VI- 2nd detailed coefficients of Epileptic subjects by Wavelet transform

No. of Subject	Mean (volt)	Max (volt)	Min (volt)	Std dev. (volt)

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E1	1.0479	85.127	-33.809	11.3624
E2	-1.0311	72.8022	-23.984	23.4166
E3	-1.0329	78.0793	-37.672	16.2447
E4	-2.031	69.8022	-33.984	13.4166
E5	-1.1101	91.2309	-46.364	14.0435

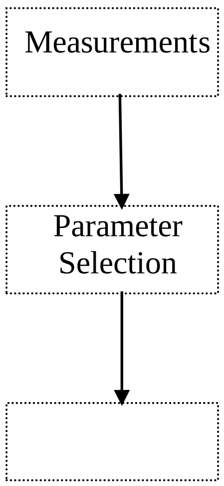
The comparison of parameter of different subject and before the comparison extract the feature i.e. mean , maximum, minimum and standard deviation for all subjects are shown in table IX . So, Wavelet's feature extraction and representation properties can be used to analyses various transient events in biological signals. The DWT was performed at 4 levels, and resulted in five sub-bands: d1-d4 and a4 (detail and approximation coefficients respectively).

Table VII- 3rd detailed coefficients of Epileptic subjects by Wavelet transform

No. of Subject	**Mean** (volt)	**Max** (volt)	**Min** (volt)	**Std dev.** (volt)
E1	2.6853	159.09	-125.61	49.1415
E2	2.0997	206.27	-252.11	71.9810
E3	-0.9848	161.0379	-179.68	57.2303
E4	2.0999	206.261	-252.11	71.9820
E5	-3.2461	150.742	-179.74	59.0590

Table VIII- 4th detailed coefficients of Epileptic subjects by Wavelet transform

No. of Subject	**Mean** (volt)	**Max** (volt)	**Min** (volt)	**Std dev.** (volt)
E1	-6.3332	245.510	-213.134	83.9259
E2	-1.8026	225.89	-206.455	92.3092
E3	-0.3309	148.939	-271.956	75.2490
E4	-1.8027	225.877	-206.456	92.3092
E5	0.2662	277.491	-191.134	94.2156



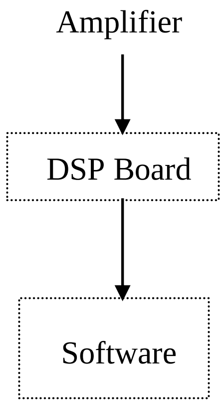


Fig. 5- EEG Measurement System Flow Diagram

IV. RESULT AND CONCLUSION

Table IX shows the extracted features of the random EEG signal for normal persons and Epileptic patient subjects. So by this study we can say that Random, non linear biomedical EEG signals can be analyzed using a strong tool called as wavelet transform, so that features can be extracted .

Table IX- Normal and Epileptic Patient's EEG Parameters Comparison.

DATA	**FEATU-RES**	**Sub band D1**	**Sub band D2**	**Sub band D3**	**Sub band D4**
Normal Patient	**Mean**	0.0074	-0.08	-0.417	2.456
	Max	8.504	26.761	85.71	175.71
	Min	-8.124	-23.782	-76.29	-160.1
	Std Dev.	2.3006	7.343	23.686	62.79
Epile-psy Patient	**Mean**	-0.011	0.002	0.0539	-0.593
	Max	13.582	55.093	143.74	188.89
	Min	-12.494	-53.561	-137.2	-190.6

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	Std Dev.	4.0043	17.709	46.443	70.633

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